Wildfire risk management

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Introduction

Where society (or an organisation) perceives unplanned fires as harmful, its objective is presumably to minimise their damage (Hatch and Jarrett 1985). Fire services have traditionally been assigned this role but their approaches vary. Most focus on the inputs, e.g. providing the best service delivery standards or the most efficient resource allocation (e.g. Sakrzewski 1993; Hearn 1993). In these cases, damage minimisation is an assumed or a hoped-for outcome, ie. an implicit goal. Few focus on damage minimisation per se as an explicit goal.

Observation on the conduct of any organisation suggests that the results it delivers are determined by what it focuses upon and what aspects of its performance are measured (ie. what gets measured gets done). Therefore, if a fire service focuses its efforts and resources on damage minimisation as an explicit goal and measures relevant outcome data, damage minimisation should be achieved efficiently. In contrast, the approach of the input focused services may be an inefficient way of achieving the minimum damage outcome.

Moreover, whether input focused services actually reduce damage is often unclear because the results they report are based on service delivery indicators rather than damage indicators. Their approach may need to be reviewed because there is evidence that excellent service delivery standards are not a guarantee of less damage. For example, the number of serious fires in the UK Fire Service increased by 32% over ten years, despite an excellent record of service delivery (Smith et al 1996).

The purpose of this paper is to describe a wildfire risk management system that explicitly aims to minimise wildfire damage. The principles are also applicable to urban fire management. The system can be applied by an individual landowner/manager as well as a fire agency. It is consistent with the recommendations of Smith el al (1996) in delivering a balance of both proactive and reactive strategies within a risk management framework.

Approaches to risk management

A fire service typically aims to address the fire problem by applying resources more or less in proportion to a measure of 'risk'. Some studies have found a positive correlation between resource allocation and 'risk' level (e.g. NZ Forest Service — Cooper and Ashley-Jones 1987), whereas others have not (e.g. CFS — Hatch and Jarrett 1985). But the key issue to address is the indicator of 'risk' being used and how relevant it is to the goal of damage minimisation.

Risk is typically understood in terms of likelihood of loss and usually includes identification of what may be harmed and the likelihood of that harm occurring (Salter 1998). For a fire event, there is a likelihood of the fire occurring and a consequence of the fire. *Table 1* summarises the inputs used currently or recently by a selection of fire services to determine a risk classification, and has them grouped into likelihood and consequences.

	Likelihood of fire	Consequences of fire	Suppression aspects	Integrated risk index	Primary uses of risk index
Queensland FS – urban and rural Sakrzewski (1993) (=Britain's system)	A measure used, but not specified	Potential damage	Spread potential	Six risk classes	Allocation of resources
NSWFB – urban Hearn (1993)	Population density, occupancy type	Size of building, installed fire protection (= potential damage)	Travel time	Three hazard classes	Allocation of resources
CFA – urban and rural O E S C (2001)	Population density	Potential damage		Five hazard classes	Allocation of resources
ACT – rural ACT RFS (1991)	Index based on recent statistics	Index of fire behaviour	Index of urgency of control	Five classes of fire hazard index	Planning protection programs, allocation of resources
NZ – rural NRFA NZ (1991)	Climatic zones index	Fuel flammability index, Potential damage index		Five fire danger classes	Allocation of resources
CALM – rural, forest CALM (1993)	Statistics	Potential damage – 7 classes	Response and line construction rate, chance of suppression as indicated by fire behaviour	No	Performance indicators, guideline for planning
PREPLAN –rural Good and Bond (1985)	Seasonal weather data	Fire behaviour to indicate relative damage		Fire behaviour indicators	To identify where fuel load is high and suppression difficult
Spain – rural Salas and Chuvieco (1994)	Index of human activity	Index of fuel flammability, index of fire behaviour		Four risk categories	For fuel management and fire suppression

Table 1: Risk Classifications (in current or recent use).

Table 1 shows that the inputs are quite different between Services, some are derived from historical data and some are arbitrary indices. The indices each have strengths and weaknesses and they are each used to achieve the purposes of each organisation.

But the measures do have some features in common. They assume that if a fire occurs, it will result in maximum damage. They don't take probable fire intensity into account. They don't take design capacity of the fire service into account. They do not specify the link between risk classification and damage reduction.

It is arguable whether some of the inputs or even the integrated risk indices are relevant to risk of fire or risk of damage. Their method of integration is also questionable.

The approach of these fire services can be characterised as follows:

- there is a fire problem that causes damage/concern/inconvenience to constituents, therefore a fire service is required
- assign resources within budget to contain the threat
- assess the fire hazard/risk in some way
- re-assign resources in proportion to the hazard/risk measure
- therefore damage/loss will be addressed equitably in all areas
- therefore the fire service provides the best level of service and investment in it is justified.

Risk of damage approach

This paper presents an approach aimed explicitly at minimising fire damage. It is based on the following hypothesis:

> *Damage is minimised when risk of damage is minimised.*
> *Risk of damage is minimised:*
> *• by minimising likelihood of damaging fire (= risk of fire incidence)*
> *• by minimising consequences of a damaging fire (= risk of fire damage)*

This approach can be characterised as follows:

- There is a fire problem that causes damage/concern/inconvenience to constituents, therefore a fire service is required.
- Its purpose is to minimise damage, etc, within its budget.
- How to minimise damage?
  - by minimising risk of damage
- How to minimise risk of damage?
  - minimise risk in each core component
- How?
  - develop meaningful indicators for these components of risk of damage
  - implement strategies to reduce risk of damage of components
- monitor the outcomes of actions
- report results to constituents in output terms—e.g. damage prevented, damage caused, costs.

The hypothesis is practical because it says that level of damage can always be minimised, because something can always be done to reduce risk of damage. For example, protection infrastructure in the right location can reduce damage from even a severe fire, or, even when a fire is temporarily beyond the capacity of fire fighting resources on a 'blow up' day, something useful can still be done to minimise risk of damage (e.g. assets protected, suppression in safety along flanks).

This hypothesis relies on three requirements for its application to be successful:

- expenditure and effort is on protection and suppression measures that focus on reducing risk of damage
- a fire service is to be fully prepared for serious fire activity each year—it is good risk management practice to prepare for the worst. It is poor practice to base future planning on historical data (Smith et al 1996). For example, rural Victoria should be prepared to deal with at least 2-4 severe fire weather days per month during each fire season (O'Bryan 1993), irrespective an area's recent fire history.
- risk of damage of a whole region will be at an acceptable level when risk of damage of individual property parcels is reduced to acceptable levels—to reduce risk of damage on a property to an acceptable level depends on the landowner's/fire manager's perception of what is acceptable to both themselves and to the community.

For example, if the owner believes that risk of loss is too high, its risk of damage will have to be reduced to an acceptable level. On the other hand, if the owner is satisfied with risk of loss on the property, but the local community regards it as too high, a fire officer may need to intervene. When this acceptability process is repeated for each property parcel, the risk of damage for the whole area is therefore reduced to an acceptable level.

Risk of damage and its components

Likelihood

Risk of fire incidence uses quantifiable historical data about fire occurrence. It includes number, location and type of fire and its causes. Examples include:

- number of house fires per 1,000 houses per year
- percentage of serious house fires per 10,000 ha per year
- number of plantation fires per 100,000 ha per year
- percentage of grass fires caused by equipment

These figures are not used to predict future occurrences, of course, because future fire incidence is a random event. Instead they are used to identify problem issues and to monitor results of prevention activities.

Consequences

Risk of fire damage is indicated quantitatively by Byram's fire line intensity (Byram 1959). The three key components of risk of fire damage are actual fire intensity, vulnerability of the asset or value and chance of successful suppression. Each is manageable to some extent and each is a function of Byram's fire line intensity.

Actual fire intensity: is determined by fuel, weather and topography and expressed as kW/m. It indicates potential damage at a specific intensity

Vulnerability: more damage is expected as fire intensity increases. This trend applies more to a broad area with many assets, and may not always apply proportionately to an individual asset (e.g. a 1000 ha wheat crop burnt by a 20,000 kw/m fire sustains the same loss as in a 50,000kw/m fire).

Suppression: as fire intensity increases, fire suppression difficulty increases, or restated, the chance of preventing damage by suppression decreases.

Looking at the risk of damage approach in another way, risk of damage is reduced when both risk of fire incidence and risk of fire damage are reduced. Risk of fire damage is reduced by firstly attempting to reduce the wildfire intensity level and then to decrease the vulnerability of the asset (both externally and internally) and finally, as extra 'insurance', to improve the chance of successful suppression.

It follows therefore that to minimise level of damage over the lifetime of an asset, minimise risk of fire damage and risk of fire incidence each year.

Wildfire risk management system

The following wildfire risk management system uses objective and quantifiable measures of risk of damage, requires practical and cost effective strategies to be implemented to reduce risk to acceptable levels and monitors results using objective criteria to measure impact of strategies.

It employs a number of sequential steps

to achieve its aim of minimising damage, which have been embedded in the framework of the Australia/New Zealand Risk Management Standard (AS/NZS 4360: 1995) (Smith et al 1996, Salter 1998):

- Establish the context
- Identify risks
- Analyse risks
- Assess and prioritise risks
- Treat risks
- Monitor and review

Establish context and identify the risks

The context refers to:

- risk of damage or loss by wildfire to the land parcel or to the local community
- the respective responsibilities and capabilities of the landowner, land manager, fire agency.

Risk is identified and quantified as gross damage caused by wildfire, either by flame effects or spotting.

Analyse, assess and prioritise risks

Assess potential damage

Evaluate the maximum damage expected when a severe wildfire occurs. For rural fires, damage to commercial assets can be estimated e.g. a crop or a plantation, and damage to non-commercial values can also be given a relative valuation. They can be documented and mapped.

For urban fires, record an estimate of standing valuation of each premises and its contents (or at least its insured value). Assume that once the fire takes hold, structure and contents will be destroyed by burning or smoke or water damage. These valuations can be documented and mapped.

Assess risk of damage

Byram's fire line intensity is estimated for each site under specified weather conditions, and can be presented on a map as an indicator of risk of fire damage. The fire manager or landowner uses it to determine whether the risk is acceptable or not for the land parcel or asset and is then able to consider strategies for risk reduction.

Risk of fire incidence: examine relevant statistics to identify problem issues and problem areas that can or cannot be reduced or eliminated.

Treat risks

Risk components

Risk of damage is reduced by managing its components, risk of fire damage—the fire intensity factors (likely fire intensity, vulnerability of the asset/value, chance of successful suppression) and the risk of fire incidence.

Likely fire intensity: is a combination of weather, topography and fuels. Consider options available for managing fire intensity. For example, fuels can be manipulated on site; weather and topography issues may be able to be managed by site selection criteria.

Vulnerability: of the asset to external or internal fire damage: Because it is usually impractical to protect an asset against a major wildfire, select a maximum fire intensity to be protected against (= design fire intensity—see *Table 2*). Ascertain what works are required, firstly to reduce adjacent fire intensity to this level and secondly, to reduce the item's vulnerability to an acceptable level. These asset protection works become part of the Fire Management Plan.

Take into account the two components of a wildfire that can cause damage, flame and spotting. Both are related to fire intensity but require different protection strategies. Consider whether the damage is permanent or temporary.

The higher the chance of successful suppression, the better the chance of least damage.

Response issues: fire response plans determine appropriate benchmark standards of fire cover, e.g. initial response times and crew strength, and also reinforcement arrangements.

To achieve these standards requires adequate pre-suppression measures like detection systems, communications, road access, equipment and training.

Facilitate suppression: location, quantity, quality of features to assist fire fighters, e.g. water supply, accessibility around perimeter and within, fire suppression infrastructure.

Limit damage: use strategic fire protection infrastructure to limit damage, e.g. fire breaks and fuel reduced zones in rural areas, design features in buildings.

Risk of fire incidence: data enables problem areas and problem causes to be identified and addressed with expenditure on prevention issues, e.g. fire publicity campaigns, enforcement/legislation, isolation strategies. It is used to help evaluate cost effectiveness of proposed risk mitigation measures, but care is needed to resist using historical data to predict the future.

Action plans to reduce risk levels

There are two categories of plans that are aimed at reducing risk of fire incidence and risk of damage levels.

- **Fire management plans:** deal with expenditure and effort in the prevention and pre suppression areas and with procedures in the suppression and recovery areas.
- **Fire response plans:** are concerned with standby and call out procedures in the event of an incident.

Effective plans are costed and funded.

Design fire intensity

It is unrealistic to plan to protect against the worst-case fire intensity. For an asset to survive direct exposure to wildfire intensities of 100,000 kW / m (as occurred in the Ash Wednesday fires) or at FDI's (Fire Danger Index) in the extreme zone (50 – 100) would probably require inordinate expense. Obviously the landowner / fire manager needs to balance the value of the asset and the cost of protecting it against the likelihood of a major fire occurring.

A useful planning tool is to determine an upper FDI or an upper intensity that an asset will be designed to withstand.

It is also wise practice for a fire service to identify its peak suppression capacity (Chandler et al, 1983).

Table 2: Design fire intensity.

Menu of strategies for treatment of risk

- **Reduce the likelihood of the risk**
  - reduce local fire incidence
  - locate in low risk zones
  - change in land management use
- **Reduce the damaging consequences of the risk**
  - vulnerability of the asset itself (external, internal)
  - fuel management of surrounding area
  - pre-suppression measures
    - detection arrangements
    - training and skill of relevant personnel
    - location and adequacy of fire fighting infrastructure
    - location and adequacy of suppression forces
    - access to, through and around perimeter
- **Avoid the risk**
  - dispersed locations
  - re-location
- **Share the risk**
  - pacts between groups of landowners
  - agreements with fire agencies
- **Transfer the risk**
  - insurance cover
- **Accept the risk**
  - nothing more can be done
  - the extra cost of protection is not worth the expected loss

Balancing likelihood and consequences

An acceptable level of damage is achieved when the owner/manager is confident that the chance of damage is low and the net damage can be tolerated if it occurs.

First priority is to minimise potential damage up to the design intensity by reducing vulnerability and increasing chance of suppression success. Also consider other risk reduction strategies (above). Then, using fire incidence figures to assess the chance of any fire occurring on site, or a major fire occurring on site, determine the chance of a fire incident over lifetime of your asset.

Acceptable level of damage varies between land owners/managers

The starting point for effective wildfire risk management is to determine what level of damage is acceptable and what expenditure is required to reduce damage to this level. These issues apply equally to fire authorities and landowners, although each is concerned with different types of damage. The fire authority aims to meet public expectation of minimising gross damage or loss (including interruption to their lives or commerce) because fire is seen as a dangerous or unwanted event. The public expects the authority to spend public money in proportion to the risk of damage or loss. Therefore, we observe one off grants being spent to reduce a perceived high risk or on going expenditure to maintain risk at a low level. The landowner seeks to minimise net damage (gross damage less recoverables) to his/her property interests. This is done by on site physical measures and insurance cover but also includes an expectation of support from the fire authority.

Acceptable level of damage varies between fire managers and landowners and also between landowners. Level of risk tolerance also varies from the perspective of the manager. The three attitudes to risk are risk avoider or minimiser, risk neutral, risk taker (gambler) (Blattenberger et al 1984). If they each live on adjacent properties, they will probably adopt different risk management strategies to achieve their own acceptable level of damage. Nevertheless, when each property is at an acceptable level, the risk level of the whole is acceptable (provided neighborhood issues are resolved).

Economic approach

The 'least cost plus net loss' model deals with the balance between protection expenditure, suppression costs and net damage (Mills and Bratten 1982). The theory states that as protection expenditure is increased, suppression costs and net damage decrease at a decreasing rate (Cooper and Ashley-Jones 1987). The optimal level of expenditure occurs when sum of costs and net damage is minimised.

Whilst this model cannot be applied in annual budgeting, a variation of it can be used to examine the balance between expenditure and risk reduction strategies selected.

To calculate total costs, add annual protection costs and insurance costs to an estimate of suppression costs should a fire occur. The estimate of suppression costs is an annualised figure based on probable size and occurrence (the factor used could vary with the risk attitude of the owner/manager).

To calculate net loss, subtract the following items from the gross valuation: valuation of the undamaged portion and salvage value (according to probability scenario) and insurance payout. Add total costs and net loss for different scenarios.

These calculations can be done annually or for a ten year period or longer to determine the most economic combination.

'Blow up' Seasons

An unfortunate fact of life for rural fires is that over 90% of damage is caused by less than 10% of fires (Chandler et al 1983). Whilst the best fire management plans, the best design fire intensity logic and the best economics based model can work well for 'normal' seasons, they cannot account for 'blow up' years when fire activity exceeds the design limit of the organisation. For example, the Tennessee Valley study found that increasing levels of protection expenditure were associated with decreasing area burnt in normal years, but no relationship in 'blow up' years (Chandler et al 1983). Similarly, in other studies where each annual protection budget was similar to the previous year, 'blow up' seasons resulted in much higher suppression costs and damage, out of all proportion to the budget (O'Bryan 1993).

How can a fire service minimise damage in these seasons?

By continuing to apply the strategies of minimising risk of damage.

Monitor and review

Performance measures

The two performance categories are inputs and outputs. In an organisation, inputs (e.g. staff, budget, resources and activities) are deployed to achieve outputs (e.g. less serious fires, less area burnt, lower damage, higher levels of public confidence). Input indicators are useful for monitoring the efficiency of fire service activities, e.g. standards of fire cover. Output indicators are used to measure the results of an organisation's efforts. They are often more difficult to measure, but are essential if achievement of results is the goal.

The following output indicators might be meaningful.

In the rural environment:

- number of fires per 100,000 ha per year
- area burnt per 100,000 ha per year
- damage ($) per standing value per year

In the urban environment:

- number of premises fires per 10,000 premises per year (categorised by city, suburb or region)
- gross damage per 10,000 premises per year
- gross damage per standing value per year

The relevant principle is: what gets measured can be improved. If the right performance indicators are used, impacts of changes in expenditure patterns or policy can be monitored. Furthermore, they can be used to justify or explain policies of policy changes to a dubious audience. Finally, they can be used as objective measures for performance appraisal.

Monitoring and on-going review

If the goal of a fire service is to reduce damage, and its performance is measured with indicators of damage, the organisation would seem to have a high level of accountability and a very high chance of achieving its goals.

When level of protection expenditure is examined against net damage over a 5 or 10 year period, question whether damage level and costs of suppression are acceptable. If yes, an equilibrium may have been reached. If not, examine where protection money is spent and weed out expenditure that will not result in damage reduction. Alternatively, an increase in protection expenditure may be required.

Caution: When comparing risk levels and protection expenditure in different districts, anomalies can be found (e.g. Robertson 1989, O'Bryan 1993). If district A has low protection costs and high damage levels, and district B has high protection costs and low damage levels, an apparently logical conclusion is to spend more where risk is highest, ie. take money from B and give to A. Resist this conclusion because an equilibrium may be operating in B or abnormal annual figures may skew the averages.

Examples of monitoring

This selection of examples shows the usefulness of good monitoring procedures and the ineffectiveness of poor monitoring.

- Cheney (1993) audited the fire management activities of the Tasmanian Forestry Commission. The performance indicators used were fire numbers, area burnt, cost of suppression and fire damage estimates. It found a significant increase in fire suppression costs, variability in area burnt and also in assessed damage. The study fell short because neither fire protection costs nor areas of fuel reduction were included.
- O'Bryan (1993) examined fire protection performance on public land in Victoria. The studies used area burnt to estimate damage because fire damage valuations had not been kept. In one study of an 18 year period (when protection expenditure kept pace with inflation), cost of suppression increased substantially (including cost per fire and cost per ha burnt) and total area burned in 'normal' fire seasons remained unchanged. A study of four decades found a steady increase in number of fires, variability in average area burnt and a slight reduction in average number of large fires.
- Hanson and Rowdabaugh (1989) monitored the effect of a change in fire policy in Alaska, in particular, the effect on fire suppression costs and area burnt in a limited action zone (areas of low value where fire is monitored rather than attacked). They found that expenditure in quiet fire seasons saved suppression costs but in severe seasons incurred higher expenditure and larger areas burned than if fires had been attacked on day one.
- In the Maniwaki region of Canada, the average fire size in the 1960's was 60 ha. After investing approx $500,000 on protection measures (prediction, detection and first attack) during the 1980's, the average fire size was 1.4 ha and this translated to a saving of $1 M of wood damage annually (Sibbald 1990).
- For many years, the fire suppression policy of the US Department of Agriculture was basically to control the fire by 10 am next day. In the 1970's, a US Senate Committee concluded that protection costs 'have risen dramatically in recent years but the Committee is unable to discern any marked benefits stemming from these expenditures'. In 1978, the USDA changed policy to require that the fire management program to be 'cost effective and become a part of integrated land management' and in 1981 included the criteria of 'economic efficiency and probability of success' as part of fire suppression decision making (Mills and Bratten 1982).
- UK Fire Service inquiry found that the number of fires had increased by 20% in the previous 10 years and the no of serious fires by 32%, despite an excellent service delivery record and significant expenditure. It also found that the fire service brigades were being funded in proportion to the number of incidents attended. This was causing wastage of resources and provided no incentive for incident prevention. It was recommended that the basis of funding be changed to provide strong incentives for incident prevention within the community. (Smith et al (1996) were advocating a broader risk management approach and the need to break the incident driven self-reinforcing cycle: incident occurs > need for response > need for investment for greater response efficiency.)
- Up until 1969, the average annual expenditure on fire protection in the British Forestry Commission was ten times the value of average losses. Expenditure was then slashed to almost one tenth and during the 1970's, annual losses increased substantially but the total of costs plus losses remained similar (Teasdale 1981).

Summary

A wildfire risk management system is outlined that is explicitly targeted at minimising damage. Damage minimisation is the expected outcome because the system focuses on reducing risk of damage to acceptable levels.

The system's on going effectiveness relies on monitoring and reporting performance data that includes meaningful damage indicators.

It is applicable for a fire authority, an organisation or for an individual landowner. It can be applied to rural and urban landscapes and to either individual properties or regional areas.

Definitions

Assets in this paper include items that have economic value or non-tangible resources or values that have an emotional or non-economic value to the community or to a person.

Damage refers to the problems caused by wildfires. It is typically measured as gross or net dollar valuation, but can also refer to the consequences of wildfire (economic losses, hardship, inconvenience, anxiety). It can also refer to the perception of damage.

Fire prevention is aimed at reducing the number of fires occurring. It includes actions such as fire publicity campaigns, enforcement patrols, legislative changes.

Hazard refers to the fuel components, e.g. fuel type, flammability, quantity.

Pre suppression is concerned with improving fire suppression effectiveness. It includes issues such as detection, communications, road access, fire fighting infrastructure, equipment, training and fuel management.

Protection in this paper is a collective term for prevention, pre suppression and asset protection works.

Risk of damage is a measure of the degree of damage caused by wildfire.

Suppression is the activity required to extinguish the fire.

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About the author

Denis has specialised for many years in wildfire protection, from the operational to the planning and policy areas, and also in training. He has worked in the two fire agencies in Victoria that deal with wildfires on both public and private land, and has had solid experience in both local and statewide roles.

He has a good understanding of wildfire risk and has developed a unique approach to its assessment and management using GIS to full effect. He is now director of Red Eagle, which provides a range of fire protection services, including this GIS application.

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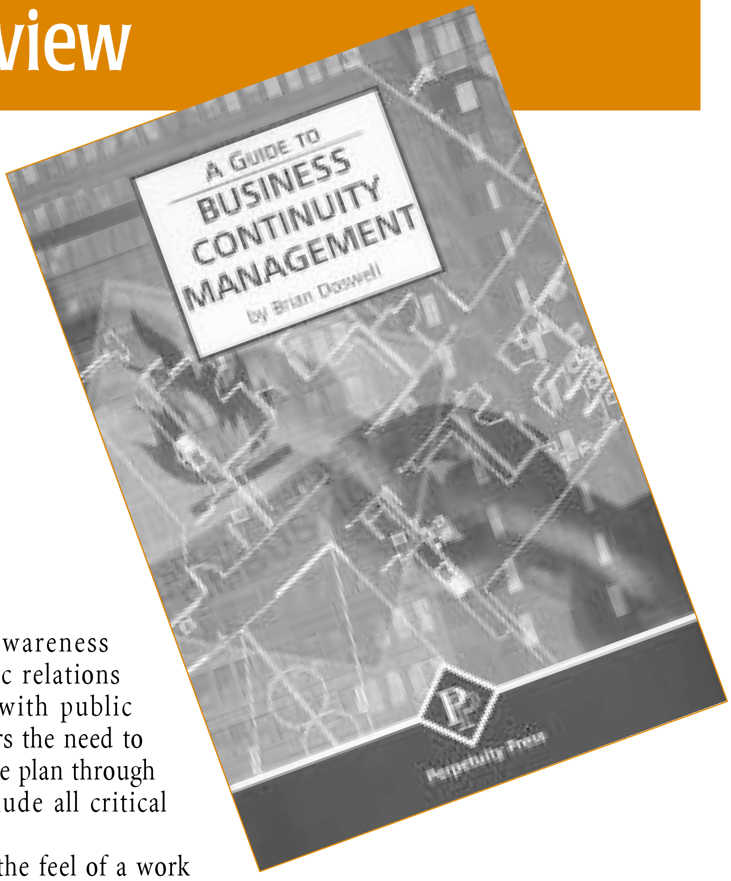
Book Review

A Guide to Business Continuity Management (2000)



by Brian Doswell

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Reviewed by Peter Woodgate
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All too frequently your smoothly running organisation can unintentionally overlook the need to review its business continuity planning. Or maybe you are a recent start-up that is consumed by the need to grow the market and continue your innovative developments. Perhaps you simply lack the experience to know how to systematically tackle the task. Whatever the reason recent world events in recent months have clearly thrown the spotlight back onto this important issue.

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The book has all the feel of a work penned from hard won experience. Its examples are mainly cited from the UK although it does have prescient references to the World Trade Centre and separately, a comment on the risk of 747's crashing into buildings. Its glossary of terms underlines its value a good working text.

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