

A guide for Local Government Field Officers & Land Managers

Fire & Biodiversity Monitoring Manual

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Preface and acknowledgement

Many individuals and groups of people who share the vision of making monitoring user-friendly, accessible, and relevant to contemporary fire and biodiversity management contributed their time and effort to producing this publication. The Southeast Queensland Fire and Biodiversity Consortium would like to extend a special thank you to those who contributed case studies, reports and accounts of monitoring methods and participated in the discussions that led to the production of this manual, particularly: Alan House, Carmel Peacock, Cuong Tran, Dan Carter, Peta Maidens, Wayne Kington, Wendy Drake, Dave Beaty and Mark Panter.

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About the Southeast Queensland Fire and Biodiversity Consortium

The Southeast Queensland Fire and Biodiversity Consortium was established in 1998 with funding from Bushcare Support, a program of the Commonwealth Government's Natural Heritage Trust. The aim of the Consortium is to gather and disseminate information on fire management practices that will support conservation of Southeast Queensland's biological diversity.

The Consortium included representatives from local authorities throughout Southeast Queensland, the Rural Fire Service, Queensland Parks and Wildlife Service, Department of Primary Industries, Landcare, Greening Australia and Griffith University. The project was proudly managed by Logan City Council.

A Monitoring Working Group of The Southeast Queensland Fire and Biodiversity Consortium was also formed to address the specific need for the monitoring of fire and its influence on the natural environment. The group comprises representatives from local government, academia, community organisations and state government agencies.

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Disclaimer:

This document has been prepared through consultation with a wide range of individuals and groups concerned with fire management, including the Rural Fire Service. However, it remains an aid to planning and management activities only, and use of this publication is in no way a guarantee of bushfire safety. The aim of fire management planning is to minimise risk. However a degree of risk will always remain where housing and other assets are located in Australia's flammable vegetation. Thus whilst every effort has been made to ensure the information presented here is as accurate and factual as possible, those involved in compiling this document take no responsibility for any outcomes, actions or losses resulting from its implementation.

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Table of contents

Preface and acknowledgement	2
Introduction	6
Section 1	
The First Step – Planning	7
1. Planning before monitoring	7
2. What is this manual for?	9
3. Who will use it?	9
4. What is fire monitoring?	9
5. Why monitor?	10
6. Planning for data analysis.....	11
7. Achieving consistency	14
Section 2	
Guidelines to monitoring	15
1. Establishing Your Plot	17
2. Sampling guide for monitoring different vegetation types	20
3. Baseline Information	21
4. Project Overview Sheet	23
Section 3	
Monitoring methods	25
1. Monitoring Decision Matrix	25
2. Monitoring fire	26
3. Vegetation Monitoring	36
4. Fauna Monitoring	51
5. Monitoring Habitat	56
Section 4	
Case Studies	61
1. Beerwah wallum vegetation—(Alan House)	61
2. Raven Street Reserve—(Seonaid Melville)	64
3. Coastal spotted gum vegetation—(Geoffrey Smith)	67
4. The effects of timber harvesting and fire on Acacia perangusta—(Jodi Rees)	69
Section 5	
References	71
Section 6	
Appendix	85

Introduction

A better understanding of the three-way link between land management, biodiversity and fire is crucial if the needs of our native flora and fauna are to be balanced with those of urban and rural development.

Many of today's land managers recognise the need to manage fire for the enhancement of biodiversity. But it is a challenge that often takes a back seat to human or safety-related priorities such as reducing fuel loads and fire hazards.

Fire and biodiversity monitoring, whether simple or intensive, is a way to learn from what we do, be adaptive in our management, and more effective in our use of resources. It shows us when something is working and when it is not. It may be the only feedback or guidance that we get from what is essentially a trial and error approach to managing vegetation in Australia.

Fire monitoring need not be highly complex or draining on resources, as this manual hopes to show.

*'Without monitoring, management is like
a ship without a rudder'*
(Gill 1986)

Section 1

The First Step - Planning

1. Planning before monitoring

Planning is the vital first step toward effective fire and biodiversity management. Monitoring should feature as part of fire planning as a useful tool for evaluating management goals and objectives.

This manual was designed to be used in conjunction with other products available from the Southeast Queensland Fire and Biodiversity Consortium, in particular:

- Individual Property Fire Management Planning Kit; and
- Strategic Fire Management Manual.

Refer to the flowchart (p.8) for full details of Consortium products.

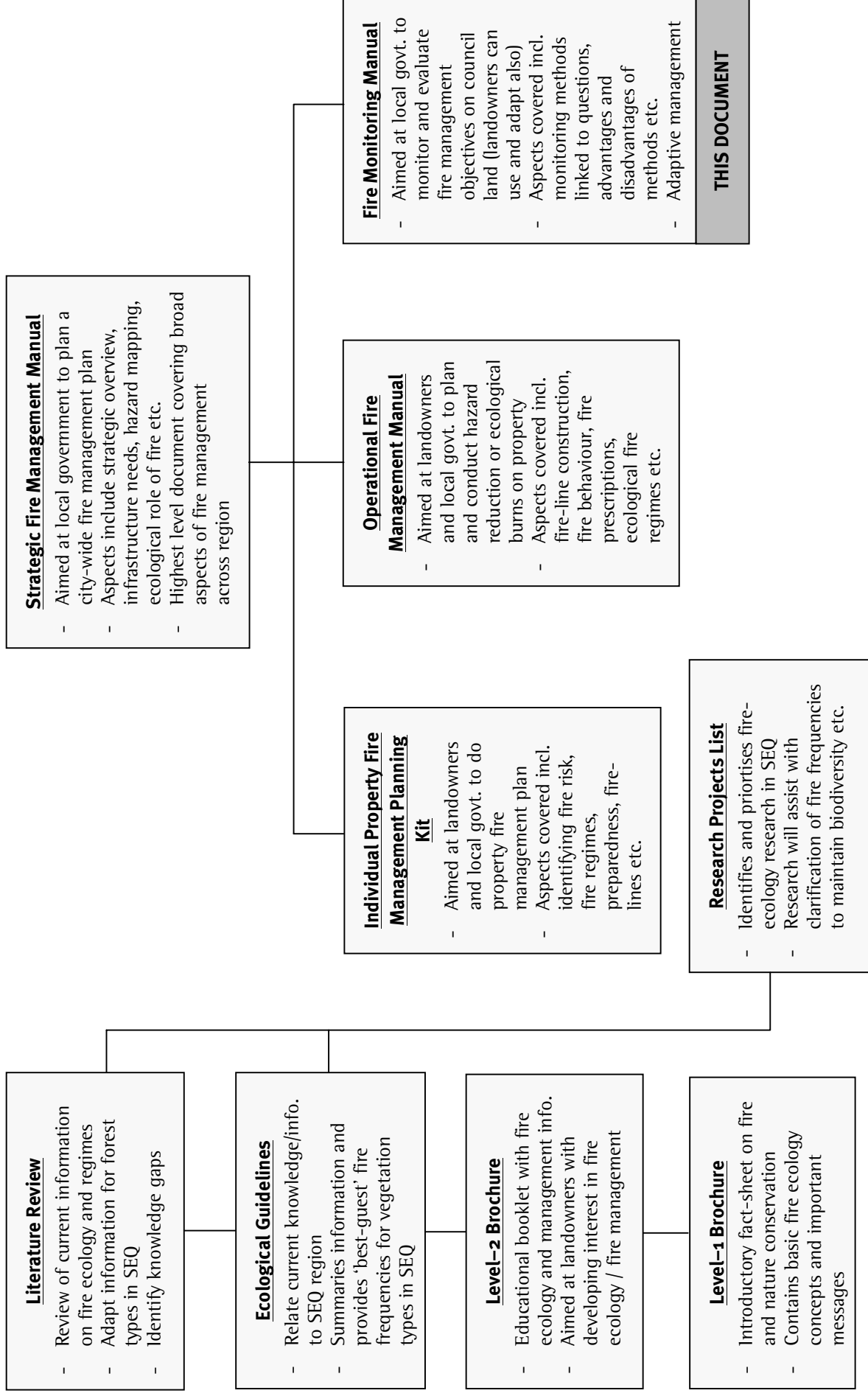
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Flowchart of Fire and Biodiversity Consortium Products

... where does this product sit in the big scheme of things?



2. What is this manual for?

This manual offers a **starting point** and **guide** for monitoring fire and biodiversity in Southeast Queensland. To the authors' knowledge, it is the first user-friendly, technical guide of its kind to be developed in Australia, and for this reason may be of use in other regions.

While monitoring can provide useful information for scientific research and on-ground management, this manual is designed to assist those involved with operations and management, and avoids data collection solely for the purpose of research and 'pure science'.

Where monitoring methods are described, simpler, less resource-intensive methods have been chosen, since these are more likely to be adopted by field officers and other land managers. More technically precise monitoring methods can allow greater confidence in demonstrating cause and effect for scientific purposes, but they are generally more difficult, time consuming and costly to undertake. This manual encourages the notion that **some** monitoring is better than **no** monitoring. More intensive methods and techniques are referenced at the end of each section.

This manual can help you use monitoring to become more objective and **adaptive** in how you manage fire and biodiversity. This is known as adaptive management.

3. Who will use it?

This manual primarily targets Local Government Field Officers and Private Landholders who have the assistance of local government or extension support networks. The manual has been designed for users who are **non-experts** in fire management for biodiversity and are most concerned with the practical aspects of land management. It is assumed that such users often have broad duties and little spare time.

4. What is fire monitoring?

'Monitoring' is simply a form of disciplined observation used to track and improve management activities. It is similar to what we do all the time by 'keeping an eye on things'. However, monitoring involves recording these observations over time in a way that is repeatable and systematic.

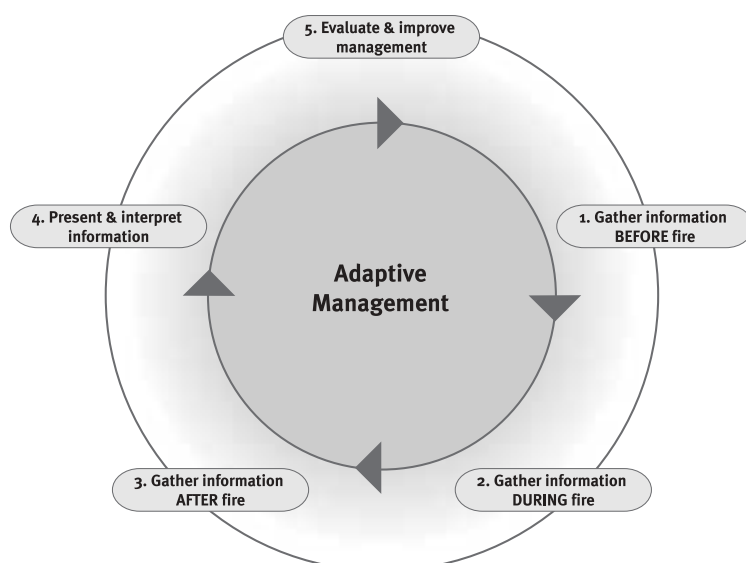
Fire monitoring can provide a tool for answering questions like:

- what are the characteristics of the fire?
- is it time to burn again to reduce fuel loads?
- what changes are occurring over time in the vegetation community?
- how has the fire affected the composition of fauna?
- what changes have occurred to the habitat?

5. Why monitor?

The benefits of fire and biodiversity monitoring include:

- better, more adaptive, management—‘learning by doing’;
- better outcomes for biodiversity;
- better understanding of the environment and how to observe it;
- earlier identification of problems;
- contribution to science;
- potential to compare monitoring information across sites and gain a landscape picture;
- informed decision making (e.g. when to burn/not to burn);
- ownership of areas and their management by local authorities and land holder groups;
- consistency and continuity over time, and despite changes in staff;
- improved cost and labour effectiveness; and
- the techniques are able to be implemented by non-scientists.



Fire Monitoring is most useful to us when we have an open-minded approach to management and are prepared to be critical of our management activities. There must be a willingness to take on board new information and trial different techniques. This is known as Adaptive Management.

Adaptive management involves planning, action, monitoring, evaluation and adjustment.

Figure 1. Simple model of fire monitoring, highlighting the monitoring-management feedback loop.

Before undertaking any kind of monitoring, it is important to be clear about what your management objective is. In other words, you need to be specific about what your management activities are setting out to achieve. Progress towards this then becomes easier to measure.

In order to be measurable, management objectives should include the amount and direction of desired change. This is the range of change (positive, negative or no change) or condition that you are willing to accept as a result of your management activities. This can be one of the most difficult decisions to make, especially if your knowledge of fire ecology and vegetation responses at a particular site is lacking.

Examples of management objectives include:

- reduce weed cover by 50–75% within two years of the initial planned burn;
- reduce fuel load to less than 10 tonnes/ha; and
- increase density of desired tree seedlings to 500/hectare within five years of the initial prescribed burn.

6. Planning for data analysis

Make your monitoring efforts worthwhile by thinking about how you will use the information to answer your monitoring question. Here are some tips to help you:

- think early. Decide up front how you plan to interpret, present and evaluate your data. Will this help to answer your monitoring question? Who else will be looking at your results? Leaving such decisions until the end can result in a mountain of data that is difficult to analyze and present in reports;
- regularly analyse and present your information, even in the early stages. You may want to do this as part of your ‘practice run’ as it could lead you to revise or improve your monitoring methods;
- consider comparing or linking different groups of data, e.g.. fauna data with vegetation data; and
- allow enough time for entering, processing and presenting your data. This can be difficult and time consuming if left until the very end.

Types of data:

- ‘quantitative’ data is produced by taking tangible measurements (e.g. size, weight, amount) and are expressed as numbers (e.g. number of surviving plants); and
- ‘qualitative’ data is produced using descriptive measures (e.g. people’s attitudes, insights, verbal, photographic or written accounts).

The two types are often gathered simultaneously and the suggestions below apply to both.

Tips for collecting and recording data:

- use standard data sheets such as the examples provided in this manual;
- give data sheets a quick ‘once over’ at the end of a monitoring session to spot any gaps or problems interpreting handwriting or to give feedback to your team;
- photocopy raw data sheets and promptly transfer information onto a computer (handwriting may be difficult to interpret at a later date); and
- store your original data sheets, in case you need to refer to them later on.

Tips for presenting data:

Examples of ways to analyse and present your data are provided after each monitoring method (p.15-59) but in general it may help to:

- use simple tables and graphs to summarise information (see Figures 2 and 3 on next page). They tend to be easier to understand than raw data and visually more attractive;
- in many cases it may be best to graph raw data, as bar charts and histograms based on averages can hide variation between plots. (Averages are also misleading unless derived from a large number of plots);
- ensure raw data is included in the appendix of a report; and
- seek expert assistance early on if you wish to undertake more complex data analysis, as this will affect the design of your monitoring program.

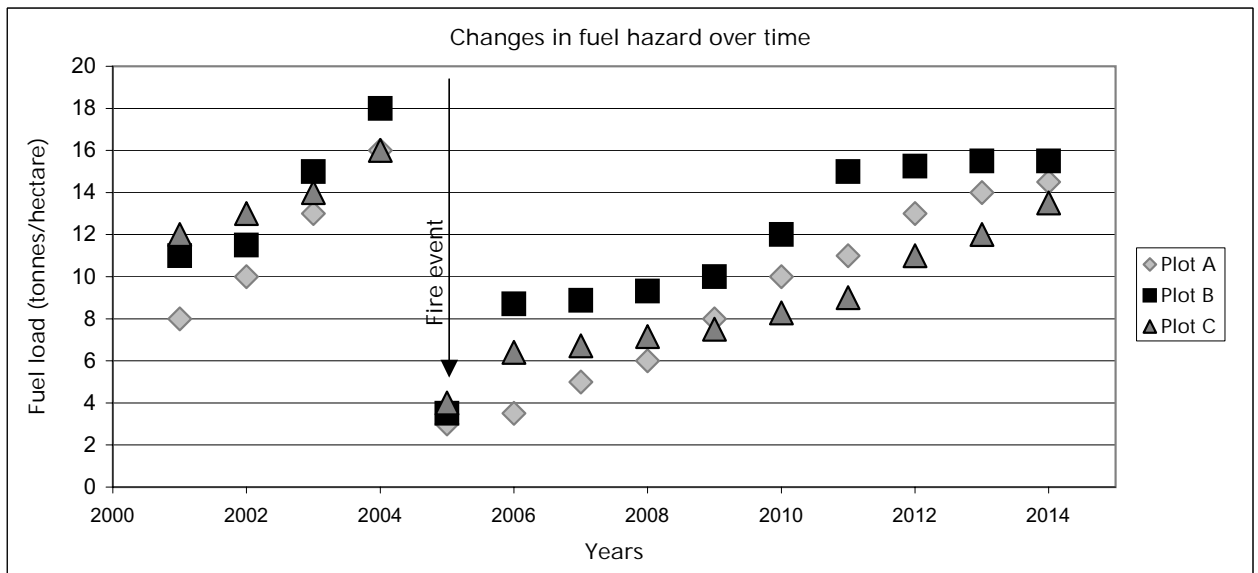


Figure 2: Changes in fuel hazard over time. This hypothetical example shows 3 plots that are used to measure fuel loads. A prescribed fire was initiated once fuel loads reached the (again, hypothetically) set-limit of 15–18 tonnes/hectare. The hazard reduction burn was conducted in 2005. Fuel loads were reduced to more acceptable levels (3–4 t/ha). Post fire monitoring of fuel loads continued. It would be appropriate to consider another burn if the fuel loads reach the preset limits for fire risk. NB: maintaining areas for conservation will need to consider the ecological implications of hazard reduction burns. This is discussed in the Ecological Guidelines available from the Fire and Biodiversity Consortium. (arrow indicates fire).

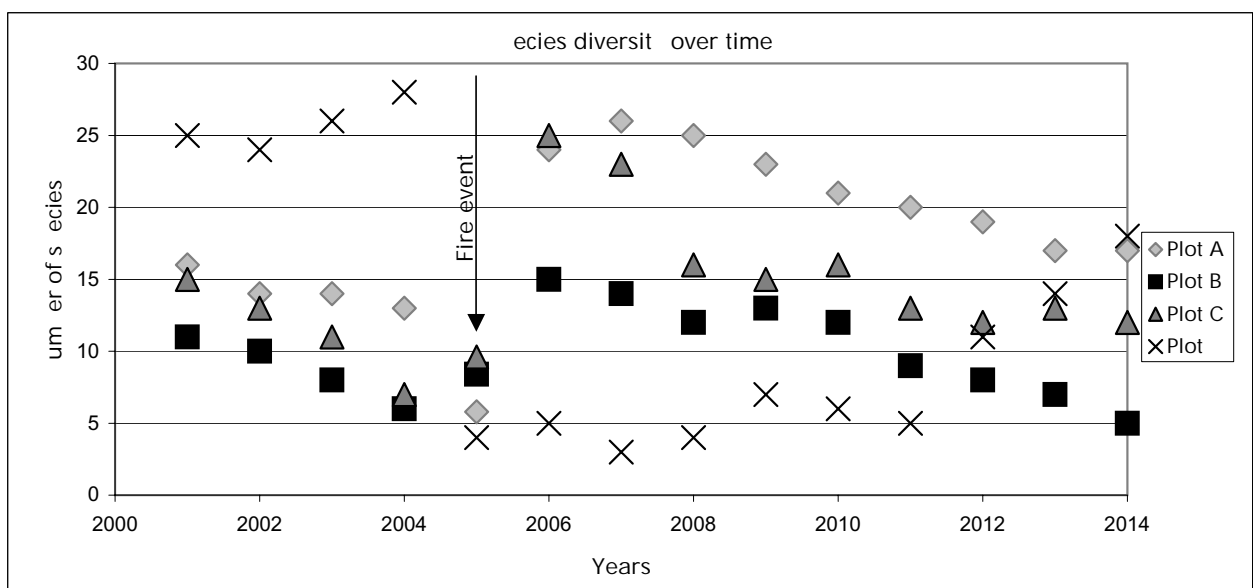


Figure 3: Species diversity over time. Much similar to monitoring fuel loads, this hypothetical graph plots the change in species diversity over time with a fire (occurring in 2005). Some species will prefer the early post-fire stages and other species prefer the thicker mid-late stages of post fire regeneration. In this graph, the species found in Plot D show animal species preferring the later stages of post-fire recovery and were adversely affected by fire ... recovering some 10 years after the fire, whereas the animals found in Plot A prefer the early stages and then showing some decline in the latter stages after the fire. The key here is balance and providing a number of different stages of post-fire recovery. Your management objectives will guide when/where you should consider prescribed fires for conservation and biodiversity. (arrow indicates fire).

Evaluating and improving management

While data analysis and interpretation involve **making sense** of the data, evaluation involves **making decisions** based on this information. That is,

“Has our fire management objective been achieved?”

If we answer “yes”, we might continue to monitor, keeping abreast of new information as it becomes available or we may decide to monitor other management objectives. If we answer “no”, we might explore possible reasons behind this, modify our management activities, revise our management objectives, revise our monitoring methods, or initiate special research projects to learn more (refer to p.16 for Steps in a Fire Monitoring Program).

7. Achieving consistency

Tips for consistency

- mark plots permanently (e.g. stakes), so that the exact plot can be revisited;
- monitor BEFORE, DURING as well as AFTER fire ;
- if areas are being compared – e.g. burnt versus unburnt plots – choose plots that are as similar as possible in all other respects (e.g. species present, vegetation cover, slope, aspect and soil type);
- ensure the person collecting information has skills appropriate to the methods;
- train any new staff who will be gathering information;
- put new staff under the guidance of those more experienced and familiar with the techniques;
- give new staff easier tasks to begin with (e.g. scribing data);
- use voucher specimens / references, e.g. when monitoring plant species;
- strive to maintain the same levels of enthusiasm and attention to detail ;
- consider seasonality, e.g. some species may be more active, conspicuous or easier to identify during particular seasons; and
- aim for minimal impact on the plot (e.g. trampling vegetation, importing weed seeds).

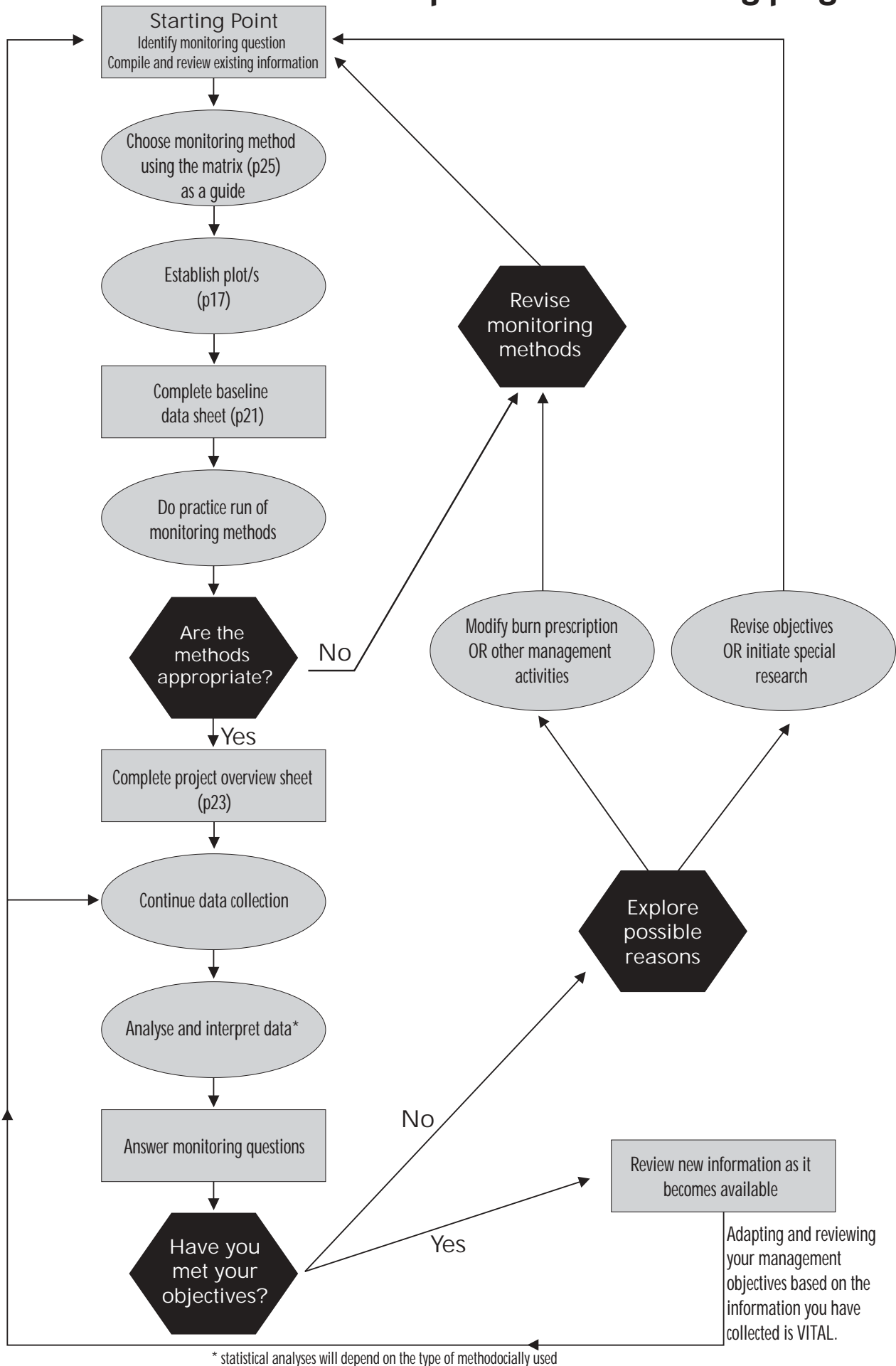
Observations are in the eye of the beholder—make sure everyone is using similar methods.

Section 2

Guidelines to monitoring

Specific steps are followed in a fire monitoring program. These include establishing your plot and recording baseline information about your plot. It is also important to document on your project overview sheet the aspects of monitoring at your site that will be kept as a reference in the future.

Steps in a fire monitoring program



* statistical analyses will depend on the type of methodology used

1. Establishing Your Plot

The site

Generally monitoring takes place in a reserve or property. This we term a 'site'.

The plot

Since most of us have limited time and resources, we often only monitor **part** of a site. This area of the site that we sample is termed a 'plot'. Whether a plot is chosen randomly or deliberately, it needs to be **representative**. In general, the more plots used, the more reliable your data will be. More numerous plots also offer 'security' in the event that a particular plot is destroyed or information is lost.

Plots are generally permanent, regular in shape and delineated somehow from the surrounding vegetation. Plots can take the form of a square, rectangle, circle or transect.

It is difficult to be prescriptive about the dimensions of plots, as this will vary depending on your monitoring objectives, your available resources (be careful about biting off more than you can chew, monitoring can be quite labour intensive), vegetation type and the type of things you are monitoring. However, some guidance is given below:

A recommended method is the circular plot. Table 1a on p.20 recommends sizes for use within different vegetation communities for circular plots. Once again, this may vary depending on what it is you are monitoring. Also, the recommendations in Table 1a can be adapted to square or rectangular plots.

Another recommended method is the transect plot. Transects vary in length from a few metres to several kilometres. Their width ranges from narrow (e.g. 1cm) to wide (e.g. a 10m wide belt transect). No prescriptive transect length is offered in this manual. Instead, it is advised that you make the transect as long and wide as necessary to encompass most of the variation within the area you are monitoring. When monitoring trees, transects should be wide and long enough to ensure a representative sample of trees is included. However, for smaller features, the transect could be as narrow as 1cm, and any feature intercepted by your transect included in your sample.

The quadrat

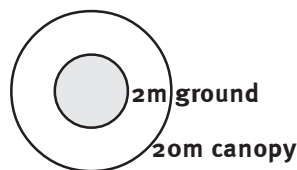
Sometimes it may be viable to monitor everything within your plot. But often, and especially for lower stratum species or where there is a lot of variation within your plot, it is difficult to monitor the entire plot.

Quadrats are used to sample part of your plot.

Quadrats can be circular, square or rectangular areas of a suitable size that are delineated from surrounding areas. Materials such as wood, wire, string or pvc are often placed on the ground to create a quadrat.

A quadrat provides a focus for your observations. The centre of the quadrat is placed randomly or deliberately (choosing a representative location) within the plot.

Quadrats can be nested one within the other (as shown below), to enable simultaneous monitoring of different aspects of your plot from the one point.



Number of plots and quadrats

In general, the more replications of a plot used, the more reliable your data will be. More numerous samples also offer 'security' in the event that a particular plot is destroyed or information is lost.

Generally, **more plots are better**, however, it is recommend a minimum of three plots be used per broad vegetation type (dependent on size of area monitored).

If you are sampling part of your plot, **the more quadrats you use the better**, however you must consider your available resources. A minimum of at least three quadrats is recommended.

Where multiple samples are taken within a plot, that data should be combined for that plot - i.e. all the data for the one plot is placed on the one form (unless you are using separate forms to record different aspects of your plot such as fauna and flora). However, you should avoid combining data between plots, as it is important to be able to see the variation between plots.

Monitoring frequency

Once again, this will depend on your monitoring question and on available resources. However, guidelines are provided in Table 1b on p.20.

Equipment needed to establish your plot

- two star pickets;
- star picket driver;
- compass;
- tape measure, 10 metres at least;
- stainless steel tags;
- wire ties;
- notebook and pen;
- map/aerial photos (if available);
- GPS (if available); and
- flagging tape.

Choosing your starting point

1. whether a plot is chosen randomly or deliberately, it needs to be **representative** of the area you are monitoring;
2. the location of your plot should assist you in answering your monitoring question(s);
3. the plot should be homogenous i.e. attempt to minimise the variation within your plot;
4. choose a plot that is easily accessed by you, but not easily noticed by passers by;
5. document the position of plot (use a map or GPS);
6. drive a 150cm star picket into the ground vertically until 120cm remains above ground; and
7. attach steel tags with tie wire to the picket, and include the following information: Your name/organisation, plot number and date. (Use steel tags if possible for long-lasting results – aluminium tags disintegrate in about five years and burn in fires).

2. Sampling guide for monitoring different vegetation types

Table 1a: Recommended plot sizes for broad vegetation types in SEQ region.







Broad Vegetation Type	Recommendations for circular plot size
Rainforest	 20m radius
Wet Eucalypt	 20m radius
Dry Eucalypt (grassy understorey)	 10-20m radius for canopy 2m radius for ground covers
Dry Eucalypt (shrubby understorey)	 10-20m radius for canopy 2m radius for ground covers
Heath	 1-2m radius
Melaleuca	 10m radius for canopy 2m radius for ground covers

Table 1b: General rules for replication of plots and frequency of sampling.

Replication (how many times you need to sample)	Frequency of sampling								
<p>General rule: More is better</p> <p>Recommend a minimum of 3 plots per broad vegetation type (dependent on size of area monitoring)</p>	<p>Suggested intervals:</p> <table> <tr> <td>First</td> <td>Pre burn</td> </tr> <tr> <td>Second</td> <td>Within three (3) months (for vegetation wait at least a month)</td> </tr> <tr> <td>Third</td> <td>Twelve (12) months after the fire</td> </tr> <tr> <td>Subsequent</td> <td>Annually ...unless there is a subsequent fire.</td> </tr> </table> <p>In the event of a subsequent fire, monitor within three months then annually.</p>	First	Pre burn	Second	Within three (3) months (for vegetation wait at least a month)	Third	Twelve (12) months after the fire	Subsequent	Annually ...unless there is a subsequent fire.
First	Pre burn								
Second	Within three (3) months (for vegetation wait at least a month)								
Third	Twelve (12) months after the fire								
Subsequent	Annually ...unless there is a subsequent fire.								

3. Baseline Information

The next step is to compile basic information relating to your monitoring plot/s. If you plan to monitor more than one plot, make multiple copies of the following data sheet.

i) Baseline Data Sheet

Complete this form once, before commencing monitoring.

Note: More than one box can be ticked.

Plot name / number:	Page 1 of 2
Name of Field Officer / Land Holder:	Date:

Fire Management Objective/s		
.....		
Plot location		
Location (GPS or map reference) Parish	Shire Portion Area (ha) Plot Size (of quadrat and/or transect)	City Lot (s) on Plan No
Land Use		
<i>Past Monitoring/ Research Activities</i> <input type="checkbox"/> permanent plots <input type="checkbox"/> other • Attach relevant documentation <i>Culturally significant resources</i> <input type="checkbox"/> bora ring <input type="checkbox"/> scar tree <input type="checkbox"/> middens <input type="checkbox"/> artefacts <input type="checkbox"/> historical tree <input type="checkbox"/> other	<i>Historical land use (if known)</i> <input type="checkbox"/> farming <input type="checkbox"/> grazing <input type="checkbox"/> mining <input type="checkbox"/> forestry <input type="checkbox"/> nature Conservation <input type="checkbox"/> military (unexploded ordnates) <input type="checkbox"/> other	<i>Current land use (if known)</i> <input type="checkbox"/> farming <input type="checkbox"/> grazing <input type="checkbox"/> ecotourism <input type="checkbox"/> nature conservation <input type="checkbox"/> other <i>Existing infrastructure</i> <input type="checkbox"/> signage <input type="checkbox"/> boardwalk / track <input type="checkbox"/> road <input type="checkbox"/> fence <input type="checkbox"/> house <input type="checkbox"/> other (eg bird hide)

Plot characteristics

Page 2 of 2

Topography

- ☐ flat
- ☐ undulating
- ☐ valley bottom
- ☐ river bank
- ☐ ridge top
- ☐ other
- ☐ elevation

.....
.....
.....

Soils

- ☐ sandy
- ☐ clayey
- ☐ loamy
- ☐ alluvial
- ☐ modified/imported soil
- ☐ pH (if known)
- ☐ erosion evident
- ☐ salinity evident

.....
.....

Rainfall

annual average rainfall (mm):

other comments

.....
.....
.....
.....
.....
.....

Vegetation

Major vegetation type/s

- ☐ wet Eucalypt Forest
- ☐ dry Eucalypt forest (grassy understorey)
- ☐ dry Eucalypt forest (shrubby understorey)
- ☐ heath
- ☐ Melaleuca wetland
- ☐ vine scrub
- ☐ rainforest
- ☐ other (e.g. grassy pasture)
.....
.....

Historical vegetation type (if known)

.....
.....
.....

Vegetation description

- ☐ significant species present
(eg Rare & Threatened)
.....
.....
- ☐ primary weeds present
.....
.....
- ☐ dense } tick one -general
☐ moderate } appearance of
☐ sparse } vegetation
☐ nil }
- ☐ scattered clumps present
- ☐ natural vegetation largely
cleared or modified
- ☐ natural regeneration evident
- ☐ ground cover present
- ☐ understorey present
- ☐ tree canopy present
- ☐ dead trees present
- ☐ live trees present

Other comments

.....
.....
.....
.....
.....
.....

- **Attach any plant species lists
for the site (if available)**

Fire History

- ☐ fire in last 3 years (if known)
- ☐ signs of recent fire
- ☐ no evidence of fire

Date of last fire at plot/...../.....
(if known)

- ☐ wildfire
- ☐ planned burn
- ☐ other (eg arson)

- **Attach fire report (if available)**

Other notes

.....
.....
.....
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.....
.....

4. Project Overview Sheet

Having designed your monitoring program and completed a 'practice run', it is important that you record vital information (metadata) about your project. This information will enable others to relocate your monitoring plots at later dates as well as enable them to undertake further data collection using the same methods. An example is provided below. This is indicative of the level of information required.

Project Overview Sheet	Example
Project title	Venman Bushland National Park Fire Response Monitoring
Location	Venman Bushland National Park
Date	23/08/00
Project officer	Wayne Kington, Conservation Officer
Additional staff	Dave Hayeston, Ranger in Charge, Venman Bushland National Park
Background	<p>Covering 415ha, Venman Bushland National Park is reached via West Mount Cotton Road in Redland Shire. The area surrounding Venman Bushland National Park is undergoing rapid urban development. The park's importance as a representative sample of the area's natural vegetation and fauna habitat is increasing.</p> <p>Fire monitoring plots were established in Venman Bushland National Park between 1992 and 1994. The experience of several years of monitoring has highlighted the need to review the monitoring projects and the methods used to monitor. This revised project proposal utilises the refined and more detailed methods for the on-going fire response monitoring in Venman Bushland national Park.</p> <p>Monitoring plots were selected on the basis of the dominant canopy species, perceived susceptibility to fire, aspect, terrain and accessibility. An attempt has been made to ensure a cross-section of vegetation communities have been included and that plots are representative of the community in which they occur. A discussion on each plot and the vegetation community in which it is located is contained in a separate document in this kit.</p>
Monitoring questions	<ul style="list-style-type: none"> • Is this a planned or wildfire? • What is the fuel load hazard? • What plant species have been eliminated by fire • Is their flora differences depending on time of burn? • Is a particular flora species being assisted by fire?
Data requirements	<ol style="list-style-type: none"> 1. record presence and abundance of plant species 2. monitor reproductive behaviour of individual species 3. gather data on post-fire regenerative strategies for individual species 4. determine how species' reproduction is influenced by fire 5. establish the minimum period for each species to reproduce and recover after fire. 6. establish the maximum period after a fire, after which species richness significantly declines.
Methods	Which data sheets will be used? How often will data be collected? When and under what conditions will data be collected? What is the size and number of plots?
Duration of project	Ongoing. Review after 5 years.
Reporting	An annual report should be prepared at the end of each year. These reports should summarise the monitoring which has occurred, present any results of data, interpret the data and make any recommendations for park management or future monitoring. In the event that no monitoring was required, this should be indicated in a brief report.
Resources	Refer to the equipment list contained in the fire response monitoring methods contained in this kit. (Koala Coast Monitoring Kit).
Costs	Refer to attached breakdown of labour and consumable materials costs.
Approvals	Senior Ranger District Manager Conservation Management Unit

Project Overview Sheet

Project title	
Date	
Location	
Project officer	
Additional staff	
Background	Background information about the reserve and property and why you are monitoring.
Monitoring questions	Your monitoring questions.
Data requirements	What sort of analysis you intend to do and what sort of data you need to achieve this.
Methods	Which data sheets will be used? How often will data be collected? When and under what conditions will data be collected? What is the size and number of plots?
Duration of project/Review	Does the project end after a specific amount of time? When will it be approved?
Reporting	How will you report your results?
Resources	Staff, people power, equipment needed etc.
Costs	Hired staff, hired equipment, consumables.
Approvals	Any necessary signatures or approvals.

Section 3

Monitoring methods

1. Monitoring Decision Matrix

The following matrix will assist you in identifying suitable monitoring methods. Commonly asked monitoring questions are listed in relation to fire, fuel, flora, fauna and habitat. Once you have chosen a monitoring question refer to the suggested monitoring method/s.

Monitoring Decision Matrix		Method						Case Study			
GETTING STARTED This matrix will help you to identify suitable monitoring method/s. Simply: 1. Select from the list of commonly asked monitoring questions given below. 2. Refer to the suggested monitoring method/s (indicated by a tick). 3. Adopt or adapt appropriate method/s. 4. Return to p.16 'Steps in a Monitoring program'.		Fire Behaviour Data Sheet, p.29	Vegetation Data Sheet, p.39	Photopoint, p.50	Plant Response Data Sheet, p.43	Fauna Data Sheet, p.53	Habitat Data Sheet, p.57	Case Study No. 1, p.61	Case Study No. 2, p.64	Case Study No. 3, p.67	Case Study No. 4, p.69
QUESTION											
Fire	Is this a planned fire or wild fire?										
	Where was the source of the fire?										
	What were the weather conditions? (temperature, humidity, wind speed/ direction)										
	What was the duration of the fire?										
	What was the rate of spread of the fire?										
	How has topography influenced the fire?										
	What is the intensity of the fire?										
Fuel	What is the fuel load hazard?										
	How much of my monitoring area was left unburnt?										
	What is the accumulation of fuel after fire?										
Flora	Which plant species have been eliminated by fire?										
	What are the changes in the vegetation structure?										
	What are the changes in plant species?										
	Has the burn effectively reduced weeds?										
	How has the fire affected individual plant species?										
	What is the reduction in vegetation cover?										
	How has the fire influenced plant species richness?										
Fauna & Habitat	What changes are occurring in fauna habitat?										
	What are the obvious changes in the fauna?										
	How has fire effected the composition of fauna?										
	How has fire affected significant species?										
	How has the fire impacted on the watercourses?										
	How has fire affected the pest (exotic) species?										
	Are there areas of fauna refuge / recolonisation?										
	How has fire affected habitat value?										
	How has fire affected habitat of a significant species?										

2. Monitoring fire

i) Monitoring the *behaviour* of fire

Once you begin to monitor fire behaviour an understanding of the complex interactions occurring at your site begins to unfold. A multitude of environmental variables influence the way a fire behaves.

Weather characteristics, fuel characteristics, features of the landscape, height of the flame and soil moisture conditions all impact upon the fire event and play a vital role in how the fire will behave.

It is important to monitor the different variables influencing fire behaviour both during and after fire. This gives us a greater understanding of what to expect under certain conditions, allows us to identify potential problems, and provides links to the fauna, flora and habitat monitoring information collected.

ii) Methods for monitoring the *behaviour* of fire

There is no simple method of monitoring fire behaviour. The best technique is to collect a range of variables that contribute to fire behaviour. Most of the important variables are listed in the Fire Behaviour Data Sheet on p. 29. It is not necessary to record information about all of the variables; what variables you record will be determined by your management objective for your site.

Plot Characteristics: Record information about features of the landscape contributing to fire behaviour.

Fuel characteristics are measured both before and after the fire where possible. There are two ways to measure fuel hazard.

Method 1: Overall Fuel Hazard Guide

The Overall Fuel Hazard Guide (p.32) is the simplest method of the two methods to use. Overall fuel hazard is derived by assessing levels of bark, elevated and surface fine fuel. These fuel component hazard ratings are combined to make up the overall fuel hazard at a plot, which can be translated into tonnes per hectare (t/ha). Although developed for Victorian conditions, this technique is in use in Southeast Queensland and is favoured over Method 2: Fuel Weighing Technique (p.34) because of its ease of use, lack of need to collect and weigh material, and the reduced need for resources (e.g. availability of drying oven). An updated, Southeast Queensland version of the Overall Fuel Hazard Guide will be available in the near future.

Fire behaviour is measured during and after the fire. It is desirable to measure these characteristics in the vicinity of any existing plots you have established, however it is not always possible or desirable to be in the vicinity of your plot during a fire. Only collect this information at your plot if it is safe and practical to do so. An alternative is to collect samples of fire behaviour in other locations. Try to collect enough samples to give you a picture of the whole fire event. Refer to the instructions below.

Weather characteristics are measured during and after the fire where possible. Once again, it is best to collect information near monitoring plots that you might have already established, or alternative, take a number of samples. For an alternative and more detailed approach to measuring weather characteristics refer to pages 13, 14, 16 & 17 of the Fire Management Operational Manual (Produced by the Southeast Queensland Fire and Biodiversity Consortium).

Fire Behaviour Data Sheet	
Location	
Name of Field Officer/Landholder	
Date of fire	

(See next page for information on how to complete this form)

Use a new column for each plot, sample or sector						
Plot, Sample or Sector						
Co-ordinate (n or lat)						
Co-ordinate (e or long)						
Photo no. (optional)						
Site Characteristics						
Slope (approx degrees)						
Aspect (slope direction)						
Fuel Assessment						
Fuel load (t/ha)						
Fire Behaviour						
Flame ht. average (m)						
Fire movement (upslope, downslope or across slope)						
Rate of spread (m/min)						
Ignition / recording time						
Post Fire Assessment						
Fuel load (t/ha)						
Scorch ht. average (m)						
Crown scorch (%)						
Proportion burnt (%)						
Intensity (code)						

[illegible]

Instructions for completing the "Fire Behaviour Data Sheet" proforma

Introduction

Fire behaviour is a term describing how fire reacts to changes in environmental and physical conditions. Fire behaviour is influenced by site characteristics, fuel characteristics and weather conditions. This form records information about fire behaviour and the conditions that influence it.

Completing the form

There are a number of columns for different monitoring events. Usually, you would record a number of samples at different locations during a fire, so that your data is representative of the whole fire event. Therefore, give each of your samples a name and use a new column to record data for each sample. If you are recording in the vicinity of a permanent monitoring plot, record the name of the plot instead. Or if your fire is managed according to sectors, you might choose to record data in relation to each sector. Where you have existing monitoring plots, you are encouraged to record fire behaviour data in relation to these plots where possible, as this will better enable you to compare your fire behaviour data to other data such as for flora or fauna.

It is not necessary to fill in every part of the form. It might be that you just want information on fuel loads, or intensity. Let your management objectives determine the sort of data you need to collect. Generally, collecting most of the data on the form will give you the greatest flexibility later, when you come to use your data.

Some fields should be filled in before fire, some during and some after fire, as indicated on the form. Weather details are not recorded in relation to the columns, but are recorded in relation to time.

Location/Park/Reserve: State the name of the location. For example, this could be the name of a reserve or property.
 Recorded by: Name of the person recording data.
 Date of Fire: The date of the fire event for which data is being collected.
 Plot, sample or sector: Use the term plot when you have an existing monitoring plot which, for example, is also used for flora monitoring. Alternatively, you can take a number of samples of fire behaviour during the fire event, give each sample a name or number. Or you can record information in relation to each fire sector.
 Coordinates: Use a map or a GPS to record the coordinates of the position in which you recorded the data or mark on map.

Slope: Refers to the angle of the slope in the vicinity of the plot. This measurement can be estimated or obtained from a clinometer.
 Aspect: Refers to the direction the slope in the vicinity of the plot. Use a compass for accuracy.

Fuel load before fire (t/ha): The Overall Fuel Hazard guide includes instructions for estimating fuel loads in tonnes/hectare.

Flame height: Estimate the average flame height in the vicinity of the monitoring plot, sample or sector.
 Fire movement: Describe the movement of the fire in relation to slope, in the vicinity of the monitoring plot, sample or sector.
 Rate of spread: Estimate the rate of spread of the fire. You can do this by observing the fire front for one minute, estimating how far it has moved.

Ignition / recording time: The time that the fire started for the plot, sample or sector or the time of recording.

Fuel load after fire (t/ha): The Overall Fuel Hazard guide includes instructions for estimating fuel loads in tonnes/hectare.
 Scorch height: Estimate the average height of scorch marks in the plot, sample or sector.
 Crown scorch %: Estimate the average amount of canopy scorch in the vicinity of the plot, sample or sector.
 Proportion burnt: Often called patchiness. Almost all fires leave some areas unburnt. These may be places where soil and fuel moisture were high or where topography caused small-scale variation in fire weather. These unburnt areas can be critical to the survival of some fauna species. Estimate how much of the area burnt for the vicinity of the plot, sample or sector.
 Intensity: Use the following codes

Grassland & open woodland	Heathland & shrubland	Forest & woodland	Code	Description
			U	Unburnt.
			L	Low: Patchy, does not remove all the litter and ground stratum, low scorch, little or no canopy scorch.
			M	Moderate: Most or all ground stratum burnt, some scorch in the midstratum, little or no canopy scorch.
			H	High: Ground stratum burnt completely (or nearly so), at least some canopy scorch.
			S	Severe: All understorey burnt (or nearly so), extensive crown scorch.
			C	Canopy fire: Burnt through canopy (with or without burning mid-strata); ground stratum largely unburnt.
			E	Extreme: All understorey burnt (or nearly so), tree branches burnt.

Wind speed: Wind speed is typically determined using an anemometer. Use average wind speed, then record peak wind speed in brackets after the average. Alternatively, estimate wind speed using the Beaufort scale below.

Beaufort Number	Term	Wind Speed (km/hr)	Description
0	Calm	0	Smoke rises vertically
1	Light air	1-5	Smoke drifts slowly; wind vanes not affected
2	Light breeze	6-11	Wind felt on face; leaves rustle; ordinary wind vanes move
3	Gentle breeze	12-19	Leaves and twigs in motion; wind extends light flag
4	Moderate breeze	20-28	Dust and loose paper raised; small branches move
5	Fresh breeze	29-38	Small trees sway
6	Strong breeze	39-49	Large branches in motion; whistling heard in telephone wires
7	Near gale	50-61	Whole trees in motion; inconvenience when walking against wind
8	Gale	62-74	Twigs broken off trees; progress of walkers impeded
9	Strong gale	75-88	Branches broken off trees; slight damage to buildings
10 - 11	Whole gale	88-101	Trees uprooted; much damage to buildings
12	Hurricane	102-120	
		120+	

Wind direction: Record the direction from which the wind is coming. Use a compass for accuracy.
 Temperature: Use a thermometer.
 Relative humidity: Many thermometers include relative humidity.
 Cloud cover: Estimate the cloud cover in eighths.

iii) Examples of data analysis and presentation – fire behaviour

Fuel load is one of the most important characteristics of fire behaviour for local government. This refers to the amount of fuel found at a plot and is measured in tonnes per hectare. The example below shows changes in fuel hazard within three plots over a period of twelve years. Raw data is used in preference to averages. (If a large number of plots were sampled, averages could be used reliably).

As would be expected, the amount of fuel per hectare steadily increases in the lead up to the fire event and post-fire monitoring shows a dramatic reduction in fuel loads (unless a high intensity fire, fuel loads are never reduced to 0). In this hypothesised example, fuel loads steadily increases over time ... the rate of accumulation will slow (depends on the vegetation type) eventually reaching a steady state or equilibrium (where decomposition equals accumulation). This type of information and precise monitoring will help guide your fire management practices.

(Note: Hypothetical example)

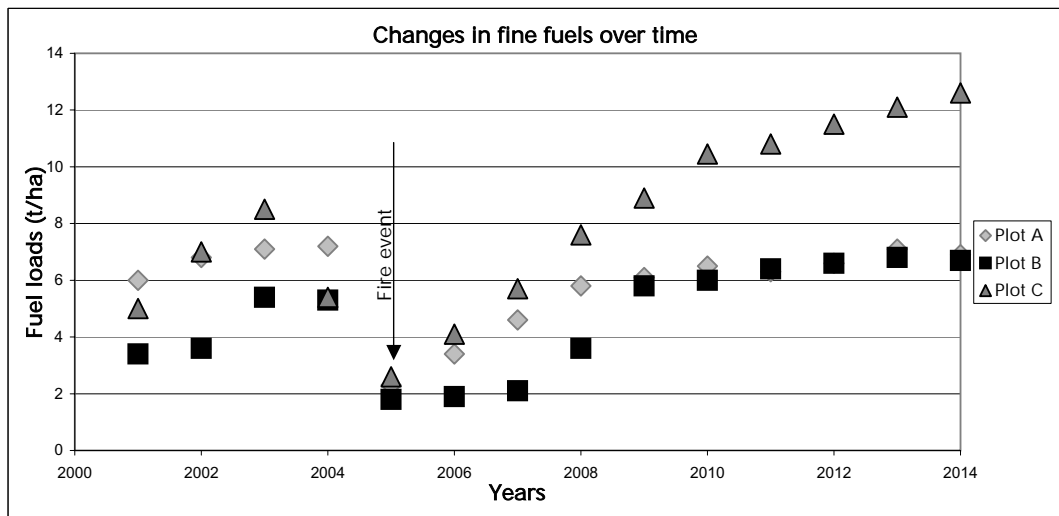


Figure 4: Changes in fine fuel hazard over time.

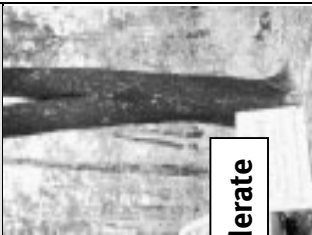

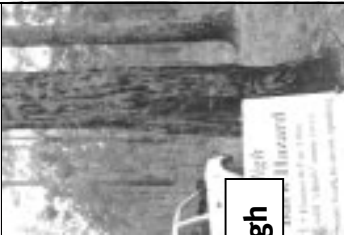
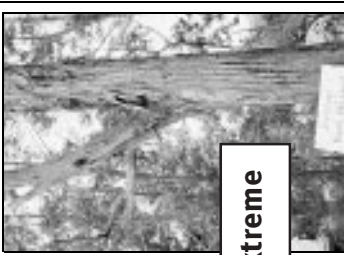
Fire Research

Overall Fuel Hazard Guide

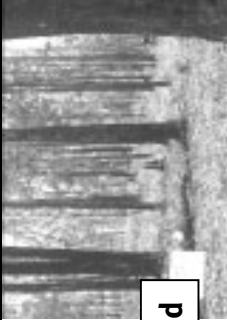

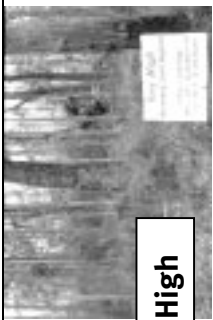
Assessing Fuel Component Hazard Ratings
(Overall = Bark + Elevated + Surface)

Assess levels of Bark, Elevated and Surface Fine Fuel Hazard as follows:

Bark Hazard Rating

Low	No flammable bark		Moderate		Significant loose bark. Fires will climb most trees. Spotting causes problems.
	Little bark to add to fire behaviour.				
	Some loose fibrous bark. Some fire will climb trees. Some spotting.		High		Large amounts of loose bark. Fires climb all trees. Severe spotting.
					Extreme

Elevated Fuel Hazard Rating

Description	Low
No elevated fuel. "Easy to walk through in any direction."	
Little elevated fuel. "Easy to walk through, but vegetation does brush legs occasionally."	
Mod	
Some scattered elevated fuel. "Moderately easy to walk through, but brush against or step over vegetation most of the time." 0.5 m high. 0 -20% dead. Patchy increase in fire behaviour	High
Very High	
Significant elevated fuel. "Difficult to walk through. Need to carefully select path and step high." 20 - 30% dead. 0.5 to 1.5 m high. Elevated fuel mostly determines fire behaviour.	Extreme
Taller, dense elevated fuel. "Very difficult to see where you are going. Need to use arms to push through vegetation." 30 - 50% dead. 2.0 m+ high. Elevated fuel completely determines fire behaviour.	

For further information: Fire Research Officers Orbst 03) 5154 1208, Creswick 03) 5321 4181. Refs: Fire Research Reports No. 45 & 47.
Prepared by Greg McCarthy Sept 2000.

Surface Fine Fuel Hazard Rating System based on Litter Bed Height

(measure with gauge)



Surface Fine Fuel Hazard	Low	Mod	High	Very High	Extreme
Litter Bed Height (mm)	<15	15-25	25-35	35-50	50+
Equivalent Surface Load (t/ha)	<4	4-8	8-12	12-20	20+

Combining Bark, Elevated and Surface Fine Fuel Hazards to give an Overall Fuel Hazard for a site:

Table 1. Bark hazard: Low or Moderate

	Surface Fine Fuel Hazard				
	L	M	H	VH	E
Elevated Fuel Hazard	L	M	M	H	H
	M	M	M	H	H
	H	M	H	VH	VH
	VH	VH	VH	VH	VH
	E	E	E	E	E

Table 2. Bark hazard: High

	Surface Fine Fuel Hazard				
	L	M	H	VH	E
Elevated Fuel Hazard	L	M	H	H	H
	M	M	H	H	H
	H	H	H	VH	VH
	VH	VH	VH	VH	E
	E	E	E	E	E

Table 3. Bark hazard: Very High/Extreme

	Surface Fine Fuel Hazard				
	L	M	H	VH	E
Elevated Fuel Hazard	L	M	VH	VH	E
	M	M	VH	VH	E
	H	M	VH	E	E
	VH	E	E	E	E
	E	E	E	E	E

Note: To use the 'Overall Fuel Hazard Card (Draft Sept 2000)' refer to Appendix 1 for detailed instructions. It is also recommended that the 'Overall Fuel Hazard Guide 3rd Edition' be used in conjunction with this card.

Equivalent Fuel Loads (t/ha) for given Hazard ratings (Insert total of components into McArthur Meter for predictions of forward rate of spread and flame height)

Fuel	Low	Mod	High	V High	Extreme
Bark	0	0	2	5	7
Litter/Surface	2	5	10	16	20
Elevated	0	0	2	6	10

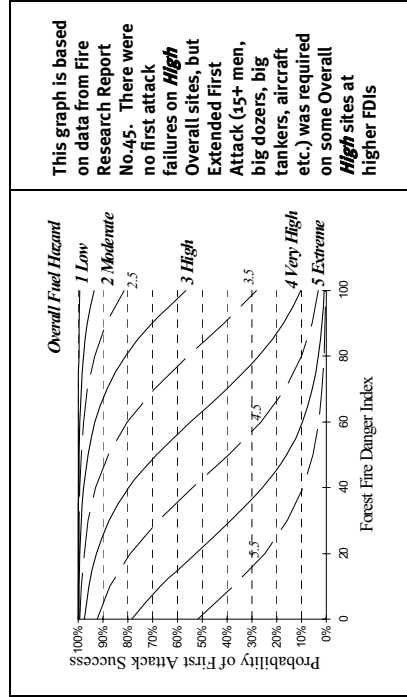
e.g. High Bark + High Surface + V.High Elevated = 2 + 10 + 6 = 18 t/ha Overall

Suggested Overall Hazard levels for Fuel Management Zones

FMZ 1 (P1) - Moderate

FMZ 2 (P2) - High

FMZ 3 (P3) - High on 50% of total area. (i.e. other 50% may be higher.)



For further information: Fire Research Officers Orbest (03) 5154 1208, Creswick (03) 5321 4181. Refs: Fire Research Reports No. 45 & 47. Prepared by Greg McCarthy Sept 2000.

Method 2: Fuel Weighing Technique

Choosing samples:

1. collect fuel loads from plots;
2. take three samples at each plot, using a modified version of the ranked set technique of McIntyre (1952) designed to increase sampling efficiency and reduce error;
3. randomly place three rings on the ground (within a 2m radius). Assess the rings visually, and assign to them a Low, Medium or High ranking for the amount of fuel present around them;
4. select the LOW one as the first site and replace with a 50cm square quadrat marked LOW;
5. repeat procedure (3);
6. select the MEDIUM one as the second site and replace with quadrat marked MED;
7. repeat procedure (3); and
8. select the HIGH one as the third site and replace with quadrat marked HIGH.

Note: Low, Med and High are only arbitrary ratings and in some instances the high sample in fact may be of a lower weight than the Low sample.

Sampling selected areas:

- (i) sample the 50cm square quadrats , removing all fuel/ vegetable matter (including live and dead material) under 10mm in diameter and up to 1.0m in height above the quadrat (or to the top of a continuous fuel layer if dense shrubby understorey exists) down to soil level;
- (ii) start from above and work down to ground level making sure to collect any overhanging plant material that falls within the confines of the quadrat;
- (iii) when trimming plants at ground level, make sure not to include dirt, sand or stones as this far outweighs vegetative material in mass to volume ratio and will produce an unacceptably high reading/error;

Note: If you can't remove sand or dirt by wiping it off; STOP and leave the small amount left behind. It will be so small it is negligible; and

- (iv) mark bags with the plot number and fuel load rating (i.e. L,M or H) and put the small bag inside the large bag.

Leave one of the wooden stakes in the ground. The next time you sample in this plot, choose a slightly different area to avoid resampling in areas from where you have already taken fuel.

Drying and weighing of samples:

Weigh individual bags prior to oven drying and record your measurement.

- (i) dry in ovens to approx 65°C for several days, or until oven dry;

Note: Check curing/drying rate by putting several of the heavier bags at front of oven and weigh periodically (3 times/day) until they stop losing weight;

- (ii) complete data sheet for individual bag weights after drying;
- (iii) average weights for each plot and convert to tonnes/hectare;
- (iv) graph results over time; and
- (v) compare estimates in field to actual fuel loads.

3. Vegetation Monitoring

i) Monitoring *plants* and fire

Monitoring can help to answer our questions about the responses of vegetation, particular plant species and individual plants to fire. We can look at whether or not our management objectives are being met, be alerted to flora responses that we didn't expect, and track vegetation changes over time.

Scientists and land managers have come up with lots of ways to record vegetation characteristics. The simplest, and most commonly used are:

- presence/absence—whether or not particular species are present;
- abundance (or density)—the numbers of plant individuals in a given area; and
- cover—the degree to which vegetation shades or covers the ground.

Often it is not possible to record this kind of information for an **entire** site, so one or more representative samples (plots) are chosen (refer to Table 1a and 1b 'Sampling guide for monitoring different vegetation types' p.20 and 'The quadrat', p.18). Photographs can also be useful as they provide a quick, visual reference to complement this information (refer to 'Photo point data sheet' on p.50).

ii) Methods for monitoring *plants* and fire

The Vegetation Data Sheet (pgs.39,40) provided is best used at one or more monitoring plots. You can use one sheet or more depending on what you are recording. The following time intervals are suggested for Local Government, but may need to be adapted (even increased) depending on your priorities and resources.

Example of monitoring time intervals :

First
Second
Third
Subsequent

Pre burn
Within three (3) months
Twelve (12) months after the fire
Annually

unless there is a subsequent fire. If this occurs, record the date in the data sheet and initial monitoring time intervals resume, i.e. within 3 months, 12 months, then annually.

Although annual monitoring can continue indefinitely, once you are satisfied that your monitoring question is answered, the frequency of monitoring may drop back to five or ten year intervals until the occurrence of another fire event.

The image shows a portion of a 'Vegetation Data Sheet'. It has a header section with 'Pre burn' and 'Within three (3) months' columns. Below this, there are columns for 'Twelve (12) months after the fire' and 'Annually'. The sheet is a grid with many rows for recording data. Arrows from the text on the left point to specific columns in the sheet.

(see Vegetation data sheet on p.39)

What if I don't know species?

If your botanical skills are lacking but you need to be able to distinguish species:

- have a botanist (or someone who knows the plants at your site) join you the first time you record species – take notes, photos, herbarium material etc;
- establish a field herbarium (labeled pressed plant materials). This can consist of loose leaf folders or on cards stored in a metal box (e.g. tool box);
- use local field guides, species lists and other references; and
- record unknown species as 'Unknown Species A', 'Unknown Species B' etc., record details of the plant and collect plant material (including any flowers, fruits, bark etc) to show an expert or submit to the Queensland Herbarium for identification.

Identifying species does require a certain amount of resources and skill. If you are setting up a monitoring program and do not wish to distinguish species, there are other options available to you. The Data Sheets can be adapted for any of the following.

Consider monitoring:

- a 'key' or 'indicator' species;
- one or more dominant shrub/tree species;
- life form instead of species e.g. 'native shrubs', 'native ground covers'; and
- age classes of a particular (key) species, e.g. 'seedlings', 'adults', 'senescents'.

Seedlings

Seedlings can often be difficult to identify, even for botanists, but are important to monitor in relation to fire. Treat unknown seedlings in the same way you would unknown species (refer to suggestions above). Take plastic bags, labels and secateurs with you into the field and collect specimens for future identification.

Target species

Monitoring could focus on a number of target species establishing in an area after a fire event (reseeders). In instances where population monitoring of all target species is impractical, monitoring of selected 'key' species can be undertaken. These are chosen according to the specific management objectives of the site (e.g. a Rare & Threatened or 'indicator' species), local expert advice or research—or, ideally, a combination of these.

Weeds

The Vegetation Data Sheet can be used to monitor weeds by recording abundance scores for either:

- individual weed species (i.e. list all weed species present – or just dominant or target weed species – in left column);
- weeds collectively (i.e. instead of listing weed species in left column, just record ‘weeds’); and
- weed groups (i.e. instead of listing weed species in left column, record group type e.g. forbs, vines, grasses, succulent, woody).

Vegetation Data Sheet Page 1 of 2

Dates of subsequent fires .../.../... .../.../... .../.../... .../.../... .../.../... .../.../... .../.../...

Dates of subsequent fires .../.../... .../.../... .../.../... .../.../... .../.../... .../.../... .../.../...

[illegible]

Vegetation Data Sheet

Page 2 of 2

Location: Plot name/number

Name of Field Officer/Land Holder: Date:

Major vegetation types

- | | |
|--------------------------------------------------------------------|----------------------------------------------------|
| <input type="checkbox"/> Wet Eucalypt forest | <input type="checkbox"/> Melaleuca wetland |
| <input type="checkbox"/> Dry Eucalypt forest (grassy understorey) | <input type="checkbox"/> Vine scrub |
| <input type="checkbox"/> Dry Eucalypt forest (shrubby understorey) | <input type="checkbox"/> Rainforest |
| <input type="checkbox"/> Heath | <input type="checkbox"/> Other (eg grassy pasture) |

Fire Monitoring question/s

Eg. To maintain plant species diversity over time.

How to use the data sheet for one or more of the following:

Abundance

Record abundance of plant species found in your plot using the following scale.

Abundance for grasses and sedges (lower stratum) use % cover: 5 = Abundant (75-100%), 4 = Common (50-75%), 3 = Frequent (25-50%), 2 = Infrequent (5-25%), 1 = Occasional (1-5%), 0 = Absent

Abundance for shrubs/trees (mid stratum and canopy) use estimate of numbers: 5 = Abundant (dominant), 4 = Common (many), 3 = Frequent (some), 2 = Infrequent (a few), 1 = Occasional (very few), 0 = Absent

or Presence/Absence

Record presence/absence of plant species in your plot using the following instructions

On the first monitoring occasion, only record those species present: 1 = present

On subsequent monitoring occasions, record if species are present or absent: 1 = present 0 = absent New species may be added.

or Dominant Species - Only abundant and common species are recorded

Abundance for grasses and sedges (lower stratum) use % cover: 5 = Abundant (75-100%), 4 = Common (50-75%)

Abundance for shrubs/trees (mid stratum, and canopy) use estimate of numbers: 5 = Abundant (dominant), 4 = Common (many)

or Weeds

- Record abundance, presence / absence or dominance of weed species only or .
- Record abundance (as above) with a * alongside the names of weed species.

or Structure - Place class beside Canopy, Mid stratum or Lower stratum in data sheet

Use of structural formation classes for woody plants

Note: For canopy crown separation, consider plants within the general vicinity as well as within your plot.

Canopy and Mid Stratum

	D Closed or dense	M Mid-dense	S Sparse	V Very sparse	I Isolated plants
Crown separation					
Field criteria	Touching-overlap	Touching – slight separation	Clearly separated	Well separated	Isolated

Lower Stratum

	D Closed or dense	M Mid-dense	S Sparse	V Very sparse	I Isolated plants
Crown class					
Foliage cover	>70	70-30	30-10	<10	<1

or All species

Record abundance or presence / absence of plant species found in your plot as described above.

Note: You may need to adapt the data sheet to accommodate more species.

or Selected layer

You may wish to record information about only a particular layer (eg lower stratum) using any of the above measures.

or Selected species

You may wish to record a particular species of interest (eg. Rare & Threatened) or group of species, depending on your site and management objective. Use any of the above measures or consider using the Plant Response Data Sheet (p.43)

Notes

Examples of data analysis and presentation - vegetation

There are a number of options available for analysing and presenting raw vegetation data. In some cases it may be best to display raw data graphically (see Figures 5 and 6 on next page), rather than with bar charts.

Species richness is often of interest to local government and other land managers. It is simply the number of different species within a plot and can be calculated from abundance or presence /absence data. The following example shows changes in species richness within three plots over time. In this instance, there appears to be a decline in species richness in the years leading up to the fire event. This should be interpreted in terms of what is already known about species at the site in relation to fire, the history of the site and any other monitoring information considered relevant (e.g. fire behaviour and plant response data). The first and second monitoring events after fire reveal an increase in richness that gradually declines over the next six years. Again, the interpreter should consider the range of complex and interactive processes at work.

The second example shows hypothetical changes in the abundance of a selected species, in this case Species 1, in three plots over time. As in the first example, there appears to be a decline in the abundance of this grass leading up to the fire event and an increase shortly afterwards. In fact, the changes in abundance follow a very similar pattern to changes to the richness example. If the information for both graphs was gathered for the same three plots, the interpreter could look at the possibility of initiating special research into the use of species as an indicator species of plant richness in this community.

(Note: Hypothetical example)

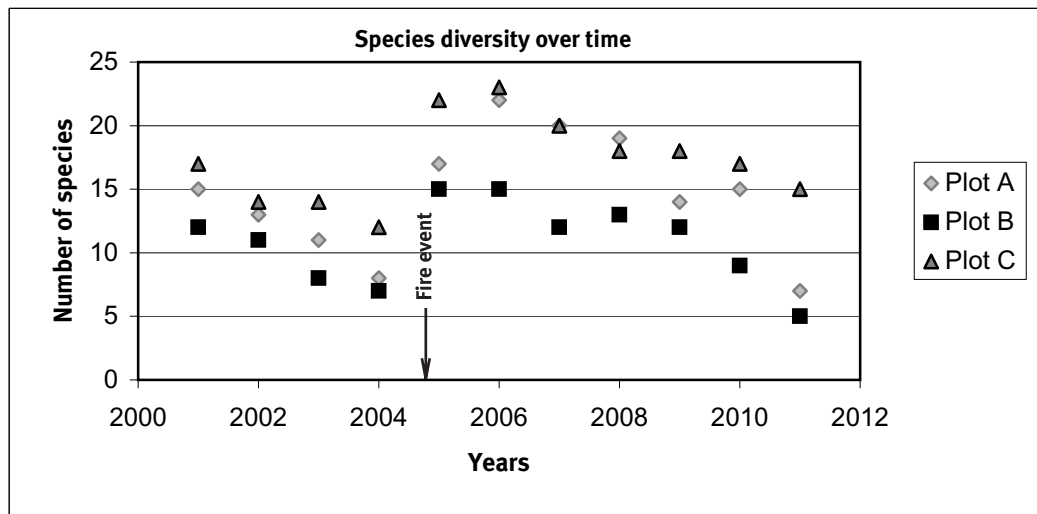


Figure 5: Species richness over time.

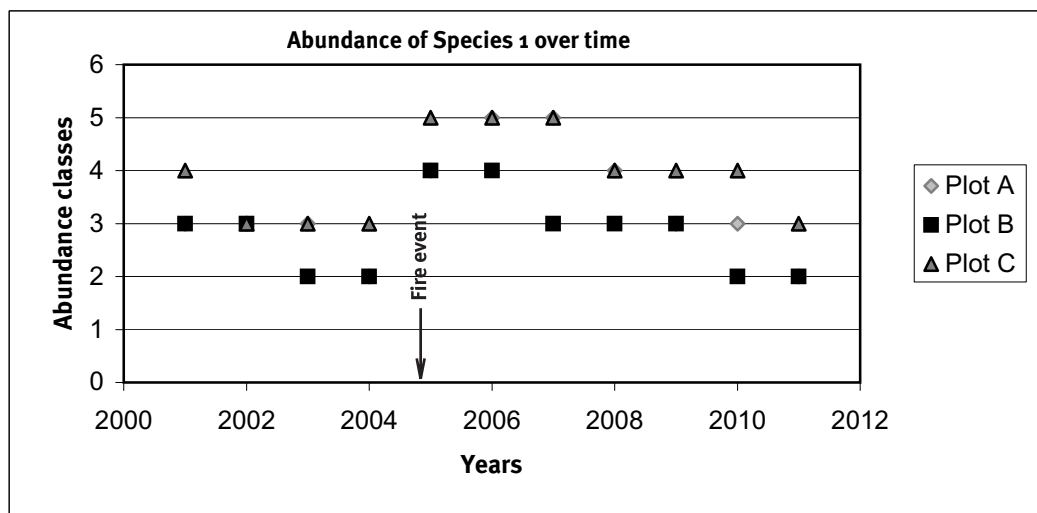


Figure 6: Abundance of Species 1 over time.

Plant Response Data Sheet

This form only needs to be used while fire responses are occurring or for flowering/fruitlet information

Date of fire

[illegible]

Location: Plot name/number

Name of Field Officer/Land Holder: Date:

Major vegetation types

- ☐ Wet Eucalypt forest
- ☐ Dry Eucalypt forest (grassy understorey)
- ☐ Dry Eucalypt forest (shrubby understorey)
- ☐ Heath

- ☐ Melaleuca wetland
- ☐ Vine scrub
- ☐ Rainforest
- ☐ Other (eg grassy pasture)

Fire Monitoring Question/s*Eg. To maintain Blandfordia sp. over time.***How to use the data sheet for one or more of the following:**

- This data sheet can be completed for a plot in conjunction with other monitoring activities (eg. fauna and flora monitoring)

Fire behaviour details

Important to complete the fire behaviour (pgs 29-30) form before using this data sheet, as fire behaviour data will help you to interpret plant response.

Selected species

This data sheet can be used for particular species found at your plot ie. rare, threatened or indicator species to record regenerative and reproductive potential over time.

To use the classes below you will need to consider all individuals belonging to the species of interest within your plot.
eg. Estimate the recovery and reproduction of *Banksia spinulosa* within the plot by considering all *Banksia spinulosa* individuals together.

Recovery classes

Indicates the recovery of a plant species after fire by estimating the amount of vegetative shoots produced.
Use the classes 1 to 3; where 1 = few, 2 = moderate, 3 = many showing response

or Seedlings

If seedlings are unidentifiable allocate a code for each seedling eg Seedling A. and collect a herbarium sample.
Ensure codes are consistently used and take herbarium samples with you on subsequent visits.

or Reproduction classes

Indicates the reproductive response, in terms of flowering/fruitletting of a plant species after fire. Two classes are used to estimate reproductive response.

Use the classes 1-3; where 1 = few, 2 = moderate, 3 = many showing response, to indicate how many individuals of the species are flowering/fruitletting

Use the classes H, M, L; where H = heavy, M = moderate, L = lowflowering/fruitletting, to indicate the average heaviness of flowers/fruit on individuals of the species.

Notes

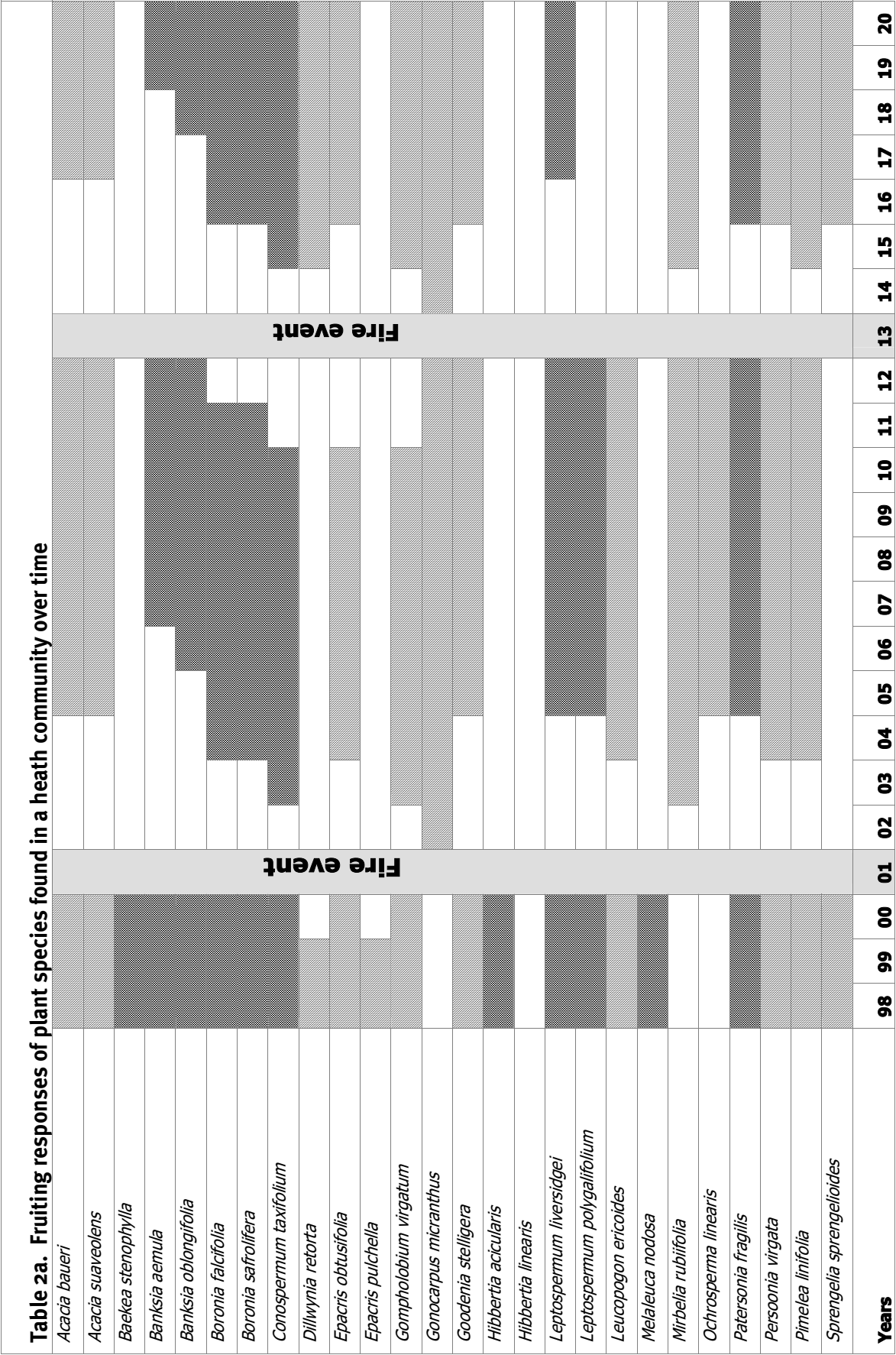
Example of data analysis and presentation – Plant response

A useful way to present plant response data is in a table that shows fruiting and/or vegetative responses. Table 2a and 2b on pgs. 46, 47 show how this information may be used to analyse a selected group of species within a heathy community over a period of 22 years. If a species displays rhizomal, basal and/or epicormic shooting at the time of monitoring, it is shown on the table as having produced a vegetative response for that year. In the same way, if a species is fruiting at the time of monitoring it is recorded on the table as having produced a fruiting response for that year.

In this example, Table 2a depicts the fruiting response of a hypothetical heath community over 20 years. During the 20 year period there have been two fire events. Presentation of the data in this form gives a clear picture of what is happening to the plant community over time. Some plant species are shown to begin fruiting after a period of time since fire. These species are likely to be facultative resprouters whereas those species that are fruiting directly after fire are the opportunistic obligate reseeders. Visually depicting fruiting response in this format can present a plant life history over time. This is useful when planning the next fire event. If a large percentage of the plant community have not reached fruiting maturity, it is likely a fire event will reduce that community's capacity for survival. Whereas if the fire event occurs when plants have reached maturity and have had quite a few flowering events the likelihood of survival is increased.

Table 2b depicts the vegetative response of the same hypothetical community over 20 years. Again two fire events occurred over the 20 year period. The species that recovered directly after each fire event are facultative resprouters whereas the species which took 2-3 years to establish are species which are obligate reseeders.

Fruiting and vegetative response data can be depicted in a number of ways eg. Structure such as forb, shrub and tree layers species.



Obligate seedling's response to fire over time

Facultative resprouter's response to fire over time

Obligate seedling's response to fire over time

Facultative resprouter's response to fire over time

Table 2b. Vegetative responses of plant species found in a heath community over time																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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Obligate seeder's response to fire over time

Facultative resprouter's response to fire over time

Obligate seeder's response to fire over time

Facultative resprouter's response to fire over time

Photopoint monitoring

Photographs allow us to see what a plot looks like (especially its vegetation) at a particular moment in time. Photos taken from the same position at specific time intervals provide allow us to rapidly assess general changes over time. This is a commonly used method known as photopoint monitoring.

However permanent photopoints offer relatively little information on their own and are much more useful when used in conjunction with other monitoring methods.

Establishing a photopoint

Refer to p.17 'Establishing your plot'. Your plot should already have a star picket to mark its location. Place a second star picket 10 metres from the first, in the direction you wish to take the photo (facing into your plot). Photopoint monitoring is best used in conjunction with other techniques, so try to include areas you are already conducting monitoring in the photo. Generally, you get a better result if you design your monitoring so your photo faces south, as the sun is usually behind you.

Taking photos

1. Use the same type of camera, settings and film that you intend to use next time.
2. Place the camera on top of the first star picket (resting) and face the second picket. Position the camera so that the second picket is in the centre of view and take a photo. (because your photopoint is established, you simply return to the same location on future occasions and take photos in the same manner).

Other photo options

You may wish to take more than one photo at each photopoint. Additional photos should reflect what it is you want to know about the plot and supplement any other monitoring information that you gather.

For example:

- **Vegetation Data Sheet** (p.39—if your area of interest is in canopy structure you will need to place more attention on the integrity of the data for the canopy). In this instance you would be interested in photos of the ground, shrub and tree layers to complement the species information recorded. For the first photo (ground layer) locate the top of the star picket at the top centre of the view finder, for the second photo (shrub layer) locate the top of the picket in the middle centre of the view finder, and for the third photo (tree/canopy layer) locate the top of the picket at the bottom centre of the view finder.

Aim to

- take photographs at the same time of day when you return to a photopoint (avoid the middle of the day);
- keep in mind that August/September can help to make different species visible because of flowering;
- utilise the recommended several photopoints for very large or very diverse plots; and
- use the permanent photopoint in conjunction with other monitoring techniques (e.g. small mammal trapping or observation; weed assessment).

Photo point data sheet

Photopoint location _____	Date _____ Time _____
Location details: _____	Compass bearing: _____
Camera type / Lens type/other camera settings: _____	GPS _____
Monitoring / Data sheets completed at plot	Negative number: _____
<input type="checkbox"/> Vegetation	Photographer's name: _____
<input type="checkbox"/> Plant response	Dates of known or recent fires: _____
<input type="checkbox"/> Other _____	Other relevant information

Attach photograph here

4. Fauna Monitoring

i) Monitoring animals and fire

It is important to monitor the response of fauna to fire. Both the immediate and/or long-term response of individual animals, populations, individual or suites of species over time may be monitored.

Like plants, native animals exhibit a range of strategies for maintaining their presence in fire-adapted communities. Some species are 'avoiders' and 'mobile', staying alive whether by moving out of the burning area, or by taking shelter underground or in hollow logs. Other species are sedentary and unable to flee so lose substantial numbers of individuals in fires, and rely on recolonisation by populations from nearby, unburnt areas.

As vegetation recovers following fire, different habitat opportunities arise, which advantage or disadvantage different animal species. The responses of plants, e.g. flowering and seeding, impact on remaining or recolonising animal species. The outcome for these species, and in particular the effect of different management regimes (prescribed burn intervals), are not well understood,.

ii) Methods for monitoring *animals* and fire

Signs

The Fauna Data Sheet provided features 'signs' (e.g. tracks, scats, runways, holes in the ground) for a range of fauna Sheets are derived from a range of fauna monitoring programs currently run in Southeast Queensland including those of Land for Wildlife, Queensland Parks and Wildlife Service, Greening Australia and CSIRO. This Fauna Data Sheet is much simpler and requires less intensive monitoring than most other methods in use. It is more generic so there are limitations. The signs included on the sheet may not be relevant to some areas and may favour some animal species or groups of species over others.

In general, fauna is more difficult to monitor than flora because animals are mobile and often cryptic. Consistency of timing is important (e.g. to cater for breeding and migratory species). Aim to monitor at the same time of day or year. Records of scats and animal remains can overcome some of the problems of "being in the right place at the right time". For actual sightings, you may decide to look carefully under logs, litter or observe streams at dawn or dusk. Some animals – particularly mammals – are most active at night.

Direct observation

For actual sightings, you may decide to look carefully under logs, litter or observe streams at dawn or dusk. More intensive fauna monitoring can involve the use of specially designed equipment (e.g. Elliott traps, cages, binoculars). You may wish to seek advice from those experienced in fauna monitoring. It may also involve spotlighting – in woodland, forest, road verges, watercourses and dams – to observe larger mammals such as wombats, koalas, echidna, possums, gliders and bats. Remember that flowering or fruiting trees are more likely to contain animals (e.g. flying foxes, sugar gliders). Nest boxes may be present and need to be checked at your management site.

The sheets provided are intended to provide a prompt to users, to let them know what they might look for and the manner in which the data can be recorded. They are not necessarily a definitive datasheet and may be modified to suit the users goals.

Fauna Data Sheet														Page 1 of 2
Dates of subsequent fires .../.../... .../.../... .../.../... .../.../... .../.../... .../.../... .../.../... .../.../...														
Monitoring dates		:	:	:	:	:	:	:	:	:	:	:	:	:
		/	/	/	/	/	/	/	/	/	/	/	/	/
		:	:	:	:	:	:	:	:	:	:	:	:	:
		/	/	/	/	/	/	/	/	/	/	/	/	/
		:	:	:	:	:	:	:	:	:	:	:	:	:
		/	/	/	/	/	/	/	/	/	/	/	/	/
Static signs of fauna														
A	Scats	Mammal droppings												
B	Footprints													
B	Fresh claw marks	On smooth barked trees (Note: Common or opportunistic species may be more obvious)												
B	Runways	Cleared through dense vegetation, grasslands etc. eg. by native rats												
C	Fresh diggings	Of foraging birds, mammals, reptiles etc.												
C	Partially eaten fruits, seeds	Birds, bats, possums etc.												
C	Fresh diggings	Of foraging birds, mammals, reptiles etc.												
D	Holes in ground	Of foxes, dingoes, quolls etc.												
D	Small tunnels in the ground	Of snakes, spiders, crabs etc. Includes small tunnels and holes.												
D	Nests in trees													
D	Nests on ground	Scrub turkey, termite, ground parrot etc.												
D	Frog egg masses / tadpoles	In creek, wetland, pools etc.												
E	Hair													
E	Feathers													
E	Shed skin	Of snakes etc.												
E	Undigested animal remains	Predators or scavengers eg. bones under owl perch												
E	Dead animals	Road kill, killed by feral cats, dogs etc.												
E	Eggs on ground	Damaged or intact												
E	Skulls													
E	Insect remains	Caught in spider webs, cocoons, moults etc.												
F	Insects heard	Bees, wasps, cicadas etc.												
F	Birds heard													
F	Nearby rustling heard	Small lizards in leaf litter etc.												
G	Others eg. Odours	Of mammals eg. urine, pheromones, guano												
Actual Sightings														
	Birds													
	Reptiles	Under bark, logs, rocks etc.												
	Insects													
	Other													

Key: A=scats and pellets, B=tracks and traces, C=feeding signs, D=nests and shelters, E=bones and other remains, F=calls and noises, G=odours.

Location: Plot name/number

Name of Field Officer/Land Holder: Date:

Major vegetation types

- | | |
|--------------------------------------------------------------------|----------------------------------------------------|
| <input type="checkbox"/> Wet Eucalypt forest | <input type="checkbox"/> Melaleuca wetland |
| <input type="checkbox"/> Dry Eucalypt forest (grassy understorey) | <input type="checkbox"/> Vine scrub |
| <input type="checkbox"/> Dry Eucalypt forest (shrubby understorey) | <input type="checkbox"/> Rainforest |
| <input type="checkbox"/> Heath | <input type="checkbox"/> Other (eg grassy pasture) |

Fire Monitoring Question/s*Eg. To maintain native animal species over time.***How to use the data sheet for one or more of the following:**

This data sheet can be completed for a plot in conjunction with other monitoring activities (eg flora, habitat monitoring). It involves recording a range of “signs” of fauna and does not involve undertaking special methods (eg trapping, spotlighting). Only static signs of fauna and any actual sightings are recorded. Such signs may not be suitable for all areas. You may need to adapt this sheet in order for it to be relevant to your plot/s and monitoring questions.

Presence/Absence of fauna signs

Record presence/absence of individual fauna signs observed within your plot

1 = present 0 = absent

For example, if feathers are present in the plot record ‘1’ alongside ‘feathers’.

or Abundance counts

Record the number of individual fauna signs observed within your plot

1, 2, 3, 4, 5, etc

or Species counts

Record the number of different species linked to signs observed within your plot

1, 2, 3, 4, 5, etc

For example, if feathers are present belonging to two different species within the plot record ‘2’ alongside ‘feathers’.

or Feral animals

If signs of fauna observed are known to have been produced by or belong to a feral animal, record an ‘F’ alongside the number.

Recording more information

You may need to adapt this data sheet if you wish to record more detailed information, eg. you may wish to include both abundance and different species information or different types of signs (eg different types of nests, diggings). Evidence of fauna can often be collected or recorded for later identification eg. bird and frog calls, scats, hair and animal remains.

Seek expert advice if you wish to undertake more intensive fauna monitoring.

Notes

Example of data analysis and presentation - fauna

There are a number of possible ways in which fauna data can be presented and interpreted. In all cases, care should be taken. Different 'signs' of fauna convey different degrees of information. 'Nests on ground', for example, could include those of termites as well as birds. Remember to interpret data in terms of what is known about the particular habitat and species that reside there. It will also be useful to consider the data in conjunction with other monitoring information (fire behaviour, vegetation, habitat, fruiting/seeding responses of plants etc.) as well as considering the range of complex and interactive processes at work.

Figure 7 below shows changes in numbers of just one measure - tree nests - over time for three plots. Displaying the raw data in this way is preferable to displaying averages, since these would make it impossible to see the variation between plots. In general, it could be said that tree nests dramatically decrease in numbers immediately following fire. If aspects of vegetation and fire behaviour were also recorded at each plot, it would be useful to look at this information to help to explain differences between plots.

Another option is to plot the total number of fauna 'signs' present in the plot over time. This would provide a very general indication of possible changes in fauna but because equal weight is placed on each sign, caution would need to be applied in its interpretation.

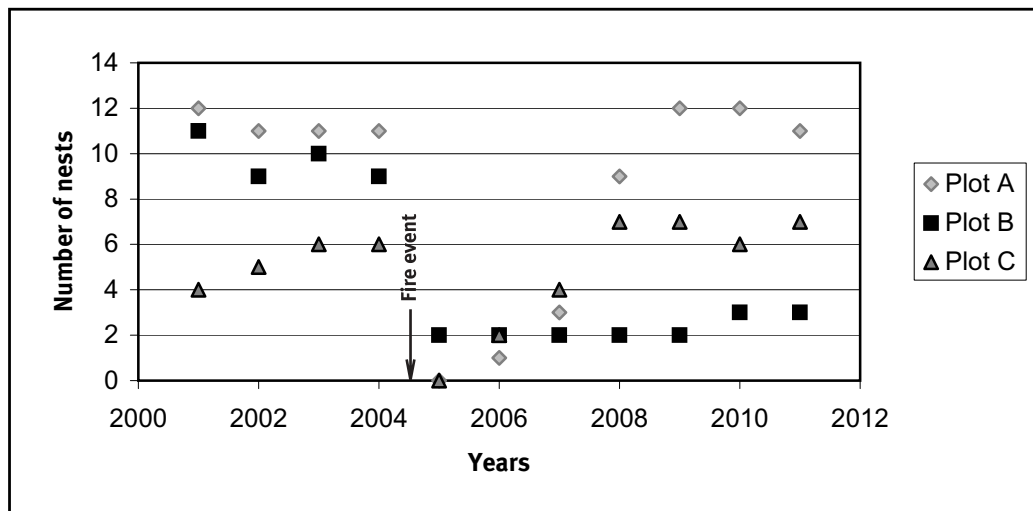


Figure 7: Changes in the number of tree nests over time.

5. Monitoring habitat

i) Monitoring *habitat* and fire

The perceived value of habitat offered by the vegetation and other structures within a plot will vary, depending on what aspects of habitat are understood or of interest to managers. 'Habitat' describes the combination of food, shelter and space that animals need to survive and reproduce and is provided by and influenced by vegetation, soil, water, other animals, as well as disturbance events including fire, erosion, flooding and clearing.



Wayne Kington

Habitats can be very complex to access therefore it is important to know what to look for. Refer to the (p.57) Habitat Data Sheet to help you access habitat complexity.

ii) Methods for monitoring *habitat* and fire

A variety of 'signs' of habitat health are featured in the Habitat Data Sheet. These have been derived from a range of fauna monitoring programs currently run in Southeast Queensland including those of Land for Wildlife, Queensland Parks and Wildlife Service, Greening Australia and CSIRO. The Habitat Data Sheet developed is much simpler and requires less intensive monitoring than most other methods in use. Being more generic, however, means there are limitations. The signs included on the sheet may not be relevant to some areas and may favour some habitats over others. This is why a section for recording 'Other – site specific' signs of habitat health has been included.

Depending on your management objectives, the Habitat Data Sheet will help you to monitor:

- general habitat characteristics and ecosystem 'health'; and
- presence/absence or abundance of specific habitat features required by particular species or groups of species of interest.

[illegible]

Location: Plot name/number

Name of Field Officer/Land Holder: Date:

Major vegetation types

- | | |
|--------------------------------------------------------------------|----------------------------------------------------|
| <input type="checkbox"/> Wet Eucalypt forest | <input type="checkbox"/> Melaleuca wetland |
| <input type="checkbox"/> Dry Eucalypt forest (grassy understorey) | <input type="checkbox"/> Vine scrub |
| <input type="checkbox"/> Dry Eucalypt forest (shrubby understorey) | <input type="checkbox"/> Rainforest |
| <input type="checkbox"/> Heath | <input type="checkbox"/> Other (eg grassy pasture) |

Fire Monitoring Question/s*Eg. To maintain habitat value over time.***How to use the data sheet for one or more of the following:**

- *This data sheet can be completed for a plot in conjunction with other monitoring activities (eg flora, fauna monitoring).*
- *It involves recording a range of “signs” that indicate habitat health and does not require specialized skills or equipment.*
- *Such signs of habitat health may not be suitable for all areas. You may need to adapt this sheet in order for it to be relevant to your plot/s and monitoring questions.*
- *Seek expert advice if you wish to undertake more intensive habitat assessment and monitoring.*

Tick & Flick

For each of the habitat features present within the plot, record a tick alongside. Add up the number of ticks. More ticks indicates ‘healthier’ habitat for native fauna.

For example, if one or more butt hollows occurs within you plot, record a tick ✓ alongside ‘Butt hollows’.

or Presence/Absence

The same process as for Tick and Flick is undertaken, except that values are assigned which may be more appropriate for data entry and analysis.

1 = present / true 0 = absent / false

For example, if one or more butt hollows occurs within you plot, record ‘1’ alongside ‘Butt hollows’.

or Abundance

An indication of the abundance of a particular habitat feature can be recorded using the following classes
5 = Abundant / dominant, 4 = Common / many, 3 = Frequent / some, 2 = Infrequent / few, 1 = Occasional very few, 0 = Absent

For example, if only a few mistletoes are present within the plot, record ‘2’ alongside ‘mistletoes’.

Other – Site specific

This section of the data sheet gives you the option of including signs of habitat health that are of interest or particular relevance to your site. For example, specific habitat requirements of a rare and threatened species.

Totals – Tick & Flick or Presence / Absence only

You can record the total number of ticks recorded at a particular plot and event for the Tick & Flick or Presence / Absence option.

In very broad terms, a higher total suggests healthier habitat.

Notes

Example of data analysis and presentation - habitat

Habitat data can be presented and interpreted in a number of ways, in all cases with care. Different 'signs' of habitat health may favour some groups of animals over others. Remember to interpret data in terms of what is known about the particular habitat and species that reside there. It will also be useful to consider the data in conjunction with other monitoring information (fire behaviour, vegetation, fauna, fruiting/seeding responses of plants etc.) as well as consider the range of complex and interactive processes at work.

The example given below shows changes within a permanent plot in the abundance of two types of hollows – those of fallen logs and tree butts – and loose bark over time. The plot shows that there are consistently 'some' fallen log hollows (class 3) in the years leading up to the fire. These are reduced to none immediately following fire and their abundance steadily increases thereafter. Within this plot, 'loose bark' follows a similar trend that might be expected from fuel load – abundant directly before the fire, absent immediately following fire, then a steady increase. 'Butt hollows' behave differently to the other two measures and, in fact, increase in abundance following the fire. All of these changes would be interesting to look at in conjunction with monitoring information on fire behaviour, vegetation and fauna.

Another option is to plot the total number of habitat 'signs' present in the plot over time. This would provide a very general indication of changes in habitat but because equal weight is placed on each sign, caution would need to be applied in its interpretation.

Changes in the abundance of hollows and loose bark over time

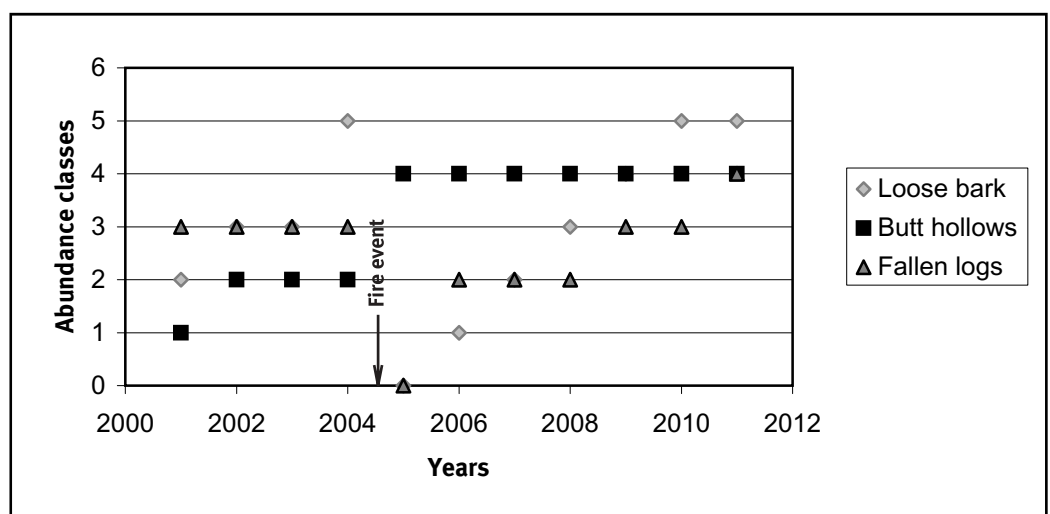


Figure 8: Changes in the abundance of hollows and loose bark over time.

Section 4

Case Studies

1. Beerwah wallum vegetation—(Alan House)

Key objectives:

- to determine the impacts of repeated prescribed burning on plant community composition in wallum open heath and heathy woodland ecosystems, in relation to ecological sustainability and asset (exotic pine plantation) protection; and
- to estimate effectiveness of prescribed burns at different frequencies on efficiency of fuel reduction.

Monitoring techniques:

- application of 3 fire frequencies (every 3 years, every 5 years, no burning) to ~ 2 ha blocks of open heath and open heathy woodland (with *Eucalyptus racemosa*);
- cover abundance estimates of all plant species within replicated (2) permanent plots in each fire treatment. Plots comprise five 25 x 1 m transects, within which every species is enumerated in five 1 x 1 m quadrats, and species not occurring in these but in remaining transect are recorded;
- measures repeated at varying intervals (ranging from annual to every 5 years); and
- pre- and post-burn fine fuel measured using 3-rank technique.

Outcomes of monitoring:

- despite sharing many species, responses of open heath and heathy woodland to fire frequencies are different;
- three and five year burning in woodland has resulted in similar plant community compositions. In open heath, burning every 5 years leads to composition more similar to no burning than burning every 3 years;
- more species were 'lost' from monitored transects in unburnt treatments than in either burn treatment; and
- more species 'lost' from five year treatment in open heath, and from 3 year treatment in woodland.

Contact details:

Dr Alan House
Senior Scientist Ecology
Queensland Forest Research Institute
80 Meiers Road
Indooroopilly QLD 4068



Three year forest panorama—similar floristic composition to 5-year site, simplified structure.



Five year forest panorama—more shrub development than in 3-year site.



Unburnt forest panorama—complex structure, with some understorey 'collapse' due to senescence after 30 years of fire exclusion.



Three year heath panorama—similar, simplified structure to 5-year site.



Five year heath panorama—despite much simpler structure, floristic composition is more similar to unburnt heath site than to 3-year site.



Unburnt heath panorama—complex structure, dominated by senescing *Hakea actites*. Most plants found in 3 and 5-year sites are still present after 30 years of fire exclusion.

2. Raven Street Reserve—(Seonaid Melville)

Remnant vegetation responses to fire in Raven Street Reserve, Brisbane.

Study background:

- dense She-oak (*Allocasuarina littoralis*) stands have low species diversity and develop on land that has been previously cleared;
- the Raven Street study area included *A. littoralis* low open forest that had not been burnt in the past 14 years (Photo 1); and
- an objective of the fire was to assess the impact of fire on these low diversity stands.

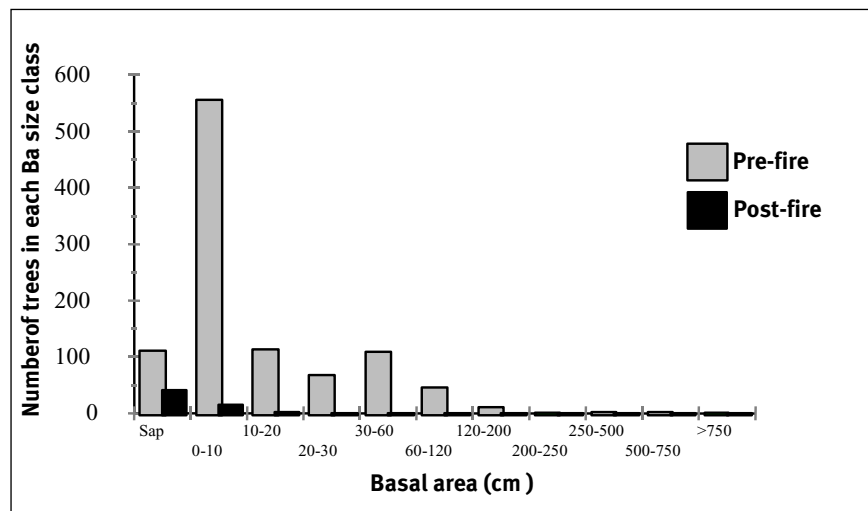
Methodology:

- the Raven Street fire study was undertaken as part of a broader investigation into dynamics of vegetation remnants in an urban environment. The fire was located in part of the Raven Street Reserve adjoining Raven Street;
- two 5m wide transects were established traversing the fire study site. Each transect was 120m long;
- in the transect, all plants over 1m tall were identified. Height, basal area and position along the transect recorded. Measures were undertaken before the fire, at 2 years after the fire and 5 years after the fire;
- understorey plants were sampled from 1m² quadrats placed at 2m intervals along the midline of the transects. All ground cover plants and seedlings were identified; seedlings were counted, cover-abundance values were assigned to ground layer plants. Ground cover was recorded prior to the fire and at 3 months, 6 months, 1 year, 2 years and 5 years after the fire;
- relative temperature of the fire was assessed by placing clay tiles marked with thermo-chromatic crayons at 5m intervals along the transects; and
- analysis of the data involved comparing the composition abundance and distribution of species before and after the fire. Eucalypt and Casuarina population dynamics were of particular interest.

Impact of fire on She-oak (*Allocasuarina littoralis*):

- the effect of the fire on the *A. littoralis* canopy was variable depending on fire intensity;
- in areas of lowest fire intensity the leaf litter under the *A. littoralis* canopy barely smouldered and the low (3m) canopy vegetation was undamaged;

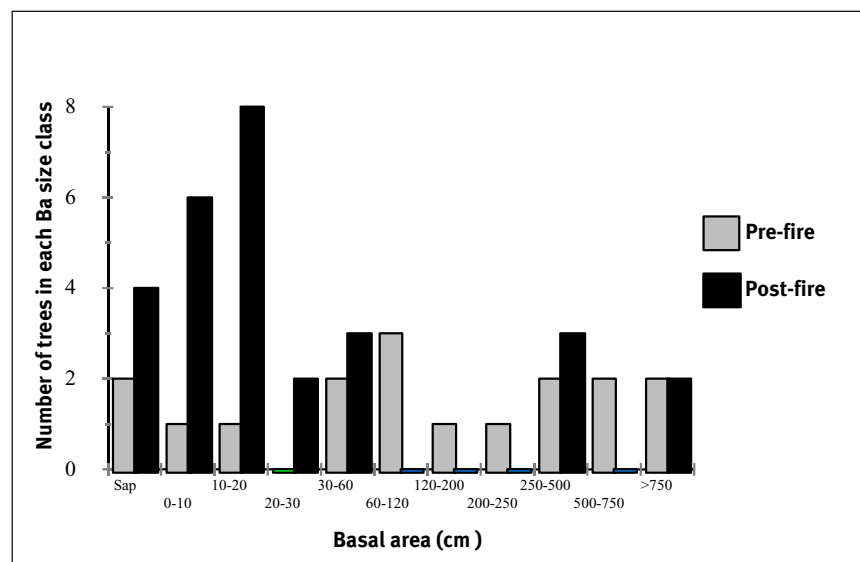
- only when the entire tree was scorched, did the *A. littoralis* tree die; and
- overall, there was a reduction of the number of *A. littoralis* stems in the burnt areas (Case Study Figure 1).



Case Study Figure 1: *Allocasuarina littoralis* population structure in Raven Street Reserve sample transect before and five years after prescribed fire.

Fire effect on eucalypts:

- mature eucalypts with damaged basal bark prior to the fire, were further damaged and died as a result of the heartwood burning. The death of large trees by fire represents a loss of an important resource for fauna;
- Eucalypt propagules present after the fire were all lignotuberous shoots;
- the number of propagules present had not increased significantly yet the vigour of the shoots was markedly increased; and
- six years after the fire, eucalypt sapling numbers had increased on pre-fire numbers. (Case Study Figure 2).



Case Study Figure 2: Eucalypt population structure in Raven Street Reserve sample transects before and five years after prescribed fire.

Weed invasion following fire:

- good rainfall three months after the fire stimulated weed seed germination. Weeds began to dominate regenerating vegetation at the edges of the vegetation patch and along drainage lines. (Photo 2); and
- by six years after the fire, a small number of weeds were confined to the margins of the remnant. Canopy tree shading excluded many weeds along the drainage lines.

Other observations:

- heath composition was relatively unchanged by the fire although there was an increase in the height and diversity of the shrubs present (Photos 3-5);
- *Banksia serrulata* and *Leptospermum* spp. regeneration increased in areas where fire intensity was the greatest;
- there was no recorded loss of species from the study area as a result of the fire;
- six years following the fire, a high volume of litter accumulated, litter depths of 30-50 cm, far exceeded pre-fire litter depths; and
- a prescribed burn is proposed for this study area 10 years after the initial fire.

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Photo 1



Photo 2



Photo 3



Photo 4



Photo 5

3. Coastal spotted gum vegetation—(Geoffrey Smith)

Key objectives:

- to determine the impacts of repeated prescribed burning on vertebrate community composition and forest structure in spotted gum forest ecosystems, in relation to ecological sustainability.

Monitoring techniques:

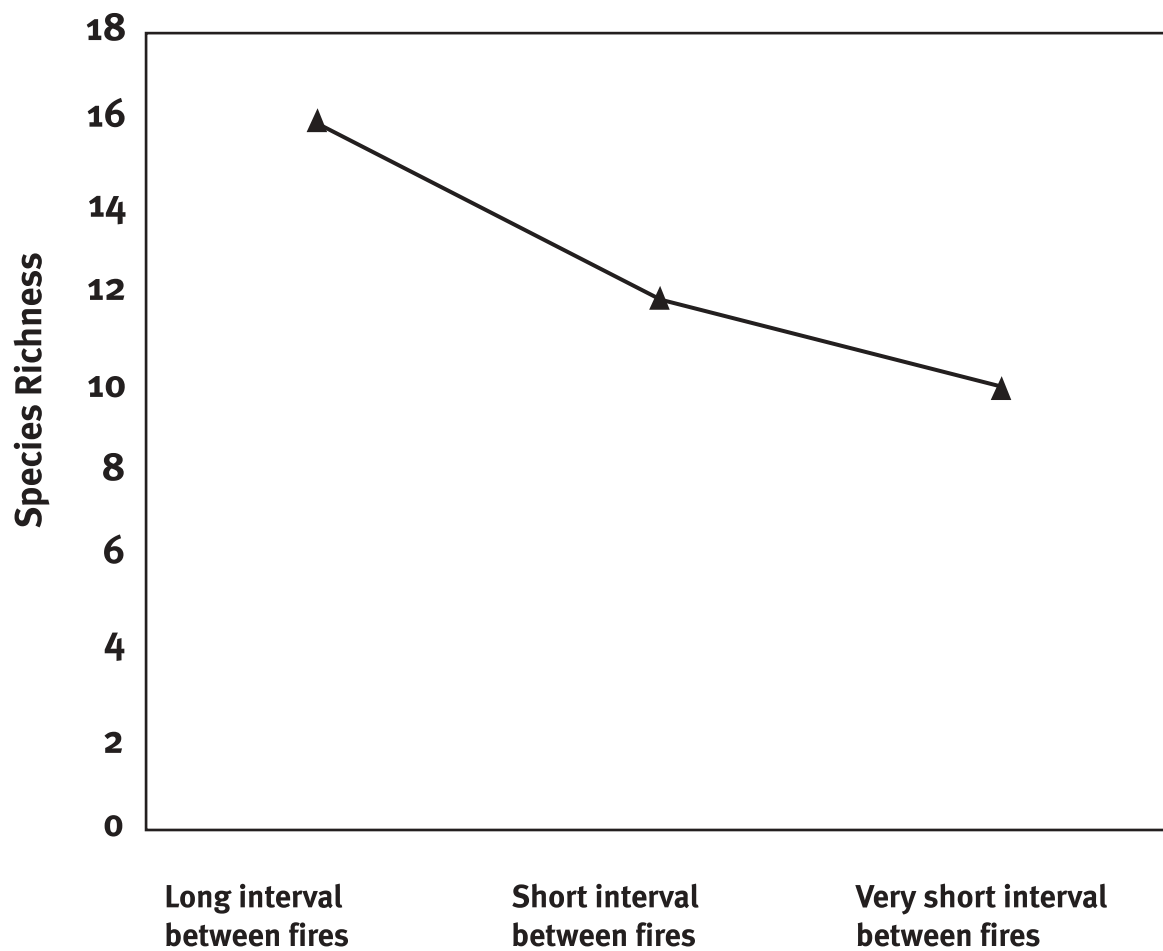
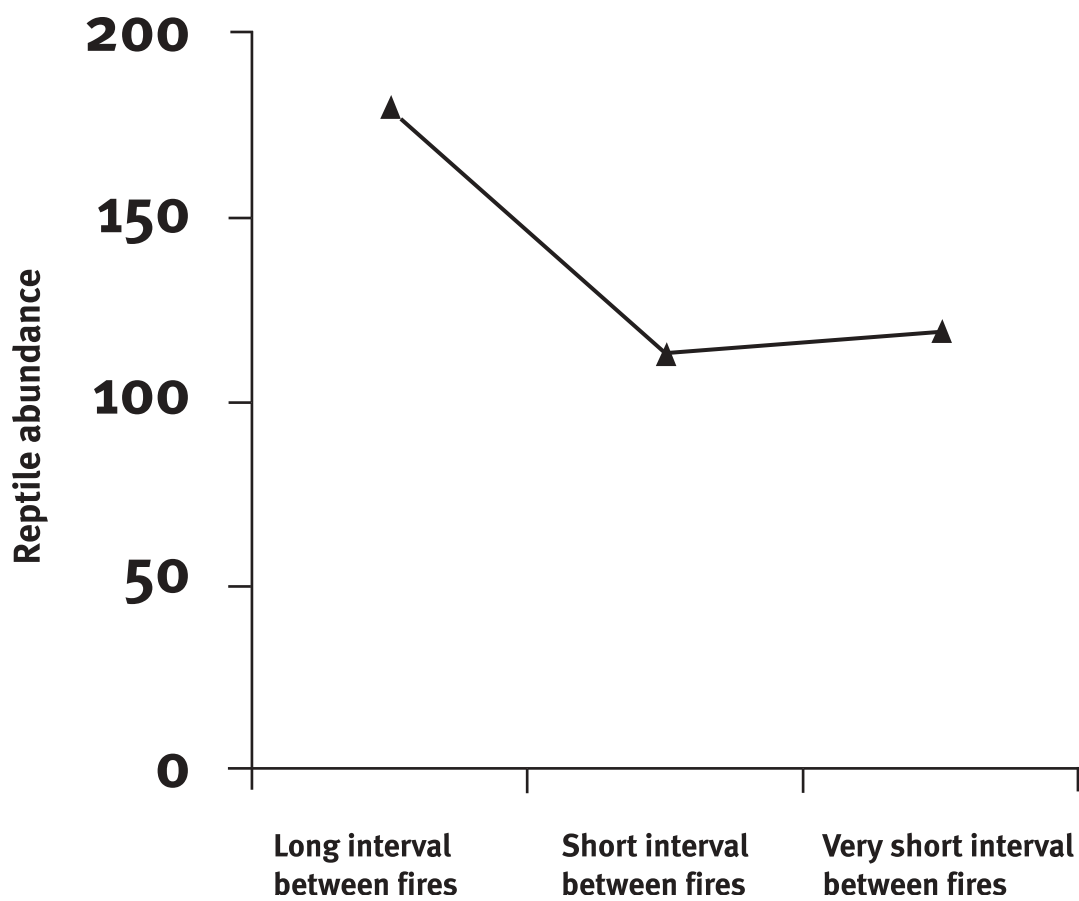
- application of 3 fire frequencies (every year, every 2-5 years, no burning) to blocks (313.6 ha, 422.5 ha, 295.8 ha, respectively) of *Corymbia citriodora* forest;
- standard plot based/pitfall trap surveys of reptiles and amphibians undertaken. Plots are searched on the basis of 30 minutes per hectare. Pitfall traps are standard buckets with drift fence; and
- a range of forest structural attributes is collected. In particular, percentage cover of bare ground, fine litter, coarse litter, logs, grasses/herbs, shrubs, stumps and trees are estimated in small (manageable) plots and related to reptile and amphibian community structure.

Outcomes of monitoring:

- reptile species richness, diversity and abundance are highest in the long unburnt plot;
- reptile species and abundance are positively correlated with the amount of fallen woody debris, which is greater where burning is absent; and
- amphibians do not show trends in relation to time since burning, but to rainfall.

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4. The effects of timber harvesting and fire on *Acacia perangusta*—(Jodi Rees)

Key objectives:

- determine the response of *Acacia perangusta* (listed as vulnerable under the Queensland Nature Conservation Act 1992) to disturbances associated with timber harvesting operations;
- utilise the results of this study to evaluate and refine management prescriptions to allow timber harvesting activities without compromising conservation of this species; and
- apply these prescriptions to other Acacias with similar life histories.

Monitoring techniques:

- plots (100 m² or 200 m²) in four classes of disturbance in eucalypt forest with *A. perangusta* present. Disturbance classes were: a) cleared, b) harvesting debris from selective harvesting present, c) minimal harvesting disturbance, and d) no harvesting disturbance with cattle exclusion. Additional experimental fire treatment imposed on disturbance types b and c. Three replicates of each disturbance class, with a total of 12 plots;
- *A. perangusta* adults and seedlings within these plots tagged and monitored. Measurements repeated every 3–6 months, including growth, health, reproduction, damage, and grazing;
- pre- and post-burn fine fuel measured using a 3-rank technique, and *A. perangusta* seedling germination depth recorded post-burn; and
- qualitative assessment of changes to vegetation structure and composition within the plots.

Outcomes of monitoring:

- fire produced high levels of mortality in *A. perangusta*, identifying it as a fire-sensitive, thin-barked species that is dependent on seed for persistence;
- cooler fires (without harvesting debris) were not as effective as hotter fires (with harvesting debris) at promoting its regeneration. Cooler fires killed mature plants without stimulating seed germination; and
- total protection of *A. perangusta* from disturbance could lead to local extinction.

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Monitoring *A. perangusta* within disturbance class b



A. perangusta adults were measured every 3-6 months



Measuring *A. perangusta* seedling post-burn

Section 5

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Section 6

Appendix

Estimating Overall Fuel Hazard for Forest Fuels (accompanies Overall Fuel Hazard Guide on p.32)

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For the purposes of assessing the Overall Fuel Hazard of a site, we need to consider the component parts which make up this Overall, these being:

Overall Fuel Hazard = f (Bark Hazard + Elevated Fuel Hazard + Surface Fine Fuel Hazard)

Why do we need to assess **bark** and **elevated fuel hazards** ?

Bark and elevated fuels allow forest fires to develop **vertically**

- they are principally responsible for:

- * increased **spotting**
- * increased **rates of spread**

Vertical development of fires is the main reason for:

- * first attack failure
- * suppression difficulties generally
- * crown fire development

A. Assessing Bark Fuel Hazard

Use the Overall Fuel Hazard Guide (McCarthy, Tolhurst and Chatto, 1998) to derive the Bark Hazard rating for the site. Rating is based on a series of Reference Photographs with an accompanying text. You must read the text as well as looking at the photographs. The following descriptive notes can be used if you do not have a copy of the Overall Fuel Hazard Guide.

Description of bark hazard

Low bark hazard

No bark present that could contribute to fire behaviour.

Moderate bark hazard

Very little bark is available to allow spotting to occur. Fires with a flame height of 0.5m will not “climb” these trees, and so spotting generally does not cause a problem.

Fibrous or Stringybarks	Platy and Subfibrous barks	Smooth or Gum barks
Bark tightly held › 90% of bole charred	Very tight bark e.g. ironbarks, boxes	No long ribbons of bark e.g. Red Gum, Yellow Gum, Snow Gum, Swamp Gum

High bark hazard

A limited amount of bark is available to cause spotting. Fires with a flame height of 0.5m will “climb” some of these trees and cause sporadic spotting.

Fibrous or Stringybarks	Platy and Subfibrous barks	Smooth or Gum barks
Few pieces of bark loosely held 50 to 90% of bole charred	Tight bark, long unburnt e.g. boxes, peppermints, bloodwoods	Long ribbons of bark, but smooth trunk e.g. Manna Gum, Candlebark

Very High bark hazard

Significant amounts of bark are available to cause spotting. Fires with a flame height of 0.5m will “climb” most of these trees and cause significant spotting.

Fibrous or Stringybarks	Platy and Subfibrous barks	Smooth or Gum barks
Significant amounts of bark loosely held 10 to 50% of bole charred Little or no charring above 1 m	Loose bark e.g. Southern Mahogany, Gippsland Grey Box, Silvertop	Long ribbons of bark to ground level e.g. Rough-barked Manna Gum, mallee species

Extreme bark hazard

Huge amounts of bark are available to cause spotting. Fires with a flame height of 0.5m will “climb” virtually all these trees, and the bark sustains the flames easily, even when there is little heating from below. Strong updrafts during almost any fire are likely to dislodge numerous “firebrands”.

Fibrous or Stringybarks	Platy and Subfibrous barks	Smooth or Gum barks
Outer bark weakly attached, bark easily dislodged ‹ 10% of bole charred e.g. Alpine Ash	Does not occur.	Does not occur.

B. Assessing Elevated Fuel Hazard

Use the Overall Fuel Hazard Guide (McCarthy, Tolhurst and Chatto, 1998) to derive an Elevated Fuel Hazard rating for the site. Again rating is based on a series of Reference Photographs with an accompanying text, and again you must read the text as well as looking at the photographs. If a copy of the Overall Fuel Hazard Guide is not available, the following descriptive notes can be used.

Description of elevated fuel hazard levels:

Low elevated fuel hazard

“Easy to walk through in any direction.”

Elevated fuel essentially absent.

Moderate elevated fuel hazard

“Easy to walk through, but vegetation does brush against legs occasionally.”

Elevated fuels add very little to the flame height or rate of spread of a fire, except at extreme levels of fire danger. The overall fuel hazard of the site depends almost entirely on the bark and surface fine fuels, except at extreme levels of fire danger.

This level is characterised by vegetation such as:

- sparse understorey vegetation;
- bracken and heath or shrubs that are re-establishing after a fire.

The elevated fuels generally have the following characteristics:

- elevated material is sparse/dispersed or arranged so that it does not sustain flames readily;
- dead material is virtually absent.

High elevated fuel hazard

“Moderately easy to walk through, but brush against or step over vegetation most of the time.”

Elevated fuels cause some patchy increases in the flame height and/or rate of spread of a fire.

The overall fuel hazard rating of the site is dominated by the bark and surface fuels, but the elevated fuels add to the fire behaviour, especially at Very High and Extreme levels of fire danger.

This level is characterised by vegetation such as:

- Bracken which has moderate density and age;
- Wire-grass which contains a low proportion of dead material or which is less than 0.5m high;
- grass which is less than about 0.3m high;
- shrubs with moderate density and moderate flammability of live foliage (e.g. *Cassinia* spp., *Goodenia* spp.);
- tall shrubs (e.g. at least 5 m high) with not much fine fuel for the first few metres above the ground (e.g. *Pomaderris* spp., *Bedfordia* spp.);
- broombush (*Melaleuca uncinata*).

The elevated fuels generally have the following characteristics:

- moderately dense;
- the proportion of dead material is 0-20% (by dry weight);
- if tall (e.g. at least 5m), then there is not much fine fuel for at least the first 2-4m above the ground.

Very High elevated fuel hazard

“Difficult to walk through. Need to carefully select path and step high.”

Elevated fuels mostly dictate the flame height and rate of spread of a fire.

Elevated fuels are a dominant part of the overall fuel hazard rating of the site. Surface fuels are less important. Fires may even spread when the surface fuels are wet. The additional presence of taller shrubs (e.g. banksias, hakeas, wattles) may further enhance the hazard.

This level is characterised by vegetation such as:

- heath which contains 20-30% dead material; bracken which contains 20-30% dead material and which is dense enough to suspend other materials such as eucalypt bark;
- wire-grass of which a substantial proportion is 0.5-1m high and which is dense enough to suspend eucalypt leaves and other fine fuel above the ground;
- shrub understoreys that are dense, contain 20-30% dead material and which are at least 1m high;
- grasses and annuals which are dense, 1m or more high and which are or will be at least 80% cured;
- *Triodia* sp. which is moderately dense.

The elevated fuels generally have the following characteristics:

- the **density** and **continuity (vertical and horizontal)** are **high**;
- the proportion of **dead material is 20-30%**;
- the general height of the vegetation is at least **0.5m and up to 1m**;
- the fuel particles are mostly less than **2mm thick**.

Extreme elevated fuel hazard

“Very difficult to see where you are going. Need to use arms to push through vegetation.”

At this level, elevated fuels almost entirely determine the flame height and rate of spread of a fire.

The Overall fuel hazard rating of the site is **Extreme** irrespective of the bark or surface fuels.

This level is characterised by vegetation such as:

- tea-tree, melaleuca or heath that is at least 2-3m high and where very fine fuels are present from top to bottom of the vegetation;
- wire-grass that is dense and at least 2-3m high.

The elevated fuels generally have the following characteristics:

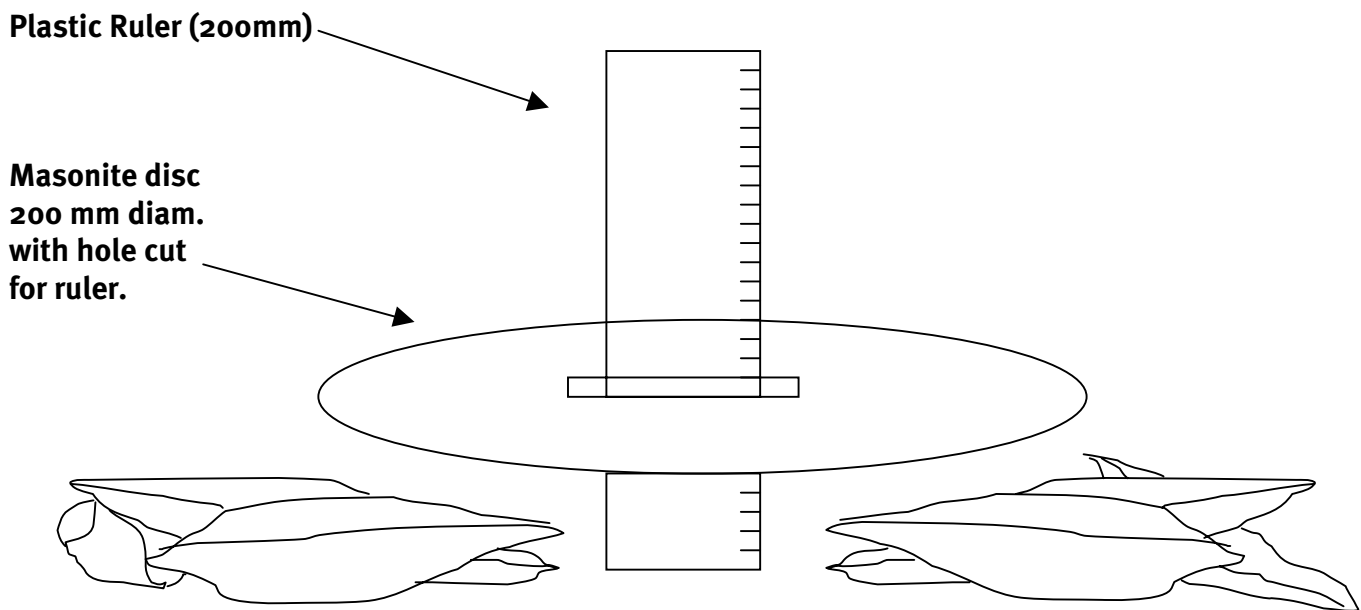
- vegetation is **tall (at least 2-3m)**, dense and continuous from top to bottom;
- large amounts of leaves, twigs and other fuel particles with maximum **thickness less than 2mm** are distributed from ground level to the top of the vegetation;
- proportion of **dead material is 30-50% (or greater)**;
- flammability of live foliage is high;
- the weight of living and dead elevated fine fuel is high (greater than about 10 t/ha).

C. Assessing Surface Fine Fuel Hazard

In the past surface fine fuel hazard was generally thought to be related closely to fuel load – i.e. the amount (in tonnes per hectare) of leaves, twigs, fallen bark and other dry vegetative material less than 6mm in thickness. A recent study in the coastal and foothill forests in East Gippsland indicates that the **height of the litter bed** is a better indicator of potential fire behaviour and therefore can be used as a **practical indicator of surface fine fuel hazard**.

This study has found that, at FDIs up to 10, **litter bed height is better correlated with forward rate of spread and flame height than is litter load.** A further advantage of using litter bed height to assess surface fine fuel hazard is that it is much simpler and quicker to measure than litter load.

Litter bed height can be measured in the field using a simple depth gauge as follows:



To use this gauge the following procedure is applied:

1. With your finger make a hole in the litter bed just wide enough for the end of the ruler to fit through and rest on the mineral soil below;
2. Holding ruler and disc together, place the zero end of the ruler through the litter bed so that it just rests on the mineral soil;
3. Making sure there are no obviously large sticks or stones underneath the disc, press the disc down with a light pressure using the fingertips - enough pressure "to hold a tennis ball underwater" (K. Tolhurst);
4. Read the ruler on top of the disc. This will be the reading of litter bed height in millimetres. Note that the extra space on the end of the ruler will be compensated for by the thickness of the disc.

To conduct litter bed height measurements **the litter should be dry so that leaf curl is at a maximum**. Wet litter sits down much flatter and could give an underestimate of the height.

A minimum of five measurements should be taken at each litter sample point, and this should be repeated about ten times at regular intervals across or around the burning block to gain a representative average of the prevailing litter bed height.

Once an average litter height has been ascertained, the following table, Appendix Table 1, can be used to relate this to both a Hazard rating and also an equivalent litter load.

Appendix Table 1 Surface Fine Fuel Hazard Rating System based on Litter bed height

Surface Fine Fuel Hazard Rating	<i>Low</i>	<i>Moderate</i>	<i>High</i>	<i>Very High</i>	<i>Extreme</i>
Litter bed height (mm)	< 15	15-25	25-35	35-50	50 >
Equivalent Litter Load (t/ha)	< 4	4-8	8-12	12-20	20+

Near Surface Fuels

If the site has high cover values of near surface fuels – i.e. grass tussocks, dead bracken, low shrubs or low wiregrass up to 0.5 metres high – then you should assign the next higher fine fuel hazard rating to it than would normally have been the case for that litter bed height. For example, a site with 30mm of litter bed height, but with the site covered by grass tussocks with cover values of 40% or greater, would go into the **Very High** class rather than the **High** class.

This surface fine fuel hazard rating can then be used, along with a hazard rating for the other two components of the complete fuel complex, Bark and Elevated Fuel, to derive an Overall fuel hazard rating for the site. The tables to do this are found on Page 28 of the Overall Fuel Hazard Guide (McCarthy, Tolhurst and Chatto, 1998). It is repeated below in Appendix Tables 2.1, 2.2, and 2.3.

D. Assessing the Overall Fuel Hazard for a Site

Overall Fuel Hazard for a site is derived by combining the assessed levels of Bark Hazard, Elevated Fuel Hazard, and Surface Fine Fuel Hazard, using Appendix Tables 2.1, 2.2, 2.3, below.

Appendix Table 2.1 Overall Fuel Hazard for Bark Level : *Low, Moderate*

		Surface Fine Fuel Level				
		L	M	H	VH	E
Elevated Fuel Level	L	L	M	H	H	H
	M	L	M	H	H	H
	H	L	M	H	VH	VH
	VH	VH	VH	VH	VH	VH
	E	E	E	E	E	E

Appendix Table 2.2 Overall Fuel Hazard for Bark Level : *High*

		Surface Fine Fuel Level				
		L	M	H	VH	E
Elevated Fuel Level	L	L	M	H	H	H
	M	L	M	H	H	H
	H	L	H	H	VH	VH
	VH	VH	VH	VH	E	E
	E	E	E	E	E	E

Appendix Table 2.3 Overall Fuel Hazard for Bark Level : *Very High|Extreme*

		Surface Fine Fuel Level				
		L	M	H	VH	E
Elevated Fuel Level	L	M	VH	VH	VH	E
	M	M	VH	VH	E	E
	H	M	VH	E	E	E
	VH	VH	E	E	E	E
	E	E	E	E	E	E

E. Overall Fuel Hazard Levels for each Fuel Management (Priority) Zone

Fuel Management (Priority) Zones should be kept *at or below* the following Overall Fuel Hazard levels so they provide optimum levels of both first attack success probability, and also wildfire controllability:

Fuel Management (Priority) Zone 1 - **Moderate**

Fuel Management (Priority) Zone 2 - **High**

Fuel Management (Priority) Zone 3 - **High** on 50% of the area

e.g. for **Moderate (Overall)** e.g. for **High (Overall)**

surface ff	Moderate	surface ff	High
bark	Moderate	bark	High
elevated	High	elevated	High

Summary Overall Fuel Hazard Important Points

1. Overall fuel hazard is a function of

Bark Hazard + Elevated (Shrub) Fuel Hazard) + Surface Fine Fuel Hazard

2. **Bark** and **elevated** fuels are those principally responsible for **vertical development of fires**

first attack failure

general suppression difficulty

(surface fuel generally only important for continuity of flame front)

3. For all 3 components need to look at how they are likely to burn

amount of dead material/amount of live material

arrangement of fuel both horizontally and vertically

size of material <6mm most likely to **burn in flaming front of fire**

< 2mm both live and dead is the most combustible

4. Need to **look** and **think** when using Overall Fuel Hazard Guide or OFH Card.

Ask question "Would I want to be in this fuel type on a bad fire day?"

Is a prescribed burn or other fuel management needed for the FMZ or location to modify the fuel hazard.

