Ecological Site Assessment and Monitoring of Bush Fire Management

A Guide for Landholders

Nature Conservation Council The voice for nature in NSW

Acknowledgements

The Hotspots Fire Project is jointly delivered by the NSW Rural Fire Service and the Nature Conservation Council of NSW.

The Hotspots Fire Project acknowledges that the preparation and implementation of this guide occurs on the traditional lands of Indigenous cultures and that this management has and continues to shape the landscape we see today.

This guide has been developed for the Hotspots Fire Project community to compliment the workshops and other written resources available at http://hotspotsfireproject.org.au. A number of resources were important in guiding the production of this booklet, see references in Section 8.

Disclaimer

This booklet has been compiled for the Hotspots Fire Project. It serves merely as an aid to planning, and in no way provides any guarantee of fire safety. Although people living in and working in fire-prone areas or areas with potential for fire can attempt to minimise risk, a degree of risk will always remain. The information contained herein reflects our understanding at the time of publication. We are learning more about fire and the environment every day and anticipate that some recommendations may change as new information comes to hand. Thus whilst every effort has been made to ensure the information presented herein is as accurate and well-informed as possible, those involved in compiling this booklet take no responsibility for any outcomes, actions or losses resulting either directly or indirectly from the booklet's interpretation, misinterpretation or implementation. The examples provided are not intended to suggest a recommended course of action. Nor is this booklet intended to be used without the help of experts, good neighbour relations, the experience of the associated Hotspots Fire Project workshops and the tools provided at those workshops. Readers should also note that the focus of this booklet is on fire management planning, as distinct from fire response planning. The NSW Rural Fire Service can assist with the latter.

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1. Scope of this guide

A key aim of the Hotspots Fire Project is to increase community understanding, confidence and capacity to sustainably manage fire for ecological and Aboriginal cultural outcomes, whilst protecting life and property. This publication furthers this aim by assisting landholders to follow-up and implement what they have learned at the Hotspots workshops, and to understand and evaluate the benefits of any management actions. It is primarily designed for use in native vegetation which includes bushland, grassland and wetland areas but many techniques can be used in agricultural or other modified landscapes.

During Hotspots workshops, attendees are provided with an overview of the ecology of their area, the recommended fire intervals for different vegetation types on their property, and how to measure fuel loads. They are also assisted to develop map-based Property Fire Management Plans for their properties, which detail key natural and built assets, their management objectives and priority fire management actions.

By applying the simple site assessment, monitoring and evaluation techniques outlined in this guide, landholders can identify changes, refine and update their management plan and actions over time. The observation and interpretation of changes to vegetation communities and fuel loads can then be incorporated into the Property Fire Management Plan periodically to keep it current.

Vegetation Monitoring

Fire Responses

Fauna Monitoring

2. Introduction

Many landholders already spend a good deal of time on their land – checking and experiencing their surroundings, observing how things are changing, learning, and planning. Most say that it's all part and parcel of land management.

This Guide provides an introduction to monitoring for non-scientists. It is not intended to cover the range of methods used by trained scientists. The idea is to see how processes such as fire shape your bushland by observing how the vegetation, fuel loads and fauna change over time. It is also an opportunity to learn through experience and informed observation. You won't be expected to devise scientific questions and come up with definitive answers. In fact, you won't be expected to carry out anything complex or unrealistic in terms of your time, skill, money, effort and expectations.

These insights can provide a 'rough guide', allowing you to link the understanding offered by rigorous science with the bush you interact with day-to-day. This is the great advantage that you - the landholder- has. In your day-to-day life you will likely be observing things in your surroundings far more regularly than a scientist usually would. You may also glean a better understanding of individual species, plants, animals and patches of bush on your property, have a greater appreciation of seasonal changes and gain more of a 'feel' for how the vegetation changes over time.

This isn't to say that a more rigorous style of monitoring cannot be pursued. In some cases, the expertise and resources may be at hand (e.g. through a landholder partnership with a university or Landcare network). It's also possible that a well-designed, low-cost monitoring program may be able to provide some useful feedback in relation to some management objectives (e.g. reducing the abundance of a weed species).

In order to effectively assess and manage land it is critical to be able to "read country" using site assessment techniques to identify what is there, measure trends, formulate objectives, plan effective management actions, monitor and evaluate the impacts of these management actions and implement modified actions if necessary. This process is called adaptive management.

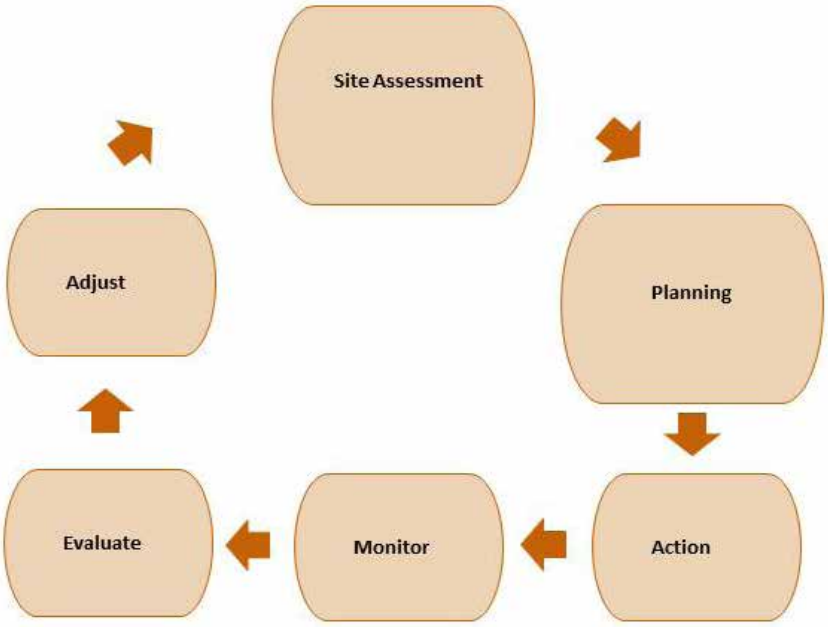
Adaptive management

Adaptive management is a feedback loop whereby the results of monitoring influence the management outcome. It is often advocated in fire and land management practices because of the uncertainties of fire and our incomplete understanding of its effects. The approach often involves setting clear management goals, consistently implementing a small number of 'best bet' management regimes plus a control, documenting management actions and fires, monitoring the outcomes, and modifying strategies and practices in light of results. The approach has shifted the emphasis of monitoring from simply recording changes to comparing the outcomes of different management regimes.

If valid insights are to be gained, there are some basic scientific 'must dos' that need to happen such as replication, randomisation and interspersion of treatments. If not, it can be easy for someone to think they have the answer when in fact they haven't.

Formal monitoring programs must therefore be carefully designed, consider landscape factors, make choices as to what to monitor, and allocate resources for the long haul. Even a constrained program can be expensive. This helps to explain why many monitoring projects fizzle out or come to an abrupt halt before having found any answers. While this means that the kind of monitoring that's feasible for most landholders will be unable to systematically answer complex scientific questions about management effectiveness, this guide aligns to the principles of adaptive management to provide a rough indication and includes links to other resources. The steps outlined in this guide may also assist landholders to collect data that could be useful in a broader scale monitoring program.

Figure 1. Adaptive management framework.



Step	Description
Site Assessment	Collect data which provide information relevant to your objectives
Planning	Identify problems or trends which could significantly affect your objectives as defined in your Fire Management Plan. Develop management actions and monitoring techniques to assess the effectiveness of these actions
Actions	Implement actions
Monitor	Collect data to compare with baseline and subsequent surveys
Evaluate	Evaluate where these values are in relation to your objectives. Evaluate the effectiveness of your actions. Are your objectives still relevant to your overall goal?
Adjust	Modify your management actions and objectives if necessary

3. How to Use This Guide

During the Hotspots workshop, you prepared a Fire Management Plan for your property which identified high, medium and low priority fire management actions. You were encouraged to review your plan on a regular basis and update it as you gain new information and insights. You can use your plan to keep a record of when fire occurs (planned and unplanned) and observe what happens to the vegetation on your property following a fire. Recording details of the weather conditions at the time of the fire and the intensity of the fire, including what layers of vegetation were burnt as well as whether unburnt areas remain within the fire perimeter, will allow you to identify the effects of different types of fire on the vegetation.

The practical tools in this guide are designed to help you assess an area; to measure values and record observations at a particular site, taking a snapshot at a particular time. Monitoring and evaluating is the act of comparing these snapshots over time, deciding what it means and coming up with actions to meet management objectives. The records will also enable you to update your fire management plan and to share your observations with co-managers, neighbours, your local NSW Rural Fire Service Office or brigade.

Reflection and discussion with others can assist you to interpret the changes you are observing and draw on that knowledge to inform your decisions about the use of fire in the future.

This guide is divided into 2 main sections:

- **Setting objectives and monitoring effectiveness of your actions (3.1 - 3.3).**
- **Site assessment and monitoring techniques for:**
    - Site location including photo points & fire history (4.1 - 4.3)
    - Vegetation including native vegetation, weeds and fuel (4.4 – 4.6)
    - Fauna (6.1-6.4).

Additional information including examples are provided for each step.

3.1. Setting your goals, management objectives and actions

Establishing goals: The goals for your property are your overall desired results. These will guide your objectives and actions to achieve these.

For example:

- Overall goal: Bush fire risk is mitigated to life and property
- Overall goal: Biodiversity is protected and enhanced.

Setting objectives: What is it you want to achieve? These may be the objectives you identified in your Hotspots Fire Management Plan for your property or management area or you may wish to set new objectives. Aim for at least one objective per management area.

For example:

- Objective to achieve asset protection: *Reduce bush fire risk to life and property in Asset Protection Zones (APZ)*
- Objective to protect and enhance biodiversity: *Manage for conservation within fire thresholds.*

Identifying actions: Setting some measurable and achievable **actions** will enable you to reach your objectives – these can be fixed points or rates, For example:

Actions to increase asset protection:

- *Develop Bush Fire Survival Plan*
- *Establish and maintain APZ using mechanical methods*
- *Undertake home maintenance such as clearing gutters*
- *Reduce fuel to less than 10 t/ha using mechanical methods or prescribed fire.*

Actions to protect and enhance biodiversity:

- Assess fire intervals and manage for more appropriate fire regimes (interval, extent, patchiness, season)
- Undertake biodiversity assessment
- Undertake weed management
- Reduce lantana - no clumps larger than $1m^2$.

For a more detailed list of Objectives and Actions refer to the Supplementary Materials section of the '**Workshop 1 - Preparing a fire management plan**'.

Undertake actions: before implementing your actions make sure you do the following:

- Prioritise and plan your actions to ensure they are as effective as possible
- Record any necessary observations prior to undertaking planned actions
- Determine what approvals are required for undertaking mechanical works or prescribed burning to achieve your management objectives (see **Section 5**).

3.2. Monitoring the effectiveness of your actions in reaching objectives

After you implement a planned fire management action, the next stage is to monitor the effectiveness of your management actions against your objectives, re-assess objectives, adapt your management action if necessary and keep monitoring. Refer to **Table 1** for examples of two objectives: 1) Reduce bush fire risk to life and property in APZ, and 2) Maintain or increase diversity of native plant vegetation.

Table 1. Monitoring objectives

Objective	Action	Treatment methods	Measurement	Revised Action
1) Reduce bush fire risk to life and property in APZ (Management Area 1)	Reduce and maintain fuel load at less than 10 t/ha. in asset protection zone (Management Area 1)	Combination of mechanical removal or prescribed fire (following recommended fire interval)	Site assessment: 1/5/2010 Fuel load is 18 t/ha. Initial treatment: 7/6/2010 Fuel load is 5 t/ha.	Monitor - once per year
			2nd assessment: Fuel load is 5 t/ha.	
			3rd assessment: Fuel load is 6 t/ha.	
			4th assesment: 1/5/2013 Fuel load is 8 t/ha.	Increase frequency of monitoring and begin to plan for action to reduce level of fuel

Objective	Action	Treatment methods	Measurement	Revised Action
2) Maintain or increase diversity of native plant vegetation	Manage lantana in Management Area 2 to no clumps larger than $1m^2$	Mechanical removal and herbicide application Consider use of fire if appropriate	Initial assessment: No thickets are present along monitoring transect	Continue monitoring
			2nd assessment: Individual plants present on transect	Continue monitoring – spot spray or mechanical removal of plants across site as resources allow
			3rd assessment: Thickets present	Implement management actions across whole site – mechanical removal, spot spray or splatter gun, consider use of fire if appropriate

Carwoola workshop © K. McShea

3.3 Features and processes to monitor

Below are examples of **features and processes** to measure and monitor. Establishing baseline data on these features can then identify processes e.g. dieback. This information then feeds into your management actions and enables you to assess if the trend is in the direction you need to achieve objectives.

Feature or Process	**Description**	**Assessment and monitoring techniques** **(these will be based on objective and scale)**
Vegetation change:	Different fire regimes can result in changes in species presence and structure of vegetation Are there any Threatened Ecological Communities (TECs) or threatened flora? Establish baseline values Observe which species are present and structure of the vegetation (the vertical and horizontal distribution of vegetation: its growth, height, cover, and strata) Monitor any changes before and after fire for example. This will assist in assessing what any changes you may observe mean for conservation values of the site or fuel hazard	• Photo points • Vegetation plot monitoring • Weed monitoring
Weed invasion:	Observe presence and abundance of weed species Changes in the ratios and abundance of weeds to native species can have an influence on biosecurity and in some instances fuel hazard	• Photo points • Vegetation plot monitoring • Weed monitoring
Overall Fuel Hazard:	This guide refers to the detailed method for measuring fuel load and fuel hazard taken from the 'Overall Fuel Hazard Guide. Third edition (1999)'. The approach measures overall fuel hazard of an area based on the sum of the influence of bark hazard + elevated fuel hazard + surface fine fuel hazard. The average of values produced using this method is then added to the recording sheets.	• Fuel assessment using 'Overall Fuel Hazard Guide'

Fire Management:	Identify the history of fire, both planned or unplanned (wildfire). Recording the time since fire, intensity, extent, season and evidence of multiple fires. Information can come from maps, written reports, NSW RFS, other agencies, media, neighbours, oral histories.	• Photo points • Vegetation plot monitoring
Wildlife Values:	Identify the habitat and species values. A range of survey techniques are introduced in this guide including observation, camera trapping, scat collection, nocturnal surveys and trapping. These are divided into simple techniques which require little or no training and more specialist techniques requiring more training and equipment.	Simple techniques: • Visual assessment of vegetation, habitat, scats & scratches More detailed techniques &/or training required: • Fauna surveys • Motion sensing camera traps • Pit fall traps etc.
Hollow-bearing trees:	Identify hollow-bearing trees.	• Photo points • Vegetation plot monitoring
Feral pest species:	Identify species present and start to assess density from scats and signs. This guide introduces techniques for identifying feral species.	• Visual assessment of vegetation, habitat, scats • Fauna surveys • Motion sensing camera traps
Grazing pressures:	Identify previous or existing pressure on vegetation and surrounding areas.	• Visual assessment of vegetation, habitat, scats • Vegetation plot monitoring • Motion sensing camera traps
Dieback:	Identify various forms of dieback including canopy, Bell Miner Associated Dieback (BMAD), psyllid, drought induced, exotic rust fungus or other.	• Photo points • Vegetation plot monitoring

> ‘I knew a lot already about my property but following the Hotspots workshop I was surprised just how much I learned through regular monitoring and recording what I’m seeing.’
>
> - Workshop participant

4. Using Site Assessment and Monitoring Techniques

The next steps walk you through the 'Hotspots Site Assessment and Monitoring Sheet*'. This can be used to establish baseline data e.g. pre-burn and for follow-up monitoring.

A blank recording sheet for your use is provided in **Appendix 1**. A description of each of the steps is below. This document is also available on the Hotspots website: http://hotspotsfireproject.org.au/ecological-resources.

4.1. Site location

It is important to record as precisely as possible the location and date when you are assessing an area. The property or street address should be recorded as well as mapping co-ordinates from a topographic map, a Global Positioning System (GPS) device or smart phone.

The location of your sites should assist you in answering your monitoring question(s). To limit bias it is important to select sites which are representative of the whole location and homogenous i.e. attempt to minimise the variation within each of your locations. By selecting multiple sites and being systematic in your monitoring you can limit any bias in your site selection.

Property details: start by adding you name, address and any information you can about the landscape you are assessing.

PROPERTY DETAILS:

Property Owner/ Recorder	*John Citizen*	
Location Information	Street address	*100 Waterfall Way, Fernbrook*
	Lot/DP	*25/7561123*
Landscape	Local Government Association, Bioregion, catchment etc. *Bellingen Shire Council, Bellinger River, North Coast Bioregion*	

Site details: add the Management Area identified in your Hotspots property fire management plan, and the details of the plot. There is space to add information on photo-point records (ID, location stored and how the spot is identified), see next section for details.

*Based on vegetation condition survey proforma in Eco Logical Australia (2009) Riverine Vegetation in the Namoi Catchment. An Assessment of type and condition Final Report prepared for: Cotton Catchment Communities CRC Namoi Catchment Management Authority. Eco logical Coffs Harbour.

SITE DETAILS:

Management Area		*Area 1 – Asset Protection*		Date *01/01/2018*	
Plot Location		GPS/ map co-ordinates: *Decimal Degrees Lat -33.8 Long 151.2 or UTM 56 H 334202 625018*			
Aspect	*90*	Slope	*8*	Soil/geology	*Sandy loam over Silurian aged metasediments*
Photo ID and where stored	*IMG 207 8.30 am 1/1/18 Fire management plan folder on Johns laptop*				
Record details if site is permanently marked e.g. (post or stump etc.) *Star picket at track intersection*					

4.2. Photo points

Photos can provide a visual representation of vegetation changes over time, especially when photos taken from the same location are compared across time. This comparison should be one of the first steps in establishing a point of reference to detect trends, identify threats, plan and guide management actions and design a monitoring and evaluation regime.

Photos can be used prior to and following a burn to assess site biodiversity, changes in vegetation structure, the presence and extent of weeds and also changes in fuel loads over time. Photo points can be used in conjunction with other monitoring techniques such as vegetation transect plot data (see next section).

Useful equipment

- Stake or star pickets to permanently identify each photo point
- Camera
- Compass
- GPS
- Notebook or recording sheet

The important thing about photo points is consistency. By writing down exactly what you do for the first photo and doing the same thing for any subsequent photos, you can easily compare the differences and similarities between them. By having clear instructions and using the same data sheet, different people can take an accurate photo even if they didn't take the original photo.

Selecting locations

Here are a few tips to help select the location for your photo point:

- Choose a site that is easy to get to in wet or dry conditions and which looks over a wide area of your site

- You will get a better result if the photo faces south as the sun is usually behind you, however this is not always possible. Overcast days are best as this reduces the shadows and contrast and allows the best image
- Permanently mark the exact spot where you are standing with a post or star picket so you or someone else can take the next photo from that exact spot or include the post in the photo as a reference point for future comparisons. Attaching a small sign with the plot number, compass bearing and date for each photo is helpful. Repaint the star picket after fire to prevent rusting. A fluorescence colour is useful for relocating the post as vegetation grows
- Try to select some identifying features in the image that will remain consistent over time such as fence lines, rocks or logs, and include these in the image each time
- Try not to pick a location where plants will grow and obscure the camera.

Other photo options

You may wish to take more than one photo at each photo point. Additional photos should reflect what it is you want to know about your plot. For example you might take photos of the ground, shrub and tree layer. Or you may wish to take photos facing in more than one direction. If you do this, ensure you record the multiple locations (compass bearings/GPS).

Recommended intervals for photo records

Intervals may vary depending on the situation and the vegetation type but the aim is to capture changes as they occur. It is recommended that you take photos before and immediately after a burn, then one, three, six and twelve months after the burn, and then annually for four to seven years. Keep in mind that taking photos in August and September can help make a number of species visible because of flowering.

An example photo point recording sheet is provided in **Appendix 3.**

Example Grassy Woodland with fire frequency too high, too low and within thresholds © P. Watson, Hotspots Fire Project

Vegetation: add as much detail as you can on the Keith Formation and Class if known, the canopy species in order of dominance and the condition of the vegetation.

Keith Formation and Class if known: At the Hotspots workshops you were assisted with identifying the vegetation types on your property. If you need further assistance the following may be helpful:

- Local Landcare officer
- Council environment staff
- Local Land Services
- Local vegetation expert
- David Keith book: 'Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT' (2004).

A summarised description of each formation can be found in your landholder booklet or you can access the booklets via the Hotspots website: www.hotspotsfireproject.org.au/ecological-resources.

Canopy Species in order of dominance: Refer to Ocean Shores to Desert Dunes and further resources in **Section 7**.

Condition: How is the site looking? Record any current or past impacts of disturbance, visual evidence of dieback, weeds or signs of condition. More details can be recorded for disturbance below.

Vegetation	Keith Formation and Class if known *North Coast shrubby Wet Sclerophyll Forest, North Coast Wet Sclerophyll Forest*
	Canopy Species in order of dominance *Spotted gum, brush box, tallowwood*

4.3 Disturbance history

The history of the site including fire, grazing, weeds etc. is important in understanding the condition of the site and how the site might respond to your management actions.

Fire: The fire history for your property is important information for guiding decisions regarding planned burns as well as how you might respond to unplanned fire (wildfire).

Are there signs which may tell you about the fire history of the site? These include the presence or absence of the following:

- Height and amount of charring on rough-barked tree trunks,

- Hollows in tree trunks or branches
- Woody debris on the ground
- Secondary growth (resprouting around the base or along branches and trunks of trees or shrubs)
- Shrub layer (in some vegetation types presence or absence of a shrub layer may indicate a lack of fire and senescing vegetation)
- Ground layer vegetation dominated by fire tolerant species such as bracken or blady grass may be an indication of frequent fire.

DISTURBANCE HISTORY:

Fire	Severity, date of last event, evidence (known or estimated) *Hot fire – canopy burnt – charring – Estimated 10 years*
Logging/ Clearing	*Numerous stumps – over 10 years old*
Grazing	Stock, native, feral, severity, time *Heavily grazed - sheep present, kangaroo/wombat scats common throughout site*
Significant Weeds (WONS or Biosecurity listed)	*Blackberry in small thickets around 2m wide*
Other	e.g. Bell Miner Associated Dieback (BMAD)

Other disturbance:

Logging/Clearing: Is there evidence of clearing for example tree stands all the same age, stumps, gaps in the canopy or logging tracks etc.

Grazing: Is there evidence of grazed vegetation, stock manure or soil compaction? Is there evidence of soil erosion?

There is also a distinction between grazing by stock and grazing by native herbivores - new growth in a small burn area with a large edge effect will have the potential to be heavily grazed by wallabies, rabbits, possums etc. Depending on how fragmented the patch is, it could be a significant management consideration.

Are there other scats present? More details on fauna monitoring is provided in **Section 6.**

Invasive Weeds - Does the site contain, or is it under threat from any Weeds of National Significance (WONS) or listed on the *NSW Biosecurity Act 2015*. Depending on your monitoring objective you can list all weed species present or just the dominant/ target weed species, you can record weeds collectively (presence/absence) or weed groups (e.g. forbs, vines, grasses, succulent, woody).

Other? Is there dieback? Is there evidence of bell miners or Bell Miner Associated Dieback (BMAD)? Are there other forms of dieback including drought-induced dieback, myrtle-rust (*Puccinia psidii*) or root-rot fungus (*Phytophthora cinnamomi*)?

For a case study on managing fire and weeds in a BMAD affected landscape, refer to Appendix 5.

Refer to **Section 7** for resources which may be helpful in identification and possible treatments. It is recommended you consult your Local Land Services for additional support: www.dpi.nsw.gov.au/biosecurity/plant.

4.4 Establishing a Hotspots monitoring plot

The next section walks you through the Hotspots data sheet for site assessments, the process of creating a monitoring plot, as used by the Hotspots team, undertaking a fuel assessment and recording habitat values.

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

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

Useful equipment

- Compass
- GPS
- 50m measuring tape
- 1m x 1m square quadrat
- Plant identification guide books
- Notebook or recording sheet

- Presence/absence – whether or not particular species are present;
- Abundance (or density) – the number of plants individuals in the given area; and
- Cover – the degree to which vegetation shades or covers the ground.

There are a number of field guides and resources available which may assist you in identifying the plants on your property, see **Section 7**.

4.4.1 Vegetation monitoring

Often it is not possible to record vegetation characteristics and other information for an entire site, so one or more representative samples (plots) are chosen.

Whether you complete all of the steps and the level of detail you add will depend on the monitoring objectives and management actions you have set. For example if you are assessing the regeneration responses to a controlled burn, or the diversity of species on your property, you may find it useful to complete all the assessment steps. If however, you are focusing on the response of a particular weed infestation to your management actions, then you may not need to complete all the steps.

Vegetation Structure

Some types of forests have several layers or strata. These are generalised as the canopy, understorey and ground (see **Figure 1**). These three strata are not always present and sometimes there are several mid strata and canopies may have emergent trees.

Tallest stratum - Canopy: *The cover of vegetation which would be seen from the air.*
Mid stratum - Midstorey: *Cover of shrubs and small trees > 1m.*
Lower stratum - Ground cover: *Normally comprises low shrubs, grasses, forbs, rushes and sedges, <1m.*

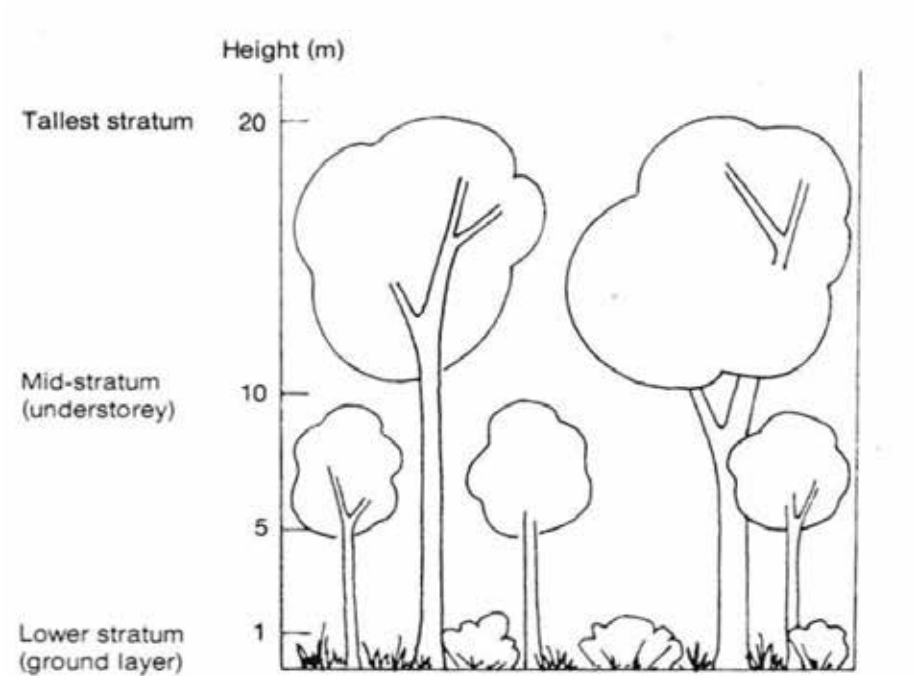


Figure. 1. Country Fire Authority (CFA), 2013.

<u>Establish your base plot (20 x 50 m):</u>

Base plot (20 x 50 m): Run a tape measure along your site 50 metres. Run a second 20m. That is your baseline plot. The line along the tape measure is your transect[1].

Since most of us have limited time and resources, we often only monitor part of a site. This area of the site that we sample is termed a 'plot'. Whether a plot is chosen randomly or deliberately, it needs to be representative. In general, the more plots used, the more reliable your data will be.

[1] **Transect** is a straight line or narrow section through an object or natural feature or across the earth's surface, along which observations are made or measurements taken.

BASE PLOT (20 X 50):

No of canopy species	Mature Regrowth *5 mature canopy species, 3 are regenerating*
No of trees with hollows	*10 trees with hollows*
Length of dead fallen timber	Diameter > 10cm and length >50cm *210 meters (total length of fallen timber)*

No. of canopy species: Within your plot record the number of different species in the canopy and if the vegetation is mature and regenerating.

No. of trees with hollows: Record how many of the trees have hollows. You can also record more detail on the size and opening in the habitat section.

Length of dead fallen timber: Record the combined length.

Establish your subplots

Subplot (20 x 20 m): this is a smaller plot within your base plot. Run the tape measure to establish your subplot and record the following:

SUBPLOT (20 X 20):

No of native shrubs and small trees >1m	*7*
No of native ground cover species	*23*

Record the Foliage Projective Cover (FPC)

2.5 m radius around points along transect: record the foliage cover (percentage of the sample site occupied by the vertical projection of foliage) at a 2.5 m radius around points along the transect at 5 m intervals (For smaller sites a lower number of points could be used to calculate an average). Use **Figures 2 & 3** to assist.

Native canopy: record the projected foliage cover (%) for native species in the canopy (tallest stratum).

Native midstorey: record the projected foliage cover (%) for native species in the midstorey

Weeds canopy & midstorey: record the projected foliage cover (%) for weeds in the canopy and midstorey.

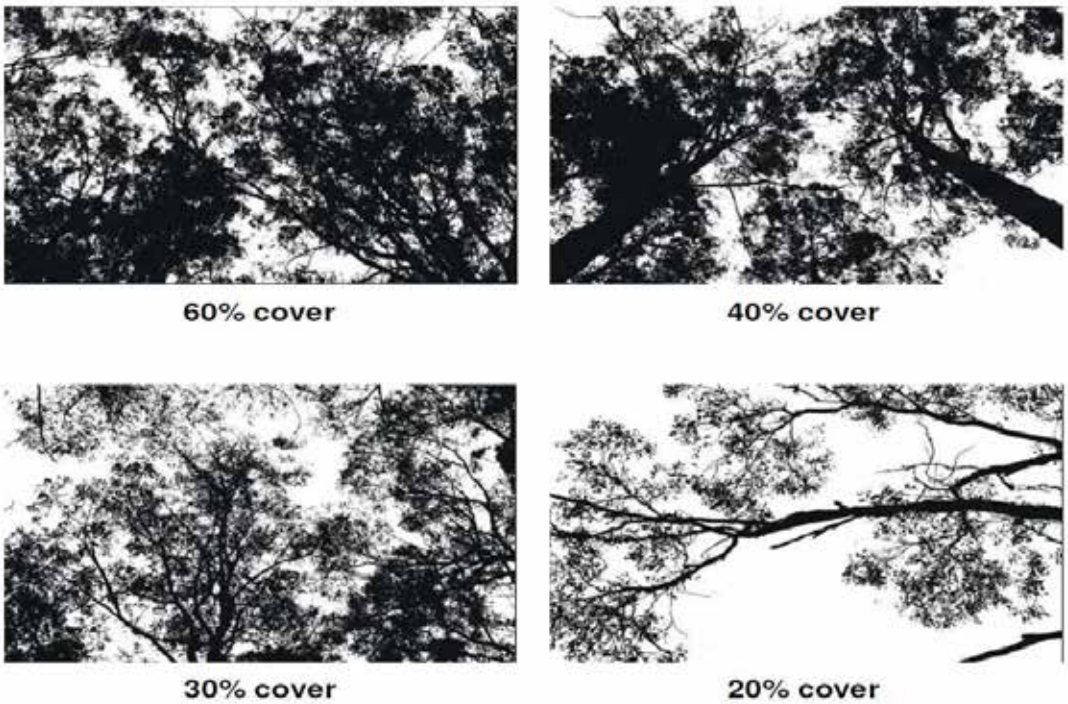


Figure. 2. Crown types (Walker & Hopkins, 1984)

2.5 M RADIUS AROUND POINTS ALONG TRANSECT:

Projected Foliage Cover (%)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Native Canopy	*35*	*40*	*15*	*10*	*5*	*20*	*15*	*25*	*25*	*40*
Native midstorey	*10*	*5*	*20*	*60*	*40*	*10*	*10*	*10*	*30*	*5*
Weeds canopy & midstorey	*5*	*10*	*5*	*10*	*5*	*0*	*0*	*10*	*0*	*10*

	Percentage foliage cover (FPC) of tallest plant layer			
Life form and height of tallest stratum	**Dense (70-100%)**	**Mid-dense (30-70%)**	**Sparse (10-30%)**	**Very sparse (<10%)**
Trees > 30 m	Tall closed-forest	Tall open-forest	Tall woodland	Tall open-woodland
Trees 10-30 m	Closed-forest	Open -forest	Woodland	Open-woodland
Trees 5-10 m	Low closed-forest	Low open-forest	Low woodland	Low open-woodland
Shrubs 2-8 m	Closed -scrub	Open-scrub	Tall shrubland	Tall open-shrubland
Shrubs 0-2 m	Closed -heath	Open-heath	Low shrubland	Low open-shrubland

Firgure 3. Structural forms of vegetation in Australia (based on Specht, 1970)

Ground Cover

Quadrats (1 x 1 m) along transect: Record the percentage cover of the following within ten 1x1 m quadrats, along the length of the transect expressed as a percentage to the nearest 5%. The five individual scores should add up to 100%.

You may find it helpful to make a square frame (1m x 1m quadrat) to record the ground cover results.

QUADRATS (1 X 1 M) ALONG TRANSECT:

Ground Cover %	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Native ground cover	*20*	*10*	*50*	*50*	*60*	*30*	*60*	*20*	*40*	*10*
Weeds	*5*	*5*	*10*	*0*	*0*	*10*	*0*	*5*	*0*	*60*
Moss & lichens	*0*	*0*	*5*	*5*	*10*	*0*	*5*	*0*	*5*	*0*
Organic litter	*70*	*80*	*35*	*35*	*30*	*30*	*35*	*75*	*55*	*30*
Rock/ bare ground	*5*	*5*	*0*	*10*	*0*	*30*	*0*	*0*	*0*	*0*
Total (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Figure 4. Example image of ground cover © K. Taylor.

4.2. Weed monitoring

The recording sheet can be used to monitor weeds by recording abundance scores for either:

- Individual weed species (i.e. list all weed species present – or just dominant or target weed species);
- Weeds collectively (i.e. instead of listing weed species, just record 'weeds'); and
- Weed groups (i.e. instead of listing weed species, record group type e.g. forbs, vines, grasses, succulent, woody).

If your objective is undertaking long term weed control you can assess your actions over time by using weed mapping and comparing photos over time.

Refer to your relevant Regional Strategic Weed Management Plan to identify if any actions are required under the *NSW Biosecurity Act 2015* and if listed priority species are found: www.lls.nsw.gov.au/biosecurity/weed-control.

Section 7 has some additional resources which may be helpful.

4.5. Assessing fuel and monitoring accumulation

Vegetation, both live and dead provides fuel for fire. In a fire prone landscape it is important to be aware of the amount and arrangement of available fuel that contributes to different effects of fire behaviour including the flame height and depth, intensity, rate of spread, and embers which can produce spot fires. In the workshops you practiced assessing fuel using the Overall Fuel Hazard Guide (cite 3rd Ed, Vic).

By using the techniques presented in the Overall Fuel Hazard Guide and observing the fuel characteristics, you can learn to recognise changes in fuel loads and reduce the risk of a high intensity fire through a controlled burn, or other means.

To assess fuel load you will need to look at the following components:

- **Fuel types**
- **Fuel Characteristics**
- **Fuel layers**

Fuel types

Generally fuels can be described as fine or coarse.

- **Fine fuels** (generally <6mm diameter) such as leaves, twigs, grasses, fibrous tree bark and leaf litter ignite quickly and burn easily.
- **Coarse fuels** are thick logs and branches. These are slower to ignite but once alight may burn for a long time.

Differences in forest and grass fuel types:

The Overall Fuel Hazard Guide assists the user to identify and assess fuel hazards in forested areas. Grassland is assessed differently to forest fires as these fires behave differently. Grass fires can spread three times faster than a bush fire and their spread is more influenced by wind. A key element of monitoring grassland fire danger and potential fire behaviour is to estimate the level of drying or curing. The percentage of grassland cured can be observed based on colour and other physiological characteristics such as the growth, maturation and seed dropping stages. The level of curing can significantly affect the ignition potential and spreading characteristic of a fire.

Refer to the '*Country Fire Authority Grassland Curing Guide (1999)*' for more information.

Fuel characteristics

There are many fuel characteristics that contribute to fire behaviour. These include:

- fuel load (amount)
- the size, shape and density of the foliage within the plant
- arrangement of fuel both horizontally and vertically (separation between plants and between the ground and branches)
- the moisture content (of the foliage, litter, soil and surrounding area)
- other chemical properties such as oil content

When planning your prescribed burn, observe the fuel characteristics at your site and consider how they could contribute to the available fuel load and how this could influence the way a fire might burn.

If the fine fuels are continuous from the ground to the canopy then there may be a greater risk that any fire may reach the canopy.

Where there is good physical vertical separation between elevated shrubs and surface or low shrub/grass understorey vegetation then the chances of flames reaching the canopy will be reduced.

If the understorey vegetation is sparse, it may not sustain flames readily and a fire will have difficulty moving through a landscape in both a vertical or horizontal capacity under controlled conditions.

Similarly, broad and fleshy foliage will unlikely carry a fire as readly as fine, dry or oil rich foliage.

Remember that other factors can have an effect on your fuels and fire behaviour. For example the weather, site characteristics such as slope and aspect, or presence of weeds can influence the flammability of vegetation.

Fuel layers

The key components of vegetation contributing to the overall fuel hazard include:

- surface fuel (including grasses, other vegetation, and some dead material low to the ground as well as leaves and twigs on the ground)
- elevated fuel (shrubs and small trees which may be under a main canopy)
- bark fuel (rough, stringy or ribbon bark on tree trunks and branches).

Tips for assessing fuel hazard

- Use the methods described in the Overall Fuel Hazard Guide, which was provided to you in your workshop. Record the fuel hazard levels for each vegetation layer, at surface, elevated shrub layer, and bark using the fuel assessment form provided in **Appendix 2**. A completed example fuel assessment sheet follows.
- Fuel should be assessed and measured both before and after a fire where possible. It is recommended that you take more than one fuel measurement across the site. You can use your photo point sites or quadrat locations for consistency. If the site you propose to burn is on a slope, aim to take fuel measurements from the top, middle and bottom of the slope.
- As described during your workshops, having some knowledge of the fire history and the type of fire (planned or wildfire) may help you verify your observatios and determine the time since the last fire.
- Avoid taking fuel measurements on the edges of your area such as tracks or trails, and immediately after rainy conditions.

Measuring fuel at Nerriga Hotspots Workshop © K. McShea

Management Area: *Management Area 1*			**Date of sample:** *1/5/2010*		
Burn Name/ ID: *Oaky Gully burn*					
Sample location details: plot location *-33.8, 151.2 Easterly aspect, <5 degree slope*					
Vegetation formation (Keith 2004): *North Coast Wet Sclerophyll Forest*					
SURFACE FINE FUEL					
			Sample no. (alternatively use quadrats locations)		
Average Litter-bed height (mm)	**Rating**	**Equiv. Fuel load (t/ha)**	**1**	**2**	**3**
<15	Low	<4	*Mod - 8*	*High - 12*	*High - 10*
15-25	Moderate	4-8	**Average surface fine fuel score (t/ha):**		*10*
25-35	High	8-12			
35-50	V High	12-20			
>50	Extreme	20+			
ELEVATED FUEL					
Rating		**Equiv. Fuel load (t/ha)**	**1**	**2**	**3**
Low		0	*V. High - 6*	*Extreme - 10*	*High - 2*
Medium		0	**Average elevated fuel score (t/ha):**		*6*
High		2			
V High		6			
Extreme		10			
BARK FUEL					
Rating		**Equiv. Fuel load (t/ha)**	**1**	**2**	**3**
Low		0	*High - 2*	*High - 2*	*High - 2*
Medium		0	**Average bark fuel score (t/ha):**		*2*
High		2			
V High		5			
Extreme		7			
Overall Fuel hazard Rating			**1**	**2**	**3**
			V. High	*Extreme*	*High*
OVERALL FUEL LOAD (t/ha) (sum of the average scores)					*18 t/ha*
NOTES: *Some rocks and logs creating gaps between fuel patches. Shrub height generally does not exceed 3 metres. Some litter build up at base of trees. Note - to rake around hollow bearing trees.*					

For an example of monitoring the overall fuel hazard refer to the Gradys Creek, Border Ranges Case study in Appendix 5.

Fuel load: Record the fuel load on your recording sheet.

FUEL LOAD:

Overall Fuel Hazard t/ha.	*18*	Comments: *fairly uniform across site.*

4.6. Habitat values

Habitat values: record the features in the plot which provide specific habitat including:

- Record the feeding and sheltering resources which are available for birds and other wildlife, for example hollows, mistletoe, fruiting shrubs, trees and grass.
- Logs are also an important habitat in a healthy environment. They provide shelter for some animals as well as food for fungi and insects. This, in turn, provides food for other animals.

Identify hollow-bearing and mature trees including den and feed trees. You can also include additional details regarding the types of hollows such as size, if the entrance is exposed to rain or wind, or if they are susceptible to fire, and include potential fire entry points.

This information may lead you to record specific actions to protect the tree or log e.g. rake away leaf litter from base.

HABITAT VALUES:

Feed trees, hollow logs, rock outcrops, nests etc. *Large mature yellow box – nectar resource; large hollow log, rocky overhang; 3 hollow*

Refer to the Monitoring to Protect Hollow-Bearing Trees case study in Appendix 7 for more details.

Logs and woody debris are important habitat and studies have shown that wildlife prefer unburnt logs to burnt ones (Croft *et al.*, 2010). Cool burns which remove the fine surface fuels and avoid burning larger material is recommended.

Habitat values © K. Taylor

5. Approvals

Fire can be a useful management tool for reducing bush fire hazards, assisting in the regeneration of some plants or conducting agricultural activities. However, the inappropriate use of fire can endanger lives, property and the environment. Your observational skills may help you decide where and when it may be appropriate to apply fire. You may need an environmental approval and a Fire Permit before you undertake any works. The type of environmental approval will depend on the purpose of your burn.

The NSW Rural Fire Service have produced a guide titled **Before you light that fire** which outlines steps you need to take before lighting a fire. View online at:

www.rfs.nsw.gov.au/__data/assets/pdf_file/0013/12451/BeforeYouLightThatFire.pdf.

If your burn is for bush fire hazard reduction or has the dual purpose of achieving bush fire hazard reduction and ecological outcomes, then a bush fire hazard reduction certificate may be issued for the environmental approval of the works. These are issued free of charge by staff at your local NSW RFS Fire Control Centre.

Contact your local NSW RFS Office to apply for a Hazard Reduction Certificate or for further advice on measurement options and appropriate burn prescriptions.

Using the McArthur Meter to predict fire behaviour, Cawoola Workshop © J. Cramp

6. Monitoring fauna

6.1. Assessments

There are a number of methods that can be used to assess and monitor native fauna at a particular site. Spotlighting, hair tubes, pit fall traps and harp traps are just a few of the techniques used to identify a species presence and population conditions. However many tend to be invasive and/or modify the behaviour of the target species. Two commonly used non-invasive visual survey methods include wildlife surveillance with a torch at dusk/night (spotlighting) and cameras that detect motion under a range of conditions (camera traps). Both of these are discussed in more detail below.

The appropriateness of each of these will depend on your monitoring objective and/or specific questions you want to answer. Fauna monitoring can be used to assess and monitor changes in biodiversity, habitat use/preference for specific trees etc. and response to management actions e.g. feral animal control.

There are two broad levels of fauna assessment:

- **Simple visual assessments:** This includes opportunistic sightings and searching for scats, scratches, diggings, feathers or other evidence of fauna species. This can be done whenever you are in the field and doesn't require a lot of training or licencing.
- **Fauna surveys:** This includes wildlife surveillance using cameras, sound recording, trapping animals using Elliott and pit fall traps etc. This is more complicated but will yield more comprehensive results. Specific training and licensing is often involved if the techniques used involve: regularly catching or handling wildlife, have the potential to impact on Threatened species, or are carried out in a systematic basis which could affect behaviour. Approval may be required under the *NSW Biodiversity Conservation Act 2016* or the *NSW Animal Research Act 1985*.

If you do not have the skills or approvals for the level of monitoring you wish to use you may be able to get assistance from your local University, Local Land Services or Office of Environment and Heritage. Refer to the OEH website for information on licencing.

http://www.environment.nsw.gov.au/licences-and-permits/scientific-licences.

Simple visual assessments*

Taking the opportunistic sighting of fauna while going about your day to day a step further can provide more detailed knowledge on the activity of species as well as assist in detecting more elusive and/or nocturnal fauna.

Sitting quietly on your property, perhaps by a creek or waterhole allows birds, mammals and invertebrates to get used to your presence and resume their normal activities.

Useful equipment

- Binoculars
- Spotlight
- Notebook or recording sheet
- Headtorch
- Camera
- Self-sealing bag for droppings, hair, feathers etc.
- Identification guide books

*Adapted from the Office of Environment and Heritage Watching and Surveying Wildlife document, see **Section 8.**

Scats and trails

The footprints and markings left in a soft surface as an animal moves over it can be used to identify which species are in the area. This can be particularly useful for reptiles or small nocturnal or secretive animals as well as feral species such as cats and foxes.

Clean, soft, damp, sandy areas such as near creeks or water can often yield the best tracks and trails as the imprints are clean and will last. You can also create your own 'sand pad' with fine-grained material such as yellow brick-layers sand, directly to an area likely to be used by fauna. Ensure the sand is certified free of weeds, lightly water to create a firm, damp consistency and smooth over the surface.

A single sand pad may get some footprints, but a number of pads will provide more coverage. For a more comprehensive survey, the distance between sand pads will depend on the species targeted and the size of the area being surveyed. For small lizards and small mammals (e.g. phascogales, dunnarts or rodents), sand plots can be as close as 50 metres. For medium-sized mammals (e.g. quolls, bandicoots, bettongs), and as a general purpose survey, 200 metres is a better distance (Watching & surveying wildlife, Office of Environment and Heritage).

Scratches: the distinct scratching or feeding scars on trees indicates the presence of possums, gliders or koalas.

Scats: the faecal pellets of carnivores can reveal the identity of the animal and its diet including prey. Droppings of herbivores are generally characteristic for a particular species. Possum and koala pellets smell strongly of eucalyptus leaves when broken, and can be differentiated by size, shape and colour.

Tips for finding fauna

Birds: Most birds are active during the day particularly morning and evening and have distinctive calls. It can take time to learn the calls of particular species but there are many guide books and audio resources available to assist. Nests can often be seen in trees and shrubs, and 'whitewash' is often seen under branches where birds roost at night. Small bundles of fur and bones around the base of large trees signal that owls are roosting above.

Mammals: Most native mammals are elusive and nocturnal, so direct observation requires after-hours work. However, kangaroos, wallabies and echidnas are often seen during the day.

Microbats, with their rapid darting flight, are easy to spot against the sky at dusk or around an outside light. An area with a reasonable amount of natural habitat may support many species, but, without capture or specialised equipment to analyse their calls, most are impossible to identify. However, some species, such as the white-striped free tailed bat (*Austronomus australis*), have calls which are audible to the human ear.

White-eared honeyeater © J. Cramp

Reptiles, amphibians and invertebrates: Reptiles and invertebrates (such as insects, spiders and snails) can be found by carefully turning over rocks, fallen timber or litter on the ground. Timber and rocks should always be replaced as they were.

Reptiles can be observed in the heat of the day, often basking in the sun on logs and rocks. Goannas are often seen during hot weather running up a nearby tree when disturbed.

Frogs are most active at night after rain, though can be difficult to see. They are often identified by calls, but can also be seen while spotlighting.

Insects are about in greater number and variety in the warmer months, and are often associated with the flowering of plants. Increased insect numbers also increase the chance of seeing the insectivorous birds and mammals which feed on them.

Rain after a dry spell will often bring wildlife out of hiding, so this is a good time to look.

6.2. Spotlighting

The activity of searching for nocturnal wildlife, such as owls, possums, gliders and invertebrates using a torch, called 'spotlighting' is a simple and inexpensive way of having a look at what is on your property. An occasional search should not impact on wildlife but if you wish to do more regular searches refer to the OEH website for information on licencing. https://www.environment.nsw.gov.au/licences-and-permits/scientific-licences.

Spotlighting at night can be done from a vehicle or on foot and involves holding a torch or spotlight at eye height and looking along the beam. The beam is moved slowly over the ground, shrubs and trees, looking for eye-shine. This is the reflection of light from the animal's retina and can be easily picked up with practice.

Binoculars can be used to identify an animal once its eye-shine is detected. It is also important to occasionally turn off the lights and motor, and to listen to the night sounds, such as those of frogs, possums or owls.

Although a lot of it is down to luck, being quiet and patient is critical.

Powerful Owl © K. Taylor

Stag watching is a technique that can also be useful which involves watching and listening for nocturnal wildlife which are leaving their den or roost sites. Target trees with hollows for 30 minutes before and after sunset.

Refer to **Section 7** for a list of additional resources and field guides which may be useful.

6.3 Motion sensing camera traps

Camera types:

Remote motion sensing cameras are an effective and efficient survey tool that can provide largely non-invasive visual and auditory records of species and natural behaviours. Data can be collected over a long period of time with minimal labour requirements.

There are many types of wildlife monitoring cameras available. Determining the correct one for your needs can be difficult as they all have a range of pros and cons that might make them more or less suitable for particular species or survey outcomes. Consideration must be given to unit cost, maintenance needs, battery life, USB connectivity, image quality, still photograph or continuous recording and other features.

In some cases, models are designed to be left active without the need for maintenance for very long periods of time (many months to a year). Some of these have solar panels as options to minimise or replace the need for batteries, and immediate wireless image transfer to a central location so that physical interaction with each camera is not required to download images. Some can also stream live continuous recording via a webcam to a chosen website.

As many of the more interesting or rarer species are small, fast-moving nocturnal animals, the cameras need to have a fast trigger, hidden flash (fully covert), and possibly the ability to capture images in bursts.

The ability to record footage and even sound can be an advantage. Many are economical enough that their batteries may last for a year before needing to be changed or recharged.

Other benefits

Wildlife cameras have practical benefits for farm management and planning, especially in pest animal control methods and targeting. Use of predator sightings (i.e. foxes) will inform vermin control, fox baiting programs, den fumigation, ripping, spot lighting and other eradication methods to assist in determining effectiveness of current controls.

Equipment

For a simple set up, you will need:

- Motion-sensing camera (there are many models and prices range from <$100 to many hundreds of dollars with lots of extra features)
- SD card for the camera (minimum 32GB)
- Batteries for the camera (6-12 AA or AAA depending on the camera model)
- Attachment cord or cable for the camera (often supplied with the camera)
- A post or star picket to attach the camera to if there is no suitable tree or existing post
- A hand mallet for driving in the camera post.

Camera trap Image from NCC Upper Coldstream Biodiversity Project © RECONYX

Cameras should be left for at least one week to allow animals to become accustomed to them. Try to identify an area that animals travel through by looking for tunnels or animal tracks through the undergrowth. Position the camera so that it has a clear view of this area.

Viewing images

After the camera has been on site for at least a week (2-3 weeks is preferable), it can be taken down and the SD card removed. Instructions for this will vary depending on the type of camera used. The SD card can be inserted into a computer with an SD card slot, or a portable card reader, in the same way any digital image can be viewed.

Image identification

Many of the images on the camera may be easy to identify as they will be common animals such as possums, foxes or wallabies. If you find an image that you can't identify, you can contact the Australian Museum, Office of Environment and Heritage, Local Council office, Local Land Services or there are a range of web based groups and online identification keys (see **Section 7**).

There will be a number of images where no animal appears. This is normal, and is because of a false trigger (something activating the motion sensor such as on a windy day), or the animal that triggered the motion sensor was particularly fast and already moved out of sight before the image was taken.

An example fauna camera data recording sheet is provided in **Appendix 4.**

Refer to the Adaptive Management case study which looks at management actions where Wildlife Monitoring Techniques have detecting threatened species in Appendix 8.

6.4. Trapping

Any surveys which include trapping to target native wildlife require approval under the *NSW Biodiversity Conservation Act 2016* and the *NSW Animal Research Act 1985*.

SCIENTIFIC LICENCE AND ANIMAL ETHICS CONSIDERATIONS

Extensive use of cameras, particularly if using bait, has the potential to affect the behaviour of wildlife and may require approval under the NSW Biodiversity Conservation Act 2016 or the NSW Animal Research Act 1985.

7. Digital Information, Monitoring Tools & Resources

The skills you develop in observational and photo point monitoring will be valuable to you in other aspects of property management. For example you may wish to exclude fire from your property if you only have rainforest but still need to manage other threats such as feral animals or weeds. You may also apply for grants that require some form of monitoring to record the progress and success of your project.

You may have wildlife conservation objectives for your property and wish to build your knowledge of the wildlife on your property. Below are a number of programs and resources designed to assist community members build their skills and at the same time contribute to publicly available records of bird and animal populations.

Survey Techniques for Citizen Scientists

The National Parks Association of NSW has produced the manual, S*urvey Techniques for Citizen Scientists* (2015) to provide information in a user friendly way to assist community groups or individuals to gather data. The manual contains general information on monitoring as well as specific survey methods for vegetation as well as terrestrial mammals, bats, reptiles, frogs, birds, invertebrates and underwater survey methods. Visit www.npansw.org.au/ to find out how to order this manual.

Atlas of Living Australia

Records from citizen science projects or general opportunistic observations can be added to the Atlas of Living Australia or searches done by location or species. www.ala.org.au/get-involved/citizen-science/. Records can also be uploaded through its phone application OzAtlas www.ala.org.au/blogs-news/new-version-of-ozatlas-app-available-now-for-download-on-android-phones-2/.

NSW Office of Environment & Heritage (OEH)

OEH is involved in a variety of citizen science programs including Wildcount, Glossies in the Mist, Koala counts, Whale Sightings and Shore birds monitoring. View on-line: www.environment.nsw.gov.au/research/citizenscience.htm.

Information on guidelines for carrying out surveys and licencing requirements can be found on the website: www.environment.nsw.gov.au/surveys/GuidelinesForCarryingOutASurvey.htm.

Watching and Surveying Wildlife:

http://www.environment.nsw.gov.au/~/media/C2C64513087E4AAAB5DDD7695CFD4A1B.ashx.

The Australian Museum

The Australian Museum has a strong history of involvement in citizen science programs and tracking wildlife distributions. It also now runs the well-known *Stream Watch* monitoring program by schools and community groups. A variety of field guides are increasingly becoming available on the Museum website or as smart phone applications: For information on their programs visit:

http://australianmuseum.net.au/blogpost/lifelong-learning/citizen-science-programs.

https://australianmuseum.net.au/frogid-project.

Birdlife Australia Birds in Backyards

Birds in Backyards is a research, education and conservation program focusing on the birds that live where people live. Find out more about Australian birds and their habitats and get involved by taking part in the online surveys. Visit: www.birdsinbackyards.net/surveys.

The Royal Botanic Garden Sydney (National Herbarium of NSW)

The RBGsyd has a botanical information service and they also have useful information on plant collecting and what features to observe and note. https://www.rbgsyd.nsw.gov.au/science/national-herbarium-of-new-south-wales.

Department of Primary Industries (DPI)

DPI manages a broad range of initiatives from resource to industry, including natural resource management, research and development, pest and disease management. Useful policy and procedure information including that pertaining to the *Biosecurity Act 2015* effective from 1 July 2017, specifically on weeds can be found here: https://www.dpi.nsw.gov.au/about-us/policies-procedures.

Flora and Fauna Identification and Guide Books and Other Resources

The listing below is not exhaustive but intended to provide a basic reference library to assist in site monitoring.

- Clarke, R. and Rogers, D. I. (2017). The Australian Bird Guide, CSIRO Publishing
- Brooker, M. and Kleinig, D. (2006). Field Guide to Eucalypts Volume 1 - South-Eastern Australia, Bloomings Books
- Cogger, H. (1975). Reptiles and Amphibians of Australia, CSIRO Publishing
- Costerman, L. (1981). Native Trees and Shrubs of South-Eastern Australia, New Holland, Frenchs Forest
- The Australian Soil and Land Survey Field Handbook. (1984). CSIRO Publishing
- Meek, P. D., Ballard, G. and Fleming, P. (2012). An Introduction to Camera Trapping for Wildlife Surveys in Australia, Invasive Animals CRC
- PestSmart Toolkit publication (2012). Invasive Animals Cooperative Research Centre, Canberra, Australia. www.pestsmart.org.au/wp-content/uploads/2012/09CameraTrapManual_2012.pdf
- Triggs, B. (2004). Tracks, scats, and other traces, Oxford University Press Australia
- Van Dyck, S., Gynther, I. and Baker, A. (2013). Field Companion to the Mammals of Australia (eds). Sydney : Australian Museum : Reed New Holland.

Electronic Guides

- Harden, G., McDonald, B., Nicholson, N., Nicholson, H., Tame, T. and Williams, J. (2014). Rainforest plants of Australia Interactive Identification Key & Information System. http://rainforestplantsofaustralia.com.

Hotspots Fire Project Resources

- Hotspots fire and weeds landholder booklet: www.hotspotsfireproject.org.au/download/fire-and-weeds-landholders-bookletfinallr.pdf
- Hotspots fire and weeds scientific review: www.hotspotsfireproject.org.au/download/fire-weeds-and-native-vegetation-of-nsw.pdf
- Recording sheets: www.hotspotsfireproject.org.au/ecological-resources.

Websites

NSW Rural Fire Service – fire information

http://www.rfs.nsw.gov.au/fire-information/fires-near-me

http://www.rfs.nsw.gov.au/news-and-media/stay-up-to-date

http://www.firebreak.com.au/mcarthur_meter.html

Ecological Information

http://www.nswthreatenedspecies.net/

http://www.bionet.nsw.gov.au/

https://www.seed.nsw.gov.au/

http://plantnet.rbgsyd.nsw.gov.au/

http://environment.nsw.gov.au/threatenedspeciesapp/

http://www.weedfutures.net/

http://www.ala.org.au/

http://www.fireandbiodiversity.org.au

http://maps.six.nsw.gov.au/

Weather and Climate Change data

http://www.bom.gov.au/australia/meteye/?ref=ftr

http://www.bom.gov.au/app/

http://www.environment.nsw.gov.au/topics/climate-change

Cultural Heritage

http://www.environment.nsw.gov.au/awssapp/login.aspx

Equipment

http://www.firetrader.com.au/

http://www.faunatech.com.au/

Satellite Data

http://firewatch-pro.landgate.wa.gov.au/home.php

http://srss.landgate.wa.gov.au/

http://www.google.com/earth/

http://www.resourcesandenergy.nsw.gov.au/miners-and-explorers

Open Source GIS

http://www.qgis.org/en/site/

Data Products

https://earth.esa.int/web/guest/data-access

http://www.data.gov.au

Sounds

http://www.naturesound.com.au/

Mobile Phone Applications

New Android and Apple (iOS) applications which can be used for monitoring are being released every day. Some examples of the more popular ones are listed below

http://www.ala.org.au/who-we-are/downloadable-tools/ala-mobile-app/

http://www.dpi.nsw.gov.au/biosecurity/weeds/nsw-weedwise-app

https://itunes.apple.com/au/app/google-maps-gps-navigation/id585027354?mt=8

8. References

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9. Appendices

Appendix 1: Example Site Assessment and Monitoring Recording Sheet

Appendix 2: Example Fuel Assessment Sheet

Appendix 3: Example Photopoint Recording Sheet

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Appendix 5: Case study 1 - Managing Fire and Weeds in a BMAD Landscape

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Appendix 1 - Example Site Assessment and Monitoring Recording Sheet

Site Assessment and Monitoring Sheet

PROPERTY DETAILS:

Property Owner/ Recorder		
Location Information	Street address	
	Lot/DP	
Landscape	Local Government Association, Bioregion, catchment etc.	

SITE DETAILS:

Management Area				Date
Plot Location		GPS/ map co-ordinates		
Aspect	Slope		Soil/geology	
Photo ID and where stored				
Record details if site is permanently marked e.g. (post or stump etc.)				
Vegetation	Keith Formation and Class if known			
	Canopy Species in order of dominance			

DISTURBANCE HISTORY:

Fire	Severity, date of last event, evidence (known or estimated)
Logging/ Clearing	
Grazing	Stock, native, feral, severity, time
Significant Weeds (WONS or Biosecurity listed)	
Other	e.g. Bell Miner Associated Dieback (BMAD)

BASE PLOT (20 X 50):

No of canopy species	Mature Regrowth
No of trees with hollows	
Length of dead fallen timber	Diameter > 10cm and length >50cm

SUBPLOT (20 X 20):

No of native shrubs and small trees >1m	
No of native ground cover species	

2.5 M RADIUS AROUND POINTS ALONG TRANSECT:

Projected Foliage Cover (%)	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Native Canopy										
Native midstorey										
Weeds canopy & midstorey										

QUADRATS (1 X 1 M) ALONG TRANSECT:

Ground Cover %	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Native ground cover										
Weeds										
Moss &lichens										
Organic litter										
Rock/bare ground										
Total (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

FUEL LOAD:

Overall Fuel Hazard t/ha.		Comments:

HABITAT VALUES:

Feed trees, hollow logs, rock outcrops, nests etc.

Based on *vegetation condition survey proforma* in Eco Logical Australia (2009) *Riverine Vegetation in the Namoi Catchment. An Assessment of type and condition* Final Report prepared for: Cotton Catchment Communities CRC Namoi Catchment Management Authority. Eco Logical Coffs Harbour. Appendix 1.

Appendix 2 - Example fuel recording sheet

Use this form to assess fuel loads using the techniques described in the *Overall Fuel Hazard Guide* as provided during workshops in your Hotspots folder. This form is designed to be used in conjunction with the *Overall Fuel Hazard Guide* (3rd edition).

Management Area:			**Date of sample:**		
Burn Name/ ID:					
Sample location details:					
Vegetation formation (Keith 2004):					
SURFACE FINE FUEL					
		Sample no. (alternatively use quadrats locations)			
Average Litter-bed height (mm)	**Rating**	**Equiv. Fuel load (t/ha)**	**1**	**2**	**3**
<15	Low	<4			
15-25	Moderate	4-8	**Average surface fine fuel score (t/ha):**		
25-35	High	8-12			
35-50	V High	12-20			
>50	Extreme	20+			
ELEVATED FUEL					
Rating	**Equiv. Fuel load (t/ha)**		**1**	**2**	**3**
Low	0				
Medium	0		**Average elevated fuel score (t/ha):**		
High	2				
V High	6				
Extreme	10				
BARK FUEL					
Rating	**Equiv. Fuel load (t/ha)**		**1**	**2**	**3**
Low	0				
Medium	0		**Average bark fuel score (t/ha):**		
High	2				
V High	5				
Extreme	7				
				OVERALL FUEL LOAD (t/ha)	
NOTES:					

Appendix 3 - Example Photopoint Recording Sheet

Photo point data sheet

Photopoint location _____

Location details _____

_____

Monitoring data sheets completed as plot

- Vegetation
- Other _____

Date_____ Time_____

Compass bearing _____

GPS_____

Photographer's name _____

Dates of known or recent fires _____

Other relevant information

_____

_____

_____

ATTACH PHOTOGRAPH HERE

Appendix 4 - Example Fauna Camera Data Recording Sheet

Fauna camera data record sheet

Burn ID: _____ (Date / Name of burn)

Location description: _____

_____

Date of installation: _____ Time of installation: _____

Personal installing cameras: _____

Date of removal: _____ Time of removal: _____

Assessment

Model of camera: _____

Bait used: _____

	Easting	Northing
Location of camera:		

Animals identified:

Animal species name	Confidence in classification (%)

Animal species name	Confidence in classification (%)

Adapted from Fire and Biodiversity Monitoring Manual for private landholders ©CFA 2014

Appendix 5 - Case Study 1

Splatter-gun demonstration at Hotspots workshop © K. McShea

Managing Fire And Weeds In A BMAD Affected Landscape:

Bowen Mountain is located at the north-eastern edge of the Greater Blue Mountains World Heritage Area and the Blue Mountains National Park. From Bowen Mountain eastwards there is a transition from the prominent infertile sandstone ridges that characterise the Blue Mountains to undulating and much more fertile landscapes with shale-derived soils to the western fringes of the Cumberland Plain.

In recent years across these relatively fertile landscapes Bell Miner Associated Dieback (BMAD) has expanded rapidly and resulted in the degradation of a range of significant eucalypt dominated forests and woodlands, many of them listed as Threatened Ecological Communities under state and commonwealth legislation (e.g. Cumberland Plain Woodland and Shale/Sandstone Transition Forest). In many areas heavily degraded by BMAD there is major canopy loss and death, and loss of dominant eucalypt species, this results in the establishment of extensive high density infestations of lantana, a Weed of National Significance, and invasion and degradation by a host of other weeds.

These lantana "thickets" provide the ideal conditions for Bell Miner colonies to thrive and strongly contribute to the expansion of BMAD. There is an urgent need to manage lantana to restore the health of these forests and woodlands and to avoid the loss of many eucalypts from the landscape. Although not well understood, fire is thought to play a role in BMAD and fire can be used as a weed management tool in certain instances, although integration with other weed management techniques (such as splatter control of lantana) is generally required for the best restoration outcomes. Splatter or "splatter gun" control of lantana refers to a highly efficient and effective lantana control technique involving the application of a stream of droplets from a knapsack or other spayer containing a high concentration of herbicide. For an instructional video see www.bmad.com.au/splattergun.html.

The Greater Sydney Local Land Services recognised the magnitude and severity of the BMAD problem in the north-eastern foothills of the Blue Mountains and worked in partnership with Hotspots to increase awareness of BMAD and to work with high priority private properties to plan for and implement fire management and ecological restoration works in an attempt to halt the rapid expansion of this insidious problem. After an expression of interest process, the top four properties were selected for their ecological values, for the potential for good environmental restoration outcomes and addressing BMAD; each of these properties had integrated bushland regeneration and fire management works implemented with the aim of addressing BMAD and restoring forest health.

In order to understand the ecological outcomes of implementing bushland regeneration works and to detect environmental changes occurring on each of these properties, a comprehensive monitoring program was established involving the gathering of baseline data (pre-works), during bushland regeneration works, and post-regeneration works for a period of approximately 2 years. There is an intention to continue monitoring annually so that ongoing ecological changes can be measured.

Monitoring methods used included the establishment of permanent monitoring plots (50x20m) within which were located photopoints and a 20x20m plant diversity plot. Specific monitoring methods used included measuring and recording ground, shrub and tree cover for native and weed species within 1x1m quadrats at 5m intervals along the 50m central transect, measures of canopy health (as a percentage), the recruitment and establishment of dominant canopy species, the number of tree hollows, and the length of fallen timber within the plot. Recording these variables from prior to works being implemented until seasons and years after regeneration works are completed enables the ecological "health" and condition of the plot to be measured and for the outcomes of regeneration works to be documented in a systematic and standardised fashion. This enables comparisons to be made within and across sites and can be used to help to identify any further management interventions that may be required and can assist in adaptively responding to any unforeseen outcomes.

> "I can now access the creek from the land which I couldn't' do before!"
>
> – Project participant

Whilst positive outcomes of regeneration works including major reductions in lantana cover and density and increased diversity of native species were achieved and measured within the permanent plots and using photopoints; canopy health in sites severely impacted by BMAD did not change significantly across the 3 years of project monitoring. Because of the lengthy life span of trees it is highly likely that changes in canopy health caused by ecological restoration works will take many years to be detectable; this provides an excellent demonstration of the need for site monitoring of ecosystems to be undertaken over longer periods to capture changes and to monitor the trajectories of sites following management interventions.

Bell Miner Associated Dieback (BMAD)

BMAD is listed as a threatening process under the N*SW Biodiversity Conservation Act 2016*. It currently occurs throughout sclerophyll forests on public and private lands in New South Wales, Victoria and Queensland and is spreading through forest ecosystems in eastern Australia. All the factors supporting BMAD are still not fully known.

The pattern of cause and effect has been described as a response to the disturbance of forest structure, where there is an open canopy, a sparse or absent mid-storey and subsequently a well-lit, dense, shrubby understorey. When the forest has tree species susceptible to attack by Glycaspis species of psyllid insects and the understorey becomes dominated by a single plant species, like lantana, which supports nesting by the bell miner, the scene is set for increasing populations of psyllids and bell miners.

The bell miner eats the sugary lerps coating covering the psyllid insect on eucalypt leaves, but it generally does not eat the psyllid itself. Because of the increased numbers of dominant bell miners in a disturbed forest, birds that do eat the psyllid are forced out. The result is an overabundance of psyllids, which suck the sap from the leaves. This causes the tree to repeatedly defoliate, which eventually kills the tree, and ultimately the forest (John Hunter, OEH, pers. comm.) Refer to the BMAD website for more information.

www.bmad.com.au/index.html.

Appendix 6 - Case Study 2

Monitoring The Overall Fuel Hazard At Gradys Creek, Border Ranges:

Background Information

Fire is a chemical reaction which requires sufficient heat, oxygen and fuel. Managing the fuel component is a major consideration of managing bush fire risk. In the bush, fuel consists of dead and living vegetation. Firefighting agencies refer to the amount of fuel available in a bush fire situation as the overall fuel hazard. Hotspots workshops demonstrate different methods of reducing fuel loads such as mechanical removal or modification and using a low intensity controlled burn to remove the surface fine fuel. To measure and monitor the effects on the fuel load of these fire management actions, the Overall Fuel Hazard Guide (3rd edition) developed by the Victorian State Government, can be used to evaluate the risk and the results used to guide ongoing management. The Overall Fuel Hazard consists of the bark, elevated fuel and the surface fine fuel (McCarthy, Tolhurst, & Chatto, 1998) and is expressed as tonnes per hectare (t/ha). At least five measurements should be taken and an average used for a given site.

Measuring Fuel Loads at Gradys Creek

The overall fuel hazard at Gradys Creek was monitored as part of management actions associated with Threatened Species recovery actions for the eastern bristlebird (*Dasyornis brachypterus*) and the Hastings River Mouse (*Pseudomys oralis*). The study took place on a north facing slope to the south of Gradys Creek and adjacent to Border Ranges National Park and Gondwana Rainforests of Australia World Heritage area (**Figure 1**).

Figure 1: Gradys Creek Site

The area receives an average of approx. 1200mm of rain per year with most of this falling in late spring to autumn (BOM, 2016) but heavy falls can occur at any time of the year and the rainfall can be double the average in some years. The site has a sub-tropical climate with moderately fertile soils.

The whole site is dissected by a series of gullies. These gully areas are often deep and rocky with thickets of Lantana (*Lantana camara*). The vegetation at the site is predominately the Keith Class Northern Hinterland grassy Wet Sclerophyll Forest but intergrades with North Coast shrubby Wet Sclerophyll Forest in the deeper gullies. Overall fuel hazard measurements were taken at the study site before and after a prescribed burn undertaken in September 2013, see **Table 1.**

	May 2013	December 2013	January 2016
Overall Fuel Hazard (t/ha.)	**20**	**7**	**17**

Table 1. Overall Fuel Hazard at Gradys Creek Site

Photos were taken at the time of fuel hazard measurements and are indicative of the site, **Figure 2**.

May 2013 December 2013 January 2016

Figure 2. Photo points at study site

Conclusions

The Overall Fuel Hazard has almost reached the levels found before the burn in 2013. This is probably a result of several wet years and the increased light levels available to the understorey vegetation after the burn. If built assets were near the site this could be cause for concern. Lantana and other weeds which had been suppressed by the burn are now returning. The results support evidence from other vegetation and fauna surveys indicating that another burn would not only be beneficial in reducing fuel loads, making a hot intensive burn less likely, but also to encourage grassy habitat for the eastern bristlebird and Hasting River mouse. Without considering the monitoring data collected and basing fire management on the state-wide thresholds (Kenny, Sutherland, Tasker & Bradstock, 2003) for grassy Wet Sclerophyll Forest, the site would not be considered for further fuel reduction until 2028. This would also allow dense thickets of Lantana to re-establish, invasion by wattle and mesic understorey species and the reduction of the grassy understorey available for the eastern bristlebird and Hastings River mouse. The elevated fuel load would also increase the intensity and impact of a wildfire or a controlled burn. The monitoring data could be used to justify another prescribed burn if resources are available.

References: see **Section 8**.

Appendix 7 - Case Study 3

Australia has more hollow-dependent species of wildlife than any other continent © K. Taylor

Monitoring And Protecting Hollow-Bearing Trees

In NSW over 170 species of wildlife are dependent on tree hollows at some stage of their lifecycle. A third of these are listed as threatened on State or Commonwealth threatened species legislation. The continued loss of hollow bearing trees, in a wide range of vegetation types, and the negative impact this has on these species led to the listing of Loss of Hollow-bearing Trees as a Key Threatening Process (NSW Scientific Committee, 2007) under the Threatened Species Conservation Act 1995.

Fire can be beneficial in increasing the rate of hollow production, particularly in stands of younger trees, but it also causes the collapse of older hollow-bearing trees, which take hundreds of years to replace, especially if large entry points are present (Parnaby, Lunney, Shannon & Fleming, 2010). Dead trees are also at high risk even from low intensity hazard reduction burns. Reducing the fuel around the base of at-risk hollow-bearing trees can significantly reduce the risk of collapse (Bluff, 2016).

Entry points like the one pictured here allow even a low intensity burn to weaken the structural integrity and cause the collapse of hollow-bearing trees.

© K. Taylor

It is important to monitor and manage the effects of fire to hollow-bearing trees where possible. A simple approach is demonstrated during Hotspots Fire Project workshops:

- Identify and record the location of hollow-bearing trees within a designated management area. If large numbers are present map the area rather than record each tree.
- Identify "at-risk" trees i.e. Entry points present, build-up of fuel around the base, dead stags, large exposed hollows where embers may lodge are present. Photopoints and GPS locations will help with this step and notes about the type of risk.
- If a decision is made to use fire as a management action then the information collected in Step 2 can be used to build safeguards into your burn plan and reduce the risk of collapse of at-risk trees.
- Using a rake-hoe to scrape back fuel around the base (1-2m) of at-risk trees is a simple method which can be used to protect trees from structural damage caused by direct flame. Wetting down the base of tree is also effective if sufficient water is available. Keeping the average flame height at a minimum will reduce the risk of embers loading inside tree hollows and forks.

Mechanically reducing fuel around their base is a cost-effective method of mitigating loss of hollow-bearing trees
© K. Taylor

The use of leaf blowers and lighting patterns can also be used to reduce the intensity of a controlled burn in the vicinity of at-risk trees. After fire is used, repeat Steps 1 and 2 and identify if any losses occurred. Monitoring should be continued well after the burn as unseen impacts on roots or other parts of a tree's structure may be present and collapse could occur days or months later. If losses are observed, try to identify what could have been done differently and incorporate those measures into future management actions at the site or in other management areas. The installation of nest boxes or the creation of artificial hollows will improve ecosystem health in landscapes where few hollow-bearing trees are present.

References: See **Section 8**.

Appendix 8 - Case Study 4

Male emu and chicks © NCC

Adaptive Management Action For Threatened Species

Coastal Emu Endangered Population – Bungawalbin Hotspots Demonstration Burn

The Bungawalbin Hotspots Fire Project was delivered across a landscape supporting the largest complex of coastal floodplain wetlands remaining in the Northern Rivers region. These nationally significant wetlands are occupied by a bewildering array of threatened species (amongst the highest of any landscape in NSW) including an isolated outlier population of the Coastal Emu (listed as an Endangered Population under NSW legislation). Considerably less than 100 birds are known to occur between Red Rock and Evans Head, with a major contraction in range and reduction in population in recent years. The Bungawalbin area provides important habitat for an isolated sub-population of the Coastal Emu and is critical to their survival as it contains approximately 30 birds.

A Hotspots demonstration burn was implemented on "Main Camp", a major commercial tea tree plantation known to periodically support most of the Bungawalbin Coastal Emu sub-population. The demonstration burn aimed to reduce fuel loads and re-invigorate the grassy layer of a small area of Coastal Valley Grassy Woodland. As part of the demonstration burn camera traps were deployed to monitor the site before, during and after the burn. The aim of the camera trapping was to document the use of the site by Coastal Emus, macropods, dingoes and pigs. An additional aim was to document the use of the burn site following fire and to attempt to define the length of time after fire at which these target species start using the burn site.

A male emu with four small chicks was detected using the site approximately 6 weeks post-fire and the time taken to return to the site of a range of macropods such as the eastern grey kangaroo and red-necked wallaby was recorded on the camera traps. With knowledge of the presence of a small family group of Coastal Emus on the demonstration burn site, trapping and other forms of pig control could be implemented to ensure the survival of these precious birds.

Spotted-tailed Quoll – Upper Coldstream Biodiversity Project Camera Trapping

Remote surveillance cameras (cameral traps) deployed as part of the Upper Coldstream Biodiversity Project detected the nationally Endangered Spotted-tailed Quoll (*Dasyurus maculatus*) which had not been definitively identified on the property, or within the broader Upper Coldstream catchment despite a range of intensive and some systematic wildlife surveys undertaken over the previous 4-5 years. With the confirmation of the ongoing existence of the Quoll within the landscape this knowledge can contribute to the development of management actions to maintain and potentially enhance populations of this highly significant native predator (the largest marsupial carnivore remaining on the North Coast). These management actions include identifying potential den sites such as hollow logs or rocky outcrops and implementing fire management techniques to protect these resources. In addition, continued camera monitoring on the status of fox and cat populations (both competitors with and potential predators of quolls), and planning trapping, den fumigation or other fox control techniques to suppress fox population density, and liaising with neighbours to mitigate potential threats such as broad-scale, intense and frequent fire and roaming domestic dogs.

New Holland Mouse – Upper Coldstream Biodiversity Project Elliott trapping

The New Holland mouse (*Pseudomys novaehollandiae*) is a nationally Vulnerable native rodent that feeds mostly on native grass seeds and plant matter. It requires the availability of recently burnt areas in the landscape because these have an abundance of grass seeds and other important food sources. Populations of the New Holland mouse have been recorded "booming" in recently burnt landscapes. As the years progress following fire, populations have been documented falling to much lower levels, surviving in very low population numbers and density. Inappropriate fire regimes have been identified as a cause of its decline throughout its range.

As part of fauna surveys undertaken for the Upper Coldstream Biodiversity project a single New Holland mouse was trapped in an area of North Coast Dry Sclerophyll Forest in which fire had been absent for at least 12 years. As part of the Pillar Valley Hotspots Fire Project a demonstration and Hazard Reduction burn (HR) was implemented within this habitat with the aim of maintaining and enhancing the New Holland Mouse population in this landscape. The HR burn was conducted to reduce the high fuel loads present and to provide a mosaic of long unburnt and recently burnt habitats to optimise and maximise habitat availability for this and other ground dwelling species. Vegetation transects and fuel load data were recorded before and after the burn. The site will continue to be monitored into the future as resources allow.

New Holland mouse © M. Graham

References:

See **Section 8**.

Landholders assisting to prepare burn site at Hotspots New Italy Workshop 2 © M. Graham

Partners and collaborators

The Hotspots Fire Project is jointly managed by the NSW Rural Fire Service and Nature Conservation Council of NSW.

This booklet was written by Kate McShea, Kevin Taylor, Mark Graham and Jennie Cramp, based on original material developed by Julie Woodroffe, Penny Watson, Waminda Parker and Stefanie Pillora. This booklet has been compiled for the Hotspots Fire Project, with input from, and in consultation with, a wide range of stakeholders. The information contained herein reflects our understanding at the time of publication. We are learning more about fire and the environment every day and anticipate that some techniques and recommendations may change as new information comes to hand.

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HOTSPOTS FIRE PROJECT

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