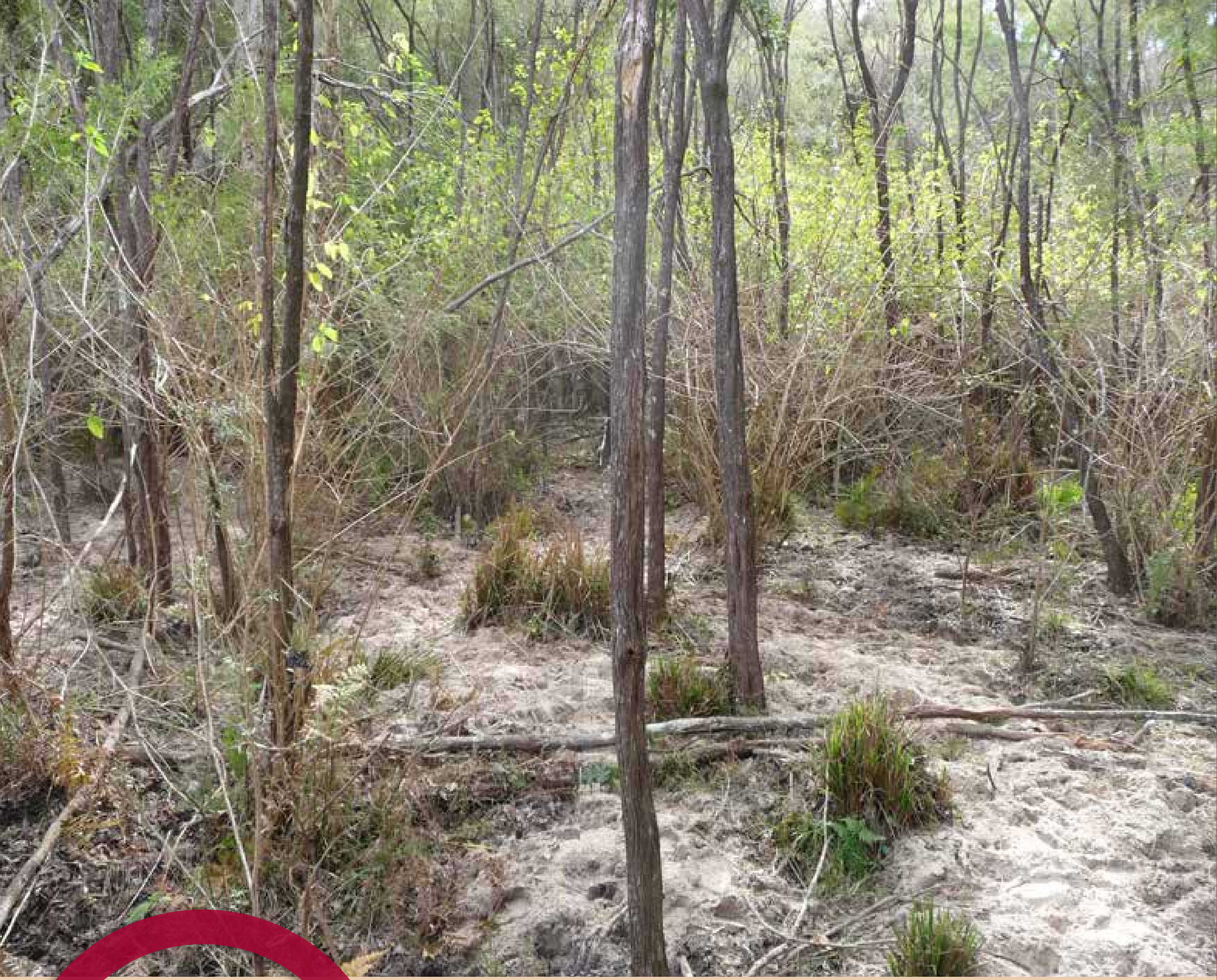
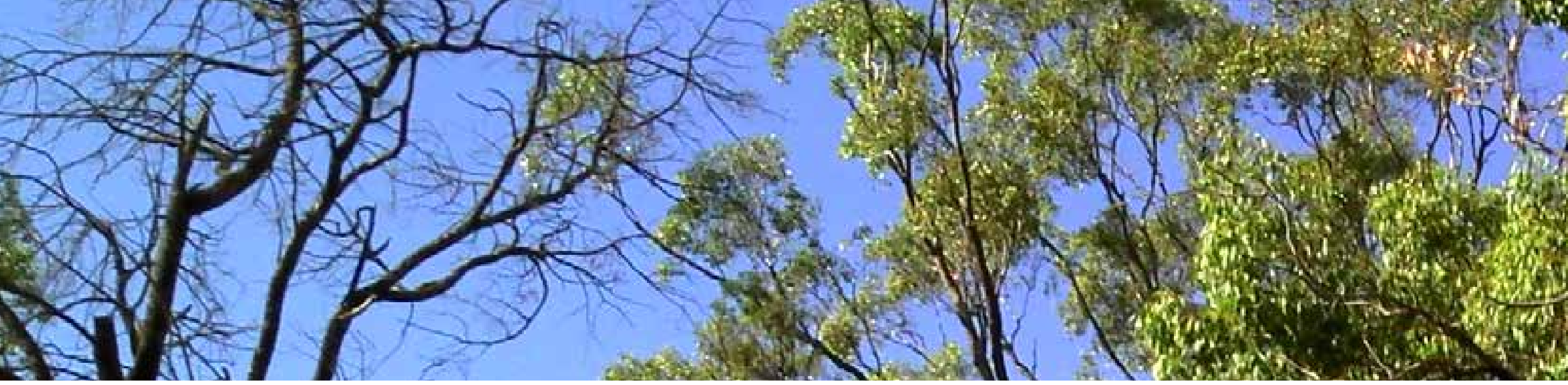


HOTSPOTS FIRE PROJECT

MANAGING FIRE ON YOUR PROPERTY

The interaction between fire and weeds:
A booklet for NSW landholders

NSW Rural Fire Service
Nature Conservation Council
The voice for nature in NSW



HOTSPOTS FIRE PROJECT

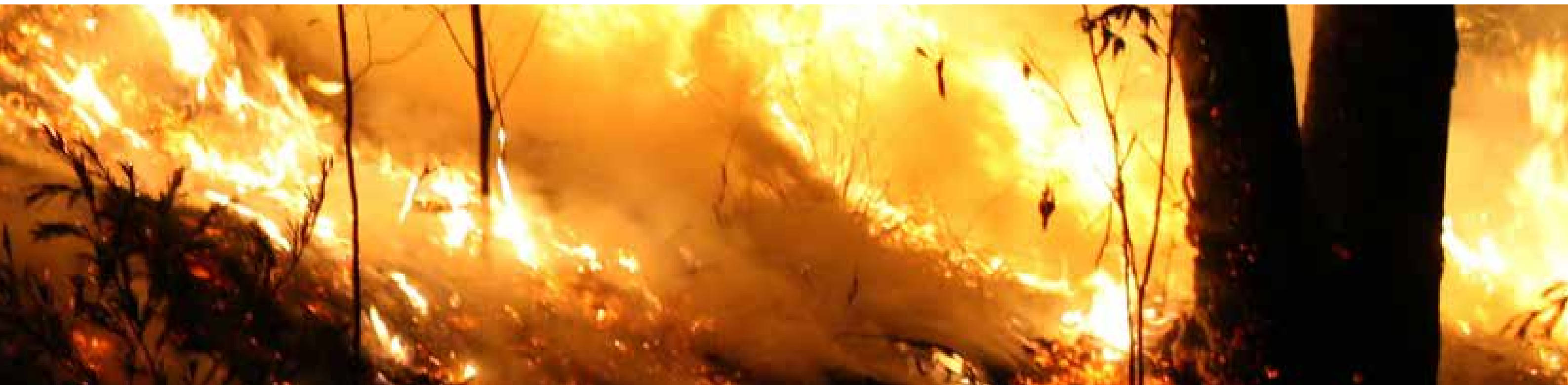
MANAGING FIRE ON YOUR PROPERTY

The interaction between fire and weeds:
A booklet for NSW landholders

Version 2, May 2017

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

WHAT DOES THIS BOOKLET COVER?



THE SCOPE OF THIS BOOKLET

Maintaining the biodiversity of New South Wales through appropriately managing fire is a key aim of the Hotspots Fire Project. This publication is designed to further this aim by raising awareness of noxious and environmental weeds across the State and how fire might be used to manage these weeds and improve the health and viability of native vegetation.

This booklet provides advice about weeds and fire for owners and managers of properties with native vegetation across New South Wales, with the exception of the far west. It is based on a statewide review of scientific literature (Fire and weeds review available via the Hotspots website: www.hotspotsfireproject.org.au/resources-materials), expert advice and land owners' practical experiences of using fire to manage weeds.

In some instances, it may be appropriate to exclude fire and in other situations a particular fire regime may provide the best results for managing weeds. Sometimes these regimes may not accord with the statewide guidelines and the Bushfire Environmental Assessment Code, for example, a series of relatively frequent fires might be required to remove a weed from a particular ecosystem. If you intend to use fire to manage vegetation on your property, you should contact your local NSW Rural Fire Service (NSW RFS) Office to determine whether a bush fire hazard exists and what necessary environmental approvals or permits apply to ensure the work can be undertaken safely. If there is no bush fire hazard then alternative approval pathways may apply. The NSW RFS have a number of documents available on their website that can help you to prepare for and safely conduct your burn. See www.rfs.nsw.gov.au.

This booklet provides an introduction on the relationship between fire and native vegetation, the relationship between fire and weeds in different vegetation types, as well as some of the factors which influence the interaction between fire and weeds. There are also in-depth case studies looking at practical examples where combinations of fire and herbicide have been used to successfully treat weeds, as well as an introduction to monitoring changes in vegetation.

1 INTRODUCTION TO FIRE AND WEEDS

> For the purposes of the Australian Weeds Strategy, a weed is considered pragmatically as a plant that requires some form of action to reduce its harmful effects on the economy, the environment, human health and amenity.
>
> – Australian Weeds Committee.

Weeds occupy most habitats in New South Wales. Generally only the least disturbed, most intact and most nutrient-deficient ecosystems have no weeds at all. Fire interacts with weeds in a myriad of ways, some positively, some negatively, depending on particular sets of environmental and landscape factors. Weeds are very prevalent across the State, and they frequently have a detrimental impact on native vegetation, biodiversity and agriculture. This means we need to carefully consider how weeds are managed. Weeds can impact on biodiversity and the health of ecosystems and threaten the survival of many plants and animals, out-competing them for space, nutrients and sunlight. Weeds can also reduce the productivity of farm and forestry operations, invade crops, smother pastures and some can harm livestock.

Knowing which weeds occupy a particular area is essential for developing management strategies. Considering new weeds are still being introduced into Australia and long-present exotic plants are establishing within native vegetation communities (including so called 'sleeper' weeds), it can sometimes be difficult to confidently identify weeds. A range of resources are available to assist in identifying weeds. These include:

- Many online botanical resources including 'PlantNet – the online flora of NSW' (go to http://plantnet.rbgsyd.nsw.gov.au)
- Online guides to weeds in particular natural resource management regions
- Numerous hard copy field guides
- Herbaria at the Royal Botanic Gardens, Sydney, and in a number of regional centres.

The process of fire (both planned and unplanned) can be a double-edged sword. In some instances fire can reduce weeds and improve ecosystem condition. In other instances, however, fire can cause an increase in both the number of weed species and the area occupied by weeds and degrade the ecosystem. Fire can also have both a positive and negative influence on weeds at the same site, particularly those sites which have a diversity of weed species.

The outcome of a fire at any site will depend on a number of factors:

- the condition of the site before the fire
- the prevalence and diversity of weeds in the landscape
- the seasonality, extent and intensity of the fires over time (what is referred to as the 'fire regime')
- the weather and climatic conditions across the burnt site after the fire
- wildlife movements
- whether there are any human interventions, such as weed control or bushland regeneration works post-fire.

The dynamics of native ecosystems are complex and there is often limited knowledge about the responses of particular weeds to fire. This means there is a great need and excellent opportunities for land owners and managers to cautiously trial a variety of fire regimes used for weed management and closely monitor the results of restoration outcomes. There is also great potential for integrating these fire management practices with other weed management strategies such as herbicide application to achieve better, more efficient, cheaper and longer-lasting weed control and ecological restoration outcomes. These real life experiences can meaningfully contribute to developing and refining best management practices for many of our most costly and ecologically damaging weed species.

Many human activities cause the spread of weeds to new areas, including the movement of machinery and vehicles from one location to another, the transport of grain and silage for stockfeed, and the dumping of garden waste. It is important to be on the lookout for new weeds in your area and to undertake appropriate weed control action as soon as possible. Other major sources of new weeds include the importation of exotic plant species for grazing purposes (primarily grasses and legumes), as well as the large number of new plant species imported into New South Wales each year by the nursery and horticultural sectors.

2 FIRE AND THE NATIVE VEGETATION OF NSW

Fire is an important process in most types of vegetation in New South Wales, and most vegetation formations need fire to regenerate and maintain their ecological health. The exceptions are Rainforests, some alpine ecosystems, some Freshwater Wetlands, Estuarine (saltwater) Wetlands and inland salt lakes.

In New South Wales, vegetation types are classified according to a statewide assessment made in 2004 by Dr David Keith. The groupings, or types, reflect specific combinations of plant species, and in some cases these include plant species found nowhere else. The vegetation types are also based on factors such as the height and spacing of the dominant plants as well as geographic indicators such as rainfall and soil type. These different vegetation types are adapted to different fire frequencies. The managing fire on your property landholder booklet for your region provides more information on the vegetation types in your area. See www.hotspotsfireproject.org.au/resources-materials.

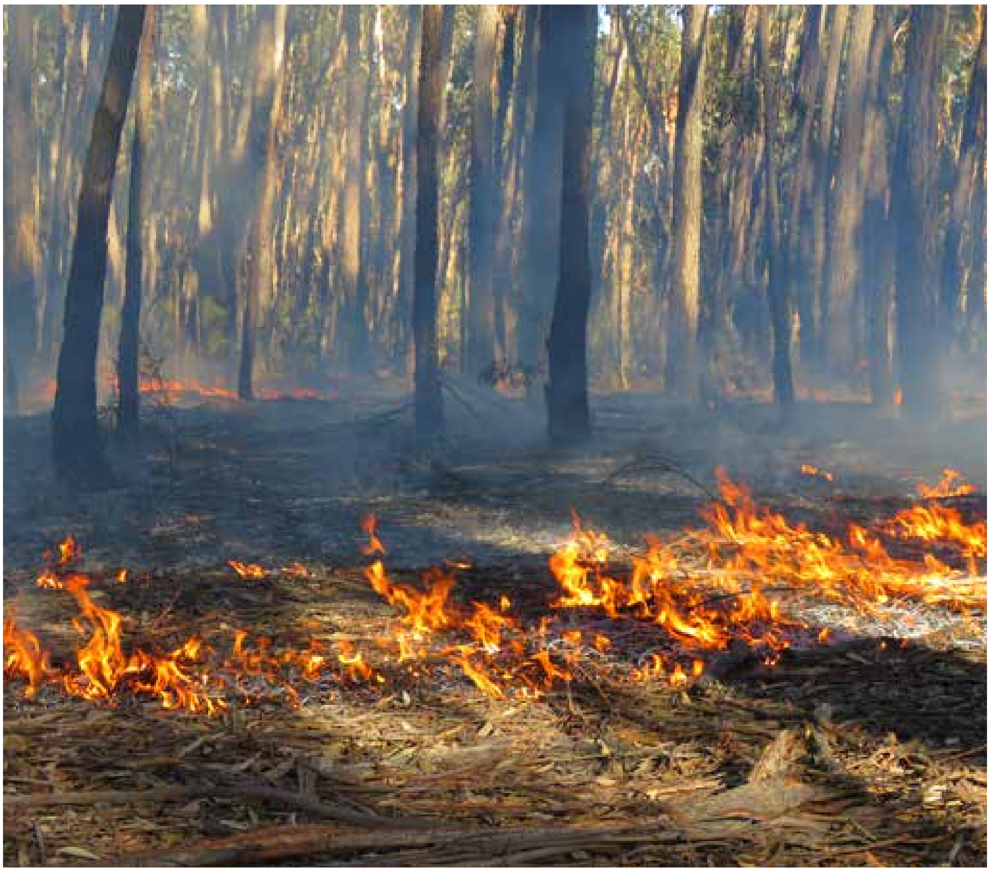
The native vegetation communities of New South Wales span a number of very broad gradients that cover substantial variations in:

- annual rainfall ranges from east to west – from more than 2000 mm atop the wettest mountains on the North Coast, to just 200 mm in the Barrier Ranges north of Broken Hill
- temperature – from the subtropical climate of the North Coast to the alpine climate of the Australian Alps
- altitude – from sea level to 2228 m above sea level at Mt Kosciusko
- soil type – from pure siliceous sands on the coastal plain to fertile clay-loam and cracking soils derived from basalt on the Liverpool Plains and Dorrigo Plateau, and waterlogged organic peaty soils in the montane wetlands atop the Great Dividing Range.

This variation has a profound influence on both the types of native vegetation occurring across the State and the range of weeds present or able to occupy any particular site.

It is highly desirable, and in many instances critically important, to have a good understanding of the composition and dynamics of native vegetation communities and the presence and identity of weeds within them before starting to use fire for managing and restoring these ecosystems. Due to the complexity of ecosystems and the influence of many environmental factors, understanding and trying to predict how native vegetation communities and weeds will respond to fire can be very difficult in many instances.

Spending time observing and getting to know your patch of bushland is a good way to develop a foundation of knowledge that will help you decide the best ways of managing fire to protect and restore native vegetation and manage weeds on your property. Observing how native vegetation and weeds in these patches respond to fire will help you refine and implement the best fire regimes and management practices to maintain and restore healthy ecosystems.

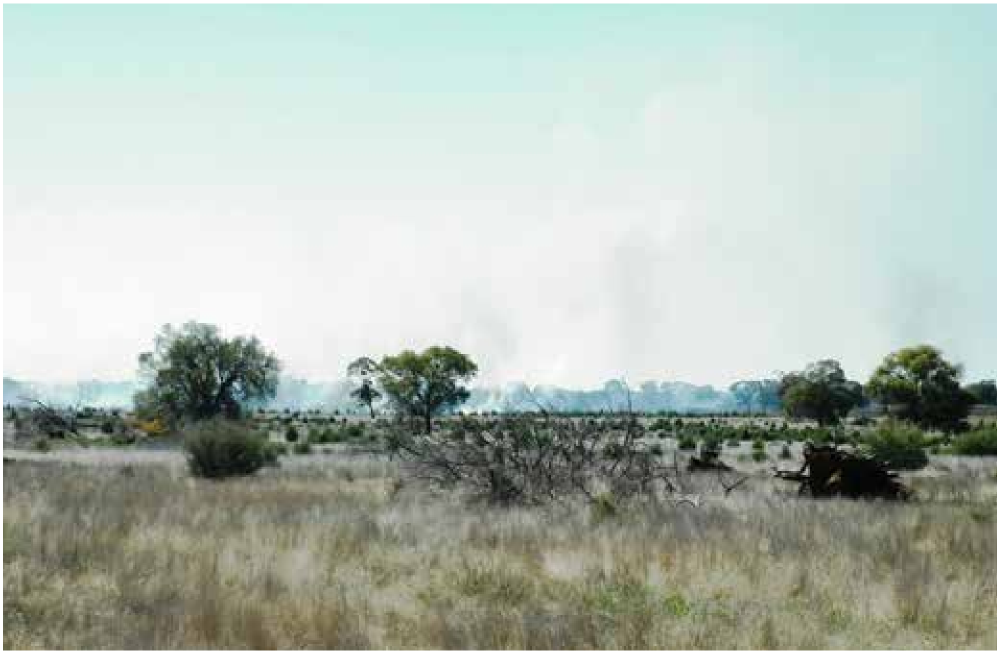


Demonstration burn, Hotspots workshop © K. McShea, Hotspots

3 RESTORATION OF NATIVE VEGETATION USING FIRE: ESTABLISHING CLEAR AND ACHIEVABLE GOALS

Weeds are present in most ecosystems across New South Wales and fire plays a key role in regeneration, nutrient cycling and critical ecological processes within these ecosystems. As such, there is a need to establish clear goals to managing fire, weeds and native vegetation. Restoring weedy native vegetation communities to a functional and resilient native ecosystem is a highly desirable outcome. However, for many fragmented and degraded ecosystems (including those with a high proportion of weeds) it is unlikely that we can achieve this. But controlling and containing weeds, and maintaining or restoring weedy vegetation communities to a moderate condition may be a more realistic goal in many such instances.

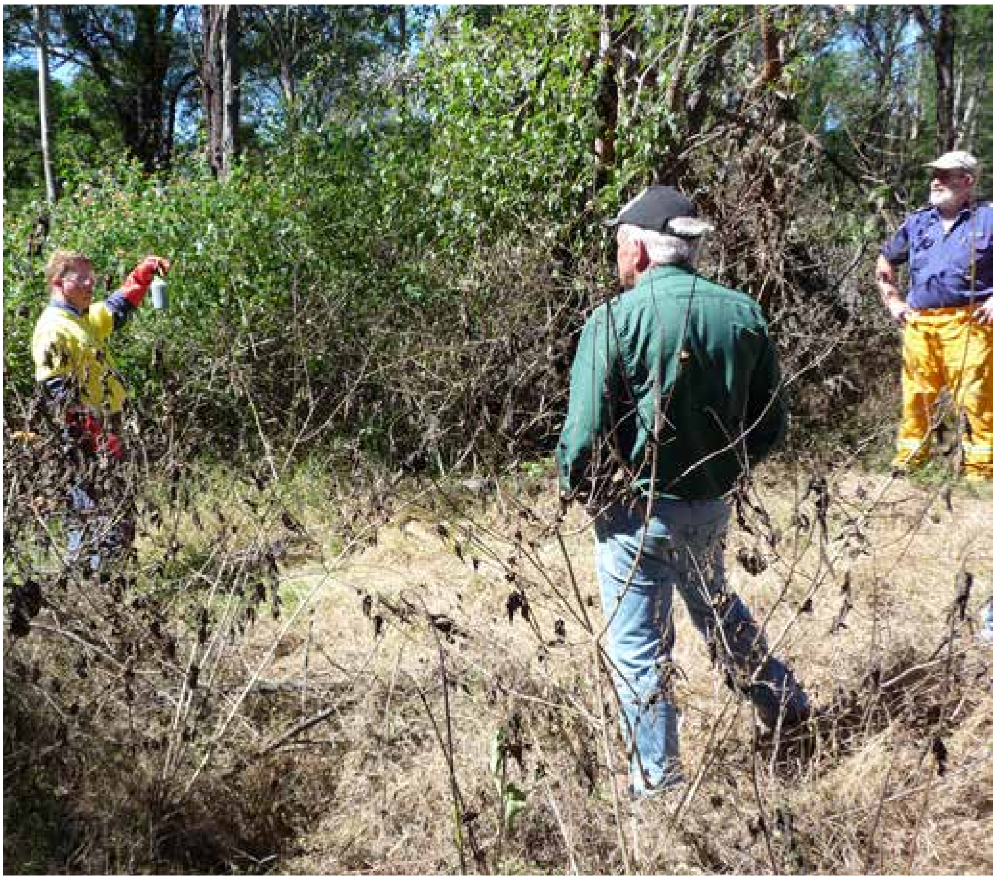
Fire in a particular site or patch of bushland should not be viewed as a single event, but part of a sequence of events. A sequence of fire events is known as a fire regime. Managing the fire regime at a particular site is likely to give landowners and managers a better opportunity to manage weeds and restore ecosystems. However, this must be done carefully to ensure that native species are not lost from the system. Long-term and strategic planning for managing fire, weeds and native vegetation on your property is the best way to improve the condition of your native vegetation.



Prescribed burn © M. Graham, Hotspots

4 INTEGRATED MANAGEMENT STRATEGIES TO ENSURE GOOD RESTORATION OUTCOMES

There are very few instances where fire can act as a 'silver bullet' to control or eradicate weeds from native vegetation. Often a combination of different techniques — such as herbicide application, repeated fires and controlled access of grazing — is required to achieve good restoration outcomes. In almost all instances, persistence and longer term follow-up management actions are also needed. If you are not able to implement management interventions such as herbicide application and repeated fires over longer timeframes then it may be best to adopt a 'do nothing' approach. Short-term interventions that are not integrated with other weed treatment methods or do not involve follow-up restoration works can, in some instances, exacerbate the severity of a weed problem and make future control and management much more difficult.



Hawkesbury River County Council staff at Bowen Mt. Hotspots workshop © M. Graham, Hotspots

5 FACTORS INFLUENCING INTERACTIONS BETWEEN FIRE AND WEEDS

Many factors influence the role that fire can play in promoting or controlling weeds. These factors include: seasonality and climate; landscape position, landform and aspect; soils; and artificially elevated nutrient status. Each of these are discussed in this section.

Seasonality and climatic factors

Seasonality can have a profound influence on the relationship between fire and weeds. In particular, the season in which a fire occurs can have a strong influence on the post-fire condition of the burn site. For example, weed seed availability can be reduced or potentially removed from a habitat or site if burnt in the appropriate season, and this can result in significantly less weeds post-fire. Conversely, if fire occurs in a season with high availability of weed seeds, then the post-fire condition of the burn site could become worse than it was before the burn. That is, the cover, abundance and diversity of weeds post-fire could increase.

An example of this could be in a Grassland or Grassy Woodland where exotic grasses have set abundant seed during the regular summer and autumn seeding period. If fire occurs in the landscape during these seasons, when seeds are abundant, then rapid germination and dominance of the site with exotic grasses post-fire is likely to occur. But, if fire were to occur on the site during winter or early spring, when there were few or no exotic grass seeds present, then the post-fire regeneration on the site is likely to be dominated by native species.

The caveat with this example is that if the exotic grass species present has a long seed dormancy compared to those present in the soil seed bank. In these situations a completely different response (or responses) is likely. This illustrates the need to gain as good an understanding as possible of the survival traits and reproductive strategies of weeds before commencing management actions or using fire without considering these factors.

Climatic factors including periods of higher than average rainfall and drought (climatic states typical of the Australian component of the El Niño Southern Oscillation) can also significantly influence the way fire and weeds interact with native vegetation communities. In some circumstance, drought-tolerant native species are negatively impacted post-fire, by weeds which are more competitive or advantaged, by wetter than average conditions.

Landscape position, landform and aspect

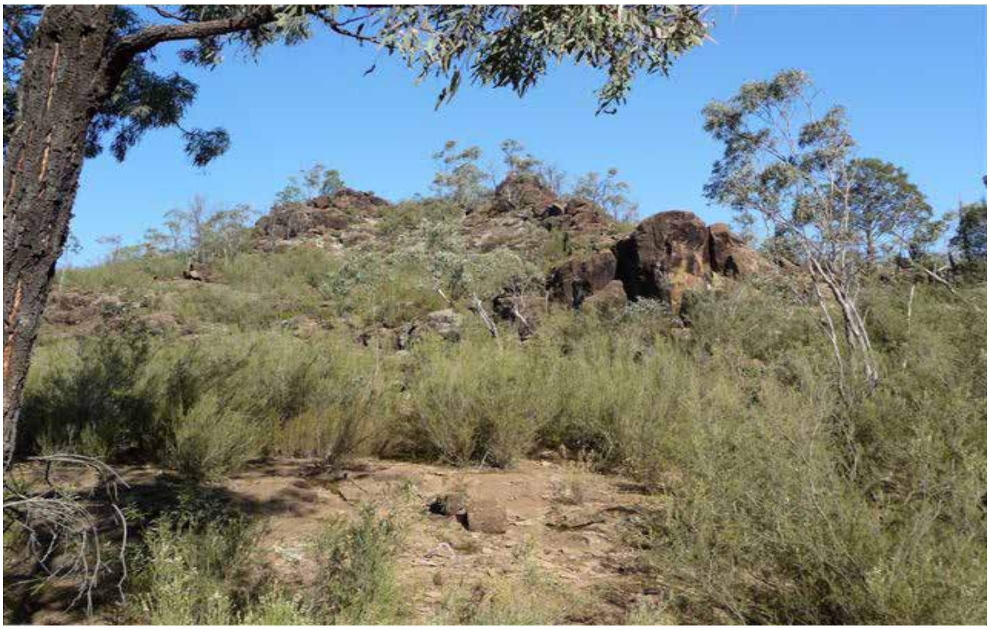
The position in the landscape of a particular site can have a great influence on both the vegetation community and the types of weeds present. Elevated and exposed rocky sites with shallow, drier and less nutritious soils are generally less prone to weed infestation and generally have a lower diversity of weeds.

Often the most exposed, rocky and nutrient-deficient sites lack weeds, while those lower in the landscape that are more sheltered with deeper soils often have a great diversity of weeds and may be dominated by weeds.

Riparian zones and areas exposed to strong edge effects, for example along roadsides or near residential developments, can also be susceptible to high numbers and a high diversity of weeds.

It is important to consider the source of weeds and what is causing changes to the local environment (e.g. disturbances or changes in light and nutrients). The source of the weeds within the landscape may not be clear or immediately identifiable, for example, the source infestation may be upslope or upstream of the site. You may need to treat the source of the weeds as well as the weeds themselves; otherwise you may be pouring resources into a site thinking you are doing the right thing, when it would in fact be better to manage the source of the infestation upstream or upslope.

Landscape position, landform and aspect also strongly influence fire regimes and the behaviour of fire. In some lower slope and valley floor landscape positions, fire may be difficult to start because of high moisture levels. Such sites typically support Rainforest or shrubby Wet Sclerophyll Forests. Sites with saturated and inundated soils on floodplains typically support a range of Forested Wetlands and open Freshwater Wetlands in which the use of fire is rarely possible.



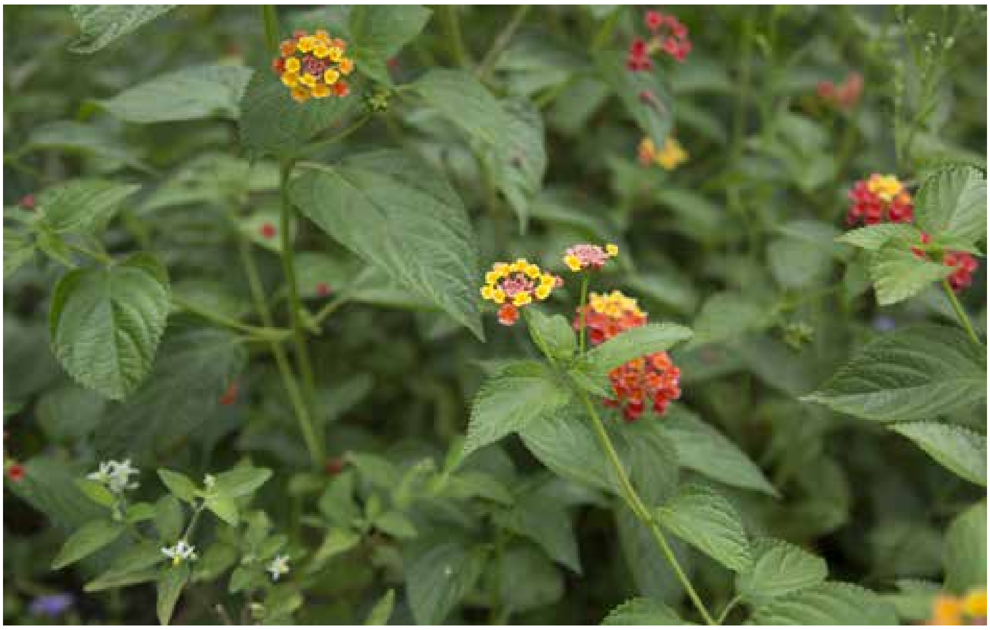
© A. Busse, Hotspots

Soils

The depth, structure, fertility and moisture content of soils play a major role in determining both the vegetation type and the suite of weeds that will occupy a site. The most fertile sites with the best soils are often those with the greatest abundance and diversity of weeds, while the least fertile (frequently sandy) soils might be entirely free of weeds.

Many weeds occupy a continuum of soils from highly fertile to those that are relatively nutrient deficient. A weed occupying different soils might behave differently depending on the fertility level of a particular site. For example, it may dominate sites of a particular fertility class, but exist at much lower densities under different fertility and nutrient conditions.

An example of a weed that occupies a wide gradient of soil conditions ranging from moist, deep and fertile soils to dry, shallow and less fertile mid and upper slope soils is lantana (a Weed of National Significance). In Rainforests and shrubby Wet Sclerophyll Forests, lantana can dominate, reaching a great height and density with a large biomass. In disturbed Rainforests and shrubby Wet Sclerophyll Forests, lantana can essentially cover the entire ground and shrub layers with dense impenetrable multi-layered canes that 'lock-up' and exclude native shrub and ground covers. In mid and upper-slope landforms, lantana is generally sparser, shorter and less vigorous. Fire behaves completely differently in each of the landforms in which lantana occurs. In some landforms other management interventions (such as splatter herbicide treatment in lower slope and valley floor sites) might be required to achieve good restoration outcomes, while fire alone is likely to be sufficient for managing lantana in some upper slope sites. Refer to the 'Splatter-gun technique and fire case study' for more details.



Lantana © R. Nicolai, OEH

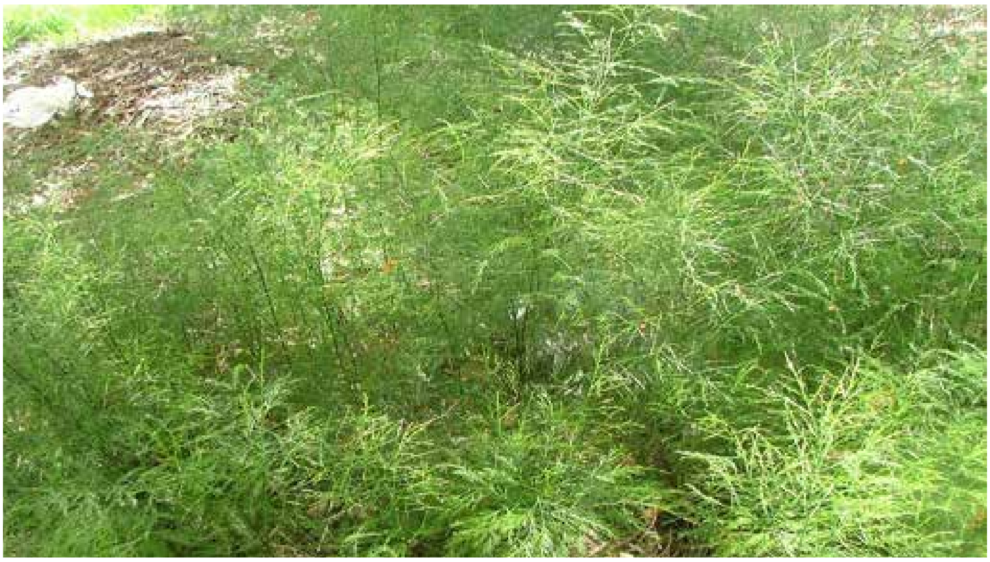
Artificially elevated nutrient status

Many landscapes across the highly developed coastal fringe of New South Wales and within extensively agriculturally developed areas have modified nutrient regimes because of the existence of nearby and adjoining urban and agricultural developments. In many instances, elevated nutrients in runoff from residential or agricultural developments have caused weed invasions into previously intact native vegetation communities and resulted in highly modified fire regimes.

Mesic shifts (i.e. a shift in habitats to a higher moisture level) have been widespread as a result of the invasion of previously drier native vegetation communities by densely crowned, fleshy fruited weed species. These shifts have caused a decline in the resilience and health of native vegetation communities. It is likely that some of these weed invasions have resulted in permanent and irreversible degradation due to an entirely new nutrient level which has altered vegetation types and fire regimes.

This has occurred at Stansfield Reserve at Coal Point in the Lake Macquarie area. Prior to treatment, this area of shrubby Dry Sclerophyll Forest was an extremely weedy site with near 100% ground cover of ground asparagus fern. As the ground asparagus fern took hold, the normal processes within the natural shrubby understory ceased to exist. Light was prevented from reaching the soil surface, which over time led to a breakdown and loss of the native seeds in the seed bank. This prevented the germination of native seed and ultimately depleted existing native seed stores.

With support from the NSW Environmental Trust, local Council Bushcare groups and volunteers, regeneration work is being carried out to improve the site and restore the native vegetation. In April 2016, Fire and Rescue NSW conducted an ecological burn. The purpose of this burn, apart from asset protection for residential properties, was to help to remove the invasive asparagus weed so that the volunteers' efforts to regenerate the area could be realised. Follow-up from the burn includes monitoring the plant responses to fire and the application of herbicide.



Asparagus fern infestation © S. Navie

6 MANAGING WEEDS WITH DIFFERENT SEED TYPES AND DISPERSAL STRATEGIES

The type of seed and reproductive strategy of a weed has a significant influence on how it interacts with fire. It also plays a key role in determining the best management and restoration strategies. It can be difficult to know or understand many of these factors, and such knowledge may be completely lacking for some weeds.

When planning for the management of fire and weeds it is very important to understand the dispersal and reproductive strategies of the weeds present in a particular landscape. Different weed fruit and seed types with different modes of dispersal require different management strategies and pose differing levels of risk to native vegetation communities in the post-fire environment. Some weeds that have particular dispersal strategies (e.g. fleshy fruits dispersed by birds) are unlikely to respond positively to fire alone and are likely to require the integration of fire and herbicide application to achieve good restoration outcomes.

Some of the different seed types and dispersal mechanisms are discussed below.

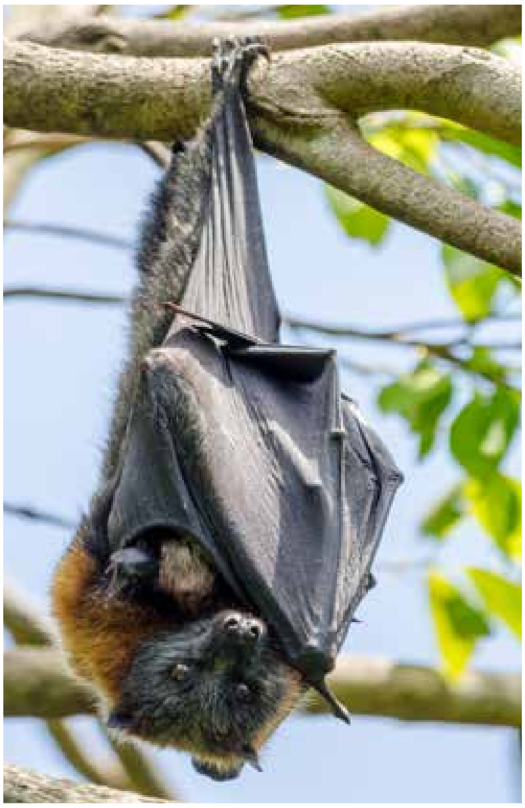
Fleshy fruits (dispersed by birds and flying-foxes)

Weeds with fleshy fruit (fleshy fruited weeds) are mostly limited to Rainforests and other mesic habitats, as well as moist tableland and riparian habitats. Often having brightly coloured fruit, they are mostly dispersed by birds, although will occasionally be distributed by flying-foxes, terrestrial mammals and reptiles.

Fleshy fruited weeds are capable of being distributed significant distances from fruiting mature plants. The limit of this dispersal capacity is determined by the distance that a bird or flying-fox can fly before needing to void the seed (defecate). Flying-foxes and frugivorous (fruit-eating) birds are known to move seeds considerable distances, with flying-foxes known to fly tens of kilometres each night from camps to feed in surrounding forests. Both birds and flying-foxes are likely to disperse fleshy fruited weeds many kilometres from the parent weed plants. Terrestrial mammals and reptiles are relatively poor dispersers of fleshy fruited weeds because they do not move great distances.

Most fleshy fruited weeds have a tree, shrub or vine habit (growth form) and are relatively moist and inflammable. As fleshy fruited weeds mostly occupy Rainforests, shrubby Wet Sclerophyll Forests and riparian areas, fire can be an infrequent and (at times) ecologically inappropriate process. Fires generally only occur in habitats supporting an abundance of fleshy fruited weeds during exceptionally dry or extreme fire weather periods.

It is very rare for fleshy fruited weeds to be killed by fire and this generally only happens as a result of a high intensity wildfire that is sufficiently hot to kill these moist weeds. When fires do occur in these habitats, this provides an opportunity to undertake appropriate weed control techniques as a follow-up treatment post-fire.



Flying-fox (*Pteropus poliocephalus*) © S. Ruming, OEH

In many coastal regions of New South Wales there has been a mesic shift caused by fleshy fruited moist shrub and tree weeds invading relatively dry habitats such as grassy Wet Sclerophyll Forests, Dry Sclerophyll Forests and other more open vegetation types including Heathlands and Forested Wetlands. This has caused a major decline in light availability and has reduced the flammability of these habitats. In some instances these changes are permanent and have resulted in major declines in biodiversity and excluded fire from habitats that require fire for key ecological processes and regeneration. Applying planned fire as a land management tool is also difficult in these environments as changes in moisture and vegetation disrupt a number of factors that are important to achieving successful burn outcomes.

Examples of fleshy fruited weeds include privet (both small-and broad-leaved forms), various types of passionfruit, camphor laurel, hawthorn, orange jessamine (or murraya), ochna (or mickey mouse bush), various climbing and ground asparagus and climbing nightshade.

Light seeds (dispersed locally by gravity)

Various groups of weeds have seeds that are light and disperse locally by gravity in close proximity to parent plants. Grasses are the dominant example of seeds that are dispersed by gravity, although they may occasionally be dispersed further by wind or water.

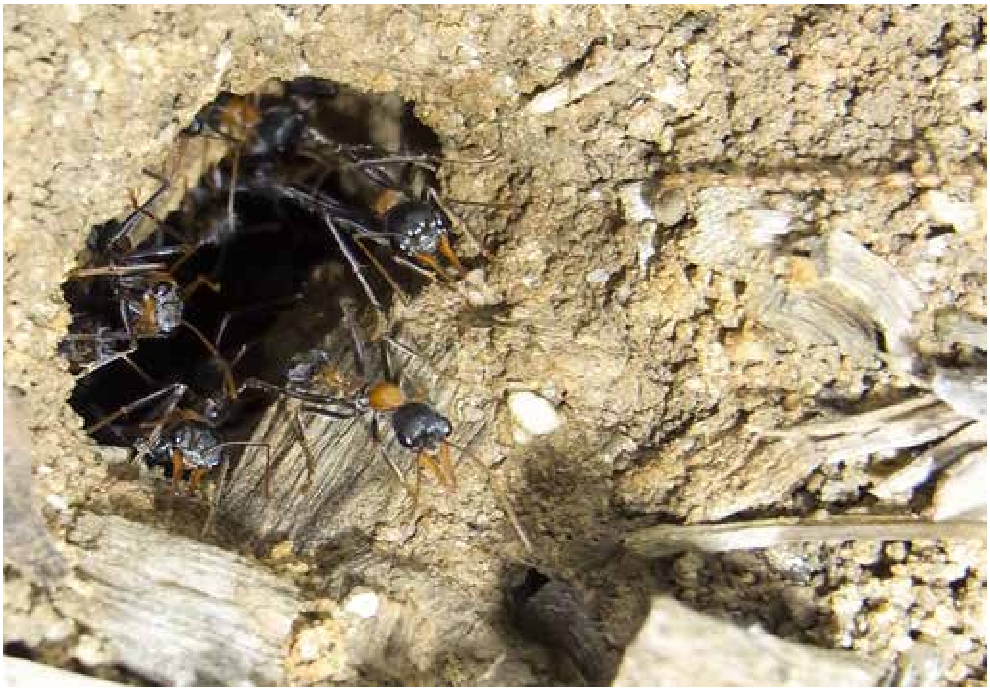
Papery and other very light seeds (wind dispersal)

Weeds that have papery and very light seeds are dominated by a great variety of exotic daisies (family Asteraceae) as well as a few exotic grasses and vines. These weeds rely on the wind to disperse seeds and can potentially travel great distances from parent plants to colonise weed-free habitats.

In many relatively intact and pristine areas, weedy wind dispersed daisies are often the only exotic species capable of establishing post-fire. Management of these species may require manual control, herbicide application or the instigation of a relatively frequent fire regime to ensure good management and regeneration outcomes.

Seeds dispersed by ants

A limited range of weeds have seeds with oily and protein-rich fleshy structures attached to them that are called 'elaiosomes'. Most of these species are wattles and closely related species that are native to areas outside New South Wales. Ants move these seeds small distances from parent trees to nearby colonies and feed upon the elaiosome, leaving the seed to form part of a soil seed bank. These weeds often have a long seed dormancy that is broken by fire, and intense fires will often trigger mass germination resulting in dense recruitment of these species. This can contribute to the post-fire establishment of a dense shrub layer in habitats not normally supporting these shrubs.



Bull ants (*Myrmecia nigrocincta*) © R. Nicolai, OEH

Seeds dispersed by water

Various weeds (including a large number of aquatic weeds) have floating seeds and plant material that rely on flowing water for dispersal. These weeds are mostly restricted to landforms that are at, or below, flood levels and mostly occupy riparian, mesic and wetland habitats. Some water dispersed weed species, such as balloon vine, are significant modifiers of riparian forests and Rainforests. Aquatic weeds are generally only able to be burnt during droughts and low-water periods, and at these times great caution must be used when considering the use of fire in wetland habitats because of the high risk of peat fires.

Burrs and other sticking mechanisms (dispersed by animals)

Many exotic grasses, herbs, shrubs, vines and forbs have fruit that adhere to the fur of mammals and the feathers of birds and are dispersed by the movement of these animals. These animals can colonise recently burnt sites, for example when kangaroos and wallabies move into an area to commence foraging in the weeks following a burn. Many animals feed on the fresh tips of the regenerating plants. The highest impacted areas are those around the edges of the burn, where these animals also have access to shelter from nearby unburnt areas. The edges of burns are also most exposed to weed colonisation. Therefore, the size and shape of the burn can play an important role in weed management.

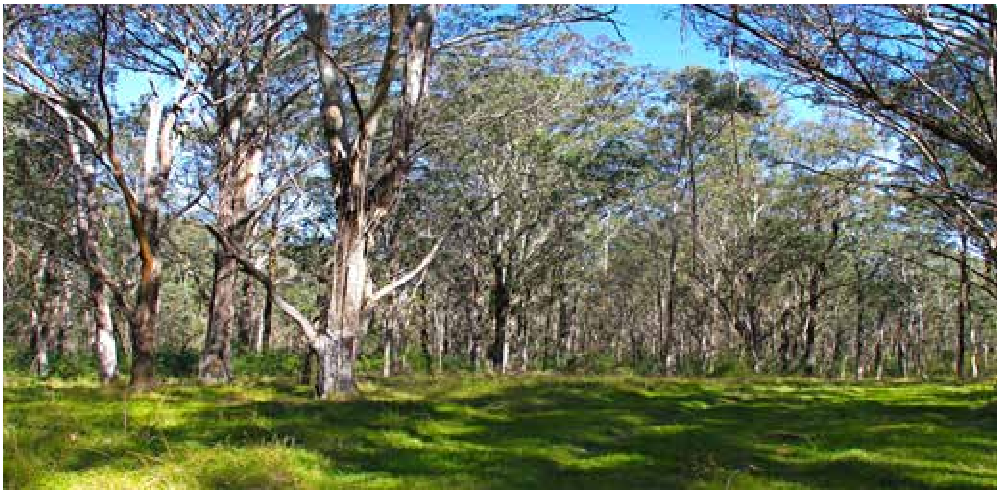
Vegetative spread and colonisation

Many weeds do not require seeds for reproduction and spread, but instead rely on runners, shoots, tubers and other means of vegetative material to spread. Examples include mother-of-millions, bamboo and similar related plants and madeira vine.

Farmer's friend (*Bidens pilosa*) © Hotspots Fire Project

7 FIRE AND WEEDS IN THE LANDSCAPE: PUTTING THE SCIENCE INTO CONTEXT

Five Case Studies



Cumberland Plain Woodland © J. Sanders

FIRE AND CUMBERLAND PLAIN WOODLAND:

Using fire to manage African lovegrass

Biodiversity in the Cumberland Plain is among the most threatened in New South Wales, with only 12% of the original vegetation still remaining. Intensive clearing, development for agriculture, ongoing disturbance, alterations to fire regimes, and the introduction of new plant and animal species mean this highly dynamic system is fast becoming a priority for conservation. Scheyville and Cattai national parks, in north-west Sydney, contain key remnants of Cumberland Plain Woodland and Shale/Sandstone Transition forest vegetation communities, listed as critically endangered and endangered ecological communities under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and National *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), respectively.

The Cumberland Plain plant communities are particularly vulnerable to weed invasion. Widely established weeds like African olive, lantana and African lovegrass are displacing native plants and affecting regeneration of plant communities. These weeds can alter systems to such a degree that the vegetation is unlikely to recover without some interference in the system. There is also the potential for these species to increase bush fire risk and alter fire behaviour. This is because their biomass may lead to increased fuel loads which can result in higher intensity fires, which are harder to control.

For the last 15 years the NSW National Parks and Wildlife Service (NPWS), along with other land managers, have been studying the role of fire in maintaining floral diversity in the Cumberland Plain. Watson, Bradstock and Morris (2009) noted fire plays an important role in helping to maintain the balance of plant species, and the understorey structure. Statewide, fire intervals for Grassy Woodlands of between 5 to 40 years are recommended. However, specific studies into the Cumberland Plain Woodland (Watson *et al.* 2008) recommend variable fire intervals between 5 and 12 years to help support diversity. Fire does, however, remove much of the standing vegetation, 'resetting' the ecosystem for both natives and exotics. It is important to understand that fire helps to make way for the natives but it can also stimulate weeds to grow.

One weed which is proving to be an issue in the Cumberland Plain is African lovegrass, an introduced perennial tussock grass which is highly invasive and resilient. Significant impacts on native flora and fauna due to the dominance of African lovegrass on systems has resulted in habitat loss for wildlife. Observations show African lovegrass is most invasive in ecosystems that are already disturbed and that it is relatively slow to invade native vegetation in good, undisturbed conditions. This shows that long-term control of this weed will have a much higher success rate if resilient vegetation can be established.

> 'Lovegrass - no good for the environment, no good for farmers, and no good for fire'
>
> – RFS Brigade member.

The 'Using Fire as a Restoration Tool in Cumberland Plain Vegetation project' was coordinated by the Nature Conservation Council's Bushfire Program and conducted in Cattai and Scheyville national parks between late 2013 and January 2016. Funded by the NSW Environmental Trust, the project included the Office of Environment and Heritage, NPWS, Western Sydney University, Muru Mittigar, Australian Association of Bush Regenerators, and Aquila Ecological Surveys. The project supported restoration efforts by examining integrated fire and weed management treatments.

Traditional protocols to manage African lovegrass suggest the use of herbicide and caution against the application of fire due to the intense heat generated and the difficulty of control. This innovative project provided an opportunity to test the potential benefits of an integrated treatment combining fire and herbicide.

Trials were held at the two national parks, in two locations across 48 plots using a total of approximately 6 ha. The project used six different treatments:

1) control (no treatment)

2) herbicide only

3) fire only

4) herbicide + fire

5) fire + herbicide

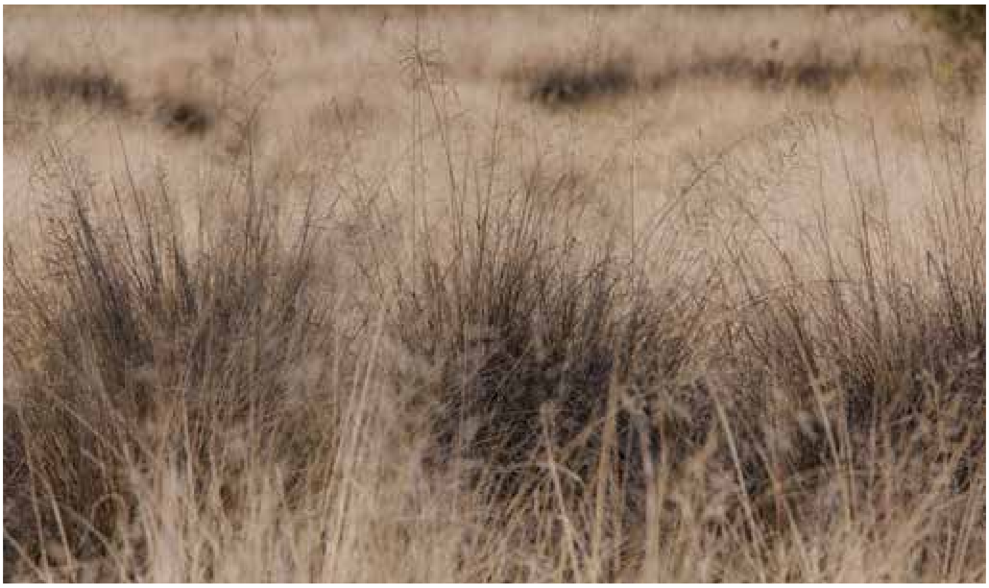
6) herbicide + fire + herbicide

To be effective, the planning of herbicide spraying and fire had to be taken into consideration. The plots were treated with the herbicide in December 2013, at the standard recommended concentration of 300 ml Taskforce® per 100 L water and sprayed to the grass just before or during light rain. This allowed the herbicide to wash from the leaves into the soil, thereby reducing killing of non-target species. As a minimum of 3–6 months is recommended between herbicide and fire treatments, this meant burns weren't conducted until October 2014. Burns took place on a mid to warm day with humidity 35–40%, with light and variable winds of up to 10–15 km/hr. This involved two people lighting from one corner on the downwind side, and then moving rapidly away from each other to the next corner, and then along to the last two sides to meet at the corner opposite the start. This meant that the fire drew in towards the middle and most of the plot received similar fire intensity, replicating the hazard reduction conditions in a large grassy block that would typically be undertaken by land managers.

The trial allowed a good comparison of herbicide application and fire, as methods of controlling African lovegrass, singly or in combination.

Of the three ways of combining herbicide and fire that were trialled, treatment (6) herbicide + fire + herbicide was the most effective at controlling the African lovegrass, closely followed by treatment (5) fire + herbicide.

> "Combining the use of fire and herbicide seems to be the answer. The lovegrass sward is consumed by the fire, and the herbicide limits lovegrass re-sprouting and germinating. The current trials have demonstrated that it is possible to break the dominance of African lovegrass, even in the most disturbed sites."
>
> – Charles Morris, Western Sydney University.



African lovegrass (*Eragrostis curvula*) © R. Nicolai, OEH

The fourth treatment (herbicide + fire) was less effective at reducing lovegrass at one of the sites (Scheyville), and so would be ranked third in effectiveness. It could still be used as a treatment for lovegrass if local conditions dictated this order of application.

The use of herbicide-only kills the African lovegrass, but leaves a thick thatch or mat of dead leaves which could potentially restrict recruitment of other species from the seed or bud/tuber bank. The application of fire-only reduces African lovegrass cover in the short-term, but resprouting of the basal shoots and seedling recruitment means that the canopy cover is restored fairly quickly. This again would limit subsequent recruitment by other species.

The results indicate that by combining fire and herbicide treatments, the benefits of both are achieved. The African lovegrass sward is removed and consumed by the fire, and the herbicide limits further resprouting and recruitment.

The current trials demonstrate that it is possible to break the dominance of African lovegrass, even in the most disturbed sites. It is very likely that the benefits from applying these treatments will be greater when they are used in more intact vegetation, where there is better potential for native recruitment. Applying these treatments in more disturbed sites may still be of benefit when combined with additional treatments to boost native species, for example the addition of native seed. However, it is still early days in seeing how the vegetation from these trials will develop, and ongoing monitoring will continue to see if further changes occur.

This treatment is intended for use when there is some native species presence that may benefit from the treatment. Of course, in the most disturbed sites, other techniques such as stripping the African lovegrass along with the uppermost soil layer may be a practical alternative. Where fire is absolutely impossible, there may be some similar benefits from slashing, as this removes the thick grass sward, but any benefits from heat and smoke effects will be absent.

It must be noted that every time a burn is implemented, a weed management program is required as well. A program such as this may take advantage of the opportunity to do pre-burn herbicide treatment, but should as a minimum include a post-burn weed control program.

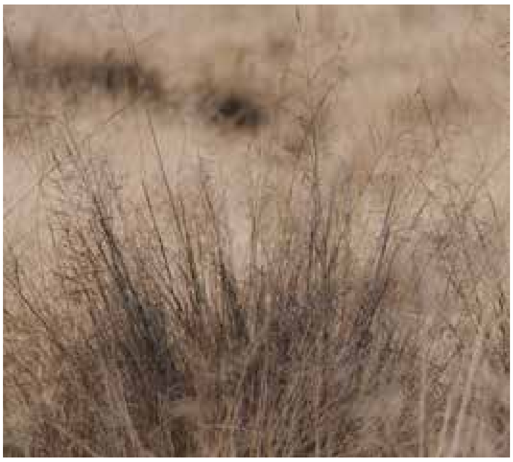
From here, the most difficult task will be restoring the ground layer of Grassy Woodlands and Grasslands. 'Enrichment' tree and patchy shrub plantings may be one option. The NPWS has already made use of the results of these trials and related projects in the region to treat more than 50 ha of land with integrated fire and herbicide treatments, and plans to use these methods in further areas targeted for restoration and hazard reduction activities.

Further details on this project can be found in the booklet: http://www.nature.org.au/media/213734/cumberland_african-lovegrass_web_jan2016.pdf. Alternatively refer to the list of additional websites and resources at the back of this booklet.

Planned burn in African lovegrass infestation at Cattai National Park © M. Rose

AFRICAN LOVEGRASS AND FIRE ON THE SOUTH COAST

The river valleys of the NSW South Coast once supported vast grassy woodlands of rich biodiversity. Most of these areas have been subject to intensive agriculture since around the 1840s. Remnant areas are now classed as Lowland Grassy Woodland in the South East Corner bioregion under the TSC Act. In many of these grassy woodlands and derived grasslands, managed as native pastures, African lovegrass is a major threat to agriculture and biodiversity and a serious fire risk to life and property.



African lovegrass © R. Nicolai, OEH

African lovegrass can grow to 1.5 m over summer before it dies back and dries out when subject to frosts over winter. In this cured state it can hold fuel hazard loads of over 15 tonnes per hectare. The risk of a fast moving grass fire during the windy months of early spring is a high priority for RFS staff and volunteers in the Bega and other coastal valleys. Each year hazard reduction burns, as well as mowing and brushcutting, are undertaken to mitigate the risk. This however is only a temporary solution. African lovegrass is adapted to fire and if follow-up control actions are not implemented it will return stronger in the next season.

A combination of slashing or burning and then spraying with the partially selective grass herbicide, Flupropanate has been used to control African lovegrass in some areas. In low rainfall areas such as the Bega Valley this can be successful for large and initial invasions, but if the treatments leave bare ground for too long the African lovegrass will come back denser than before. This can occur if the herbicide dose is too high and competing species such as kangaroo grass are affected. The method of application is also important to avoid killing desirable species.

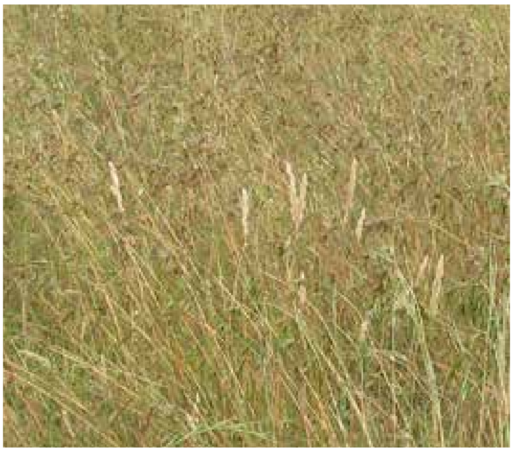
In grassy woodland areas of the Bega Valley, the native weeping grass is more common in the ground layer compared to other areas in the State. This species is highly susceptible to Flupropanate so a different approach is being used on the South Coast. This involves using a raised roller wiper which treats the taller, faster-growing and less palatable African lovegrass with glyphosate. The treatment is timed so desirable grass species are just starting to germinate or resprout in spring after being heavily grazed, slashed or burnt in late winter. The advantage of using glyphosate is that the non-target species are less likely to be affected. One disadvantage however is that the seeds in the soil will not be killed so follow-up will be required.

Weeping grass grows well under low light conditions found under eucalypt canopies where African lovegrass is less competitive. Healthy and diverse grassy woodlands are much less susceptible to invasion by African lovegrass than open pastures.

For more information refer to the Far South Coast Farmers Network and Far South Coast Landcare Association http://www.fscla.org.au/.

FIRE AND WEEDS IN SOUTHERN NSW: Maritime Grasslands on headlands in Eurobodalla Shire

Eurobodalla Shire Council has been using fire to manage coastal grassy headlands between Kianga and Dalmeny, north of Narooma on the NSW South Coast. The sites are characterised by the presence of kangaroo grass and classed as the endangered ecological community (EEC) Themeda Grassland on Seacliffs and Coastal Headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions under the TSC Act. The sites are threatened by exotic shrubs and grasses as well as encroachment from native shrubs and trees.



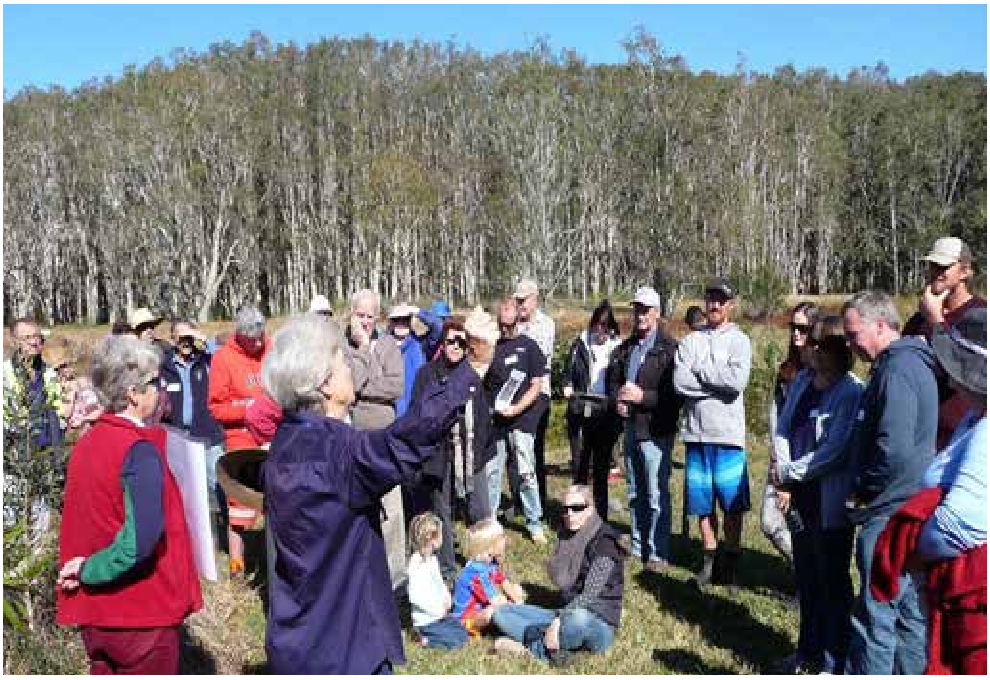
Kangaroo Grass © G. Basnett, Hotspots

Previously the sites have been managed by slashing annually but were in decline due to the thick layers of dead grass left from slashing which suppressed the growth of the kangaroo grass and seemed to facilitate the growth of exotic shrubs and grasses. Council has been consulting with local Elders about the traditional practice of burning the headlands. In addition to campfires, cooking fire would have also kept the sites open to watch for migrations of fish and maintain clear lines of sight to significant places such as Montague Island, mountains and other headlands.

Vegetation transects and photo points were set up in 2012 to monitor the sites before annual burning began in 2013. Spring rather than autumn was chosen as the most appropriate season to conduct the prescribed burn. This was to avoid leaving bare ground over winter, as many exotic annual grasses grow in winter and flower and set seed in spring. A spring burn could be done safely with winter-growing exotic grasses being killed or aboveground material reduced, enabling the summer growing kangaroo grass to compete.

Burns in 2014 and 2015 have resulted in an increase in diversity of the EEC and a reduction in exotic weed species, in particular, quaking grass and rat's tail fescue. Two other problematic grass species, kikuyu and paspalum, are not killed by fire but are severely reduced allowing for more targeted and effective chemical or mechanical control when they resprout. Encroachment from seedlings of woody shrubs, such as coastal banksia and wattle species, has also been held in check by the burns.

For more information contact Eurobodalla Shire council on 02 4474 1000.



Julie-Anne Coward & Tein McDonald at Hotspots workshop © S. Pillora

FIRE AS A RESTORATION TOOL:
Using fire and herbicide to regenerate Forested Wetland

A few years after purchasing their previously grazed property, both Julie-Anne and Murray Coward noticed their paddocks were becoming dominated by setaria grass. Setaria was first introduced to Australia in the early 1960s. Originally from Africa, the problem weed is prolific on the NSW North Coast and has been an issue for conservation and agriculture, and increases fire risk. The Coward's Woodburn property is now well on its way towards a restored Forested Wetland, thanks to the judicious use of herbicide and fire to reduce setaria and increase opportunities for regeneration of native Forested Wetland species.

The restoration work benefited from a grant application in 2012 from the Foundation for National Parks and Wildlife (advised by the Nature Conservation Trust) which allowed the employment of the Minyumai Green Team to assist the landholders, working to a plan prepared and supervised by bush regenerator, Tein McDonald. Rangers from the Minyumai Indigenous Protected Area (IPA) are now pursuing similar trials on their own property further along the same road. These trials hope to similarly restore previously cleared Forested Wetlands which are now dominated by setaria and other weed species.

Setaria is a summer-growing weed suited to the moist subtropics of the Northern Rivers, Mid Coast and Manning districts of New South Wales. It performs best on coastal lowlands receiving more than 1000 mm average annual rainfall. Setaria infestations can become so dense that they out-compete other species growing from seed. They are also quick to regenerate after disturbances such as fire unless fire is combined with the skilled use of herbicide. Invasive by nature, this weed can increase the fire risk along road sides and towards residential areas. However, in fire-adapted vegetation communities, fire can stimulate native species to germinate in higher quantities and can be used to 'flush out' germination from soil-stored weed seed, allowing it to be then more efficiently treated.

At the Coward's property, the extent of setaria domination was so high that the team didn't know whether planting would be required or not. It turned out, however, that natives germinated prolifically after burning and some judicious herbicide spraying, although setaria and approximately seven other weed species also germinated and required regular follow-up treatment.

The method used was to initially spray the nearly 100% seteria grass cover with glyphosate (1:100 glyphosate:water mixture) during the growing season, and to burn the dry thatch in the next burning season. The setaria germinates prolifically after the first rains and is then blanket-sprayed, killing off a high proportion of the setaria and leaving room for native regeneration. When natives then germinate, treatment shifts to spot-spraying. Julie-Anne is now managing follow-up on the sites, with the help of contractors, and is carrying out ongoing monitoring using quadrats to sample

> ‘ Weeds are resilient to fire as well of course; they're resilient to pretty-well everything. So, if you don't actually treat the weeds as well, you're not going to get the result you need, you've got to apply your weed control after a fire. ’ - Tein McDonald.

results of herbicide use in hot burn and cool burn areas as well as areas where fire was not used. Within each area, six random quadrats (each 9 m^2) were established prior to treatment and weeds and natives have been recorded every six months (in May and November) for the last 4 years. The results showed the regeneration to be quite dramatic, despite the site having been cleared and grazed 25 years ago.

On a site where the team wondered if planting might be needed, there are now nearly 50 naturally regenerated native species; 21 forbs, 7 sedges, 8 grasses, 2 shrubs and 11 tree species. Regenerating species now cover the site and include three species of paperbark, willow bottlebrush, swamp oak, two eucalypts and geebung. Ground covers include a range of reeds, grasses (such as Indian cupscale) and forbs such as native pennyworts, centella and native buttercups. A similar range of species has recovered in both the burnt and unburnt areas, although it has taken a lot longer for these species to recover in the unburnt area, where they also occur in lower densities.

Weeds in the unburnt site have been also slower to decline, showing the efficiencies that can be gained by the use of fire when it is combined with regular follow-up.

There are similar trials at Minyumai Indigenous Protected Area (IPA). Near the Coward property is the 2000 hectare IPA which includes a 16-hectare area that was previously cleared and grazed. Prior to treatment setaria dominated the site to the same very high level as the Cowards. Within this 16-hectare clearing, 3 hectares have been selected for treatment, each divided into 0.2-hectare treatment blocks.

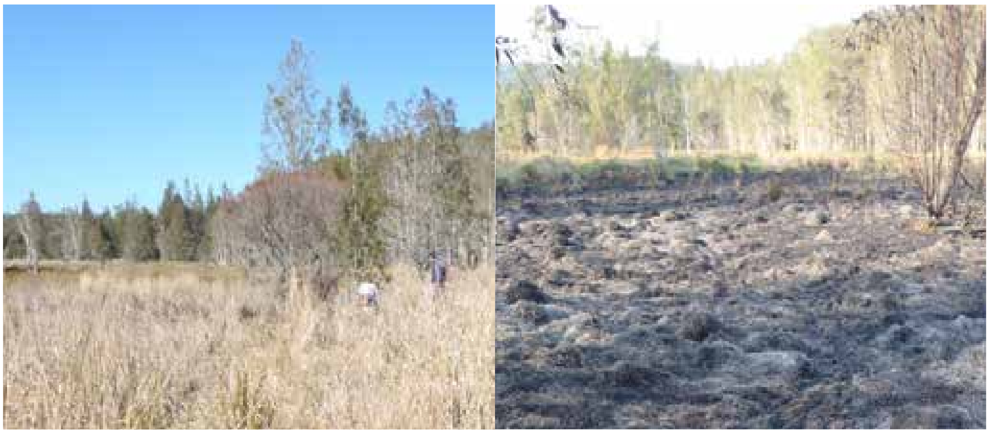
Each has been sprayed with glyphosate (1:100 mixture) and the blocks are being progressively burnt and sprayed in a follow-up regime similar to that applied at the Cowards.

> "I was very grateful for Tein and the Green team as we could not have done it without them."
>
> - Julie-Anne Coward

A trial burn in the spring of 2015 saw regeneration of 22 native species, including banksia species, broad-leaved paperbark and she oaks. It was revealed, however, that like Coward's there were many other weed species present that required ongoing follow-up.

With some funding from the NSW Environmental Trust, support from the Nature Conservation Council Firesticks program and the Federal Government's IPA program, it is hoped there will be excellent outcomes over the next 3 years and beyond. The Minyumai Aboriginal rangers have already developed technologies for burning to get the desired heat to penetrate the soil, with a great deal of finesse to the fire-break edges leading to more confidence when conducting these burns.

Trials have also focused on spraying in regrowth forest and native seed collection for direct seeding and raising tubestock are also underway. The knowledge gained

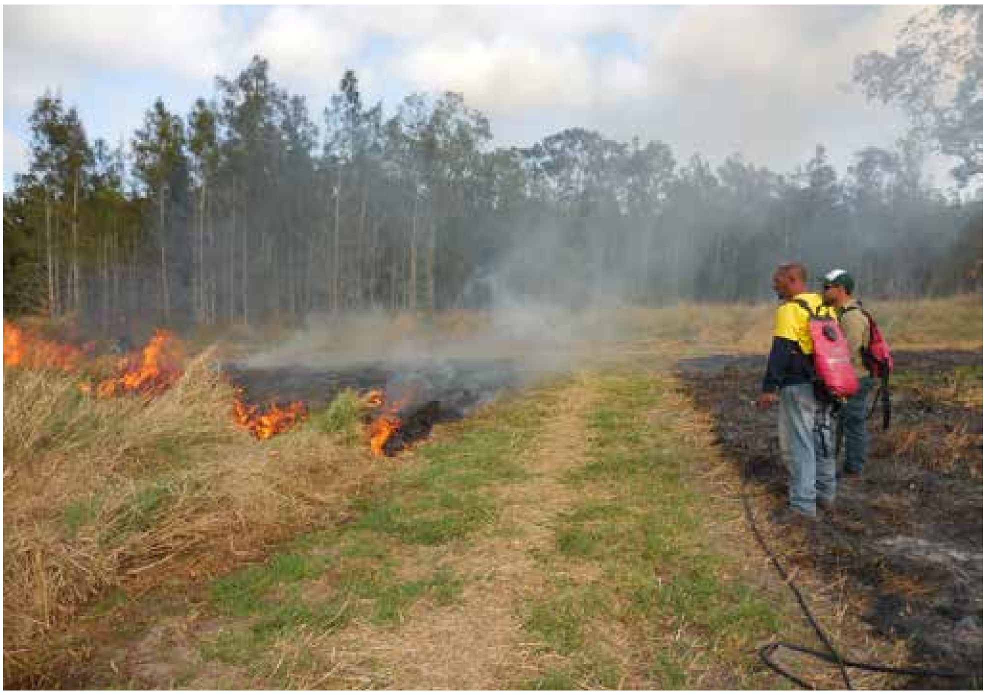


Winter and spring 2012 © T. Donalld

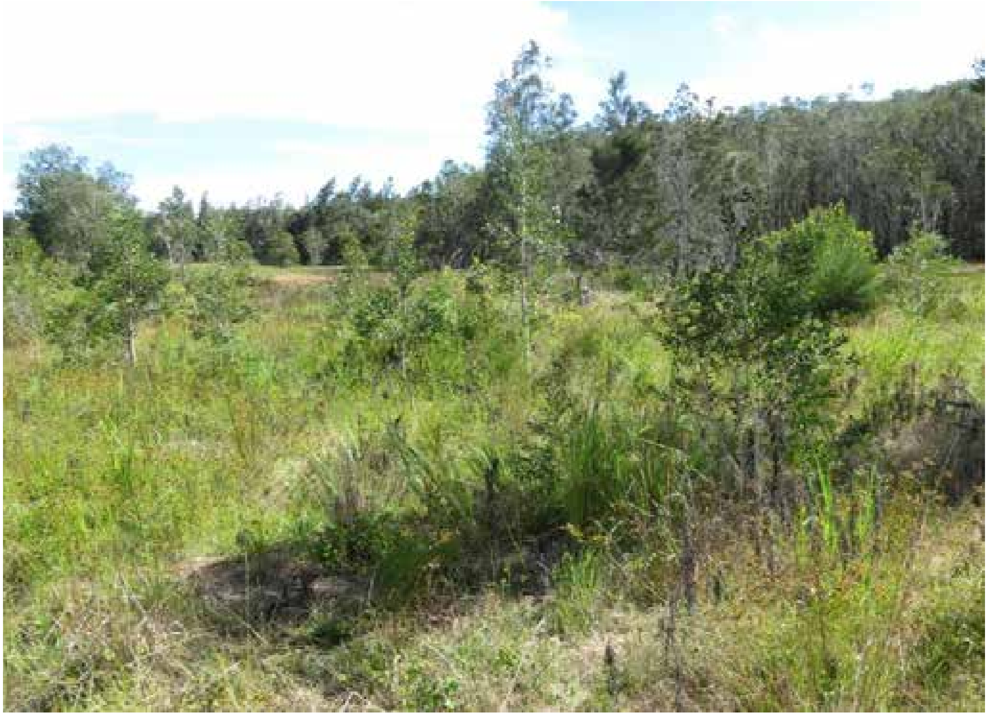
> The works are going well but it is important to collect seeds of tree species as well, just in case we do not get tree seed blowing into the site and need to direct sow or propagate these trees.
>
> - Daniel Gomes IPA Ranger

through this work will enable the Minyumai Team to manage weeds effectively using fire and also help prevent severe wildfires by reducing the fuel hazard these grasses create.

In August 2015, the Hotspots Fire Project ran a workshop with 46 local residents using this site as a demonstration and focused on managing fire for biodiversity as well as mitigating risk. Tein presented at this workshop and representatives from the Minyumai IPA were also involved on the day. Julie-Anne made an active contribution to the Hotspots workshop series, making her property available for a site visit which demonstrated the result of planned burns, with weed follow-up. Her Fire Management Plan was also used as an example for participants creating their own property plans.



Minyumai IPA burn © T. McDonald



Winter 2014 © J-A.Coward

> In the spring time you can feel overwhelmed with all the new growth, but once you put your plan into action it becomes manageable.
>
> – Julie-Anne Coward.

From the work undertaken, it is clear that different combinations of treatment strategies will need to be applied for other species and in other areas. The key however is to poison the weed prior to burning to ensure both a good kill and high enough temperatures to trigger regeneration — then to ensure follow-up weed treatment prior to weed seeding. Because of this need for follow-up treatment and the unpredictability of the response from any site, it is extremely important that landowners start small and observe what comes back. It is hoped that this case study can be used to assist landowners with similar problems on their land.

BMAD Toonumbar Valley 2009 © Cliff Guy Productions

SLATTER-GUN TECHNIQUES & FIRE:
Using fire and herbicide to remove lantana and regenerate native forest

Until the 1980s, there was little presence of lantana and few bell miners in the forests of Toonumbar, west of Lismore, New South Wales. However, by the 1990s when logging disturbances caused the native understorey to be replaced by 50–90% lantana cover and bell miners were becoming more common, property owners Susan and Wayne Somerville knew something had to be done. Not only were lantana and bell miners becoming a problem, the bell miner associated dieback (BMAD) was now also rapidly spreading. (See page 36 for a description of BMAD.)

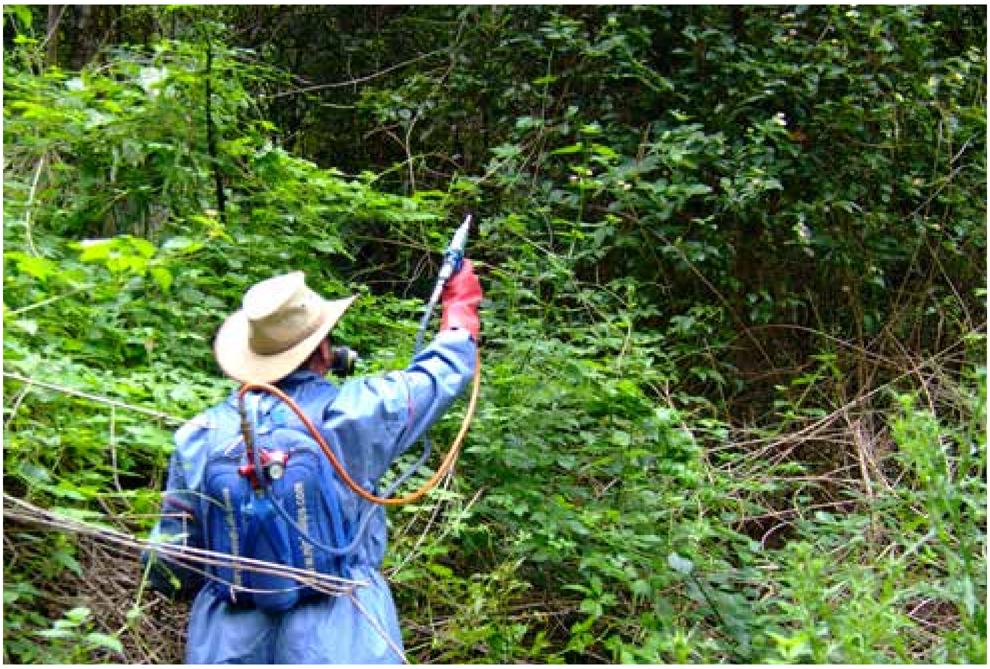
The Somervilles own a 470-hectare property with Dry Sclerophyll Forest on the ridges and Wet Sclerophyll Forest and Rainforest in the gullies and most sheltered parts. In 1980 cattle were excluded from the forested areas of the property and the forests were left to regrow naturally, but this was hampered by the growth of lantana. By the 2000s, 350 ha of forest had been infested with 25–80% lantana cover and there was only one small area of healthy intact forest. BMAD affected 80% of the property and was always associated with dense lantana and bell miners. The Somervilles began a program of removing lantana using a combination of herbicide and fire, testing their hypothesis that a combined approach might play a key role in breaking the BMAD cycle and allowing healthy regeneration of native forest to occur on their property.

Treatments

Herbicide

Usual methods of lantana treatment were not appropriate for the Somerville's property due to the size of the area, the extent of infestation and the steep and rugged terrain. The Somervilles set about testing a technique they termed 'splatter-gun technique' based on work by NPWS ecologist John Hunter and successes by Queensland Forestry. Hunter described the success his father had by squirting small quantities of glyphosate–water mix onto the lantana, while Queensland Forestry used herbicide guns. This technique uses jets of a high concentration and low volume glyphosate mixture (9:1 glyphosate:water) which is applied to lantana hedges in parallel lines, spaced 1–2 m apart, wetting only a minority of leaves on the plant.

Trials were undertaken by opening previous logging tracks with a small tractor so two operators could move through the solid lantana hedges. The tracks were treated using a small 4WD utility (Suzuki Sierra soft top) with a 100-litre spray unit, with a splatter-gun nozzle mounted on the back. One operator drove while the other walked behind, using the splatter-gun nozzle. Both sides of the track were treated to a depth of between 4 and 20 m, depending on the terrain. About a month later, a single operator would return with a splatter-gun backpack and, working off the track, treat the rest of the area. In 2007 the Somervilles began a 5-year program to implement work across approximately 300 ha of degraded forest after encouraging preliminary results. This work was made possible through initial grants obtained through North Coast Local Land Services (formally Northern Rivers Catchment Management Authority). Publicly funded works continue to this day.



Splatter-gun spraying of lantana © Cliff Guy Productions

Fire

In July 2007, a planned fire was conducted on the property. This fire was extinguished, but it reignited from a tree stump and burnt a large area of their property. In 2008 and 2009 the Somervilles decided to take advantage of the areas opened up by the fire to splatter-gun the dead and the regrowing lantana. This fire burnt four out of the five sites that were being monitored for responses. In 2009 the Somervilles hosted a Hotspots workshop series where a small (0.5 ha) demonstration burn took place. This ecological burn targeted blady grass and lantana and resulted in good germination of native seedlings, including wattles, grey gums and ironbark, the smallest of which are currently 3 m tall.

Monitoring

To keep an eye on the treatments, a photographic record was kept before, during and after treatments, as well as a formal photo point monitoring at three locations. A regular six-monthly or annual observation of the treated sites were undertaken. These observations helped to understand the nature of the response of lantana, as well as ensuring follow-up treatments were delivered at appropriate times so regeneration of natives was optimised. To quantify bell miner density, visual and audio sampling along 100-metre transects began in 2005.

> “We have combined fire and herbicide in two ways; first where accidental or deliberate fire has gone through we have followed-up with herbicide. This we have found the most successful. The second method uses herbicide to kill lantana and then a low intensity fire is used to clear the lantana and leaf litter and stimulate eucalypts, wattles and other fire-loving species.”
>
> – Susan Somerville

Results

Due to the 2007 fire, the amount of herbicide that was required to treat the lantana with splatter-gun was greatly reduced. While a combination of fire and herbicide treatments improved the condition of vegetation in the areas of Dry Sclerophyll Forest, herbicide-only was effective in the wetter areas. Lantana responded quickly to splatter-gun treatment where it was well hydrated and actively growing.

Where conditions were drier, lantana was less responsive to herbicide. The splatter-gun technique reliably killed individual plants and large hedges of lantana with very little reshooting from the base or roots. When reshooting did occur, it could be readily retreated. However, most regrowth of lantana occurred from seed.

In areas where the lantana consisted of isolated plants in an otherwise intact forest with good canopy cover, it was slow to resprout from seed and was out-competed by the native understorey and no follow-up was necessary. Recolonisation from seed happened in areas containing up to 50% lantana in the understorey. There was at least one follow-up treatment within 12 months to give native plants an advantage over the weeds. In large degraded areas there was strong competition between lantana growing from seed and regenerating natives, and it was necessary to continue treating the weeds over a few follow-up visits. This continued until some mid-storey developed to shade out the lantana.

In November 2005, high numbers of bell miners existed in all five monitoring sites. By April 2008 the bell miners at three of the sites had significantly decreased and the birds were absent at these sites by August 2011. Where the bell miners did remain it was thought to be due to these sites being adjacent to degraded, lantana infested forest. These sites have recently been treated with herbicide. There is strong evidence that tree canopies on the property have returned to health in areas with previously severe BMAD. The most affected tree species remain the grey ironbark in the drier ecotones and the flooded gum and blue gum in the moister areas.

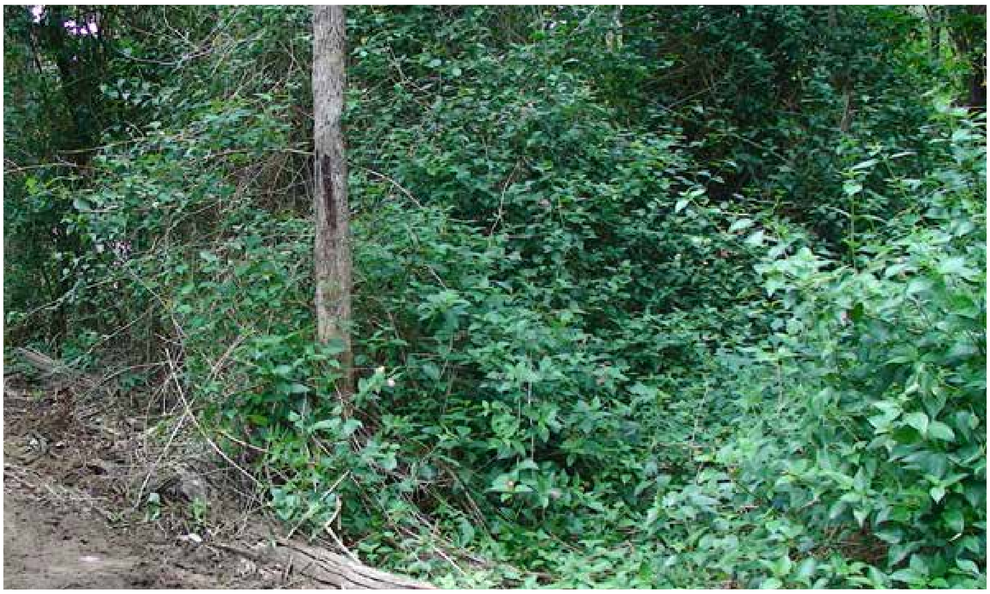
> "The previous 20 years of logging and weed incursion means large areas of the region are unhealthy. We now need to find ways of healing the land. If we take out the lantana, the forest can re-seed itself and once the canopy is intact again the system is more robust and resilient."
>
> – Susan Somerville

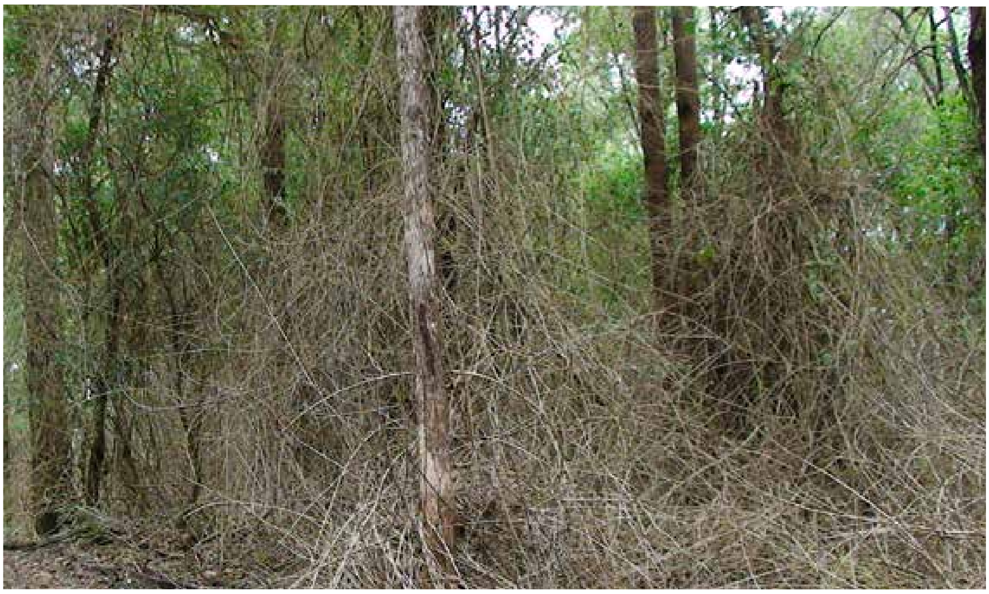
Conclusion

Results from the Somerville's property show lantana infestation can be effectively and efficiently treated. However, lantana follow-up treatments are likely to be required for some years to come, albeit at a much-reduced level once weed seeds in the soil are depleted. Once the lantana understorey is removed, complex structure and species biodiversity can return. Fire reduced weed cover and provided an opportunity to gain access into dense lantana thickets, and assisted native species regeneration. The treatments also indicate that native forest badly degraded by BMAD can show large levels of recovery.

However, follow-up is important and the best results are shown through the combination of fire and herbicide, particularly in Dry Sclerophyll Forest areas. It is also important to consider what seeds might be available for regeneration in the soil (soil seed bank) as well as what is seasonally available for recruitment, for the most appropriate management outcomes.

Work undertaken on the Somerville's property has links with other projects. Forestry Corporation of NSW has been using the splatter-gun techniques with controlled burns to manage lantana on their adjoining land. The local Githabul Rangers have also been working to reduce weeds across 110,000 ha of the neighbouring Gondwana World Heritage Area. The combination of these efforts is helping to maintain these precious areas.





Pre- and post-herbicide treatment © S. Somerville

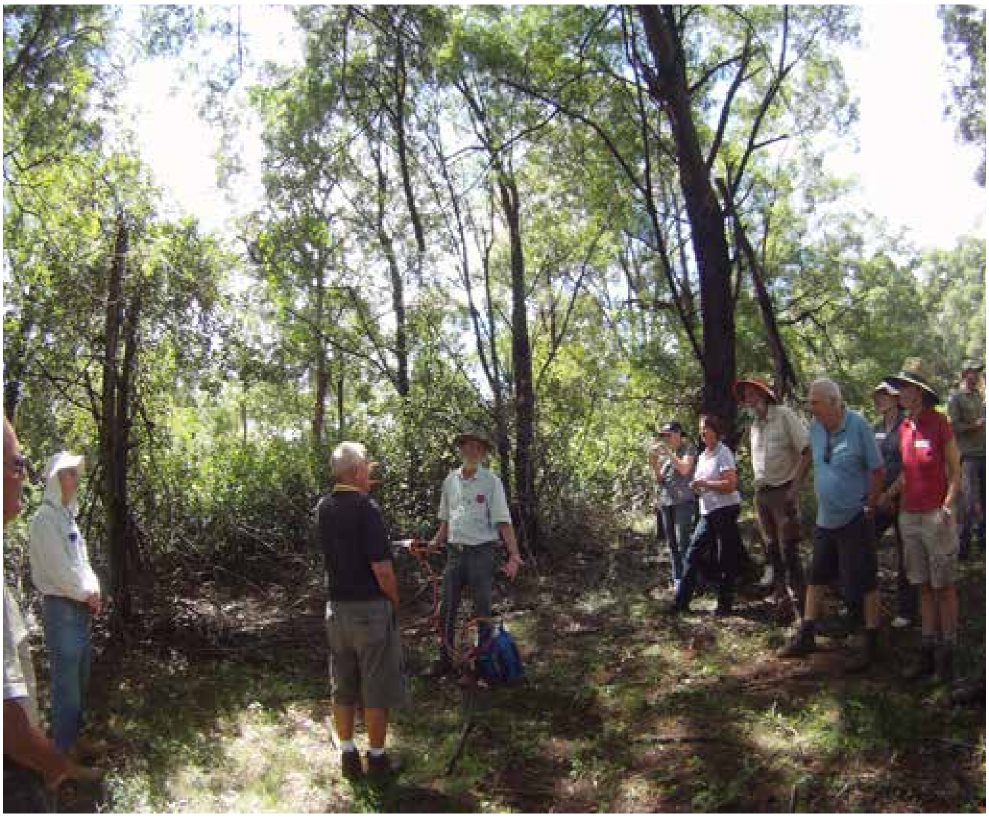
Bell Miner Associated Dieback (BMAD)

BMAD has been listed as a threatening process under the TSC Act 1995. 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 http://www.bmad.com.au/index.html.

This case study is based on the journal article by Somerville, Somerville and Coyle 2011, Regenerating native forest using splatter-gun techniques to remove Lantana, *Ecological Management and Restoration*, Vol 12, No 3, and discussions with Susan Somerville.



Splatter-gun demonstration at Hotspots workshop © K. McShea

Following the success of the work that occurred on the Somerville property, Jim Morrison (Chairman, BMAD Working Group), demonstrates the splatter-gun technique for treating lantana to a group of landholders at the first workshop of the Hotspots Bowen Mountain series at the foothills of the Blue Mountains.

8 WEEDS IN DIFFERENT VEGETATION TYPES

This section provides a summary of the interactions between weeds and the different vegetation types in New South Wales. Weeds will respond differently to the characteristics of the different vegetation types in the State. As described previously, these characteristics include fire history, soil type and climatic conditions. When considering how to manage weeds in different vegetation types it is important to start small and monitor what responses occur.

It may also be useful to talk to an ecologist or a Local Land Services, NPWS or NSW RFS representative for more information and advice on identifying and managing different weed species.

A. Busse © Hotspots

Rainforest © G. Basnett, Hotspots

Fire and weeds in Rainforest

Planned fire is not legally permitted in Rainforests in New South Wales, but fires do sometimes occur naturally, mostly during seasonally dry periods and when extreme fire weather conditions prevail. Fire will rarely entirely kill weeds within rainforest habitats, but has the potential to reduce weed biomass, enable access to previously inaccessible sites and to make other control methods (such as herbicide application or mechanical control) easier to implement and more likely to succeed.

Many Rainforest trees and shrubs are known to have the capacity to resprout or coppice following fire, but repeated fires at a site will ultimately lead to the loss of many Rainforest species. Dry Rainforests as well as those surrounded by extensive areas of eucalypt forest are the most vulnerable and prone to experiencing fire. There are, however, documented instances of where fire has burnt into even the wettest and most ancient (refugial) Rainforests, such as the stands of Antarctic beech–dominated Cool Temperate Rainforest on the Barrington Tops, during fire events occurring many centuries apart.

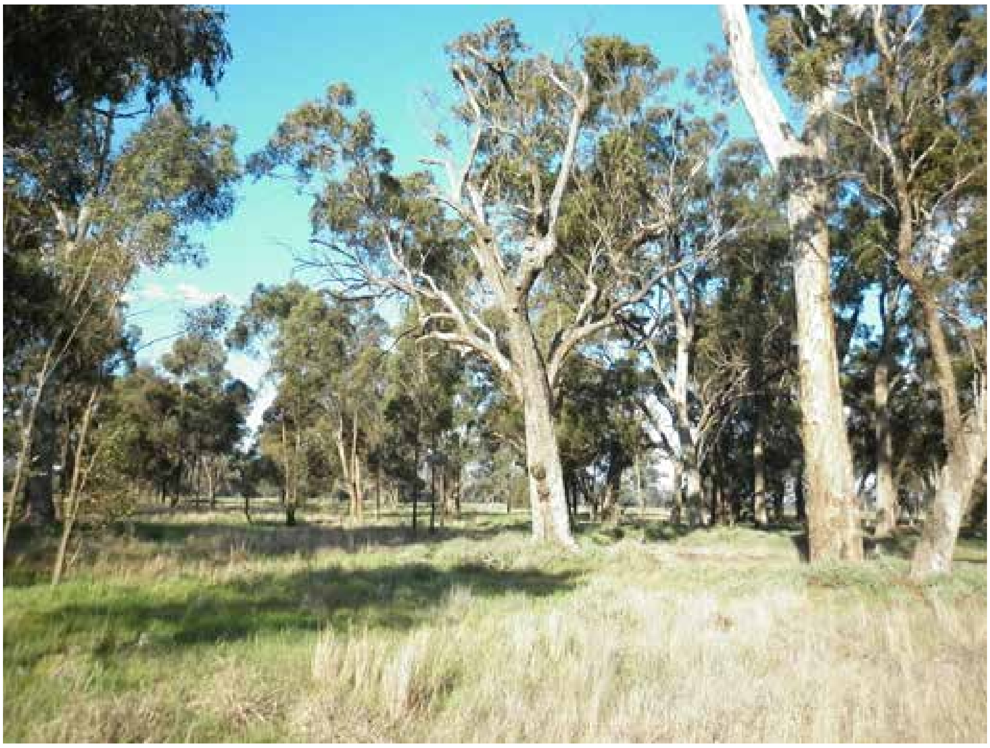
Most patches of Rainforest below 300 m above sea level (i.e. Lowland Rainforest) are regarded as threatened ecological communities. This is because Lowland Rainforests on flat terrain with fertile soils are highly fragmented. They generally exist in the landscape as degraded and isolated remnants and many are heavily infested with weeds.

A diverse range of weeds are known from Rainforest habitats around New South Wales, many of them are fleshy fruited and bird-dispersed species. This is because of the abundance and diversity of frugivorous (fruit-eating) birds found in Rainforest habitats, such as pigeons and doves, catbirds, figbirds, bowerbirds, currawongs and a diversity of smaller species such as honeyeaters, silvereyes and varied trillers.

Prominent examples of bird-dispersed weeds in Rainforests include lantana, large-and small-leaved privets, camphor laurel, tobacco bush, various asparagus species (with both ground and vine habits), a wide range of vines including white and corky passionfruit, as well as shrubs such as murraya, ochna, coral berry, various cestrum species and a large complement of garden and horticultural escapees that grow annually. Birds can be responsible for the introduction of many of these weed species into Rainforests and similar mesic vegetation communities post-fire. By carefully monitoring a site after a fire, the risk of this occurring can be reduced and if new weeds are found then appropriate actions can be undertaken to control the new infestation. This is likely to avoid a much bigger problem in the future.

Wind- and water-dispersed and vegetatively propagated weeds are less common in Rainforest than bird-dispersed species, but there are still many examples of these types of weeds. The highly ecologically destructive madeira vine is spread by the movement of its aerial tubers and stem sections; and balloon vine is spread by water, mostly along riverbanks. Wind-dispersed weeds that are known to invade intact Rainforests include mistflower, an exotic daisy with wind-dispersed seeds that are blown long distances. Other examples include the highly ecologically destructive cat's claw creeper and moth vine. Mistflower has been known to invade otherwise pristine creek banks within extensive tracts of rainforest at distances a long way (greater than 5 km) from the nearest known populations. Cat's claw creeper, a wind-dispersed weed, has also been found several kilometres from adult vines within intact subtropical rainforest.

Weeds exert a strong negative influence on Rainforests, and infestations of highly destructive weed species (such as madeira vine) can, over time, lead to a major degradation or loss of Rainforest from a site. Ongoing, and in some instances permanent, implementation of ecological restoration strategies and bushland regeneration works is needed to limit the degradation and prevent the loss of these highly diverse ecosystems. Fire is not a suitable management action that can generally play a positive role in strategies used in Rainforest.



Grassy Woodland © M. Graham, Hotspots

Fire and weeds in Grasslands and Grassy Woodlands

Grasslands and Grassy Woodlands occupy some of the most productive and fertile landscapes. As a consequence they are amongst the most heavily cleared and fragmented ecosystems and often have a high proportion of weeds in the understorey.

There has been a lot of valuable research undertaken into the role that fire plays in managing and maintaining native Grasslands and the understorey of Grassy Woodlands. Much of it has investigated the role that fire plays in addressing weeds within these productive native habitats.

Great successes have been achieved through the use of fire regimes that advantage native grasses, herbs and forbs and disadvantage exotic varieties. This is particularly the case where fire kills weeds and depletes or exhausts the availability of their seeds. Use of these fire regimes can contribute to a much greater dominance of native species post-fire. Many native species in Grasslands and the understorey of Grassy Woodlands are advantaged by relatively frequent fire. At the same time, relatively frequent fire kills, reduces seed numbers or diminishes the viability of many exotic grasses, herbs and other weeds.

Other successes have been achieved where fire has been used in combination with conventional bushland regeneration techniques, such as herbicide application. Careful consideration of the specific timing, sequencing and seasonality of these mixed fire and herbicide application strategies is needed to ensure the best restoration outcomes.

There are a limited number of examples where these approaches have been used successfully (refer to case studies, Section 7) and there is a great need for landowners, land managers and ecological restoration practitioners to apply, monitor and refine a range of combinations of restoration techniques to establish those that lead to the most successful ecological restoration outcomes.

For some weed species, such as Coolatai grass and Scotch broom, fire is known to promote and exacerbate existing infestations. In these types of instances, fire should be actively avoided and excluded until other management strategies such as herbicide or mechanical treatment have contained, reduced and controlled the infestations present.

Wet Sclerophyll Forest © W. Parker, Hotspots

Fire and weeds in Wet Sclerophyll Forest

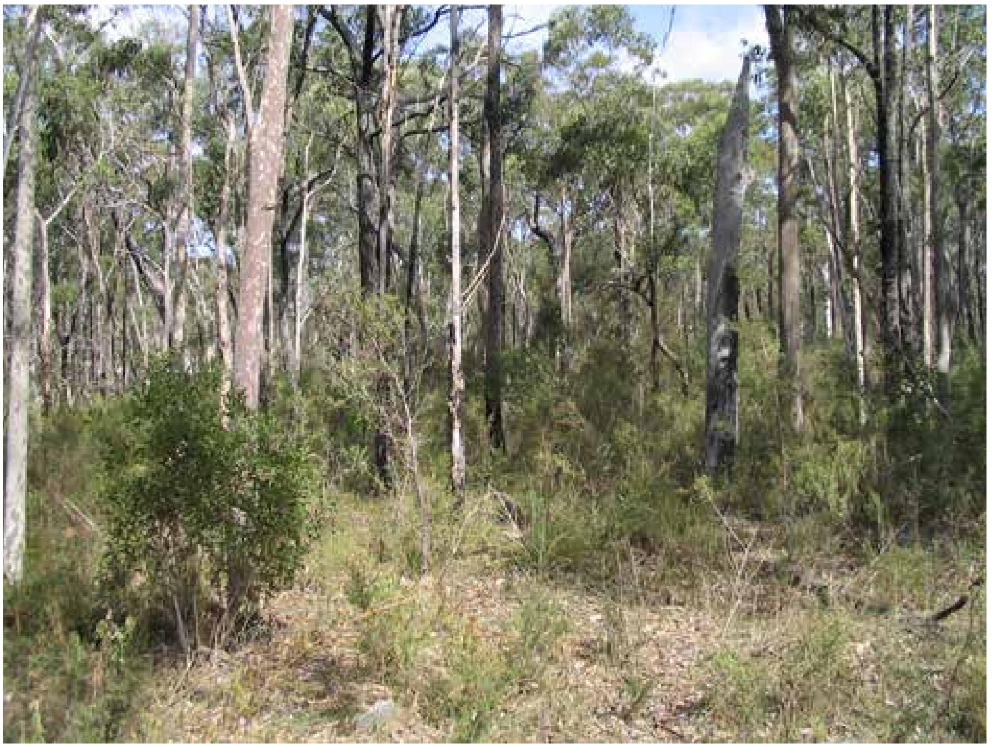
Shrubby Wet Sclerophyll Forests are the best developed of all eucalypt forests and among the tallest forests on earth, frequently reaching heights greater than 50 m. These forests occupy some of the highest rainfall and most sheltered sites, often with deep and fertile soils. While Rainforests usually grow in the wettest and more fertile landscapes, they tend to have fewer emergent eucalypts than Wet Sclerophyll Forests. However, the two vegetation types often share a similar mesic shrub or small tree layer. In this sense, as shrubby Wet Sclerophyll Forests are fertile and have a higher productivity than other eucalypt forest types they can be quite prone to weed invasion following disturbance, and can become heavily infested with weeds such as lantana or privet.

Like Rainforests, many of the weeds that impact shrubby Wet Sclerophyll Forests are fleshy fruited species that are dispersed by birds and flying-foxes. Fires can impact these weed species in variable ways depending on site conditions, seasonality and fire intensity. Managed fire can be used as part of integrated management strategies to limit the spread of weeds and reduce the availability of weed seeds post-fire. It can however be difficult to achieve the desired intensities at the right time of year, therefore limiting the ability to reduce the bush fire risk and achieve desirable ecological outcomes.

Grassy Wet Sclerophyll Forests occupy drier, more exposed and elevated sites than shrubby Wet Sclerophyll Forests. With more frequent fire this sub-formation generally has a greater proportion of grasses in the understorey, but in areas with less frequent fire shrubs are likely to dominate. As they have lower moisture levels, shallower and less fertile soils, grassy Wet Sclerophyll Forests are less prone to invasion by the many mesic weeds prevalent in Rainforests and shrubby Wet Sclerophyll Forests. Grassy Wet Sclerophyll Forests, particularly those at the driest end of the spectrum, are vulnerable to invasion and degradation by a range of exotic grasses and wind-dispersed herbs and forbs.

The influence of unplanned fire on weeds in Wet Sclerophyll Forests can be either positive or negative or sometimes both, particularly at sites with a diversity of weeds. The outcome will depend on the condition of the site before the fire, the prevalence and diversity of weeds in the landscape, the seasonality and intensity of the fire (regime) and the weather and climatic conditions over the site post-fire. At sites with fewer weeds and greater coverage of native species, intense unplanned fires can cause significant mortality of weeds (occasionally causing their disappearance from a site) and can trigger good regeneration of native species, improving the condition of these ecosystems post-fire. These conditions can be difficult to replicate in a planned fire scenario without supplementary weed management pre- or post-fire.

Both planned and unplanned fires can offer good opportunities to gain access to sites previously inaccessible due to heavy weed infestations or dense native shrub and vine layers. This is particularly the case with lantana in disturbed, logged and previously cleared sites. Gaining access post-fire can enable a targeted follow-up control of regenerating weeds, potentially resulting in a significant reduction in weed density and diversity and leading to improvements in the condition of these ecosystems. Having access to a site post-fire can also allow for active monitoring of the site to ensure that new weeds do not establish and to undertake works to control them if they do appear. This can be a particularly important activity to undertake post-fire because birds and wind can be responsible for the introduction of many weed species into recently burnt Wet Sclerophyll Forests. By carefully monitoring a site post-fire, the risk of this occurring can be reduced and if new weeds are found then appropriate actions can be undertaken to control the new infestation. This is likely to avoid a much bigger problem in future years.



Dry Sclerophyll Forest © G. Basnett, Hotspots

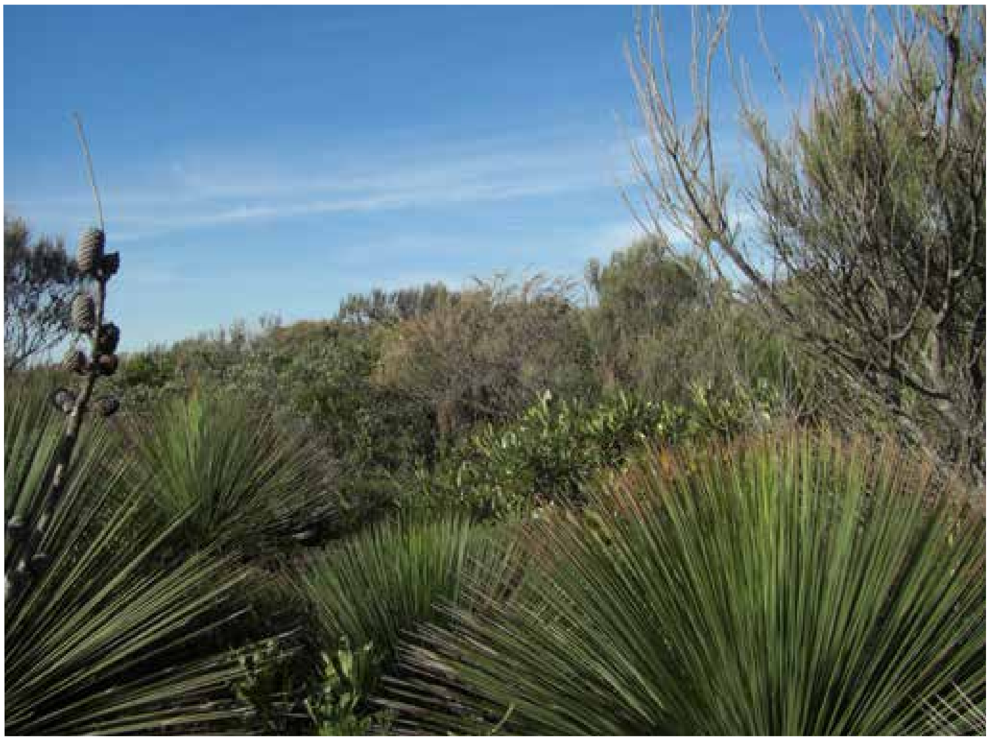
Fire and weeds in Dry Sclerophyll Forests

Dry Sclerophyll Forests occupy sites with less nutritious and shallower soils, lower rainfall, more exposure and generally harsher conditions than Wet Sclerophyll Forests. As a result, they reach a comparatively much lower canopy height with less structural complexity and are generally less impacted by weeds.

Fire is a relatively frequent occurrence in both shrubby and shrub/grass Dry Sclerophyll Forests. The general lack of fertility in these forests (particularly those shrubby Dry Sclerophyll Forests growing on nutrient-deficient sands and sandstone) means that they have a limited number and smaller range of weeds when compared to some other vegetation formations. These factors mean that Dry Sclerophyll Forests are often more resistant to weed invasion and there are significant intact expanses of Dry Sclerophyll Forest entirely lacking weeds and in good ecological condition.

Where Dry Sclerophyll Forests occur adjacent to urban and intensive agricultural areas, nutrient enrichment of these otherwise nutrient-deficient forests often occurs. This frequently results in degradation by weed infestation, mostly consisting of nutrient-loving escapees from nearby suburban gardens. Another consequence of nutrient enrichment within Dry Sclerophyll Forests in or adjoining urban areas, such as the Great Sydney Metropolitan, area can be a 'mesic shift' in the vegetation. This arises where otherwise dry and open forests are invaded by moisture-loving and thickly growing weed trees and shrubs such as privet. Once established, the presence of these weeds results in much higher moisture levels and lower light levels than those found naturally in Dry Sclerophyll Forests.

In some instances native species such as sweet pittosporum can also play a significant role in causing mesic shifts in Dry Sclerophyll Forests. If left unchecked these changes can result in the loss of a significant proportion of the understorey plant diversity within these biodiverse forests. Over time these changes can even cause dieback and death of dominant canopy species such as eucalypts, bloodwoods and angophoras. Fire may be a suitable management action that can have a positive role to play in weed management strategies.



Heathland © K. McShea, Hotspots

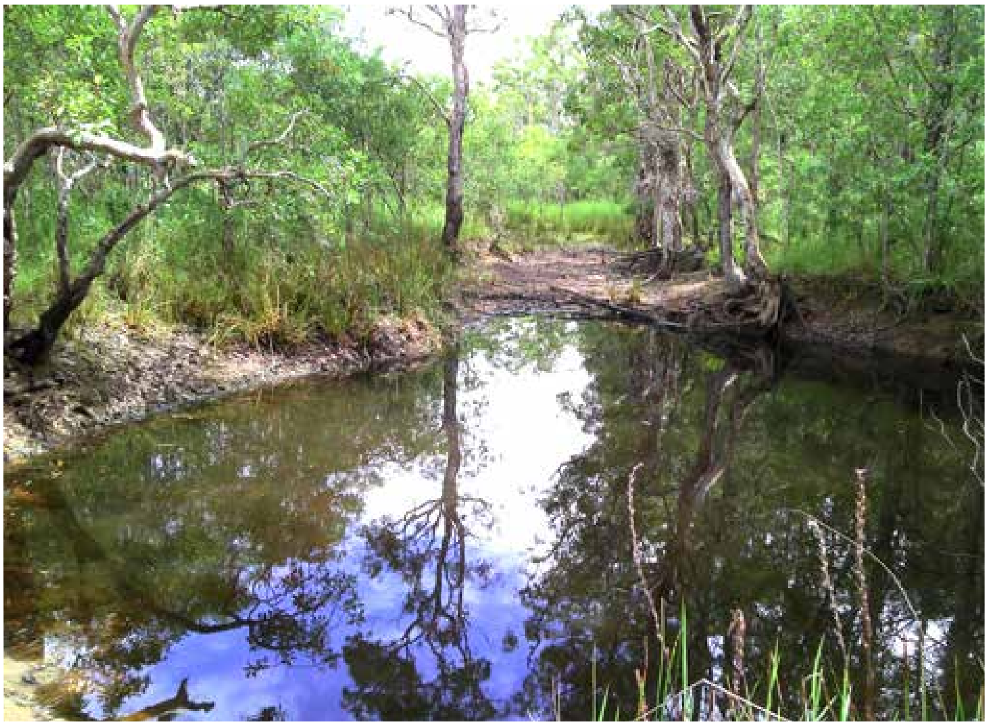
Fire and weeds in Heathlands

Heathland is characterised by a dense shrub layer generally with a limited height of less than 3 m. Their dense, oil-rich vegetation makes them highly flammable and they are generally well adapted to relatively frequent fire. Heathlands generally occupy sites with the lowest fertility and the poorest or shallowest soils. They are often the dominant vegetation type on exposed coastal plains and headlands composed of sand, or in harsh rocky areas with very shallow soils. Significant areas of Heathland have been cleared for coastal residential development and mining for mineral sands along the coast.

Due to the generally infertile nature of Heathlands and the relatively high frequency of fire, weeds are generally less of a management concern in these habitats than for many other vegetation formations. Many large expanses of Heathland are completely free of weeds. In some Heathlands weeds are limited in extent and diversity, and often only occupy disturbed fringes, tracks and the ecotone (or interface) with other vegetation formations.

Exceptions to this are found in highly fragmented patches of Heathland and areas of Heath adjoining residential and agricultural landscapes where nutrient enrichment and the prevalence of weeds in the landscape can result in heavily weed infested and highly degraded patches of Heathland. Nevertheless, the physical limitations imposed by the highly infertile soils on which Heathlands occur exert a strong influence that limits the number and coverage of weeds on these sites.

Unless adjoining areas of more mesic habitats such as Rainforest, Wet Sclerophyll Forest and Forested Wetlands, there are generally few bird-dispersed weeds in Heathlands. Weeds known from Heathland tend to be dominated by wind dispersed species such as whisky grass, pampas grass and slash pine. In patches of heathland adjoining suburban landscapes there can be a range of garden escapees, including vegetatively spread weeds such as mother-of-millions.



Forested and Freshwater Wetland © M. Graham, Hotspots

Fire and weeds in Forested & Freshwater Wetlands

Coastal Forested Wetlands are characterised by a number of trees including paperbarks, swamp mahogany and swamp oak, sometimes occurring as a monoculture. Forested Wetlands further inland are dominated by river oak, and across the Murray–Darling Basin by river red gum. Here they occupy the main riverine channels and floodplains. Forested Wetlands occur in landscapes that are periodically inundated, however, the frequency and length of inundation is often highly variable. Because of this they are relatively fertile vegetation formations occurring mostly on the fertile soils that are deposited by floodwaters.

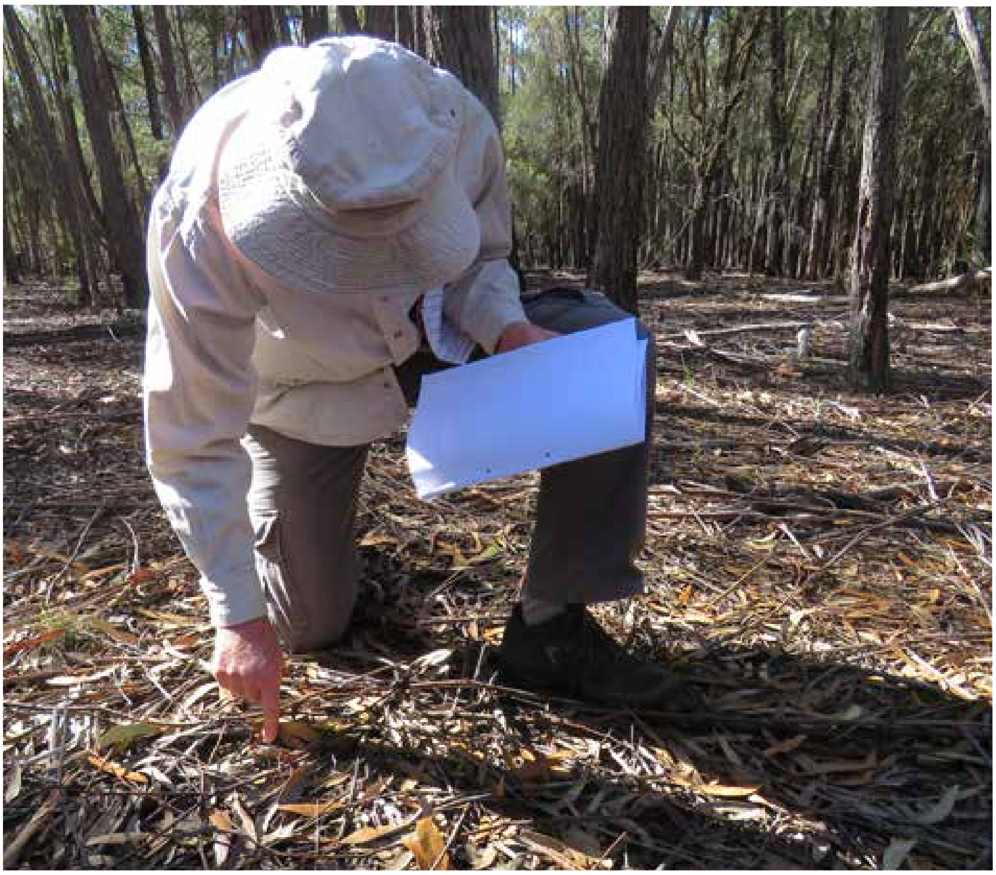
These landscapes have been extensively cleared and heavily fragmented by agricultural development and urban sprawl. In many landscapes only small fragments remain, many of them regarded as threatened ecological communities. These fragments are often degraded by a large number and great density of weeds, including many water dispersed weeds.

Fire regimes can vary greatly within Forested Wetlands due to their existence across a large climatic gradient from wet coastal floodplains to the Paroo River at the western edge of the Murray–Darling Basin. Using fire to manage weeds within Forested Wetland habitats can be challenging because of the wide variation in water availability and inundation levels, the presence of peat in many wetland complexes, and the sensitivity to fire of many wetland plants and animals (including numerous threatened species).

9 MONITORING FIRE AND WEEDS

During the Hotspots workshops it is stressed that one of the first steps in preparing a Fire Management Plan is to develop good baseline information about the natural features of your property. Some important information in your record should include the different native vegetation types as described in the statewide Keith Vegetation Classification system (Keith 2004). You should also identify other key features such as hollow-bearing trees and the extent and type of weeds.

By observing your bushland on a regular basis you will see the changes that occur over time and will recognise that what you see is influenced by when you look. The changing seasons, the amount of time that has passed since the last fire, and how recently and how much it has rained, all influence the state of the vegetation. These factors also apply when monitoring the extent, condition and spread of weeds, as well as response to any weed treatments that are applied.



Fuel assessment exercise, Hotspots workshop, Nerriga K. © McShea, Hotspots

Both planned and unplanned fires can provide opportunities to gain access to sites which may have previously been inaccessible due to heavy weed infestation. Gaining access can allow for post-fire monitoring and targeted treatment of the site to ensure that new weeds do not establish. By carefully monitoring a site post-fire, the risk of new weeds establishing can be reduced and if new weeds are found then appropriate actions can be undertaken to control the infestation. This is likely to avoid a much bigger problem in future years.

There are a number of monitoring techniques you could use including those outlined here.

Using photos to record changes

Photos can provide a visual representation of vegetation changes over time, especially if you take the photos from the same location because this allows you to compare the same area over different time periods. This comparison can be used as an easy form of monitoring in conjunction with observation.

This technique is called 'photo point monitoring'. The success of photo point monitoring is based on establishing permanent photo locations or photo points. Your photos will allow you to track changes in vegetation structure, the presence and extent of weeds, and flowering intervals. It may also be a useful tool to monitor changes to fuel loads.

Measuring fuel loads

In a fire-prone landscape it is important to be aware of the amount of bark fuel, elevated fuel (i.e. upright plants and organic matter over approximately 0.5 m in height) and surface fine fuel (i.e. leaves, twigs) in the event of a planned or unplanned fire. There are a number of methods of measuring fuel, the most detailed of which is using the *Overall fuel hazard guide third edition* (Victorian Department of Natural Resources and Environment 1999). An adapted version of this can be found in the Hotspots Monitoring Guide, details below.

You can learn to recognise changes in fuel loads both before and after a fire by using these fuel assessment techniques. Contact your local NSW RFS Office for advice on measurement options or to obtain a Hazard Reduction Certificate.

Further information, step-by-step guides and templates are available for monitoring changes on your property and can be found in the Hotspots Monitoring Guide available via the Hotspots website: www.hotspotsfireproject.org.au/resourcesmaterials.

10. REFERENCES

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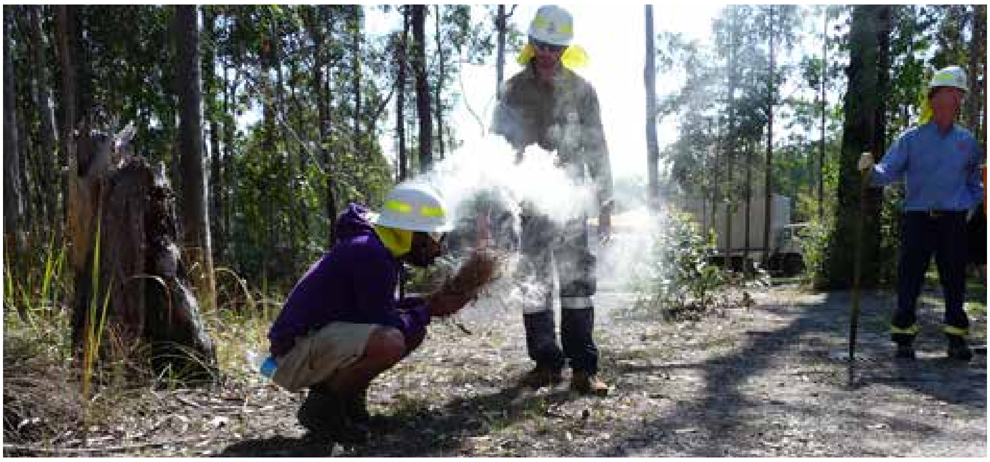
11. ABOUT THE HOTSPOTS FIRE PROJECT

Based on best available science and operational knowledge, the Hotspots Fire Project delivers workshops and resources to landholders and land managers to provide them with the skills and knowledge they need to participate in fire management planning.

Hotspots operates on a core belief that well-informed and well-prepared communities complement the roles of land managers and fire agencies and that a shared approach to fire management is critical to any form of planning.

Under the guidance of the nine project partners in the Advisory Committee, Hotspots is delivered through the coordinated efforts of the NSW Rural Fire Service and the Nature Conservation Council of NSW.



Traditional fire starting at Minyumai IPA © M. Graham

12. LIST OF COMMON AND SCIENTIFIC NAMES

Plants

Broad-leaved paperbark	*Melaleuca quinquenervia*
African lovegrass*	*Eragrostis curvula*
African olive*	*Olea europaea* subsp. *cuspidate*
Climbing asparagus fern*	*Asparagus plumosus*
Balloon vine*	*Cardiospermum grandiflorum*
Bamboo*	*Phyllostachys* spp.
Buttercups, native	*Ranunculus* spp.
Camphor laurel*	*Cinnamomum camphora*
Cat's claw creeper*	*Dolichandra unguis-cati*
Centella	*Centella asiatica*
Climbing nightshade*	*Solanum seaforthianum*
Coastal banksia	*Banksia integrifolia*
Coolatai grass *	*Hyparrhenia hirta*
Coral berry *	*Ardisia crenata*
Flooded gum	*Eucalyptus grandis*
Geebung	*Persoonia stradbrokensis*
Ground asparagus*	*Asparagus aethiopicus*
Grey ironbark	*Eucalyptus siderophloia*
Hawthorn*	*Crataegus monogyna*
Indian cupscale	*Sacciolepis indica*
Kangaroo grass	*Themeda triandra*
Kikuyu*	*Pennisetum clandestinum*
Lantana*	*Lantana camara*
Madeira vine*	*Anredera cordifolia*
Mistflower *	*Ageratina riparia*
Moth vine*	*Araujia sericifera*
Mother-of-millions*	*Bryophyllum* spp.
Ochna* (or Mickey Mouse bush)	*Ochna serrulata*
Orange jessamine* (or Murraya)	*Murraya paniculata*
Pampas grass*	*Cortaderia* spp.
Paspalum*	*Paspalum dilatatum*
Passionfruit*	*Passiflora* spp.
Pennyworts, native	*Hydrocotyle* spp.
Privet* (small and broad-leaved)	*Ligustrum sinense* and *L. lucidum*
Quaking grass*	*Briza maxima*
Rat's tail fescue*	*Vulpia* spp.
River oak	*Casuarina cunninghamiana*
River red gum	*Eucalyptus camaldulensis*
Scotch broom *	*Cytisus scoparius* subsp. *scoparius*
Setaria *	*Setaria sphacelata* var. *sericea*
Small-fruited grey gum	*Eucalyptus propinqua*
Slash pine*	*Pinus elliottii*
Swamp mahogany	*Eucalyptus robusta*

*Weed species

Swamp oak	*Casuarina glauca*
Sweet pittosporum	*Pittosporum undulatum*
Sydney Blue gum	*Eucalyptus saligna*
Tea Tree	*Melaleuca alternifolia*
Tobacco bush*	*Solanum mauritianum*
Various cestrum species *	*Cestrum* spp.
Wattles	*Acacia* spp.
Weeping grass	*Microlaena stipoides*
Whisky grass*	*Andropogon virginicus*
Willow bottlebrush	*Calistemon salignus*

*Weed species

Animals

Bell miner	*Manorina melanophrys*
Bowerbirds (satin, regent bowerbird)	*Ptilonorhynchus violaceus, Sericulus chrysocephalus*
Green Catbird	*Ailuroedus crassirostris*
Currawongs	*Strepera* spp.
Australasian figbird	*Sphecotheres vieilloti*
Flying-foxes (Grey-headed flying-fox, black flying-fox)	*Pteropus poliocephalus* *Pteropus alecto*
Honeyeaters	*Family Meliphagidae*
Silvereye	*Zosterops lateralis*
Varied triller	*Lalage leucomela*

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

Partners and collaborators

This booklet has been compiled by 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 weeds and the environment every day and anticipate that some recommendations may change as new information comes to hand.

This booklet was written by Mark Graham with assistance from Kate McShea, Kevin Taylor, Kate Foreman, and Jennie Cramp. Thank you to Donella Andersen from Nature Edit for editing this document. The Hotspots Fire Project is jointly managed by the Nature Conservation Council of NSW and the NSW Rural Fire Service. Thank you to the Office of Environment and Heritage for photographs.

For further information on the Hotspots Fire Project contact:

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Email: hotspots@rfs.nsw.gov.au

The Nature Conservation Council of NSW
(02) 9516 0359
Email: info@hotspotsfireproject.org.au

The following agencies have useful websites and may be of assistance:

Forestry Corporation of NSW
http://www.forestrycorporation.com.au

Hotspots Fire Project
www.hotspotsfireproject.org.au

Local Land Services
www.lls.nsw.gov.au

Nature Conservation Council of NSW
www.nature.org.au

Nature Conservation Council of NSW Bushfire Program
www.nature.org.au/healthy-ecosystems/bushfire-program

NSW National Parks & Wildlife Service
www.nationalparks.nsw.gov.au

NSW Rural Fire Service
www.rfs.nsw.gov.au

NSW State Emergency Services
www.ses.nsw.gov.au

Southeast Queensland Fire and Biodiversity Consortium
www.fireandbiodiversity.org.au

HOTSPOTS FIRE PROJECT

NSW RURAL FIRE SERVICE

Nature Conservation Council
The voice for nature in NSW