Flora monitoring protocols for planned burning: **a user's guide**

Fire and adaptive management

report no. 74

Jane Cawson, Land and Fire Management Division, DSE and
Annette Muir, Biodiversity and Ecosystem Services Division, DSE

September 2008

Published by the Victorian Government Department of Sustainability and Environment

Melbourne, September 2008. Reprinted in June 2009 with minor changes.

Authorised by the Victorian Government, 8 Nicholson Street, East Melbourne.

Printed by Stream Solutions

Printed on 100% Recycled paper

ISBN: 978-1-74208-230-1 (print); 978-1-74208-231-8 (online)

For more information contact the DSE Customer Service Centre 136 186

Cover photograph: Aaron Kennedy, Parks Victoria

Acknowledgements

Many people have worked toward the development of this monitoring protocol. We would like to thank all of these people, including those who used the methodologies and provided us with comments. We would especially like to thank the following people who were critical to our efforts:

- Andrew Wilson (DSE) for steering the project, and for his considerable involvement in developing the methods and extensive feedback on draft versions
- Francis Hines (DSE) for involvement in the pilot studies, feedback on draft versions and co-development of the fire severity assessment
- Gordon Friend, Laurance Ferns and Stephen Platt (DSE) for guidance throughout the project and feedback on the draft versions
- Stephen Henry (DSE) for instigation of the monitoring project and Liam Fogarty (DSE) for ongoing support and promotion of the protocols
- Graham Hepworth (University of Melbourne) who was contracted to provide detailed statistical advice
- Those who provided detailed feedback on the draft of the *User's guide* and *Rationale report*: David Cheal (Arthur Rylah Institute, DSE), Kevin Tolhurst (University of Melbourne), Doug Binns (State Forests, NSW), Cuong Tran (Griffith University, Qld), Rob Poore (DSE) and Marie Keatley (Parks Victoria)
- Those who assisted with the pilot trials and feedback on the methodology: Rob Poore (DSE), Matt Dell (Universal Ecology Services), Allen Trumbull-Ward (DSE), Deanna Marshall (DSE), Kane Weeks (PV), Kylie Stafford (PV), Dan Jamieson (PV), Aaron Kennedy (PV), Anna Chiczewski (DSE), Danielle Cotter (DSE), Tony Varcoe (PV) and Stephen Henry (DSE)
- The members of the Fire Ecology Scientific Reference Group for their advice on the methodology: Gordon Friend (DSE), David Cheal (DSE), David Parkes (DSE), Richard Loyn (DSE), Andrew Wilson (DSE), Kevin Tolhurst (University of Melbourne), Alan York (University of Melbourne), Mike Clarke (La Trobe University) and David Dunkerley (Monash University)
- Simone Blair (DSE) and Shannon Treloar (DSE) for assistance in publication of this report.

We would like to gratefully acknowledge the funding provided by the Attorney-General's Department as part of the Natural Disaster Mitigation Programme. Some initial funding for this project was also provided by the Natural Heritage Trust via the East Gippsland Catchment Management Authority.

Australian Government

Attorney-General's Department
Emergency Management Australia

Natural Heritage Trust

Helping Communities
Helping Australia

An Australian Government Initiative

Fire and adaptive management

Contents

Minister's foreword

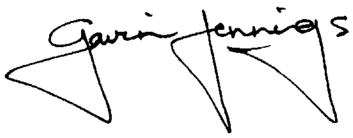
Victorians live in a fire-prone environment, with bushfires increasing in number, size and severity. Although fire is a natural part of the landscape, it may also pose risks to native plants and animals. The Government's planned burning program is intended to help protect the natural values of the bush as well as human lives and property.

The flora monitoring protocols are an important part of the toolkit to assist the planned burning program in Victorian parks and forests. These protocols have been developed by Victorian land and fire managers with the support of the Commonwealth Natural Disaster Mitigation Program. Other tools for planned burning, such as monitoring fauna habitat, will be incorporated in the near future.

Systematic use of the new flora monitoring protocols will help managers learn from past experiences and use this knowledge to improve future management practices. Adaptive management is a high priority in the Victorian Government's approach to managing land with fire and monitoring is a requirement of the Code of Practice for fire management on public land. The protocols are supported by a web-based database which will allow efficient feedback on burn planning.

Department of Sustainability and Environment and Parks Victoria staff will use the protocols to provide ecological input into planning burns and to measure changes in vegetation composition before and after fires. Also, the methods are designed so that anyone with an interest in fire management, such as volunteer groups and local government, can use them. There has been extensive engagement with the scientific community and with field practitioners. The roll-out of the monitoring protocols commenced in Spring 2007.

The protocols are particularly relevant given the conditions expected with climate change and could be adapted more widely in Australia. The application of flora monitoring in Victoria is a significant step towards integrating human and ecological needs in fire management. Partnerships between government agencies and the community will be strengthened as we learn from, and then improve, fire management practices.

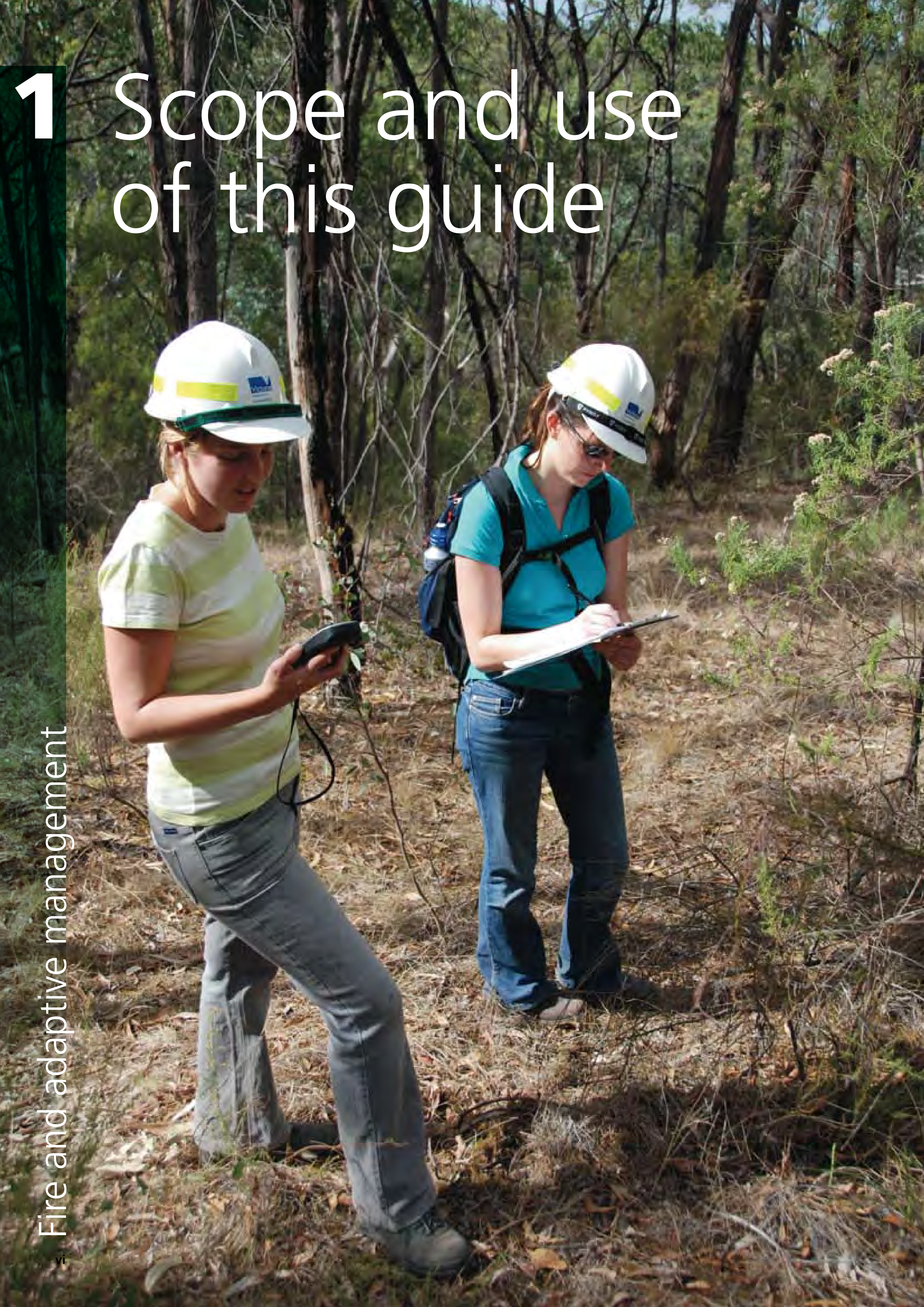


Gavin Jennings MLC
Minister for the Environment and Climate Change

1

Fire and adaptive management

1 Scope and use of this guide



1. Scope and use of this guide

1.1 Introduction

Managers of public lands and natural resources need to be good at predicting, monitoring, learning and adapting – as well as planning and doing. Those activities, as Figure 1 illustrates, are the core elements of 'adaptive management'.

Adaptive management is a framework for managing natural resources where gaps in knowledge are recognised and addressed in a continuous cycle. The cycle helps managers learn from past experiences and use this new knowledge to improve future management practices. The adaptive management framework underlies this *User's guide*, with flora being the natural resource of interest.

This guide touches on the 'learn' and 'review' elements of adaptive management, but the main emphasis is on 'monitor'. Monitoring is the collection of repeated observations. This guide introduces several field-assessment types for flora that, if undertaken over time and across the landscape, can be used to evaluate changes in condition and progress towards management objectives.

The aims of this guide are two-fold:

1. to guide managers as they plan, implement and draw conclusions from their flora monitoring programs
2. to provide supporting materials for field assessors.

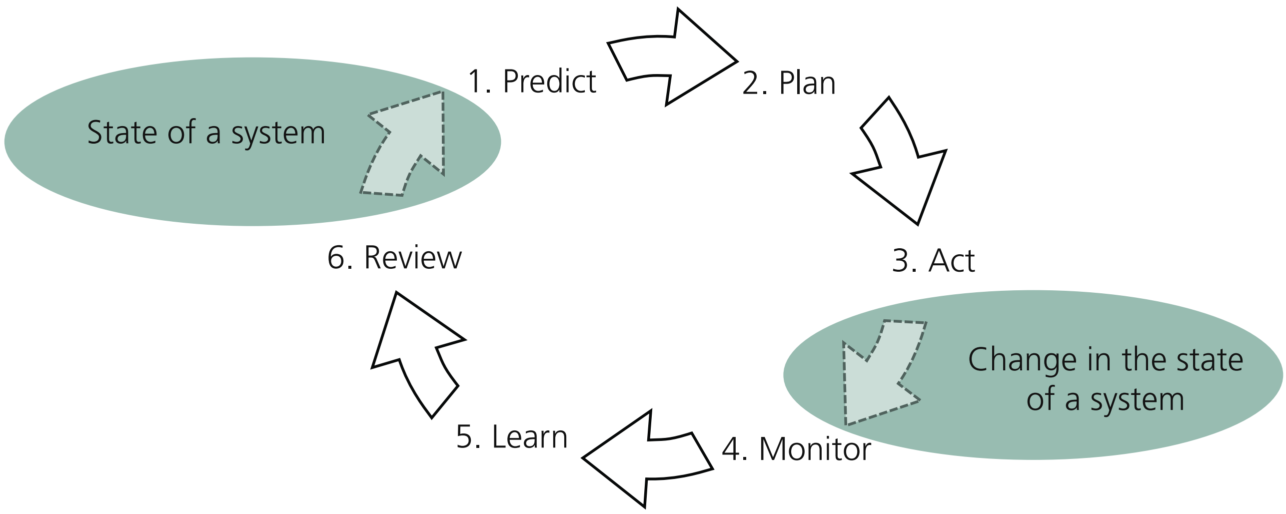


Figure 1: An adaptive management cycle. This cycle shows the actions required to achieve adaptive management.[1] To begin with there is a system and it is in a particular state (e.g. a forest ecosystem). We **predict** the outcomes of various management options on the system. We base these predictions on our current understanding of the system. Then we use our predictions to select and **plan** for a particular management action (other influencing factors must also be considered). We **act** by carrying out the planned management action. This may lead to a change in the state of a system (e.g. from mature vegetation to juvenile vegetation). Afterwards we **monitor** these changes to the state of the system and then learn by interpreting the monitoring data and gaining knowledge from this interpretation. **Review** is about revisiting our understanding of the system to check for accuracy and refine if this is required.

1 'No action' is a management action in itself and may lead to a change in the ecosystem. Also, variables other than the management action, such as climate change, may be acting on the system at the same time, causing it to change independently of management.

The structure of the guide reflects these dual objectives. For managers there is detailed information about each assessment type. For field assessors there are datasheets with summaries of the methods on the reverse side.

The guide begins by introducing general concepts that are relevant to all assessment types. Then it describes the individual assessment types in stand-alone chapters. The five standard and agreed methods for monitoring flora and the effects of planned burning are described not only in terms of the technical details about the methodology, but also in terms of how to use the data to learn and then review land management models. A related report, Flora monitoring protocols for planned burning: a rationale report (DSE 2008) describes the thinking and choices that underlie the methods this guide describes.

1.2 Context

The Department of Sustainability and Environment (DSE) and Parks Victoria have been working for several years to develop an integrated approach to fire management on public land to achieve both asset protection and ecological objectives. This guide for flora monitoring is another step towards achieving that goal.

The *Code of practice for fire management on public land: revision 1* (DSE 2006) clearly states that monitoring should be included in Fire Management Plans and it should be done using 'soundly based sampling on an ongoing basis' to measure the effects of burning on fuel levels, flora, fauna and other values. The methods described in this *User's guide* will help meet those requirements for flora, and support existing processes for planning ecological burns.

1.3 Limitations

Although this guide is the result of extensive consultation and field trials, the methods presented will continue to evolve. We will incorporate improvements as further knowledge is gained and these methods are used more extensively.[2]

The limitations of monitoring must be acknowledged when making conclusions about the effects of planned burns (or other causal factors) on flora. Monitoring can demonstrate the size of a change and these changes can be correlated with a potential cause. However, a correlation between a change to the flora and a potential causal factor such as a planned burn does not mean that the burn caused that change. Unfortunately monitoring data provides limited capability to determine a cause, so your conclusions should be cautious. This is reiterated and explained further throughout the guide.

The assessment types this guide describes do not suit monitoring rare and threatened species. DSE's over-arching fire ecology principles advocate managing ecosystems as a whole, by using the maximum and minimum fire intervals defined by key fire response species, rather than targeting rare and threatened species (Fire Ecology Working Group, 2004). Although an assessment may detect rare or threatened species, generally the number of plots will be too few to generate meaningful results regarding their status.

The assessment types are designed to monitor the effects of planned burning rather than bushfire. However, you can use the methods after a bushfire if existing flora monitoring plots are burnt.

DSE is developing methods for monitoring other factors such as fuel hazards, fauna habitat, fire severity and fire behaviour. Consideration of these other factors is an important part of management planning. Results of flora monitoring provide only a partial picture of the changes that occur in an area after burning. You should keep this in mind when using the outcomes of flora monitoring to inform management decisions.

2 Care must be taken to maintain consistency in the data if improvements are made to the methods. Inconsistent methods may make the data incompatible over time, which would interrupt the time sequence of data.

2

Fire and adaptive management

2 Steps for monitoring

2

2. Steps for monitoring

Careful planning helps a monitoring program to be effective. Planning will define objectives and clarify methods. Figure 2 outlines the key steps you would use to plan and implement a monitoring program and then use the data. It also shows the way these steps fit within the **monitor**, **learn** and **review** steps of the adaptive management cycle.

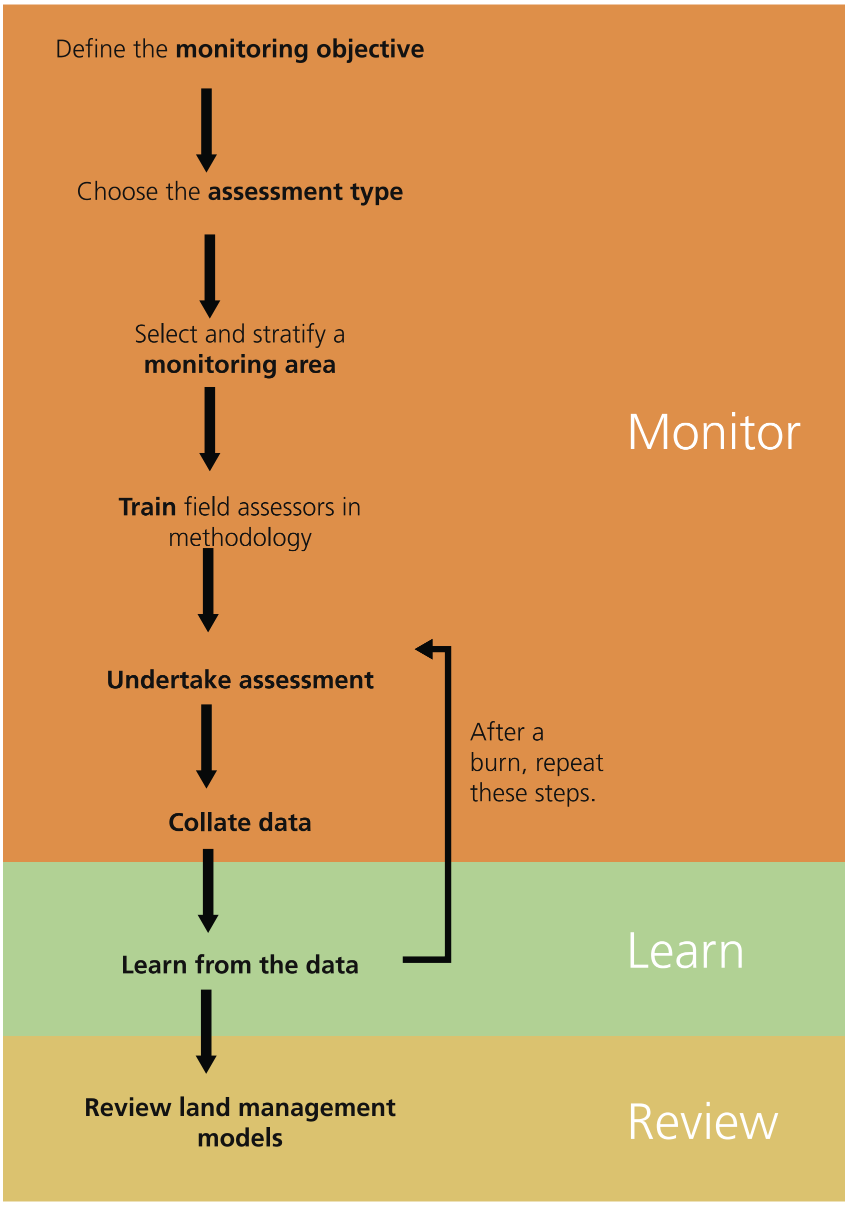
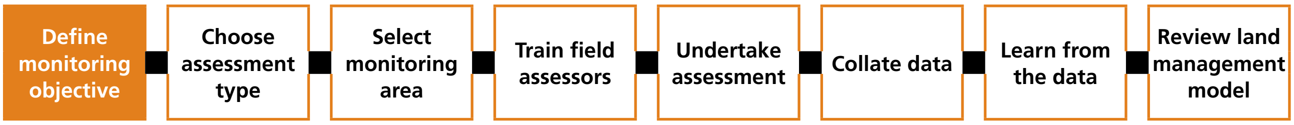


Figure 2: Effective monitoring involves the steps in this flowchart. Colours show how each step links within the 'monitor,' 'learn' and 'review' activities from the adaptive management cycle.

2.1 Define the monitoring objective



The first step in any monitoring program is to define your monitoring objective. A monitoring objective states what you would like to achieve through monitoring. This section explains how to develop a monitoring objective and then introduces the monitoring objectives that form the basis of this guide.

2.1.1 The role of land management models in fire planning and monitoring

A land management model is essential for defining monitoring objectives.[3] It can be used to **predict** the outcomes of various management actions (Figure 1). Land managers can then use these predictions to make decisions. Monitoring data can be used to test and **review** land management models and therefore the relationship between the monitoring objectives and a land management model should be close.

One such land management model involves using knowledge about flora vital attributes[4] to identify the minimum and maximum fire intervals for an Ecological Vegetation Class (EVC). The remainder of this User's guide refers to that model as the Flora Vital Attributes Model. Noble and Slatyer (1980; 1981) developed this model and DSE and Parks Victoria have since adopted it as a tool to guide ecological burn planning in Victoria (Tolhurst and Friend 2001; Fire Ecology Working Group, 2004).

Land managers can use the flora vital attributes model to predict the outcomes of a planned burn. For example, the model may predict that certain species will become locally extinct[5] if fire is too frequent or too infrequent.

Key fire response species are a central feature of the flora vital attributes model. They are 'species within an EVC whose vital attributes indicate that they are vulnerable to either a regime of frequent fires or to long periods of fire exclusion' (Fire Ecology Working Group 2004). The model assumes that if the fire frequency fits within the 'tolerable fire interval'[6] defined by the key fire response species then all species of vascular flora within the area should survive. This assumption is largely untested.

Land managers often use the flora vital attributes model to plan ecological burns (Fire Ecology Working Group 2004). An underlying management objective for ecological burning is to ensure that 'environmental values including the ecological health of the state's indigenous flora and fauna are protected and promoted, as far as is practicable, from the deleterious effects of successive bushfires, inappropriate fire regimes, and fire management activities' (DSE 2006). Ecological burn planning strives to meet this management objective by creating a mosaic of age-classes across the landscape, with the majority of the vegetation being burnt within the tolerable fire intervals defined by the flora vital attributes. As part of this process Tolhurst and Friend (2001) recommend that field assessments are undertaken to check that the life-stages of the flora, which are predicted by the model, actually occur at the potential burn site.

The flora vital attributes model has limitations, despite it being a useful tool for ecological burn planning. Those limitations mostly reflect knowledge gaps in our understanding of flora responses to fire – gaps that monitoring can begin to address:

- Firstly, we don't have information on vital attributes for many flora species in our records. This flags a need for more baseline data collection about flora vital attributes.
- Secondly, we lack knowledge about the effects of other attributes of the fire regime (fire intensity, extent and season) on flora vital attributes – the model deals mostly with fire frequency (Noble and Slatyer 1980). The same species may respond differently (i.e. have different vital attributes) depending on those other attributes of the fire regime. For example, the regeneration response for a species in a forest may be vegetative after a surface fire or seed-based after a crown fire (Tolhurst and Friend 2001). Vital attributes may also vary depending on the impact of other non-fire influences such as grazing or climate (Noble and Slatyer 1980). Although the current model largely ignores these influences, monitoring could produce more knowledge about them.

---

3 In this context 'models' are simplified representations or descriptions of how fire interacts with flora. They incorporate our current knowledge in ways that make it easier to use the information to make predictions about the effects of fire.

4 Vital attributes are the key life-history features that determine how a species lives and reproduces. With respect to fire, these attributes govern how a species responds to fire and/or persists within a particular fire regime (Fire Ecology Working Group, 2004).

5 If a species is 'locally extinct' it means that the local site has lost the population that existed there, either through senescence or a disturbance; and that there is no seed of the species at the site to allow regeneration. The species may still occur in other nearby areas.

6 The tolerable fire interval is defined here as the fire interval that suits the persistence of the vegetation type. It does not refer to other aspects of tolerance, such as human acceptance.

- Finally the model does not predict how fire will affect the relative dominance of a species (Noble and Slatyer 1980) – the model provides only for the prediction of species presence or absence. Predicting relative dominance could be important because it may be related to habitat structure or the ability of a species to persist. Other fire ecology models provide general guidance about the relative dominance of species following fire and how that changes over time (Whelan et al. 2002; Figure 3). The results from monitoring may help to add numbers to these general trend lines and could lead to the eventual incorporation of this kind of information into the flora vital attributes dataset.

2.1.2 Monitoring objectives for this guide

The monitoring objectives and methods for this guide address the limitations of the flora vital attributes model. Assessment types aim to check and improve our knowledge of the response of flora species to fire (flora vital attributes), assess the effectiveness of management actions in achieving their objectives and test the model in relation to the effectiveness of using key fire response species as indicators for all species.

The assessments can collect information about the flora species' response to different fire severities and seasons in addition to fire frequency. Information can be collected about non-fire factors as well that may affect plant responses to fire such as climate or grazing. Using this information may lead to a better understanding of how vital attributes change as these other factors change. Some assessments also collect information about species abundance, which may better inform our understanding about changes to relative abundances after fire.

The monitoring objectives that this guide uses are:

- to obtain information on flora vital attributes for those species that lack such data
- to predict whether the vegetation in an area is likely to respond positively to burning at a particular time
- to estimate the size of change in the presence and abundance of indicator species after a fire
- to determine the extent to which key fire response species can be used as indicators for all species following fire
- to estimate the size of change in species composition following fire.

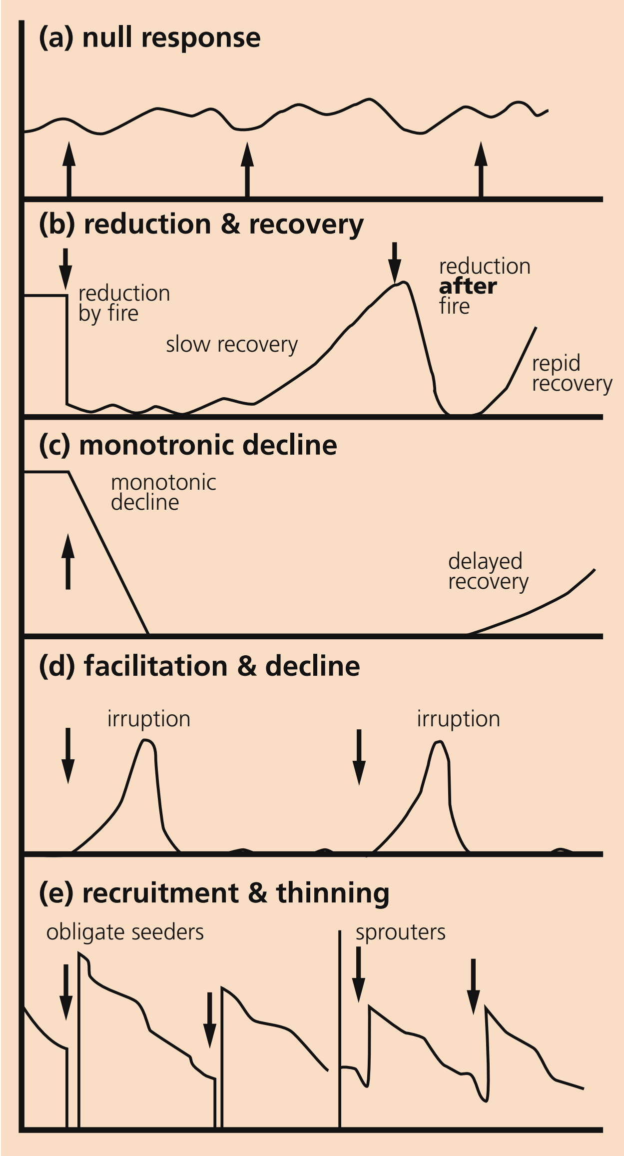


Figure 3: Schematic diagram showing the range of fire response patterns that populations may exhibit over time (Whelan *et al.* 2002). (a) Null response – population remains unchanged in response to a fire; (b) Reduction and recovery – population size declines soon after fire and remains low for some period followed by recovery (fast versus slow recovery); (c) Monotonic decline in population size, leading to local extinction, perhaps with eventual recovery; (d) Facilitation and decline – population size increases following fire and then declines; (e) Recruitment and thinning – population size dramatically decreases immediately after fire, then rapidly increases, followed by gradual decline, for obligate seeders (left) and resprouters (right).

2.1.3 Choosing a monitoring objective

To choose the most suitable monitoring objective:

1. Read through the descriptions in Table 1 to determine which objective best meets your needs. The second column in the table describes how a particular objective should help management activities. Those statements are useful for determining the best way to interpret the data (see Table 4).
2. Consider the method associated with your chosen objective to determine whether or not you have the background flora data, available skills and time to undertake this assessment. The methods you choose should not only meet your needs but also be achievable (see Section 2.2).

Table 1: Flora monitoring objectives and how they help management activities

Monitoring objective	Role in helping management activities
To obtain information on flora vital attributes for those species which lack such data.	Improve our knowledge of the vital attributes of particular flora species in relation to fire frequency and hence refine the tolerable fire intervals for different vegetation types. Contribute to a better understanding of the effects of other factors on vital attributes e.g. fire season, fire severity, drought or grazing.
To predict whether the vegetation in an area is likely to respond positively to burning at a particular time.	Assist with the selection of burn areas (by verifying the model's prediction about the timing of life-stages for key fire response species).
To estimate the size of change in the presence and abundance of indicator species following fire.	Assess the effectiveness of management actions in achieving their objectives at the local or landscape scale. Verify the model's predictions with regard to the response of key fire response species following fire. Contribute to a better understanding of the effects of other factors (e.g. fire season, fire severity, drought or grazing) on the timing of life-stages and relative dominance of the indicator species
To determine the extent to which key fire response species can be used as indicators for all species following fire.	Test the effectiveness of using key fire response species as surrogates for all species.
To estimate the size of change in species composition following fire.	Assess the effectiveness of management actions in achieving their objectives at the landscape scale. Contribute to a better understanding of the effects of other factors (e.g. fire season, fire severity, drought or grazing) on the timing of life-stages and the relative dominance of all species

2.2 Choose an assessment type

Define monitoring objective ■ **Choose assessment type** ■ Select monitoring area ■ Train field assessors ■ Undertake assessment ■ Collate data ■ Learn from the data ■ Review land management model

Each monitoring objective relates to an assessment type. This section introduces the assessment types and then describes them in terms of their baseline data, skill and time requirements. You should check that you can meet these requirements before starting an assessment.

2.2.1 Introducing the flora assessment types

Each monitoring objective is addressed by an assessment type. Figure 4 illustrates the relationship between the assessment types and monitoring objectives. There are four flora assessment types:

- **vital attributes assessment**
- **life-stage assessment for burn planning**
- **indicator-species assessment**
- **all-species assessment.**

Objective:	Assessment type:
To obtain information on flora vital attributes for those species which lack such data.	Vital attributes assessment
To predict whether the vegetation in an area is likely to respond positively to burning at a particular time.	Life-stage assessment for burn planning
To estimate the size of change to the presence and abundance of indicator species following fire.	Indicator-species assessment
To determine the extent to which key fire response species can be used as indicators for all species following fire.	All-species assessment
To estimate the size of change in species composition in following fire.	All-species assessment

Figure 4: Monitoring objectives and their associated assessment types.

2.2.2 Assessing factors that may influence the response of flora to burning

Each of the flora assessments requires the collection of data about both the flora in an area and the fire frequency, with the intention of correlating this data. You may also wish to collect data about additional factors that could influence the flora (potential causal factors). Those factors could be other attributes of the fire regime or something else altogether. Some examples are:

- fire severity
- fire season
- fire extent
- grazing
- climate e.g. extreme drought
- post-fire weed infestations
- cinnamon fungus
- erosion.

Section 2.3 tells you how to set up your monitoring area if you choose to investigate those additional factors and provides the datasheets for you to record information about them. Depending on the nature of the factor you are investigating, you may need to revisit the area at a different time to specifically assess it. Except for fire severity, this guide does not provide advice on how to undertake those additional assessments.

A fire severity assessment is included in this guide because it is essential for the indicator-species and all-species assessments. In areas where you have undertaken either of those flora assessments you should assess fire severity after the burn. Without assessing the fire severity, the value of the flora monitoring data diminishes because you don't reliably know whether the burn actually burnt a particular plot, or how severely.

Table 2 shows each of the assessment types in relation to:
- the target flora species
- potential causal factors that should always be investigated
- other factors that could be investigated depending on how you intend to use the data.

While it is useful to collect information about potential causal factors that may be influencing the flora, you should remember that you may not be able to prove causal relationships from your data. A correlation between a change to the flora and a potential causal factor such as the season of the burn does not mean that the season is the cause for that change – later sections of the guide will explain this in more detail.

Table 2: The assessment types in relation to the target flora species, potential causal factors always assessed and other potential causal factors that could be assessed.

Flora assessment type	Target flora species	Potential causal factors always being assessed.	Other potential causal factors to assess (optional)
Vital attribute assessment	All flora species	Fire frequency	Fire severity, season or extent, grazing, climate, weeds, cinnamon fungus. Erosion or another factor.
Life-stage assessment for burn planning	Key fire response species	Fire frequency	None until the flora vital attributes model accommodates those additional variables.
Indicator-species assessment	Indicator species (usually key fire response species)	Fire frequency Fire severity	Fire season or extent, grazing, climate, weeds, cinnamon fungus. Erosion or another factor.
All-species Assessment	All flora species	Fire frequency Fire severity	Fire season or extent, grazing, climate, weeds, cinnamon fungus. Erosion or another factor.

2.2.3 Checking the requirements for the assessment type

In Section 2.1 you will have identified the most suitable monitoring objective to meet your needs. Figure 3 shows the assessment type associated with this monitoring objective. Now you should check that you can meet the requirements for baseline data, skills and time for each assessment type. Table 3 describes those requirements.

If you find that one or more of those requirements will prevent you from undertaking your preferred assessment type then select a different monitoring objective and assessment type.

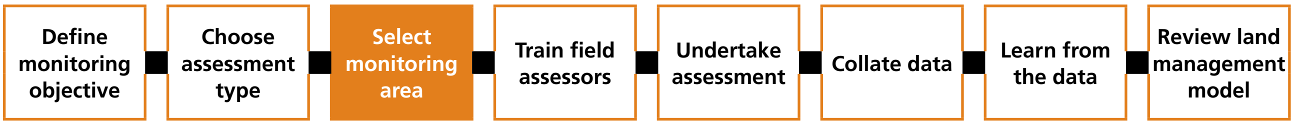
Table 3: Requirements for each flora assessment type.

Assessment type	Existing vegetation information	Skills available	Time commitment[7]
Vital attribute assessment	There is no requirement for existing data. However, the flora vital attribute database can help you to determine which species lack vital attribute data.[8]	At least one assessor should have plant identification skills.	Requires about half a day per monitoring area. Assessments are one-off, so you don't need to reassess the same area.
Life-stage assessment for burn planning	Reliable flora vital attribute data are required so that you can select the key fire response species.	At least one person should have a botanical background to select key fire response species and initially identify them in the field. Then anyone competent can do the assessments.	Requires about two hours per monitoring area (after you have chosen the key fire response species and if the area is quite small i.e. < 300 hectares). Assessments are one-off, so you don't need to reassess the same area.
Indicator-species assessment	If you are monitoring key fire response species then reliable flora vital attribute data are required so that you can select these species.	At least one person should have a botanical background to select key fire response species and initially identify the indicator species in the field. Then anyone competent can do the assessments.	Requires about a day per EVC within a monitoring area (after you have chosen your indicator species). This assumes you assess 20 plots. Monitoring areas must be reassessed several times over a ten-year period.
All-species assessment	There is no requirement for existing data.	At least one assessor should have plant identification skills.	Requires one day per EVC within a monitoring area. This assumes you assess three plots. Monitoring-areas must be reassessed several times over a ten-year period.

7 The time commitment is quite variable depending on the number of assessors, efficiency of the assessors, size and accessibility of the monitoring area, the vegetation type and the age of the vegetation.

8 The flora vital attributes database can be accessed through the DSE website. Search for 'flora vital attributes'.

2.3 Select and stratify a monitoring area



The third step in monitoring is to select a monitoring area and then identify sub-areas that you will assess individually. This section provides some general guidance about selecting and stratifying a monitoring area. Section 3 provides specific advice relating to each assessment type.

A monitoring area is an area of land where monitoring occurs. It usually coincides with an area where a planned burn is planned. To select and stratify a monitoring area you should undertake the following steps:

1. Generate a list of all potential monitoring areas. This will usually be a list of the planned burns in your local area.

2. Select your monitoring area using the specific criteria for the assessment type (described in Section 3) as well as the general criteria listed below. You should choose areas that meet as many criteria as possible.[9]
   - New or different fire management practices are planned for the area. There may be more opportunities for learning something new in these areas.
   - The Ecological Vegetation Class (EVC) is deemed to be a priority for monitoring (i.e. EVCs where a large number of hectares are being burnt relative to the total area of the EVC, the fire responses of the constituent species are poorly known or where the constituent species are considered sensitive to fire).
   - Fire and/or other disturbance histories are known for the area.
   - The remoteness of the area (and therefore the travel-time) is justified and achievable. For remote areas you should consider whether there is enough time to travel to the area and whether this time would be better spent monitoring more areas that are closer. The amount of new knowledge to be gained from assessing a remote area may justify the travel-time.

3. Identify the EVC within the monitoring area. If a monitoring area contains several different EVCs you may need to conduct several assessments (one for each EVC of interest).

   Dividing the area into sub-areas based on a variable (such as the EVC) is called stratification (see Figure 5).

   In this step you should stratify your area into EVC sub-areas and then decide which of these sub-areas you are interested in assessing. This stratification is necessary because the indicator species and key fire response species vary depending on the EVC.

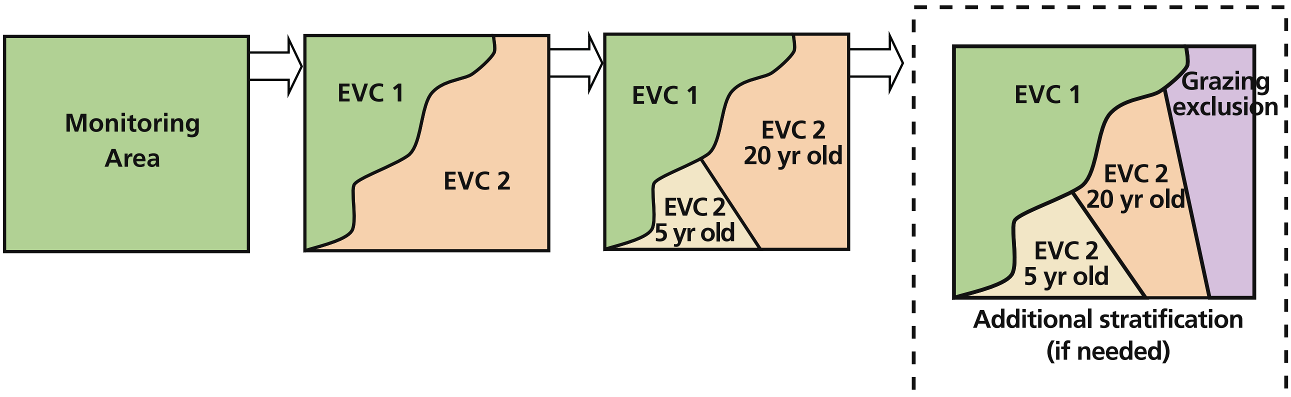


Figure 5: Stratification of a monitoring area by EVC, last-burnt year and grazing.

9 Those criteria are not as important for the life-stage assessment for burn planning. This assessment is designed for any area that is planned for burning.

4. Identify the number of years since the area was last burnt. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map.' You may need to do some field reconnaissance if the last-burnt records are inaccurate.

   In this step you should stratify your area into last-burnt sub-areas and then decide which of these sub-areas you want to assess. This stratification is necessary because the amount of time between fires affects the ability of flora species to regenerate following a fire and is fundamental to the flora vital attributes model.

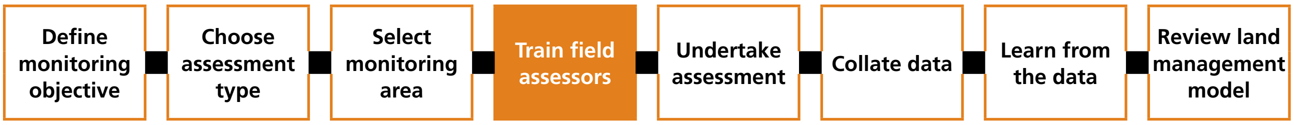
5. Decide if there are any other factors that you would like to consider (such as grazing, weeds, cinnamon fungus). If so, then you should stratify your monitoring in relation to those factors so that each assessment occurs in an area that is as uniform as possible.

   Sometimes you will want to consider another attribute of the fire regime such as fire severity which obviously cannot be stratified for prior to the burn. In these case the stratification will be done when you analyse the data. By assessing a larger number of plots throughout the entire area you can help make this post-burn stratification more effective.

6. Tally up the number of assessments that you require in your monitoring area based on the number of stratification units you identified (EVC, by year last burnt, by other factor). You should do an individual assessment in each stratification unit.

7. Confirm that you have sufficient resources to undertake this number of assessments (remember that you may need to reassess the same area several times). If you do not have enough resources then you should select a subset of the most important stratification units to assess.

2.4 Train field assessors



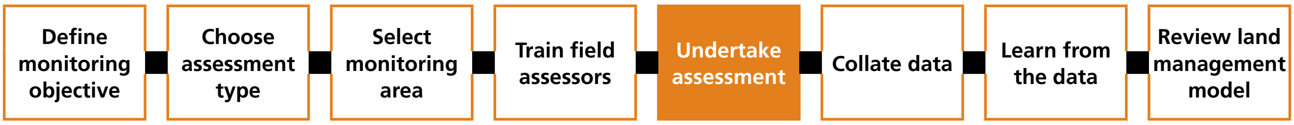
After you have done the preliminary planning for your monitoring project, you will need to train the field assessors to undertake the assessment. Topics to cover during the training are:

- the assessment methodology and how to fill out the datasheet. You can do this in the field by undertaking a series of practice plots.
- use of a Global Positioning System (GPS) to navigate to waypoints and mark them
- identification of key fire response species for the indicator species assessment where assessors may not have a botanical background. Assessors may need instruction on plant identification at the start of every assessment or group of similar assessments
- use of the Argus database for storing monitoring data
- use of safe and healthy work practices.

You can compare the data from individual assessors to make sure that the data they collect are consistent with the data from other assessors. To do this, ask each person to assess the same plots separately during the training.

You should record assessor names on the top of the datasheet and enter this into Argus. Retaining this information is important as it helps keep the assessors responsible for their data, helps future users of the data to track and filter the origins and credibility of data, and enables assessors to establish credibility for themselves as data collectors.

2.5 Undertake assessment



Before starting an assessment, ensure that you have the appropriate equipment and have complied with relevant health and safety procedures. Section 3 provides equipment lists, which vary depending on the assessment type.

Follow the directions in Section 3 to undertake an assessment.

If possible, keep track of how long it takes to measure a plot or a series of plots. You can use these times for resource planning in future monitoring programs.

Note: Care should be taken whenever working within forested areas. Trees and limbs may fall at any time. This risk is even greater in areas that have been recently affected by fire.

2.6 Collate data

Define monitoring objective	Choose assessment type	Select monitoring area	Train field assessors	Undertake assessment	**Collate data**	Learn from the data	Review land management model

Store all data in Argus, the fire monitoring database (see Box 1 for further details about Argus). This database is available over the internet to registered users at https://fireweb.dse.vic.gov.au/argus. You can become a registered user of the database by requesting access via the login page.

Use the following procedure for adding new data into the database:

1. Receive the raw data.
Assessors usually enter the data into the database. However, where this is not possible, the people who enter the data need to be familiar with the assessment method the assessors used. They should record in the database any deviations from the assessment methods in this User's guide.

2. Clarify the data.
While the data is still in paper form, the assessors should clarify any uncertain aspects of the data. This includes clarifying any unclear writing or shorthand, checking species names and ensuring the identification of any unknown species.

3. Set-up a 'monitoring area' within the database.
The person who enters the data must first define the 'monitoring area' in the database. A 'monitoring area' is a geographic area in which monitoring takes place.

4. Set-up groups of assessment points withing the database.
An assessment point grouping is a set of geographic points, or plots, at which monitoring takes place. Each assessment relates to a particular group of points. If the assessment occurs at the same points as those of an existing assessment in the database, then the data can be entered using that group of points.

However if any of the points differ, a group of points must first be created. The new group can reuse points from an existing group. For each plot enter the coordinates and relevant information.

5. Enter the data.
Select the assessment type and monitoring area and group of assessment points then add the new data for each plot.

6. Check the data that the person has entered.
Check that the process of entering the data has not introduced any errors. Then upgrade the status of your data from 'draft' to 'complete.' Checking is often more reliable if another person does it.

Box 1: **Introducing the philosophy underlying Argus**

What is Argus?

Argus is a database for recording fire monitoring data. The Department of Sustainability and Environment (DSE) manages it and is responsible for its development. Argus is available over the internet for registered users from both within DSE and outside of DSE.

What is the philosophy behind Argus?

1. Long-term, landscape usefulness
Monitoring data no longer needs to be lost and isolated in filing cabinets or spreadsheets.

Argus provides a central data repository. It makes data accessible to a wide range of users who can pool those data for multiple sites and over time to undertake broad-scale analysis.

2. Importance placed on the 'who,' 'how' and 'where,' not just the 'what'
Too often the useability and credibility of data diminishes because critical information about it becomes lost, especially about who collected the data, and about how, when and where they collected it.

Argus places as much emphasis on metadata as it does on the data itself. This means that Argus carefully stores and retains details about assessors, methodology, location and time, and keeps those details closely coupled with the actual data.

3. Lots of involvement
Rather than tightly restricting access and keeping out data that may be useful, Argus allows involvement from a broad range of people. To help achieve that aim DSE aspires to build future versions of Argus with new approaches to manage data quality, such as a scheme for assessor credibility and a process for rating the quality of data that others collect.

2.7 Learn from the data

Define monitoring objective	Choose assessment type	Select monitoring area	Train field assessors	Undertake assessment	Collate data	**Learn from the data**	Review land management model

Monitoring is useful only when someone learns from the data. So far this guide has been mostly concerned with the **monitor** step in the adaptive management cycle (Figure 1). This section discusses the **learn** step. Learning from the data is a two-step process:

1. analyse the data

2. interpret the outcomes of your data analysis.

This section provides some background information about these steps. Table 4 provides some detail about each step in relation to the monitoring objectives. Section 3 provides more detail in relation to individual assessment types.

2.7.1 Key principles of statistical data analysis

Usually we can't assess or measure every unit in a population (for example, all the plants in a burn area) because the effort would be too great. Therefore we don't know what the *true* value of the quantity or parameter of interest is (such as the average density for plants in an area).

Instead, we assess some units (a sample) and extrapolate from the results of that sample. We calculate an *estimate* of the *true* value. A major aspect of statistics is the derivation of appropriate estimates of population parameters from samples.

Another major concern of statistics is with uncertainty. Any estimate of a parameter has a degree of uncertainty due to variability within the population (i.e. the spread of values) and the size of the sample. Providing an estimate of a population parameter, such as average density, without a measure of the uncertainty associated with the estimate can be misleading. For example, if you are only presented with an estimated average value, such as 22 individuals, you cannot determine if all the plots had 22 individuals or if the number of individuals varied between plots from zero to fifty. Often this is an important distinction.

Estimating population parameters and quantifying the uncertainty of such estimates is fundamental to statistical analysis. It's important therefore to provide an indication of the degree of uncertainty when estimating an average.

There are many different ways of describing uncertainty. The simplest is the 'range.' The range is the largest value minus the smallest value in the sample. Another common quantity is the sample standard deviation. This can be easily calculated in Microsoft Excel. Confidence intervals can be derived from the sample standard deviation, the sample size and the sample mean. The 95% confidence interval is used throughout this guide.

A 95% confidence interval is a range of values for the true average. You should say that you are 95% confident that the *true* average falls somewhere within this range. A narrow confidence interval is preferable as it allows you to be more confident about the conclusions you draw from the data because you are more confident that your *estimated* value is close to the *true* value.

When you show an average value on a graph you should also show a measure of the precision such as the 95% confidence interval. When you quote an average value you should also state the confidence interval (e.g. 26 ± 11).

2.7.2 Selecting an appropriate analysis method

Section 3 provides some recommended analysis methods for each assessment type. These methods mostly involve summarising the data, which includes describing the variability within it. More specifically, for assessments comparing pre-burn and post-burn observations, the analysis involves estimating the difference between pre-burn and post-burn parameters (such as the difference in average density for a species) and providing some measure of the variability of that estimate (such as a confidence interval).

You should consider several factors when selecting the most appropriate analysis method for your data. Some of these factors are:

- Monitoring objective. The analysis method will vary depending on the question that you want to answer.
- Type of data. Different analysis methods are appropriate for different data types.
  1. Numerical data are numerical values such as counts of individuals or measurements on a continuous scale such as height in metres.
  2. Categorical data are qualitative groups or categories. Such data can be made up of two categories, i.e. binary data (for example, presence/absence data) or it can have more than two categories (for example, cover class data).
- Amount of data. The types of analysis that you can undertake and degree of confidence about the conclusions drawn will depend on the amount of data. Small data sets are unsuitable for many types of statistical analysis.
- Amount of experience in data analysis. The use of some analysis methods requires someone with a thorough understanding of statistics. This is especially true when you pool data across the landscape for broad-scale analysis. You may need to employ a statistician for this more complex analysis.

2.7.3 Analysis methods beyond the scope of this *User's guide*

The methods of data analysis described in Section 3 are suited to data from a single monitoring area or to comparisons between a few monitoring areas. This guide includes those methods because they are relatively simple and you can use them on small datasets. However, while these methods may provide useful insights and highlight major changes following fire, small sample sizes can have high uncertainty and thus low levels of confidence.

This limitation of small datasets is a major reason for developing a state-wide monitoring protocol with standard assessment methodologies. Over time it will be possible to pool data from different areas, resulting in a larger dataset. This larger dataset will be more representative of the broader landscape and enable broader monitoring objectives to be addressed with more confidence.

As the dataset becomes larger, a greater array of analysis methods can be used with confidence. For numerical data, another method for investigating the statistical significance of differences between pre-burn and post-burn data is to use analysis of variance (ANOVA). Methods of analysing categorical data include chi-squared tests, logistic regression and ordinal logistic regression. These methods are beyond the scope of this guide. Generally these methods require someone with a thorough understanding of statistics.

2.7.4 Interpreting the outcomes of your data analysis

After you have analysed your data you should interpret the outcomes of your analysis in relation to the objectives for the assessment type. Table 4 gives a brief summary of how to analyse and then interpret the data for each monitoring objective. Section 3 provides more detail. The first and second columns repeat the information from Table 1 to remind you about the objectives and the specific ways they help management.

2.7.4.1 Ecological significance

The data interpretation step requires you to consider the ecological significance of what the data show (see Box 2). For the life-stage assessment this means you might consider: *what proportion of individuals need to be mature for the species to regenerate in sufficient numbers after the burn?* For the indicator-species assessment or the all-species assessment you might consider: *what amount of change following fire is needed (or should be avoided) from an ecological point of view?*

Defining ecological significance is not an easy task. Data collected from monitoring will help inform this process in the future. In the interim, general trend lines (such as those shown in Figure 3) and data from scientific literature can be used to make better-informed decisions about what the ecological significance level may be for an individual circumstance.

Box 2: **Statistical significance versus ecological significance**

In statistics a result is described as statistically significant if it is unlikely to have occurred by chance.

For example, if data from an indicator-species assessment show a statistically significant difference between pre-burn and post-burn data, this means that there is statistical evidence of a difference between the true pre-burn and post-burn parameters being measured. This is not the same as saying that the difference is large, important or significant in the common meaning of the word.

To usefully apply the outcomes of a statistical analysis you should consider data that have statistical significance in relation to ecology. This is where the idea of ecological significance emerges.

If a result is described as ecologically significant then it is likely to be important from an ecological perspective.

Determining what is ecologically significant is not as clear-cut as determining what is statistically significant. It can depend on the type of data, the objective of your management action, the vegetation type, the species of interest and the successional stage of the vegetation. Monitoring data should help determine thresholds for ecological significance in the future.

2.7.4.2 Causation

For the indicator-species assessment and all-species assessment much of the analysis involves estimating the size of change following a burn in relation either to the density, cover, richness or composition of flora species. The next logical step is to attribute a cause to this change. However, as already stated, this can be difficult.

The issue is that association is not the same as causation. The data may show that two variables are strongly associated but this does not necessarily mean that one of these variables is causing the other to behave in that way. This is because 'confounding variables' not obvious in the data may be influencing the situation. The influence of those confounding variables means that 'even a very strong association between two variables is not by itself good evidence that there is a cause and effect link between the variables' (Moore and McCabe 1999).

So, how can direct causal links be established? The best approach is through carefully designed experimentation where all the possible confounding variables are controlled. However, this is not possible for broad-scale monitoring such as the flora monitoring methods described in this guide. Even if the flora monitoring involved controlled experimentation, it would be extremely difficult to achieve the desired level of precision due to the variability of nature. The next best solution is lots of replication (many plots) together with careful stratification of your monitoring areas to eliminate the effect of as many potential confounding variables as possible. This needs to be done as you set up your monitoring area and locate your plots (see Section 2.3). Further stratification can be done when the data from several monitoring areas are pooled for analysis.

In the absence of experimentation, Moore and McCabe (1999) describe the following criteria for establishing causation:

- the association is strong
- the association is consistent
- higher levels of the alleged causal factor are associated with larger changes
- the alleged causal factor precedes the effect in time
- the alleged cause is plausible.

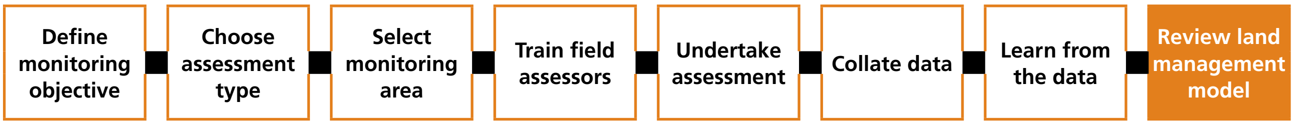
This is discussed further for the individual assessment types.

Table 4: Summary of the steps for data analysis and interpretation in relation to each monitoring objective.
The first and second column reproduce the contents of Table 1.

Monitoring objective	Role in helping management activities	Steps to analyse data	Steps to interpret the results of the data analysis
To obtain information on flora vital attributes for those species which lack such data.	Improve our knowledge of the vital attributes of particular flora species in relation to fire frequency.	The curators of the vital attributes database should analyse data at a state-wide level (other persons may also undertake the analysis).	The curators of the vital attributes database should pool the data for each species to identify their vital attributes in relation to fire frequency.
	Contribute to a better understanding of the effects of other factors on vital attributes (such as fire season, fire severity, drought or grazing).	The curators of the vital attributes database should analyse data at a state-wide level (other persons may also undertake the analysis).	The curators of the vital attributes database should pool the data for each species to identify how their vital attributes change when other factors vary. The difficulties with attributing a cause should be kept in mind (see Section 2.7.4.2).
To predict whether the vegetation in an area is likely to respond positively to burning at a particular time.	Assist with the selection of burn areas (by checking that the timing of life-stages predicted by the flora vital attributes model is the same as what is occurring in the potential burn area)	Formal analysis is unnecessary. Simple interpretation of the raw data is sufficient to meet operational needs.	You should compare the observed life-stages with those that the flora vital attributes model predicted. Where there is a discrepancy you should record this and a likely explanation (such as drought). To predict whether the key fire response species are likely to regenerate following fire you should determine whether the proportion of mature individuals is enough to allow sufficient regeneration. Section 3.2.8. explains this matter further.
To estimate the size of change in the presence and abundance of indicator species following fire.	Assess the effectiveness of management actions in achieving their objectives at the local or landscape scale.	You can analyse the data to estimate: • The amount that frequency of occurrence, density and abundance changed for each indicator species and the statistical significance of those changes. • The amount of variability in the dataset.	You should compare the change in abundance estimated from your data analysis with the planned burn outcome (that would usually be stated in a management objective) to assess whether that planned outcome was achieved.
	Verify the model's predictions with regard to the response of key fire response species following fire.	You can analyse the data to estimate: • The amount that frequency of occurrence, density and abundance changed for each indicator species and the statistical significance of those changes. • The amount of variability in the dataset.	You should compare the change in abundance estimated from your data analysis with what would be expected from the flora vital attributes model.
	Contribute to a better understanding of the effects of other factors (such as fire season, fire severity, drought or grazing) on the timing of life-stages for indicator species.	The curators of the Flora vital attributes database should analyse data at a state-wide level (other persons may also undertake the analysis).	The curators of the vital attributes database should pool the data for each species to identify how the timing of the life-stages changes when other factors vary (the difficulties with establishing causation should be kept in mind).
	Contribute to a better understanding of the effects of other factors (such as fire season, fire severity, drought or grazing) on the relative dominance of the indicator species.	You should pool data from a number of monitoring areas. For each monitoring area calculate the frequency of occurrence for a species or the average density. Then examine the correlation of these values with the factor of interest to measure the form, direction and strength of the association.	Use the outcomes of your analysis and common sense to decide whether the factor of interest stands a good chance of being a causal factor. Remember the limitations of monitoring in terms of establishing cause and effect relationships.

Monitoring objective	Role in helping management activities	Steps to analyse data	Steps to interpret the results of the data analysis
To determine the extent to which key fire response species can be used as indicators for all species following fire.	Test the effectiveness of using key fire response species as surrogates for all species.	You should pool data from a number of monitoring areas. Calculate the average species richness (and confidence intervals) for groups of monitoring areas that were burnt (1) within, (2) above, and (3) below the tolerable fire interval defined by the key fire response species. Use confidence intervals of the pre-burn versus post-burn differences to determine the statistical significance of any differences between pre-burn and post-burn data.	For those fire regimes (i.e. within, above or below the tolerable fire interval) where the difference between pre-burn and post-burn data is statistically significant, consider whether this difference matters from an ecological perspective – what level of change in species richness is acceptable and what level signifies that the key fire response species are not defining a fire interval that is 'tolerable' for all species?
To estimate the size of change in species composition following fire.	Assess the effectiveness of management actions in achieving their objectives at the landscape scale.	You can use species richness or species composition data to address this objective. For species richness data it is relatively simple to pool data from numerous monitoring areas and calculate the average difference between pre-burn and post-burn species richness and the 95% confidence interval for this value. You can use these confidence intervals to determine the statistical significance of any differences between pre-burn and post-burn species richness.	You should compare the estimated differences between pre-burn and post-burn species richness, composition and diversity with the planned management outcome (as stated in a management objective).
	Contribute to a better understanding of the effects of other factors (such as fire season, fire severity, drought or grazing) on the timing of life-stages for all species.	The curators of the vital attributes database should analyse data at a State-wide level (other persons may also undertake the analysis if they so wish).	The curators of the vital attributes database should pool the data for each species to identify how the timing of the life-stages changes when other factors vary. The difficulties with attributing a cause should be kept in mind (see Section 2.7.4.2).
	Contribute to a better understanding of the effects of other factors (such as fire season, fire severity, drought or grazing) on the relative dominance of all species.	You should pool data from a number of monitoring areas. For each monitoring area calculate the species richness. Then examine the correlation of these values with the factor of interest to measure the form, direction and strength of the association.	Use the outcomes of your analysis and common sense to decide whether the factor of interest stands a good chance of being a causal factor. Remember the limitations of monitoring in terms of establishing cause and effect relationships.

2.8 Review the land management model



The final stage in the adaptive management cycle is to use what you have learnt to review land management models – in this case the flora vital attributes model.

If your observations from monitoring match the predictions that you made using your land management model then this step is relatively simple because your monitoring has not provided evidence that the model needs changing. You should continue using the adaptive management cycle and perhaps target your monitoring to a different scenario where you may learn something new.

If your monitoring observations do not fit with the predictions you made then you should consider why this may be the case. Unexpected outcomes may reflect the influence of a factor which is not included in the flora vital attributes model (such as fire severity, grazing or climate). You should look for associations between those possible causes but remember that it can be difficult to attribute a cause to a change, especially when you have a small amount of data. Unexpected outcomes could also be the result of measurement error or a bias in the assessment method.

The extent of variability in your data will help you determine the amount of credence to give to an unexpected outcome. If you find that your data are unduly variable (e.g. the confidence intervals are wide[10]) then more monitoring should probably be your next step in order to strengthen the confidence surrounding what you have learnt. You should look for similar areas to monitor where you may make similar observations.

Even where the variability in the data is low, unexpected outcomes will often prompt more monitoring, to help verify the result. If the unexpected outcome recurs across several monitoring areas then the flora vital attributes model may need revising.

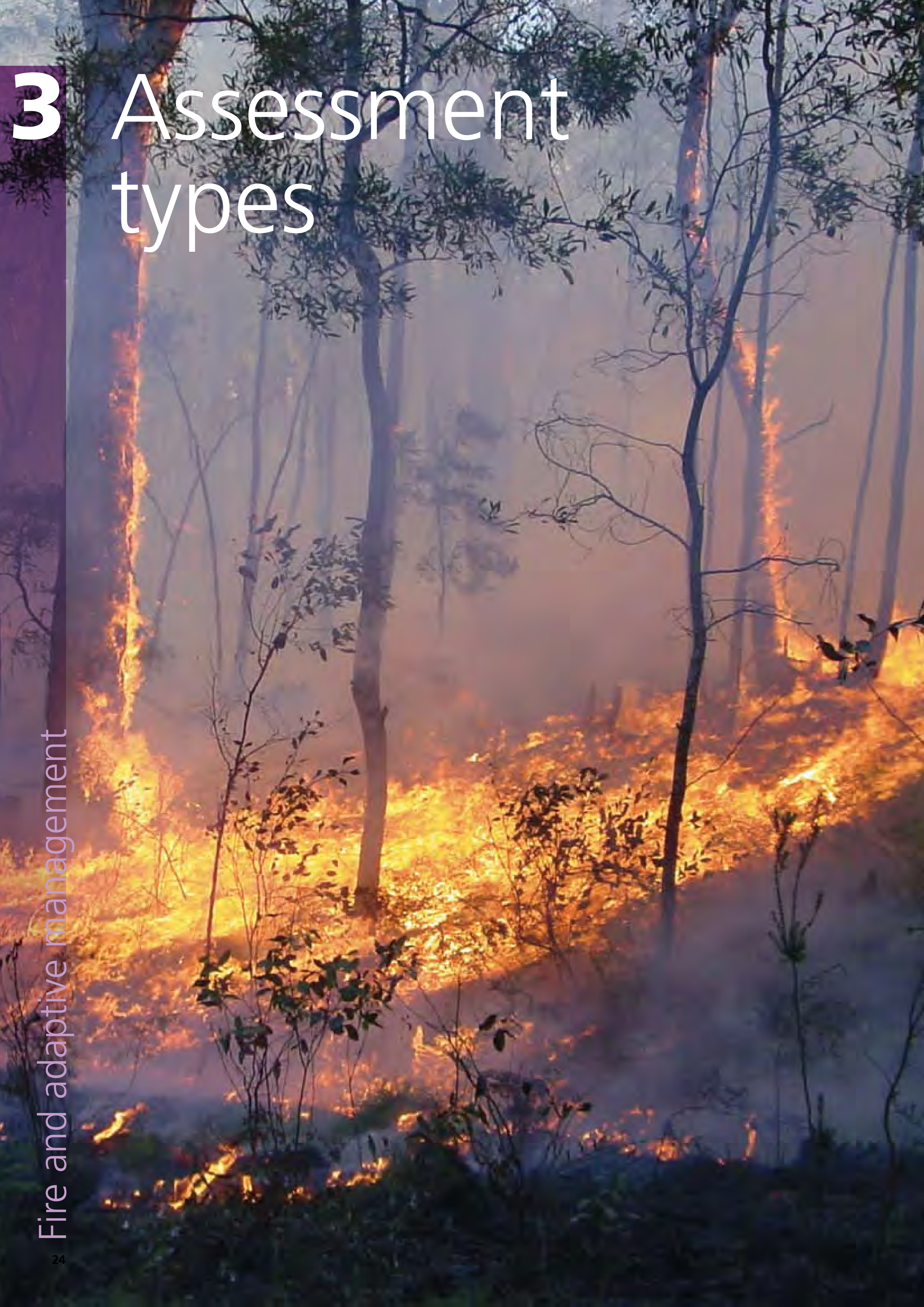
An unexpected outcome may also signal an opportunity to refine a management practice to achieve more desired outcomes. In doing so you would also consider a number of other factors (such as other objectives, the fuel management zone, safety, resources and community views).

10 There is no rule-of-thumb when it comes to determining if a confidence interval is too wide. It depends on how much variability around your estimate you are willing to accept. If the confidence interval for a difference value overlaps zero when you compare pre-burn and post-burn data then you could conclude that no statistically significant change has occurred.

3

Fire and adaptive management

3 Assessment types



3. Assessment types

This section of the User's guide describes each of the four flora assessment types in detail. You need to read only about the assessment types that you plan to undertake. If you read about two assessment types that have steps in common (such as the selection of key fire response species) then you may notice that the descriptions of some steps are the same.

3.1 Flora vital attributes assessment

Objective: To obtain information on flora vital attributes for those species that lack such data.

Undertake a vital attributes assessment in an area where the year of last burn is known. You may also choose an area where other aspects of the fire regime are known.	→	Repeat the assessment in other areas where the same species occur but the year of the last burn is different or other variables are different.	→	Enter the results into Argus where people can use them to refine the database of flora vital attributes.

This is an opportunistic assessment of the vital attributes of particular flora species.

'Vital attributes are the key life-history features that determine how a species lives and reproduces. In relation to fire, these attributes govern how a species responds to fire and/or persists within a particular fire regime.' (Fire Ecology Working Group, 2004).

The use of flora vital attributes in fire ecology planning and management is well-established in Victoria (Tolhurst and Friend 2001; Fire Ecology Working Group 2004). The methods that this section discusses are an adaptation of existing, unpublished methods for vital attribute assessment (Fire Ecology Working Group 2003).

For many species, records of vital attributes don't exist. For other species that do have vital attributes there is often little information about how those attributes change when aspects of fire regimes and other non-fire factors are different. The vital attributes assessment aims to fill these information gaps.

Vital attributes assessments take place at a single point in time. You should select monitoring areas where the time since the most recent burn is known. To gain comprehensive information about the vital attributes of a particular flora species in relation to fire frequency you will need to undertake a number of assessments in areas with different last-burnt years. Areas affected by other factors such as drought or grazing may also be of interest (e.g. in relation to grazing, seedlings may be very palatable and be selectively browsed out, leading to the impression that there has been no seedling regeneration). To better understand the effects of other factors you should select areas that exhibit a range of these other factors.

If you enter the data into the Argus database, DSE can use it to improve the flora vital attributes database.

You may need to obtain a research permit to undertake this assessment if you need to dig up plants to assess the mode of regeneration.

3.1.1 Assessor requirements

You can undertake a flora vital attributes assessment with a large or small group of assessors. We recommend that the group include at least two assessors, one of whom has skills in plant identification.

The time required is half-a-day per assessment. With more assessors this time may be less.

You should allocate extra time in the office to identify difficult species and to enter data into the Argus database.

3.1.2 Equipment requirements

You will need the following items of equipment:

- GPS
- field datasheets
- clipboard
- plant identification books
- chisel or equivalent (for digging up plants to determine the mode of regeneration)
- bags for plant samples
- blank notebook for each assessor (for sticking plant samples into)
- sticky tape
- pencils
- eraser
- research permit.

3.1.3 Timing

You should preferably undertake the vital attributes assessment in spring when the plants and their life-stages are easiest to identify. However, you can undertake the assessments at any time of year if you can identify the plants and their life-stages.

Ideally you should undertake the flora vital attributes assessment only where you have good information about fire severity at that particular place. Within a few weeks of the burn, you should undertake the fire severity assessment (see section 3.5) within the area where you plan to assess flora vital attributes.

3.1.4 Selecting a monitoring area

In addition to the selection criteria that Section 2.3 presents, you must consider the following factors when selecting your monitoring area:

- number of years since the area was last burnt. To interpret your data in relation to fire frequency you need to know when the most recent burn or fire occurred in the monitoring area. Ideally knowing information about other aspects of the fire regime would also be useful
- existing flora vital attribute information – more knowledge gaps can be addressed if the flora species within the target EVC are lacking in flora vital attribute information
- the amount known about other factors that may affect the vital attributes (such as fire season or grazing). Often very little will be known about how those other factors affect the vital attributes for a species. This information could be very useful to collect.

To gain comprehensive information about the effects of fire frequency on plant vital attributes you will need to undertake a number of assessments in areas with different last-burnt years.

- To assess mode of regeneration you should select an area that fire has burnt in the previous three years. However, older age-class areas are useful if you are assessing the mode of the regeneration for 'tolerant' species, i.e. species that can regenerate without disturbance.
- To assess longevity, time to maturity and method of persistence you should select areas with a range of older age-classes.

To gain comprehensive information about the effects of other factors on plant vital attributes you will need to undertake a number of assessments in areas where there are different levels of these other factors, e.g. different fire severities or different amounts of grazing.

3.1.5 Assessment methodology

You should undertake the following steps during an assessment:

1. Identify the location of your plot within the monitoring area. The plot should be:
   - an area of about 100m by 100m
   - the same EVC throughout
   - the same last-burnt year throughout
   - consistent for any other factor of interest (for example, the same fire severity)
   - at least 50 metres from any road or track.

   The plot doesn't need to be marked out as it is just an approximate area that will not be reassessed at some later date.

2. Record the following general information at the top of your assessment sheet:
   - area name, e.g. Wilson's Promontory – Tidal Overlook
   - burn number (from FireWeb)
   - plot name
   - plot description
   - page number of assessment sheet and the number of assessment sheets used
   - assessor names
   - assessment date i.e. the date that the assessment took place in the field
   - Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
   - number of years since the area was last burnt. You should use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map'
   - make any additional comments about the area particularly in relation to other factors you have stratified for (such as evidence of heavy grazing or drought).

3. Record the location of your plot by taking a GPS reading from the centre of the area. You should record coordinates in a field datasheet and also mark them as a waypoint within the GPS. In the datasheet you need to record:
   - the full easting and northing coordinates using the Geocentric Datum of Australia '94 (GDA94). Both coordinates have seven digits but the datasheet already shows the first digit of the easting because that digit in Victoria is always zero
   - the zone, i.e. Zone 54 or Zone 55
   - the GPS accuracy in metres (this should be better than 10 metres). You may need to wait a little longer until the GPS acquires signals from more satellites.
4. Record the species name (genus and species) for every species you plan to assess.

   For species that you can't immediately identify:
   - record in datasheet as 'unknown species 1' or 'unknown species 2', etc.
   - collect a sample of the plant and sticky tape this sample into a notebook. The specimen should include flowers and fruit if possible
   - name the specimen in the notebook using the same name that you recorded on the datasheet
   - identify the unknown species with plant books or seek assistance from a botanist.
5. Record the life-stage for each species using the following classes:
   - **juvenile (J)** – a plant that is not reproductively mature
   - **mature (M)** – a plant that is reproductively mature and that shows evidence of flowers, fruit or seed[11]
   - **senescing (S)** – a plant that is senescing or dying. Include plants that are completely dead if you can identify them.

Record an estimate of the percentage of individuals for each species within each class. You should check that the percentage estimates add to 100%.

Generally to determine life-stage you should look for evidence of flowers or fruit. This will be difficult if you undertake the monitoring in winter or autumn.

6. Record the mode of regeneration for each species using the following classes:
   - **seedling (S)** – a plant that has grown from seed. Generally you can dig up a seedling easily and it has fine, small roots
   - **resprouter (R)** – a plant that has regenerated vegetatively via:
     - epicormic shoots, i.e. shoots on the stem and branches
     - lignotuberous shoots, i.e. shoots from the base of existing plant or large underground stem
     - rhizomous shoots, i.e. shoots from an underground stem that runs horizontally and connect with other above ground shoots.

   Record an estimate of the percentage of individuals for each species within each category. Make sure the percentage estimates add to 100%.

   To determine whether or not a species has regenerated from seed or vegetatively you will need to dig up several specimens and examine the roots.

   Generally a plant has regenerated from seed when it has fine, small roots. Conversely, a plant is a resprouter when the roots are larger or run horizontally and appear to be connected to multiple shoots. You will not need to dig up some epicormic resprouters or lignotuberous resprouters to identify the mode of regeneration. You should note that some species can regenerate from both seed and resprouting.

   Do not dig up plants of any rare or threatened species.

   In long-unburnt plots you should only collect this information for the 'tolerant' species that can regenerate beneath a canopy without disturbance.
7. Return to the office and complete datasheet by identifying any unknown species.
8. Enter the data into the Argus database.

11 The presence of flowers, fruit or seed does not necessarily mean that the species will regenerate adequately after the burn. Full, mature seed production often occurs some years after the first flowering season. Before this stage, there may not be enough seed for adequate regeneration. Of course regeneration is also a function of other influencing factors in the area such as drought, grazing pressure or fire severity. Furthermore, the definition of 'adequate regeneration' is a function of the management objective, which may vary over time and space. All this needs to be kept in mind when using the life-stage data collected from this assessment.

3.1.6 Interpreting your data

The curator of the flora vital attributes database should analyse the flora vital attributes data. After you have added your data to Argus the curator can routinely review it together with all the other new vital attributes data from across the state. The curator will make any necessary changes or additions to the flora vital attributes database.

3.1.7 Datasheet

The following two pages comprise the blank field datasheet with reminders of the methodology on the reverse side. Photocopy this datasheet and the reminders to use in the field.

Flora vital attributes assessment **(September 2008)**

Page ____of _____

Area name			
Assessors and organisation		Assessment date	
Plot name		Burn No	
EVC			

Number of years since the area was last burnt (from FirePlan)		Verify last-burnt data (tick one box)		Appears to be correct
				Appears to be more years since last burnt
				Appears to be less years since last burnt

Further comments about fire severity, including date and coordinates of severity assessment if completed	
Further comments Record details about other variables of interest (e.g. drought, grazing)	

Coordinate for plot (GDA94)	Easting	0							Zone	54 55 (circle one)	GPS accuracy (m) (< 10 m if possible)	
	Nothing											

Species name	Life stage (% of individuals)			Mode of regeneration (% of individuals)		Further comments about the species.
	Juvenile	Mature	Senescing	Seedling	Resprouter	

Life-stage categories

J = Juvenile, a plant that is not reproductively mature
M = Mature, evidence of flowers or seed
S = Senescing, dead or dying

Mode of regeneration categories

S = Seedling, evidence that plant has grown from seed.
R = Resprouter, evidence that plant has regenerated vegetatively.

More space to record species information:

Page ____of _____

Species name	Life stage (% of individuals)			Mode of regeneration (% of individuals)		Further comments about the species.
	Juvenile	Mature	Senescing	Seedling	Resprouter	

Life-stage categories
J = Juvenile, a plant that is not reproductively mature
M = Mature, evidence of flowers or seed
S = Senescing, dead or dying

Mode of regeneration categories
S = Seedling, evidence that plant has grown from seed.
R = Resprouter, evidence that plant has regenerated vegetatively.

Reminders for the assessor

- Ensure that the location for your plot is:
  1. an area of about 100m by 100m
  2. the same EVC throughout
  3. the same last-burnt year throughout
  4. consistent for any other variable of interest, e.g. the same fire severity
  5. at least 50 metres from any road or track.
- Record the Ecological Vegetation Class (EVC). Use a map to identify the EVC and then verify this in the field.
- Record the number of years since the area was last burnt. Use a map to identify the year that the area was last burnt and then verify this in the field.
- The reading from the GPS needs to have an accuracy better than 10 metres.
- Record the genus and species of plants, not common names.
- If you cannot identify a species then:
  1. Record in datasheet as 'unknown species 1' or 'unknown species 2', etc.
  2. Collect a sample of the plant. The specimen should include flowers and fruit if possible.
  3. Name the specimen using the same name as used on the datasheet.
  4. Identify the unknown species later using plant books or with the assistance of a botanist.
- Record an estimate of the percentage of individuals for a species within each category of life-stage and mode of regeneration. These must add up to 100%.

Page 2 of 2

3.2 Life-stage assessment for burn planning

Objective: To predict whether the vegetation in an area is likely to respond positively to burning at a particular time.

Undertake the life-stage assessment for burn planning.	→	Analyse the results to decide whether to undertake the burn.	→	Use the results to nominate a burn or comment on an existing burn plan.

This is a routine assessment of life-stage for key fire response species. You should plan to undertake this assessment in all potential burn areas (or as many as practicable).

This assessment provides a snapshot of life-stage for key fire response species at a particular point in time before burning. From the data you can predict the likely response of the key fire response species to burning at that time based on the proportions of plants within each life-stage category (juvenile, mature and senescing). You can use this prediction to inform your decision of whether or not to burn the area.

Although you can predict the likely response of flora to burning at a particular time since fire using the flora vital attributes model, verifying those predictions in the field is important before committing to a burn schedule (Tolhurst and Friend 2001). The model may wrongly predict the time to maturity or longevity of a species, so it may not regenerate adequately after the burn. Factors such as drought or a particularly severe fire may slow the rate of development from the juvenile to mature life-stage, or may prevent seedling recruitment after the fire.

You should remember that this assessment, though more reliable than a desk-based analysis, still enables the response of flora to burning only to be *predicted*. This prediction is based on the underlying principles and assumptions of the flora vital attributes model. You can assess the accuracy of this prediction by monitoring the responses of the key fire response species after the burn (using an indicator-species assessment or an all-species assessment).

3.2.1 Assessor requirements

At least two assessors should work together to undertake a life-stage assessment for burn planning. You will initially need at least one person with botanical skills to select and identify the key fire response species. However, the key fire response species may be the same for a number of burn areas and therefore botanical skills may not be necessary for every assessment.

Undertaking the assessment for a given area should take about one hour per EVC.

You should allow extra time for data entry.

3.2.2 Equipment requirements

You will need the following items of equipment:

- GPS
- field datasheets
- clipboard
- pencils
- eraser.

3.2.3 Timing

Preferably you should undertake a life-stage assessment for burn planning in spring when plants and their life-stages are easiest to identify. However, you can undertake assessments at any time of year if you can identify the plants and their life-stage.

3.2.4 Selecting a monitoring area

You should aim to undertake the life-stage assessment for burn planning in as many potential burn areas as practicable. You should typically give priority to assessing areas that are long unburnt or that are likely to be burnt near the minimum tolerable interval predicted by the flora vital attributes model.

3.2.5 Choosing the key fire response species

You should select three or more key fire response species to monitor. According to the flora vital attributes model, key fire response species are used to predict the minimum and maximum tolerable fire intervals for an EVC. The selection of key fire response species is an important step in the assessment method. Poor selection can render the assessment worthless. Investing sufficient time and resources into this stage of the assessment is important. A person with good botanical knowledge and an understanding of flora vital attributes should assist in selecting and identifying key fire response species.[12]

To select key fire response species you should undertake the following steps:

1. Obtain a full species list for the EVC by pooling data from flora species plots within or near the monitoring area. You can obtain this plot data from the Flora Information System (FIS). If you do not have access to the FIS then you will need to contact a DSE Flora and Fauna Officer for assistance.

2. Examine the flora vital attributes for every species in the EVC (as per your species list).[13] Obtain this data from the vital attributes database (available on the DSE website – search for 'flora vital attributes'). Highlight species that have one or more of the following characteristics:
- G – seed germination: long-lived seed bank, complete germination after fire
- C – seed germination: short-lived seed bank, complete germination after fire
- V – vegetative regeneration: all-ages survive, but all become juvenile (i.e. non-reproductive)
- Y – vegetative regeneration: mature become juvenile (i.e. non-reproductive), juveniles die
- I – able to establish immediately after a fire (within the first two years, and usually within the first season), but cannot continue recruitment as the vegetation ages further, unable to establish in mature vegetation
- the longest juvenile period for the species in that area EVC
- the shortest extinction time for the species in that area. Extinction occurs after above-ground plants have disappeared and viable seed is insufficient to regenerate the population.[14]

Vital attribute information for key fire response species in Victoria is currently incomplete and consequently identifying a sufficient number of key fire response species from the flora vital attributes database may be difficult. If this is the case then a botanist may be able to advise which species are likely to be key fire response species. The best candidates may be found in familiar genera, such as Acacia, Banksia, Hakea or Pultenaea.

3. Prepare a list of potential key fire response species from the list of highlighted species that you produced in Step 2.

4. Further refine this list by selecting key fire response species that are most suitable for a life-stage assessment for burn planning. Consider the following factors:
- If the plan is to burn the area near or below the minimum tolerable fire interval then you should choose key fire response species that have:
  – the longest juvenile period, and are also
  – seeders with either G or C characteristics, or
  – resprouters with V or Y characteristics.
- If the plan is to burn the area near or above the maximum tolerable fire interval for the EVC then you should choose key fire response species that have:
  – the shortest extinction time, and are also
  – I – unable to regenerate beneath a mature canopy.
- If the plan is to burn within the tolerable fire interval then:
  – choose a range of key fire response species.
- Within your monitoring area search for each of the potential key fire response species on your shortlist and make the final decision based on what species you can find and identify easily.

  Note: If you are near or above the maximum fire interval and you can't find any of the key fire response species in the field then perhaps these species are naturally absent, have become extinct from the area or survive only in the soil seed-bank.

---

12 DSE intends to develop a shortlist of key fire response species for major EVCs in each bioregion. This would lessen the need for botanist input into each assessment. Alternatively, if a 'fire ecology assessment' (formerly known as 'fire ecology strategy' or 'ecological burn strategy') exists for your monitoring area then you can obtain a potential list of key fire response species from this.

13 Vital attributes are the key life-history features that determine how a species lives and reproduces. With respect to fire, these attributes govern how a species responds to fire and/or persists within a particular fire regime (Fire Ecology Working Group, 2004).

14 This assessment type considers a species to be nearing extinction from an area when the majority of individuals are senescing. This measure of extinction is technically incorrect because it doesn't consider the longevity of the soil-seed bank. Soil-seed bank surveys are too difficult to include in this guide, and the proportion of senescing individuals must suffice as an indicator of a species nearing local extinction. As a result, it is likely that maximum tolerable fire intervals will be underestimated.

3.2.6 Assessment methodology

You should undertake the following steps during an assessment:

1. Obtain a map of the monitoring area that shows contours, watercourses, roads, EVCs and a coordinate grid.

2. Determine the number of assessments that you will undertake in the area. This will depend on:
- how many EVCs you are interested in, and
- how many last-burnt years you are interested in
- how many other factors (e.g. fire season or grazing) you are interested in.

Calculate how many combinations of the 'EVC by last-burnt year by other factor' you plan to assess within the area (i.e. calculate how many 'stratification units' you plan to assess).

3. Select the key fire response species to monitor for each EVC by following the steps in Section 3.2.5.

4. This assessment does not involve plots. Instead, you make observations along an assessment route. Using your map of the area, plan at least four different assessment routes in each stratification unit. Figure 6 illustrates some examples of assessment routes. Each assessment route should cover as much of the variation within the stratification unit as possible (i.e. variation across elevations, aspects and slopes).

For each stratification unit, randomly select one or more of the planned assessment routes. You could do this by, for example, numbering each assessment route and then drawing numbers out of a hat to select a route. For larger burns you will probably need to identify more possible routes, then select more than one assessment route to adequately cover the variation in the area.

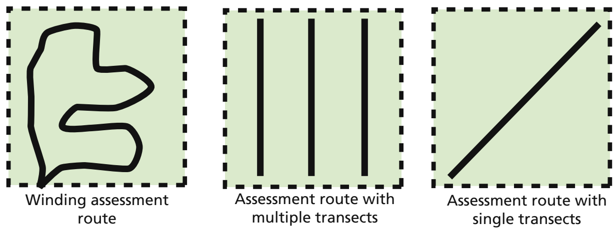


Figure 6: Examples of assessment routes within monitoring areas.

5. Record the following general information at the top of your datasheet:
- area name, e.g. Wilson's Promontory – Tidal Overlook
- burn number (from FireWeb)
- assessor names
- assessment date, i.e. the date that the assessment took place

6. For each assessment record the following general information in the datasheet:
- Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
- number of years since the area was last burnt. You should use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map'
- species name (genus and species) for each key fire response species.

7. Record the location of your assessment route by taking a GPS reading somewhere inside the monitoring area or burn area (at least 50 metres from the edge). You should record coordinates in a field datasheet and also mark them as a waypoint in the GPS. In the datasheet you need to record:
- the full easting and northing coordinates using the Geocentric Datum of Australia 1994 (GDA94). Both coordinates have seven digits but the datasheet already shows the first digit of the easting because that digit in Victoria is always zero
- the zone i.e. Zone 54 or Zone 55.
- the GPS accuracy in metres (this should be better than 10 metres). You may need to wait a little longer until the GPS acquires signals from more satellites.

8. You should make any additional comments about the area that may be important, e.g. evidence of heavy grazing or cinnamon fungus.

9. For each assessment, walk through the monitoring area along the planned assessment route and observe the percentage of individuals for each species that are in each of the following life-stage categories:
   - **juvenile** (**J**) – a plant that is not reproductively mature
   - **mature** (**M**) – a plant that is reproductively mature and there is evidence of flowers, fruit or seed.[15]
   - **senescing** (**S**) – a plant that is senescing or dying. Include plants that are completely dead if you can identify them.

   Generally to determine life-stage you should be looking for evidence of flowers or fruit. You may find that difficult when monitoring in winter or autumn.
10. At the end of the assessment route estimate and record the percentage of individuals that are juvenile, mature and senescing for each key fire response species. Ensure that the data for each species add to 100%.

3.2.7 Analyse the data

Formal analysis is unnecessary. Simple interpretation of the raw data is sufficient to meet operational needs.

3.2.8 Interpret the outcomes of your data analysis

You can use the data from this assessment to:
1. Check the accuracy of the flora vital attributes model in relation to the predictions it makes about the timing of critical life-stages for the key fire response species.
2. Predict the likely response of the flora to a fire at this time. Use the flora vital attributes model together with the observed proportions of each life-stage.

To check the accuracy of the flora vital attributes model you should compare the dominant life-stage that you observed for each species with those predicted by the model. If there is a discrepancy between the observations and predictions this may mean that the data on the timing of the life-stages for those species need reviewing in the flora vital attributes database. However, any proposed changes to the database should first consider monitoring data from other areas.

You should record factors about your monitoring area that may make it different from other areas (such as grazing) or make it different from other points in time (such as drought). These factors could provide an explanation for why the timing of the life-stages is different to that predicted by the flora vital attributes model. In the longer term it may be useful to include these other factors in the model.

To predict the likely response of the flora to fire you should consider the proportion of mature individuals that occur within the area for each key fire response species. There needs to be enough mature individuals for the key fire response species to regenerate in sufficient numbers. If the key fire response species can regenerate in sufficient numbers then, according to the flora vital attributes model, all flora species in the area should be able to regenerate in sufficient numbers.

The most challenging part of this interpretation is determining what proportion of mature individuals is enough. Over time, indicator-species assessments should result in data you can use to determine suitable values for that proportion. In the interim you should use your best judgement and be cautious of situations where:
- the area was recently burnt and there are high proportions of juvenile plants. In these cases some species may be unable to regenerate in sufficient numbers following fire
- the area is long unburnt and there are large high proportions of senescing plants. In these cases some species may become locally extinct from the area in the continued absence of fire (depending on the longevity of the soil-stored seed).

3.2.9 Datasheet

A blank field datasheet with key reminders of the methodology on the reverse side is provided on the following pages. Photocopy these two pages for use in the field.

15 The presence of flowers, fruit or seed does not necessarily mean that the species will regenerate adequately after the burn. Full, mature seed production often occurs some years after the first flowering season. Before this stage, there may not be enough seed for adequate regeneration. Of course regeneration is also a function of other influencing factors in the area such as drought, grazing pressure or fire severity. Furthermore, the definition of 'adequate regeneration' is a function of the management objective, which may vary over time and space. All this needs to be kept in mind when using the life-stage data collected from this assessment.

Page ____of _____

Flora life-stage assessment for burn planning **(September 2008)**

Area name		Assessment date	
Assessors and organisation		Burn No.	

Assessment 1: (Complete a different assessment for each EVC x last-burnt year combination of interest)

EVC				
Number of years since the area was last burnt (from 'fire plan' map)		Verify the last burnt year (tick one box)		Years since last burnt appear to be correct
				Appears to be more years since last burnt
				Appears to be less years since last burnt
Further comments about the fire regime e.g. fire season or severity				
Further comments. Record details about other variables of interest (e.g. drought, grazing)				

Coordinate for area (GDA94)	Easting	0							Zone	54 55 (circle one)	GPS accuracy (< 10 m)	
	Northing											

Name of key fire response species	Life-stage (% of individuals)		
	Juvenile	Mature	Senescing

Assessment 2:

EVC				
Number of years since the area was last burnt (from 'fire plan' map)		Verify the last burnt year (tick one box)		Years since last burnt appear to be correct
				Appears to be more years since last burnt
				Appears to be less years since last burnt
Further comments about the fire regime e.g. fire season or severity				
Further comments. Record details about other variables of interest (e.g. drought, grazing)				

Coordinate for area (GDA94)	Easting	0							Zone	54 55 (circle one)	GPS accuracy (< 10 m)	
	Northing											

Name of key fire response species	Life-stage (% of individuals)		
	Juvenile	Mature	Senescing

Page ____of _____

Assessment 3:

EVC	

Number of years since the area was last burnt (from 'fire plan' map)		Verify the last burnt year (tick one box)		Years since last burnt appear to be correct
				Appears to be more years since last burnt
				Appears to be less years since last burnt

Further comments about the fire regime e.g. fire season or severity	
Further comments. Record details about other variables of interest (e.g. drought, grazing)	

Coordinate for area (GDA94)	Easting	0							Zone	54 55 (circle one)	GPS accuracy (< 10 m)	
	Northing											

Name of key fire response species	Life-stage (% of individuals)		
	Juvenile	Mature	Senescing

Reminders for the assessor

- You should monitor three key fire response species. Use genus name and species, not common names.
- Each assessment should occur in an area that has the same EVC and last burnt-year.
- You make observations along an assessment route, rather than within plots. For each assessment, plan an assessment route:
  1. Record the Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field.
  2. Record the number of years since the area was last burnt. You should use a map to identify the year that the area was last burnt and then verify this in the field
  3. The reading from the GPS needs to have an accuracy better than 10 metres.
  4. Record the percentage of individuals for each species that are juvenile, mature and senescing. Ensure these add up to 100%

Life-stage categories:

- **juvenile** (**J**) – a plant that is not reproductively mature.
- **mature** (**M**) – a plant that is reproductively mature and there is evidence of flowers, fruit or seed.
- **senescing** (**S**) – a plant that is senescing or dying. Include plants that are completely dead if you can identify them.

3.3 Flora indicator-species assessment

Objective: To estimate the size of change in the presence and abundance of indicator species following fire.

Pre-burn: Undertake the indicator-species assessment → Conduct the burn → Post-burn (one month): Undertake a Fire Severity Assessment ↓ Post-Burn (two years): Undertake an indicator-species assessment. → Learn from the data (through data analysis and data interpretation). → Post-burn (ten years): Undertake an indicator-species assessment. ↓ Learn from the data (through data analysis and data interpretation).

This is a routine assessment of density, cover and life-stage for indicator species. Indicator species will usually be key fire response species but could be other species of interest. By assessing the indicator species you should be able to infer something about the state of all species within the monitoring area.

Undertaking this assessment is quick and simple. After some initial training, assessors do not need a botanical background to undertake this assessment. However, identifying the chosen plants correctly is vital.

In an area over a period of years you should repeat this assessment several times (pre-burn, two years post-burn, five years post-burn (optional) and ten years post-burn). You should also undertake a fire severity assessment after a burn. Section 3.5 presents the method for this.

You should establish at least 20 plots per Ecological Vegetation Class (EVC) in each monitoring area. You undertake the series of assessments (i.e. pre-burn and post-burn assessments) at these same plots.

3.3.1 Assessor requirements

Before starting an assessment you need to consider the assessor requirements to determine whether or not you can meet them now and in the future.

Assessors should work in pairs. They do not need a botanical background, provided that they can re-identify the indicator species that a botanist has taught them to identify. They must also be able to use a GPS.

A person with a botanical background should select the indicator species for an area and help the field assessors identify these species at the start of each assessment.

Assessments take about half–a-day per EVC in a given area (based on ten minutes per plot plus travel time between plots). Often in a given area you will need to assess only one EVC.

You should allocate additional time for data entry.

3.3.2 Equipment requirements

You will need at least the following items of equipment:

- GPS
- specimens of indicator species and/or other materials to help identify them
- 2.5 metre pole or measuring tape (to measure the plot radius)
- field datasheets
- clipboard
- pencils
- eraser.

3.3.3 Timing

You should undertake the series of assessments according to the timeline shown in Figure 7, which recommends that:

- All the flora assessments occur at the same time of year (preferably late spring to early summer). This is because:
  - the evidence of many species depends a lot on the time of year
  - identifying species during autumn and winter when they are not in flower is often much more difficult.
- The pre-burn flora assessment occurs less than two years before the burn and preferably less than one year before it.
- The first post-burn flora assessment occurs about two years after the burn. This will allow enough time for the plants to grow to a size where you can identify them.
- Subsequent post-burn assessments occur five years (optional) and ten years after the burn.
- The post-burn severity assessment occurs before the flora species recover much from the fire. The timing of this will depend on the vegetation type and post-fire climatic conditions, but could be any time from a few weeks to a few months after the burn.

If a bushfire burns in the monitoring area during the ten-year monitoring period then you should plan to undertake another post-burn severity assessment and re-monitor the area using the same indicator-species assessment methodology at new two-year, five-year (optional) and ten-year intervals. If the bushfire burns a large number of plots across many monitoring areas then, due to resource constraints, you may need to prioritise and re-monitor only some areas, or adjust the timeframes, or both.

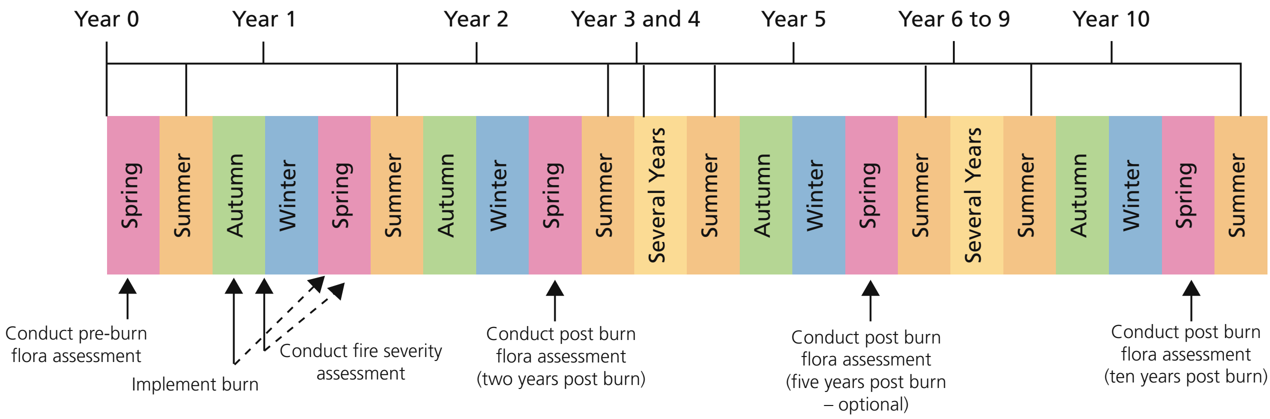


Figure 7: Timeline for indicator-species assessment.

3.3.4 Selection of a monitoring area

You should undertake the indicator-species assessment at a selection of burns in a given season, rather than all burns. You should spend some time selecting the most appropriate areas to monitor and should consider several criteria in addition to those general criteria that Section 2.3 describes (knowledge gaps, access, topography and terrain). You should give priority to areas where several of the criteria are met:

1. New or different management practices
To optimise the amount that you and others can learn from the monitoring, you should target areas in which the management action is new or different. For example, you may choose to target an area in which the season of burning is to be spring rather than autumn, or the ignition pattern is to be unusual or different.

2. Ecological Vegetation Class
You should target your monitoring towards Ecological Vegetation Classes (EVCs) that are identified as being a priority for monitoring. Generally EVCs are a high priority for monitoring when:
- the number of hectares in the planned burn program is high for that EVC relative to the total area of that EVC, and/or
- understanding of the flora response to fire within the EVC is lacking, (i.e. little vital attribute information is available), and/or
- it is thought that the plants of the EVC are sensitive to fire or a species is declining from an EVC as a result of fire or the lack of fire.

3. Fire management zone
You can undertake monitoring in any fire management zone. However, the 'strategic wildfire moderation zone' (formerly Zone 2) and the 'ecological management zone' (formerly Zone 3) are more useful areas in which to target your monitoring because burn regimes in those areas are more flexible and therefore the outcomes of your monitoring can influence those burning regimes more readily.

4. Fire and disturbance history
To optimise the potential use of your data you should select areas for which the disturbance history is known. Fire is a common disturbance but you should also consider others such as logging, disease, drought and storm damage.

Where the last-burnt year is known you should target your monitoring towards areas that are either long unburnt or near the minimum tolerable fire interval for that EVC. EVCs with repeated fires recorded near the minimum interval should also be targeted.

5. Existing plots
Before selecting a monitoring area, you should identify in Argus any other monitoring plots in the area. Using existing plots may be valuable if they fall within the proposed monitoring area even if the previous assessment type was different.

6. Degree of interest
You may choose to give priority to areas that are of a greater interest to the general public and/or land managers (e.g. 'high profile burns'). There could be a variety of reasons for this interest such as the geographic location of the burn or the value of the area to a local community.

3.3.5 Choosing indicator species

You should select six or more species to monitor. These species will usually be key fire response species. However, they can also be species of interest to the public or weed species. They can be rare and threatened species if their density in the area is high – methods to assess these species in low densities should be more intensive.

The choice of indicator species for the pre-burn assessment directly affects the post-burn assessments. Post-burn assessments use the same indicator species so that you can compare pre-burn and post-burn results.

If your indicator species are going to be key fire response species then you should take extra care when selecting them. Poor selection can render the assessment worthless and therefore investing sufficient time and resources into this stage of the assessment is important. A person with good botanical knowledge and an understanding of flora vital attributes should assist in selecting and identifying key fire response species.[16]

You should undertake the following steps to select key fire response species:

1. Obtain a full species list for the EVC by pooling data from existing flora species plots within or near the monitoring area. You can obtain these species lists from the Flora Information System (FIS). If you do not have access to the FIS then you will need to contact a DSE Flora and Fauna Officer for help (or purchase a copy).

2. Examine the data about flora vital attributes[17] for every species in the EVC. You can obtain this data from the flora vital attributes database (available on the DSE website – search for 'flora vital attributes' or go to fireweb and click on Information > Fire Ecology > Monitoring > Flora Vital Attributes). Highlight species that have one or more of the following characteristics:
- G – seed germination: long-lived seed bank, complete germination after fire
- C – seed germination: short-lived seed bank, complete germination after fire
- V – vegetative regeneration: all ages survive, but all become juvenile (i.e. non-reproductive)
- Y – vegetative regeneration: mature become juvenile (i.e. non-reproductive), juveniles die
- I – able to establish immediately after a fire (within the first two years, and usually within the first season), but cannot continue recruitment as the vegetation ages further, unable to establish in mature vegetation
- the longest juvenile period for the species in that EVC. Extinction may occur if plants do not reach reproductive maturity before another fire.
- the shortest extinction time for the species in that area. Extinction may occur after above-ground plants have disappeared and viable seed is insufficient to regenerate the population.[18]

16 DSE intends to develop a shortlist of key fire response species for major EVCs in each bioregion. This would lessen the need for botanist input into each assessment.

17 Vital attributes are the key life history features that determine how a species lives and reproduces. With respect to fire, these attributes govern how a species responds to fire and/or persists within particular fire regimes.

18 This assessment type considers a species to be nearing extinction from an area when the majority of individuals are senescing. This measure of extinction is technically incorrect because it doesn't consider the longevity of the soil-seed bank. Soil-seed bank surveys are too difficult to include in this guide. Therefore the proportion of senescing individuals must suffice as an indicator of a species nearing local extinction.

Vital attribute information for key fire response species in Victoria is currently incomplete. Consequently, choosing a sufficient number of key fire response species may be difficult. If this is the case then a botanist may be able to advise which species are likely to be key fire response species. The best candidates may be found in familiar genera, such as Acacia, Banksia, Hakea or Pultenaea. Alternatively you should consider getting a botanist to undertake an all-species assessment instead.

3. Prepare a list of potential key fire response species from the list of highlighted species produced in Step 2.
4. You should make the final decision in the field before you begin monitoring. Search for all the species on the list of potential key fire response species in your monitoring area to determine whether they occur. When making the final decision you should consider the following criteria:
   - Is the species present in the area OR likely to be present post-burn? It is important to include in your pre-burn assessment any species of interest that are absent before the burn but likely to be present after the burn, even if those species are recorded as absent in every pre-burn plot. Otherwise you will have no definite record that the species was absent before the burn.
   - Can assessors identify the species easily?

   Ideally the selected key fire response species should include a mix of vital attributes. In areas that are long unburnt you may choose some species that do not occur pre-burn but that are likely to reappear post-burn.

3.3.6 Assessment methodology: pre-burn

You should undertake the following steps during an assessment:

1. Obtain a map of the monitoring area that shows contours, watercourses, roads, EVCs and a coordinate grid.
2. Determine the number of assessments you will undertake in the area. This will depend on:
   - how many EVCs you are interested in
   - how many last-burnt years you are interested in
   - how many other factors (e.g. fire season or grazing) you are interested in.

   Calculate how many combinations of the 'EVC by last-burnt year by other factor' you plan to assess within the area (i.e. calculate how many 'stratification units' you plan to assess).
3. Select the key fire response species to monitor for each EVC of interest by following the steps in Section 3.3.5. To assist with field identification, you can collect samples of each species and use these samples in the field to assist with identification. You could also take photos of each species for future reference.
4. Using your map of the area, plan at least four different assessment routes in each stratification unit. Figure 8 illustrates some examples of assessment routes. Each assessment route should cover as much of the variation with the stratification unit as possible (i.e. variation across elevations, aspects and slopes).

   For each stratification unit, randomly select one or more of the planned assessment routes. You could do this by, for example, numbering each assessment route and then drawing numbers out of a hat to select a route. For larger burns you will probably need to identify more assessment routes, then select more than one route to adequately cover the variation in the area.

   When planning the assessment you should preferably consult the Fire Management Officer or Burn Officer in Charge to find out how they expect to conduct the burn. This will provide further guidance to locations that are more likely to be burnt.

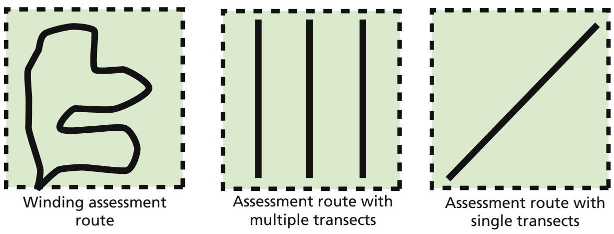


Figure 8: Examples of assessment routes within monitoring areas.

5. Record the following general information on your datasheet:
- area name e.g. Wilsons Promontory – Tidal Overlook
- burn number (from FireWeb)
- page number of assessment sheet and the number of assessment sheets used
- assessor names
- assessment date, i.e. the date that the assessment took place in the field
- Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
- number of years since the area was last burnt. You should use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'Fireplan'
- species names (genus and species) for the key fire response species
- plot name – a unique code for each plot, e.g. W01, W02, etc. Choose codes that are least likely to become confused with plots names from other assessments over the years
- make any additional comments about the area, particularly in relation to other variables you have stratified for (such as evidence of heavy grazing or drought).

6. Walk into the monitoring area along the assessment route until you are at least 50 metres from any road. The actual distance in from the road should vary randomly for each assessment route you assess but it should always be more than 50 metres to avoid edge effects. You can draw numbers from a hat to randomly determine this distance.

After you have walked into the area for a randomly defined distance, stop and make this point the first plot. Use go-to points in the GPS to navigate along the assessment route if this is helpful.

7. Record the location of your plot point by taking a GPS reading. You should record coordinates in a field datasheet and also mark them as a waypoint within the GPS. In the datasheet you need to record:
- the full easting and northing coordinates using the Geocentric Datum of Australia 1994 (GDA94). Both coordinates have seven digits but the datasheet already shows the first digit of the Easting because that digit in Victoria is always zero
- the zone, i.e. Zone 54 or Zone 55
- the GPS accuracy in metres (this should be better than 10 metres). You may need to wait a little longer until the GPS acquires signals from more satellites.

Permanent marking of plots with star pickets is unnecessary.

8. Identify the perimeter of the plot using a stick (or rope) of known length (2.5 metre). Each plot is circular with a 2.5 metre radius (see Figure 9). See Box 4 for a discussion on plot sizes in sparse vegetation.

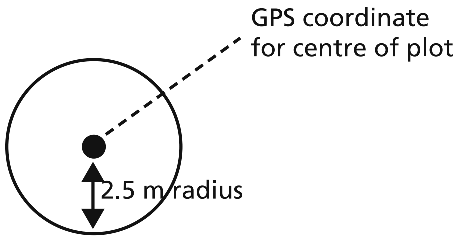


Figure 9: Plot layout for indicator-species assessment.

9. Estimate the density (number of individuals) for each indicator species in the plot (see Box 3 for tips on estimating density).

Box 3: **Tips for estimating density**

The most important part of the assessment is in determining whether a species is present or absent in each plot. If the only specimen of a species is on the boundary of the plot then you should count it as 'in'.

The next step is to estimate the number of individuals that are present for each species of interest.

When only a few individuals (e.g. < 10) are present you can count them quite easily.

When more than about 10 individuals are present you should estimate the number of them. The level of accuracy of this estimate will depend on the overall number of individuals in the plot. The aim is to estimate density to within 10% of the actual value that you could have obtained by carefully counting. As a general rule of thumb:

Density range	Estimation procedure
0 to 20	Count individuals
21 to 50	Estimate to the nearest 5
50 to 100	Estimate to the nearest 10
100 to 300	Estimate to the nearest 20
300 to 1000	Estimate to the nearest 50
Over 1000	Estimate to the nearest 100

To assist in estimating density when large numbers of individuals are present, count the number of individuals in a small, representative part of your plot and then scale this number up to calculate the estimated density for the whole plot.

You should not attempt to estimate the density of multi-stemmed plants or grasses because these species are too difficult to count. Instead you should estimate their abundance by estimating their percentage cover.

10. Estimate and record the percentage cover for each indicator species using the modified Braun-Blanquet cover classes described below:
0 = cover 0%, species absent
+ = cover < 5%, few individuals
1 = cover < 5%, more than a few individuals
2 = cover 5–20%, any number of individuals
3 = cover 20–50%, any number of individuals
4 = cover 50–75%, any number of individuals
5 = 75–100%, any number of individuals

11. Estimate and record the dominant life-stage for each indicator species using the following categories:

- **juvenile** (**J**) – a plant that is not reproductively mature.
- **mature** (**M**) – a plant that is reproductively mature and shows evidence of flowers, fruit or seed.[19]
- **senescing** (**S**) – a plant that is senescing or dying. Include plants that are completely dead if you can identify them.
- **Unknown** (**U**) – you are unable to determine life-stage because there is no evidence of flowers, fruit or seed, or for some other reason. If you are in doubt then use this category. Though a lack of data is disappointing, wrong data can be quite misleading and have bad consequences.
- **Absent (A)** – a plant that was not found in the plot.

To determine life-stage the assessor should look for general evidence of flowers or fruit. In winter or autumn this may be difficult.

'Dominant' is defined as the life-stage that you observe for the greatest number of individuals. If two life-stages are equally dominant, record both.

19 The presence of flowers, fruit or seed does not necessarily mean that the species will regenerate adequately after the burn. Full, mature seed production often occurs some years after the first flowering season. Before this stage, there may not be enough seed for adequate regeneration. Of course regeneration is also a function of other influencing factors in the area such as drought, grazing pressure or fire severity. Furthermore, the definition of 'adequate regeneration' is a function of the management objective, which may vary over time and space. All this needs to be kept in mind when using the life-stage data collected from this assessment.

12. Walk along your assessment route to the next plot. It doesn't matter how far apart your plots are, as long as:
- the plots don't overlap
- the distance is approximately the same between all plots
- the plots are randomly located, i.e. you don't specifically choose locations where a rare plant can be included or where there is no bare ground.

About 50 metres will usually be a suitable distance between plots. Where the vegetation is sparse or you intend to cover a large area you may increase the distance between plots. Where the monitoring area is small you may need to reduce the distance between plots so that you can fit enough plots in the area.

Use your GPS to measure the distance between the plots. Once you arrive at the next plot point, mark out the boundary of this plot (see Figure 10 for plot layout).

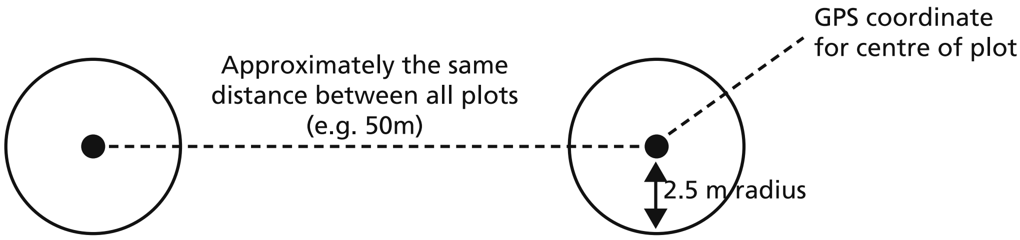


Figure 10: Plot Layout for indicator-species assessment.

13. Repeat steps 7 to 12 until you have completed at least 20 plots and covered the assessment route (see Box 4 to find out more about how many plots are required).

14. When returning to the office, map the plot coordinates from your GPS, to confirm their correct placement in relation to known features.

Box 4: **How many plots?**

This guide recommends a minimum of 20 plots for the indicator-species assessment. However, you may need to assess more plots if the area is large (i.e. more than about 100 hectares), the EVC highly variable across the area or the vegetation is sparse (such as mallee).

As a general rule of thumb, assess 20 plots then have a look at your data to work out if you should do more plots.

Twenty plots are probably sufficient if:
- the species that you have assessed are consistently present with similar cover classes and densities for most of the plots
- the area is 100 hectares or less.

You will need to assess more plots if:
- the area is greater than about 100 hectares
- the species that you assessed are frequently absent
- the species that you assessed are consistently present but the densities/cover often vary dramatically, or
- the vegetation is sparse e.g. a mallee EVC
- you want to make statistically valid conclusions about a particular area (as opposed to pooling data across several areas).

In sparse vegetation you should assess more plots rather than larger plots. This will ensure consistency in the methodology so that you and others can pool the data across numerous monitoring areas.

More plots shouldn't mean a longer assessment time. When the vegetation is sparse the time required to assess each plot is lower.

Stipulating how many more plots you should assess is difficult. Collection of more data over time should help in identifying better advice. Until such advice is available an additional 20 plots would be a good start.

3.3.7 Assessment methodology: post-burn

You should undertake the following steps to do an assessment after a burn:

1. Download the pre-burn plot coordinates from Argus, the fire monitoring database. Upload these coordinates into a GPS. You will undertake the post-burn assessments at the same plots.
2. Review the pre-burn data to find the indicator species to monitor for each EVC. Use the same species post-burn.
3. Record the following general information on your datasheet:
   - area name. Use the same name as the data show for the pre-burn assessment
   - page number of the assessment sheet and the number of assessment sheets you will use
   - assessor names
   - assessment date
   - Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
   - number of years since the area was last burnt. Given that this is a post-burn assessment, you should have a good record of this from your fire severity assessment (see Section 3.4). If not, use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map'
   - species names (genus and species) for the key fire response species
   - plot names. Use the same names as the data show for the pre-burn assessments
   - make any additional comments about the area particularly in relation to other variables you have stratified for (such as evidence of heavy grazing or drought).
   - Navigate to the first plot using the pre-burn coordinates as waypoints.
4. At that plot record the GPS accuracy in metres (this should be better than 10 metres).
5. Repeat steps 8 to 11 from the pre-burn assessment methodology.
6. Navigate to the next plot.
7. Repeat steps 5 to 8 until you have re-assessed all the pre-burn plots.

3.3.8 Analysing the data

The monitoring objective for this assessment type is 'to estimate the size of change in the presence and abundance of indicator species following fire'. Therefore, the primary purpose of the data analysis is to compare the pre-burn data with the post-burn data to estimate the size of any changes.

The indicator-species assessment collects binary data (frequency of occurrence), numeric data (density) and categorical data (cover). This section of the guide discusses data analysis methods for each of these data types.

After the size of change has been estimated, those changes can be correlated with a potential causal factor to measure the strength of the association. The method for doing this is described for numeric causal factors, such as the number of years between fires.

Data about the timing of the life-stages for the indicator species are also collected by the indicator-species assessment. This information should be used, together with the data from the flora vital attributes assessment, by the curator of the flora vital attributes database.

3.3.8.1 Estimating change in the frequency of occurrence (presence or absence)

If you are interested in changes to the frequency of occurrence of a species then you should use presence or absence data to determine the proportion of plots for which a species of interest is present. Table 5 defines the parameters that this analysis requires.

Frequency of occurrence is a useful parameter when the species of interest is difficult to count (e.g. it has a clumping habit). It is also useful if there is likely to be some assessor bias in the estimation of density or cover for the species or the population size of the species fluctuates on a yearly basis. You should avoid using frequency of occurrence if the distribution of the species is patchy (i.e. if it occurs in high density in some areas and not at all in other areas within the monitoring area), unless you have data from a large number of plots (e.g. > 40).

Table 5: Definitions for data analysis using frequency of occurrence data

Population (all individuals of a species within the monitoring area)	Population proportion (frequency of occurrence of species in population)	Count of successes (number of times species present in plots)	Sample size (number of plots)	Sample proportion[20] (proportion of times the species is present in plots within a monitoring area)
1 (e.g. Pre-Burn)	p_1	X_1	n_1	$\hat{p}_1 = \frac{X_1}{n_1}$
2 (e.g. Post-Burn)	p_2	X_2	n_2	$\hat{p}_1 = \frac{X_1}{n_1}$

To compare two population proportions (e.g. pre-burn and post-burn populations) calculate the difference between the two sample proportions:

$$Difference = \hat{p}_2 - \hat{p}_1$$

To calculate the 95% confidence interval of the *Difference*, first calculate the standard error ($SE_{Difference}$).

$$SE_{Difference} = \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

Then calculate the 95% confidence interval:

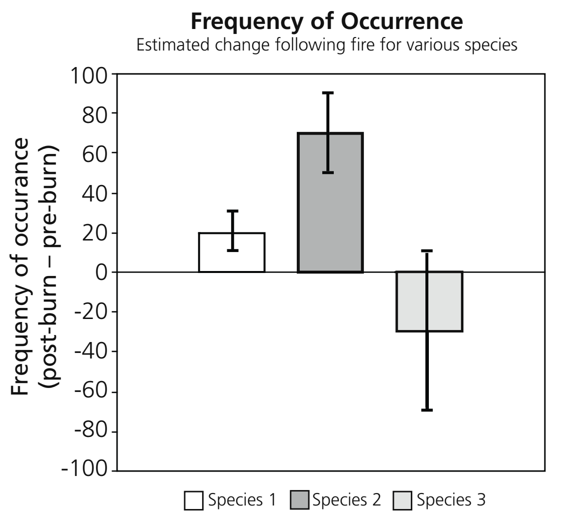
$$Difference \pm 1.96 \times SE_{Difference}$$

As a general rule, this 95% interval is approximately correct when the sample sizes n_1 and n_2 are sufficiently large (for example, when the number of plots is at least 20) and the proportions are not close to 0 or 1.

You can display the difference between two sample proportions for a species in a single monitoring area and the confidence intervals for these differences in a graph (see Figure 11). If there are several similar monitoring areas then it may be useful to compare the results for those areas to determine whether the trend you observe in a single area is consistent across other areas.

You should consider the width of the confidence intervals when drawing any conclusions about the data. We can be 95% confident that the true difference between pre-burn and post-burn proportions occurs within the confidence interval.

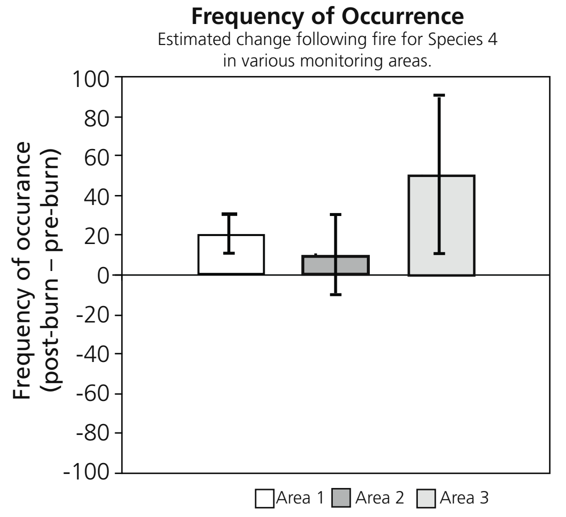
20 When this symbol appears above a letter (such as p) it means that we are referring to an estimate of a true value rather than the true value. This estimate is based on data from a sample rather than an entire population.



Sample statement:

'The changes in frequency of occurrence for Species 1 and Species 2 are statistically significant at the 5% level. Species 1 increased in occurrence by 20% (±10%) while Species 2 increased by 70% (±20%). The change for Species 1 is of particular ecological significance because the overall frequency of this species in the area is only 5%. For Species 3 there is too much variability in the data to assert that the change (-30% ±40%) is statistically significant at the 5% level.'

[The amounts in brackets are the 95% confidence intervals around the estimates.]



Sample statement:

'The changes in frequency of occurrence for Species 4 in Areas 1 and 3 are statistically significant at the 5% level. In Area 1 the frequency of occurrence increased by 20% (±10%) while in Area 3 it increased by 50% (±40%). For Area 2 there is too much variability in the data to assert that the change is statistically significant at the 5% level. The management objective for these areas is to double the frequency of occurrence of Species 4 and therefore statistically significant changes in Area 3 that are larger than 50% are ecologically significant. The estimated change for Area 3 was greater than 50%. However, this size of change is quite uncertain because the confidence interval is wide (ranging from 10% to 90%).'

When interpreting these sample graphs you should consider:

- the **statistical significance** of any changes. If the 95% confidence interval crosses zero, then there is too much uncertainty in the estimated change to be confident that a change has occurred (at the 5% level) – the estimated change is not statistically significant
- the **ecological significance** of any statistically significant changes. This is where you consider the size of change – how much change matters from an ecological perspective? This will vary depending on life-history of the species, management objectives for that species and how frequently the species occurs in the area. For example, a 20% decrease in the frequency of occurrence of a species may have more ecological significance if the species is rare in the area as opposed to being common.

Figure 11: A graph with sample data about estimated change in frequency of occurrence for several species in a single monitoring area (left); and a single species across several monitoring areas (right). Accompanying this graph are some suggestions for interpreting the graph and a sample statement for describing each graph.

3.3.8.2 Estimating change in the density

If you are interested in changes to the number of individuals of a species across a monitoring area then you should look at average densities. Species density is the number of individuals per unit area (e.g. number of hectares):

$$Density = \frac{Number\ of\ individuals}{Area}$$

Density is an effective measure for estimating change caused by recruitment or loss of individuals (as opposed to changes to the vigour of individuals). You should avoid using density when the species is difficult to count (e.g. it has a clumping growth form).

The first step is to calculate the density per hectare for each 2.5 metre radius plot. For each plot divide the number of individuals in the plot by 0.001963:

$$Density\ (per\ Ha) = \frac{Number\ of\ individuals}{0.001963}$$

You can compare pre-burn and post-burn density for a particular species to determine whether on average there has been a change in density for that species across a monitoring area.

For each pair of plots subtract the pre-burn density ($Density_1$) from the post-burn density ($Density_2$) to determine difference:

$$Difference = Density_2 - Density_2$$

Then to estimate the average change in density in an area ($\hat{x}$), sum the *Difference* values and divide the results of that sum by the total number of plots (n):

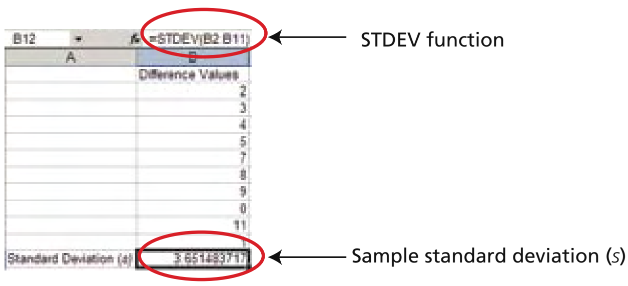
$$\hat{x} = \frac{\Sigma Difference}{n}$$

This average value is the estimated average difference between pre-burn and post-burn densities for a particular species in a monitoring area.

To calculate a 95% confidence interval for the estimated average difference first calculate the standard error ($SE_{Difference}$):

$$SE_{Difference} = \frac{s}{\sqrt{n}}$$

s is the sample standard deviation (i.e. the standard deviation of the sample of plots). You can use Microsoft Excel to calculate it by entering in all the *Difference* values and then using the STDEV function (as illustrated below).



You can then calculate the 95% confidence interval:

$$Difference = t\ x\ SE_{Difference}$$

You can determine t values by using Table 6 or by looking at a table of the t distribution in many statistical books. A 95% confidence interval requires the 0.975 quantile of the distribution. Find the corresponding t-value for the number of plots (n) that you assessed.

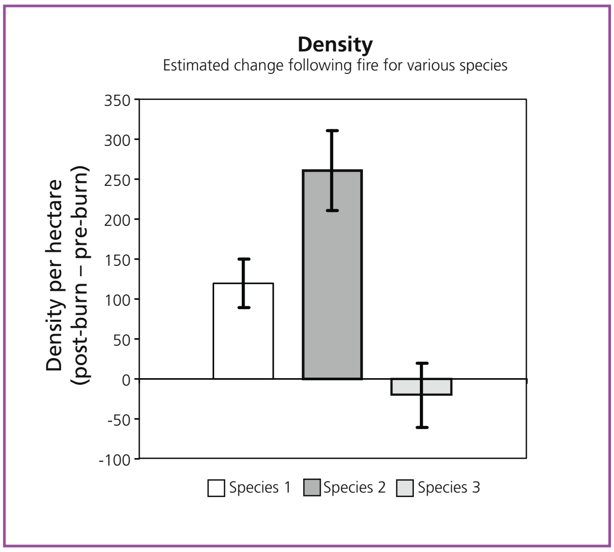
As a general rule, this 95% interval is approximately correct when the sample size (n) is sufficiently large, e.g. when the number of plots is at least 20.

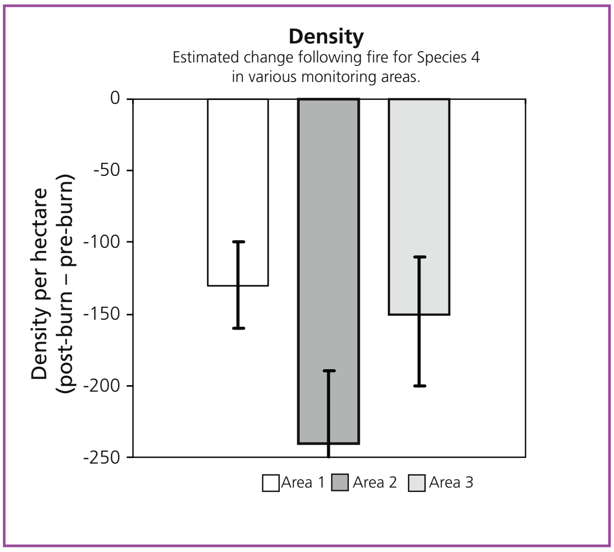
You can display the estimated average difference in density between the pre-burn and post-burn plots in a monitoring area and the confidence intervals for these estimated averages in a graph (see Figure 12).

When drawing any conclusions about the data you should take into account the width of the confidence intervals. There is 95% confidence that the *true* difference between pre-burn and post-burn density occurs somewhere within the confidence interval.

Table 6: A selection of t-values for various sample sizes and 95% confidence

n (number of plots)	*Degrees of Freedom (n–1)*	*t – value*
20	19	2.093
21	20	2.086
22	21	2.080
23	22	2.074
24	23	2.069
25	24	2.064
26	25	2.060
27	26	2.056
28	27	2.052
29	28	2.048
30	29	2.045
31	30	2.042
41	40	2.021
51	50	2.009
61	60	2.000
81	80	1.990
101	100	1.984
1001	1000	1.962





Sample statement:

'The changes in density for Species 1 and Species 2 are statistically significant at the 5% level. The density of Species 1 increased by 120 (±30) individuals per hectare while Species 2 increased by 260 (±50). Both species more than doubled their density following the fire, which is expected because they are seeders. For Species 3 there is too much variability in the data to assert that the estimated change (-20 ±40) is statistically significant at the 5% level.'

[The amounts in brackets are the 95% confidence intervals around the estimates.]

Sample statement:

'The changes in density for Species 4 in all areas are statistically significant at the 5% level. The density per hectare decreased by 130 (±30) in Area 1, 240 (±20) in Area 2 and 150 (±50) in Area 3.

The management objectives for the burns were to at least halve the density of Species 4 (because it is a pest plant). The pre-burn densities were about 250 individuals per hectare in all areas, which means that the density needed to decrease by at least 125 individuals. This management objective was only achieved in Area 2. In Areas 1 and 3 the confidence intervals overlap -125, which means that although density is estimated to have decreased by at least 125 individuals per hectare, there is insufficient precision in those areas to assert that the density has halved (using a test at the 5% level).'

When interpreting these sample graphs you should consider:

- the **statistical significance** of any changes. If the 95% confidence interval crosses zero, then there is too much uncertainty in the estimated change to be confident that a change has occurred (at the 5% level) – the change is not statistically significant
- the **ecological significance** of any statistically significant changes. This is where you consider the size of change – how much change matters from an ecological perspective? This will vary depending on life history of the species, management objectives for that species and how frequently the species occurs in the area. For example, a 20% decrease in the density of a species may have more ecological significance if the species is rare in the area as opposed to being common.

Figure 12: A graph with sample data about estimated change in density for several species in a single monitoring area (left); and a single species across several monitoring areas (right). Accompanying this graph are some suggestions for interpreting the graph and a sample statement for describing each graph.

3.3.8.3 Estimating change in the cover

If you are interested in differences in the cover of a species within a monitoring area then you should consider looking at the number of plots within each cover class for a species.

Cover is most sensitive to changes that are related to plant vigour (rather than recruitment or loss). It can be sensitive to the growing season and thus you should make sure the pre-burn and post-burn assessments occur at the same time of year. You should use cover for clumping species that are difficult to count.

Tally the number of plots in each cover class for a species (see Table 7) using pre-burn data and then post-burn data.

Table 7: Tally of the number of plots within each cover class for various species. In this example the total number of plots equals 20.

		Species name				
		Species 1	**Species 2**	**Species 3**	**Species 4**	**Species 5**
Cover class	0	0	18	4	2	19
	+	0	2	6	0	1
	1	3	0	9	12	0
	2	12	0	1	6	0
	3	5	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0

Combine the pre-burn and post-burn tallies into a single table for easy visualisation of the results (see Table 8). You can display the change between assessments for each cover class as an additional row. You can also display the change data graphically in a bar chart.

Table 8: A table with sample data about differences in the number of plots within each cover class for flora species across a burn unit. Accompanying this table are some factors to consider when interpreting the data and a sample statement of how to describe the data.

Cover Class	Timing of Observation	Species 1	Species 2	Species 3	Species 4	Species 5
0	Pre-burn	0	18	4	2	19
	Post-burn	0	5	7	2	20
	Difference	0	-13	+3	0	+1
+	Pre-burn	0	2	6	0	1
	Post-burn	5	10	10	12	0
	Difference	+5	+8	+4	+12	-1
1	Pre-burn	3	0	9	12	0
	Post-burn	12	5	3	3	0
	Difference	+9	+5	-6	-9	0
2	Pre-burn	12	0	1	6	0
	Post-burn	3	0	0	3	0
	Difference	-9	0	-1	-3	0
3	Pre-burn	5	0	0	0	0
	Post-burn	0	0	0	0	0
	Difference	-5	0	0	0	0
4	Pre-burn	0	0	0	0	0
	Post-burn	0	0	0	0	0
	Difference	0	0	0	0	0
5	Pre-burn	0	0	0	0	0
	Post-burn	0	0	0	0	0
	Difference	0	0	0	0	0

Sample statement:

'The cover within the 20 plots appears to have decreased for Species 1, 3 and 4 while for Species 2 it has increased and for Species 5 it remains unchanged. How representative these differences are of the monitoring area in general has not been assessed.'

When interpreting this data you should consider that:

- no formal **statistical analysis** was undertaken. This means that there is no measure of the statistical significance of the changes that you are observing. The explanation for any differences may be variability in the data or a real difference – without analysis you have no means for deciding which.

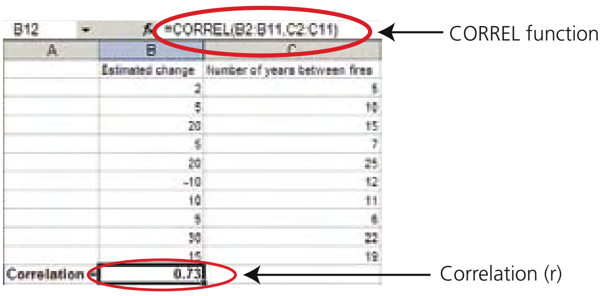
3.3.8.1 Investigating associations

If data have been collected from several monitoring areas then you may be interested in investigating an association between a population parameter (such as frequency of occurrence, density or cover) and a possible causal factor (such as the number of years between fires). There are several different ways of investigating these relationships. One simple way is to summarise the data in a scatterplot. This approach can be used when the possible causal factor is numerical rather than categorical. When undertaking and interpreting this type of analysis the difference between associations and causations should be made very clear (see Section 2.7.4.2).

Figure 13 is a scatterplot comparing frequency of occurrence to the number of years between fires for ten different monitoring areas. Scatterplots can illustrate the *form*, *strength* and *direction* of associations.

- The *form* of the scatterplot is the general shape of the data (if any) (such as linear or exponential).
- The *strength* of an association is determined by how closely the points follow a clear form.
- The *direction* is either negative or positive (does frequency of occurrence increase or decrease with the factor of interest).

If the form of the association appears to be roughly linear (as a straight line) then you can calculate the correlation coefficient (*r*) to measure the strength and direction of the relationship. The correlation can be most simply calculated in Microsoft Excel by using the CORREL function:

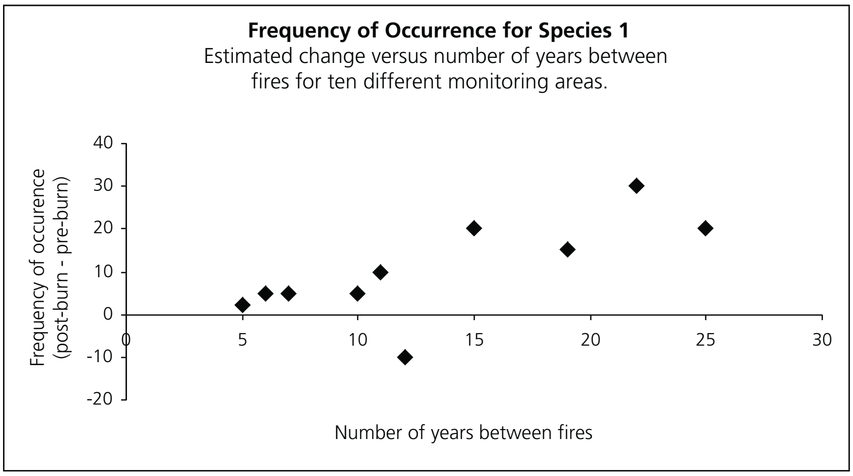


B12 =CORREL(B2:B11,C2:C11)

A	B	C
	Estimated change	Number of years between fires
	2	5
	5	10
	20	15
	5	7
	20	25
	-10	12
	10	11
	5	6
	30	22
	15	19
Correlation	0.73	

The correlation is always between -1 and 1. The strength of the association increases as the *r* value moves closer to either -1 or 1. The points lie exactly along a straight line if the r value is -1 or 1. A positive *r* indicates a positive association between the variables (i.e. the variables increase together) and a negative r indicates a negative association between the variables (i.e. the variables decrease together).

You should also look for any striking deviations in your scatterplot. An outlier is an important deviation (the -10 value in Figure 13 is a potential outlier). The correlation may be strongly affected by outliers, so be cautious if outliers exist in your data.



Sample statement:

'The association between the change in frequency of occurrence for Species 1 and the number of years between fires can be reasonably summarised in a straight line (linear) relationship. The size of the post-burn frequency of occurrence relative to the pre-burn frequency of occurrence increases as the number of years between consecutive fires increases. The correlation coefficient suggests that this relationship is moderately strong for the ten monitoring areas (r = 0.73).'

Figure 13: A scatterplot with sample data for ten different monitoring areas of the estimated change in frequency of occurrence for Species 1 versus the number of years between fires. Accompanying this graph is a sample statement for describing the graph.

When you are investigating an association you should be careful in your choice of monitoring areas for pooling data. The monitoring areas need to be as similar as possible in all respects except the causal factor that you are investigating. For example, if the causal factor is the number of years between fires then you should try to select monitoring areas where the EVC, fire severity, burn season and extent of grazing are the same. This is particularly important when there are not many monitoring areas from which to pool the data.

3.3.9 Interpreting the outcomes of your data analysis

In Section 3.3.8, we introduced methods for estimating change and then associating this change with causal factors. This section discusses how to interpret the outcomes of this analysis.

Three broad ways in which the data from this assessment can help management were outlined earlier in the guide (Table 3). To recap, they were:

- assess the effectiveness of management actions in achieving their objectives at the local or landscape scale
- better understand the effects of other factors (such as fire season, fire severity, drought or grazing) on the timing of life-stages for indicator species
- better understand the effects of different fire regimes on the relative dominance of the indicator species.

For the first of these, you need to have a clear idea of what was planned to occur as a result of the burn. This should be a part of the management objective for the burn. Your burn may have been planned to double the density of a particular species by a specified time interval after the burn, or eliminate a weed species. Whatever the objective, you should compare the change in abundance (frequency or occurrence, density or cover) that you estimated during the data analysis to the planned burn outcome to assess whether that outcome was achieved. Sometimes the planned outcomes from the burn may not be clearly stated in the management objective. For these situations you should use existing monitoring data or trend lines such as those shown in Figure 3 to predict what is likely to occur as a result of the burn and then compare the observed outcomes to see whether or not those predictions were correct.

The curator of the flora vital attributes database should interpret the data for each species in relation to the timing of life-stages. The curator should consider whether the timing of the life-stages differs when attributes of the fire regime or other causal factors vary.

Finally, you should use scatterplots (and correlation values) to better understand the effects of the fire regime (and other potential causal factors) on the relative dominance of indicator species. As discussed in Section 2.7.4.2 associations are not the same as causations. However, in your interpretation of a scatterplot (such as that shown in Figure 13) you can use common sense to decide whether the factor of interest stands a good chance of being a causal factor. Consider the following:

- the strength of the association. For a straight line (linear) association this is measured by the correlation coefficient (r). The closer this value is to 1 or -1, the stronger the association. For other types of associations you should look at how closely the data fit a curve
- the consistency of the association. You should look at data from many different monitoring areas to assess whether the association you have observed occurs in other areas
- the timing of the causal factor and the change. To cause a change the factor needs to precede the change
- the plausibility of this factor being the causal factor. Does it seem logical and reasonable that this factor be a causal factor?

3.3.10 Datasheet

The following two pages contain the blank field datasheet with key reminders for the method on the reverse side. You should photocopy these pages to use for your monitoring in the field.

Indicator-species assessment (September 2008)

Page ____of _____

Area name			
Assessors and organisation		Assessment date	
EVC		Burn No.	

Number of years since the area was last burnt (from 'fire plan' map)		Verify last-burnt data (tick one box)		Appears to be correct
				Appears the be more years since last burnt
				Appears to be less years since last burnt

Further comments (about fire regime, e.g. fire season or fire severity)	
Further comments Record details about other variables of interest (e.g. drought, grazing)	

Plot name or number	Zone	54 55 (circle one)						GPS accuracy (m)	Indicator species																	
	GPS coordinates (GDA94) Easting / Northing								Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		

Cover-abundance classes
0 = cover 0%, species absent
+ = cover < 5%, few individuals
1 = cover < 5%, more than a few individuals
2 = cover 5-20%, any no. of individuals
3 = cover 20-50%, any no. of individuals
4 = 50-75%, any no. of individuals
5 = 75-100%, any no. of individuals

Rules for density estimation
0-20: count individuals
20-50: estimate to the nearest 5
50-100: estimate to the nearest 10
100-300: estimate to the nearest 20
300-1000: estimate to the nearest 50
Over 1000: estimate to the nearest 100

Life-stage categories
J = juvenile, a plant that is not reproductively mature.
M = mature, evidence of flowers or seed.
S = senescing, dead or dying.
U = unknown, uncertain about other categories.
A = species absent.

More space to record species information…

Page ____of _____

Plot name or number	Zone			54 55 (circle one)				GPS accuracy (m)	Indicator species																	
	GPS coordinates (GDA94) Easting Northing								Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage	Cover	Density	Life stage
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		
	0																									
								Comments:																		

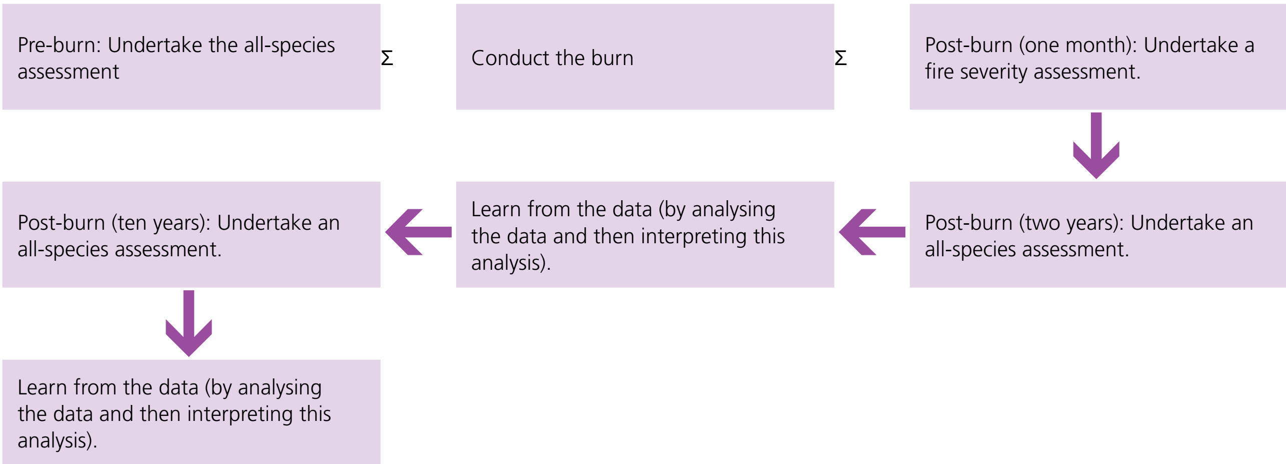
Reminders for the assessor

- You should monitor at least six key fire response species. See description in Section 3.2.5 of the *User's guide* for detailed steps for key fire response species selection.
- Record genus and species, not common names.
- For each assessment there should be only one EVC and last-burnt year.
- Use a map to identify the EVC and then verify this in the field.
- Use a map to identify the year that the area was last burnt and then verify this in the field.
- Plots should be circular with a 2.5 metre radius.
- Plots should be roughly equal distances apart (generally at least 50 metres, smaller distances may be necessary if the monitoring area is small).
- There should be a minimum of 20 plots in a monitoring area. Do more plots if area is large or vegetation sparse.
- The accuracy of the GPS reading needs to be better than 10 metres.
- Record the number of individuals and percentage cover for each indicator species.
- Before recording a species as absent you should make sure that it definitely isn't there.
- Record the dominant life-stage for each indicator species. Choose and record the category that describes the majority of individuals for a species. If there is more than one dominant life-stage then record them both.

3.4 Flora all-species assessment

Objective: To determine the extent to which key fire response species can be used as indicators for all species following fire.

Objective: To estimate the size of change in species composition following fire.



This assessment looks at the cover and life-stage for all vascular flora species. By assessing all species you should be able to learn directly about species composition, rather than infer it from indicator species. However, the time to assess each plot is longer than for the indicator-species assessment.

You should repeat this assessment in an area several times over a period of years (pre-burn, two years post-burn, five years post-burn [optional] and ten years post-burn). You should also undertake a fire severity assessment after the burn. Section 3.5 presents the method for this.

You should establish at least three plots per Ecological Vegetation Class (EVC) in each monitoring area. You should mark these plots permanently so they can be accurately and reliably relocated for repeat assessments.

3.4.1 Assessor requirements

Before starting an assessment you need to consider the assessor requirements to determine whether you can meet them now and in the future.

Preferably assessors should undertake this assessment in pairs. At least one assessor needs to have botanical skills to identify flora species in the field. The assessors must also known how to use a GPS.

Assessments would need to take about a day per EVC in an area (two hours per plot plus travel time between plots). Often in a given area you will need to assess only one EVC.

You should allocate additional time in the office for plant identification and data entry.

3.4.2 Equipment requirements

You will need at least the following items of equipment:

- GPS
- 100 metres measuring tape
- plant identifcation books
- field datasheets
- clipboard
- pencils
- bags for plant samples
- research permit (if samples are collected).

3.4.3 Timing

You should undertake the series of assessments according to the timeline shown in Figure 14, which recommends that:

- All the flora assessments should occur at the same time of year (preferably late spring to early summer). This is because:
  - the evidence of many species is highly dependent on the time of year
  - identifying species during autumn and winter when they are not in flower is often much more difficult.
- The pre-burn flora assessment should occur less than two years before the burn and preferably less than one year beforehand.
- The first post-burn flora assessment should occur about two years after the burn. This will allow enough time for the plants to grow to a size where you can identify them.
- Subsequent post-burn assessments should occur five years (optional) and ten years after the burn.
- The post-burn severity assessment should occur before the plants recover much from the fire. The timing of this will depend on the vegetation type and post-fire climatic conditions but could be any time from two weeks to a few months after the burn.

If a bushfire burns in the monitoring area during the ten year monitoring period then you should plan to undertake another post-burn severity assessment and then re-monitor the area using the same indicator-species assessment methodology at new two-year, five-year (optional) and ten-year intervals. If the bushfire burns a large number of plots across many monitoring areas then, due to resource constraints, you may need to prioritise and re-monitor only some areas, or adjust the timeframes, or both.

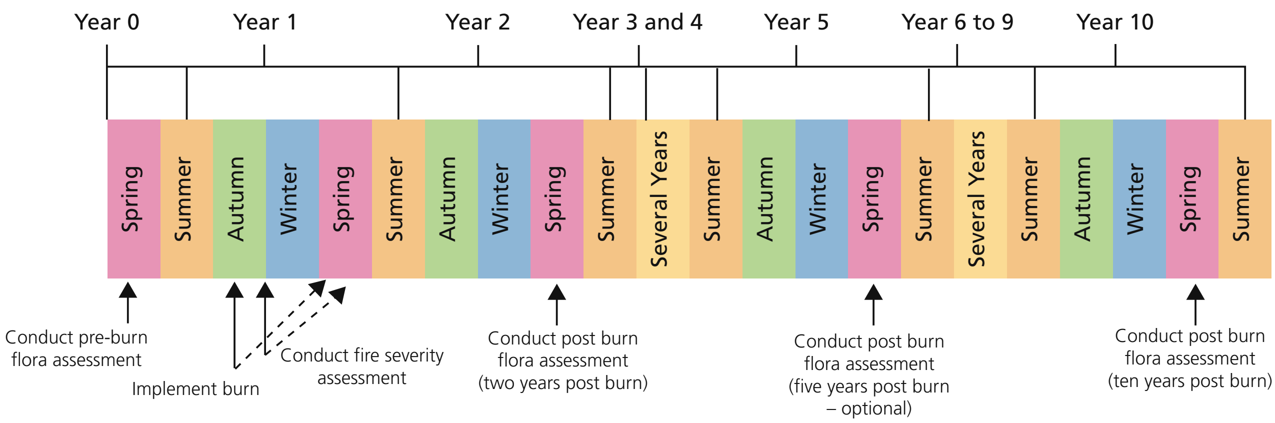


Figure 14: Timeline for the flora all-species assessment

3.4.4 Selecting the monitoring area

You may apply the all-species assessment to a selection of burns in a given season, rather than to all burns. You should spend some time selecting the most appropriate areas to monitor and should consider several factors in addition to those described in Section 2.3 (knowledge gaps, access, topography and terrain). You should give priority to areas where these factors intersect. The additional factors are:

1. New or different management practices
To optimise the amount that you and others can learn from the monitoring, you should target areas where the management action being applied is new or different. For example, you may choose to target an area in which the season of burning is to be spring rather than autumn, or the ignition pattern is to be unusual or different.

2. Ecological Vegetation Class
You should target your monitoring towards Ecological Vegetation Classes (EVCs) that are a priority for monitoring. Generally EVCs are a high priority for monitoring when:
- the number of hectares in the planned burn program is high for that EVC relative to the total area of that EVC
- understanding of the flora response to fire within the EVC is lacking (i.e. little vital attribute information is available)
- people think that the plants of the EVC are sensitive to fire events or they think there is a decline of a species from an EVC as a result of fire.

3. Fire management zone
You can undertake monitoring in any fire management zone. However, the 'strategic fuel reduced corridor' (formerly Zone 2) and the 'ecological management zone' (formerly Zone 3) are more useful areas in which to target your monitoring because burn regimes in those areas are more flexible and therefore the outcomes of your monitoring can influence those burning regimes more readily.

4. Fire and disturbance history
To optimise the potential useability of your data you should select areas for which the disturbance history is known. Fire is a common disturbance but you should also consider others such as logging, disease, drought and storm damage.

Where the last-burnt year is known you should target your monitoring towards areas that are either long unburnt or planned to be burnt near the minimum tolerable fire interval for that EVC. You can also target EVCs with repeated fires recorded near the minimum tolerable fire interval.

5. Existing plots
Before selecting a monitoring area, you should identify in Argus any other monitoring plots in the area. Using existing plots may be valuable if they fall within the proposed monitoring area even if the previous assessment type was different.

6. Degree of interest
You should choose to give priority to areas that are of a greater interest to the general public or land managers (e.g. high profile burns). There could be a variety of reasons for this interest such as the geographic location of the burn or the value of the area to a local community.

3.4.5 Assessment methodology: pre-burn

You should undertake the following steps during an assessment:

1. Obtain a map of the monitoring area that shows contours, watercourses, roads, EVCs and a coordinate grid.

2. Determine the number of assessments you will undertake in the area. This will depend on
- how many EVCs you are interested in
- how many last burnt years you are interested in.
- how many other factors (e.g. fire season or grazing) you are interested in.

Calculate how many combinations of the 'EVC by last-burnt year by other factor' you plan to assess within the area (i.e. calculate how many 'stratification units' you plan to assess).

3. Using your map of the area, identify 10–20 potential locations for your plots in each stratification unit. If practicable, first drive around the perimeter of the monitoring area to get a quick idea of the site characteristics and best potential locations for plots. Ideally you should locate plots where:
- access is reasonably easy
- roads and tracks are more than 50 metres away – to avoid edge effects
- the vegetation is representative of the EVC in the area
- the EVC boundary is at least 200 metres away
- there is some distance between each plot
- the planned burn is likely to burn
- Identify at least ten potential plot locations

For each stratification unit, randomly select three or more of the potential plot locations. You could do this by, for example, numbering each potential plot and then drawing numbers out of a hat to select three.

When planning the assessment you should preferably consult the Fire Management Officer or Burn Officer in Charge to find out how they expect to conduct the burn. This will provide further guidance on placing plots in locations that are more likely to be burnt.

4. Navigate to the first plot.

5. Use a measuring tape and flagging tape to mark the plot boundary (see Figure 15 for plot layout). The plot should be square with 20 metres length.

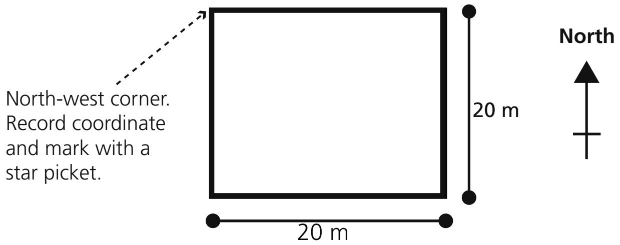


Figure 15: Plot layout for all-species assessment.

6. Mark the north-west corner of the plot with a star picket so that you or someone else can find the exact location of it at another time, perhaps several years after the burn.

7. Record the following general information on your datasheet:
- area name, e.g. Wilsons Promontory – Tidal Overlook
- plot name – a unique code for each plot, e.g. W01, W02 etc. Choose codes that are easy to enter into the GPS and least likely to become confused with plots names from other assessments over the years
- plot location – provide a brief description of how to find your plot and any significant landmarks that will make it easier to find
- assessor names
- assessment date i.e. the date that the assessment took place in the field
- aspect – the direction that the plot is facing
- slope – the slope of the plot in the direction that it is facing
- Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
- number of years since the area was last burnt. You should use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map'
- make any additional comments about the area particularly in relation to other variables you have stratified for (such as evidence of heavy grazing or drought).

8. Record the location of your plot point by taking a GPS reading from the north-west corner. You should record the coordinates on the field datasheet and also mark them as a waypoint in the GPS. In the datasheet you need to record:
- the full easting and northing coordinates using the Geocentric Datum of Australia 1994 (GDA94). Both coordinates have seven digits but the datasheet already shows the first digit of the easting because that digit in Victoria is always zero
- the zone, i.e. Zone 54 or Zone 55
- the GPS accuracy in metres (this should be better than 10 metres). You may need to wait a little longer until the GPS acquires signals from more satellites.

9. Identify every species of vascular plant within the plot and record the species name (genus and species) on the datasheet.

10. Estimate and record the percentage cover for each species using the modified Braun-Blanquet cover classes:
0 = cover 0%, species absent
+ = cover < 5%, few individuals
1 = cover < 5%, more than a few individuals
2 = cover 5–20%, any number of individuals
3 = cover 20–50%, any number of individuals
4 = cover 50–75%, any number of individuals
5 = 75–100%, any number of individuals

11. Estimate and record the dominant life-stage for each species using the following categories:

- **juvenile** (**J**) – a plant that is not reproductively mature.
- **mature** (**M**) – a plant that is reproductively mature and shows evidence of flowers, fruit or seed.[21]
- **senescing** (**S**) – a plant that is senescing or dying. Include plants that are completely dead if you can identify them.
- **unknown** (**U**) – you are unable to determine life-stage because there is no evidence of flowers, fruit or seed, or for some other reason. If you are in doubt then use this category. Though a lack of data is disappointing, wrong data can be quite misleading and have bad consequences.

Generally to determine life-stage the assessor should look for evidence of flowers or fruit. In winter or autumn this may be difficult.

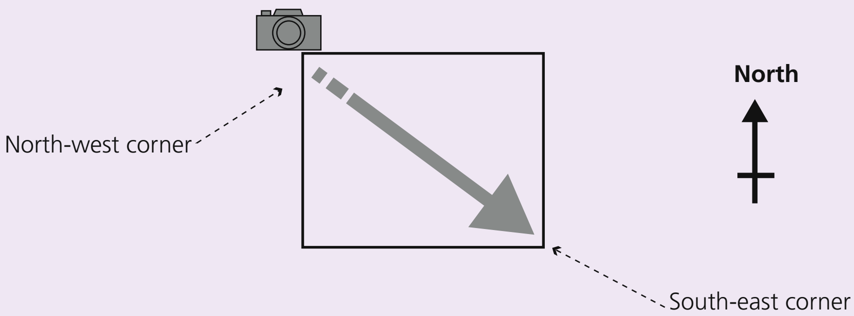
'Dominant' is defined as the life-stage that you observe for the greatest number of individuals. If two life-stages are equally dominant, record both.

12. Take a photo of the plot following the steps outlined in Box 5.

Box 5: **How to set up a photo point for the all-species assessment**

You can add value to your data by taking a photo of your plot to create a visual reference. If you take it well, these photos can become a useful communication tool. You should undertake the following steps:

1. Prepare a label for your photo. A black marker pen on a laminated piece of white cardboard can do the trick or you can use a small white board. On the label you should record the:
   - name of the monitoring area
   - name of the plot
   - date.
2. If possible, choose a time of day with few shadows, such as in the middle of the day when the sun is overhead, or preferably when the sun is behind cloud.
3. Stand in the north-west corner of the plot (where the star picket is located) and face towards the south-east corner.
4. Compose your photo in the view-finder of your camera. Point the camera diagonally across the plot towards the south-east corner. Have someone hold the photo label in the corner of the photo. Make sure that it is close enough to read but doesn't obstruct the photo too much.
5. Take the photo.
6. Record the photo number on your data sheet.
7. Repeat process from south-east corner of the plot.



13. Repeat steps 4 to 9 for the remaining plots within the monitoring area.
We recommend at least three plots per monitoring area. This number is based on the assumption that you or others will pool data across numerous monitoring areas to analyse data and draw conclusions.
If you wish you may complete more plots in an individual monitoring area. This would be particularly useful if the number of monitoring areas within the same EVC is likely to be small or if you want to make conclusions about an individual area.

21 The presence of flowers, fruit or seed does not necessarily mean that the species will regenerate adequately after the burn. Full, mature seed production often occurs some years after the first flowering season. Before this stage, there may not be enough seed for adequate regeneration. Of course regeneration is also a function of other influencing factors in the area such as drought, grazing pressure or fire severity. Furthermore, the definition of 'adequate regeneration' is a function of the management objective, which may vary over time and space. All this needs to be kept in mind when using the life-stage data collected from this assessment.

3.4.6 Assessment methodology: post-burn

You should undertake the following steps during a post-burn assessment:

1. Download the pre-burn plot coordinates from Argus, the fire monitoring database. Upload these coordinates into a GPS. You will undertake the post-burn assessments at these same plots.
2. Navigate to the first plot. It may help to use the plot coordinates (from the pre-burn assessment) as waypoints in your GPS.
3. Record the following general information on your datasheet:
   - area name – use the same name as the data shows for the pre-burn assessment
   - plot name – use the same name as the data shows for the pre-burn assessment
   - plot location – record any changes to navigational landmarks, etc. that help with finding the plot
   - page number of assessment sheet and the number of assessment sheets used
   - assessor names
   - assessment date
   - aspect of plot – this should be the same as the data shows for the pre-burn assessment
   - slope within the plot – this should be the same as the data shows for the pre-burn assessment
   - Ecological Vegetation Class (EVC) – you should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
   - number of years since the area was last burnt. Given that this is a post-burn assessment, you should have a good record of this from your fire severity assessment (see Section 3.4). If not then use a map to identify the year that the area was last burnt and then verify this in the field. You can find fire history maps on the DSE website. Search for 'interactive maps' and then open the 'fire plan map'.
4. Make additional comments about the area that may be important, e.g. evidence of heavy grazing or cinnamon fungus.
5. At the plot point record the GPS accuracy in metres (this should be better than 10 metres).
6. Repeat steps 8 to 10 from the pre-burn assessment methodology.
7. Navigate to the second plot point.
8. Repeat steps 2 to 7 until you have re-assessed all the pre-burn plots.

3.4.7 Analyse the data

The monitoring objectives for this assessment type are:

- to estimate the size of change in species composition following fire
- to determine the extent to which key fire response species can be used as indicators for all species following fire.

Therefore the data analysis should compare the pre-burn and post-burn data to estimate the size of any changes to species composition and then compare those changes with any changes observed solely for the key fire response species.

Since the all-species assessment collects information about all species, several new population parameters can be used that were not available with the data from the indicator-species assessment. These parameters are species richness, species diversity and species composition. This section discusses ways in which changes to these parameters can be estimated and correlations between changes and potential causal factors can be investigated.

The all-species assessment also collects categorical data for each species (presence or absence and species cover). This data can be analysed using the same methods described in Section 3.3.8 for the indicator-species assessment, except that there is no point calculating 95% confidence intervals for individual monitoring areas because there are only three plots. You should be particularly cautious of any conclusions that you draw from an individual monitoring area because of the small number of plots.

Data about the timing of the life-stages for all species is also collected by the all-species assessment. This information should be used, together with the data from the flora vital attributes assessment, by the curator of the flora vital attributes database.

3.4.7.1 Estimating change in species richness (for above-ground species)

A measure of species richness is a simple way of summarising your data for an individual monitoring area or for several monitoring areas. Species richness is the number of species in an area. It provides no indication of the types of species.

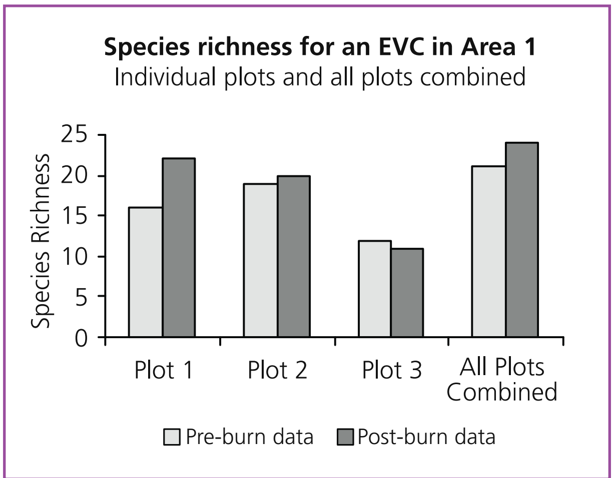
You can compare the species richness on a plot-by-plot basis or compare the combined species richness for pre-burn and post-burn plots. **Take care when simplifying the data into species richness figures because such simplification can mask important detail** (such as an increase in a weed species offsetting a loss in an indigenous species).

The graph on the left in Figure 16 shows the species richness for an individual monitoring area. Data is displayed on a plot-by-plot basis and then for all three plots combined (i.e. the total number of species observed across the area).

The graph on the right in Figure 16 shows the average species richness for a group of similar monitoring areas. The 95% confidence intervals for these average values are also shown.

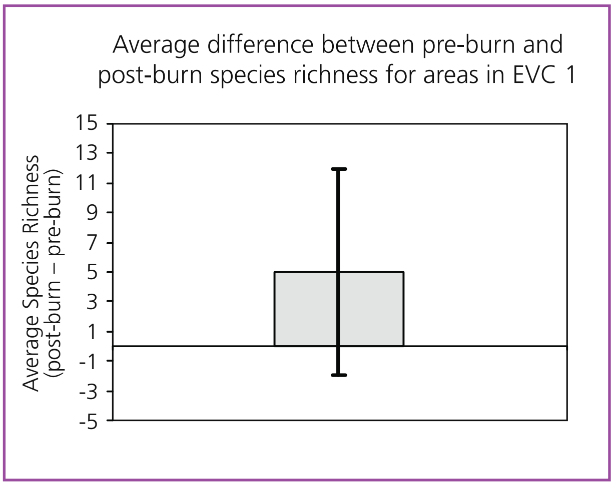
Box 6 describes the methodology for calculating the average species richness and the 95% confidence interval for this average. This method is very similar to the method described in Section 3.3.8 for species density. When pooling data from several different monitoring areas for this analysis you should make sure that the monitoring areas are as similar as possible (same EVC, same fire regime, etc.) so there is minimal variability in the data.

To determine whether there is a statistically significant difference between the pre-burn and the post-burn species richness you should calculate a difference value (as described for frequency or occurrence and density in Section 3.3.8) and the 95% confidence interval for this value. There is a statistically significant difference if the confidence interval does not overlap zero.



Sample statement:

'In plots 1 and 2, as well as overall, the pre-burn species richness was slightly lower than the post-burn species richness. How representative these differences are of the monitoring area in general has not been assessed.'



Sample statement:

'The estimated difference between the pre-burn species richness and the post-burn species richness is not statistically significant at the 5% level (5 ±7).'

When interpreting these sample graphs you should consider:

- the **statistical significance** of any changes. For the graph on the left the statistical significance of the changes has not been calculated for individual plots or for all plots combined because there are too few plots and therefore any statistical analysis would be weak. For the graph on the right, the substantial overlap of the 95% confidence intervals for the pre-burn and post-burn data indicate that there is too much variability in the data for the estimated difference between the pre-burn and post-burn data to be significantly significant (at the 5% level). To further confirm this, you should calculate difference values and 95% confidence intervals for these values to see if they overlap zero.
- the **ecological significance** of any statistically significant changes. This is where you consider the size of change – what level of change to species richness matters from an ecological perspective?

Figure 16: A graph with sample data about differences in species richness for flora across a monitoring area. Accompanying this graph is a sample statement of how to describe the data.

Box 6: **Steps for calculating the average species richness for several monitoring areas, the average difference between pre-burn and post-burn species richness and the 95% confidence interval for this average difference.**

Species richness is the number of species within a defined area.

Calculate the species richness for an individual monitoring area:

To calculate the species richness for an individual monitoring area count the total number of species that you observed across all the plots (usually three) within a stratification unit (e.g. the same EVC and same last burnt year).

For example, the species richness for three plots would be 16 if:

- plot 1 has 10 species,
- plot 2 has 12 species but 6 are the same as those observed in plot 1, and
- plot 3 has 8 species but all are the same as those observed in plots 1 and 2.

Calculate the average difference between pre-burn and post-burn species richness:

In an individual area if you compare the pre-burn and post-burn species richness it may appear that the richness has changed (increased or decreased). The next step would be to see whether this change is occurring across more than one area.

For each individual monitoring area you should subtract the pre-burn species richness ($R_{pre\text{-}burn}$) from the post-burn species richness ($R_{post\text{-}burn}$).

$$R_{Difference} = R_{post\text{-}burn} - R_{pre\text{-}burn}$$

You should then calculate the average difference values for several monitoring areas by summing the difference values for each monitoring area and then dividing this by the total number of monitoring areas.

$$\hat{R}_{Difference} \quad \frac{(R_{Difference1} + R_{Difference2} + R_{Difference3} \ldots + R_{Difference"n"})}{n}$$

Where is $\hat{R}_{Difference}$ the average difference in species richness between pre-burn and post-burn areas, $R_{Difference"n"}$ is the richness for an individual area and n is the number of monitoring areas.

Calculate the 95% confidence interval for the average difference:

To calculate a 95% confidence interval for the estimated average difference first calculate the standard error ($SE_{Difference}$):

$$SE = \frac{s}{\sqrt{n}}$$

Where s is the sample standard deviation. The STDEV function in Microsoft Excel can be used to calculate the sample standard deviation (as illustrated in Section 3.3.8).

Then calculate the 95% confidence interval:

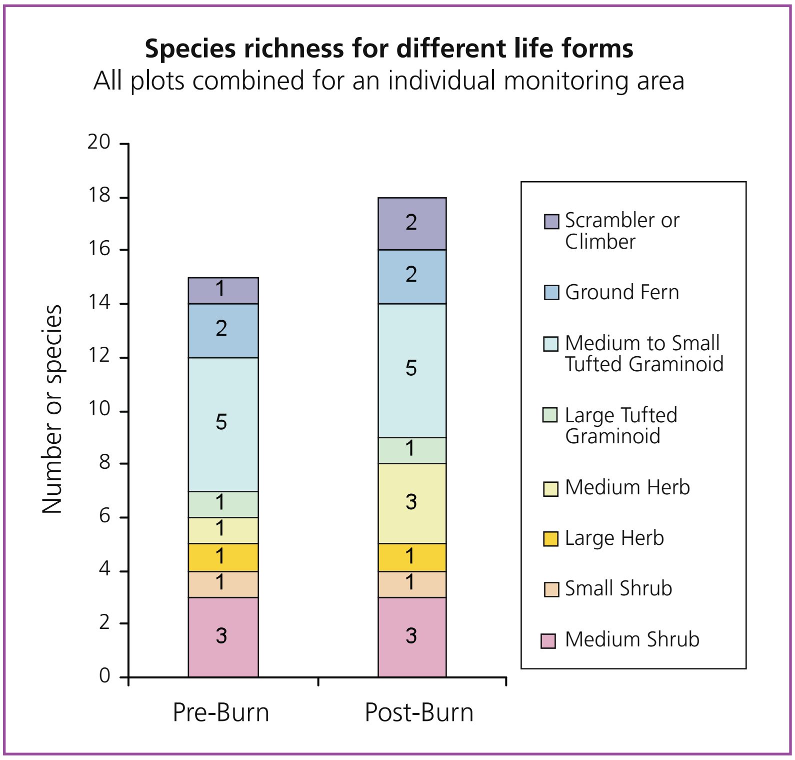
$$\hat{R}_{Difference} \pm t \times SE$$

You can determine t values by using Table 4 (in Section 3.3.8) or by looking at a table of the t distribution in many statistical books. A 95% confidence interval requires the 0.975 quantile of the distribution. Find the corresponding t-value for the number of monitoring areas (n) that you assessed.

As a general rule, this 95% interval is approximately correct when the sample size (n) is sufficiently large, e.g. when there are more than 20 monitoring areas.

When drawing any conclusions about the data you should take into account the width of the confidence intervals. There is 95% confidence that the *true* difference between pre-burn and post-burn density occurs somewhere within the confidence interval.

It can be useful to show more detail about the types of species that are appearing or being lost from an area. This can be done by continuing to use species richness but separating the data into life-form groups. Figure 17 provides an example of how this can be done for an individual monitoring area.



Sample statement:

'Overall species richness has increased. There are two more medium herb species and one more scrambler species. How representative these differences are of the monitoring area in general has not been assessed.'

Figure 17: A graph with sample data about changes in overall species richness for different life-forms across a monitoring area. Accompanying this graph is a sample statement of how to describe the data.

3.4.7.2 Estimating change in species composition

The species composition refers to the composition (or mix) of species in an area. Although the all-species plots may not detect every species in the stratification unit (e.g. same EVC and same last-burnt year) of a monitoring area, the plot size should be large enough to detect most species in at least one of the three plots.

The most common way to view data on species composition is in a species list. However, rather than listing the species alphabetically, you can gain more value by ranking them from most to least according to some parameter such as cover. Before ranking them, grouping them according to life-form can add further value. Table 9 provides an example that compares pre-burn and post-burn results and groups species according to life-form.

Table 9: A table with sample data about differences in species composition across a burn unit. Accompanying the table are some factors to consider when interpreting the data and a sample statement of how to describe the data.

			Cover class					
			Plot 1		Plot 2		Plot 2	
Life form	**Species name**	**Common name**	**Pre-burn**	**Post-burn**	**Pre-burn**	**Post-burn**	**Pre-burn**	**Post-burn**
Medium shrub	*Leptospermum continentale*	Prickly Tea-tree	3	4	3	4	4	4
	Melaleuca squarrosa	Scented Paperbark	2	3	3	2	3	1
	Epacris obtusifolia	Blunt-leaf Heath	1	+	+	0	+	+
Small shrub	*Epacris lanuginosa*	Woolly-style Heath	1	+	1	1	+	0
Large herb	*Xyris operculata*	Tall Yellow-eye	0	+	0	+	+	+
Medium herb	*Selaginella uliginosa*	Swamp Selaginella	+	+	0	0	2	+
Large tufted graminoid	*Xanthorrhoea australis*	Austral Grass-tree	1	+	2	1	2	+
Medium to small tufted graminoid								
	Lepidosperma filiforme	Common Rapier-sedge	1	+	1	+	0	1
	Leptocarpus tenax	Slender Twine-rush	1	+	+	+	0	0
	Empodisma minus	Spreading Rope-rush	0	0	+	0	1	+
	Baumea tetragona	Square Twig-sedge	+	+	0	0	+	+
	Schoenus brevifolius	Zig-zag Bog-sedge	+	0	0	+	0	0
Ground fern								
	Gleichenia dicarpa	Pouched Coral-fern	2	+	2	+	1	+
	Lindsaea linearis	Screw Fern	1	+	0	0	+	+
Scrambler or climber	*Cassytha glabella*	Slender Dodder-laurel	+	+	+	+	+	+

Sample statement:

'In the three plots there was little difference in the species present but there was some difference in cover. *Leptospermum continentale* and *Xyris operculata* increased in cover after the burn while *Epacris obtusifolia*, *Xanthorrhoea australis* and *Gleichenia dicarpa* decreased in cover. How representative these differences are of the monitoring area in general has not been assessed.'

When interpreting this data you should consider that:

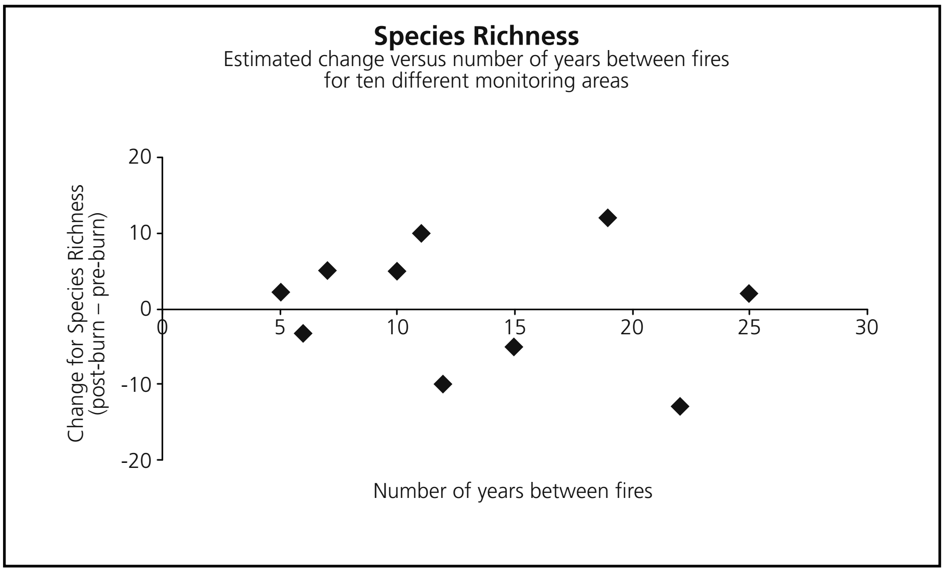
- no formal statistical analysis was undertaken. This means that there is no measure of the **statistical significance** of the apparent changes that you are observing. The explanation for any differences may be variability in the data or a real difference – you have no means for deciding which.

3.4.7.3 Associations

If data have been collected from several monitoring areas then you may be interested in investigating an association between a population parameter (such as species richness) and a possible causal factor (such as the number of years between fires). There are several different ways of investigating these relationships. One simple way is to summarise the data in a scatterplot. This same approach was described for the indicator-species assessment.

Figure 18 is a scatterplot examining the relationship of species richness to the number of years between fires for ten different monitoring areas. You should refer to Section 3.3.8.1 in the indicator-species assessment for further detail about interpreting this graph and calculating the correlation coefficient. When undertaking and interpreting this type of analysis the difference between associations and causations should be made very clear (see Section 2.7.4.2).

When you are investigating an association you should be careful in your choice of monitoring areas for pooling data. The monitoring areas need to be as similar as possible in all respects except the causal factor that you are investigating. For example, if the causal factor is the number of years between fires then you should try to select monitoring areas where the EVC, fire severity, burn season and extent of grazing are the same. This is particularly important when there are not many monitoring areas from which to pool the data.



Sample statement:

'The changes in species richness involve either increases or decreases of varying sizes from 0 to 13 species. There is no clear association between these changes and the number of years between fires (r = -0.12).'

Figure 18: A scatterplot with sample data for ten different monitoring areas comparing the estimated change in species richness to the number of years between fires. Accompanying this graph is a sample statement for describing the graph.

3.4.7.4 Testing the flora vital attributes model

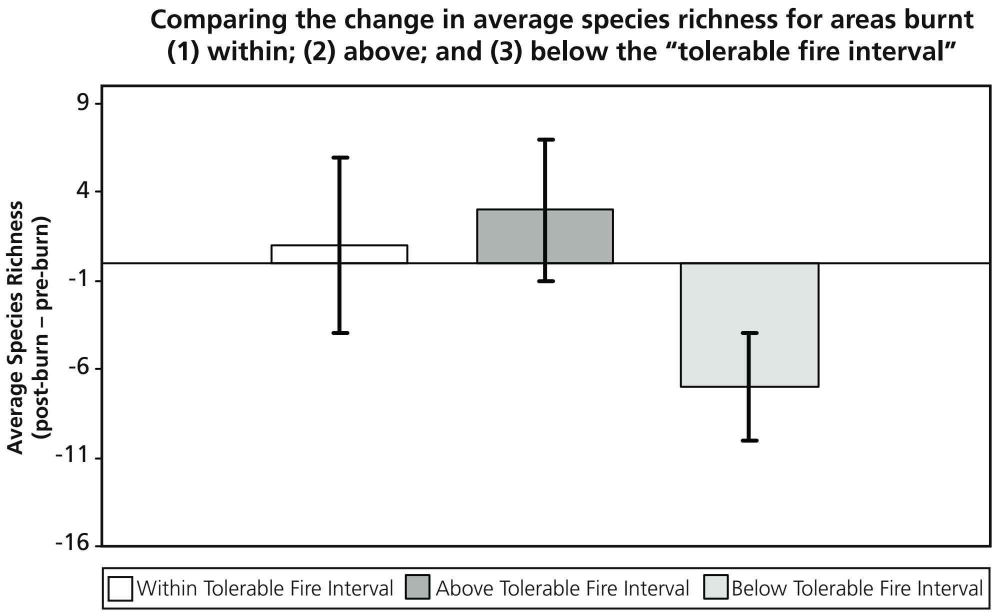
One of the monitoring objectives for this assessment type was to determine the extent to which key fire response species can be used as indicators for all species in a monitoring area. There are various ways of addressing this objective using a range of different population parameters for the all-species data (e.g. species richness, species diversity, species composition or species by species analysis). A simple example using species richness data is described here.

Figure 19 is the outcome of this simple analysis. It compares the average difference between pre-burn and post-burn species richness for monitoring areas within the same EVC that have been burnt within, above and below the 'tolerable fire interval'. You will need data from a number of monitoring areas to undertake this analysis. (For example, ten monitoring areas that have been burnt below the minimum fire interval, ten that have been burnt within the tolerable fire interval and ten that have been burnt above the tolerable fire interval.).

Ideally you should have the same number of monitoring areas in each category and they should be as similar as possible to reduce the amount of variability in the data. Follow the steps described in Box 8 to estimate the average difference between pre-burn and post-burn species richness and the 95% confidence intervals for this average difference.

To interpret the graph you should look at the 95% confidence intervals. If they overlap zero then the estimated difference between the average pre-burn and post-burn species richness is not statistically significant. Based on the flora vital attributes model you would expect that there may be a change in richness for areas burnt outside (above or below) the tolerable fire interval. Statistically significant changes should then be considered in relation to ecological significance. To do this, you need to have some idea of the amount to which species richness can fluctuate without detriment to the EVC, so you can determine the point at which the tolerable fire interval is not representative of the species in the EVC.

Species richness is a very convenient way to summarise the all-species data because it is a simple numerical value that can be more easily analysed than species composition data. However, you should always remember that **species richness data can mask important detail**. Therefore, species richness data should only be used to flag potential changes and should always be considered in conjunction with the more detailed data about the flora.



Sample statement:

'The average difference between the pre-burn species richness and post-burn species richness is not statistically significant at the 5% level for areas burnt within (1 ±5) and above (3 ±4) the tolerable fire interval. For areas burnt below the tolerable fire interval the difference is statistically significant with the average richness decreasing by 7 (±3). For this EVC a decrease of 5 indigenous species or more is considered ecologically significant. A closer examination of the species involved is required to determine ecological significance.'

When interpreting these sample graphs you should consider:

- the **statistical significance** of any changes. If the 95% confidence interval crosses zero, then there is too much uncertainty in the estimated change to be confident that a change has occurred (at the 5% level) – the estimated change is not statistically significant
- the **ecological significance** of any statistically significant changes. This is where you consider the size of change – how big a change in species richness are we willing to accept within a 'tolerable fire interval' and at what point do we say that the 'tolerable fire interval' is not representative of the species in the EVC.

Figure 19: Comparing the average difference between pre-burn and post-burn species richness for EVC 1 in monitoring areas burnt (1) within, (2) above and (3) below the tolerable fire interval. Accompanying this graph is a sample statement for describing the graph.

3.4.8 Interpreting the outcomes of your data analysis

This section discusses how to interpret the outcomes of the data analysis for the all-species assessment. Earlier this guide outlined four broad ways in which the data from this assessment can help management (Table 3). To recap, they were:

- assess the effectiveness of management actions in achieving their objectives at the landscape scale
- better understand the effects of other factors (such as fire season, fire severity, drought or grazing) on the relative dominance of all species
- better understand the effects of other factors (such as fire season, fire severity, drought or grazing) on the timing of life-stages for all species
- test the effectiveness of using key fire response species as surrogates for all species.

For the first of these, you need to have a clear idea of the landscape-level objectives in relation to planned burning. Your landscape objective may be to promote species diversity by creating a mosaic of age-classes across the landscape. Whatever the objective, you should compare the changes to all flora species that you estimated during the data analysis (species richness, composition or abundance for individual species) to the planned management outcome to assess whether it was achieved.

You can use scatterplots (and correlation values) to better understand the effects of fire regime (and other factors) on the relative dominance a flora species. As discussed in Section 2.7.4.2 associations are not the same as causations. However, in your interpretation of a scatterplot (such as that shown in Figure 23) you can use common sense to decide whether the factor of interest stands a good chance of being a causal factor. Consider the following:

- the strength of the association – for a straight line (linear) association this is the correlation (r). The closer this value is to 1 or -1, the stronger the association. For other types of associations you should look at how closely the data fit the model being considered
- the consistency of the association – you should look at data from many different monitoring areas to assess whether the association you have observed is occurs in other areas
- the timing of the causal factor and the change – to cause a change the factor needs to precede the change
- the plausibility of this factor being the causal factor – does it seem logical and reasonable that this factor be a causal factor?

The curator of the flora vital attributes database should interpret the data for each species in relation to the timing of life-stages. The curator should consider whether the timing of the life-stages differs when attributes of the fire regime or other causal factors vary.

Finally, for testing the effectiveness of using key fire response species graphs such as Figure 23 are a good start. There will usually be some change following fire, even if the fire interval is tolerable (as defined by the key fire response species). You need to decide what level of change is acceptable when burning within a tolerable fire interval and what level of change is not acceptable. The species richness data can be used to flag when a statistically significant change has occurred. The actual species that have been gained or lost will probably determine whether this change is acceptable. If a change is found to be unacceptable then this may mean that the key fire response species have been incorrectly selected for that EVC or their vital attributes are incorrectly recorded.

3.4.9 Datasheet

The following two pages contain the blank field datasheet with key reminders for the method on the reverse side. You should photocopy these pages to use for your monitoring in the field.

Flora all-species assessment (September 2008)

Page ____of _____

Area name		Plot name			
Assessors and organisation		Assessment date		Burn No.	
EVC					
Aspect (circle one)	N NE E SE S SW W NW N	Slope (degrees)			

Number of years since the area was last burnt (from 'fire plan map')		Verify last burnt data (tick one box)		Appears to be correct
				Appears the be more years since last burnt
				Appears to be less years since last burnt
Further comments (about fire regime e.g. fire season or fire severity)				
Further comments Record details about other variables of interest (e.g. drought, grazing)				

Coordinate for north-west corner of plot (GDA94)	Easting	0							Zone (circle one)	54 55	GPS accuracy (<10 m)		
	Northing												

Species name	Cover	Life stage		Species name	Cover	Life stage

Cover-abundance classes
0 = cover 0%, species absent
+ = cover < 5%, few individuals
1 = cover < 5%, more than a few individuals
2 = cover 5-20%, any no. of individuals
3 = cover 20-50%, any no. of individuals
4 = 50-75%, any no. of individuals
5 = 75-100%, any no. of individuals

Life-stage categories
J = Juvenile, a plant that is not reproductively mature
M = Mature, evidence of flowers or seed
S = Senescing, dead or dying
U = Unknown, uncertain about other categories. If you're in doubt, use this category.
A = Species absent

More space to record species information…

Page ____of _____

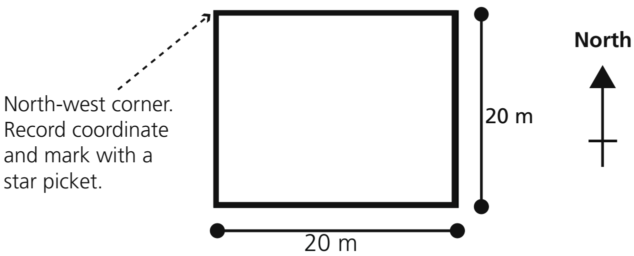
Species name	Cover	Life stage		Species name	Cover	Life stage

Cover-abundance classes
0 = cover 0%, species absent
+ = cover < 5%, few individuals
1 = cover < 5%, more than a few individuals
2 = cover 5-20%, any no. of individuals
3 = cover 20-50%, any no. of individuals
4 = 50-75%, any no. of individuals
5 = 75-100%, any no. of individuals

Life-stage categories
J = Juvenile, a plant that is not reproductively mature
M = Mature, evidence of flowers or seed
S = Senescing, dead or dying
U = Unknown, uncertain about other categories. If you're in doubt, use this category.
A = Species absent

Reminders for the assessor

- Assess all species of vascular flora. Use genus and species, not common names.
- For a particular assessment there should be only one EVC and one last burnt year.
- Record the Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field.
- Record the number of years since the area was last burnt. You should use a 'fire plan map' to identify the year that the area was last burnt and then verify this in the field.
- Plots should be square, 20 x 20 m.
- There should be a minimum of three plots in a monitoring area.



- The reading from the GPS needs to have an accuracy better than 10 metres.
- Record the percentage cover for each species.
- Record the dominant life-stage for each species. Dominant is defined as the life-stage that describes the majority of individuals for a species. If there is more than one dominant life-stage, then record them both.

3.5 Fire severity assessment

This assessment involves estimating the amount of vegetation that has been consumed following fire (that is, the fire severity).

You should assess fire severity after the burn in every plot where you have undertaken an indicator-species assessment or an all-species assessment. This is important because without assessing severity there is no way of knowing whether the plots were burnt and to what extent.

The method described here closely resembles the method that has been developed for ground-truthing a remotely sensed assessment of fire severity. Thus it should be possible to use the data collected from the flora plots to validate severity maps derived from remote sensing.

3.5.1 Assessor requirements

Before starting an assessment you need to consider the assessor requirements to determine whether or not you can meet them.

Preferably assessors should undertake the assessment in pairs. They must know how to use a GPS.

Assessments should take about ten minutes per plot plus travel time between plots.

You should allocate additional time for data entry into Argus.

3.5.2 Equipment requirements

You will need at least the following items of equipment:

- GPS
- field datasheets
- 100 metre measuring tape
- clipboard
- pencils
- eraser.

3.5.3 Timing

You should undertake the severity assessment before the vegetation begins to regenerate. The timing of this will depend on the vegetation type and post-fire climatic conditions but generally you should aim to undertake the assessment between two and six weeks after the burn.

Undertake assessments of severity after the burn and after any bushfires that affect your plots during the ten-year monitoring period.

3.5.4 Assessment methodology

You should undertake the following steps during an assessment:

1. Download the pre-burn plot coordinates from Argus, the fire monitoring database. Load these coordinates into a GPS.
2. Record the following general information on your datasheet:
   - area name – use the same name that the data show for the pre-burn assessment
   - page number of assessment sheet and the number of assessment sheets used
   - assessor names
   - assessment date
   - Ecological Vegetation Class (EVC). You should use a map to identify the EVC and then verify this in the field. You can find EVC maps on the DSE website. Search for 'interactive maps' and then open the 'biodiversity interactive map'
   - plot names – these should be the same as the pre-burn plot names
   - burn date – the date that the most recent burn was conducted
   - additional comments about that area that may be important such as 'lots of rain since burn completed'.
3. Navigate to the first plot. You may use the go-to points in the GPS to assist with navigation.
4. At the plot record the GPS accuracy in metres (this should be better than 10 metres).
5. Pace out the plot boundary. The size and shape of the plot will vary depending on what type of flora plot it is:
   - For the indicator-species assessment the severity plot should be circular with a 10 metre radius. The GPS coordinate will be the centre point in the plot (see Figure 23a).
   - For the all-species assessment the severity plot should be square and the same size as the pre-burn all-species plots. The GPS coordinate will be in the north-west corner where the star picket is located (Figure 23b).
   - For the vital attributes assessment the severity plot of 20m x 20m should be representative of the 100m x 100m area of the proposed vital attributes assessment.

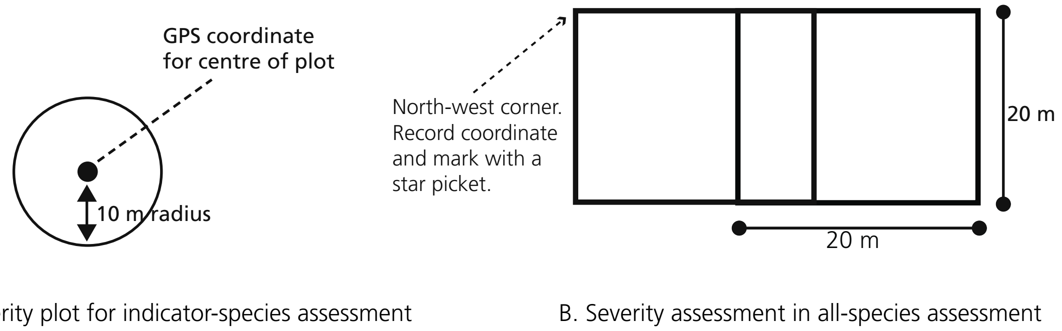


Figure 20: Plot layout for the fire severity assessment in an (A) indicator-species plot and (B) all-species plot.

6. Determine how many layers of vegetation occur within the plot. The maximum number of layers is three: (1) tree canopy layer; (2) shrub and heath layer; (3) leaf litter or grass layer.

The tree canopy should be assessed as a separate layer only when the trees are more than four metres in height. If the trees are less than four metres in height they should be considered as part of the shrub layer.

7. For the litter and grass layer estimate the percentage of the total area that is unburnt (to the nearest 10%). Percent cover diagrams are provided below and on the data sheet as a guide.

This information should be used to help inform your decisions about severity. If the majority of the surface layer hasn't been burnt then it is unlikely that the other layers will be scorched or burnt.

8. Estimate percentage of the total area that is covered by the heath and shrub layer. This is the degree to which the heath and shrub layer shades or covers the ground. If there is no heath or shrub layer then you should record 0%.

9. Estimate the percentage of the total area that is covered by the tree canopy (to the nearest 10%). This is the degree to which the canopy shades or covers the ground. If there is no tree canopy then you should record 0%.

10. Estimate the amount of the vegetation in the heath and shrub layer that is burnt, scorched and unburnt using percentage values to the nearest 10%. These three estimates should add to 100%. Box 7 provides some advice for assessing fire severity.

11. Estimate the amount of vegetation in the canopy that is burnt, scorched and unburnt using percentage values to the nearest 10%. These three estimates should add to 100%.

12. Make additional comments for the plot about factors that may influence the fire severity or what is seen in the remotely sensed image (such as evidence of fire retardant or large areas or rock).

13. Navigate to the next plot.

14. Repeat steps 4 to 13 until you have assessed all the plots in the monitoring area.

Box 7: **Tips for assessing fire severity**

When assessing fire severity you should remember that:

- You should base your assessment on the leaves, twigs and other fine fuels only. Fine fuels are fuels such as grass, leaves, dead pine needles and fine twigs that ignite readily. When they are dry fire consumes them readily. Dead fine fuels are < 6 mm in thickness; live fine fuels are < 2 mm in thickness (Tolhurst and Cheney 1999).
- Burnt vegetation is black, disintegrates easily or has been completely consumed by fire.
- Scorched vegetation is brown and dry in appearance.
- Scorched leaves may still be attached to branches or they may have fallen to the ground. Therefore you should look for scorched leaves on the ground, as well as on the branches, to determine whether or not the vegetation is scorched or burnt. Be careful not to wrongly classify vegetation without leaves as burnt. Scorched leaves may have fallen to the ground leaving the vegetation with a burnt appearance.
- Take care not to record vegetation dying due to drought stress or old age as scorched. Dying bracken for example also turns brown. Look to see if the surface litter has been burnt before determining if it has been scorched.

3.5.5 Datasheet

The following two pages contain the blank field datasheet with key reminders for the method on the reverse side. You should photocopy these pages to use for your monitoring in the field.

Fire severity assessment **(Updated June 2009)**

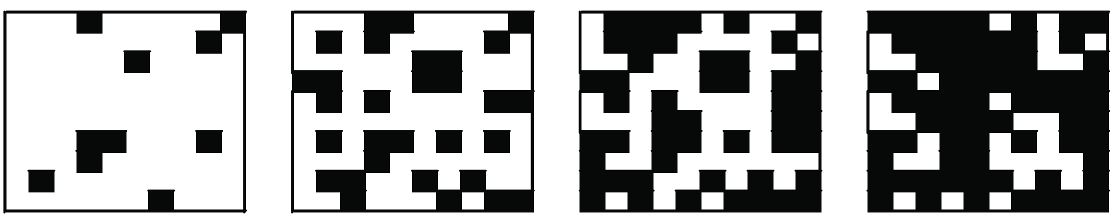
Page ____of _____

Area name:			
Assessors and organisation:		Burn No.	
Assessment date:		Burn date(s)	
Comments:			

Plot name	Zone 54 55 (circle one) / GPS coordinates (GDA94) Easting / Northing	GPS accuracy (m)	Area estimates (to the nearest 10%)			Severity assessments (to the nearest 10%)						Comments (add comments on back of sheet)
			Litter and grass layer	Shrub and heath layer	Tree canopy layer	Shrub and heath layer (< 4m in height) % of vegetation that is			Tree canopy layer (> 4m in height) % of vegetation that is			
			% Area unburnt	% Area covered	% Area covered	Burnt	Scorched	Unburnt	Burnt	Scorched	Unburnt	
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N
												Y / N

You can use the following diagrams as a visual reference for making estimates of percentage cover.

- Where a fuel layer is absent (i.e. no understorey layer) record the percent cover and severity assessments as A for absent.
- Where percent cover or amount burnt, scorched or unburnt is between 1 and 9% record <10%.



10% 30% 50% 70%

Comments:

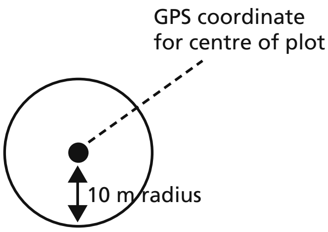
Page ____of _____

If you have ticked the comments column on the front of the sheet please add your comments below.

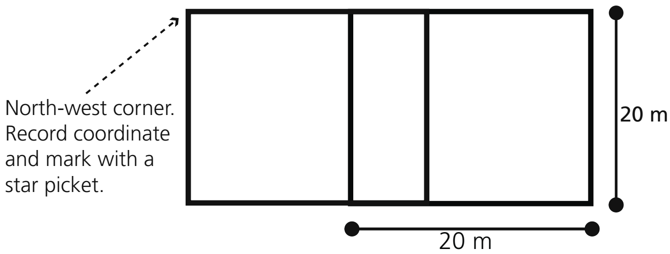
Plot No.	Comments.

Reminders for the assessor:

- The size and shape of the plot will vary depending on what type of flora plot it is:



A. Severity plot for indicator-species assessment



B. Severity assessment in all-species assessment

When assessing fire severity you should remember that:

- You should base your assessment on the **leaves, twigs and other fine fuels only**. Fine fuels are fuels such as grass, leaves, dead pine needles and fine twigs that ignite readily. When they are dry fire consumes them readily. Dead fine fuels are < 6 mm in thickness; live fine fuels are < 2 mm in thickness (Tolhurst and Cheney 1999).
- **Burnt** vegetation is black, disintegrates easily or has been completely consumed by fire.
- Scorched vegetation is brown and dry in appearance.
- **Scorched** leaves may still be attached to branches or they may have fallen to the ground. Therefore you should look for scorched leaves on the ground, as well as on the branches, to determine whether or not the vegetation is scorched or burnt. Be careful not to wrongly classify vegetation without leaves as burnt. Scorched leaves may have fallen to the ground leaving the vegetation with a burnt appearance.
- Take care not to record vegetation dying due to drought stress or old age as scorched. Dying bracken for example also turns brown. Look to see if the surface litter has been burnt before determining if it has been scorched.

4

Fire and adaptive management

4 Glossary

4. Glossary of terms

Age-class distribution	The actual distribution of the proportion/area of the classes (groups of similar age) of a particular vegetation type or community. This is usually represented as a plot of area (y-axis) versus age class (x-axis) (Fire Ecology Working Group, 2004).
Biodiversity	The variety of life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form (Fire Ecology Working Group, 2004).
Bioregion	A landscape-scale approach to classifying the environment using a range of attributes such as climate, geomorphology, geology, soils and vegetation. There are 28 bioregions identified within Victoria. EVCs are arranged by bioregions.
Bushfire	An unplanned grass, scrub or forest fire (see 'wildfire' in Fire Ecology Working Group, 2004).
Cover	The degree to which vegetation shades or covers the ground. Usually expressed in percentage cover.
Density	Number of individual plants per unit area, such as the number within a defined area such as a 2.5 m radius circle.
DSE	Department of Sustainability and Environment
Epicormic shoots	Shoots from the stem and branches that grow from dormant buds beneath the bark.
Ecological burn	Treatment of vegetation in nominated areas by use of fire, primarily to achieve specified ecological objectives (Fire Ecology Working Group, 2004).
Ecological Vegetation Class (EVC)	A collection of floristic communities (i.e. groups based on co-occurring plant species) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating. Approximately 300 EVCs have been described for Victoria.
Flora Information System	A database system that stores information flora life history, vital attribute and location records for Victoria.
Fire ecology	The study of the inter-relationships between fire and the biota (Fire Ecology Working Group, 2004).
Fire history	The record of fire events over time at a particular site or over a particular area of vegetation type. This is best depicted in spatial form using maps or computer-based Geographic Information Systems (Fire Ecology Working Group, 2004).
Fire interval	The time period between successive fires at a particular site or over a particular area or vegetation type (Fire Ecology Working Group, 2004).
Fire regime	The season, intensity, frequency and scale of fire in a given area over a period of time. Some definitions also include the type of fire (Fire Ecology Working Group, 2004).
Fire season	The time of year or season in which a fire occurs (Fire Ecology Working Group, 2004).
FireWeb	An internal DSE system that provides fire management information including locations and status of fires/burns, burn plans, current and forecasted weather, a mapping tool and background information/manuals.
Floristic community	An assemblage within a hierarchical vegetation classification system identified on the basis of the plant species present. This may comprise one or more sub-communities and reflects the vegetation's response to environmental influences (e.g. geology, soils, aspect and disturbance such as fire) at a regional or sub-regional scale (Fire Ecology Working Group, 2004).
Fire management zone	Areas that DSE has zoned for various proposes of hazard and/or ecosystem management by planned burning.
Juvenile	A plant that is not reproductively mature.

Key fire response species	Those species whose life histories or vital attributes indicate that they are vulnerable to either a regime of frequent fires or to long periods of fire exclusion (Fire Ecology Working Group, 2004).
Life history	The combination of attributes with respect to growth, shelter, food/nutrients and reproduction which determine a species requirement for existence (Fire Ecology Working Group, 2004).
Life-stage	The stage of development of a plant: juvenile, mature or senescing.
Lignotuberous shoots	Shoots from the base of an existing plant or large underground stem.
Mature	A plant that is reproductively mature.
Mode of regeneration	The method by which a flora species regenerates: seedling or resprouter.
Planned burning	The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity and rate of spread required to attain planned resource management objectives (DSE 2005).
Presence or absence	Whether or not particular species occurs in an area.
PV	Parks Victoria
Rare or threatened	When used in the context of species or communities of flora or fauna, refers to those indigenous species or communities which are listed under Schedule 2 of the Flora and Fauna Guarantee Act 1988 and/or other lists maintained by the Department, including lists of vulnerable or endangered species (Fire Ecology Working Group, 2004).
Resprouter	A plant species that regenerates vegetatively. An 'obligate' resprouter is a species that can regenerate only in that way.
Rhizomous shoots	Shoots from an underground stem that runs horizontally and is connected to other above ground shoots.
Seeder	A plant species that can regenerate from seed. An 'obligate' seeder is a species that regenerates from seed only.
Seedling	A young plant that has grown from seed.
Senescing	A plant that is dying.
Species composition	The full range of species which occur in the area studied. In composition lists the species are often ranked from most to least important on some stated parameter (e.g. number of individuals, biomass or cover) or categorised as being rare, occasional or common (Fire Ecology Working Group, 2004).
Species diversity	The variety and abundance of different types of organisms. In relation to flora it is the variety and abundance of flora species.
Species richness	The number of different species within a plot or area (Fire Ecology Working Group, 2004).
Tolerable fire intervals	The maximum and minimum fire intervals for fire disturbance across an area or vegetation type which are within the limits set by the constituent species' life histories. These guide how frequent fire need to be in the future to allow persistence of all species at the site (Fire Ecology Working Group, 2004).
Vital attributes	Vital attributes are the key life history features that determine how a species lives and reproduces. With respect to fire, these attributes govern how a species responds to fire and/or persists within a particular fire regime (Fire Ecology Working Group, 2004).

5

Fire and adaptive management

5 References

5. References

Cawson, J. and Muir, A. (2006) (unpublished) 'A review of fire ecology planning and monitoring within Parks Victoria and Department of Sustainability and Environment.' Internal Report, Parks Victoria and the Department of Sustainability and Environment, Melbourne.

Cawson, J. and Muir, A. (2008) *Flora monitoring protocols for planned burning: a rationale report*. Department of Sustainability and Environment.

Department of Sustainability and Environment (2008) (draft) 'Flora vital attributes database.' A copy of this can be found on the DSE website (search for 'flora vital attributes').

Department of Sustainability and Environment (2006) *Code of practice for fire management on public land: revision 1*. Department of Sustainability and Environment, East Melbourne.

Fire Ecology Working Group (2003) (unpublished) 'Developing an ecological burning strategy: a practitioner's manual.' Department of Sustainability and Environment, Victoria.

Fire Ecology Working Group (2004) *Guidelines and procedures for ecological burning on public land in Victoria*. Department of Sustainability and Environment, Melbourne.

Moore, D. S. and McCabe, G. P. (1999) *Introduction to the practice of statistics*. Third Edition, W.H. Freeman and Company, New York.

Noble, I. R. and Slayter, R. O. (1980) 'The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances.' *Vegetation*, 43, pp 5–21.

Noble, I. R. and Slatyer, R. O. (1981) 'Concepts and models of succession in vascular plant communities subject to recurrent fire.' In *Fire and the Australian Biota*. A. M. Gill, R. H. Groves and I. R. Noble (eds), Australian Academy of Science, Canberra, Ch.13, p 311–335.

South-East Queensland Fire and Biodiversity Consortium (2002) *Fire and biodiversity monitoring manual: a guide for local government field officers and land managers*. Queensland.

Tolhurst, K. G. and Cheney, N. P. (1999) *Synopsis of the knowledge used in prescribed burning in Victoria*. Department of Natural Resources and Environment, East Melbourne.

Tolhurst, K. G. and Friend, G. R. (2001) 'An objective basis for ecological fire management in Victoria.' *Proceedings of the Australasian Bushfire Conference.* July 2001, Christchurch, New Zealand, p220–228, New Zealand Forest Research Institute.

Walker, B. (1998) 'The art and science of wildlife management.' *Wildlife research*, 25, 1–9.

Whelan, R. J., Rodgerson, L., Dickman, C. R. and Sutherland, E. F. (2002) 'Critical life cycles of plants and animals: developing a process-based understanding of population changes in fire-prone landscapes.' In *Flammable Australia: the fire regimes and biodiversity of a continent*, R. A. Bradstock, J. E. Willams and A. M. Gill (eds), Cambridge University Press, Cambridge.

5

List of reports in this series

1. 1977. A Study of the distribution of aerially applied fire retardant in softwood plantations. R. Rawson.
2. 1978. Low intensity prescribed burning in three *Pinus radiata* stand types. D.S. Thomson.
3. 1978. Fuel properties before and after thinning in young Radiata Pine plantations. D.F. Williams.
4. 1979. Using fire to reduce fuel accumulations after first thinning in Radiata Pine plantations. P.R. Billing.
5. 1979. Some of the effects of low intensity burning on Radiata Pine. P.R. Billing.
6. 1980. A low intensity prescribed burning operation in a thinned Radiata Pine plantation. P.R. Billing.
7. 1980. Some aspects of the behaviour of the Caroline Fire of February 1979. P.R. Billing.
8. 1981. Changes in understorey vegetation in Sherbrooke Forest following burning or slashing. R. Rawson and B. Rees.
9. 1981. Hazard reduction burning in the Big Desert. P.R. Billing.
10. 1981. The effectiveness of fuel-reduction burning: five case histories. P. Billing.
11. 1982. A fire tornado in the Sunset Country January 1981. P. Billing and R. Rawson.
12. 1982. A summary of forest fire statistics, 1972–73 to 1980–81. R. Rawson and B. Rees.
13. 1982. Fuel moisture changes under Radiata Pine. M. Woodman.
14. 1982. Fuel reduction burning in Radiata Pine plantations. M. Woodman and R. Rawson.
15. 1982. Project MAFFS/HERCULES: the Modular Airborne Fire Fighting System in Victoria. R. Rawson, B. Rees, E. Stuckey, D. Turner, C. Wood, and M. Woodman.
16. 1982. Using fire to reduce aerial fuels in first thinned Radiata Pine. P.R. Billing and J.V. Bywater.
17. 1982. Fuel properties before and after second thinning in Radiata Pine. M. Woodman.
18. 1983. Retardant distributions from six agricultural aircraft. B. Rees.
19. 1983. The Bright plantation fire: November, 1982. N. Watson, G. Morgan, and D. Rolland.
20. 1983. Otways Fire No 22 – 1982/83: Aspects of fire behaviour. P. Billing.
21. 1983. Otways Fire No 22 – 1982/83: A case study of plantation protection. P. Billing.
22. 1984. Forest Fire Statistics, 1974–75 to 1983–84. B. Rees.
23. 1985 The Avoca Fire, 14 January 1985. P. Billing.
24. 1985. Fuel management in Radiata Pine following heavy first thinning. P. Norman.
25. 1985. Effectiveness of Fuel Reduction Burning – 10 Case Studies. R. Rawson, P. Billing and B. Rees.
26. 1986. Operational aspects of the Infra-Red Line Scanner. P. Billing.
27. 1987. Heathcote fire: Bendigo Fire No.38 – 1986–87. P. Billing.
28. 1990. Fire behaviour and Fuel Reduction Burning – Bemm River. A. Buckley.
29. 1991. Fire hazard and prescribed burning of thinning slash in eucalypt regrowth forest. A. Buckley and N. Corkish.
30. 1987. Monitoring the ecological effects of fire. F. Hamilton (ed.)
31. 1992. Assessing fire hazard on public land in Victoria: fire management needs, and practical research objectives. A.A.G. Wilson.
32. 1992. Eucalypt bark hazard guide. A.A.G. Wilson.
33. 1992. Fuel reducing a stand of eucalypt regrowth in East Gippsland – a case study. A.J. Buckley.
34. 1992. Monitoring vegetation for fire effects. M.A. Wouters.
35. 1993. Elevated fuel guide. A.A.G. Wilson.
36. 1993. Wildfire behaviour in heath and other elevated fuels: a case study of the 1991 Heywood fire. M.A. Wouters.
37. 1993. The accumulation and structural development of the wiregrass (*Tetrarrhena juncea*) fuel type in East Gippsland. L.G. Fogarty.
38. 1993. A case study of wildfire management in the Byadlbo and Tringaringy Wilderness Areas. A.G. Bartlett.
39. 1993. Developing Fire Management Planning in Victoria: a case study from the Grampians. M.A. Wouters.
40. 1993. Fuel reducing regrowth forests with a wiregrass fuel type: fire behaviour guide and prescriptions. A.J. Buckley.
41. 1993. The effect of fuel reduction burning on the suppression of four wildfires in western Victoria. S.R. Grant and M.A. Wouters.
42. 1994. Fire behaviour and fire suppression in an elevated fuel type in East Gippsland: Patrol Track wildfire, February 1991. A.J. Buckley.
43. 1996. Fuel hazard levels in relation to site characteristics and fire history: Chiltern Regional Park case study. K. Chatto.
44. 2004. Surface fine fuel hazard rating – forest fuels in East Gippsland. G.J. McCarthy.
45. 1998. Effectiveness of firefighting first attack operations by the Department of Natural Resources and Environment from 1991/92–1994/95. G.J McCarthy and K.G. Tolhurst.
46. 1997. The development and testing of the Wiltronics T-H Fine Fuel Moisture meter. K. Chatto and K. Tolhurst.
47. 1998. Overall fuel hazard guide. G.J. McCarthy, K. Chatto and K. Tolhurst.
48. 1999. Development, behaviour, threat, and meteorological aspects of a plume-driven bushfire in west-central Victoria: Berringa Fire February 25–26, 1995. K. Chatto, K. Tolhurst, A. Leggett and A. Treloar.
49. 1997. Analysis of fire causes on or threatening public land in Victoria 1976/77–1995/96. C. Davies.
50. 2000. Assessment of the effectiveness and environmental risk of the use of retardants to assist in wildfire control in Victoria. CSIRO Forestry and Forest Products.
51. 2001. Effectiveness of broadscale fuel reduction burning in assisting with wildfire control in parks and forests in Victoria. G.J. McCarthy and K. Tolhurst.
52. 2003. Effectiveness of aircraft operations by the Department of Natural Resources and Environment and Country Fire Authority 1997–1998. G.J. McCarthy.
53. 2003. Modelling transport, dispersion and secondary pollutant formation of emissions from burning vegetation using air quality dispersion models. O.D. Valianatos, K. Tolhurst, S. Seims and N. Tapper.
54. 2003. Determination of sustainable fire regimes in the Victorian Alps using plant vital attributes. G.J. McCarthy, K. Tolhurst and K. Chatto.
55. 2004. Analysis of wildfire threat: issues and options. A.A.G. Wilson.
56. 2003. Prediction of firefighting resources for suppression operations in Victoria's parks and forests. G.J. McCarthy, K. Tolhurst, M. Wouters.
57. 2003. Ecological effects of repeated low-intensity fire in a mixed eucalypt foothill forest in south-eastern Australia. Summary report (1994–1999). Department of Sustainability and Environment.
58. 2003. Effects of repeated low-intensity fire on the understorey of a mixed eucalypt foothill forest in south-eastern Australia. K. Tolhurst.
59. 2003. Effects of a repeated low-intensity fire on fuel dynamics in a mixed eucalypt foothill forest in south-eastern Australia. K. Tolhurst and N. Kelly.
60. 2003. Effects of repeated low-intensity fire on carbon, nitrogen and phosphorus in the soils of a mixed eucalypt foothill forest in south eastern Australia. P. Hopmans.
61. 2003. Effects of repeated low-intensity fire on the invertebrates of a mixed eucalypt foothill forest in south-eastern Australia. N. Collett and F. Neumann.
62. 2003. Effects of repeated low-intensity fire on bird abundance in a mixed eucalypt foothill forest in south-eastern Australia. R.H. Loyn, R.B. Cunningham and C. Donnelly.
63. 2003. Effects of repeated low-intensity fire on terrestrial mammal populations of a mixed eucalypt foothill forest in south-eastern Australia. M. Irvin, M. Westbrooke, and M. Gibson.
64. 2003. Effects of repeated low-intensity fire on insectivorous bat populations of a mixed eucalypt foothill forest in south-eastern Australia. M. Irvin, P. Prevett, and M. Gibson.
65. 2003. Effects of repeated low-intensity fire on reptile populations of a mixed eucalypt foothill forest in south-eastern Australia. M. Irvin, M. Westbrooke, and M. Gibson.
66. 2003. Effects of repeated low-intensity fire on tree growth and bark in a mixed eucalypt foothill forest in south-eastern Australia. K. Chatto, T. Bell and J. Kaellas.
67. 2003. A review of the relationship between fireline intensity and the ecological and economic effects of fire, and methods currently used to collect fire data. K. Chatto and K. Tolhurst.
68. 2003. Effects of fire retardant on vegetation in eastern Australian heathlands: a preliminary investigation. T. Bell.
69. 2003. Effects of fire retardant on heathland invertebrate communities in Victoria. N. Collett and C. Schoenborn.
70. 2003. Effects of fire retardant on soils of heathland in Victoria. P. Hopmans and R. Bickford.
71. 2004. An evaluation of the performance of the Simplex 304 helicopter belly-tank. H. Biggs.
72. 2004. Operational performance of the S-64F Airecrane Helitanker – 1997–98 fire season. H. Biggs.
73. 2008. Underpinnings of fire management for biodiversity conversation in reserves. M. Gill.
74. 2008. Flora monitoring protocols for planned burning: a user's guide. J. Cawson and A. Muir.
75. 2008. Flora monitoring protocols for planned burning: a rationale report. J. Cawson and A. Muir.

Supplementary report

1992. Ecological effects of fuel reduction burning in a Dry Sclerophyll Forest. K. Tolhurst et al.