PROJECT PHOENIX

BUSHFIRE IMPACTS

A NATIONAL MODEL FOR ASSESSING LOCAL LANDSCAPE RESTORATION PRIORITIES

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Project Phoenix

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Australian Government

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Across all of our Project Phoenix activities and actions we pay respect to the Traditional Owners and Custodians of the lands and waters on which we work. We honour the resilience and continuing connection to country, culture and community of all Aboriginal and Torres Strait Islander people across Australia. We recognise the decisions we make today will impact the lives of generations to come.

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CONTENTS

EXECUTIVE SUMMARY

- The Black Summer bushfires of 2019–20 were unprecedented in terms of their spatial extent, intensity, ecological consequences and coverage of different vegetation communities (e.g. rainforest, sclerophyll forest, woodlands, grasslands, heathland and shrubland).
- The extent and severity of these fires highlighted the need for a science-based framework that can be used by managers and practitioners to make decisions regarding when and how to intervene to assist the recovery of fire-affected vegetation communities.
- Having decision-making tools can provide the basis for a management approach based on facilitating natural regeneration and one where limited resources — particularly seed — can be strategically directed to specific situations and combined with other interventions to maximise environmental benefits.
- The basis of these tools is understanding the inherent regenerative capacity of different community types (based on species composition and traits). This information is then used to assess how intervention can facilitate regeneration, followed by an assessment of where seed input may be needed to assist the recovery of non-regenerating functional groups and species.
- We present a framework that can be used to assess the need for intervention based on:
  - pre- and post-fire vegetation condition
  - fire severity
  - landscape context and
  - community composition.
- We then illustrate how this can be applied using case studies and for the management and restoration of the 19 fire-affected Threatened Ecological Communities (TECs) that were burnt >10% of their range in the 2019/20 fires. To inform this assessment we include specific information on life history and fire response traits for species within each TEC and fire-affected species within these areas.
- We conclude by discussing restoration of fire-affected communities in a rapidly changing world. This involves considering where establishing new habitat patches via restoration may be helpful as insurance or as a protective measure for existing remnants to increase the resilience of threatened ecological communities to current and ongoing threats.

1 INTRODUCTION

1.1 2019–20 Black Summer fires and the role of native seed in recovery

The 2019–20 fire season brought about a shift in how we see fire across the Australian landscape. During this season — known as Black Summer — the fires were unprecedented in terms of their spatial extent, intensity, types of vegetation communities affected (e.g. rainforest) and ecological consequences.[1,2] This season included the occurrence of several 'mega-fires' in NSW, which resulted in more area being burnt in this fire season than in any of the previous 20 years.[3]

In terms of their impact on vegetation communities, these fires burnt more than eight million hectares of vegetation across south-east Australia: this included 7.34 million ha of eucalypt forest and woodland, 0.33 million ha of rainforest and vine thickets, 0.22 million ha of shrublands and heathlands, and 0.25 million ha of other forest and woodland ecosystems.[2]

Of the 88 nationally listed threatened ecological communities (TECs), over 35% (33) were burnt in the fires, with some of these burnt more than 50% of their range (see Table 7-1 of this report). The context of record-breaking temperatures and extremely low rainfall contributed to the extreme scale and intensity of these fires[3] — highlighting the unique pre-disturbance context in which species and communities experienced the 2019–20 fire season.

The fact that Australia's Black Summer bushfires were so unprecedented led to uncertainties regarding the extent to which vegetation communities may recover, and if restoration interventions may be required. This led to Project Phoenix and the need to assess the requirements for native seed for bushfire recovery. Yet, this raised many questions on the role and importance of native seed for post-bushfire vegetation recovery, and how this may vary both between vegetation communities and across different patches within a community type.

Vegetation communities differ in their fire sensitivity, structure and composition. It is therefore imperative that this information is included to ensure tailored management responses that work with the inherent regenerative capacity of vegetation communities to recover post-fire.

Equally, within a vegetation community, variation in management history and degradation can drive differences in regenerative capacity and lead to a spectrum of recovery that needs to be accounted for in post-fire management. There is, therefore, the need for a science-based framework that can be used by managers and practitioners to make decisions regarding when and how to intervene to assist the recovery of vegetation communities affected by fire events.

This decision-making framework can provide the basis for an 'ecological triage' approach where limited resources — particularly seed — can be strategically directed to specific situations and combined with other interventions to maximise environmental benefits.

1.2 Fire ecology and restoration

Given the fire-prone nature of the Australian landscape,[4,5] the field of fire ecology and its application to different vegetation types is well established. As an emerging field, restoration ecology involves the study and application of the processes involved in assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.[6]

Restoration ecology recognises that degradation is a spectrum, ecosystems are complex and that the goal of intervention is to establish or facilitate a trajectory of recovery so that the community is self-sustaining and resilient to disturbance. For restoration, the point of reference for this trajectory is a particular reference community.

In this report we aim to bring together the fields of fire ecology and restoration to better understand how to assist the post-fire recovery of vegetation communities. The fire ecology literature helps to identify how species respond to fire and how historical and contemporary fire regimes (fire frequency, fire intensity, spatial pattern and extent and seasonality) can interact with species functional traits to determine community composition and post-fire recovery. While the restoration literature helps us to understand the importance of habitat condition and degradation, weed management and seed input to habitat recovery following disturbance, it is the intersection of fire ecology and restoration ecology that is vital for understanding:

- the inherent regenerative capacity of different communities,
- how we can facilitate regeneration, and
- where there may be the need for seed input to assist the recovery of non-regenerating functional groups or species.

Here we outline a staged approach that aims to minimise seed input through targeted seed use.

This is important given that restoration activities aim to use seed most effectively and efficiently and that there is a general lack of seed supply — especially for threatened ecological communities.

This approach advocates interventions that work with, and enhance, the regenerative capacity of a community before seed inputs are considered. However, it recognises that, due to management prior to fire, historical fire regimes and other disturbances, seed inputs may be required to maintain a particular reference community composition.

Here, targeted seed use — in combination with other management activities — can specifically focus on groups or species with minimal regeneration within a community context.

We also use this framework to help understand where establishing new native vegetation patches via restoration may be helpful as insurance or as a protective measure for existing remnants in the face of changing environments (future fire and climate change). Reconstruction of vegetation communities is inherently challenging and requires broad seed inputs, but the strategic use of these activities may increase the resilience of threatened ecological communities to current and ongoing threats.

1.3 Aims and objectives

The overall aim of this report is to outline a conceptual model that can be applied to the management and restoration of fire-affected vegetation communities. Here we focus on 19* TECs of which >10% of their areas were burnt in the 2019–20 fires (Table 7-1). The six specific aims are to:

1. Outline a general **conceptual model** to assess the need for intervention based on pre- and post-fire vegetation condition, fire severity, landscape context and community composition.
2. Establish a general **decision-making framework** (including a decision tree) to assist in the prioritisation of restoration activities.
3. Outline potential **restoration approaches** for fire-affected communities based on output from the decision tree.
4. Present **case studies** of two broad vegetation types (rainforest and grassy woodland) to assess the application of these conceptual frameworks and decision tools. Highlight case studies of special case seed input for post-fire habitat restoration to support threatened fauna.
5. Generate restoration scenarios for 19 different **threatened ecological communities** (TECs) affected by the 2019–20 fires using this conceptual framework and a spatially explicit GIS model.
6. Discuss restoration scenarios in the broad context of future fire mitigation strategies and climate-adjusted approaches.

* The Aquatic Root Mat Community in Caves of the Swan Coastal Plain (WA) was removed from the original list of 20 TECs due to inconsistencies in fire mapping.

2 BUILDING A CONCEPTUAL MODEL

2.1 Predicting regenerative potential

Predicting the regenerative potential of a vegetation community requires an understanding of:

- the fire response of species within that community and
- the abiotic and biotic variables that can reduce this regenerative capacity.

Pre-disturbance factors can affect the capacity of individuals of different species within communities to have the capacity (seed and/or vegetative reserves) to recover after fire, while the *post-disturbance* context will influence the degree of germination, regrowth, establishment and survival (Figure 2-1).

2.1.1 Fire response traits

Species can generally be classified into three broad groups of fire response strategies:

1. **obligate seeders (OS; R-S+)** — species that lack the ability to resprout (killed by fire) and rely entirely on seed germination for post-fire recovery
2. **facultative seeders**[†] **(FS; R+S+)** — species that can regenerate via resprouting and seed germination after fire (although one means of regeneration may be dominant) and
3. **resprouters (RS; R+S-)** — species that solely regenerate post-fire from shoots from dormant buds in the stems, plant bases, roots and/or tubers.

Where the classification of the traits of resprouting and seeding is: R = post-fire resprouting, S = post-fire seeding, + = present, - = absent (see[7,8]). It is important to note that seed storage and persistence are not distinguished in these broad categories. In this report we consider seed storage separately.

Standardised classification systems are important for enabling comparison of fire response across different communities and for broadly assessing fire sensitivity. However, it is crucial to acknowledge that species can vary in this response depending on fire intensity, seasonality, plant size/age, population differences (based on genetic and/or environmental differences) and resource gradients. To date, these response categories have largely been based on species from fire prone environments.

[†] Facultative seeders can also be called facultative resprouters but represent the same functional group for fire response.

The Black Summer bushfires illustrate how fire has become more prevalent in communities that are not normally fire prone such as rainforest and sub-alpine areas.[9] Within these communities, post-fire plant responses may reflect strategies that have evolved for recovery from other disturbances (e.g. insect attack, drought, tree fall). As such, data collection after these most recent fires is still limited and so will likely contribute to a greater understanding of fire response in these systems once collected.

For this report, allocation of the above three categories to species listed in each TEC is based on published surveys of germination and resprouting of these species after fire.

Yet, for many species (especially from rainforest and sub-alpine communities) this response was unknown. Consequently, further observation or analysis may place a species in a different category and ongoing data collection will also help refine data on species' responses across a range of communities.

2.1.2 Pre- and post-disturbance condition

The interaction of plant traits with disturbance

For obligate seeders and facultative seeders that regenerate post-fire via seed, the amount of seed available for recruitment will depend on plant age and/or stand age (for species that recruit predominately following disturbance) (Figure 2-1). For plant age, the time to flowering (reproductive maturity) from seed is the **primary juvenile period**.[10,11] For obligate seeders (and to a lesser extent facultative seeders), the length of the primary juvenile period is particularly important because population decline or localised extinction may occur if the fire interval is shorter than the time taken to reach reproductive maturity and accumulate an adequate seedbank.[12,13]

Even though a seed bank may not be exhausted by a single fire event, developing and/or replenishing an adequate seed bank may require several years of seed set. The primary juvenile period can vary between individuals within a species (e.g. Alpine Ash)[14] and among populations and sites due to variation in productivity gradients (e.g. soil and rainfall)[15,16] as well as the length of the growing season (e.g. longer primary juvenile periods in montane communities).[17]

This means that species or populations in certain environments may require longer fire-free periods to ensure their capacity to regenerate after fire. In addition, given this potential variation, the primary juvenile period of a species should be expressed as a median (middle) and range of values when multiple measurements are available.

The importance of seed production and seed banks

The amount of seed available for post-fire recruitment will also depend on levels of seed production in the years preceding the fire event and how seed is stored (canopy, serotinous or in soil-stored seed banks). Some species — particularly obligate seeders — can form persistent soil-stored seed banks. Others store seed in serotinous cones that require fire for seed release.

Seed production can be influenced by a range of factors including water stress, landscape modification, productivity and resource gradients, competition from invasive species, and herbivory by native and introduced herbivores.[18–22] In addition, for small and fragmented populations, pollinator availability and low genetic diversity can reduce seed set.[23–25]

The regenerative capacity of the seed bank is also affected by the viability and genetic diversity of the seed produced. Small population processes and fragmentation effects can increase inbreeding which can have detrimental effects on seed viability.[25] In tandem, plant stress (abiotic and biotic) and resource limitation can reduce seed viability both during development and post-dispersal.[20,26]

Resprouting capacity and disturbance history

For obligate resprouters (and facultative seeders that resprout), regenerative capacity is related to plant age and condition. Most species need to reach a certain age before they have the capacity to survive and resprout post-fire. This age-related capacity will also interact with fire intensity (i.e. more time may be required to survive a high intensity compared to low intensity fire).

Population decline may therefore occur when the fire interval is less than the age at which a plant reaches fire tolerance. Similarly, too frequent fire can also deplete plant resources which reduces their capacity to regenerate after fire and may increase their susceptibility to post-fire mortality.[27]

The **secondary juvenile period** is the time taken for resprouting individuals to flower (reproductive maturity). A fire frequency less than the secondary juvenile period may result in population decline, especially if the species does not generally have 100% post-fire survival.[13] Resprouting capacity is also related to abiotic and biotic stress, so that drought, competition, herbivory and disease can reduce plant productivity and condition.[28,29] Decreased plant growth can reduce the development of resource stores in roots or tubers and/or the development of buds and protective structures thereby diminishing regenerative capacity.

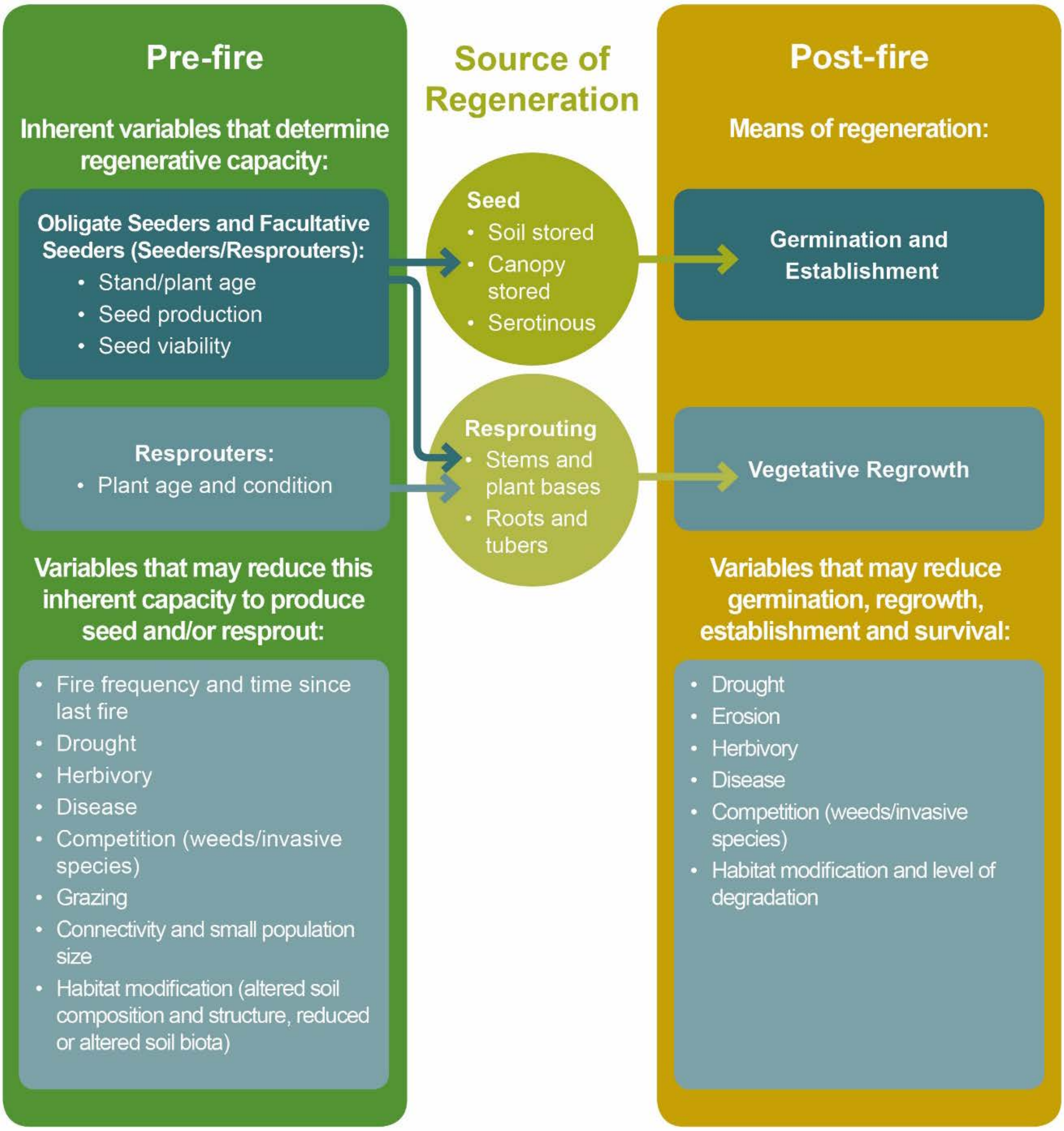
The importance of post-disturbance context

Post-disturbance context will also influence the levels of post-fire regeneration. Drought, herbivory, disease and competition can reduce the level of seed germination and seedling establishment (e.g. Rodman *et al.*,[30] Cohn and Bradstock),[31] as well as vegetative growth and survival (e.g. Enright and Goldblum[32], Moreno and Oechel).[33]

Due to the loss of ground cover, erosion and above average rainfall can be detrimental to post-disturbance recovery through direct damage to plants and through the loss of topsoil and seed bank reserves. Habitat modification such as soil compaction, loss of topsoil and soil structure can impede germination and seedling survival.

These changes can also increase plant stress (through changes in nutrient and water availability), reducing the capacity for resprouters to undertake vegetative growth. Taken together, it is important to recognise that even if a community has the regenerative capacity to recover post-fire (i.e. is in good condition pre-disturbance), this may be reduced by abiotic and biotic factors in the post-disturbance environment.

FIGURE 2-1. THE IMPORTANCE OF PRE-FIRE VEGETATION CONDITION AND POST-FIRE CONTEXT FOR THE INTRINSIC REGENERATIVE CAPACITY OF OBLIGATE SEEDERS (OS), FACULTATIVE SEEDERS (SEEDERS/RESPROUTERS) (FS) AND RESPROUTERS (RS) FOLLOWING DISTURBANCE BY FIRE. PRE-FIRE FACTORS CAN AFFECT THE CAPACITY OF INDIVIDUALS OF DIFFERENT SPECIES WITHIN COMMUNITIES TO HAVE THE SEED AND/OR VEGETATIVE RESERVES (CAPACITY) TO RECOVER AFTER FIRE, WHILE THE POST-FIRE CONTEXT WILL INFLUENCE THE DEGREE OF GERMINATION, REGROWTH, ESTABLISHMENT AND SURVIVAL.



2.2 The restoration continuum and seed input

2.2.1 Restoration approaches

The restoration spectrum recognises that sites vary in the degree of damage or degradation and therefore the level of management intervention required, especially in relation to the necessary seed inputs (Figure 2-2). For all restoration approaches, we use the typology outlined within the recently revised SERA standards.[34]

At the lower end of the degradation spectrum are sites that require protection/natural regeneration.

These sites have a high potential for natural regeneration and no restoration intervention is usually required. However, as with all restoration approaches across the spectrum, ongoing threatening processes need to be mitigated to maintain habitat condition.

The next restoration approach is facilitated regeneration (*synonym:* assisted regeneration).

Seed input is generally not required due to the high potential for natural regeneration (although there may be exceptions for threatened species conservation or other special case seed input). Other management activities such as weed control may be implemented to facilitate and secure natural regeneration.

A combined regeneration/reintroduction approach is applied to sites where there is potential for natural regeneration, but seed addition is considered for some specific non-regenerating species and/or functional groups (Figure 2-2).

These reintroduced elements will depend on the adequate availability of propagules and may provide specific habitat functions, be critical structural elements and/or be of high conservation significance. This combined approach is often undertaken sequentially, with facilitated regeneration activities initiated first to provide an assessment of the underlying regenerative potential before seed addition is considered. Management to mitigate ongoing threatening processes is essential to support regeneration and ensure the effective use of seed resources.

Reconstruction is the restoration approach that requires the greatest seed input (Figure 2-2).

This approach is implemented in sites with few if any remaining native species and hence minimal natural regeneration potential. These sites usually have the highest damage due to pre-existing degradation and frequently require a combination of broad seed input and ongoing threat management.

FIGURE 2-2. THE RANGE OF RESTORATION APPROACHES FROM PROTECTION/NATURAL REGENERATION, THROUGH TO FACILITATED REGENERATION TO COMBINED REGENERATION/REINTRODUCTION AND RECONSTRUCTION IN RELATION TO THE SPECTRUM OF HABITAT DAMAGE/DEGRADATION AND SEED INPUT REQUIREMENTS. FOR ALL INTERVENTION APPROACHES, THREAT MANAGEMENT IS REQUIRED TO MITIGATE THREATENING PROCESSES.

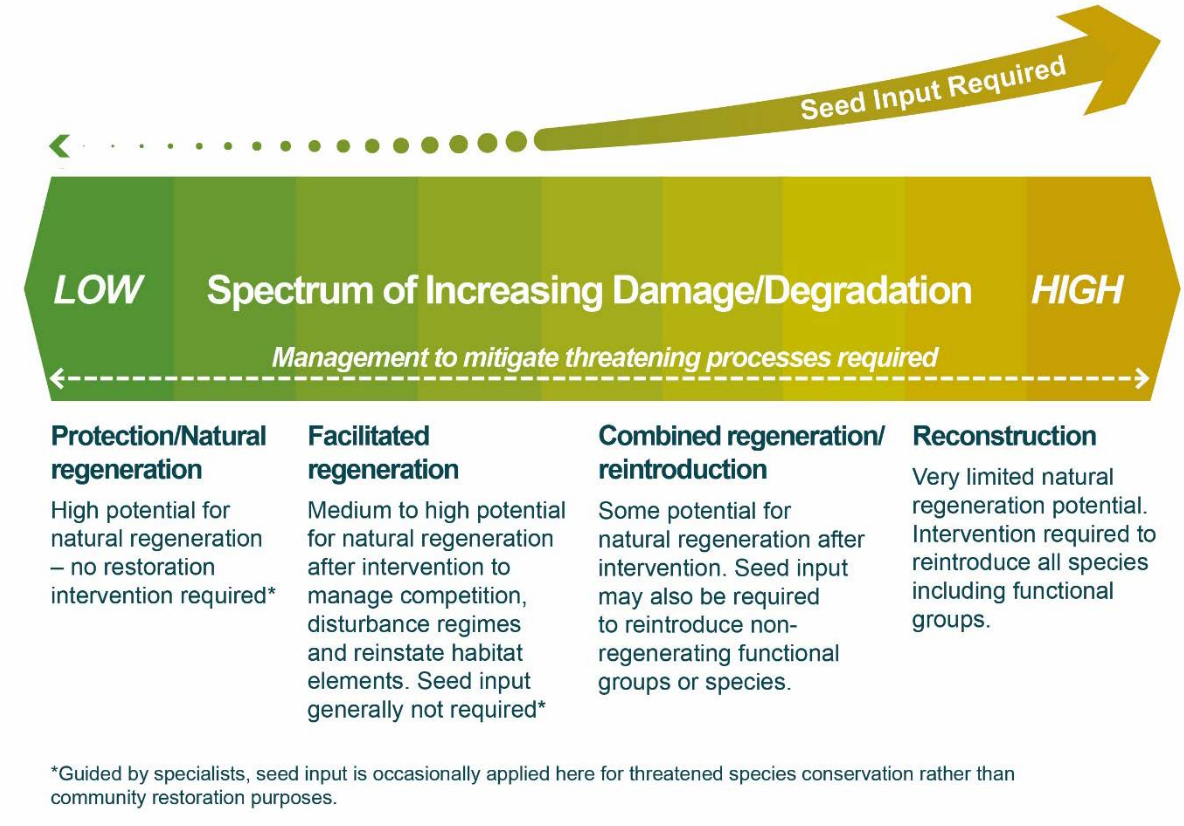


TABLE 2-1. (SEE NEXT PAGE) VEGETATION CONDITION CLASSIFICATION FOR ASSESSMENT OF THE NEED FOR SEED INPUT POST-FIRE (RECOVERY CATEGORY) (ADAPTED FROM MCDONALD).[35] THIS ASSESSMENT IS CENTRED ON THE INHERENT REGENERATIVE CAPACITY OF A VEGETATION COMMUNITY BASED ON CONDITION INDICATORS PRIOR TO FIRE. FOR EACH RECOVERY CATEGORY, THE RECOVERY MECHANISMS AVAILABLE RELATE TO THE INHERENT REGENERATIVE POTENTIAL OF THE SPECIES WITHIN A COMMUNITY WHICH IN TURN RELATES TO THE RESTORATION APPROACH REQUIRED AFTER DISTURBANCE BY FIRE.

[1] The boundary between facilitated regeneration and combined regeneration/reintroduction may or may not include Class 2 sites due to potential for colonisation

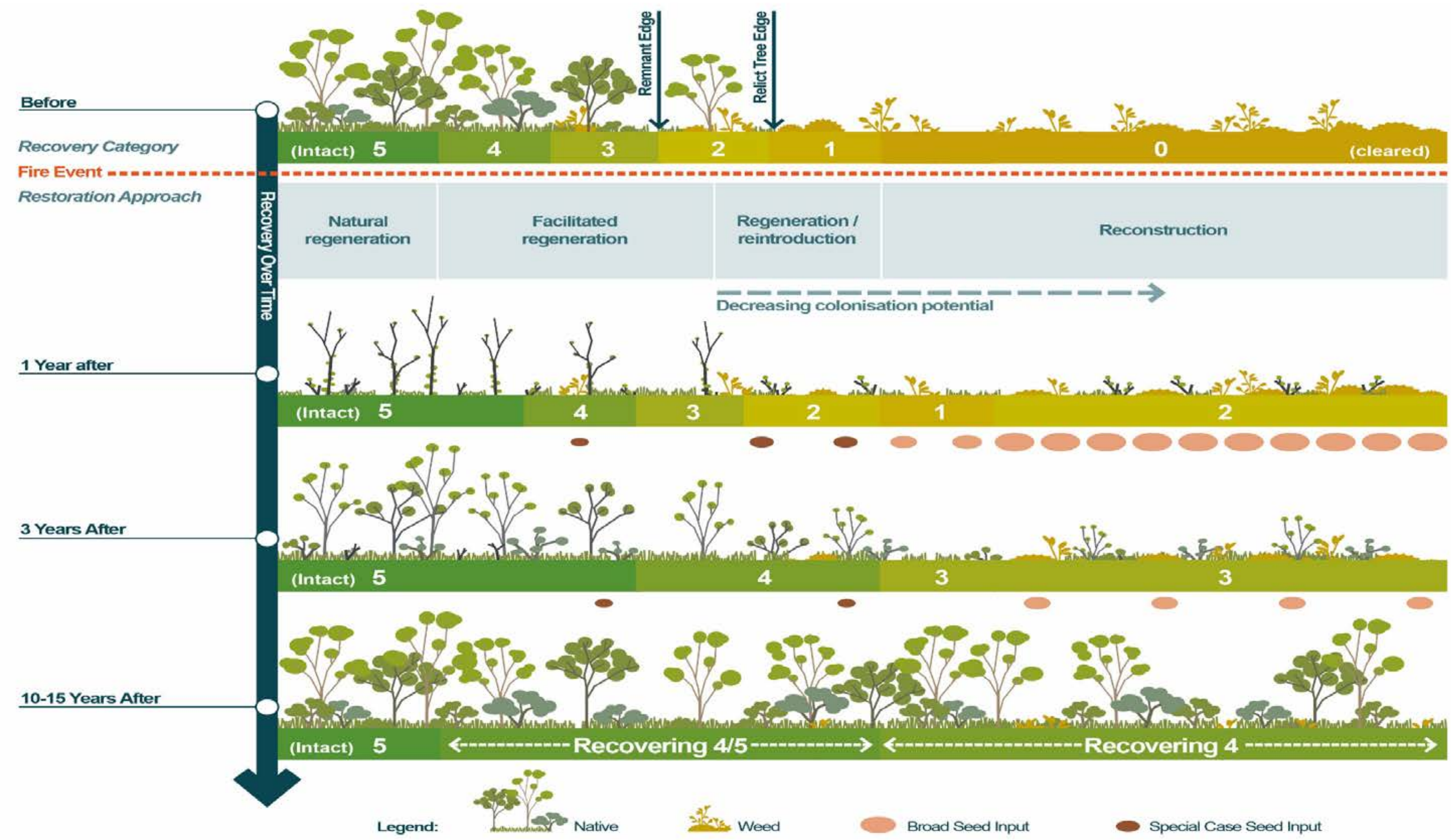
[2] Weed and native plant presence is measured by both the number of species and the area covered by those species relative to that number and cover found in a healthy reference ecosystem of this kind

[3] The difference in seed inputs required reflects grazing history

Special case seed input = may only require seed from species of specific conservation interest (e.g. threatened species)

RECOVERY CATEGORY	VERY HIGH 5	HIGH 4	MEDIUM 3	LOW 2	VERY LOW 1	NIL 0
RECOVERY MECHANISMS AVAILABLE	Soil seed, Seed rain, Resprouting	Soil seed, Seed rain, Resprouting	Soil seed, Seed rain, Resprouting	Lower soil seed, Seed rain; Colonisation	Low soil seed, Colonisation (if close enough to the propagule source)	Colonisation (if close enough to the propagule source)
RESTORATION APPROACH	**Protection/ natural regeneration**	**Facilitated regeneration**		**Combined regeneration/ reintroduction[1]**		**Reconstruction**
UNGRAZED NATIVE VEGETATION						
NATIVE RECOVERY INDICATORS	**5**	**4**	**3**	**2**	**1**	**0**
Remnant vegetation in a Reserve or National Park: Generic diagnostic characteristics	Above ground native vegetation and topsoil intact – very low to nil weed levels[2]	Above ground native vegetation and topsoil intact but moderate levels of weed present above ground	Above ground native vegetation modified, weeds may be dominant, but substantial rootstocks and topsoil intact	Above ground native vegetation removed (except some scattered individuals), weed usually dominant but soil profile intact	Above ground native vegetation entirely removed and weed or other vegetation dominant but soil profile intact	Above ground native vegetation entirely removed and soil profile not intact
Examples of the gradient of zones of different condition extending from within undisturbed remnants to the modified edges and beyond into fully cleared areas	E.g., Core areas of conservation reserves protected from utilisation and with nil to minimal anthropogenic disturbance history	E.g., Interface areas, but still within the remnant, where edge effects from adjacent land uses are starting to be evident	E.g., Boundary zone where edge effects from adjacent land uses are strongly evident, but natives still present.	E.g., Boundary zone where edge effects long entrenched and where weeds fully dominate over natives	E.g., Just outside the vegetation boundary where sites are non-native dominated but soil profile intact	E.g., Long converted to other vegetation or land use that has a disturbed soil profile
Need for seed	**Nil or special case**	**Nil or special case**	**Nil or special case**	**Nil to low**	**Medium[3]**	**High**
NATIVE VEGETATION AFFECTED BY GRAZING OR OTHER DIFFUSE AND VARIABLE IMPACTS (e.g. selective harvesting)						
NATIVE RECOVERY INDICATORS	**5**	**4**	**3**	**2**	**1**	**0**
Remnant vegetation within an agricultural landscape: Generic diagnostic characteristics	Above ground native vegetation and topsoil intact – very low to nil weed levels[2]	Above ground native vegetation and topsoil largely intact but moderate levels of weed presence above ground	Above ground native vegetation modified and/or weed dominated, but some perennial rootstocks and topsoil intact	Above ground native vegetation removed (except for scattered individuals), weeds usually dominant, but soil profile intact	Above ground native vegetation entirely removed, and weed or other vegetation dominant, but soil profile intact	Above ground native vegetation entirely removed and soil profile not intact
Examples of the gradient of zones of different condition extending from within uncleared remnants, to the cleared and grazed edges and beyond into long altered agricultural areas	E.g., Rocky sites protected from grazing or clearing	E.g., Sites affected by light grazing and weed invasion	E.g., Sites affected by high levels of clearing and grazing and substantial weed invasion	E.g., Long cleared and grazed but not pasture improved, scattered dominants and original soil profile present.	E.g., Long cleared and heavily grazed Some pasture improvement but no substantial tillage.	E.g., History of cropping or other agricultural land use that has a disturbed soil profile
Need for seed	**Nil or special case**	**Nil or special case**	**Nil to Low**	**Low to Medium**	**Medium to High[3]**	**High**

FIGURE 2-3. (SEE NEXT PAGE) CONCEPTUAL MODEL OF POST-FIRE RECOVERY AND SEED ADDITION NEEDS OF NATIVE VEGETATION. THIS MODEL DEPENDS ON HABITAT CONDITION (LEVEL OF DEGRADATION) AND THE INHERENT RECOVERY POTENTIAL OF ITS SPECIES' (COMMUNITY COMPOSITION), WHICH IN TURN DICTATES THE RESTORATION APPROACH. THE SPECTRUM OF INTERVENTION APPROACHES RANGES FROM PROTECTION/NATURAL REGENERATION AND FACILITATED REGENERATION (WHERE SEED ADDITION IS RARELY NEEDED) TO COMBINED REGENERATION/REINTRODUCTION AND RECONSTRUCTION (WHICH UTILISE TARGETED AND BROAD SEED ADDITION). ALL THESE APPROACHES NEED TO BE PLACED IN THE CONTEXT OF THREAT MANAGEMENT TO FACILITATE REGENERATION AND ENSURE THE EFFECTIVE USE OF LIMITED SEED RESOURCES (SEE ALSO FIGURE 2-2). THE RECOVERY CATEGORIES 0–5 RELATE TO THOSE OUTLINED IN TABLE 2-1. PREDICTING RECOVERY POTENTIAL PRIOR TO FIRE IS BASED ON IMPACT AND DISTURBANCE HISTORIES, DROUGHT, HABITAT CONNECTIVITY, THE PRESENCE OF INTACT SOIL PROFILES AND KNOWLEDGE OF RECOVERY TRAITS (SEED BANKS, RESPROUTING AND COLONISATION POTENTIAL) OF THE INDIVIDUAL SPECIES (SEE FIGURE 2-1); WHILE AFTER FIRE AND SUFFICIENT RAINFALL, RESTORATION APPROACHES CAN BE ALLOCATED ON THE BASIS OF DIRECT EVIDENCE OF THE SPECIES' AND COMMUNITY RECOVERY. WITHIN AND AT THE MARGINS OF AN UNGRAZED REMNANT CANOPY, SEED ADDITION IS GENERALLY UNLIKELY TO BE NEEDED (EXCEPT IF SITE ASSESSMENT IDENTIFIES A NEED FOR SPECIAL CASE SEED INPUTS FOR FIRE-KILLED SPECIES, PARTICULARLY FOR THREATENED SPECIES OR SPECIES OF CONSERVATION SIGNIFICANCE). SEED OF SOME SPECIES MAY NEED TO COMPLEMENT REGENERATION IN AN 'OVERLAP ZONE' BETWEEN THE REMNANT AND THE ADJACENT CLEARED AREA. THE ZONE IN WHICH SEED IS NEEDED MAY BE GREATER IN GRAZED, COMPARED TO UN-GRAZED REMNANTS. IN LONG CLEARED AREAS WITH NO INHERENT RECOVERY POTENTIAL, A FULL RECONSTRUCTION APPROACH INVOLVING SITE PREPARATION PLUS BROAD SEED INPUTS (I.E. A BIODIVERSE MIX OF SPECIES THAT ALIGNS WITH THE REFERENCE COMMUNITY COMPOSITION) IS LIKELY TO BE REQUIRED.



Remnant Edge
Relict Tree Edge
Before
Recovery Category
(Intact) 5
4
3
2
1
0
(cleared)
Fire Event
Restoration Approach
Natural regeneration
Facilitated regeneration
Regeneration / reintroduction
Reconstruction
Decreasing colonisation potential
Recovery Over Time
1 Year after
(Intact) 5
4
3
2
1
2
3 Years After
(Intact) 5
4
3
3
10-15 Years After
(Intact) 5
Recovering 4/5
Recovering 4
Legend:
Native
Weed
Broad Seed Input
Special Case Seed Input

2.2.2 Recovery category, habitat condition and restoration

Condition classes and recovery

We advocate a restoration approach that recognises that the inherent recovery potential (condition) of a community at a site is spatially variable and may change through time. We introduce a framework that can be used to identify the recovery potential and mechanisms present within a community prior to a disturbance event such as fire. This can help with site assessments to develop appropriate post-fire restoration approaches and establish how these may assist a recovery trajectory that maintains and/or enhances habitat condition (see Table 2-1, Figure 2-3).

> In applying this framework, it is important to recognise that there will likely be spatial variation in vegetation condition within a site.

For example, within an area there may be patchiness that leads to a smaller scale mosaic pattern of vegetation condition. However, when assessing overall condition for a site it is essential to make an assessment based on the general condition of the community recognising that there maybe be other classes within this area.

Degradation and the importance of grazing impacts on seed needs for restoration

When considering habitat condition, a spectrum of condition classes (recovery categories) can be aligned against the four restoration intervention approaches (Table 2-1). Each of these condition classes is illustrated by descriptive indicators that consider above ground vegetation cover, topsoil condition and the presence of weeds.

A wide range of impacts can occur within native vegetation across the entire landscape: from protected reserves to utilised production landscapes. Examples of these impacts that reduce habitat condition include clearing, soil disturbance, compaction, chemical contamination and inappropriate fire regimes. Even though the extent and degree of impact in agricultural areas can be higher than in conservation reserves, the types of impacts and their biophysical effects are similar enough to allow the use of a single tool for site assessment.

There are, however, distinct differences in the impacts of grazing on vegetation communities that warrants the use of separate indictors and may result in different gradients of regenerative capacity and the need for seed inputs in restoration.

This is because impacts in ungrazed landscapes tend to largely reflect a core to edge pattern of fragmentation. This involves a core of higher condition habitat, with edge effects becoming increasingly prominent towards the boundary adjacent to the source of the impact. In these systems, protection/natural regeneration or facilitated regeneration is usually all that is needed within the remnant and its edge, with a narrow overlap zone (suited to combined regeneration/ reintroduction approaches) occurring at the interface between the remnant and the reconstruction zone (see Figure 2-3).

In contrast, the pattern of degradation occurring in native vegetation in agricultural landscapes often reflects a more variegated pattern due to diffuse impacts of grazing and/or other activities such as selective harvesting.

This can result in extensive areas where some native species may well persist or be recoverable but where other species (e.g. palatable and grazing-sensitive species) are no longer present. This means that in grazed landscapes, the overlap zone where seed reintroduction may need to be combined with regeneration approaches can be wider than in ungrazed sites. This difference in potential seed needs in grazed vs ungrazed sites is outlined in Table 2-1 and discussed elsewhere in this report.

Framework examples

We present three examples of this framework for high to low recovery category sites, with and without a history of grazing, to illustrate how site management can affect recovery potential.

Example 1: Ecological restoration to improve habitat condition and facilitate recovery post-fire for high condition sites (see column 2 in Table 2-1, Figure 2-3).

For a site of recovery category 4 that is ungrazed (rows: ungrazed native vegetation, Table 2-1), the above ground vegetation and topsoil are intact but substantial weeds may be present. This category includes interface areas where edge effects are evident from adjacent land use. The recovery mechanisms include soil seed, seed rain and resprouting.

Similar to the medium recovery category, there may be an increased weed presence post-fire, but this may present the opportunity to significantly lower weed loads through depleting the seed bank. Weed loads may be higher within grazed sites, requiring more intensive management (rows: native vegetation affected by grazing and other diffuse and variable impacts, Table 2-1).

For both ungrazed and grazed sites, seed is usually not required except for special case seed inputs for species of conservation concern. Over time, this site could move to category 4/5 (see Figure 2-3).

Example 2: Ecological restoration to improve habitat condition and facilitate recovery post-fire for medium condition sites (see column 3 in Table 2-1, Figure 2-3).

For a site of recovery category 3 (medium) that has not been grazed (rows: ungrazed native vegetation, Table 2-1), the above ground vegetation has been modified, weeds may be dominant, but substantial rootstocks and topsoil are intact. The recovery mechanisms remaining in this habitat include soil stored seed banks, seed rain from existing vegetation and resprouting.

Seed or plant propagules may also colonise this site from adjacent higher quality remnants (sites with a recovery category 4 or 5). An example of these areas may be boundary zones where the effects from adjacent land use are strongly evident.

Facilitated regeneration could be implemented post-fire and this site may require more intensive weed management due to a flush of weeds following fire. However, this increased weed presence after fire presents the opportunity to exhaust or diminish the weed seed bank to increase native regeneration. For native species, disturbance by fire can also unlock regenerative potential providing the opportunity for recruitment from more extensive soil stored seed banks in medium condition sites.

> This is an example of where skilled practitioners play a vital role in distinguishing between native and weed seedlings to enable the selective removal of invasive species as part of facilitated regeneration.

Over time, this habitat along the remnant edge could be improved and move to category 4 (high) (see Figure 2-3). No seed would generally be required unless there was the need for special case seed inputs (e.g. species of conservation significance). However, if this site has a history of grazing and clearing (rows: native vegetation affected by grazing and other diffuse and variable impacts, Table 2-1), key species (e.g. palatable species and/or those most susceptible to clearing) may be absent.

Low amounts of targeted seed may be required to augment missing species. In addition, this site may require ongoing weed management and the need for special case seed input will need to be reassessed at intervals (see Figure 2-3). Over time, this site could move to category 4/5.

Example 3: Ecological restoration to improve habitat condition and facilitate recovery post-fire for more degraded (low recovery) condition sites (see column 4 in Table 2-1, Figure 2-3).

For a site of recovery category 2 (low recovery category) that has not been grazed (rows: ungrazed native vegetation, Table 2-1), the above ground vegetation has been largely removed, weeds may be dominant, but the topsoil is usually intact. In this case, a combined regeneration/reintroduction approach would be applied.

Facilitated regeneration would be implemented post-fire and more intensive weed management may be required due to a flush of weeds after fire. However, this increased post-fire weed presence presents the opportunity to exhaust or diminish the weed seed bank to increase native regeneration.

For native species, disturbance by fire can also unlock regenerative potential from any remaining soil stored seed banks. Low seed input would generally be required to augment non-regenerating species and/or functional groups, with the magnitude of seed inputs likely dependent on characteristics of the fire event (fire intensity, extent, seasonality). However, it is expected that seed inputs would be greater for grazed sites (low to medium seed inputs), due to the selective loss of species through grazing (e.g. more palatable species) and selective clearing (rows: native vegetation affected by grazing, Table 2-1).

Over time, this habitat between the remnant and relict tree edge could move to category 3 (medium) or 4 (high) (see Figure 2-3). Special case seed inputs (e.g. species of conservation significance) may be required depending on conservation objectives and prior management.

This site may require ongoing weed management, and the requirement for special case seed input will need to be reassessed at intervals (see Figure 2-3). Over time, this site could move to category 4 or 5 with ongoing evidence of recovery.

3 DEVELOPING A DECISION TREE FRAMEWORK

3.1 Predicting regenerative potential

Knowledge of the variables that influence regenerative (recovery) potential can be used to provide information to feed into a decision-making framework on restoration scenarios for fire-affected vegetation communities. The variables discussed below are not exhaustive but provide a basis for estimating recovery potential for fire-affected communities. Many of the variables can be assessed using spatial tools (i.e. GIS) and, when combined with local and specialist knowledge, can provide a foundation for restoration scenario planning.

The final goal of the decision tree framework is to prioritise conservation activities in fire-affected areas (i.e. provide a form of ecological triage) within a specific vegetation community. This will ensure the efficient use of limited resources — including native seed — and that these resources are allocated to treat areas of greatest need and where action will provide the greatest benefits.

This general model can be applied to different vegetation communities as the data and assessment is undertaken in relation to a specific community type based on the broad vegetation category (e.g. rainforest, wet sclerophyll, grassy woodland, shrubland, heathland), species composition (diversity, life history data and fire response), community structure (ground cover, understorey, mid-storey and over-storey) and ecological function.

Local and specialist knowledge should be used to help interpret spatial data in relation to these variables. We also advocate the need for on ground assessments (ground truthing) to verify spatial data.

We have described six variables below that were used to provide information for the decision tree (see Figure 3-1).

1. **Fire frequency — Fire frequency can be defined by measures such as the number of fires in a specified time period, time since the last (most recent) fire and average fire interval (average time between fires).**

   The fire frequency for a particular area or site is then assessed along a spectrum of appropriate to inappropriate based on data from a combination of sources including:

   - broad vegetation type (fire sensitive vs fire adapted communities) and general mean fire interval recommendations
   - species composition in relation to fire response traits (proportion of obligate seeders, facultative seeders and resprouters)

- species' fire response in relation to life form (the proportion of fire sensitive (obligate seeders and facultative seeders) vs resprouters for trees, shrubs, herbaceous and climbers/vines) and
- primary juvenile periods (mean and range) for fire sensitive species.

The amount of data available will likely vary for each community type and should be assessed in combination with specialist knowledge.

An appropriate fire interval is one where there has been adequate time between fires for fire sensitive species to regenerate, reach reproductive maturity and re-establish and/or replenish seed banks. Conversely, an inappropriate fire interval is where the fire frequency has been too high to allow adequate time for regeneration and replenishment of seed banks.

There is also the case where long fire intervals can be inappropriate and result in the loss of species due to the lack of opportunity for post-fire recruitment of species reliant on fire for regeneration.

Inappropriate historical fire frequency is likely to result in changes to species composition with the selective loss of fire sensitive species. At the community level, this assessment recognises that species vary in their response and that the fire intervals that favour one species may be detrimental to another.

2. **Drought (rainfall) — Average rainfall in the pre-fire period may influence the inherent ability of a community to regenerate post-fire by reducing seed production, seed viability and resprouting capacity (see Figure 2-1).**

Deficits in precipitation that may reflect drought can be described by measures such as rainfall percentiles for a specified pre-fire time period[36] or the Standardised Precipitation Index (SPI).[37] The SPI assigns a single numeric value to the precipitation so that it can be compared across regions with different climates.

Rainfall percentiles range from very much below average through to below average to average to above average and then very much above average. When assessing the potential impact of deficits in precipitation on seed set and plant growth, it is important to define a relevant time period (e.g. 6 months, 2 years or 5 years prior to fire) and select the relevant measure of rainfall.

3. **Degraded habitat condition — Habitat condition and management history can influence the recovery capacity of a vegetation community.**

The framework presented in Section 2.2.2 (Table 2-1) can be used to assess potential recovery indicators. This will require local specialist knowledge to assess recovery capacity and how this may vary across the burnt area based on whether the area is at the centre or towards the edge of the remnant or if it is a vegetation remnant within an agricultural landscape. Higher degradation, and a management history of grazing or clearing, likely reflects a lower recovery potential.

4. **Connectivity — In fragmented landscapes, populations with high connectivity are likely to have greater long-term viability due to increased gene flow and higher effective population sizes.**

Gene flow into populations from nearby sources can counteract the loss of genetic diversity by drift (random chance) in small and fragmented populations. Higher genetic diversity is important for plant fitness and adaptive potential and is therefore central to the capacity of a population to recover from disturbance. Proximity to reserves with similar vegetation types could be used as a proxy for landscape connectivity.

5. **Distance to cleared areas — The distance to cleared areas can be used as a broad proxy for weed propagule pressure and load.**

Competition from weeds (non-native species) can reduce the regenerative capacity of individual species and vegetation communities. Weed load following disturbance can arise from two means:

- firstly, the germination and establishment of 'sleeper' or 'stealth' weeds within the seed bank that may not have been obvious prior to fire but germinate after disturbance and
- secondly the colonisation of weeds from the surrounding landscape matrix after the fire event.

For both these weed sources, invasion success after fire may be predicted by the interaction of propagule pressure (the number of propagules),[38] habitat and landscape condition[39,40] and species traits.[41] For propagule pressure, the greater the number of propagules arriving in a habitat, the higher the likelihood of establishment, persistence and spread of the weed. Distance to weed populations in human-dominated/cleared landscapes has been identified as a contributing factor to propagule pressure.[40]

In addition, grazing is often associated with higher weed species abundance, especially for animal-dispersed species;[42] so that sites closer to cleared areas where grazing may be apparent can have increased propagule pressure.

6. Disease

The known presence and/or extent of native and exotic plant diseases and pathogens (e.g. Phytophthora, Botrytis, rust) can reduce the regenerative potential of a vegetation community through negative effects on plant growth and survival.[32] The potential impact of disease on plant populations will likely interact with other variables such habitat quality and degradation, changes in environment and reductions in genetic diversity.[43]

Different species (and groups) will have variable susceptibility to diseases and so assessment of the importance of disease for post-fire recovery in communities will require information on species composition.

As discussed above, deciding on appropriate restoration scenarios for fire-affected vegetation communities requires combining information on the recovery potential of the community and how this interacts with species composition and their functional traits — together we call this the **Predicted Regenerative Potential** (PPR) (see Figure 3-1).

Although the level of information on the variables that can influence regeneration may vary among sites and vegetation communities, collectively, they can be brought together to provide a broad estimate of regenerative potential.

From the variables that influence regenerative potential (fire frequency, rainfall, degraded habitat condition, connectivity, distance to cleared areas, disease) we infer broad estimates of recovery potential, which can be classified along a spectrum and assigned into three general categories:

1. **Low** — more limited capacity for post-fire recovery relative to the pre-fire and/or reference condition. A lower recovery potential is recorded for multiple variables (e.g. fire frequency, rainfall, degraded habitat condition, connectivity, distance to cleared areas, disease).
2. **Moderate** — intermediate capacity for post-fire recovery. A combination of lower, moderate and/or high recovery assessment is recorded across different variables (e.g. fire frequency, rainfall, degraded habitat condition, connectivity, distance to cleared areas, disease).
3. **High** — an area with good potential for post-fire recovery. This represents a robust community where a moderate and/or higher recovery potential was assessed across multiple variables (e.g. fire frequency, rainfall, degraded habitat condition, connectivity, distance to cleared areas, disease).

3.2 Decision tree

3.2.1 Overall objectives

The overall goal of the decision tree is to provide a framework that, when combined with site assessments, can assign restoration approaches to fire-affected areas. These restoration approaches vary in the intensity of inputs and management required; it is therefore important to have a framework to distinguish the most appropriate strategies so that resources (especially seed) can be used most efficiently and effectively. For example, this spectrum of restoration aims to work with the inherent regenerative potential of the community before augmenting with propagules, seed or plants. This decision tree process requires a combination of five steps that relate to different stages and inputs into the decision-making process (Figure 3-2).

3.2.2 Decision tree steps

1. **Provides information on the Predicted Regenerative Potential (PRP), which encompasses the capacity of individuals of different species within communities to have the seed and/or vegetative reserves to recover after fire.**

The PRP (either low or moderate/high) uses information from the PRP framework (Figure 3-1) and plant trait data based on community composition. This is assessed based on the pre-disturbance state.

2. **Uses information on the conditions associated with the most recent fire event.**

Fire intensity at a site is classified as either low/moderate or high/very high with intensity rated using values from 2 (low), 3 (moderate), 4 (high) to 5 (very high) intensity. Even though there are important differences between the impact of high vs very high fire intensity for plant response and/or survival, these are grouped together for the purposes of the decision tree. Moreover, the importance of fire intensity may differ between communities; for example, a high intensity fire in a fire-sensitive rainforest is more detrimental than in a similar intensity in a more fire-resilient sclerophyll community.

3. **Requires on-ground assessment to identify which species and/or functional groups are regenerating and which groups/species are missing from post-fire regeneration.**

This will inform the required restoration approach based on missing structural elements or species. It is important that this assessment is completed after sufficient rainfall (and considering seasonality) to enable an accurate assessment of post-fire regeneration. Adequate time should also be given for regeneration to occur. For some species, this may take several seasons and require repeated assessments over time.

It should also be recognised that an assessment of missing species and/or structural elements will depend on the reference community list and how species composition within a community varies with underlying environmental variables (e.g. soil type, aspect, elevation, moisture gradients).

Local and/or specialist knowledge should be used to identify priority species for assessment based on species distributions, conservation significance and/or their value as a food source or habitat for threatened fauna.

4. Involves allocating a restoration approach (natural regeneration/protection, facilitated regeneration, combined regeneration/reintroduction and reconstruction), addressing whether targeted or broad seed inputs are available and whether ongoing threats can be managed.

Facilitated regeneration/reintroduction should be undertaken as a staged process where facilitated regeneration is applied first (with adequate rainfall) to unlock regenerative potential. Then, if species are still not regenerating, seed can be reintroduced. Biobanking of seed reserves from other sources can be done during the time where facilitated regeneration is being undertaken. Then, if seed is needed, it can be used in response to this fire/disturbance event. If it is not required, and facilitated regeneration is enough to stimulate recovery, then this seed could be stored in the biobank for response to future fire/disturbance events.

5. Information from the previous steps will determine the potential outcomes for fire-affected communities

Potential outcomes include:

- a recovery trajectory towards the identified reference community
- assisted recovery towards a reference community
- species loss and/or a state change and
- a state change (transition from one ecological state to another, e.g. forest to shrub dominated community).

However, it is important to recognise that the desired outcomes of the different restoration approaches are unlikely to be realised without ongoing threat management. For example, if targeted seed inputs are applied in combination with facilitated regeneration, yet threats such as exotic herbivores are not controlled, then it is possible that there may still be species loss or state change rather than assistance to recover towards the reference community.

Figure 3-1. Variables that influence the regenerative potential and contribute to the overall recovery potential of a vegetation community: (i) Fire frequency, (ii) Drought, (iii) Habitat degradation and condition, (iv) Connectivity, (v) Distance to cleared areas, and (vi) Presence of disease. Cumulatively, and through their interaction, these variables will determine the inherent recovery potential of a community prior to a fire event. This information can be assessed to determine the Predicted Regenerative Potential (PRP) of a community, which is information that – in combination with plant trait information – can be used in step 1 of the Restoration Scenario Planning Decision Tree (see Figure 3-2; C).

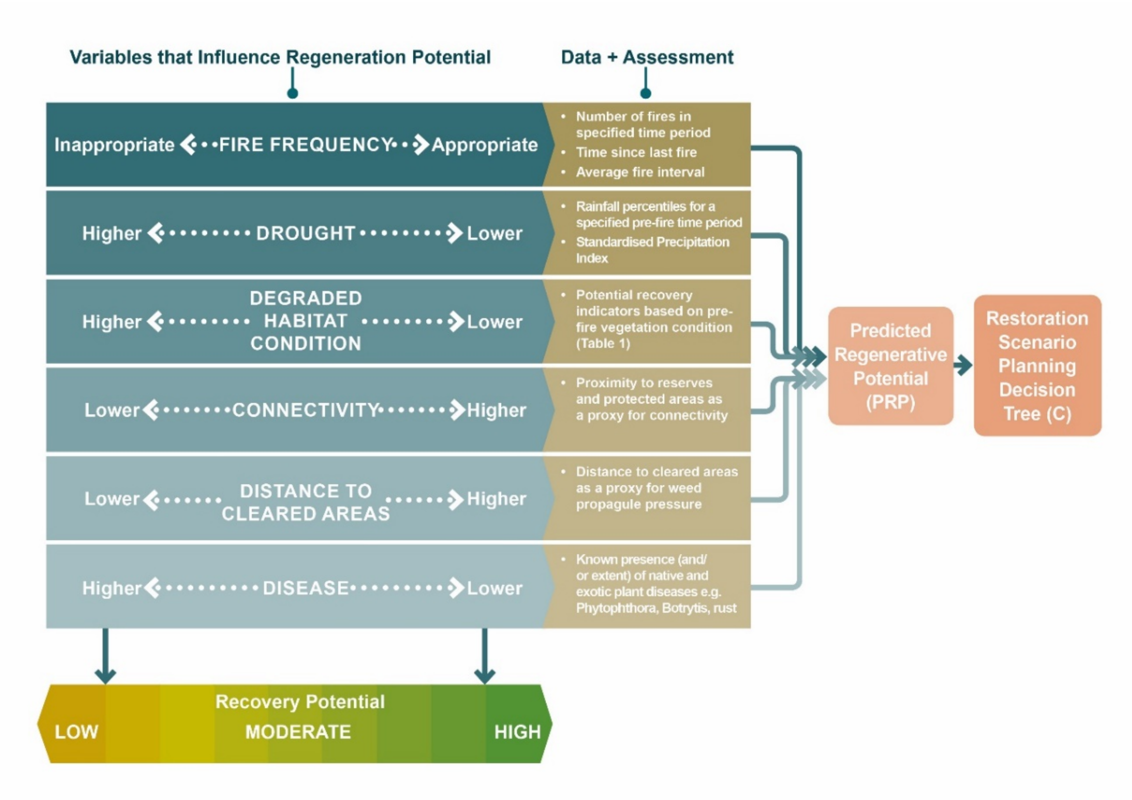
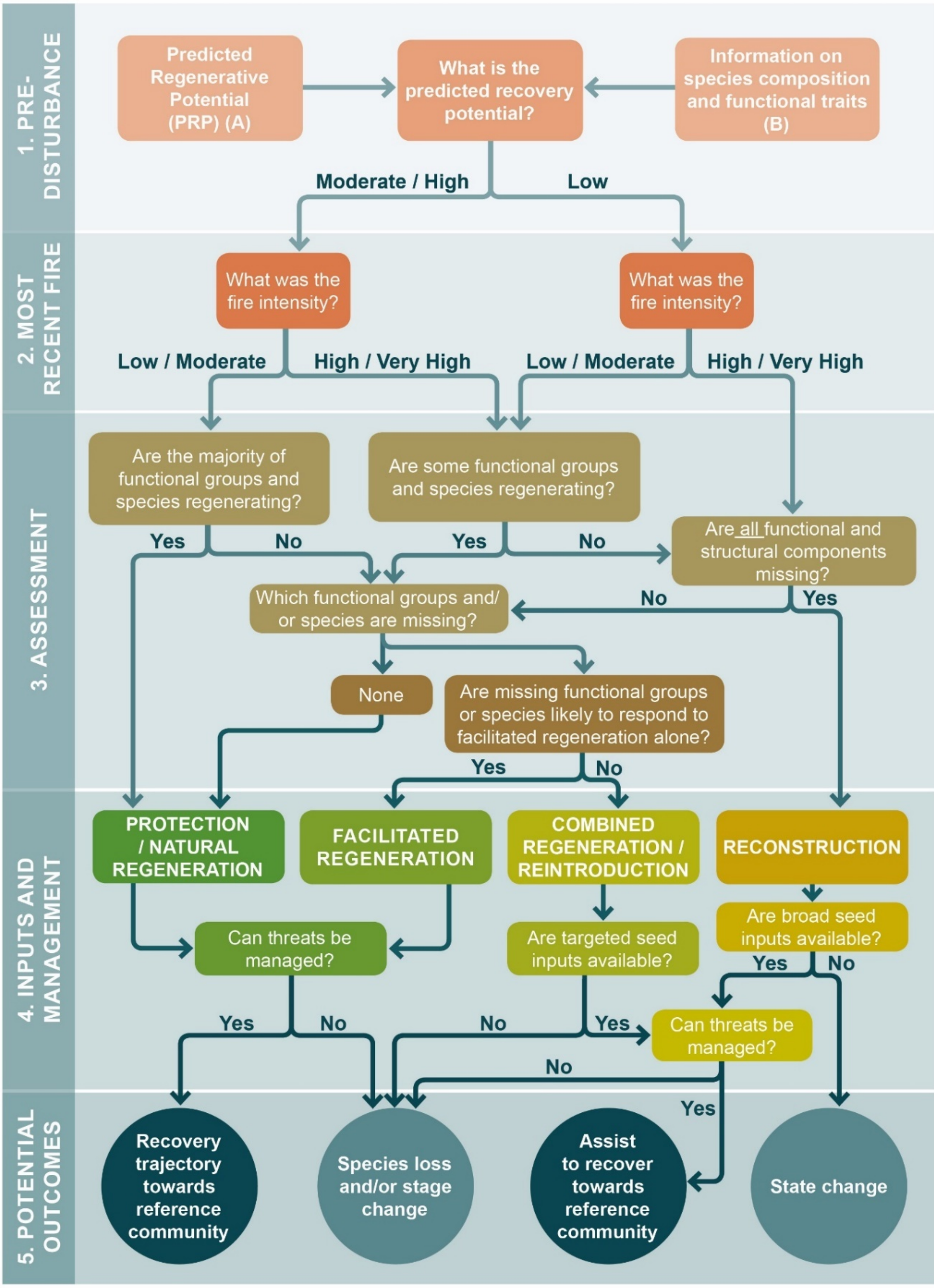


Figure 3-2. (see next page) Decision tree for restoration scenarios in fire affected areas. This decision tree has five steps that relate to different stages and inputs into the decision process.

1. Step 1 relates to information on the Predicted Regenerative Potential (PRP), which encompasses the capacity of individuals of different species within communities to have the seed and/or vegetative reserves to recover after fire. The predicted regenerative potential (either low or moderate/high) uses information from the Predicted Regenerative Potential (PRP) framework (Figure 3-1) and plant trait data based on community composition.
2. The second step relates to information on the conditions associated with the most recent fire event. The fire intensity at a site is classified as either low/moderate or high/very high.
3. Step 3 of the decision tree requires on-ground assessment to identify which species and/or functional groups and regenerating and which groups/species are missing from the post-fire regeneration. This will inform the required restoration approach based on missing structural elements or species. Note that this assessment should be completed after sufficient rainfall (and considering seasonality) to enable an accurate assessment of post-fire regeneration.
4. Step 4 involves allocating a restoration approach (Natural regeneration/Protection, Facilitated regeneration, Combined regeneration/reintroduction and Reconstruction), addressing whether targeted or broad seed inputs are available and whether ongoing threats can be managed.
5. Information from the previous steps will determine the potential outcomes for fire-affected communities; from (i) a recovery trajectory toward the identified reference community, (ii) assisted recovery towards a reference community, (iii) species loss and/or a state change, and (iv) a state change (transition from one ecological state to another, e.g. forest to shrub dominated community).


1. PRE-DISTURBANCE
Predicted Regenerative Potential (PRP) (A)
What is the predicted recovery potential?
Information on species composition and functional traits (B)
Moderate / High
Low
2. MOST RECENT FIRE
What was the fire intensity?
What was the fire intensity?
Low / Moderate
High / Very High
Low / Moderate
High / Very High
3. ASSESSMENT
Are the majority of functional groups and species regenerating?
Are some functional groups and species regenerating?
Yes
No
Yes
No
Are all functional and structural components missing?
Which functional groups and/ or species are missing?
No
Yes
None
Are missing functional groups or species likely to respond to facilitated regeneration alone?
Yes
No
4. INPUTS AND MANAGEMENT
PROTECTION / NATURAL REGENERATION
FACILITATED REGENERATION
COMBINED REGENERATION / REINTRODUCTION
RECONSTRUCTION
Are broad seed inputs available?
Can threats be managed?
Are targeted seed inputs available?
Yes
No
Yes
No
No
Yes
Can threats be managed?
No
Yes
5. POTENTIAL OUTCOMES
Recovery trajectory towards reference community
Species loss and/or stage change
Assist to recover towards reference community
State change

4 CASE STUDIES

We illustrate the application of the conceptual framework through case studies of the use of different restoration approaches for fire-affected communities. The first two case studies are for burnt Rainforest and Sclerophyll Grassy Woodland sites and illustrate the four different restoration approaches:

1. protection and natural regeneration
2. facilitated regeneration
3. combined regeneration/reconstruction and
4. reconstruction.

Box 1 provides a worked example for a rainforest ecosystem within the Lowland Rainforests of Subtropical Australia TEC. In Box 2, a sclerophyll woodland and grassland are assessed using the Grassy Box Woodland and Derived Native Grasslands as the example site. For Box 3 we present two examples of where restoration of plant species is important for the conservation of threatened fauna. The first example focuses on the Mountain Plum Pine (*Podocarpus lawrencei*) as habitat for the Endangered Mountain Pygmy Possum (*Burramys parvus*), and the second centres on the Drooping Sheoak (*Allocasuarina verticillata*) as an important food source for the Endangered Kangaroo Island Glossy Black Cockatoo (*Calyptorhynchus lathami halmaturinus*).

Box 1: An illustration of the spectrum of restoration approaches for post-fire recovery of rainforest

These case studies focus on the national TEC **Lowland Rainforests of Subtropical Australia (LROSA)**. Below we outline examples of the application of the four restoration approaches:

- protection and natural regeneration
- facilitated regeneration
- combined regeneration/reintroduction and
- reconstruction.

Protection and natural regeneration

Site

Nightcap National Park (Nightcap NP) sites containing lowland subtropical rainforest (with Booyong-dominated sub-associations) on basalt-derived or basalt enriched soils.

Pre-wildfire condition

Prior to the 2019 fires, most of the sites were considered intact native ecological communities with no history of utilisation, although several locations in Terania Creek basin had been selectively logged during the preceding 50 years. While the presence of sclerophyll canopy emergents in some cases indicates that fires did occur during Quaternary climate cycles and across evolutionary time frames, the last fire known to have burned the edges of rainforest areas of the Park was in 1968. The path of that fire was not mapped. These sites and other intact lowland rainforest areas collectively represent the reference ecosystem for LROSA restoration.

Most recent fire

Observations at Nightcap National Park, NSW, show that the November 2019 Mt Nardi fire burned along sclerophyll-dominated northerly slopes and ridges into the rainforest assemblages. An estimated 100 ha of rainforest burned in Nightcap NP, mainly but not exclusively in a 30–40m zone around the main rainforest sections. The fire largely burned the rainforest understories in these zones at a relatively low intensity with a low flame height, but higher intensity flare-ups also occurred depending on slope, aspect and time of day (Figure 4-1).

Assessment post-wildfire

In many cases, even a low intensity understorey fire induced high mortality in thin-barked rainforest trees. For example, mortality was high for species in *Argyrodendron* (Malvaceae), *Cinnamomum* (Lauraceae), *Sloanea woolsii* (Elaeocarpaceae) and *Syzygium* (Myrtaceae). Resprouting and coppicing was a feature for a range of species including *Doryphora sassafras* and *Daphnandra apatela* (Atherospermataceae) and occurred in some species in *Cryptocarya* and *Endiandra* (Lauraceae), as well as *Karabina benthamiana* and *Schizomeria ovata* (Cunoniaceae). Despite the resprouting, recovery of the pre-fire height and girth of these trees will take very long time frames (100s of years).

An important impact of fire on this community type is the loss of the rainforest seedling banks. For rainforest these are the above-ground equivalent of soil seed banks in fire-adapted community types, and the seedling banks may be decades to hundreds of years old. There has been some germination of some fresh seed of early secondary species such as White Cedar (*Melia azederac*), as well as germination from soil stored seed of colonisers and disturbance opportunists such as the Giant Stinger (*Dendrocnide excelsa*), *Alphitonia* spp., and *Acacia* spp.

Another serious impact of the fire is the mortality and lack of recruitment in the dominant large tree species of this ecological community at different locations: White and Black Booyong (*Argyrodendron trifoliolatum* and *A. actinophyllum*). These species were observed to be killed by the fire with little seedling germination to date. The species in this genus have (on occasion) been observed to resprout following low intensity fire, but with loss of the large stem. Recovery time frames of Booyongs are predicted to be many hundreds of years as they are slow growing, with wind-dispersed seeds and rely on adult stature to be effectively dispersed.

Non-native plant regeneration was largely limited to short-lived species not considered a threat to the native recovery trajectory. However, some problematic non-natives such as Camphor Laurel (*Cinnamomum camphora*) are present in some sites.

Inputs and management

The recommendation for these areas is to rely upon natural regeneration processes, with no seed input, while protecting the sites from future fire. Some management of overabundant pyrophytic species (including wattles *Acacia* spp.) may be an important consideration to both secure the recovery of sensitive rainforest seedlings and protect recovering rainforest from increased risk of fire.

Potential outcomes

This community is likely to recover its former structure if protected from current and future threats including Myrtle rust and fire, although recovery of the more severely fire-affected sites to their prior mature structure is likely to take many decades if not hundreds of years. Protection from fire and from excessive drying will become increasingly difficult in the context of ongoing climate change and increase in pyrophytic biomass near rainforests.

FIGURE 4-1. RAINFOREST SPECIES IN TERANIA CREEK BASIN OF NIGHTCAP NATIONAL PARK ABOUT THREE WEEKS AFTER THE MT NARDI WILDFIRE OF 9TH NOVEMBER 2019. WHILE THE FIRE WAS MAINLY LOW INTENSITY, THERE WERE FLARE-UPS, AND SOME SMALL AREAS WERE STILL BURNING DUE TO LIT BRUSH BOX TREE COLLAPSING AND RESTARTING THE FIRE. AFTER THE INITIAL BURN THERE WAS EXTENSIVE LEAF FALL THAT ADDED TO THE FUEL. (PHOTOS: DAILAN PUGH).

FACILITATED REGENERATION

Site

18 ha private property at Wanganui, NSW, adjacent to Nightcap National and Whian Whian NP, NSW. The ecosystem is mixed forest (i.e. rainforest occurring within a wet sclerophyll framework).

Pre-wildfire condition

The forest edge was previously cleared for cattle grazing and banana growing. The condition ranged from class 5 (within the uncleared and regrowth forest) to class 2 condition (at the cleared edges) (Table 2-1).

Most recent fire

The site was subject to the same Mt Nardi wildfire at Nightcap National Park, NSW (November 2019). The intensity of the fire at the site could be described as generally low intensity with flare-ups depending on slope, aspect and time of day.

Assessment post-wildfire

Observations after one year and sufficient rainfall indicate that a wide suite of rainforest, sclerophyll and heath species have regenerated from seed and/or are resprouting alongside diverse weeds representing all growth forms (Figure 4-2).

Some weed species may be playing a facilitation role for rainforest recovery, while others should be targeted to reduce their inhibiting effect on native regeneration.

Given the level of regeneration across functional groups, this community is likely to benefit from facilitated natural regeneration focusing on removal of weeds that are competing with native regeneration. Where possible it is desirable to use the wildfire as an opportunity to deplete populations of weeds at the site to increase the community's resilience to future fire. No reintroductions or seed input is needed at the site.

Inputs and management

The landholders are applying weed management treatments to facilitate recovery and reduce the diverse weed populations, representing all growth forms. They are also giving preference to rainforest species in the areas closer to the residential Asset Protection Zone through selective thinning of sclerophyll species along with weeds, while retaining sclerophyll elements outside this zone (by removing rainforest species) to retain current and future compositional diversity at the site.

Potential outcomes

This community is on a trajectory to full recovery assuming ongoing management is applied to manage any current and future threats. See EMR short summary on this project as well as an EMR short summary on facilitated regeneration of littoral rainforest after the Black Summer bushfires of 2019–20.

FIGURE 4-2. RAINFOREST SPECIES RECOVERING AT PRIVATE PROPERTY BOUNDARY A LITTLE OVER 12 MONTHS AFTER THE NOVEMBER 2019 MT NARDI WILDFIRE AND GOOD RAINFALL. TOP L TO RIGHT. MIXED RAINFOREST AND HEATHY SCLEROPHYLL SPECIES; MIDDLE: BOLWARRA (*EUPOMATIA LAURINA*) COPPICING; AND RIGHT: CREEK FIG (*FICUS CORONATA*) COPPICING. BOTTOM LEFT: MIXED EARLY PHASE RAINFOREST SPECIES INCLUDING BLEEDING HEART (*HOMALANTHUS POPULIFOLIUS*) AND PENCIL CEDAR (*POLYSCIAS MURRAYI*); MIDDLE: DENSE BROWN KURRAJONG SEEDLINGS WITH DEAD BANGALOW PALM (*ARCHONTOPHOENIX CUNNINGHAMII*) (PHOTOS: JOANNE GREEN).

COMBINED REGENERATION/REINTRODUCTION

Site

Private property at Huonbrook, NSW, directly below the escarpment of Mt Jerusalem NP and about 1.5 to 2 km from Nightcap NP. The ecosystem was previously subtropical rainforest.

Pre-wildfire condition

At this site (private property), subtropical rainforest had been cleared for dairy farming and replaced by non-native plantings and weeds. Some rainforest understory and pioneer species were present prior to the fire. The condition of the sites prior to the fire is likely to have been a mosaic of Class 1 with patches of Class 2 condition (Table 2-1).

Most recent fire

This site was subject to the same fire that burnt through Nightcap National Park, NSW, in November 2019, burning through the Huonbrook area on 9th November 2021.

Assessment post-wildfire

The fire provided an opportunity and motivation to replace the highly combustible non-native vegetation with more fire-retardant subtropical rainforest vegetation. Rather than all species needing to be replanted, however, site inspection after good rainfall found seven understory species had resprouted and that a total of 12 subtropical rainforest species had germinated after the fire from recently dispersed or soil stored seed (Figure 4-3).

Substantial post-fire rainfall led to the germination of weed species, resulting in the need for weed management before any planting could occur. The site inspection identified a need for a combined regeneration/reintroduction approach that involves two complementary strategies:

- releasing regenerating natives and future colonisation niches from weed competition and
- reintroducing a selection of missing subtropical rainforest species likely to have originally occurred at the site.

Inputs and management

After site preparation, including substantial weed management that brought the condition of the site to a higher classification (at least Class 3), an additional 600 subtropical rainforest plants (trees and understorey) were planted to replace subtropical rainforest species that had been long absent and could not colonise the site within short time frames. This combination of facilitated regeneration work, ongoing colonisation of frugivore-dispersed species, and seedling addition will accelerate the development of a more mature and diverse rainforest characteristic of the reference community. See EMR short note on this project https://wp.me/p1oGXT-KL.

Potential outcomes

With enough time, and If ongoing threats (including weeds) are managed, these activities will likely assist the vegetation community to further recover and progress towards the reference condition, i.e. a diverse subtropical rainforest native to the area.

FIGURE 4-3. TOP LEFT: HIGH DENSITIES OF NATURALLY REGENERATING SEEDLINGS OF LARGELY EARLY PHASE RAINFOREST SPECIES WERE EVIDENT WITHIN A FEW MONTHS AFTER FIRE AND GOOD RAINFALL AT A PRIVATE PROPERTY AT HUONBROOK. TOP RIGHT: MADHIMA GULGAN'S INDIGENOUS BUSH REGENERATION TEAM ASSISTED LANDHOLDERS WITH RELEASING NATIVES FROM WEED. BOTTOM LEFT: HIGH DENSITY OF RED CEDAR (*TOONA CILIATA*) SEEDLINGS WERE AMONG THE SPECIES THAT REGENERATED. BOTTOM RIGHT: SOME OF THE 600 RAINFOREST PLANTS INSTALLED ON SITE TO ACCELERATE THE MATURATION OF THE RAINFOREST ASSEMBLAGE AND TO HELP PROTECT THE RESIDENTIAL COMMUNITY FROM FUTURE FIRE. (PHOTOS: UPPER TWO: RAINFOREST4. LOWER TWO: JOANNE GREEN).

RECONSTRUCTION

Site

Multiple Big Scrub Landcare private properties in the Alstonville plateau, NSW, that were once lowland subtropical rainforest prior to clearing for agriculture. As they are in less demand for agriculture, these sites have potential for rainforest replanting to provide wildfire-free refugia for plants and animals, including animal species moving between Nightcap National Park and the coast.

Pre-wildfire condition

The sites include (but are not confined to) cleared paddocks with low regenerative potential due to their relatively long history of clearing and grazing.

Most recent fire

These sites have not recently burnt and are at sufficient distance from wildfire-prone sclerophyll areas to effectively function as wildfire refugia and thus provide opportunities for increasing landscape level resilience of this ecosystem to future wildfire.

Assessment post-wildfire

Sites that fall into the Reconstruction category are largely paddocks with little woody components and hence are best suited to reintroduction of a subtropical rainforest assemblage through mass planting (broad seed input). This activity is common practice within previously rainforest-dominated sites in the Big Scrub agricultural landscape, encouraged by Big Scrub Landcare (Figure 4-4).

Over the last three decades Big Scrub Landcare has facilitated the planting of more than 2.5 million trees by its members and other landholders, leading to the restoration of more than 600 ha of rainforest. This represents an increase of 75% of the total area of the remnants of the Big Scrub. The current rate of planting exceeds 200,000 trees per year but even this rate of planting is insufficient to counter current extinction pressures of an ecosystem of which the area of remnant and restored rainforest is less than 2% of its original area. There is potential for replanting thousands more hectares to increase landscape level resilience of this national Threatened Ecological Community.

Inputs and management

High diversity tree plantings are based on the models published in Big Scrub Landcare's Rainforest Restoration Manual for reconstruction of subtropical rainforest in cleared areas distant from seed sources. Plantings include a mix of later phase, earlier phase and pioneer species from a total list of about 150 species. These plantings are located to minimise the risk of fire from highly fire-prone vegetation.

Big Scrub Landcare, Royal Botanic Gardens Sydney and their partners are implementing a long-term program called Science Saving Rainforests to enhance the recovery and ongoing resilience of planted areas of lowland subtropical rainforest. This involves development of a seed production area for Big Scrub restoration works, designed in consultation with conservation geneticists, to provide seed with optimal genetic diversity of 23 key structural Big Scrub species and up 30 Big Scrub threatened species. All threatened species recovery plantings will be protected by permanent conservation covenants and landholders will carry out comprehensive site preparation and follow maintenance protocols including inputs to manage ongoing threats including weeds.

Potential outcomes

Restoration plantings will become actively used by rainforest frugivores. This will provide two beneficial outcomes: (i) increased species diversity in plantings due to seed dispersal from remnants; and (ii) increased species and genetic diversity in species-poor regrowth areas across the landscape, particularly if plantings are strategically located as seed source nuclei.

Over time, and if ongoing threats (particularly from weeds) are managed, this will result in the development of higher levels of similarity to the lowland subtropical rainforest reference in both strategically placed plantings and the extensive regrowth areas. This is in addition to the increase in the area of lowland subtropical rainforest planted. This task of establishing wildfire-free refugia in already cleared sites distant from Nightcap NP is urgent at a time of increasing fire exposure of remnant subtropical rainforest in the region's hinterland national parks. Also see EMR journal project summary Big Scrub Landcare (https://onlinelibrary.wiley.com/doi/abs/10.1111/emr.12008).

FIGURE 4-4. BIG SCRUB LANDCARE'S MISSION IS TO RESTORE AND CARE FOR THE CRITICALLY ENDANGERED LOWLAND SUBTROPICAL RAINFORESTS OF FAR NORTH COAST NSW THROUGH BOTH REPLANTING AND REMNANT MANAGEMENT. THE GROUP WORKS WITH GOVERNMENTS, BUSINESS, PRIVATE LANDHOLDERS, COMMUNITY ORGANISATIONS AND THE COMMUNITY GENERALLY TO ACHIEVE ITS AIMS INCLUDING ACTING TO PROTECT RAINFOREST FROM THE THREAT OF WILDFIRE THROUGH THE SAVING OUR RAINFORESTS FROM FIRE PROJECT. SEE HTTPS://WWW.BIGSCRUBRAINFOREST.ORG/WHAT-WE-DO/ **(PHOTOS: BIG SCRUB LANDCARE AND ENVITE ENVIRONMENT)**

Acknowledgements: **Thanks go to Joanne Green, Zia Flook, Robert Kooyman, Matthew Wiseman, Brett Howland and Phil Palmer for providing information for this case study.**

Box 2: An illustration of the spectrum of restoration approaches for post-fire recovery of grassy woodlands

These case studies focus on **Grassy Box Woodland and Derived Native Grasslands**. Below we outline examples of the application of the four restoration approaches to this community:

- protection and natural regeneration
- facilitated regeneration
- combined regeneration/reintroduction and
- reconstruction.

Protection and natural regeneration

Site

Scottsdale Reserve, near Bredbo in south-central NSW is a 1328ha private conservation reserve on the Murrumbidgee River that is owned and managed by Bush Heritage Australia since 2006. A range of grassy woodland associations intergrade across the property, with substantial areas of derived native grassland. Around 300ha of the 1328ha property had been cleared and utilised until some two decades prior to the fire.

Pre-wildfire condition

A few small sites on remote, high elevation ridges containing grassy woodland and derived grassland were considered intact native ecological communities prior to the fire, with a history of only light clearing and grazing. Containing a high diversity of plants and animals — including threatened woodland birds, mammals and 13 species of reptiles — these provide high quality reference sites for the management of similar but lower elevation ridges at Scottsdale (Figure 4-5).

Most recent fire

At the height of an extremely dry summer, the Clear Range Fire on February 2–3, 2020 burned along the Murrumbidgee River through Scottsdale (Figure 4-6). The most intense fires occurred in woodland on the steep slopes arising from the river to the high ridgelines, with canopy consumption in many areas, while some flatter terraces and ridgeline areas burnt less intensely. Combustibility, and therefore fire severity, was high due to two years of below average rainfall prior to the fire.

Assessment post-wildfire

High levels of mortality occurred for many of the trees on steep slopes in the path of the fire, with evidence of epicormic or lignotuberous growth by the end of the first year for all eucalypts except Inland Scribbly Gum (*Eucalyptus rossii*), which was already in decline due to drought prior to the fire. Above-average rainfall in the 2020 winter-summer period resulted in recovery of many individuals of most species (from resprouting and seed) across the property. By March 2021, some germination of Inland Scribbly Gum had occurred, but not resprouting.

Inputs and management

In higher quality areas with little weed, recovery has relied upon natural regeneration, with no active weed management or need for seed input required.

Potential outcomes

This community is likely to recover its former structure if protected from current and future threats including fire; however, recovery of the more severely fire-affected sites to a state similar to the prior mature structure is likely to take at least a decade. The long-term future of the drought-sensitive *Eucalyptus rossii* may be uncertain due to predictions of increasingly hot and dry climates, which may contribute to potential shifts in the composition of tree dominants over time in some areas.

FIGURE 4-5. HIGH QUALITY BOX WOODLAND AND DERIVED GRASSLAND (PHOTO: BRETT HOWLAND)

Figure 4-6. Trees burning in wildfire near Bredbo in early February 2020. Once the fire front passed, many of the older trees with hollows kept burning and many collapsed. Epicormic growth occurred for some species, with others (e.g., Snow Gum) resprouting from lignotubers and root suckers. Regeneration of the drought-affected Inland Scribbly Gum is occurring from seed. (Photo *New York Times*)

Facilitated regeneration

Site

Higher condition parts of Rutidosis Ridge at Scottsdale, Bredbo NSW. Apple Box (*Eucalyptus bridgesiana*) / Snow Gum (*Eucalyptus pauciflora*) grassy woodland and derived grasslands. The site's name refers to the fact that, prior to the fire, this ridge contained an extant population of the nationally endangered plant Button Wrinklewort (*Rutidosis leptorrhynchoides*).

Pre-wildfire condition

Rutidosis Ridge had been partially cleared and long set-grazed by sheep for many decades until grazing ceased ~ 13 years prior to the fire. At the time grazing ceased the site appeared to be wholly dominated by the weeds African Love Grass (*Eragrostis curvula*) and Serrated Tussock (*Nasella tricotoma*). Aerial spraying of these species (with flupropinate grass-selective herbicide at a rate of 1L/ha in winter) was carried out approximately four years prior to the fire. This single spray treatment resulted in a high kill rate but persistence of a dead grass thatch at the time of the fire. Condition was not assessed in detail prior to the fire, but while there was evidence of some clusters of eucalypts and other natives, the proportion of natives in the rest of the site appeared very low.

Most recent fire

The Clear Ridge Fire on February 2–3, 2020 burned at a high intensity across Rutidosis Ridge consuming the African Love Grass thatch and any other groundcover. While some very small patches of the thatch and some tree canopies remained unburnt, some old trees with hollows were lost, and all unburnt leaf dropped to the ground as leaf litter.

Assessment post-wildfire

Post-fire observations in March 2020 revealed that a wide suite of native grassland species were starting to resprout or germinate alongside diverse herbaceous weeds.

It rapidly became clear that there was a gradient of habitat condition at the sites with some sites closer to the previously cropped flat areas assessed as Class 2, while habitat condition improved to as high as Class 4 towards any tree clusters, particularly at the peak of the ridge. The largest area was considered condition Class 2 with patches of 3 and 4 around or near tree clusters (Figure 4-7 and Table 4-1).

Predominant weed species included African Love Grass, Viper's Bugloss (*Echium vulgare*), St John's Wort (*Hypericum perforatum*), Yellow Catsear (*Hypochoeris radicata*), Common Plantain (*Plantago major*), a range of thistles and up to 25 other weed species.

Class 2–4 areas were considered likely to respond to weed management treatments alone, without the need for any seed input, although the need for seed addition in Class 2 areas will be reassessed once regenerative capacity is fully tested with sufficient time for post-weeding colonisation. This approach was also considered an important initial step (i.e. as a pre-treatment) for any further inputs to Class 1 sites and, to some extent, buffer zones (see next section).

The extant population of Button Wrinklewort was burnt but recovered quickly. A new satellite population was found during the post-fire assessment of the site. The species was somewhat protected from the fire due to its preference for bare ground.

Inputs and management

An approx. 10 ha area of grassy woodland and derived grassland including Rutidosis Ridge (and adjacent areas) was placed under a program of 'bush regeneration' style spot-spraying of weeds with a range of herbicides appropriate to the species, commencing in March 2000 and continuing at least fortnightly during the growing season.

Both paid and volunteer personnel were engaged; both groups were skilled in recognising natives and weeds at the seedling stage and in spot-spraying with negligible off-target damage (Figure 4-8).

The aim of these activities was to treat all weed prior to seeding to: (a) take advantage of post-fire recruitment flushing out the weed soil seed bank and avoid its further recharge; and (b) retain maximum open spaces for further natives to emerge and colonise.

Adjacent Class 0 areas were slashed repeatedly during the growing season to reduce potential for weed seed blowing into the higher quality areas.

Regeneration of around 30 weed species occurred after each rainfall event, particularly African Love Grass. Yet the size of the site was larger than could be treated in time to thoroughly prevent all weed seeding. Nonetheless, the cover and seed production of all weed species was very substantially reduced over the first 12 months of regular treatment. Conversely, cover and flowering and fruiting of native species increased over that time, with negligible off-target damage from the spray treatments. Native germination continued for over a year in response to rainfall episodes and the germination season for each species.

In December 2020, over 50 native herbaceous and sub-shrub species (including at least 11 Asteraceae, 9 Poaceae, 4 Fabaceae and 2 Liliaceae) were recorded within the work zones, with the cover of natives very high in the higher condition zones. By March 2021 (one year after work commenced), the Class 4 areas near trees and the peak of the ridge were on a firm trajectory to Class 5 condition, a pattern of increase in condition that was repeated for all other condition class areas. This prediction assumes that the planned winter aerial spraying of African Love Grass will successfully control the remaining seedlings and germinating seed for at least three years. With successful winter spraying, the process of increasing native cover and richness in each zone is likely to continue over time as native species reproduce and disperse across the site.

Potential outcomes

Given time for colonisation from the higher to lower condition classes and ongoing weed management, this site is on a recovery trajectory to high similarity to the grassy woodland and derived grassland reference state.

FIGURE 4-7. DIAGRAM OF GRADIENTS OF CONDITION AT RUTIDOSIS RIDGE, SCOTTSDALE JUST AFTER THE FIRE AND PRIOR TO SPOT-SPRAYING, AS INFORMED BY REGENERATION OF WEEDS AND NATIVES IN THE FIRST SIX MONTHS OF THE FIRE. (DIAGRAM T. MCDONALD)

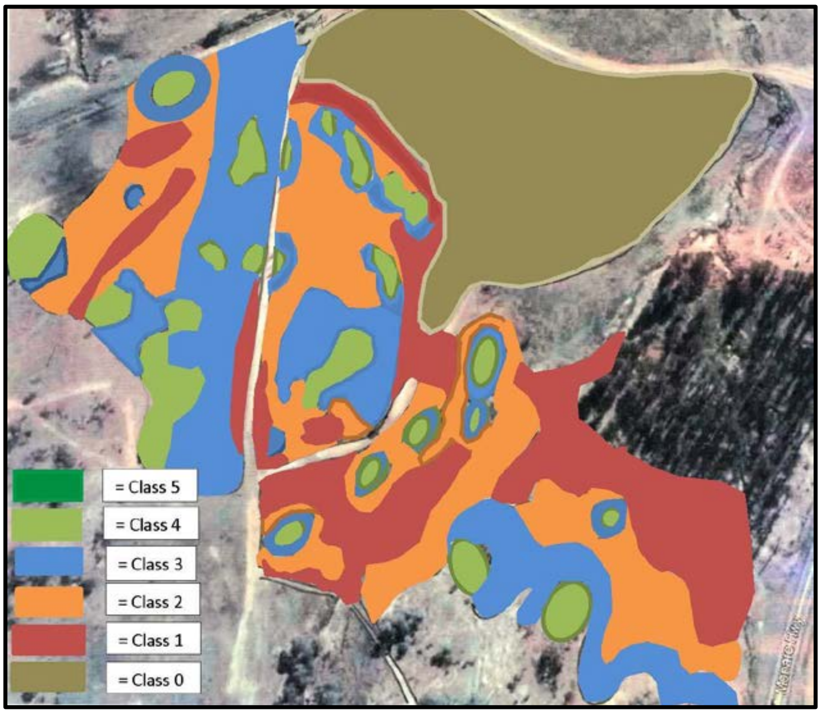


FIGURE 4-8. RAINFALL IN SPRING AND SUMMER 2020 WAS ABOVE AVERAGE AND CAME AT THE RIGHT TIMES TO INCREASE VEGETATIVE GROWTH AND STIMULATE FLOWERING AND FRUITING OF NATIVES. THIS ALSO PROMOTED FURTHER WEED GERMINATION AND PROLIFERATION, REQUIRING INTENSIVE SPOT-SPRAYING OF WEEDS. (PHOTO G. LITTLE)

Table 4-1. The native grassland species (and their DAFOR abundance score) found to be characteristic of each condition class at Rutidosis Ridge Scottsdale during treatment. DAFOR abundance score (% cover): Dominant (D) >75%, Abundant (A) 51-75%, Frequent (F) 26-50%, Occasional (O) 11-25%, Rare (R) 1-10%.

CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
Snow gum (O)				
Candlebark (O)				
Apple Box (O)				
Creeping Bossiaea (R)				
Clustered Everlasting (O)				
Blue Devil (R)	Blue Devil (R)			
Windmill grass (O)	Windmill grass (R)			
Enneapogon (O)	Enneapogon (R)			
Yellow Rice Flower (O)	Yellow Rice Flower (O)	Yellow Rice Flower (R)		
Kangaroo Grass (F)	Kangaroo Grass (F)	Kangaroo Grass (O)		
Wallaby Grass (O)	Wallaby Grass (O)	Wallaby Grass (R)		
Stackhousia (F)	Stackhousia (O)	Stackhousia (R)		
Common Everlasting (A)	Common Everlasting (F)	Common Everlasting (O)	Common Everlasting (R)	
Silky Swainson's Pea (O)	Silky Swainson's Pea (O)	Silky Swainson's Pea (R)	Silky Swainson's Pea (R)	
Dianella (O)	Dianella (O)	Dianella (R)	Dianella (R)	
Spear grasses (F)	Spear grasses (A)	Spear grasses (A)	Spear grasses (O)	
Redleg Grass (O)	Redleg Grass (F)	Redleg Grass (A)	Redleg Grass (F)	
Goodenia (O)	Goodenia (O)	Goodenia (O)	Goodenia (F)	
Rock Fern (O)	Rock Fern (O)	Rock Fern (O)	Rock Fern (O)	
Small St Johns Wort (O)	Small St Johns Wort (O)	Small St Johns Wort (O)	Small St Johns Wort (O)	
Urn Heath (O)	Urn Heath (O)	Urn Heath (O)	Urn Heath (O)	
Bears Ears (F)	Bears Ears (F)	Bears Ears (F)	Bears Ears (O)	Bears Ears (R)
Fuzzweeds (A)	Fuzzweeds (A)	Fuzzweeds (F)	Fuzzweeds (O)	Fuzzweeds (R)
Bindweed (O)	Bindweed (O)	Bindweed (O)	Bindweed (O)	Bindweed (O)
Bidgee Widgee (O)	Bidgee Widgee (O)	Bidgee Widgee (O)	Bidgee Widgee (O)	Bidgee Widgee (O)
Common Raspwort (F)	Common Raspwort (F)	Common Raspwort (F)	Common Raspwort (F)	Common Raspwort (F)
Lomandra filiformis (O)	Lomandra filiformis (O)	Lomandra filiformis (O)	Lomandra filiformis (O)	Lomandra filiformis (O)
Cudweeds (O)	Cudweeds (O)	Cudweeds (O)	Cudweeds (O)	Cudweeds (O)
Bluebell (F)	Bluebell (F)	Bluebell (F)	Bluebell (F)	Bluebell (F)

Combined Regeneration/Reintroduction

Site

Lower condition parts of Rutidosis Ridge at Scottsdale, Bredbo NSW. Apple Box (*Eucalyptus bridgesiana*)/Snow Gum, (*Eucalyptus pauciflora*) grassy woodland and derived grasslands.

Pre-wildfire condition

The sites were highly weed dominated prior to the fire, with largely herbaceous weeds including a range of introduced grasses (e.g. African Love Grass), Paspalum (*Paspalum dilatatum*) and the broad-leaved weeds described above.

Most recent fire

The same Clear Ridge Fire on February 2–3, 2020 burned at a high intensity across Rutidosis Ridge and its perimeter, exacerbated by high levels of African Love Grass and its dead thatch where it had been previously sprayed.

Assessment post-wildfire

Only very limited regeneration of native species was observed after the first rainfall after the fire in Class 1 areas, in contrast to prolific weed regeneration.

These sites would suit a combination of facilitated regeneration treatment combined with some reintroduction of natives after regenerative potential was fully tested. Testing to see the level of native recruitment before adding seed is important given that some natives might take longer time frames to germinate, and some native species may quickly colonise bare ground. In addition, potential exists for reintroduction of some trees in derived grassland zones to reinforce connectivity for woodland birds across the site.

Inputs and management

Bush regeneration style spot-spraying was carried out thoroughly across all lower condition classes to the same degree as in higher condition classes, taking just as much, if not more, care to preserve what few natives occurred. A small amount of native grass seeds (including Redleg Grass were sown in 15 x 0.25m patches in what was thought to be a Class 1 area in November 2020 (Figure 4-9)). Further germination of natives continued to occur throughout the Class 1 areas throughout the year after above average rainfall.

While the sowing may not have been needed (due to a high colonisation potential from patches (nuclei) of Class 2 condition through the Class 1 area), seed addition may increase species richness in the area and the resistance of the site to any new weed invasions.

Furthermore, this zone and possibly some Class 2 areas, lend themselves to supplementary reintroduction of species that may take long time frames to colonise, or which provide important habitat. For example, some years prior to the fire, a small number of Eucalypts characteristic of the zone were planted along a potential linkage between remnant stands of trees within Rutidosis Ridge. Most of these specimens resprouted after the fire and have thrived in the above-average rainfall that followed. These provide a demonstration of the potential compatibility of facilitated regeneration and special case seed addition or planting in some zones.

Potential outcomes

With enough time, and if ongoing threats (including weeds) are managed, the combination of facilitated regeneration-style weed management and special case, low-level reintroductions are likely to assist the vegetation community to further recover and progress towards the reference condition, i.e. a grassy woodland with large areas of open grassland.

FIGURE 4-9. A SMALL AMOUNT OF NATIVE GRASS SEEDS (INCLUDING REDLEG GRASS) WERE SOWN IN 15 X 0.25M PATCHES IN WHAT WAS ORIGINALLY THOUGHT TO BE A CLASS 1 AREA IN NOVEMBER 2020. NATURAL REGENERATION CONTINUED IN THAT AREA OVER TIME, AS WELL AS GERMINATION OF SMALL AMOUNTS OF SOWN SEED. WHILE THE SEEDING WAS NOT ESSENTIAL IN THIS ZONE DUE TO CONTINUED NATURAL REGENERATION AND WOULD NOT BE AN EFFECTIVE ALTERNATIVE TO RIGOROUS WEED MANAGEMENT, THE INTRODUCTION OF SEED INTO SUCH LOW CONDITION AREAS CAN ASSIST THE RATE OF RECOVERY TO THE DESIRED REFERENCE ECOSYSTEM. (PHOTO RACHAEL BUZO)

Reconstruction

Site

A 5ha grassy flat below and adjoining Rutidosis Ridge at Scottsdale, Bredbo NSW that was repeatedly cropped prior to its acquisition as a private conservation reserve (Figure 4-10).Pre-wildfire condition

The site was completed dominated by weed species prior to the fire, with over 90% cover of African Love Grass. However, an experimental Redleg Grass direct seeding project had been conducted in a corner of the site many years prior.

Most recent fire

The Clear Ridge Fire on February 2–3, 2020, burned at a high intensity across the site exacerbated by high levels of live African Love Grass.

Assessment post-wildfire

This site recovered with resprouting African Love Grass after the fire, attaining a similar cover by Autumn 2020. Other weeds but few natives were evident in the zone.

Inputs and management

The site was aerially sprayed in May (autumn) 2019 (with flupropanate grass-selective herbicide at a rate of 1L/ha). By summer 2020, the African Love Grass had died and formed a thick layer of thatch which was later burnt. This lack of thatch (due to the burn) and recent fire provided ideal conditions to stimulate germination of a similar suite of broad-leaved weed species to those occurring at Rutidosis Ridge after fire (with negligible germination of other grass species at this site).

The site was slashed multiple times throughout summer to reduce weed seeding. Plans exist to apply a range of weed management treatments over 2–3 years to reduce the weed status of the site in preparation for sowing Redleg Grass, and to allow time for the collection of more Redleg Grass seed.

This reconstruction project, guided by specialists in native grass agronomy, will be carried out in stages, with the first stage aiming to establish a cover of Redleg Grass to ensure that the site is captured by a native species.

This followed by the sowing of other native grasses (e.g. in a nucleating pattern) as seed becomes available, will then allow further management of broad-leaved weeds (using broad-leaf selective herbicides) prior to the reintroduction of any native forbs. The initial area of sowing will be limited to the amount of seed in the Scottsdale seed store (Figure 4-10) and produced in seed production areas at Scottsdale. There is currently 1ha of Redleg grass and 4ha of Kangaroo grass being established in Scottsdale's grass seed production area.

Potential outcomes

Successful grass sowing and weed management will enable other grass species to be seeded into the proposed stands over time, followed by planting of nursery stock of forbs and trees (Figure 4-10). This would ideally be done on an experimental (adaptive management) basis to enable clear lessons to be learnt from the process. While the long-term goal is to restore the site to a grassy woodland community, the site may undergo a period where it is used as a seed production area for other sites on Scottsdale where natural regeneration of the prior grassy woodland is not possible due to decades of intensive grazing and cropping.

FIGURE 4-10. TOP LEFT: APPROXIMATELY 5 HA LOWLAND AREA ABUTTING RUTIDOSIS RIDGE AT SCOTTSDALE THAT IS IN A WEED REDUCTION PHASE IN PREPARATION FOR RECONSTRUCTING NATIVE GRASSY WOODLAND FROM SEED. TOP RIGHT: SCOTTSDALE STAFF MEMBER KIM JARVIS, INSPECTING NATIVE GRASS SEED COLLECTED OR PURCHASED FOR SOWING AT SCOTTSDALE. (KIM JARVIS PICTURED). BOTTOM LEFT: SCOTTSDALE' NURSERY PRODUCE A RANGE OF SPECIES OF TREES, SHRUBS AND GROUND STRATUM SPECIES ANNUALLY, FROM PROPAGULES LARGELY COLLECTED FROM THE PROPERTY. BOTTOM RIGHT: SCOTTSDALE SEED COLLECTION AND STORAGE (PHOTOS T. MCDONALD)

Acknowledgements: Information in this case study is based on work undertaken by Tein McDonald (Australian Association of Bush Regenerators) and Phil Palmer (Bush Heritage Australia)

Box 3: Examples of reintroduction of fire-sensitive plants important to threatened animals

Introduction

There may be a need for reintroduction of plant species in cases where a threatened animal species is particularly dependent upon a plant species for habitat or food and where that plant species is fire sensitive (killed outright by fire). In these cases, supplementary revegetation can be of importance to the persistence of the threatened animal due to the time taken for post-fire regeneration (germination and growth of seedlings), and if there were shortages of the plant prior to fire. The following examples highlight the importance of having insurance populations (in the form of seed or seedlings) of critical habitat or food species to enable a rapid response to ecological disasters such as fire.

EXAMPLE 1

The **Mountain Plum Pine** (*Podocarpus lawrencei*) is a major food source for the nationally Endangered Mountain Pygmy Possum (*Burramys parvus*). Multiple patches of fire sensitive *P. lawrencei* were killed during the 2020 wildfires in Kosciuszko National Park, NSW. The plant is highly sensitive to fire and does not resprout or germinate on mass after fire. Revegetation was carried out in the first growing season after the wildfire in small but critical Mountain Pygmy Possum (boulderfield) habitats within the Park (Figure 4-11), using plant material that was already available within the Park's former Snowy Hydro spoil dumps rehabilitation program. Propagation was from cuttings to ensure inclusion of both male and female plants.

FIGURE 4-11. PLANTING OF PLUM PINE WAS UNDERTAKEN IN AUTUMN 2020 IN KOSCIUSZKO NP, AFTER THE PREVIOUS SUMMER WILDFIRE. TOP LEFT: PLANTED CUTTINGS PROTECTED BY TREE GUARDS. BOTTOM LEFT: DEAD MOUNTAIN PLUM PINE LAYING ON BOULDERS AFTER WILDFIRE. RIGHT. THE NATURAL BOULDERFIELD AFTER FIRE, WHICH IS A GENERALLY FIRE-FREE HABITAT FOR THE ENDANGERED MOUNTAIN PYGMY POSSUM. THE SITE IS BEING INTENSIVELY MONITORED FOR MOUNTAIN PYGMY POSSUM (DATA LOGGERS AND MOTION-SENSITIVE CAMERAS) BY DR LINDA BROOME FROM DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT NSW.

EXAMPLE 2

The **Drooping Sheoak** (*Allocasuarina verticillata*) is the primary food sources for the nationally Endangered Kangaroo Island Glossy Black Cockatoo (*Calyptorhynchus lathami halmaturinus*), a formally widespread species that is now restricted to Kangaroo Island. Drooping Sheoak trees can take up to 15-20 years to recover sufficiently from seed after fire to provide a food source again. Planting additional Drooping Sheoak patches on Kangaroo Island is one strategy being used for creating additional (or post-fire 'insurance') food sources to support the Glossy Black Cockatoo (Figure 4-12). Seedlings are planted with a greater spacing to enable revegetated Drooping Sheoak to reach cone production significantly quicker than fire regeneration.

These plantings will reduce the time until food resources are available again in some areas. Data on usage of the Kangaroo Island plantings by the Glossy Black Cockatoo are not yet available and planting locations are currently being considered at distances from bushland to better protect them from future wildfires. Extensive plantings of Drooping Sheoak have also been carried out in the 'Bringing back the Glossy Black Cockatoo' program on the mainland's Fleurieu Peninsula over the last two decades. The aim of this work is to create an additional food source should the Glossy Black-cockatoo self-colonise the mainland again. Plantings on the Peninsula are now cone-bearing, providing a potential future food source for this species.

FIGURE 4-12. LEFT: GLOSSY BLACK COCKATOO FEEDING ON DROOPING SHEOAK (PHOTO MIKE BARTH). TOP RIGHT: DROOPING SHEOAK PLANTING SITE AT KANGAROO ISLAND TO SUPPLEMENT HABITAT OF THIS ENDANGERED SPECIES (PHOTO KARLEAH BERRIS). BOTTOM RIGHT: MATURE PLANTINGS PLANTED FOR GLOSSY BLACK COCKATOO IN ITS PRIOR RANGE ON THE FLEURIEU PENINSULA. (PHOTO COREY JACKSON)

Acknowledgements: Thanks go to Gabriel Wilks (NSW National Parks and Wildlife Service), Karleah Berris (Kangaroo Island Landscape Board) and Corey Jackson (District Council of Yankalilla) for the text and photos provided for this case study.

5 RESTORATION SCENARIOS IN A CHANGING WORLD

5.1 Fire mitigation strategies

Projected climate change presents ongoing challenges for the management of fire prone landscapes.[44] The predicted increase in the annual frequency of dangerous fire weather days across Australia is likely to result in increases in the incidence and severity of fires, longer fire seasons, increases in the area burnt and more difficult fire control. Moreover, a decrease in winter rainfall is likely to enhance fire risk by increasing dry fuel conditions coming into the fire season, thereby intensifying fire risk and severity.[45]

These changing conditions highlight the need to examine and include fire mitigation strategies in the management and restoration of fire-affected vegetation communities.[46]

5.1.1 Species functional traits and invasive species

Functional plant traits can drive differences in flammability and may differ between exotic and native species. For dry sclerophyll forest, differences in leaf size between natives and exotics may result in greater flammability in weed species with larger leaves.[47] Similarly, in grassland systems, exotic grasses can act as transformer weeds, increasing flammability and fire intensity.[48]

Even a low abundance of highly flammable invasive weeds can establish positive feedbacks that increase fire dynamics in communities.[49] Consequently, the management of weeds and exotic species in vulnerable communities via facilitated regeneration can not only improve biodiversity outcomes, but potentially reduce the likelihood of inappropriate fire regimes (fires that are too frequent and intense).

5.1.2 Vegetation buffers

One way in which native seed could be utilised in post-fire restoration is in the creation of vegetation buffers around vulnerable vegetation communities (Box 1, Figure 4-3). For example, wet sclerophyll or rainforest vegetation could be planted in cleared areas around existing rainforest remnants to reduce the likelihood of fire reaching the core of the rainforest remnant.

This could be particularly important where rainforest exists in more exposed topographic locations as well as within parts of the landscape that are more protected from fire (i.e. topographic fire refugia).

For other vegetation community types such as woodlands, restoration buffers may also be incorporated as a bushfire mitigation tool. For these plantings the choice of species and structural elements can supress direct flame contact, reduce the impact of embers and alter the impact of wind dynamics on fire behaviour. For example, the absence of a mid-storey fuel layer can supress crown fires and disrupt wind driven fire spread.

The strategic planting of low flammability species across the landscape — green firebreaks — is another potential fire management tool. These strips of low flammability species reduce fire spread by stopping or slowing the fire front, extinguishing embers and blocking radiant heat.[50] If they are planted with native species, they may also provide biodiversity benefits.

However, to date this option has not been extensively tested and needs to be assessed in the context of the structure of the vegetation established, the longevity of the species planted and biodiversity outcomes. Despite potential limitations, and the need for more research, green firebreaks could be considered as part of a revegetation strategy following extensive wildfires.

5.2 Climate-adjusted approaches to seed sourcing

One of the biggest challenges for restoration in the coming decades is the pace of climate change and the implications for plant fitness and survival. There are three potential responses of species to the rapid changes in environment predicted under climate change scenarios: adapt, migrate or perish.[51]

For adaptation, this is a change in a population in response to changes in the environment so that individuals are better able to survive and reproduce in that particular environment (e.g. one that is hotter and drier). The process of adaptation requires that the population has the genetic variation so that individuals that are best suited to the environment have greater survival and reproduction. Persistence through migration is the process whereby a species moves (disperses) to more suitable environments.

For many species, the predicted rate of environmental change is too rapid to enable populations to naturally disperse and colonise more suitable habitats (especially those with limited dispersal and long generation times). This is in addition to the detrimental effect of habitat loss and fragmentation on available patches in the landscape matrix. The final option is the loss of a species from an area due to the environment being no longer suitable for its survival and persistence.

Climate-adjusted provenancing is one strategy that can be used to enhance climate resilience in restoration plantings by introducing seed sourced from populations that represent the direction of the predicted climate change.[52]

This strategy includes a mix of both local genotypes and genotypes from a climate gradient that represents future predictions. This combination of local and 'climate ready' genotypes increases the chance that restored populations have the genetic variation necessary for adaptation.

For seed used in post-fire restoration (combined regeneration/reintroduction and/or reconstruction approaches), it will be vital to consider seed sourcing strategies that maximise genetic diversity and consider future environmental conditions. This approach to seed collection maximises the chance that restored populations have the genetic variation to cope with changing conditions (hotter and drier climates and more variable rainfall).

Ultimately this approach requires more resources to implement, but the long-term return on this investment is the establishment of more resilient populations which potentially require less inputs in the future (e.g. lower probability of replanting and/or the need for further seed inputs).

This is particularly important for long-lived species with longer generation times (e.g. trees) compared to short-lived species (e.g. herbaceous or short-lived shrubs). Information on life history, mating system and functional traits is therefore essential for understanding which species might be more susceptible to changes in climate, and where these occur in fire-prone landscapes. This should also be combined with information on other underlying environmental variation (e.g. soils).

As discussed below, the predictions under a changing climate also involve more frequent and intense fires. For plant species, fires resilience traits (e.g. bark thickness, lignotuber size, time to first reproduction) can vary among populations. For relevant species, one option for seed sourcing for fire recovery is identifying and quantifying populations with greater fire tolerance and using these for fire-recovery restoration in areas with a predicted increase in fire frequency and severity.

This, in combination with a climatic approach, would provide the greatest genetic basis for adaptation in a changing world.

There is also the prediction that for many woody obligate seeders reliant on regeneration from seed, climate change will reduce the fire interval window that is compatible with population persistence. Under this scenario, due to declines in seed production and survival, plants may require longer fire-free intervals to reach reproduction and replenish the seed bank.[46]

This interaction between climate, reproduction, survival and fire regime should be considered in the future planning of seed reserves for obligate seeders. In this situation, seed biobanking could play an important role in providing seed reserves for species where increases in fire frequency, extent and/or severity lead to extensive post-fire seed limitation.[46]

To tackle these challenges of restoration under rapid environmental change, we suggest several ways forward:

1. Investment to understand which species of high conservation priority after wildfire are most vulnerable to changing climates. This would involve combining species distribution models with bioclimatic modelling (present and future) to identify vulnerable populations and populations that may harbour potentially favourable genetic variation.
2. Combine information on life history, mating system and functional traits with species distribution and bioclimatic models to prioritise species for climate-adjusted approaches.
3. Greater investment in research partnerships to identify the genetic and genomic predictors of adaptive variation in relation to changing climates across a range of species and/or functional groups. This will be central to understanding how patterns of genetic variation my predict adaptive potential in a rapidly changing world.

6 RECOMMENDATIONS

There are several recommendations for the ten-year Strategy[‡] that will extend and utilise the information presented in this report. This relates to both the conceptual model and decision tree as well as the application of this framework to the post-fire management of TECs.

1. **The conceptual models and frameworks presented here should be integrated with data collection Apps to facilitate field surveys, site assessments and ground truthing.**

This would be done through partnerships between land managers, researchers, NGOs, communities and practitioners. Remote sensing tools could also be included as a complementary tool for assessing regeneration and post-fire recovery of vegetation structure and cover.

2. **The application of the conceptual model to the TECs needs to be tested through site assessments that engage with community groups, land managers, practitioners and local experts.**

3. **Weed management — especially of transformer weeds and weeds of national significance — plays a key role in facilitated regeneration for bushfire recovery.**

Fire provides the rare opportunity to exhaust or significantly reduce the weed seed bank by targeted removal of post-fire weed germinants. Continual investment in weed removal (prior to seed set) over the first few seasons can then deplete this weed seed bank and provide the chance for native regeneration. Thus, timely post-fire weed control can be an effective and economical means of progressing towards eradication.

Conversely, if weeds are not removed, and post-fire conditions are favourable, weeds may establish and reproduce prolifically after fire — thereby compounding weed issues in these systems. It is therefore essential that weed management be included in any strategy focused on facilitating native regeneration in bushfire recovery.

Moreover, investment in weed control in tandem with the development and deployment of native seed stocks will provide the chance that any seed or propagules used will contribute to improved ecological outcomes.

[‡] This report contributes to the evidence base for a ten-year strategy to guide the native seed and landscape sector. The document, which is untitled until endorsement in September 2021, is referred to as the Strategy in all Project Phoenix publications.

4. To maximise the impact of native seed inputs for bushfire recovery, it is essential that there is continuity of funding for ongoing threat management (e.g. pests, herbivores, disease).

Potential outcomes (recovery trajectory towards a particular reference community) will be negatively affected without direct management of present and ongoing threats.

5. After fires, there is often a limited window of opportunity to undertake management interventions in an ecologically and cost-effective manner. This report advocates for bushfire preparedness to ensure that ecological management interventions can be undertaken in a timely way after fire events.

For example, having predictive models of regenerative capacity across communities of conservation concern can identify potential seed needs and enable these to be collected in a sustainable and ecologically sensitive way as part of networked seed banks. These predictions can then be tested post-fire and used to enable rapid deployment of weed control and assessment tools to evaluate levels of native regeneration.

This will maximise the availability of post-disturbance niches for native species and avoid having to reintervene later when more effort and resources may be required to support recovery.

6. The success of post-fire restoration approaches will depend on defining the appropriate reference community and determining potential successional pathways.

This information needs to be considered in light of rapidly changing environments (climate change and fire) and how this may influence species composition and functional traits within a community.

7. As part of the ten-year Strategy, the native seed sector needs a coordinated approach to the development of seed banking for fire-sensitive native species across a range of priority vegetation communities.

This will require partnerships between government, academics, NGOs, land managers, community groups and practitioners.

8. The GIS models presented here lay the groundwork for predicting areas in greatest need of post-fire management intervention.

Given the short time frame of this project, these models are preliminary and would benefit from further extension and analysis especially by including finer scale state-based fire history data.

9. **These GIS models could be applied to: (i) other fire-affected Threatened Ecological Communities; (ii) fire-affected communities that are key habitat for (listed) threatened fauna species; and (iii) vegetation communities that are important for biodiversity and ecological function at the landscape scale (e.g. for connectivity, large patches, protected reserves).**

This broader approach will be essential to give a longer-term view of the scale of intervention required and associated seed needs in line with the ten-year Strategy. This information will be key for knowing how much the native seed industry needs to scale up to increase resilience through biobanking vulnerable species to reduce the risk of species loss from future fire events.

10. **As part of the ten-year Strategy, we recommend an assessment of the seed needs to build landscape resilience to future fire events.**

Broad seed inputs are required to establish new patches of a vegetation community to allow expansion and reconnection of habitat patches as well for as establishing insurance populations. Here restoration plays a key role in improving habitat value and protecting ecosystems from future detrimental fire events (e.g. by creating buffers around certain communities).

This is where landscape level conservation planning can be used to identify where in the landscape these should be established to maximise environmental gains. This should also be considered using climate change and species distribution models.

7 RESTORATION SCENARIOS FOR THREATENED ECOLOGICAL COMMUNITIES (TEC)

7.1 Threatened Ecological Communities (TEC)

7.1.1 Definition and spatial extent

An ecological community is a unique habitat comprising an assemblage of native plants, animals and other organisms that naturally occur together and interact.[53] Environmental factors (including soil type, landscape position, climate, water availability and altitude) determine ecological communities' composition, distribution and structure so that these cover a range of vegetation types such as grasslands, shrublands, woodlands, forests, wetlands and cave communities.

A **Threatened Ecological Community (TEC)** is at risk of extinction and has had its ecological community and function significantly depleted across its full range.[54] Currently, there are 88 TECs listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (*EPBC Act 1999*).

TEC distribution can be described in terms of 'may occur' and 'likely to occur'. The 'may occur' category refers to the broadest extent where the TEC could potentially be encountered; however, it is possible that the TEC could still occur outside of this boundary.[55] This 'may occur' boundary is based on the ecological and biophysical characteristics defined by the listing advice. The 'likely to occur' category refers to an approximate boundary of the TECs' current extent and is a more conservative estimate of its distribution. The boundary is often based on state and federal vegetation mapping polygons, but there is a level of uncertainty in the 'likely to occur' boundary.[55]

The difference in spatial extent between the 'likely to occur' and 'may occur' scenarios is illustrated by three TECs representing different vegetation communities:

- Upper Basalt Eucalypt Forest of the Sydney Basin Bioregion — Wet sclerophyll (Figure 7-1a, Figure 7-1b)
- Lowland Rainforest of South-Eastern Australia — Rainforest (Figure 7-2a, Figure 7-2b) and
- Lowland Grassy Woodland in the South East Corner Bioregion — Grassy Woodlands (Figure 7-3a, Figure 7-3b).

For each of the 19 TECs, we have undertaken the Restoration Scenario analysis for both 'likely to occur' and 'may occur' (see Figure 7-1, Figure 7-2 and Figure 7-3 for a representation of the results), but in this report only present data for the 'likely to occur' areas.

7.1.2 Data collection methods

Location data of the 19 TECs was sourced from the priority list of TECs affected by 2019–20 bushfires (Australian Government, Department of Agriculture, Water and the Environment, Parkes, ACT 2600). A list of the flora species commonly found in each TEC was compiled from listing advices, final determinations, conservation advices and/or recovery plans where available from the Species Profile and Threats (SPRAT) database.

For the Eastern state species, fire response data were sourced primarily from the Australian Fire Ecology Database (R. Bradstock; accessed through TRY plant trait database)[56] and supplemented by searching specific published references. For Western Australian species, fire response data were sourced from journal articles, literature and government databases (for most commonly used literature see).[57–65]

Data collected included scientific and common name, verified fire response (RS, FS, OS), life form (shrub (S), herbaceous (H), climber/vine (C), tree (T)), reference list, seed storage (canopy (C), soil (S), transient (T)), seed persistence (years), primary and secondary juvenile period (years) as well as any additional fire response notes.

Some species names had changed over time, so the most recent naming was used, and previous names or synonyms were listed to be cross checked with older sources.

FIGURE 7-1. SPATIAL DISTRIBUTION OF THE LOWLAND RAINFOREST OF SUBTROPICAL AUSTRALIA TEC BASED ON WHERE IT IS: (A) LIKELY TO OCCUR (LEFT) AND (B) MAY OCCUR (RIGHT)

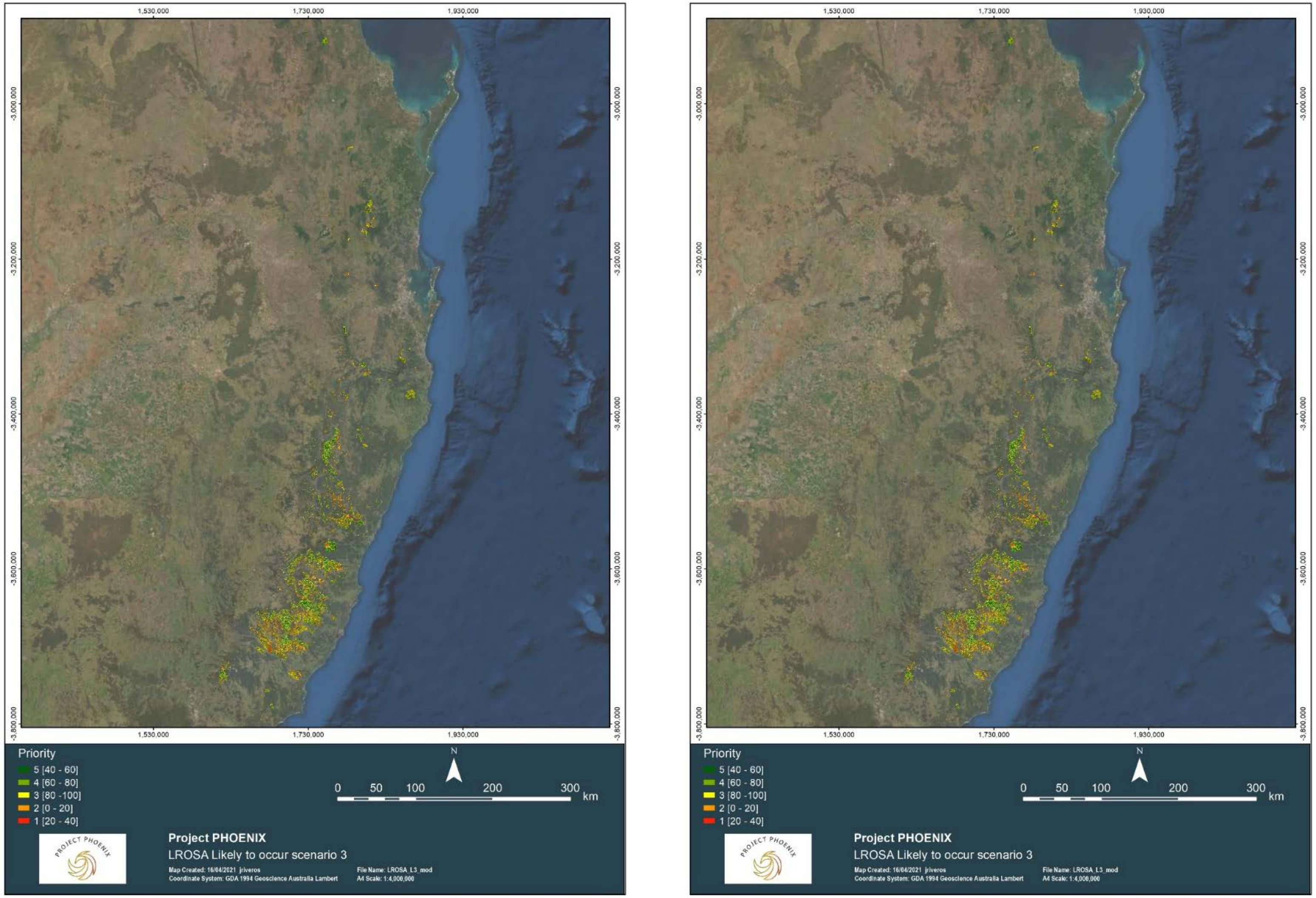


FIGURE 7-2. SPATIAL DISTRIBUTION OF THE LOWLAND GRASSY WOODLAND IN THE SOUTH EAST CORNER BIOREGION TEC BASED ON WHERE IT IS: (A) LIKELY TO OCCUR (LEFT) AND (B) MAY OCCUR (RIGHT)

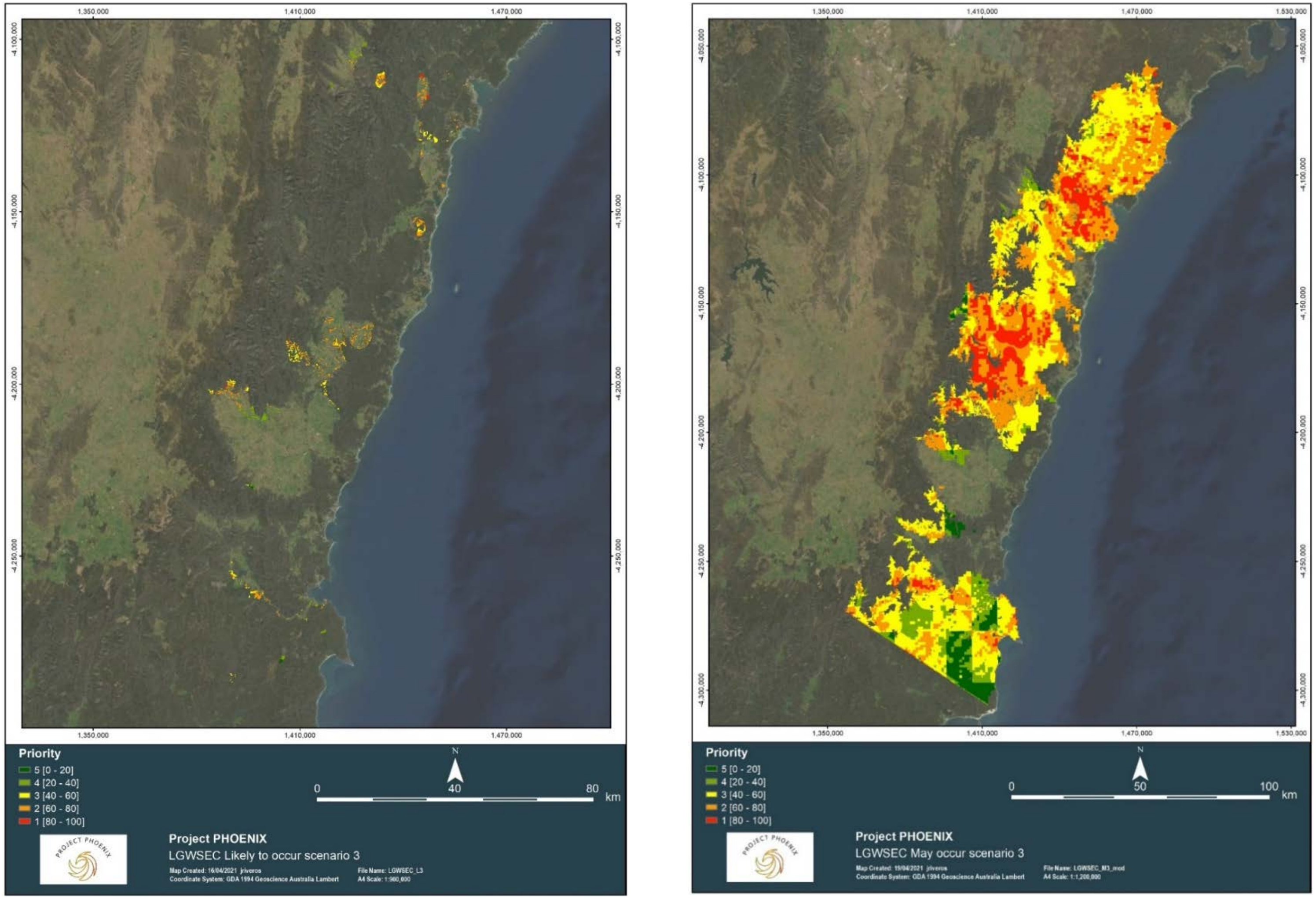


TABLE 7-1. THE VEGETATION COMMUNITY TYPE, STATUS AND LOCATION OF THE 19 THREATENED ECOLOGICAL COMMUNITIES (TECS) WITH >10% OF THEIR ESTIMATED DISTRIBUTION WITHIN THE AREAS BURNT IN THE 2019–20

THREATENED ECOLOGICAL COMMUNITY	DISTRIBUTION WITHIN FIRE-AFFECTED AREAS	VEGETATION TYPE	EPBC ACT LISTED THREATENED STATUS*	STATE AND TERRITORY LOCATIONS
1. Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion (UBEFS)	> 50%	Wet sclerophyll forest	EN	NSW
2. Eastern Stirling Range Montane Heath and Thicket (ESRMHT)	> 50%	Heathland	EN	WA
3. Temperate Highland Peat Swamps on Sandstone (THPSS)	> 50%	Peatland	EN	NSW
4. New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands (NEPGW)	30–50%	Grassy woodland	CR	NSW, QLD
5. Lowland Rainforest of Subtropical Australia (LROSA)	30–50%	Rainforest	CR	NSW, QLD
6. Lowland Grassy Woodland in the South East Corner Bioregion (LGWSEC)	30–50%	Grassy woodland	CR	NSW
7. Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions (SLPS)	10–30%	Shrubland	EN	VIC
8. Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion (ISSR)	10–30%	Rainforest	CR	NSW
9. Turpentine-Ironbark Forest of the Sydney Basin Bioregion (TIFSBB)	10–30%	Wet/dry sclerophyll forest	CR	NSW
10. Illawarra and South Coast Lowland Forest and Woodland Ecological Community (ISCLF)	10–30%	Grassy woodland/dry sclerophyll forest	CR	NSW
11. Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain (SIHDS)	10–30%	Sedgeland	EN	WA
12. Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland Ecological Community (CSOEC)	10–30%	Coastal floodplain forest	EN	QLD, NSW
13. Alpine Sphagnum Bogs and Associated Fens (ASBAF)	10–30%	Peatland	EN	ACT, NSW, TAS, VIC
14. Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion (CSGW)	10–30%	Grassy woodland/dry sclerophyll forest	EN	NSW
15. Natural Temperate Grassland of the South Eastern Highlands (NTGSEH)	10–30%	Grassland	CR	ACT, NSW
16. Robertson Rainforest in the Sydney Basin Bioregion (RRSBB)	10–30%	Rainforest	CR	NSW
17. Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	10–30%	Grassy woodland/dry sclerophyll forest	CR	NSW
18. Shale Sandstone Transition Forest of the Sydney Basin Bioregion	10–30%	Dry sclerophyll forest	CR	NSW
19. Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	10–30%	Dry sclerophyll forest	CR	NSW

7.2 A guide to the TEC summaries

TEC NUMBER AND NAME

Community Characteristics

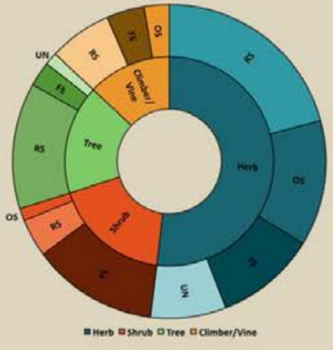
- This column outlines the number of species in the TEC (from the general TEC list)
- It then breaks the species down by life history group (Tree, Shrubs, Herbaceous and Climbers/Vines)
- Having this information paints a picture of the community composition and vegetation type

Fire Response

- This column displays information on the breakdown of fire responses within the TEC
- A higher proportion of resprouters represents a generally more fire tolerant community
- While a more fire sensitive community would generally have a higher proportion of obligate seeders and facultative seeders
- The proportion of unknown fire responses provides information on how much we currently know about the potential responses of species within a community

Life History and Fire Response

- Breaking down fire response by life history group enables us to identify which groups have the highest proportion of fire sensitive and fire tolerant species
- It also shows how much information there is on fire response in certain groups
- The inner circle shows the breakdown of the different life history groups (like in column 1)
- The outer circle of each colour shows the proportion of each fire response within a life history group
- For all figures: Green (Trees), Orange (Shrubs), Blue (Herbaceous) and Yellow (Climber/Vine)
- RS = Resprouter, OS = Obligate seeder, FS = Facilitative seeder, UN = Unknown



Primary Juvenile Periods for Fire Sensitive Species

- The **primary juvenile period** is the time taken for a fire sensitive species (killed by fire) to reach reproductive maturity (flowering and seed set) after regeneration from seed
- Fire sensitive species include **obligate seeders** (killed outright by fire and regenerates from seed) and **facultative seeders** (can regenerate from seed and/or resprouting after fire)
- Information on primary juvenile periods can help define the minimum fire interval for a community
- As a general rule, the **minimum fire interval** of a community can be estimated as twice the primary juvenile period of the fire sensitive species
- Breaking down the primary juvenile period by life history group provides information on which groups might be more sensitive to frequent fire
- For example, short lived herbaceous species tend to have shorter primary juvenile periods compared to longer-lived trees
- This helps to identify 'at risk' groups within a community that has be subject to inappropriate fire regimes (e.g. too frequent fire)
- For all figures: Green (Trees), Orange (Shrubs), Blue (Herbaceous) and Yellow (Climber/Vine)
- Information on seed storage for OS and FS species is in **Appendix 1**

Priority areas 1 and 2 for the TEC: Variables influencing regenerative potential

Priority Area (GIS band)	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)										
2 (60-80)										
3 (40-60)										
4 (20-40)										
5 (0-20)										

- This Table provides the summary information from the GIS analysis of each TEC for the five priority areas
- Priority areas are ranked from **1** (most in need of assessment/management intervention) to **5** (least in need of assessment/intervention)
- Each priority area is classified based on **mean fire interval**, **fire intensity**, **rainfall percentile** and **distance to cleared areas**
- This prioritisation aims to predict where the greatest need for assessment and management intervention is *within* a TEC
- This assessment, combined with on-ground assessment, can be used within the **Restoration Scenario Planning Decision Tree** to determine which restoration approach may be required: (i) Protection/Natural regeneration, (ii) Facilitated regeneration, (iii) Combined regeneration/reintroduction, and (iv) Reconstruction

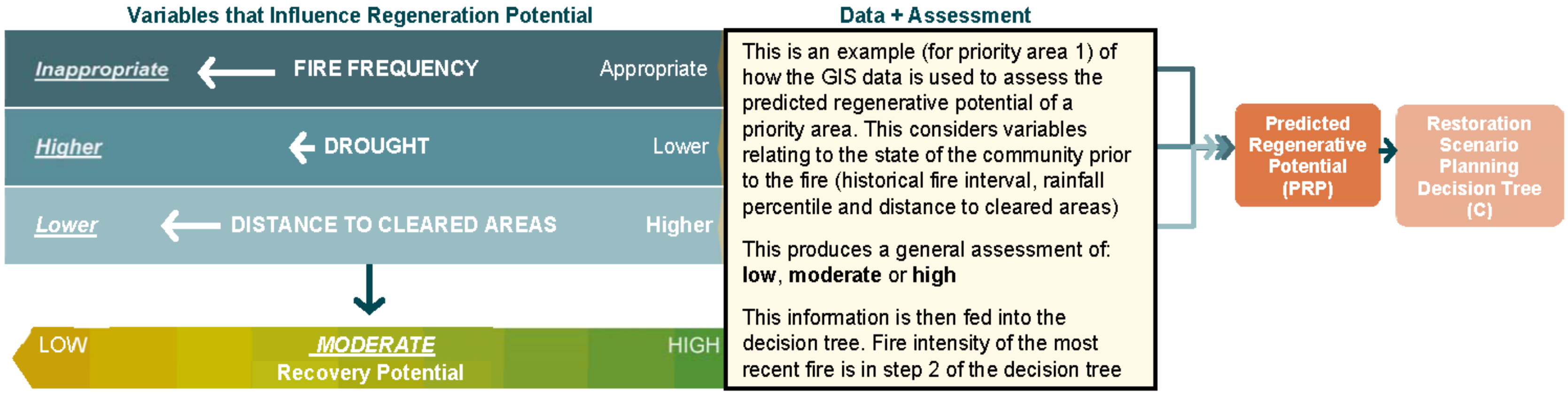
Finer scale analysis of NSW fire data

This is the NSW fire interval data for priority area 1 and 2 (for TECs in NSW). The finer resolution data can be used in conjunction with the national model to interpret prioritisation

See Figure for distribution of each priority area

This is the spatial mapping of the five priority areas for a TEC

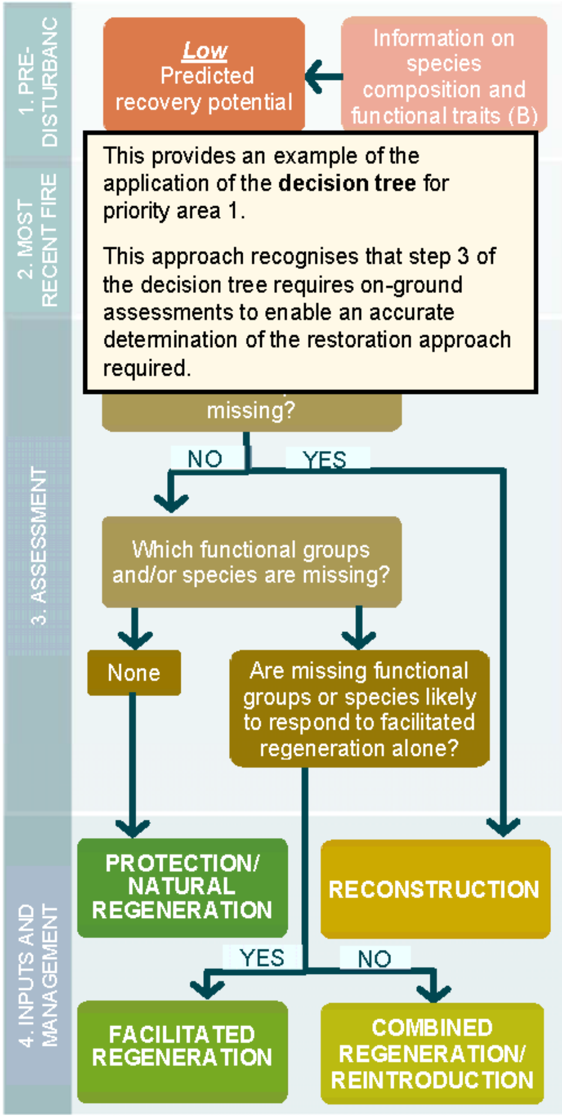
Priority Area 1: Predicted Regenerative Potential



This is an example (for priority area 1) of how the GIS data is used to assess the predicted regenerative potential of a priority area. This considers variables relating to the state of the community prior to the fire (historical fire interval, rainfall percentile and distance to cleared areas)

This produces a general assessment of: **low**, **moderate** or **high**

This information is then fed into the decision tree. Fire intensity of the most recent fire is in step 2 of the decision tree



This provides an example of the application of the **decision tree** for priority area 1.

This approach recognises that step 3 of the decision tree requires on-ground assessments to enable an accurate determination of the restoration approach required.

RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Restore non-regenerating patches** • **Extend current patches and build buffers** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats**	**Manage threats** (see Protection) **Weed removal**. Key weeds include:	**Weed removal** (see Facilitated regeneration) **Reintroduction**:	• Requires broad seed inputs

This table outlines the four potential restoration approaches that could be used post-fire to assist recovery of a TEC. They include:

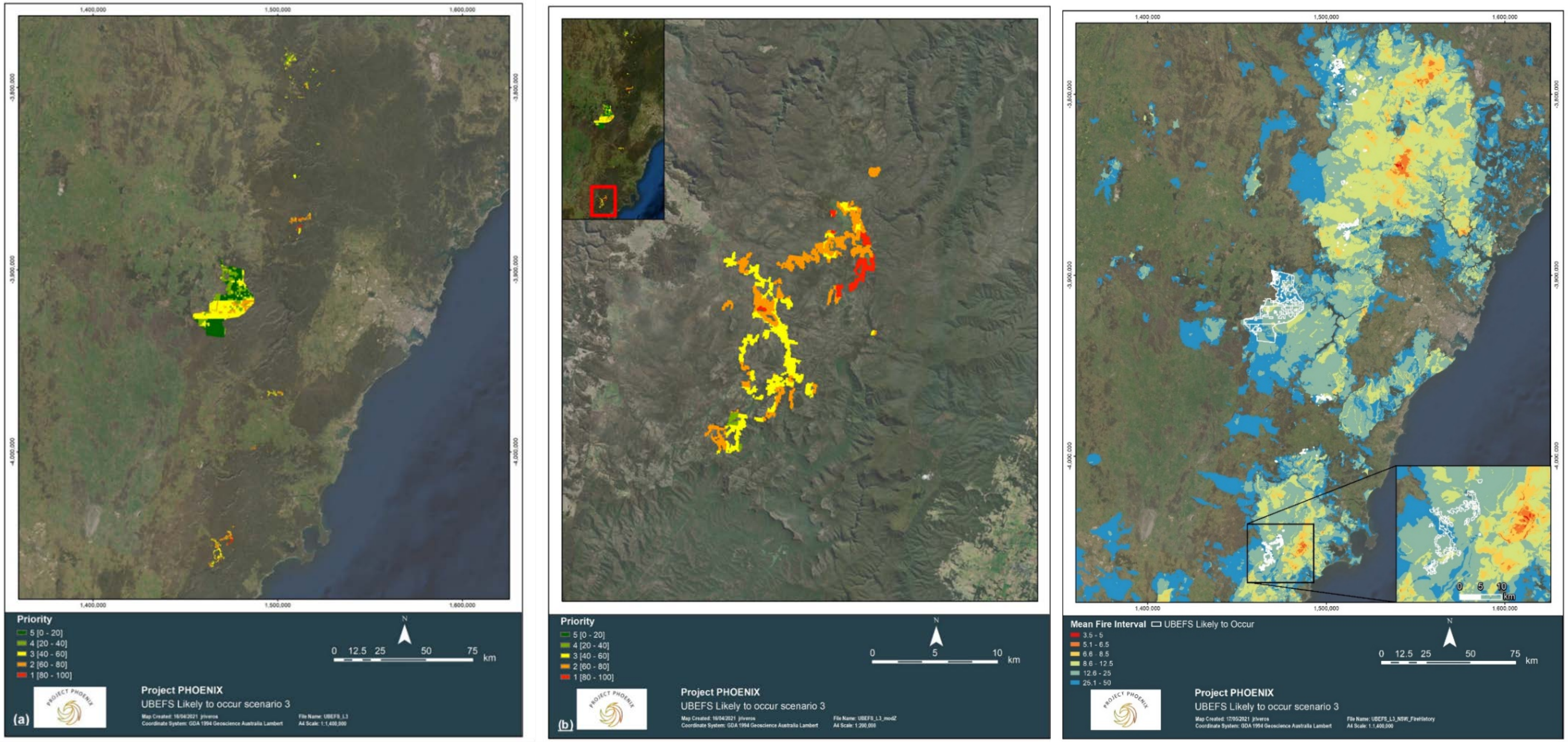
(1) Protection/Natural regeneration
(2) Facilitated regeneration
(3) Combined regeneration/ reintroduction
(4) Reconstruction

It outlines the goals of each as well as key threats and weed species that may require management intervention.

In combination with site assessments, this framework can assist decision making and determine what intervention may be required to work with the natural regenerative potential of communities.

Spatial distribution of priority areas for the TEC

These figures provide a visual guide to the different priority areas of a TEC as outlined in the above Table (Figure (a)). The Code relates to the TEC (e.g. UBEFS = Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion). For some TECs with a broad distribution, we provide a zoomed in perspective on the priority areas of a certain region Figures (b) and (c). To illustrate the differences between the national and NSW fire interval data, for some TECs we provide an additional map (separate figure) outlining the finer resolution fire interval data in relation to the bounds of the TEC (an example is the figure on the far right below).



We then provide a list of the fire sensitive species (obligate seeders and facultative seeders where the parent may be killed by the fire) for each TEC. This was done as a means of prioritising the species most sensitive to inappropriate fire regimes. We include their life form (Herbaceous (H), Shrub (S) or Tree (T)) and Fire response (Obligate seeder, OS) or Facultative seeder, FS). We also include information on seed storage type (where it was available). Seed storage: Soil (S), Transient (T), Canopy (C), Unknown (UN). This table include a source of information for the species to be included:

- TEC species list = the general species list for a TEC. This list was compiled using information from the TEC recovery plans, conservation advice, listing advice and final determinations all sourced from SPRAT (Species Profile and Threats Database) or other government websites.
- Fire-affected species = Species with >80% their estimated range or known sites burnt in the 2019/20 fire. Our GIS model was used to map the distribution of these species with the 'Likely to Occur' boundaries for each TEC. This could be used to identity which fire affected species occurred within each TEC. For these species, post-fire conservation management intervention has been advised by the Expert Panel.[125]

SAMPLE TABLE

TABLE 7-5. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE UPLAND BASALT EUCALYPT FORESTS OF THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia elata*	S	OS	S	
TEC species list	*Ajuga australis*	H	OS	UN	
TEC species list	*Austrocynoglossum latifolium*	H	OS	S	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Clematis aristata*	C	OS	S	
TEC species list	*Marsdenia flavescens*	C	OS	UN	
TEC species list	*Plantago debilis*	H	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Pyrrosia rupestris*	H	OS	UN	

...

7.3 TEC 1: Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion

7.3.1 Description

The Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion occurs roughly from Denman to Yadboro in parts of the Blue Mountains, Southern Tablelands and Southern Highlands in New South Wales. It is a wet sclerophyll vegetation type that is defined by a tall eucalypt canopy, a diverse native understorey of grasses, ferns and herbs with a dense layer of vines and shrubs.[66] Elevation is usually 650m above sea level (ranging from 350m to 1200m above sea level)[67, 68] on volcanic, basalt or basalt-like substrates. Rainfall is typically high, ranging from 950 to 1800mm/year.

This community now exists largely as scattered remnants, with species composition of a site dependent on patch size, aspect, slope, rainfall and time since disturbance.[67, 68] The tree canopy layer is dominated by eucalypt trees, with a minimum canopy cover of 30%, while the shrub layer is variable and can range from spare and dry, to dense and mesic.

7.3.2 Species and fire response traits

In the Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion there are 78 listed plant species representing 60 different genera; this list is indicative and the total species list across the community is likely to be much larger. Species composition across the TEC may differ given that patches span a range of environments (slope, aspect, rainfall) and vary in disturbance history. Sites may also contain other species not listed here (species that are rare, patchy and/or have low abundance).

Of these 78 plant species, 44% are resprouters, 29% are facultative seeders and 17% are obligate seeders, with 10% having an unverified fire response (Table 7-2). Herbaceous species make up 51% (n = 40) of all listed species, trees make up 17% (n = 13), shrubs make up 18% (n = 14) and climbers/vines make up 14% (n = 11) (Table 7-2).

For further information on fire response, life form and primary juvenile period see the summary for this TEC below.

TABLE 7-2. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE)

NUMBER (AND %) OF EACH FIRE RESPONSE					
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	10 (25)	8 (20)	16 (40)	6 (15)	**40**
Shrub	1 (7)	10 (71)	3 (22)	0 (0)	**14**
Tree	0 (0)	2 (15)	10 (77)	1 (8)	**13**
Climber/Vine	2 (18)	3 (27)	5 (46)	1 (9)	**11**
Total count	**13**	**23**	**34**	**8**	**78**

7.3.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity, rainfall and distance to cleared areas (see Table 7-3).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Upland Basalt Eucalypt Forests and outlined below and described in Appendix 2 (Section 11.1).

TEC 1: Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 78 [60 genera]

Trees:
- 17% (n = 13)

Shrubs:
- 18% (n = 14)

Herbaceous:
- 51% (n = 40)

Climbers/Vines:
- 14% (n = 11)

Fire Response

Resprouters:
- 44% (n = 34)

Obligate seeders:
- 17% (n= 13)

Facultative seeders:
- 29% (n = 23)

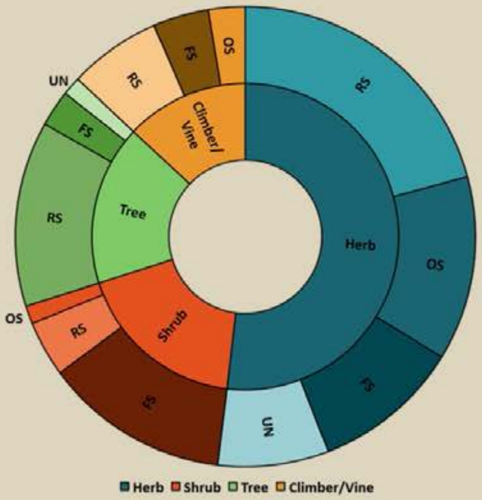
Unknown:
- 10% (n = 8)

Life History and Fire Response

Resprouters (RS):
- Ranged from 22% of shrubs to 77% of trees

Facultative (FS) and Obligate (OS) seeders:
- 71% of shrubs are facultative seeders, only 7% are obligate seeders
- Herbaceous species had similar proportions of obligate seeders (25%) and facultative seeders (20%)

For each life form:
- Low proportion of unknown (UN) fire responses (0-15% of species)

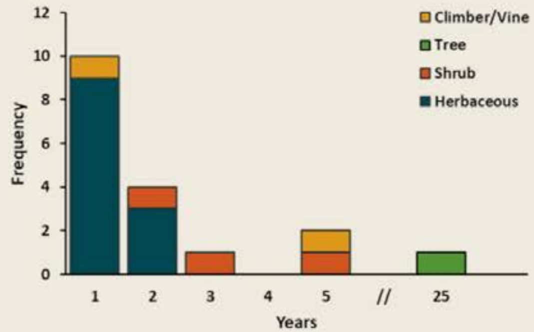


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 25 - 60 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-10 years
- Herbaceous = 2-4 years
- Climbers/vines = 2-10 years
- Trees = 50 years



[1]Obligate seeders and facultative seeders

Table 7-3. Priority Areas 1 and 2 Upland Basalt Eucalypt Forest: Variables influencing regenerative potential

Priority Area (GIS band)	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	746.9	1.1	2.8[a]	2.3-5.6	4.8	2-5	42.6	38.3-44.7	524.8	0-1702.9
2 (60-80)	8001.2	11.5	4.1[b]	1.9-16.7	4.4	2-5	40.5	36.1-45.9	2766.1	0-9765.2
3 (40-60)	25774.8	37.0	5.1	1.9-16.7	3.7	2-5	39.8	36.1-45.9	2653.7	0-12520.8
4 (20-40)	14889.1	21.4	7.2	3.6-25	3.4	2-5	39.5	37.1-43.1	2533.8	0-13649.9
5 (0-20)	20309.4	29.1	10.0	2.3-25	3.1	2-5	39.5	37.4-41.9	3193.0	0-12932.1

Finer scale analysis of NSW fire data: Priority area 1[a] = 23.5 years (8.3 – 50 years); Priority area 2[b] = 24.1 (7.1 – 50 years)

See Figure 7-4 for distribution of each priority area

Priority Area 1: Predicted Regenerative Potential

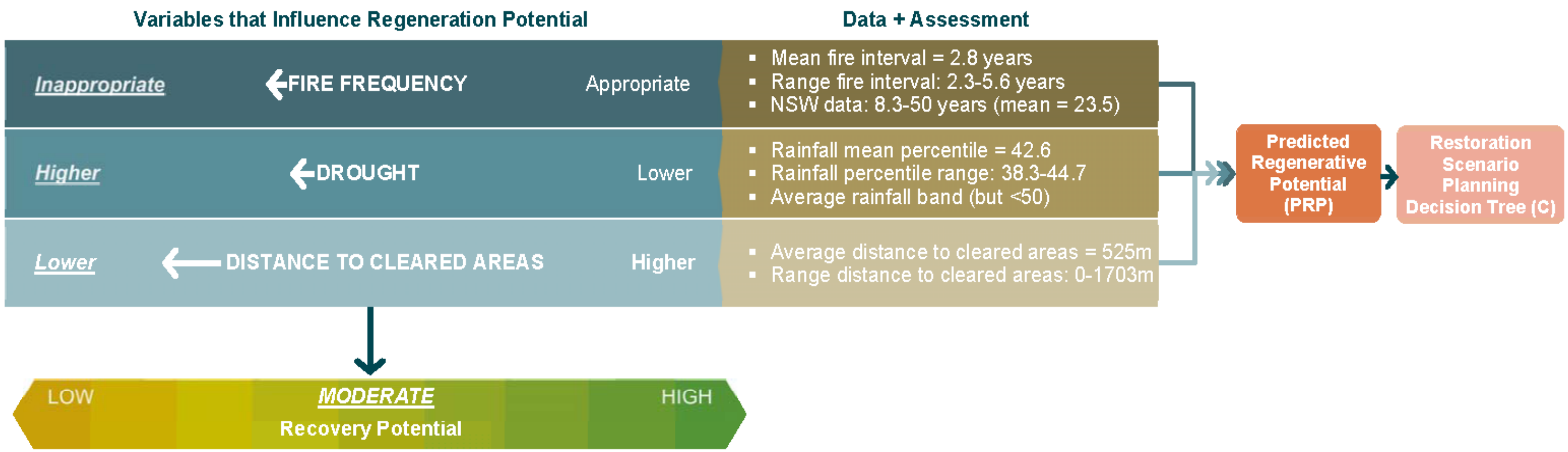
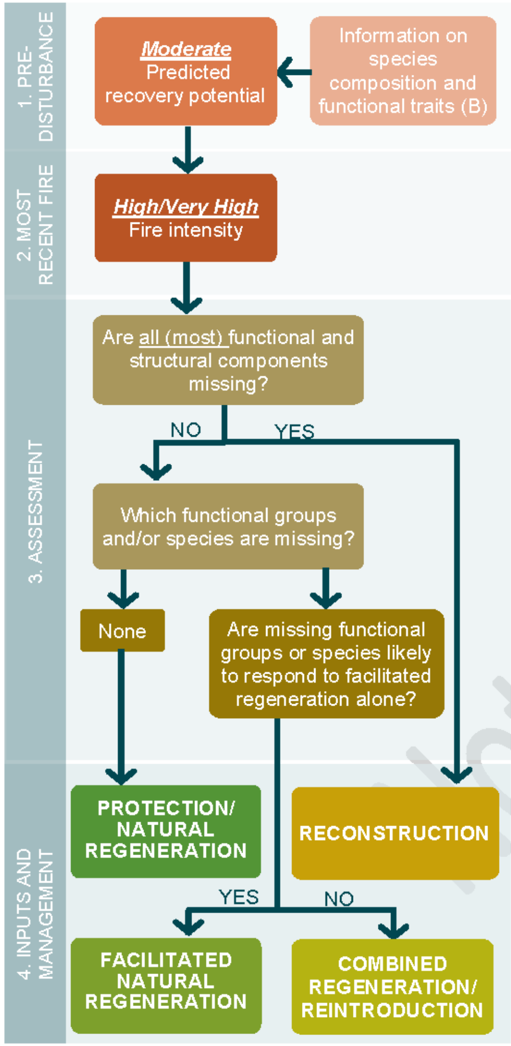


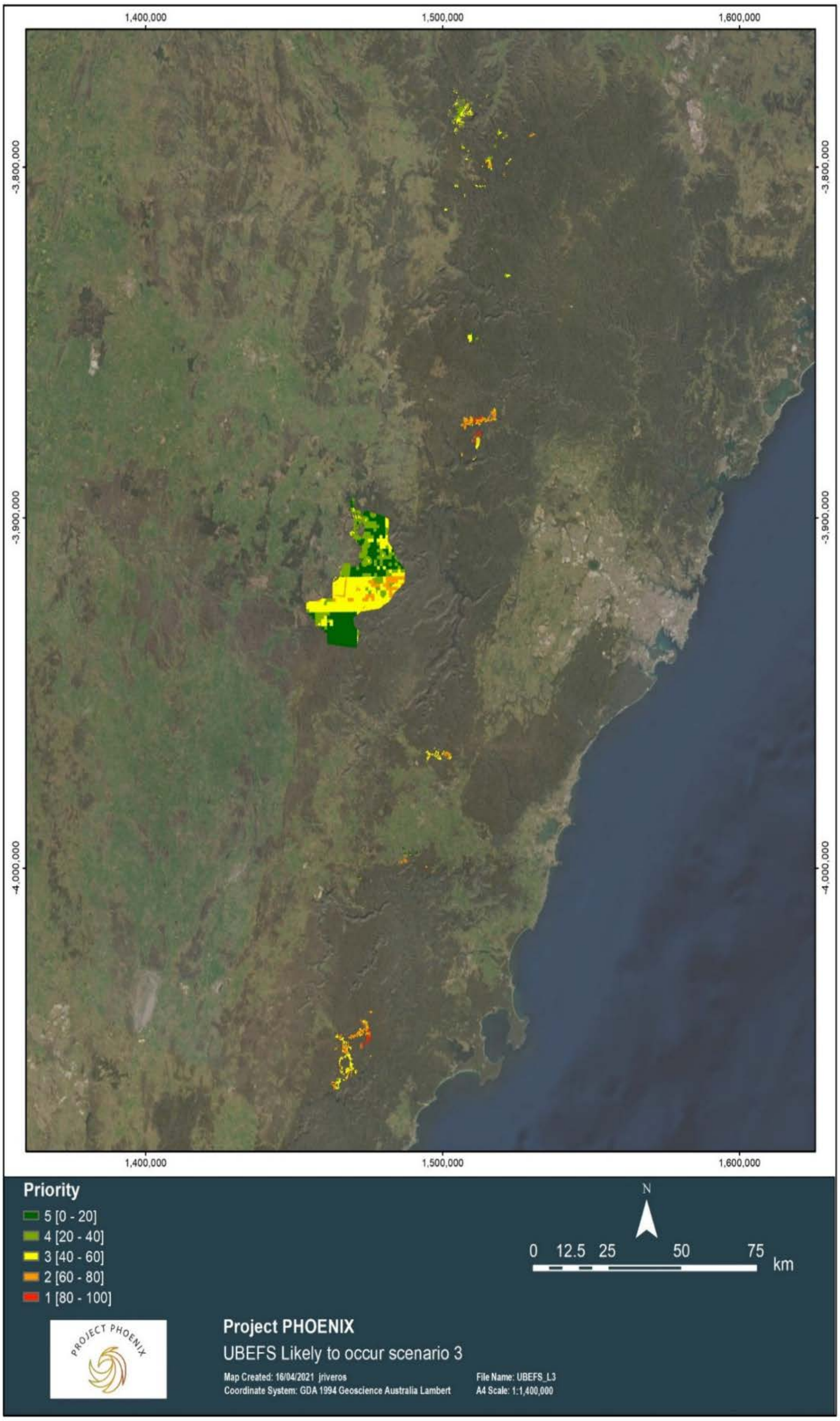
TABLE 7-4. RESTORATION APPROACHES FOR UPLAND BASALT EUCALYPT FOREST

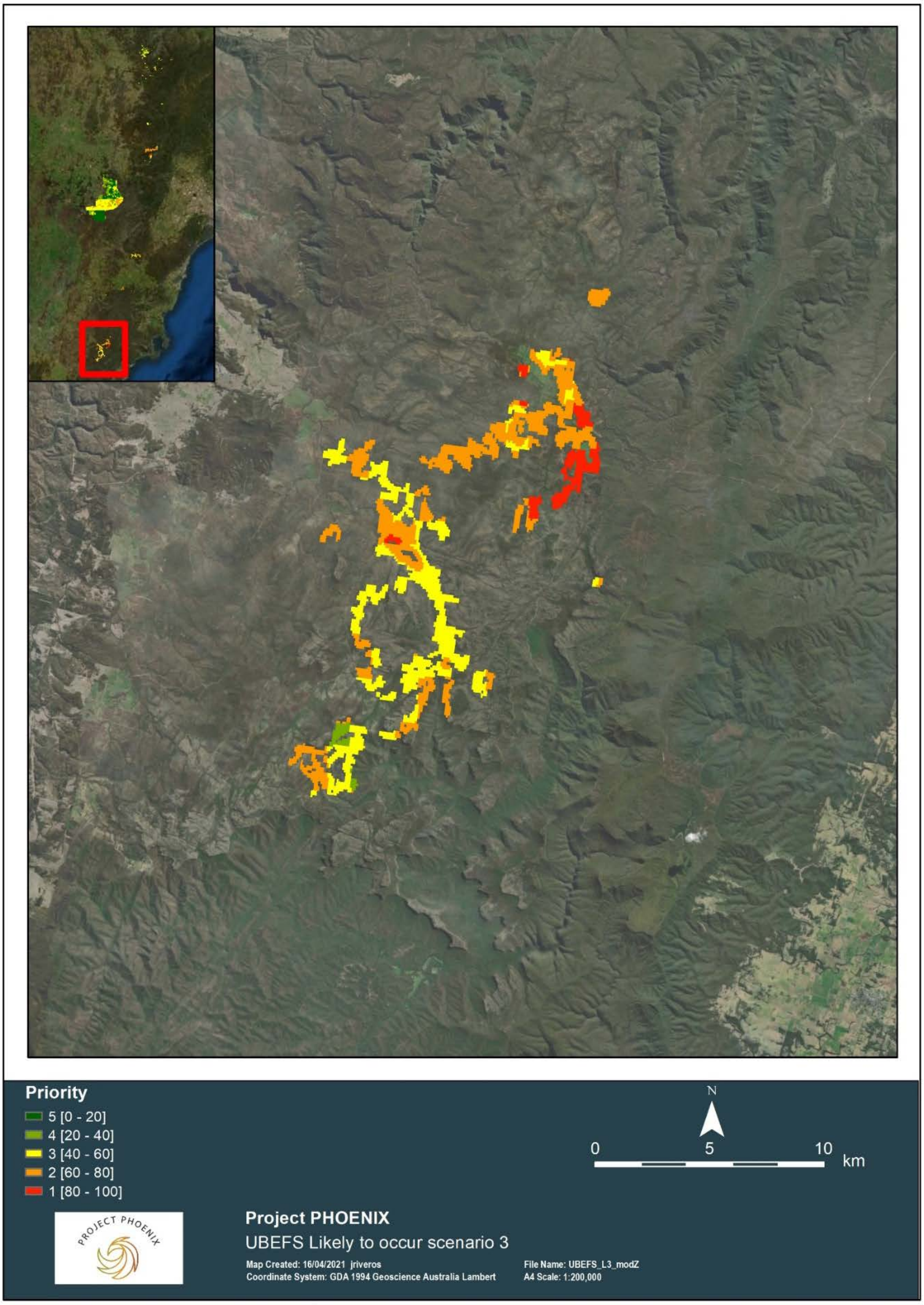


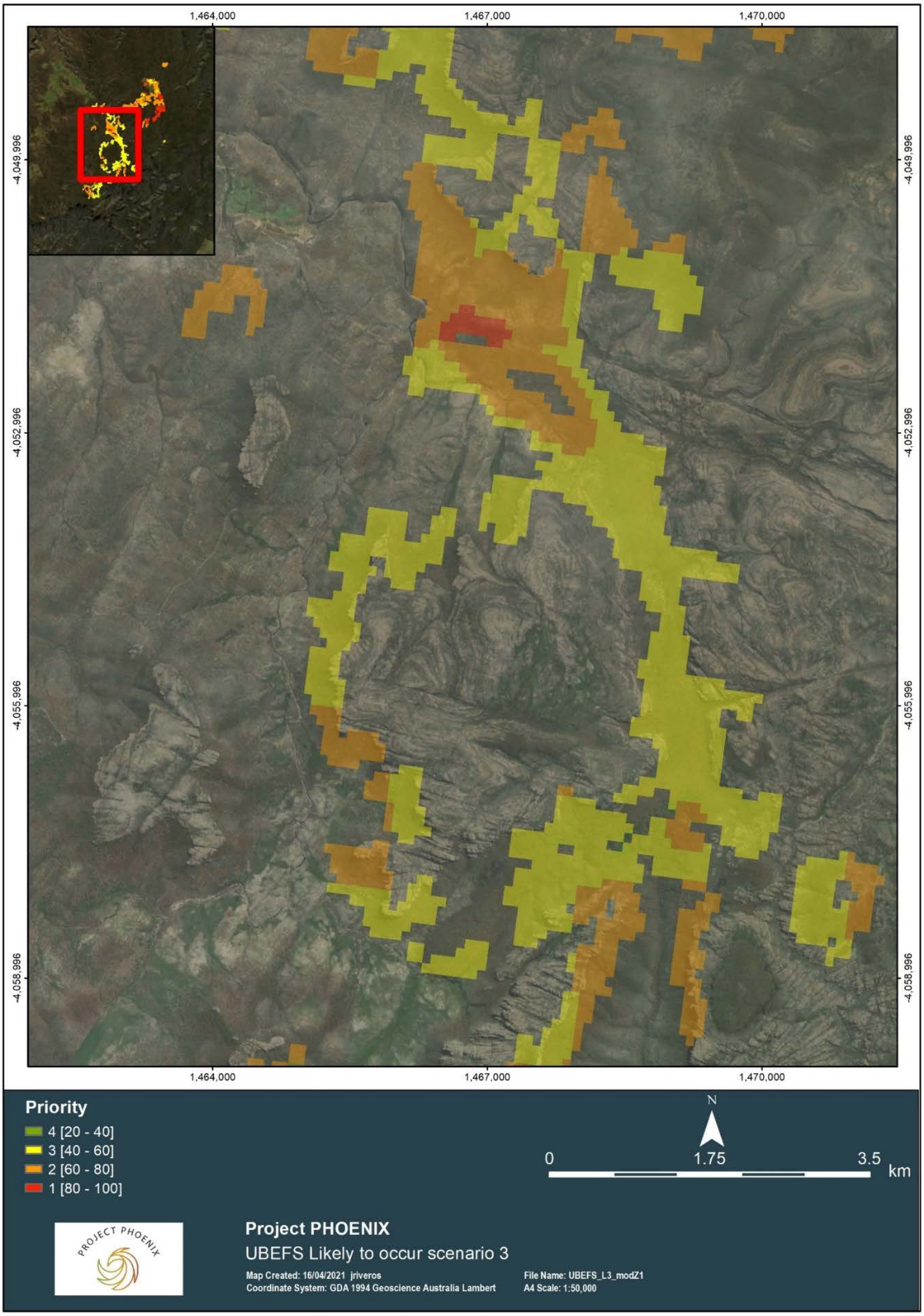
RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• Manage threats	• Weed removal to facilitate regeneration	• Weed removal • Facilitate recovery of fire sensitive species	• Restore non-regenerating patches • Extend current patches and build buffers • Improve connectivity between remnants
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing of land for urban, rural and agricultural development • Fragmentation and edge effects • Grazing by stock • Fertiliser and herbicide use on adjacent farmland • Improper recreational use e.g. informal trail forming, rubbish dumping, trampling, visitation of cats and dogs, firewood collection • Inappropriate fire regimes • Invasion by weeds and feral animals • Climate change • Potential future quarrying and mining	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Asparagus asparagoides* (Bridal Creeper) • *Berberis vulgaris* (Barberry) • *Genista spp.* (Broom) • *Hedera helix* (English Ivy) • *Ilex aquifolium* (English Holly) • *Lonicera japonica* (Japanese Honeysuckle) • *Nassella spp.* • *Pyracantha spp.* (Firethorn) • *Rubus fruticosus aggregate* (Blackberry)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species are more likely to be affected by inappropriate fire regimes • Obligate seeders and facultative seeders are listed in Table 7-5 • Due to the extent of impact, fire-affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-5).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Upland Basalt Eucalypt Forest (UBEFS)

FIGURE 7-3 (A–C). THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR UPLAND BASALT EUCALYPT FOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-3 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.




Priority
5 [0 - 20]
4 [20 - 40]
3 [40 - 60]
2 [60 - 80]
1 [80 - 100]
N
0
5
10
km
Project PHOENIX
UBEFS Likely to occur scenario 3
Map Created: 16/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: UBEFS_L3_modZ
A4 Scale: 1:200,000



1,464,000
1,467,000
1,470,000
-4,049,996
-4,052,996
-4,055,996
-4,058,996
Priority
4 [20 - 40]
3 [40 - 60]
2 [60 - 80]
1 [80 - 100]
N
0
1.75
3.5
km
Project PHOENIX
UBEFS Likely to occur scenario 3
Map Created: 16/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: UBEFS_L3_modZ1
A4 Scale: 1:50,000

FIGURE 7-4. THE MEAN FIRE INTERVAL (MEANFI) FOR THE UPLAND BASALT EUCALYPT FORESTS OF THE SYDNEY BASIN BIOREGION (UBEFS) AND SURROUNDING AREA BASED ON THE NSW FIRE HISTORY DATA. WHITE POLYGONS DESIGNATE THE BOUNDS OF THE TEC AND RELATE TO THE AREAS IN FIGURE 7-4 (ABOVE).

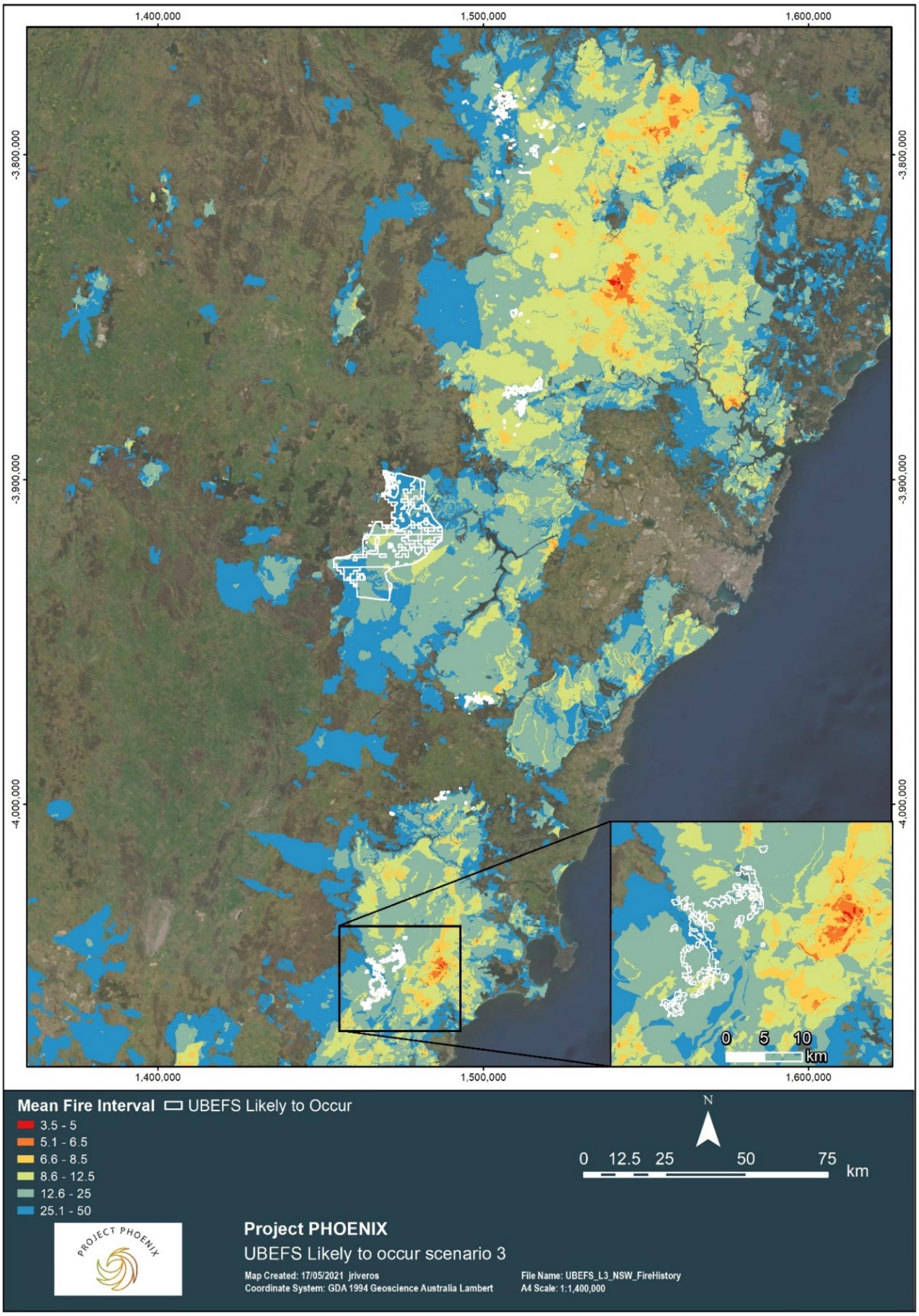


Table 7-5. A list of the fire sensitive species (obligate seeders (OS) and facultative seeders (FS)) from the Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion TEC species list and the fire-affected species within the TEC 'likely to occur' boundary. Life form: Herbaceous (H), Shrub (S), Tree (T), Climber/Vine (C). Seed storage: Soil (S), Transient (T), Canopy (C), Unknown (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia elata*	S	OS	S	
TEC species list	*Ajuga australis*	H	OS	UN	
TEC species list	*Austrocynoglossum latifolium*	H	OS	S	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Clematis aristata*	C	OS	S	
TEC species list	*Marsdenia flavescens*	C	OS	UN	
TEC species list	*Plantago debilis*	H	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Pyrrosia rupestris*	H	OS	UN	
TEC species list	*Senecio linearifolius*	H	OS	S	
TEC species list	*Sigesbeckia orientalis subsp. orientalis*	H	OS	S	
TEC species list	*Stellaria flaccida*	H	OS	S	
TEC species list	*Urtica incisa*	H	OS	S	
TEC species list	*Acacia melanoxylon*	S/T	FS	S	
TEC species list	*Acaena novae-zelandiae*	H	FS	UN	
TEC species list	*Carex breviculmis*	H	FS	S	
TEC species list	*Coprosma quadrifida*	S	FS	T	
TEC species list	*Cyathea leichhardtiana*	S	FS	T	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Dichelachne inaequiglumis*	H	FS	UN	
TEC species list	*Dichondra spp.*	H	FS	UN	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Eucalyptus elata*	T	FS	T	
TEC species list	*Eucalyptus oreades*	T	FS	C	
TEC species list	*Eustrephus latifolius*	C	FS	UN	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Hedycarya angustifolia*	S	FS	UN	
TEC species list	*Hibbertia scandens*	C	FS	S	
TEC species list	*Indigofera australis*	S	FS	S	
TEC species list	*Leucopogon lanceolatus*	S	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Myrsine howittiana*	S/T	FS	UN	
TEC species list	*Polyscias sambucifolia*	S	FS	S	
TEC species list	*Polystichum proliferum*	H	FS	UN	
TEC species list	*Prostanthera lasianthos*	S	FS	S	
TEC species list	*Stellaria pungens*	H	FS	S	
Fire-affected species	*Acacia clunies-rossiae*	S	OS	UN	Yes
Fire-affected species	*Acacia hamiltoniana*	S	OS	UN	Yes

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Banksia penicillata*	S	OS	C	Yes
Fire-affected species	*Boronia subulifolia*	S	OS	UN	Yes
Fire-affected species	*Cyphanthera scabrella*	S	OS	UN	Yes
Fire-affected species	*Darwinia taxifolia subsp. macrolaena*	S	OS	S	Yes
Fire-affected species	*Epacris gnidioides*	S	OS	UN	Yes
Fire-affected species	*Eucalyptus fraxinoides*	T	OS	C	Yes
Fire-affected species	*Grevillea aspleniifolia*	S	OS	S	Yes
Fire-affected species	*Grevillea baueri subsp. asperula*	S	OS	S	Yes
Fire-affected species	*Grevillea evansiana*	S	OS	S	Yes
Fire-affected species	*Hakea constablei*	S	OS	C	Yes
Fire-affected species	*Hakea dohertyi*	S	OS	C	Yes
Fire-affected species	*Persoonia mollis subsp. budawangensis*	S	OS	S	Yes
Fire-affected species	*Prostanthera saxicola var. montana*	S	OS	S	Yes
Fire-affected species	*Zieria caducibracteata*	S/T	OS	UN	Yes
Fire-affected species	*Zieria murphyi*	S	OS	S	Yes
Fire-affected species	*Boronia deanei subsp. deanei*	S	FS	UN	Yes
Fire-affected species	*Philotheca scabra subsp. latifolia*	S	FS	S	Yes
Fire-affected species	*Tetratheca ericifolia*	S	FS	S	
Fire-affected species	*Baloskion longipes*	H	RS	UN	Yes
Fire-affected species	*Callistemon subulatus*	S	RS	C	Yes
Fire-affected species	*Dillwynia stipulifera*	S	RS	S	Yes
Fire-affected species	*Eucalyptus bensonii*	T	RS	C	Yes
Fire-affected species	*Eucalyptus corticosa*	T	RS	C	Yes
Fire-affected species	*Eucalyptus cunninghamii*	T	RS	C	Yes
Fire-affected species	*Eucalyptus gregsoniana*	T	RS	T	Yes
Fire-affected species	*Eucalyptus stellulata*	T	RS	T	
Fire-affected species	*Grevillea imberbis*	S	RS	UN	Yes
Fire-affected species	*Grevillea renwickiana*	S	RS	T	Yes
Fire-affected species	*Leptospermum macrocarpum*	S	RS	C	Yes
Fire-affected species	*Luzula flaccida subsp. Long Anther (K.L.Wilson 828 et al.)*	H	RS	S	Yes
Fire-affected species	*Pterostylis crebra*	H	RS	UN	Yes
Fire-affected species	*Schoenus evansianus*	H	RS	UN	Yes
Fire-affected species	*Telopea mongaensis*	S	RS	UN	Yes
Fire-affected species	*Trachymene scapigera*	H	RS	UN	Yes
Fire-affected species	*Veronica blakelyi*	S	RS	T	
Fire-affected species	*Veronica brownii*	H	RS	UN	Yes
Fire-affected species	*Epacris sprengelioides*	S	UN	UN	Yes
Fire-affected species	*Kunzea aristulata*	S	UN	UN	Yes
Fire-affected species	*Leptospermum petraeum*	S	UN	UN	Yes
Fire-affected species	*Veronica lithophila*	H	UN	UN	Yes

7.4 TEC 2: Eastern Stirling Range Montane Heath and Thicket

7.4.1 Description

The Eastern Stirling Range Montane Heath and Thicket TEC is contained within the Stirling Range National Park in Western Australia from altitudes 900m to 1090m above sea level; however, there are two occurrences around 750m.[69] It extends from Ellen Peak to Coyanarup Peak with 3.34km^2 over 10 mountain summits. The community consists of heath and thicket, with scrub vegetation on skeletal soils and key characteristic species include *Andersonia axilliflora* (giant andersonia), *Kunzea montana* (mountain kunzea) and *Banksia brownii* (Brown's banksia, feather-leaved banksia).[69] In combination with inappropriate fire regimes, *Phytophthora cinnamomi* dieback is a key threat to this community. Some of the most fire sensitive species (Proteaceaous obligate seeders with serotinous seed storage) are also the species most susceptible to *P. cinnamomic*.[70,71]

This highlights the importance of interacting threats in communities recovering from disturbance. For montane communities with high proportions of fire sensitive species, longer inter-fire periods may be required due to generally slower growth rates that reduce the speed of post-fire recovery.

7.4.2 Species and fire response traits

In the Eastern Stirling Range Montane Heath and Thicket, there are 79 plant species representing 55 different genera. Of these plant species, 53% (n = 42) are obligate seeders, 3% (n = 2) are facultative seeders and 6% (n = 5) are resprouters, with 38% (n = 30) having an unverified fire response (Table 7-6). Shrub species make up 66% (n = 52) of all species present, and herbaceous species make up 34% (n = 27) (Table 7-6). Fire sensitive obligate seeder species had either soil-stored (64%) or canopy-stored (29%) seed (Table 7-6).

Table 7-6. The number and per cent of each fire response (obligate seeder (OS), facultative seeder (FS), resprouter (RS), unknown) of each life form (herbaceous and shrub)

	Number (and %) of each fire response				
Life form	OS	FS	RS	Unknown	Total count
Herbaceous	8 (29)	0 (0)	1 (4)	18 (67)	**27**
Shrub	34 (65)	2 (4)	4 (8)	12 (23)	**52**
Total count	**42**	**2**	**5**	**30**	**79**

7.4.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-7).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Eastern Stirling Range Montane Heath and Thicket and outlined below and described in Appendix 2 (Section 11.2).

TEC 2: Eastern Stirling Range Montane Heath and Thicket

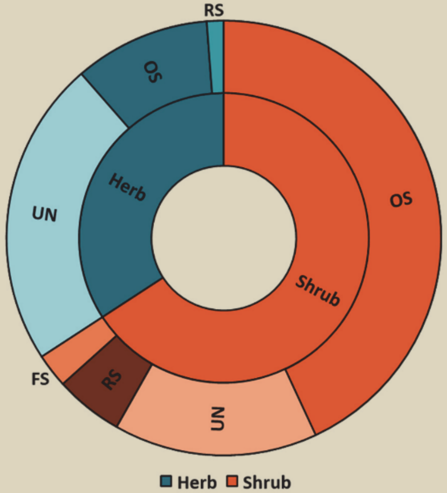
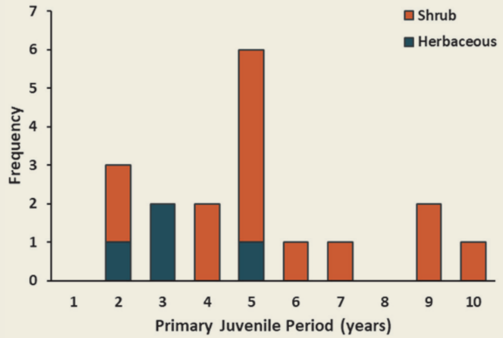
Community Characteristics	Fire Response	Life History and Fire Response	Primary Juvenile Periods for Fire Sensitive Species
Number of species: • 79 [55 genera] **Shrubs:** • 66% (n = 52) **Herbaceous:** • 34% (n = 27)	**Resprouters:** • 6% (n = 5) **Obligate seeders:** • 53% (n= 42) **Facultative seeders:** • 3% (n = 2) **Unknown:** • 38% (n = 30)	**Resprouters (RS):** • Ranged from 4% of herbaceous species to 8% of shrubs **Facultative seeders (FS):** • Low proportion of shrubs (4%) **Obligate seeders (OS):** • Higher proportion of shrubs (65%) **For each life form:** • Higher unknown (UN) fire responses in herbaceous species (67%) compared to shrubs (23%) 	**The frequency of primary juvenile periods for sensitive species[1] of different life forms** **General recommendation for fire free interval:** • > 25 years **Minimum fire interval based on primary juvenile period:** • Shrubs = 4-20 years • Herbaceous = 4-10 years  [1]Obligate seeders

TABLE 7-7. PRIORITY AREAS 1 AND 2 EASTERN STIRLING RANGE MONTANE HEATH AND THICKET: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	542.0	63.6	8	8-8	4.9	2-5	41.1	41-41.3	3972.4	3036.4-5197.1
2 (40-60)	128.4	15.1	8	8-8	4	3-5	41.1	41-41.3	4047.4	2751.4-5080.4
3 (20-40)	1.0	0.1	8	8-8	4	4-4	41.0	41-41	5040.6	4982-5099
4 (0-20)	180.8	21.2	8	8-8	2.7	2-5	41.1	41-41.3	4419.5	3883.3-5000

See Figure 7-6 for distribution of each priority area

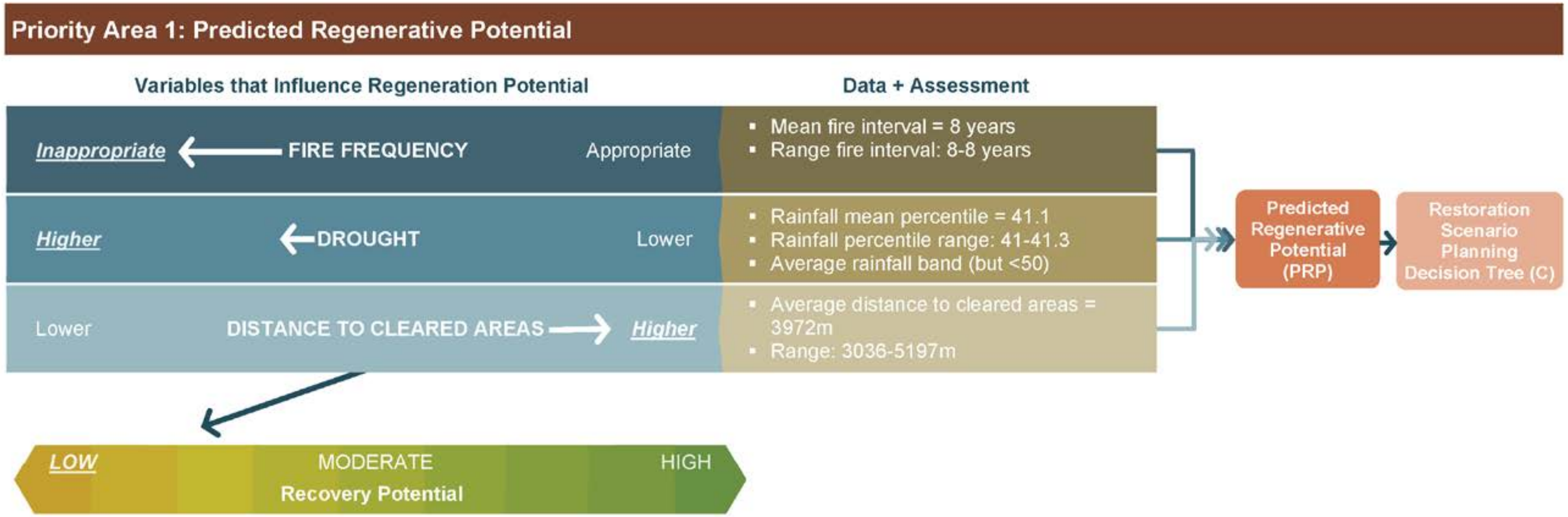
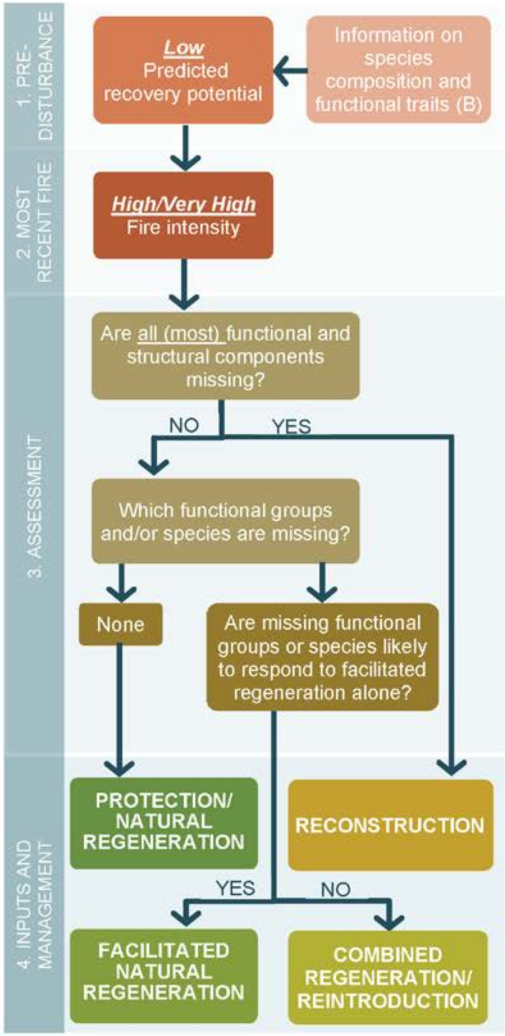


TABLE 7-8. RESTORATION APPROACHES FOR EASTERN STIRLING RANGE MONTANE HEATH AND THICKET



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnant patches** • **Build insurance populations in *Phytophthora* free areas**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Phytophthora dieback (*Phytophthora cinnamomic*) infestation • Inappropriate fire regimes • Grazing • Recreational activity disturbances e.g., litter, track braiding, erosion • Climate change	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Aira spp.* • *Avena barbata* (Bearded Oat) • *Briza minor* (Shivery Grass) • *Bromus diandrus* • *Centaurium spp.* • *Ehrharta calycina* (Perennial Veldt Grass) • *Eragrostis curvula* (African Lovegrass) • *Moraea setifolia* • *Phalaris minor* (Lesser Canary Grass) • *Romulea rosea* (Guilford Grass) • *Trifolium spp.*	**Weed removal** (see facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and facultative seeders are listed in Table 7-9. • Obligate seeders susceptible to Phytophthora dieback are also identified	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to reduce the risk of *Phytophthora*, maximise genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Eastern Stirling Range Montane Heath and Thicket

FIGURE 7-5. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR EASTERN STIRLING RANGE MONTANE HEATH AND THICKET. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-7 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

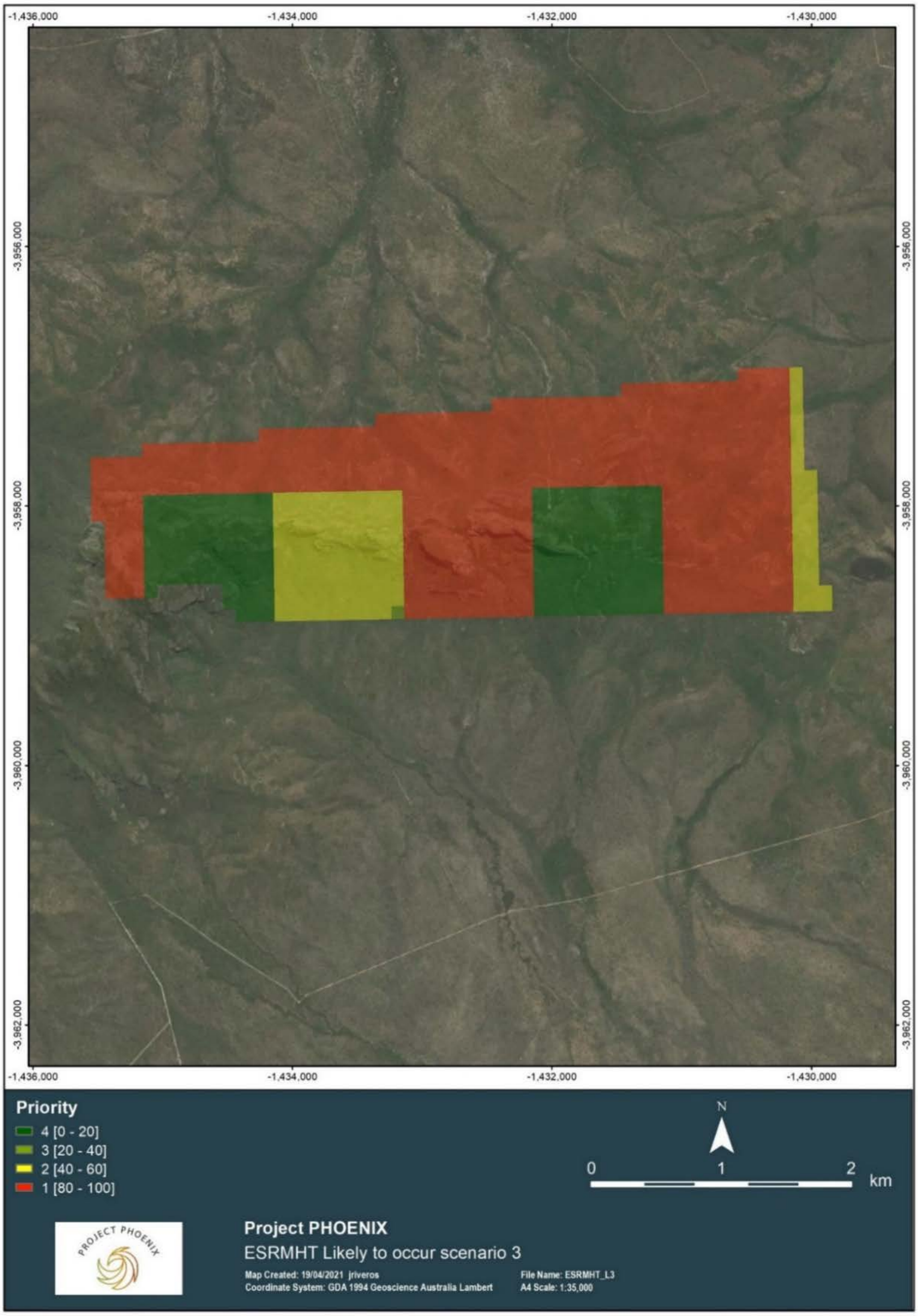


Table 7-9. A list of the fire sensitive species (obligate seeders (OS) and facultative seeders (FS)) from the Eastern Stirling Range Montane Heath and Thicket TEC species list and the fire-affected species within the TEC 'likely to occur' boundary. Life form: Herbaceous (H), Shrub (S), Tree (T), Climber/Vine (C). Seed storage: Soil (S), Transient (T), Canopy (C), Unknown (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	SUSCEPTIBLE TO PHYTOPHTHORA
TEC species list	*Acacia drummondii subsp. elegans*	S	OS	S	
TEC species list	*Actinotus rhomboideus*	S	OS	S	
TEC species list	*Adenanthos filifolius*	S	OS	S	Y
TEC species list	*Andersonia axilliflora*	S	OS	S	Y
TEC species list	*Andersonia echinocephala*	S	OS	S	Y
TEC species list	*Aotus genistoides*	S	OS	S	
TEC species list	*Banksia brownii*	S	OS	C	Y
TEC species list	*Banksia concinna*	S	OS	C	Y
TEC species list	*Banksia formosa*	S	OS	C	Y
TEC species list	*Banksia montana*	S	OS	C	Y
TEC species list	*Banksia solandri*	S	OS	C	Y
TEC species list	*Banksia oreophila*	S	OS	C	Y
TEC species list	*Beaufortia anisandra*	S	OS	C	Y
TEC species list	*Billardiera drummondii*	H	OS	S	
TEC species list	*Cassytha glabella*	H	OS	UN	
TEC species list	*Darwinia collina*	S	OS	S	Y
TEC species list	*Darwinia nubigena (sp. Stirling Range)*	S	OS	UN	Y
TEC species list	*Darwinia squarrosa*	S	OS	UN	Y
TEC species list	*Deyeuxia drummondii*	H	OS	S	
TEC species list	*Gastrolobium leakeanum*	S	OS	S	Y
TEC species list	*Hibbertia argentea*	S	OS	S	Y
TEC species list	*Isopogon latifolius*	S	OS	C	Y
TEC species list	*Kunzea montana*	S	OS	S	Y
TEC species list	*Lambertia fairallii*	S	OS	C	Y
TEC species list	*Lambertia uniflora*	S	OS	C	Y
TEC species list	*Latrobea colophona*	S	OS	S	Y
TEC species list	*Leptomeria squarrulosa*	S	OS	C	
TEC species list	*Leucopogon atherolepis*	S	OS	S	Y
TEC species list	*Leucopogon gnaphalioides*	S	OS	S	Y
TEC species list	*Microcorys sp. Stirling Range*	S	OS	S	
TEC species list	*Muiriantha hassellii*	S	OS	S	
TEC species list	*Persoonia micranthera*	S	OS	S	Y
TEC species list	*Platysace sp. Stirling Range*	S	OS	S	Y
TEC species list	*Sphenotoma drummondii*	S	OS	S	Y
TEC species list	*Sphenotoma sp. Stirling Range*	S	OS	S	Y
TEC species list	*Spyridium montanum*	S	OS	S	
TEC species list	*Stylidium bellum*	H	OS	S	
TEC species list	*Stylidium keigheryi*	H	OS	S	
TEC species list	*Stylidium rosulatum*	H	OS	S	
TEC species list	*Stylidium sp. Bluff Knoll*	H	OS	S	
TEC species list	*Taxandria floribunda*	S	OS	C	
TEC species list	*Xyris exilis*	H	OS	S	
TEC species list	*Astartea montana*	S	FS	S	
TEC species list	*Daviesia obovata*	S	FS	S	Y

7.5 TEC 3: Temperate Highland Peat Swamps on Sandstone

7.5.1 Description

The ecological community occurs at altitudes ranging from 600m to 1100m above sea level in permanent and temporary swamps on a sandstone substrate.[72] As of 2005, there was 3000 hectares remaining across the Blue Mountains, Southern Highlands, Lithgow and Bombala regions of New South Wales.[72] Drier areas contain sedges and shrubs while sphagnum bogs and fens occur in the wetter areas.[73]

Nationally threatened plant species found in this community include *Pultenaea glabra* (Swamp Bush-pea), *Gentiana wingecarribiensis* (Wingecarribee Gentian) and *Rulingia prostrata* (Dwarf Kerrawang).[73]

7.5.2 Fire response traits

In the Temperate Highland Peat Swamps, there are 65 plant species representing 55 different genera. Species composition across the TEC may differ given that patches span a range of environments (slope, aspect, soils) and vary in disturbance history. Sites may also contain other species not listed here (species that are rare, patchy and/or have low abundance).

Of these plant species, 55% (n = 33) are resprouters, 17% (n = 14) are facultative seeders and 8% (n = 5) are obligate seeders, with 20% (n = 13) having an unverified fire response (Table 7-10). Herbaceous species make up 68% (n = 44) of all species present, shrub species make up 29% (n = 19) and tree species make up 3% (n = 2) (Table 7-10).

TABLE 7-10. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS AND SHRUB)

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	1 (2)	7 (16)	24 (55)	12 (27)	**44**
Shrub	4 (21)	7 (37)	7 (37)	1 (5)	**19**
Tree	0	0	2 (100)	0	**2**
Total count	**5**	**14**	**33**	**13**	**65**

7.5.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-11).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Temperate Highland Peat Swamps and outlined below and described in Appendix 2 (Section 11.3).

TEC 3: Temperate Highland Peat Swamps on Sandstone[74]

Community Characteristics

Number of species:
- 65 [55 genera]

Trees:
- 3% (n = 2)

Shrubs:
- 29% (n = 19)

Herbaceous:
- 68% (n = 44)

Fire Response

Resprouters:
- 55% (n = 33)

Obligate seeders:
- 8% (n= 5)

Facultative seeders:
- 17% (n = 14)

Unknown:
- 20% (n = 13)

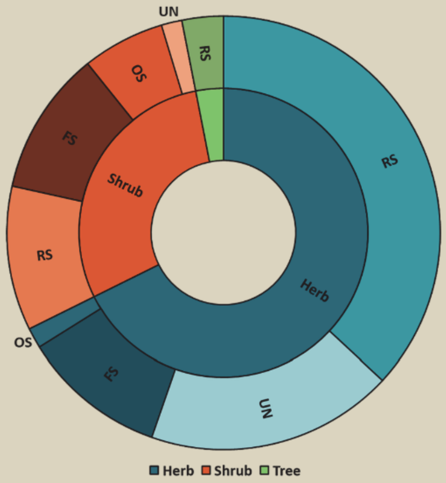
Life History and Fire Response

Resprouters (RS):
- Highest proportion of shrubs (37%), herbaceous species (55%) and trees (100%)

Obligate seeders (OS):
- Ranged from 2% of herbaceous species to 21% of shrubs

Facultative seeders (FS):
- Higher proportion of shrubs (37%) and herbaceous species (16%)

For each life form:
- 27% of herbaceous species have unknown (UN) fire responses

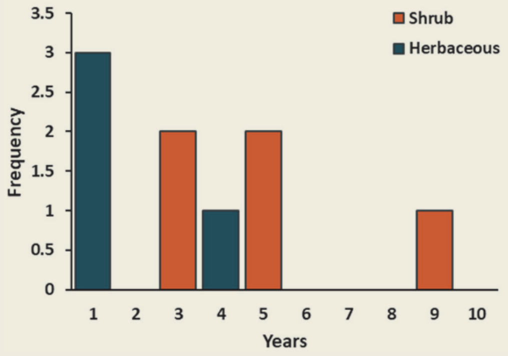


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 11-25 years[2]

Minimum fire interval based on primary juvenile period:
- Shrubs = 6-18 years
- Herbaceous = 2-8 years



[1]Information only available for facultative seeders
[2]Hammil *et al.*[74]

TABLE 7-11. PRIORITY AREAS 1 AND 2 TEMPERATE HIGHLAND PEAT SWAMPS: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	44.6	3.4	3.1[a]	2.4-3.8	4.7	2-5	45.2	43.8-46	180.4	0-360.6
2 (60-80)	188.5	14.3	2.8[b]	1.8-4.2	4.3	2-5	45.3	41.8-46.8	227.4	0-854.4
3 (40-60)	678.4	51.5	2.6	1.8-4.2	3.6	2-5	45.2	41.8-46.8	235.1	0-1216.6
4 (20-40)	251.4	19.1	2.5	1.8-4.2	2.9	2-5	44.3	41.8-46.8	346.5	0-922
5 (0-20)	154.4	11.7	2	1.8-4.2	2.5	2-5	43.2	42.6-46.8	905.1	400-2119

Finer scale analysis of NSW fire data: Priority area 1[a] = 16.0 years (8.3 – 25 years); Priority area 2[b] = 23.3 (8.5 – 50 years)

See Figure 7-7 for distribution of each priority area

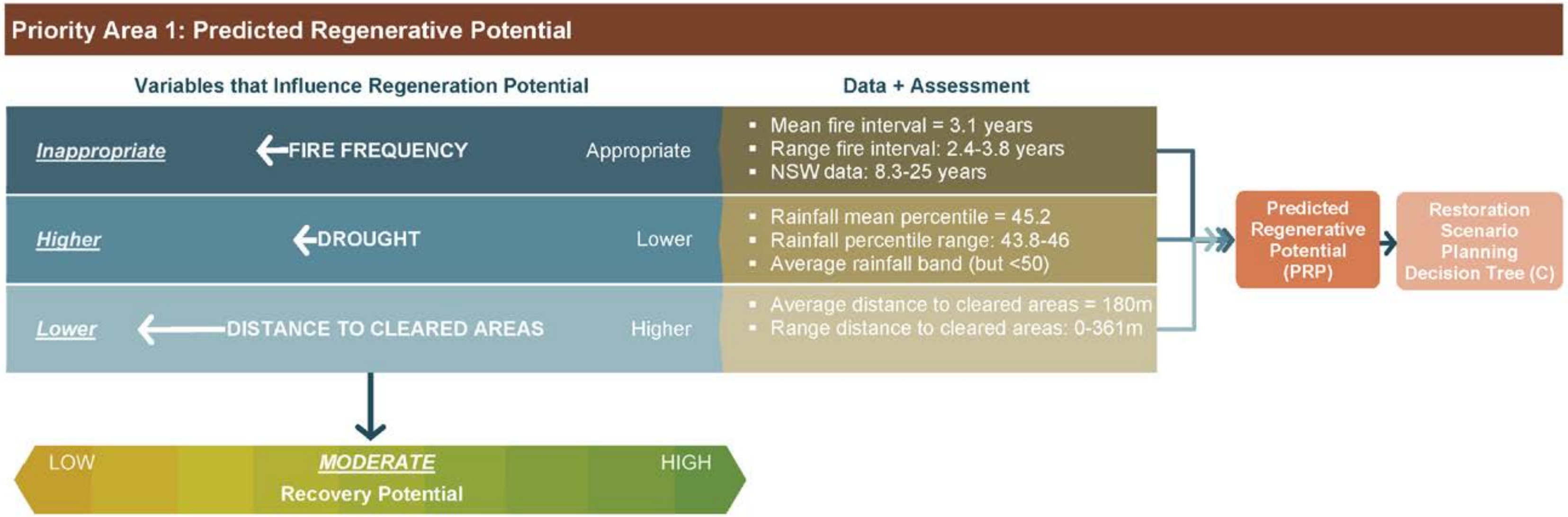
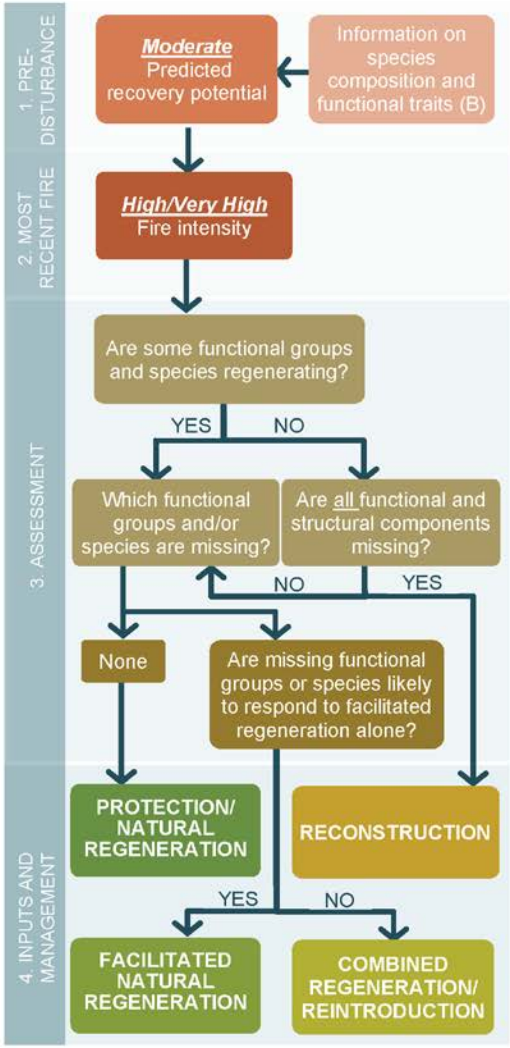


TABLE 7-12. RESTORATION APPROACHES FOR TEMPERATE HIGHLAND PEAT SWAMPS



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnant patches** • **Extend patch size into suitable habitat** • **Improve connectivity between patches**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Grazing and trampling by stock • Concentrated urban runoff causing channelisation and bank slump • Erosion • Drying of the swamp due to channelization • Invasion and establishment of weed species • Invasive fauna • Clearing for rural, agricultural and urban development • Inappropriate fire regimes	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Acacia podalyriifolia* • *Ageratina riparia* (Mistflower) • *Berberis aristate* (Barberry) • *Buddleia davidii* (Butterfly Bush) • *Bryophyllum spp.* • *Echium plantagineum* (Paterson's Curse) • *Eragrostis curvula* (African Lovegrass) • *Erica lusitanica* (Portuguese Heath) • *Hyparrhenia hirta* (Coolatai Grass) • *Ligustrum spp.* (Privet) • *Ochna serrulate* • *Ricinus communis* • *Rubus fruticosus* (Blackberry)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-13. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-13).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Temperate Highland Peat Swamps

FIGURE 7-6. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR TEMPERATE HIGHLAND PEAT SWAMPS. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-11 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

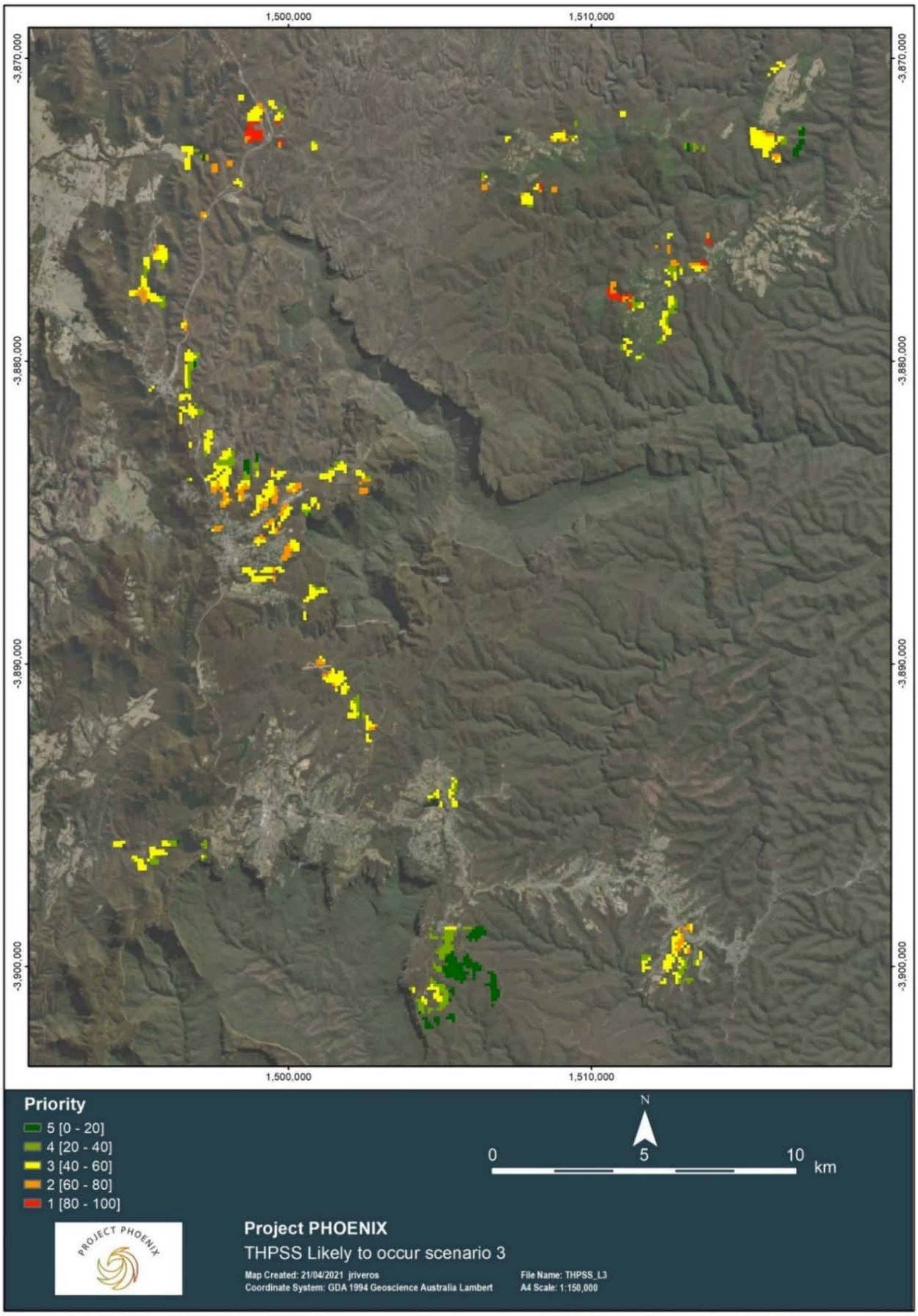


FIGURE 7-7. THE MEAN FIRE INTERVAL (MEANFI) FOR THE TEMPERATE HIGHLAND PEAT SWAMPS ON SANDSTONE (THPSS) AND SURROUNDING AREA BASED ON THE NSW FIRE HISTORY DATA. WHITE POLYGONS DESIGNATE THE BOUNDS OF THE TEC AND RELATE TO THE AREAS IN FIGURE 7-7 (ABOVE).

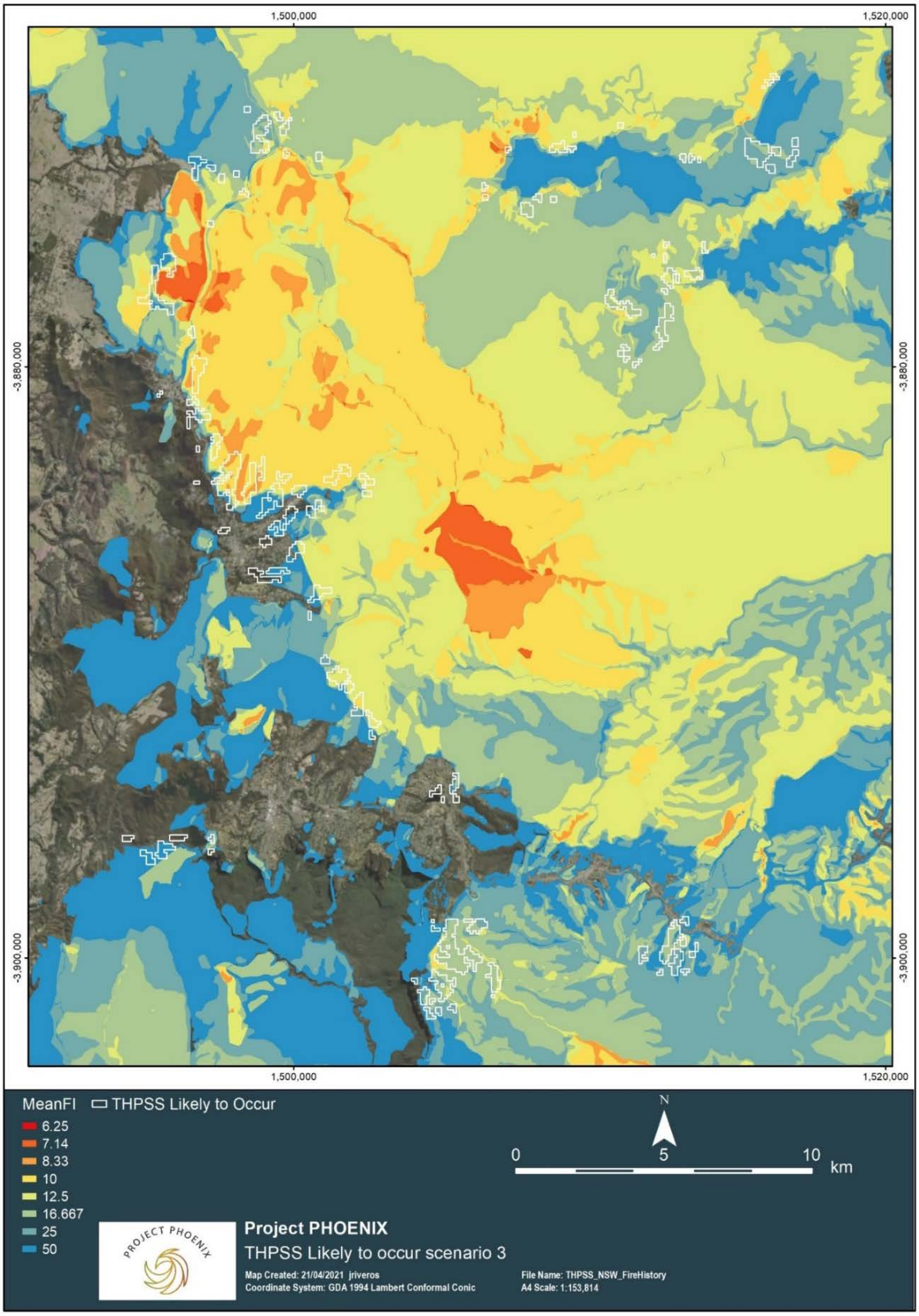


Table 7-13. A list of the fire sensitive species (obligate seeders (OS) and facultative seeders (FS)) from the Temperate Highland Peat Swamps on Sandstone TEC species list and the fire-affected species within the TEC 'likely to occur' boundary. Life form: Herbaceous (H), Shrub (S), Tree (T), Climber/Vine (C). Seed storage: Soil (S), Transient (T), Canopy (C), Unknown (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Commersonia prostrata*	S	OS	S	
TEC species list	*Gentiana wingecarribiensis*	H	OS	S	
TEC species list	*Grevillea acanthifolia*	S	OS	S	
TEC species list	*Pultenaea glabra*	S	OS	S	
TEC species list	*Pultenaea parrisiae*	S	OS	S	
TEC species list	*Boronia deanei*	S	FS	UN	
TEC species list	*Dichelachne inaequiglumis*	H	FS	UN	
TEC species list	*Dillwynia sericea*	S	FS	S	
TEC species list	*Epacris microphylla*	S	FS	S	
TEC species list	*Epacris obtusifolia*	S	FS	S	
TEC species list	*Epacris paludosa*	S	FS	S	
TEC species list	*Hibbertia cistiflora*	S	FS	S	
TEC species list	*Lepidosperma evansianum*	H	FS	S	
TEC species list	*Leptospermum squarrosum*	S	FS	C	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Luzula modesta*	H	FS	S	
TEC species list	*Schoenus apogon*	H	FS	S	
TEC species list	*Sprengelia incarnata*	H	FS	S	
TEC species list	*Todea barbara*	H	FS	T	
Fire-affected species	*Acacia hamiltoniana*	S	OS	UN	Yes
Fire-affected species	*Hakea constablei*	S	OS	C	Yes
Fire-affected species	*Prostanthera saxicola var. montana*	S	OS	S	Yes
Fire-affected species	*Zieria murphyi*	S	OS	S	Yes
Fire-affected species	*Eucalyptus baeuerlenii*	T	RS	T	Yes
Fire-affected species	*Eucalyptus cunninghamii*	T	RS	C	Yes
Fire-affected species	*Eucalyptus gregsoniana*	T	RS	T	Yes
Fire-affected species	*Leptospermum macrocarpum*	S	RS	C	Yes
Fire-affected species	*Pterostylis crebra*	H	RS	UN	Yes
Fire-affected species	*Veronica brownii*	H	RS	UN	Yes
Fire-affected species	*Celmisia longifolia*	H	UN	UN	
Fire-affected species	*Epacris sprengelioides*	S	UN	UN	Yes
Fire-affected species	*Leptospermum petraeum*	S	UN	UN	Yes

7.6 TEC 4: New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands

7.6.1 Description

The New England Peppermint (*Eucalyptus nova-angilca*) Grassy Woodlands occur from southern Queensland to northern New South Wales with a tree canopy co-dominated or dominated by the New England Peppermint (*Eucalyptus nova-anglica*).[75] Other tree species that may co-dominate include Snow Gum (*Eucalyptus pauciflora*) and Mountain Gum (*Eucalyptus dalrympleana subsp. heptantha*).[75] Shrubs are sparse or absent in the understory which consists of a diverse layer of herbs and grasses.[75]

7.6.2 Fire response traits

In the New England Peppermint Grassy Woodland, there are 101 plant species representing 78 different genera. Of these plant species, 49% (n = 49) are resprouters, 30% (n = 30) are facultative seeders and 13% (n = 13) are obligate seeders, with 9% (n = 9) having an unverified fire response. Herbaceous species make up 78% (n = 79) of all plant species present, shrubs make up 14% (n = 14), trees make up 5% (n = 5) and climbers/vines make up 3% (n = 3) (Table 7-14).

Table 7-14. The number and per cent of each fire response (obligate seeder (OS), facultative seeder (FS), resprouter (RS), unknown) of each life form (herbaceous, shrub, tree, climber/vine)

	Number (and %) of each fire response				
Life form	OS	FS	RS	Unknown	Total count
Herbaceous	11 (14)	24 (30)	36 (46)	8 (10)	79
Shrub	2 (14)	4 (29)	8 (57)	0 (0)	14
Tree	0 (0)	0 (0)	4 (80)	1 (20)	5
Climber/Vine	0 (0)	2 (67)	0 (0)	1 (33)	3
Total count	13	30	49	9	101

7.6.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-15).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the New England Peppermint Grassy Woodland and outlined below and described in Appendix 2 (Section 11.4).

TEC 4: New England Peppermint (Eucalyptus Nova-Anglica) *Grassy Woodlands*

Community Characteristics

Number of species:
- 101 [78 genera]

Trees:
- 5% (n = 5)

Shrubs:
- 14% (n = 14)

Herbaceous:
- 78% (n = 79)

Climbers/Vines:
- 3% (n = 3)

Fire Response

Resprouters:
- 49% (n = 49)

Obligate seeders:
- 13% (n= 13)

Facultative seeders:
- 30% (n = 30)

Unknown:
- 9% (n = 9)

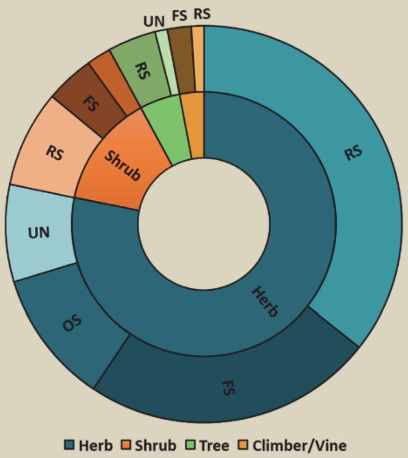
Life History and Fire Response

Resprouters (RS):
- Highest proportion of herbaceous species (46%), shrubs (57%) and trees (80%)

Obligate seeders (OS):
- Low proportion of herbaceous species (14%) and shrubs (14%)

Facultative seeders (FS):
- Ranged from 29% of shrubs to 67% of climbers/vines

For each life form:
- Unknown (UN) fire responses varied from 10% of herbaceous to 33% of climbers

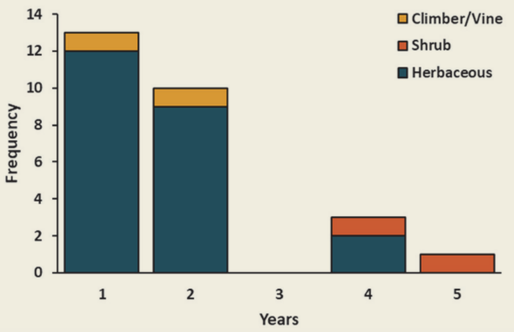


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 10 -15 years
- But depending on composition, site productivity and historical fire regime, this can be <10 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 8-10 years
- Herbaceous = 2-8 years
- Climbers/vines = 2-4 years



[1]Obligate seeders and facultative seeders

TABLE 7-15. PRIORITY AREAS 1 AND 2 NEW ENGLAND PEPPERMINT GRASSY WOODLANDS: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	144.9	1.2	2.0[a]	1.5-3.8	4.9	3-5	39.8	38.8-41.1	1288.1	0-2624.9
2 (60-80)	2300.7	19.3	2.2[b]	1.5-16.7	4.3	2-5	40.7	37.8-45.9	3526.5	0-9213
3 (40-60)	5432.7	45.5	3.2	1.5-50	3.5	2-5	41.2	33.2-46	3812.1	0-9838.7
4 (20-40)	2667.7	22.3	20.7	5.0-50	3.7	2-5	39.5	32.7-45.9	478.8	0-2751.4
5 (0-20)	1401.6	11.7	40.9	16.7-50	3.6	2-5	35.3	32.3-41.8	1028.5	0-3401.5

Finer scale analysis of NSW fire data: Priority area 1[a] = 18.4 years (6.3 – 50 years); Priority area 2[b] = 23.3 (6.3 – 50 years)

See Figure 7-9 for distribution of each priority area

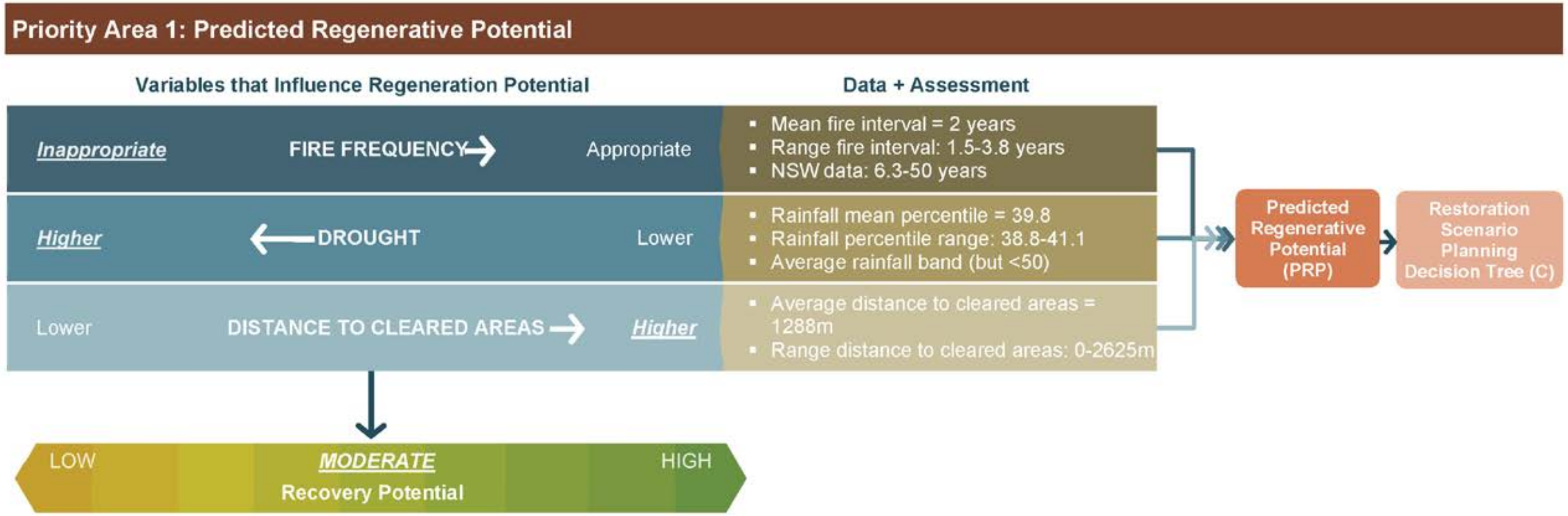
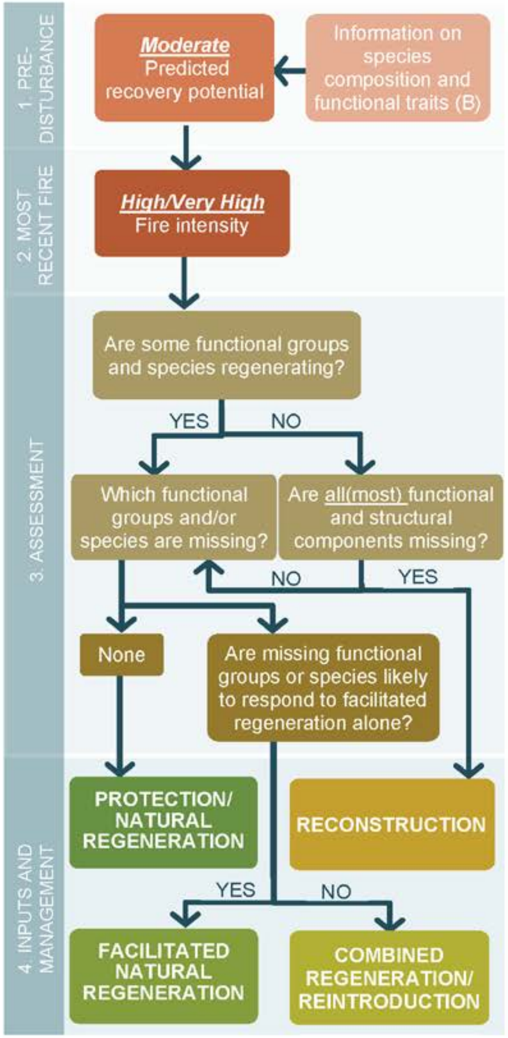


TABLE 7-16. RESTORATION APPROACHES FOR NEW ENGLAND PEPPERMINT GRASSY WOODLANDS



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Invasion and establishment of transformer weed species • Climate change • Clearing from rural, agricultural and urban development • Grazing • Eucalypt dieback • • Inappropriate fire regimes • Reduced pollination and lack of seed	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Aira elegantissima (Delicate Hairgrass)* • *Briza minor* (Shivery Grass) • *Bromus brevis* • *Bromus hordeaceus* (Soft Brome) • *Cirsium vulgare* (Spear Thistle) • *Gamochaeta coarctata* • *Hypochaeris radicata* (Catsear, Flatweed) • *Leucanthemum vulgare* (Ox-eye Daisy) • *Petrorhagia nanteuilii* • *Plantago lanceolata* (Lamb's Tongues, Plantain) • *Vulpia myuros* (Rat's Tail Fescue)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-17. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-17).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for New England Peppermint Grassy Woodlands

FIGURE 7-8. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR NEW ENGLAND PEPPERMINT GRASSY WOODLANDS. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-15 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

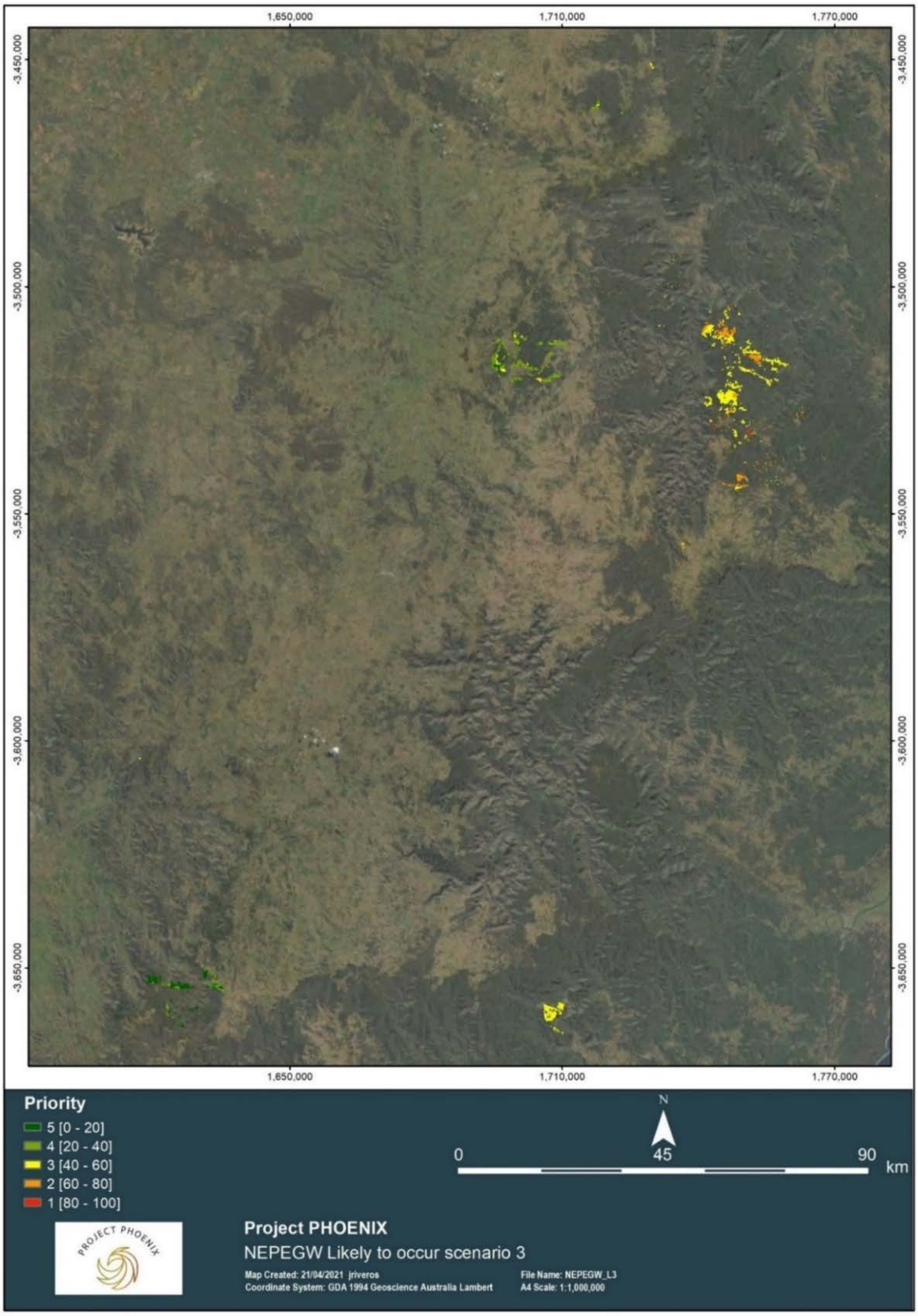


TABLE 7-17. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE NEW ENGLAND PEPPERMINT (*EUCALYPTUS NOVA-ANGILCA*) GRASSY WOODLANDS TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Ammobium alatum*	H	OS	T	
TEC species list	*Craspedia variabilis*	H	OS	UN	
TEC species list	*Crassula sieberiana*	H	OS	S	
TEC species list	*Cymbonotus lawsonianus*	H	OS	UN	
TEC species list	*Dillwynia sieberi*	S	OS	S	
TEC species list	*Einadia nutans*	H	OS	UN	
TEC species list	*Gonocarpus micranthus*	H	OS	S	
TEC species list	*Kunzea parvifloria*	S	OS	S	
TEC species list	*Lachnagrostis aemula*	H	OS	UN	
TEC species list	*Lachnagrostis filiformis*	H	OS	UN	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Sorghum leiocladum*	H	OS	UN	
TEC species list	*Thesium australe*	H	OS	S	
TEC species list	*Acaena novae-zelandiae*	H	FS	UN	
TEC species list	*Chrysocephalum apiculatum*	H	FS	S	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Dichopogon fimbriatus*	H	FS	UN	
TEC species list	*Drosera peltata*	H	FS	T	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Euchiton gymnocephalus*	H	FS	T	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Gonocarpus tetragynus*	H	FS	S	
TEC species list	*Haloragis heterophylla*	H	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Hybanthus monopetalus*	S	FS	S	
TEC species list	*Hydrocotyle laxiflora*	H	FS	UN	
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Leucopogon lanceolatus var. lanceolatus*	S	FS	S	
TEC species list	*Melichrus urceolatus*	S	FS	S	
TEC species list	*Opercularia aspera*	H	FS	S	
TEC species list	*Oxalis exilis*	H	FS	S	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Poa sieberiana*	H	FS	UN	
TEC species list	*Pultenaea microphylla*	S	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Schoenus apogon*	H	FS	S	
TEC species list	*Scleranthus biflorus*	H	FS	S	
TEC species list	*Sporobolus creber*	H	FS	UN	
TEC species list	*Stackhousia monogyna*	H	FS	S	
TEC species list	*Stellaria angustifolia*	H	FS	S	
TEC species list	*Stylidium graminifolium*	H	FS	S	
TEC species list	*Veronica calycina*	H	FS	T	
TEC species list	*Wahlenbergia communis*	H	FS	S	
TEC species list	*Wahlenbergia stricta subsp. stricta*	H	FS	S	
Fire-affected species	*Hibbertia villosa*	S	OS	UN	Yes
Fire-affected species	*Persoonia rufa*	S	OS	S	Yes
Fire-affected species	*Deyeuxia reflexa*	H	RS	UN	Yes
Fire-affected species	*Eucalyptus olida*	T	RS	UN	Yes
Fire-affected species	*Eucalyptus stellulata*	T	RS	T	
Fire-affected species	*Persoonia procumbens*	S	RS	UN	Yes

7.7 TEC 5: Lowland Rainforest of Subtropical Australia

7.7.1 Description

The Lowland Rainforest of Subtropical Australia ranges from Maryborough (Queensland) to Clarence River (New South Wales).[76] Its upper limit is typically 300m above sea level on alluvial and basalt soils with high annual rainfall.[76] The community generally has a canopy cover of more than 70 per cent with a moderate to tall closed forest comprising of a diverse range of tree and vine species.[76,77] Threatened flora species in this TEC include *Diploglottis campbellii* (Small-leaved Tamarind), *Gossia fragrantissima* (Sweet Myrtle) and *Owenia cepiodora* (Onion Cedar).[78]

7.7.2 Fire response and life history traits

Rainforests are generally fire-sensitive communities which have not evolved with frequent fire, or when subject to fire, generally only experience lower intensity fire events. Consequently, there is more limited information on species' responses to fire, and this may vary with fire intensity. For example, *Ehretia acuminata* and *Sarcomelicope simplicifolia* are both obligate seeders that can resprout after low, but not high, intensity fire.

Mechanisms that enable recovery after other disturbances (e.g. floods, tree fall), may also enable rainforest species to resprout after fire. For this TEC, data on fire response is being collected after the 2019/20 fires and could be used in the future to refine and amend currently available data.

In the Lowland Rainforest TEC there were 119 species listed, representing 106 genera. However, the total species list is likely to be larger than the 119 species, with species present at only one or two sites or in low abundance. Of these 119 plant species, 35% (n = 42) are classified as resprouters, 16% (n = 19) obligate seeders, 8% (n = 10) facultative seeders and 1% (n = 1) are geophytes, with 40% (n = 47) having an unverified fire response (Table 7-18). Trees represent 47% (n = 56) of all plant species present, shrubs 23% (n = 27), climbers/vines 20% (n = 24) and herbs 10% (n = 12) (Table 7-18).

Table 7-18. The number and per cent of each fire response (obligate seeder (OS), facultative seeder (FS), resprouter (RS), geophyte (GEO), unknown) of each life form (herbaceous, shrub, tree, climber/vine).

	Number (and %) of each fire response					
Life form	OS	FS	RS	GEO	Unknown	Total count
Herbaceous	4 (33)	0 (0)	5 (42)	0 (0)	**3 (25)**	**12**
Shrub	4 (15)	5 (18)	8 (30)	0 (0)	**10 (37)**	**27**
Tree	11 (19)	1 (2)	20 (36)	0 (0)	**24 (43)**	**56**
Climber/Vine	0 (0)	3 (12)	10 (42)	1 (4)	**10 (42)**	**24**
Total count	**19**	**10**	**42**	**1**	**47**	**119**

7.7.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-19).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Lowland Rainforest and outlined below and described in Appendix 2 (Section 11.5).

TEC 5: Lowland Rainforest of Subtropical Australia

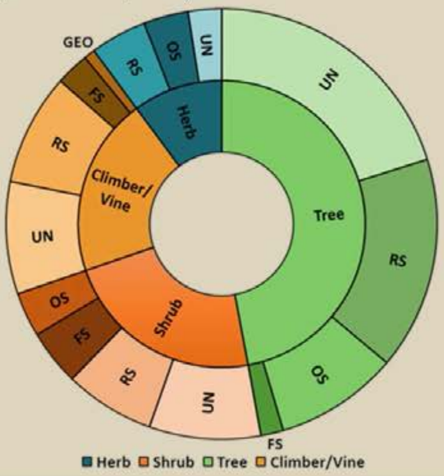
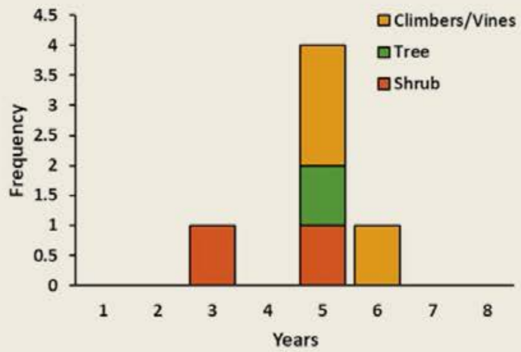
Community Characteristics	Fire Response	Life History and Fire Response	Primary Juvenile Periods for Fire Sensitive Species
Number of species: • 119 [106 genera] **Trees:** • 47% (n = 56) **Shrubs:** • 23% (n = 27) **Herbaceous:** • 10% (n = 12) **Climbers/Vines:** • 20% (n = 24)	**Resprouters:** • 35% (n = 42) **Obligate seeders:** • 16% (n= 19) **Facultative seeders:** • 8% (n = 10) **Geophytes:** • 1% (n = 1) **Unknown:** • 40% (n = 47)	**Resprouters (RS):** • Ranged from 30% of shrubs to 42% of herbaceous species **Obligate seeders (OS):** • Higher proportion of herbaceous species (33%) and trees (19%) **Facultative seeders (FS):** • Higher proportion of shrubs (18%) and climbers/vines (12%) **For each life form:** • High proportion of unknown (UN) fire responses (25-43% of species) 	**The frequency of primary juvenile periods for sensitive species[1] of different life forms** **General recommendation for fire free interval:** • > 25 years (fire should be avoided) **Minimum fire interval based on primary juvenile period:** • Shrubs = 6-10 years • Climbers/vines = 10-12 years • Trees = 10 years  [1]All data from facultative seeders

TABLE 7-19. PRIORITY AREAS 1 AND 2 LOWLAND RAINFOREST: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (20-40)	6230	20.4	35[a]	3.6-50	3.4	2-5	38.8	32.5-47	1306	0-4386
2 (0-20)	5663	18.5	39[b]	3.9-50	2.7	2-5	41.9	32.3-47	1682	0-5045
3 (80-100)	6756	22.1	5.4	1.1-50	4.5	2-5	41	31.8-47.4	708	0-2640
4 (60-80)	6190	20.3	5.7	1.1-25	3.7	2-5	40.8	31.8-47.4	1425	0-9044
5 (40-60)	5719	18.7	6	1.5-50	2.8	2-5	41.8	31.8-47.4	2563	0-9456

Finer scale analysis of NSW fire data: Priority area 1[a] = 37.7 years (5.6 – 50 years); Priority area 2[b] = 36.4 (5.0 – 50 years)

See Figure 7-10 for distribution of each priority area

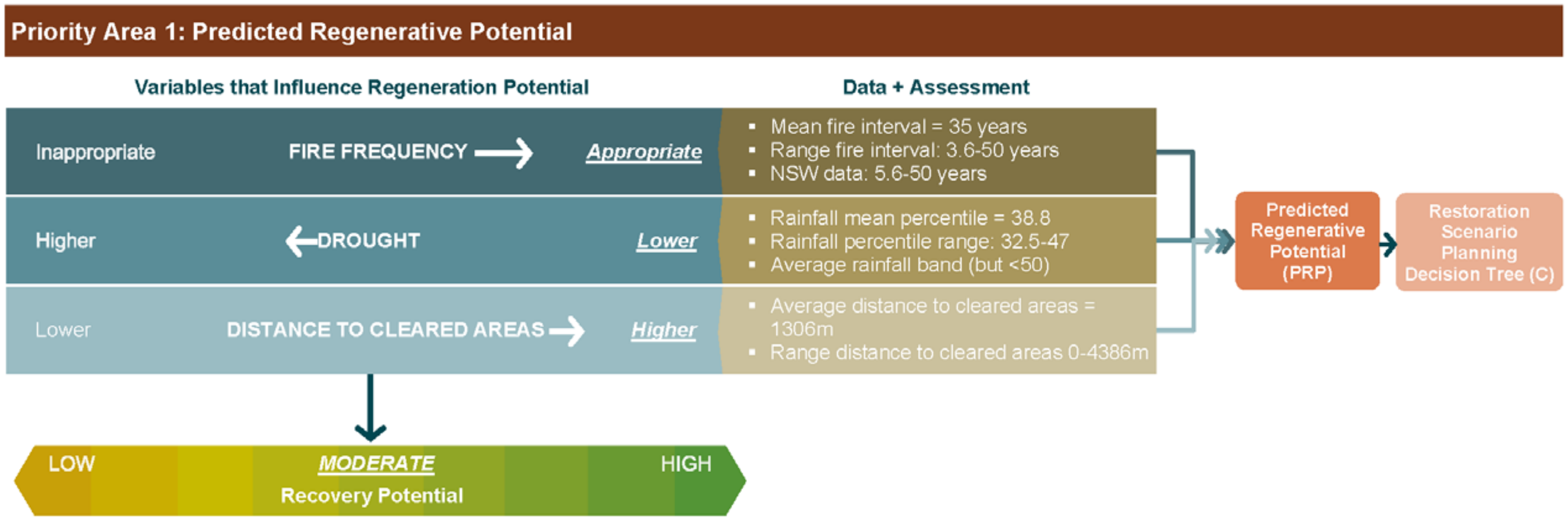
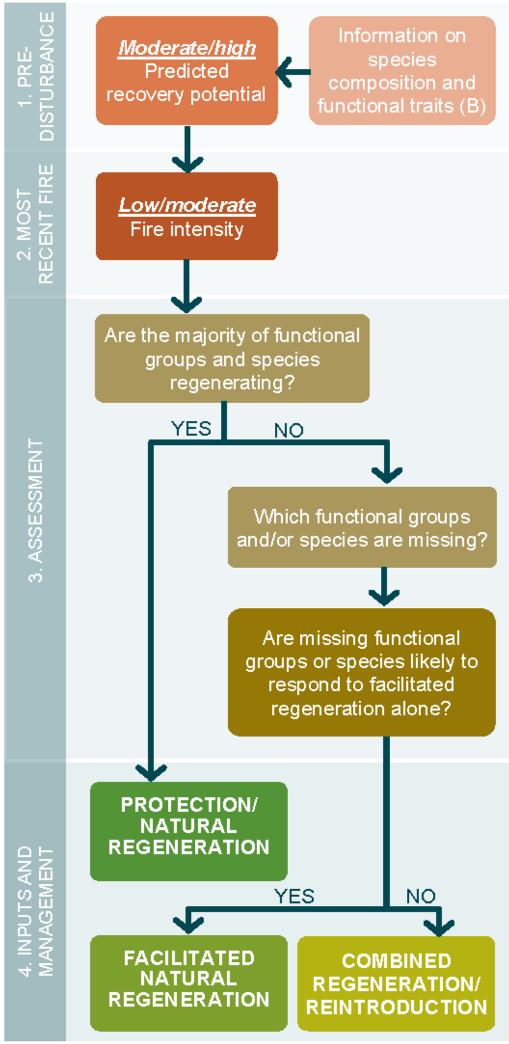


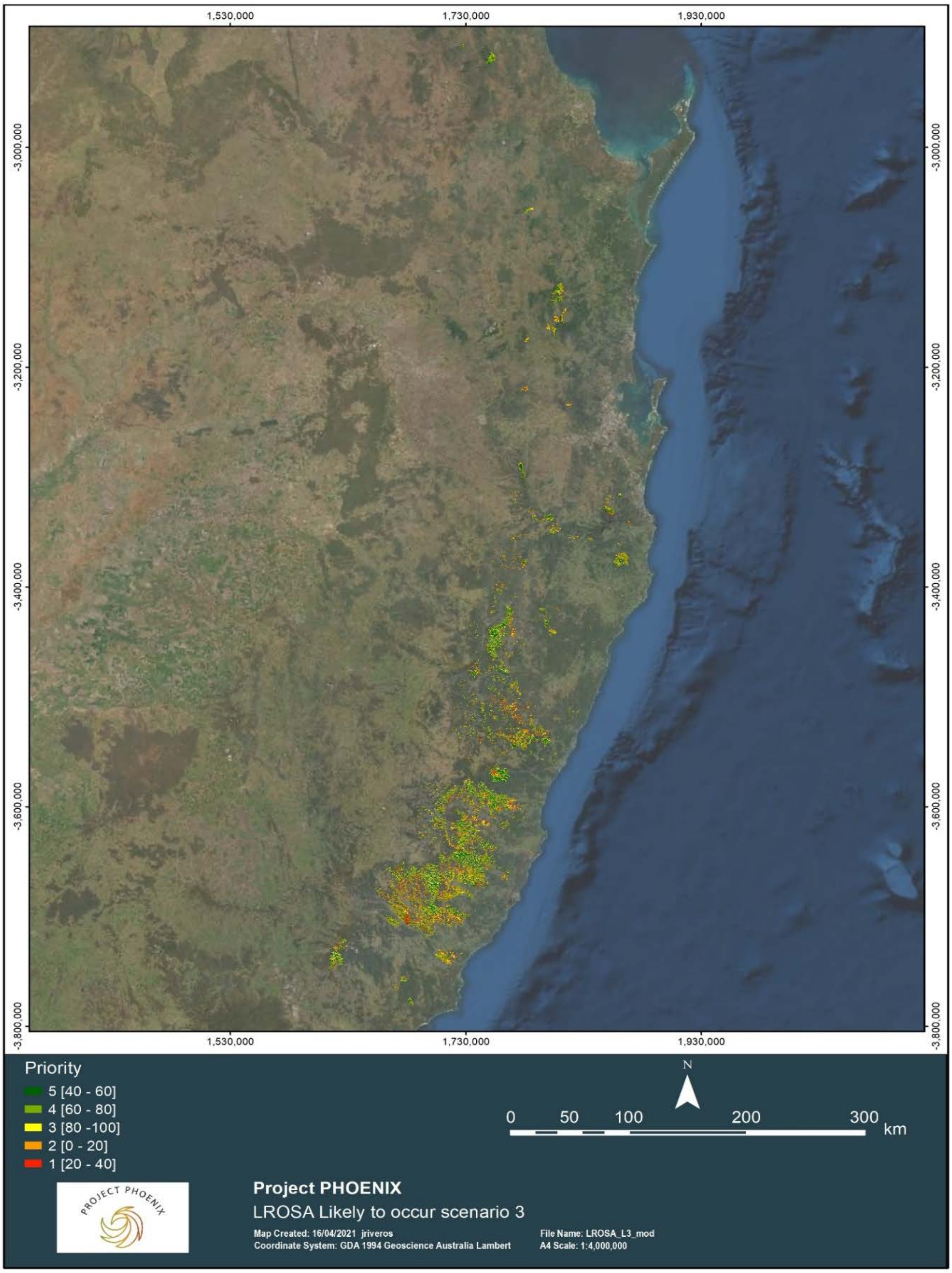
TABLE 7-20. RESTORATION APPROACHES FOR LOWLAND RAINFOREST

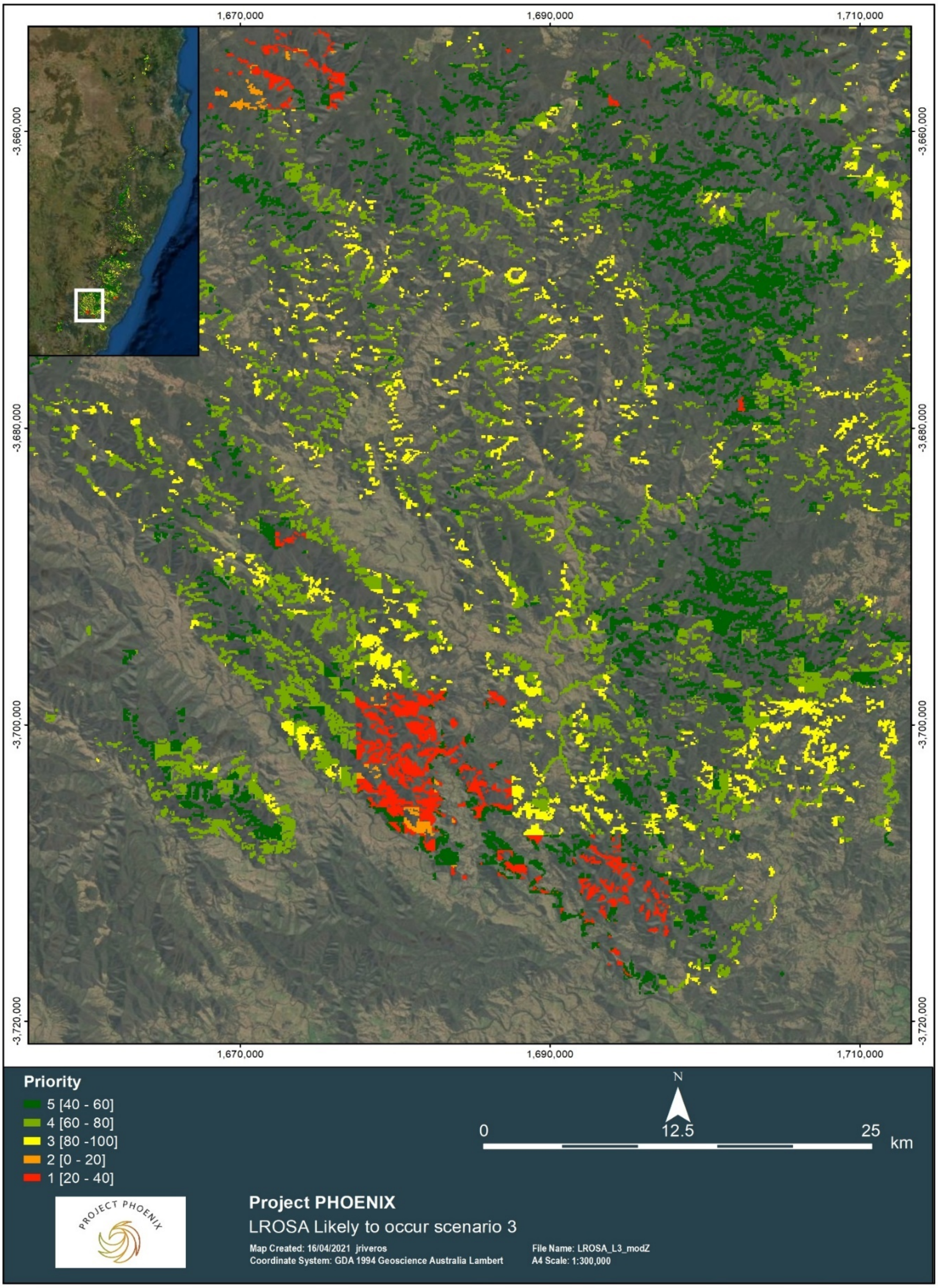


RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Impacts associated with remnant fragmentation • Private native forestry	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Anredera cordifolia* (Madeira Vine) • *Asparagus plumosus* (Climbing Asparagus) • *Cinnamomum camphora* (Camphor Laurel) • *Ipomoea spp.* (Morning Glory) • *Ligustrum sinense* (Small-leaved Privet) • *Macfadyena unguis-cati* (Cats Claw Creeper) • *Ochna serrulata* (Ochna) • *Passiflora subpeltata* (White Passionflower) • *Solanum mauritianum* • *Tradescantia fluminensis*	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-21. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-21).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Lowland Rainforest

FIGURE 7-9 (A–C). THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR LOWLAND RAINFOREST OF SOUTH EASTERN AUSTRALIA. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-19 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.




1,670,000
1,690,000
1,710,000
-3,660,000
-3,680,000
-3,700,000
-3,720,000
Priority
5 [40 - 60]
4 [60 - 80]
3 [80 -100]
2 [0 - 20]
1 [20 - 40]
N
0
12.5
25
km
Project PHOENIX
LROSA Likely to occur scenario 3
Map Created: 16/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: LROSA_L3_modZ
A4 Scale: 1:300,000

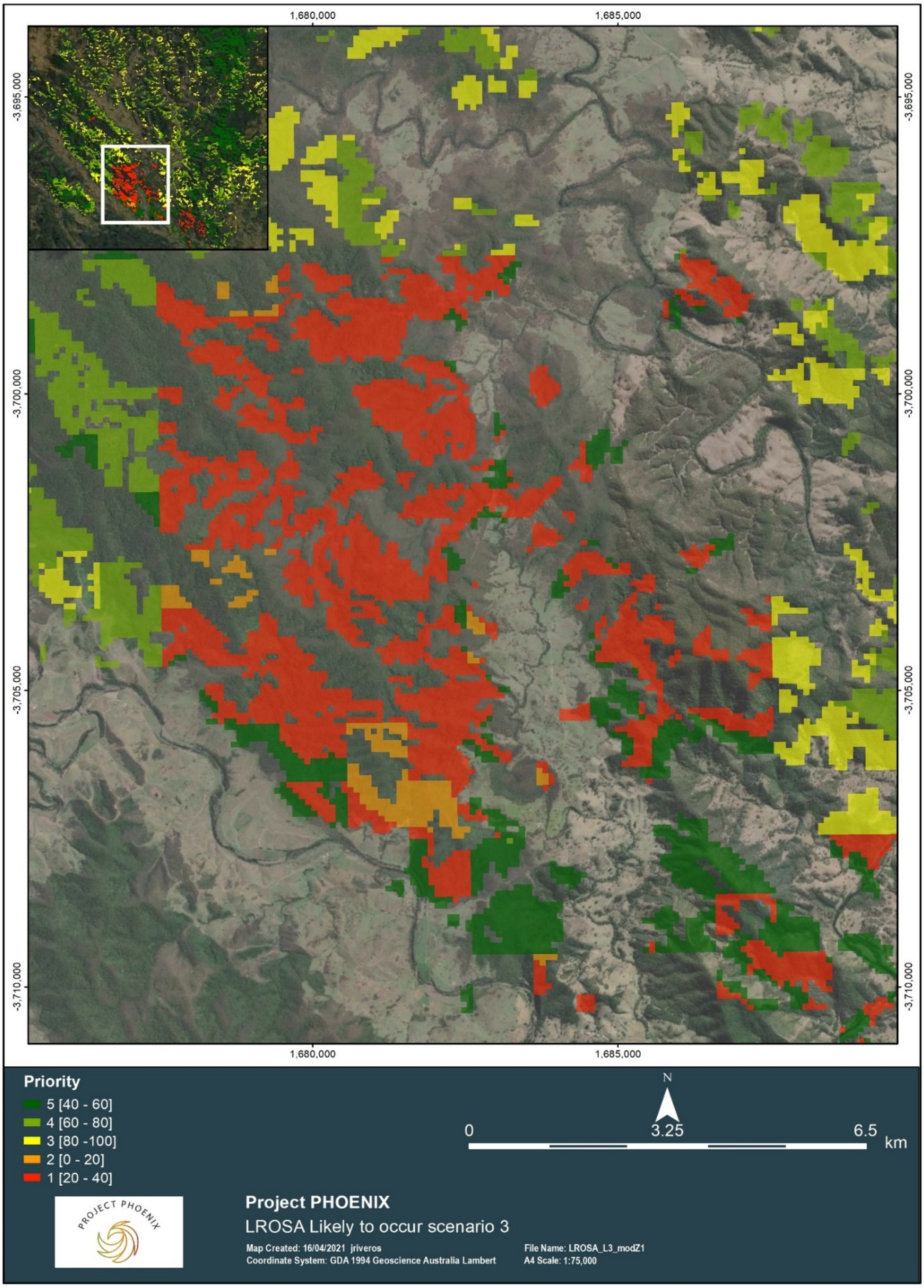

1,680,000
1,685,000
-3,695,000
-3,700,000
-3,705,000
-3,710,000
Priority
5 [40 - 60]
4 [60 - 80]
3 [80 -100]
2 [0 - 20]
1 [20 - 40]
N
0
3.25
6.5
km
Project PHOENIX
LROSA Likely to occur scenario 3
Map Created: 16/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: LROSA_L3_modZ1
A4 Scale: 1:75,000

Table 7-21. A list of the fire sensitive species (obligate seeders (OS) and facultative seeders (FS)) from the Lowland Rainforest of Subtropical Australia TEC species list and the fire-affected species within the TEC 'likely to occur' boundary. Life form: Herbaceous (H), Shrub (S), Tree (T), Climber/Vine (C). Seed storage: Soil (S), Transient (T), Canopy (C), Unknown (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Alphitonia petrei*	T	OS	UN	
TEC species list	*Archontophoenix cunninghamiana*	T	OS	T	
TEC species list	*Asplenium australasicum*	H	OS	T	
TEC species list	*Caldcluvia paniculosa*	T	OS	UN	
TEC species list	*Cinnamomum oliveri*	T	OS	UN	
TEC species list	*Citronella moorei*	T	OS	UN	
TEC species list	*Dendrocnide excelsa*	T	OS	S	
TEC species list	*Ehretia acuminata*	T	OS	T	
TEC species list	*Elaeodendron australe*	S/T	OS	UN	
TEC species list	*Litsea reticulata*	T	OS	UN	
TEC species list	*Platycerium spp.*	H	OS	UN	
TEC species list	*Plectranthus spp.*	H	OS	UN	
TEC species list	*Polyscias elegans*	T	OS	S	
TEC species list	*Pyrrosia spp.*	H	OS	UN	
TEC species list	*Sarcomelicope simplicifolia*	S/T	OS	T	
TEC species list	*Sloanea australis*	T	OS	UN	
TEC species list	*Sloanea woollsii*	T	OS	S	
TEC species list	*Streblus brunonianus*	S/T	OS	T	
TEC species list	*Trema aspera*	S/T	OS	S	
TEC species list	*Acacia irrorata*	C	FS	S	
TEC species list	*Acacia melanoxylon*	S	FS	S	
TEC species list	*Breynia oblongifolia*	S	FS	S	
TEC species list	*Cissus hypoglauca*	C	FS	UN	
TEC species list	*Gossia spp.*	S/T	FS	UN	
TEC species list	*Mallotus philippensis*	T	FS	T	
TEC species list	*Melia azedarach*	T	FS	T	
TEC species list	*Omalanthus populifolius*	S/T	FS	UN	
TEC species list	*Pandorea pandorana*	C	FS	S	
TEC species list	*Wilkiea huegeliana*	S/T	FS	UN	
Fire-affected species	*Acacia cangaiensis*	S	OS	UN	Yes
Fire-affected species	*Acacia tessellata*	S	OS	UN	Yes
Fire-affected species	*Bertya sp. Clouds Creek (M.Fatemi 4)*	S	OS	S	Yes
Fire-affected species	*Cestichis reflexa*	H	OS	UN	
Fire-affected species	*Grevillea acanthifolia subsp. paludosa*	S	OS	S	Yes
Fire-affected species	*Hibbertia villosa*	S	OS	UN	Yes
Fire-affected species	*Kardomia prominens*	S	OS	UN	Yes

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Persoonia rufa*	S	OS	S	Yes
Fire-affected species	*Philotheca obovatifolia*	S	OS	UN	Yes
Fire-affected species	*Pomaderris ligustrina subsp. latifolia*	S	OS	T	Yes
Fire-affected species	*Prostanthera saxicola var. major*	S	OS	S	Yes
Fire-affected species	*Zieria floydii*	S	OS	UN	Yes
Fire-affected species	*Zieria lasiocaulis*	S/T	OS	S	Yes
Fire-affected species	*Acacia beadleana*	S	RS	UN	Yes
Fire-affected species	*Chiloglottis anaticeps*	H	RS	UN	Yes
Fire-affected species	*Cryptocarya williwilliana*	S/T	RS	UN	Yes
Fire-affected species	*Deyeuxia reflexa*	H	RS	UN	Yes
Fire-affected species	*Eucalyptus olida*	T	RS	UN	Yes
Fire-affected species	*Eucalyptus scias subsp. apoda*	T	RS	UN	Yes
Fire-affected species	*Eucalyptus stellulata*	T	RS	T	
Fire-affected species	*Grevillea rhizomatosa*	S	RS	T	Yes
Fire-affected species	*Macrozamia johnsonii*	H	RS	UN	Yes
Fire-affected species	*Macrozamia montana*	H	RS	UN	Yes
Fire-affected species	*Podolobium aestivum*	S	RS	UN	Yes
Fire-affected species	*Telopea aspera*	S	RS	UN	Yes
Fire-affected species	*Triplarina imbricata*	S	RS	UN	Yes
Fire-affected species	*Astrotricha sp. Mount Boss*	S	UN	UN	
Fire-affected species	*Eucalyptus rudderi*	T	UN	UN	Yes
Fire-affected species	*Leptospermum benwellii*	S	UN	UN	Yes
Fire-affected species	*Lepyrodia oligocolea*	H	UN	UN	Yes
Fire-affected species	*Pultenaea tarik*	S	UN	UN	Yes
Fire-affected species	*Senecio scabrellus*	H	UN	UN	
Fire-affected species	*Solanum curvicuspe*	S	UN	UN	Yes
Fire-affected species	*Xerochrysum sp. Mt Merino*	H	UN	UN	

7.8 TEC 6: Lowland Grassy Woodland in the South East Corner Bioregion

7.8.1 Description

The Lowland Grassy Woodland in the South East Corner Bioregion currently occurs only in modified fragments ranging from Araluen Valley (New South Wales) to the Victoria border.[68] It occurs in areas below 500m above sea level on undulating terrain with a mean annual rainfall of 750–1100mm per year.[79] The community structure is usually an open tree canopy (grassy woodland) with ground cover dominated by grasses and herbs, with occasional shrubs and small trees (variable mid-storey).

An open forest is also possible depending on the site size, disturbance history and drought conditions.[79] Time since fire and fire frequency (as well as fire intensity and seasonality) are known to affect the relative species abundance.[16,80] Threatened flora species include *Thesium australe* (austral toadflax) and *Galium australe* (tangled bedstraw).[79]

7.8.2 Fire response traits

In the Lowland Grassy Woodland there are 151 plant species representing 99 different genera. This list is indicative and species composition will vary across the TEC given that patches span a range of environments (productivity gradients — soils and rainfall) and vary in disturbance history (e.g. grazing and historical fire frequency). Of these plant species, 52% (n = 79) are resprouters, 24% (n = 36) are facultative seeders and 17% (n = 25) are obligate seeders, with 7% (n = 11) having an unverified fire response (Table 7-22). Herbaceous species dominate this community, making up 77% (n = 117) of all plant species present, while trees make up 11% (n = 16), shrubs make up 8% (n = 12) and climbers/vines make up 4% (n = 6) (Table 7-22).

TABLE 7-22. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	21 (18)	25 (21)	60 (51)	11 (10)	**117**
Shrub	3 (25)	4 (33)	5 (42)	0 (0)	**12**
Tree	1 (6)	4 (25)	11 (69)	0 (0)	**16**
Climber/Vine	0 (0)	3 (50)	3 (50)	0 (0)	**6**
Total count	**25**	**36**	**79**	**11**	**151**

7.8.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-23).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Lowland Grassy Woodland and outlined below and described in Appendix 2 (Section 11.6).

TEC 6: Lowland Grassy Woodland in the South East Corner Bioregion

Community Characteristics

Number of species:
- 151 [99 genera]

Trees:
- 11% (n = 16)

Shrubs:
- 8% (n = 12)

Herbaceous:
- 77% (n = 117)

Climbers/Vines:
- 4% (n = 6)

Fire Response

Resprouters:
- 52% (n = 79)

Obligate seeders:
- 17% (n= 25)

Facultative seeders:
- 24% (n = 36)

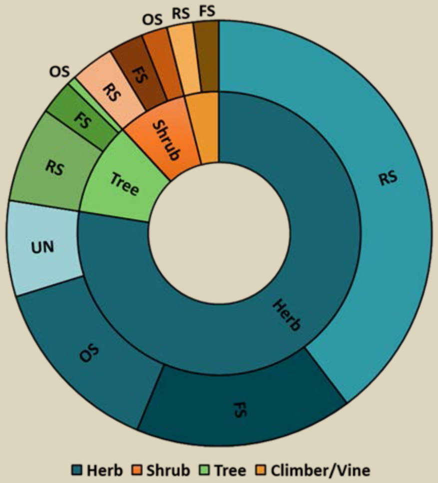
Unknown (UN):
- 7% (n = 11)

Life History and Fire Response

Resprouters (RS):
- Highest proportion of all life history groups: 69% of trees, 51% of herbaceous species, 50% of climbers/vines and 42% of shrubs

Facultative seeders (FS):
- Higher proportion of climbers/vines (50%) and shrubs (33%)

Obligate seeders (OS):
- Ranged from 6% of trees to 25% of shrubs

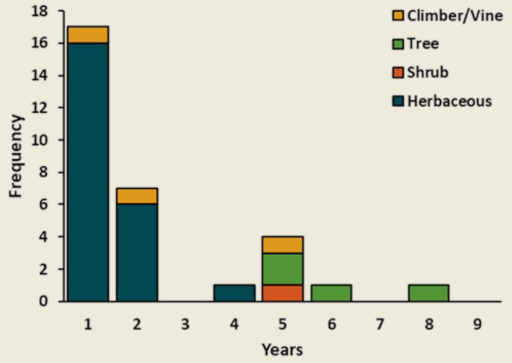


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 10-16 years
- But depending on composition, site productivity and historical fire regime, this can be <10 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 10 years
- Herbaceous = 2-8 years
- Climbers/vines = 2-4 years
- Trees = 10-16 years



[1]Obligate seeders and facultative seeders

TABLE 7-23. PRIORITY AREAS 1 AND 2 LOWLAND GRASSY WOODLAND: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	263.6	3.0	2.5[a]	1.9-5.6	4.8	2-5	43.8	42.8-46.5	330.3	0-2282.5
2 (60-80)	4434.6	50.4	3.4[b]	1.4-16.7	3.6	2-5	44.4	38.5-47.1	261.0	0-4967.9
3 (40-60)	2244.4	25.5	4.0	1.9-10	3.2	2-5	44.1	38.3-46.6	535.3	0-4701.1
4 (20-40)	1716.4	19.5	7.2	3.6-16.7	3.1	2-5	41.6	38.3-44.9	685.8	0-6113.1
5 (0-20)	134.0	1.5	10	4.2-12.5	2.3	2-3	41.3	39.5-43.7	1243.4	0-4294.2

Finer scale analysis of NSW fire data: Priority area 1[a] = 35.8 years (10 – 50 years); Priority area 2[b] = 42.0 (7.1 – 50 years)

See Figure 7-11 for distribution of each priority area

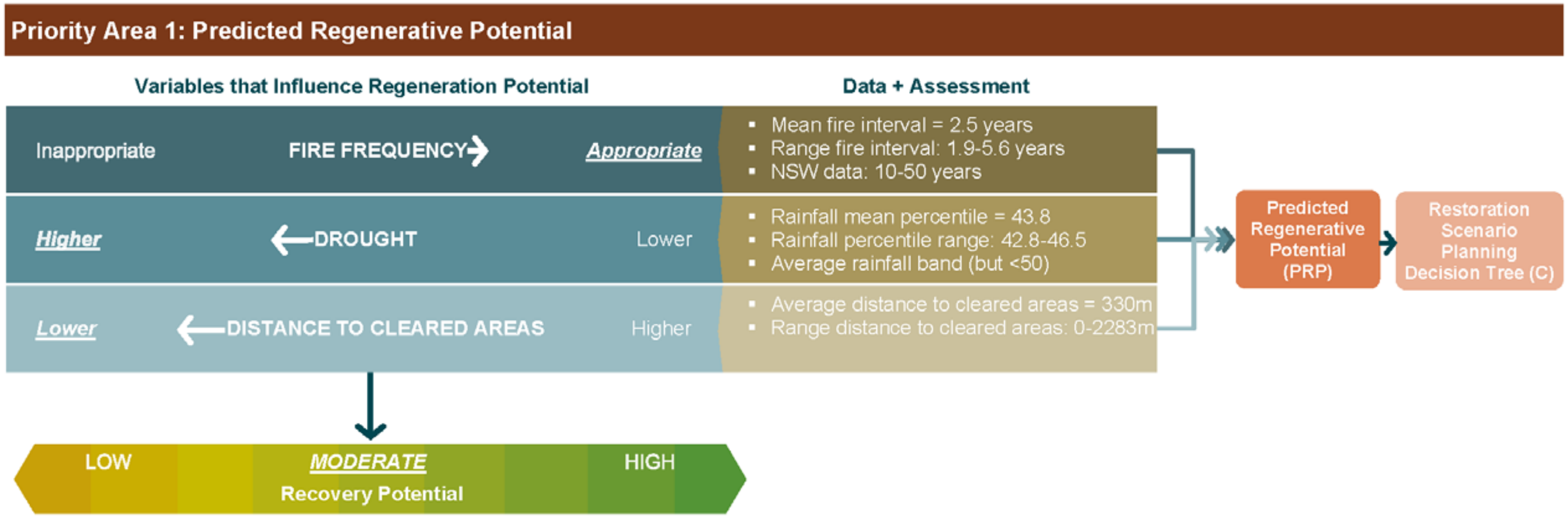
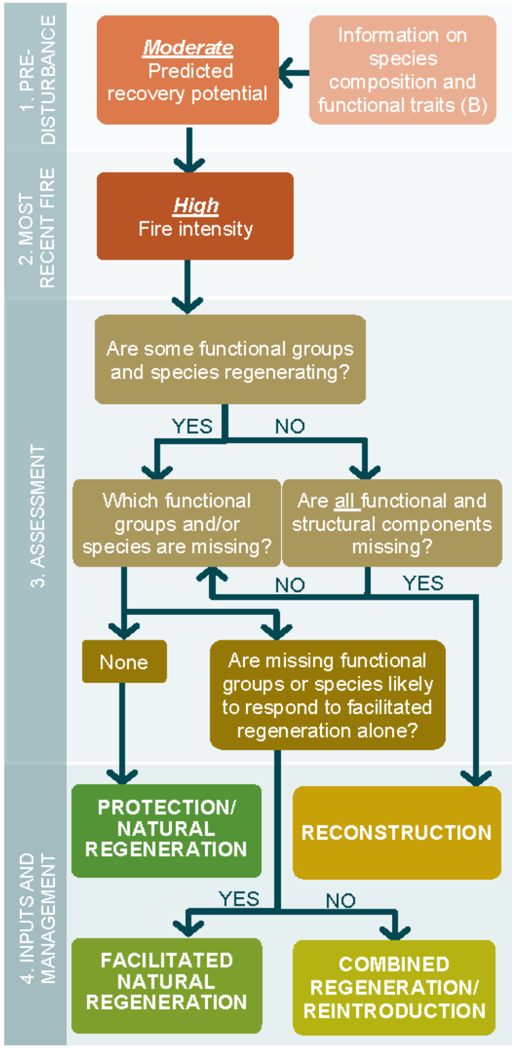


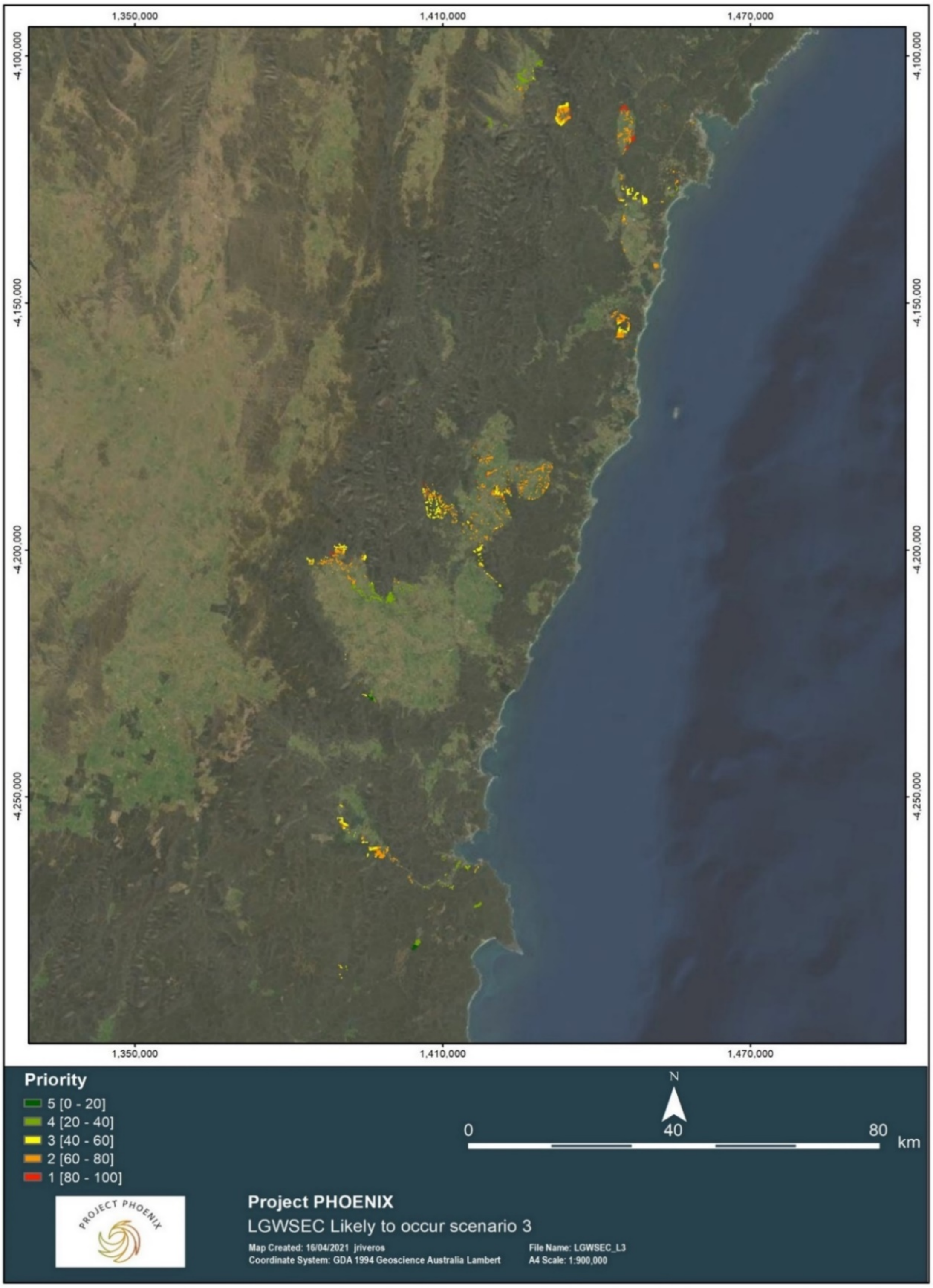
TABLE 7-24. RESTORATION APPROACHES FOR LOWLAND GRASSY WOODLAND

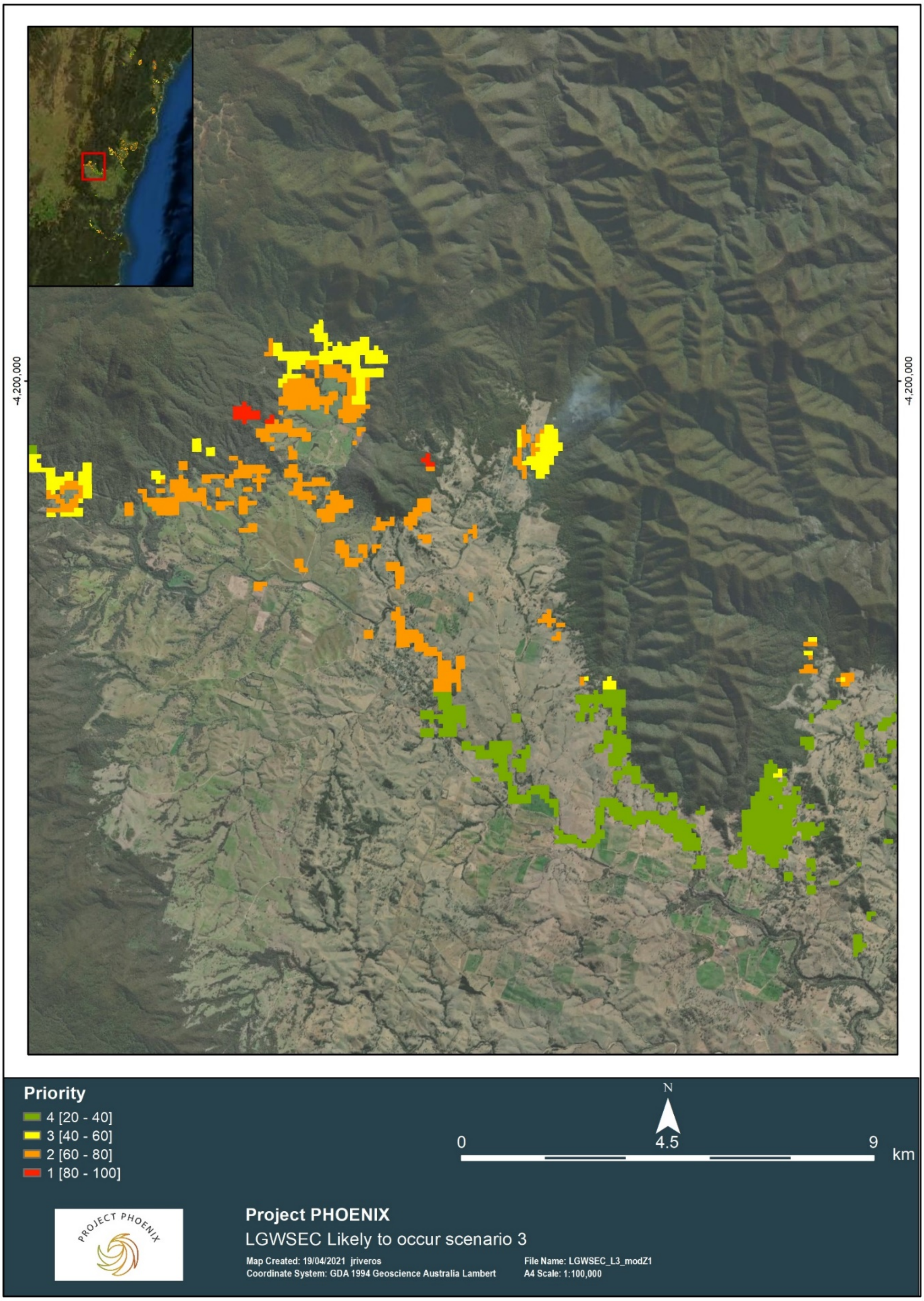


RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing for rural, agricultural and urban development • Invasion and establishment of transformer weed species • Degradation and competition by rabbits, deer, feral honeybees • Removal of habitat trees • Climate change	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Cenchrus clandestinus* (Kikuyu) • *Cirsium vulgare* (Spear Thistle) • *Crataegus monogyna* • *Eragrostis curvula* (African Lovegrass) • *Hypericum perforatum* • *Lycium ferocissimum* (African Boxthorn) • *Nassella trichotoma* • *Rosa rubiginosa* • *Rubus spp.* (Blackberries) • *Solanum spp.* (Nightshades) • *Sporobolus africanus* • *Trifolium repens* (Clover)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-25. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-25).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Lowland Grassy Woodland

FIGURE 7-10 (A–C). THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR LOWLAND GRASSY WOODLAND. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-23 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.




-4,200,000
-4,200,000
Priority
4 [20 - 40]
3 [40 - 60]
2 [60 - 80]
1 [80 - 100]
N
0
4.5
9
km
PROJECT PHOENIX
Project PHOENIX
LGWSEC Likely to occur scenario 3
Map Created: 19/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: LGWSEC_L3_modZ1
A4 Scale: 1:100,000

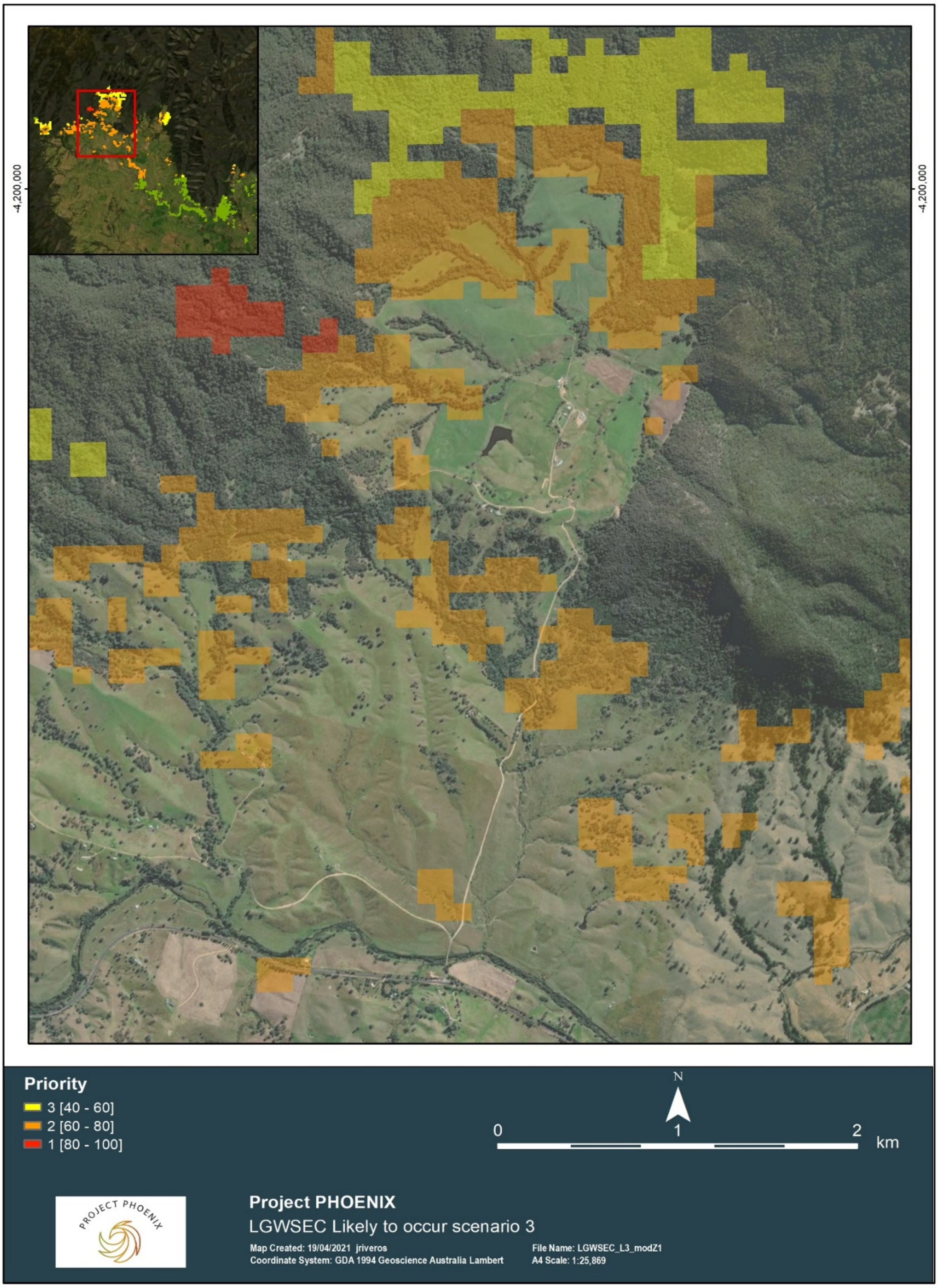

-4,200,000
-4,200,000
Priority
3 [40 - 60]
2 [60 - 80]
1 [80 - 100]
N
0
1
2
km
Project PHOENIX
LGWSEC Likely to occur scenario 3
Map Created: 19/04/2021 jriveros
Coordinate System: GDA 1994 Geoscience Australia Lambert
File Name: LGWSEC_L3_modZ1
A4 Scale: 1:25,869

TABLE 7-25. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE LOWLAND GRASSY WOODLAND IN THE SOUTH EAST CORNER BIOREGION THREATENED ECOLOGICAL COMMUNITY (TEC) SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia mearnsii*	T	OS	S	
TEC species list	*Ajuga australis*	H	OS	UN	
TEC species list	*Calotis lappulacea*	H	OS	UN	
TEC species list	*Cassinia aculeata*	S	OS	S	
TEC species list	*Chenopodium carinatum*	H	OS	UN	
TEC species list	*Cullen microcephalum*	H	OS	S	
TEC species list	*Cynoglossum australe*	H	OS	UN	
TEC species list	*Dodonaea viscosa subsp. angustifolia*	S	OS	UN	
TEC species list	*Dysphania pumilio*	H	OS	UN	
TEC species list	*Einadia hastata*	H	OS	UN	
TEC species list	*Einadia nutans*	H	OS	UN	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Galium leiocarpum*	H	OS	UN	
TEC species list	*Lagenophora stipitata*	H	OS	UN	
TEC species list	*Lobelia purpurascens*	H	OS	UN	
TEC species list	*Ozothamnus argophyllus*	S	OS	T	
TEC species list	*Polygala japonica*	H	OS	T	
TEC species list	*Ranunculus lappaceus*	H	OS	T	
TEC species list	*Senecio hispidulus var. hispidulus*	H	OS	UN	
TEC species list	*Senecio quadridentatus*	H	OS	T	
TEC species list	*Sigesbeckia orientalis subsp. orientalis*	H	OS	S	
TEC species list	*Solanum prinophyllum*	H	OS	UN	
TEC species list	*Solanum pungetium*	H	OS	UN	
TEC species list	*Sorghum leiocladum*	H	OS	UN	
TEC species list	*Thesium australe*	H	OS	T	
TEC species list	*Acacia implexa*	T	FS	S	
TEC species list	*Allocasuarina littoralis*	T	FS	T	
TEC species list	*Carex breviculmis*	H	FS	S	
TEC species list	*Cassinia longifolia*	S	FS	T	
TEC species list	*Cassinia trinerva*	S	FS	UN	
TEC species list	*Chrysocephalum apiculatum*	H	FS	S	
TEC species list	*Chrysocephalum semipapposum*	H	FS	S	
TEC species list	*Clematis glycinoides var. glycinoides*	C	FS	S	
TEC species list	*Convolvulus erubescens*	H	FS	S	
TEC species list	*Cyanthillium cinereum*	H	FS	T	
TEC species list	*Cynoglossum suaveolens*	H	FS	UN	
TEC species list	*Dichondra spp.*	H	FS	UN	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Euchiton gymnocephalus*	H	FS	T	
TEC species list	*Exocarpos cupressiformis*	T	FS	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Hydrocotyle laxiflora*	H	FS	UN	
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Laxmannia gracilis*	H	FS	S	
TEC species list	*Leucopogon juniperinus*	S	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Opercularia aspera*	H	FS	S	
TEC species list	*Opercularia varia*	H	FS	S	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Ozothamnus diosmifolius*	S	FS	S	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Rytidosperma pilosum*	H	FS	S	
TEC species list	*Scleranthus biflorus*	H	FS	S	
TEC species list	*Sporobolus creber*	H	FS	UN	
TEC species list	*Tricoryne elatior*	H	FS	T	
TEC species list	*Veronica calycina*	H	FS	T	
TEC species list	*Wahlenbergia communis*	H	FS	S	
TEC species list	*Wahlenbergia gracilis*	H	FS	UN	
TEC species list	*Wahlenbergia stricta subsp. stricta*	H	FS	S	
TEC species list	*Zornia dyctiocarpa var. dyctiocarpa*	H	FS	S	
Fire-affected species	*Acacia trachyphloia*	S	OS	UN	Yes
Fire-affected species	*Boronia subulifolia*	S	OS	UN	Yes
Fire-affected species	*Eucalyptus fraxinoides*	T	OS	C	Yes
Fire-affected species	*Zieria caducibracteata*	S/T	OS	UN	Yes
Fire-affected species	*Callistemon subulatus*	S	RS	C	Yes
Fire-affected species	*Brachyscome salkiniae*	H	UN	UN	Yes
Fire-affected species	*Grevillea rhyolitica subsp. semivestita*	S	UN	UN	

7.9 TEC 7: Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions

7.9.1 Description

The Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alp Bioregion is known from only one site at the Marble Gully Nature Conservation Reserve in eastern Victoria.[81] The mean annual rainfall of this area is 645mm/year and it is located 600m above sea level.[81] It is characterised and dominated by the rare shrub *Pomaderris oraria* subsp. *calcicole* (Limestone Pomaderris) and the ground layer predominantly consists of *Ozothamnus adnatus* (Winged Everlasting) and *Themeda triandra* (Kangaroo Grass).[81] This community can vary in structure depending on slope and underlying soils, ranging from grassland to shrubland and woodland forms.

7.9.2 Fire response traits

In the Silurian Limestone Pomaderris Shrubland there are 26 plant species representing 24 different genera. Of these plant species, 35% (n = 9) are obligate seeders, 31% (n = 8) are facultative seeders, 27% (n = 7) are resprouters and 8% (n = 2) have an unverified fire response (Table 7-26). Herbaceous species make up 62% (n = 16) of all plant species present, shrubs make up 31% (n = 8).

TABLE 7-26. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	5 (31)	6 (38)	5 (31)	0 (0)	**16**
Shrub	4 (50)	1 (13)	1 (12)	2 (25)	**8**
Tree	0 (0)	1 (50)	1 (50)	0 (0)	**2**
Total count	**9**	**8**	**7**	**2**	**26**

7.9.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-27).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Silurian Limestone Pomaderris Shrubland and outlined below and described in Appendix 2 (Section 11.7).

TEC 7: Silurian Limestone Pomaderris Shrubland of the South East Corner And Australian Alps Bioregions

Community Characteristics

Number of species:
- 26 [24 genera]

Trees:
- 8% (n = 2)

Shrubs:
- 31% (n = 8)

Herbaceous:
- 62% (n = 16)

Fire Response

Resprouters:
- 27% (n = 7)

Obligate seeders:
- 35% (n= 9)

Facultative seeders:
- 31% (n = 8)

Unknown:
- 8% (n = 2)

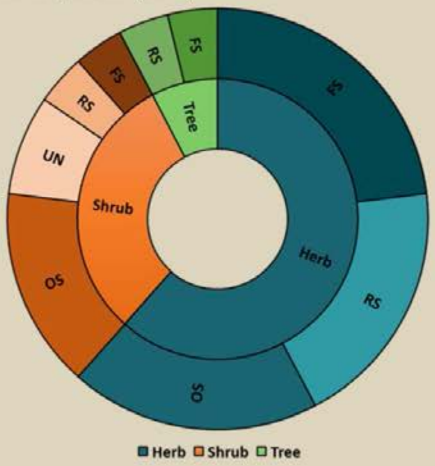
Life History and Fire Response

Resprouters (RS):
- Ranged from 12% of shrubs to 31% of Herbaceous species and 50% of trees

Facultative seeders (FS):
- Higher proportion of herbaceous species (38%) and trees (50%)

Obligate seeders (OS):
- Higher proportion of herbaceous species (31%) and shrubs (50%)

Unknown fire response (UN):
- Shrubs had the highest proportion of unknown fire responses (25%)

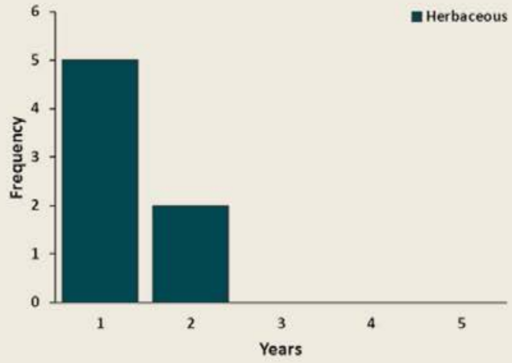


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 35-50 years[2]

Minimum fire interval based on primary juvenile period:
- Limited information on primary juvenile periods
- Herbaceous species = 2-4 years



[1]Obligate seeders and facultative seeders
[2]Cheal[82]

Table 7-27. Priority areas 1 and 2 Silurian Limestone Pomaderris Shrubland: Variables influencing regenerative potential

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (Higher)	8.4	26.4	50	50-50[1]	3	3-3	42.8	42.8-42.8	773.6	500-1029.6
2 (Lower)	23.4	73.6	50	50-50[1]	3	3-3	42.8	42.8-42.8	1515.5	943.4-2088.1

[1]Moorrees[81] state that this TEC was burnt in 2003, so fire interval may be 17 years (which is inappropriate)

See Figure 7-12 for distribution of each priority area

Priority Area 1: Predicted Regenerative Potential

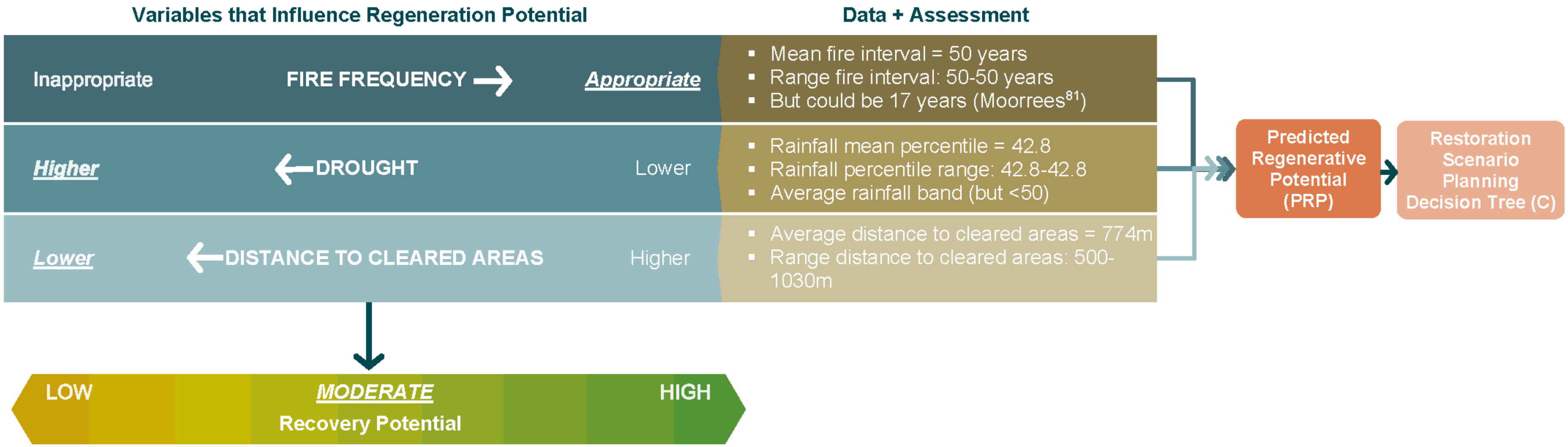
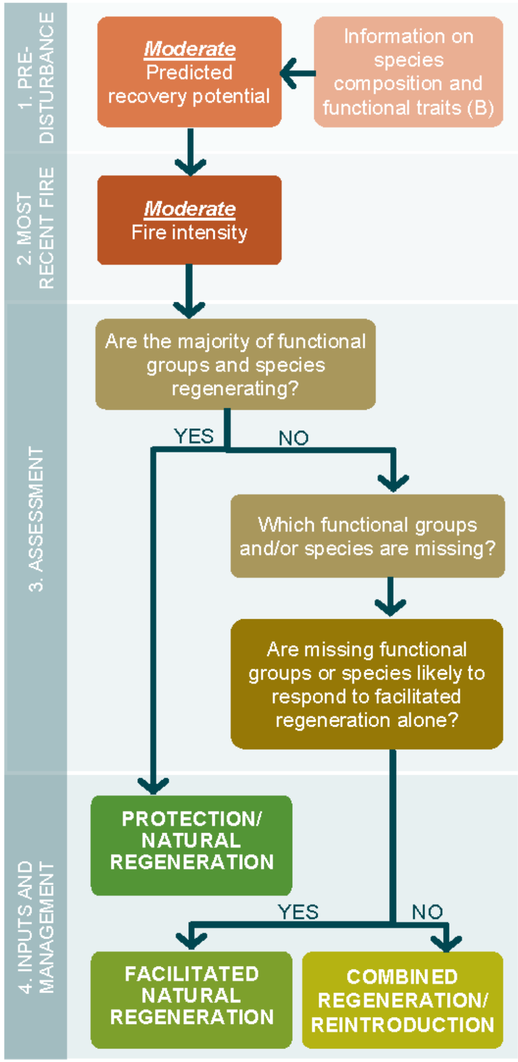


TABLE 7-28. RESTORATION APPROACHES FOR SILURIAN LIMESTONE POMADERRIS SHRUBLAND



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal** **Facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around existing patches** • **Extend the spatial extent of current patches**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Grazing (domestic cattle and rabbits) • Invasion and establishment of weed species • Increased fire frequency • Potential disturbance from mining and recreational use	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Rubus fruiticosus* (Blackberry) • *Anagallis arvensis* (Pimpernel) • *Cardamine hirsute* (Common Bittercress) • *Catapodium rigidum* (Rigid Fescue) • *Centaurium erythaea* (Common Centaury) • *Marrubium vulgare* (Horehound) • *Petrorhagia velutina* (Velvet Pink) • *Rosa rubiginosa* (Sweet Briar)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-29. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-29).	• Requires broad seed inputs • Given the small spatial extent of this community, conservation planning can identify where in the surrounding landscape these established populations are positioned to: (i) maximise biodiversity benefits, and (ii) provide protection from future fire events

Spatial distribution of priority areas for Silurian Limestone Pomaderris Shrubland

FIGURE 7-11. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR SILURIAN LIMESTONE POMADERRIS SHRUBLAND. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-27 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

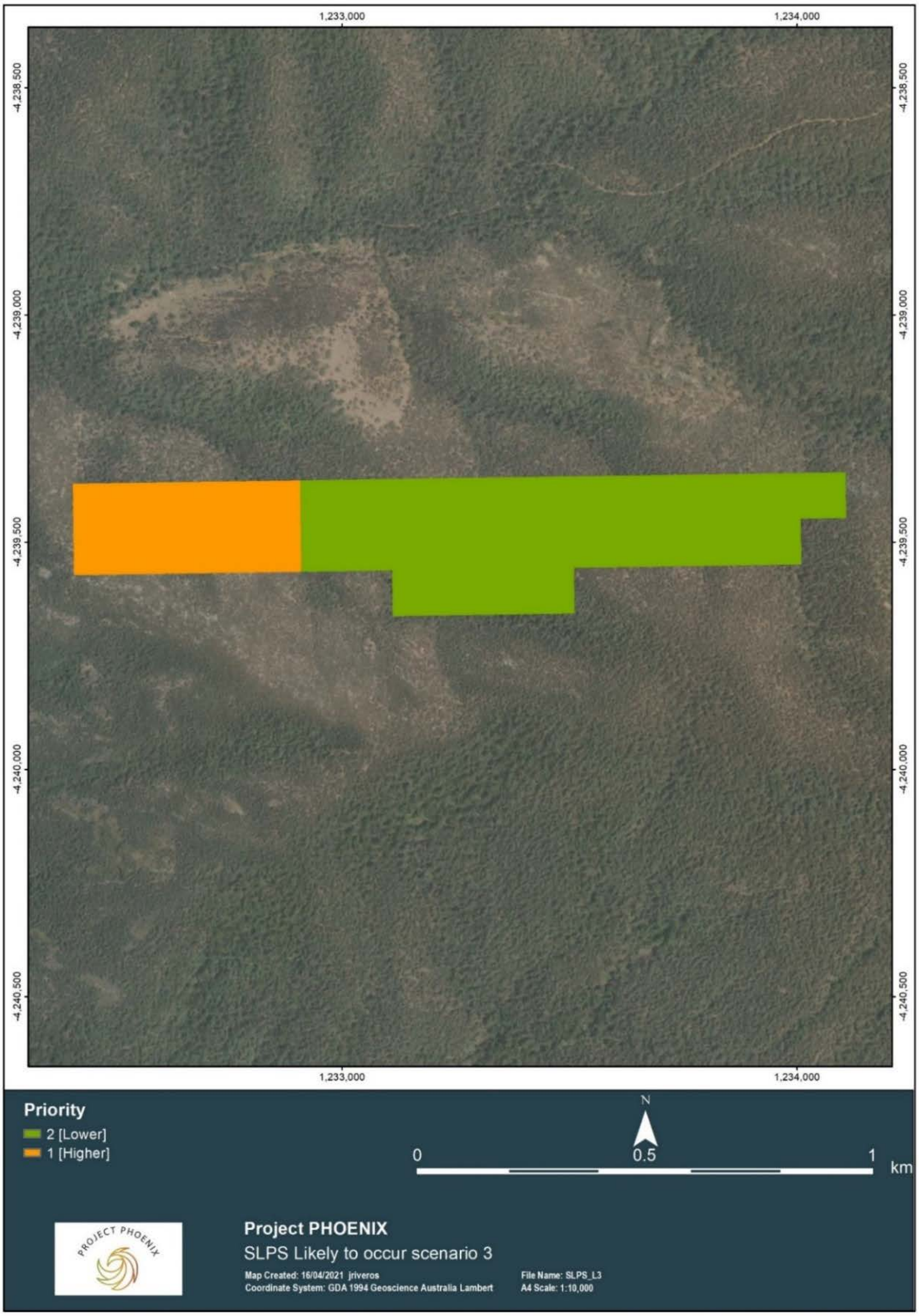


TABLE 7-29. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE SILURIAN LIMESTONE POMADERRIS SHRUBLAND OF THE SOUTH EAST CORNER AND AUSTRALIAN ALP BIOREGION THREATENED ECOLOGICAL COMMUNITY (TEC) SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Asplenium trichomanes subsp. quadrivalens*	H	OS	UN	
TEC species list	*Irenepharsus magicus*	H	OS	UN	
TEC species list	*Isoetopsis graminifolia*	H	OS	UN	
TEC species list	*Pimelea flava*	S	OS	UN	
TEC species list	*Pimelea flava subsp. dichotoma*	S	OS	UN	
TEC species list	*Pimelea pauciflora*	S	OS	S	
TEC species list	*Pomaderris oraria subsp. calcicola*	S	OS	S	
TEC species list	*Senecio quadridentatus*	H	OS	T	
TEC species list	*Vittadinia tenuissima*	H	OS	UN	
TEC species list	*Allocasuarina verticillata*	T	FS	T	
TEC species list	*Carex breviculmis*	H	FS	S	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Olearia astroloba*	H	FS	S	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Ozothamnus adnatus*	S	FS	UN	
TEC species list	*Poa sieberiana*	H	FS	UN	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
Fire-affected species	*Lomandra confertifolia subsp. leptostachya*	H	RS	UN	Yes

7.10 TEC 8: Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion

7.10.1 Description

The Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion occurs patchily throughout the Sydney Basin Bioregion from Port Hacking estuary to just north of Batemans Bay.[83] It requires relatively high-nutrient, greater water-holding, fertile soils such as volcanic soils or on escarpment benches.[83] The vegetative structure contains a multilayered canopy, climbers and epiphytes, a sparse understorey and groundcover. Characteristic species include *Dendrocnide excelsa* (Giant Stinging Tree), *Toona ciliata* (Red Cedar), *Alectryon subcinereus* (Native Quince) and *Diploglottis australis* (Native Tamarind).[68,83,84] Species composition may vary between sites across the TEC due to environmental gradients, size of the site, recent rainfall or drought condition and disturbance (including fire) history.

7.10.2 Fire response traits

Rainforests are generally fire-sensitive communities which have not evolved with frequent fire, or when subject to fire, generally only experience lower intensity fire events. Consequently, there is more limited information on species' responses to fire, and this may vary with fire intensity.

In the Illawarra-Shoalhaven Subtropical Rainforest, there are 127 plant species representing 99 different genera. It is likely that the total species list of the community is larger, and that species composition varies across the TEC as many species may have very low abundance and/or be present in only one or two sites. Of these plant species, 55% (n = 70) are resprouters, 21% (n = 27) are obligate seeders and 11% (n = 14) are facultative seeders, with 13% (n = 16) having an unverified fire response (Table 7-30). Tree species make up 35% (n = 44) of all species present, shrubs comprise 28% (n = 36), herbs 20% (n = 25) and climbers/vines 17% (n = 22) (Table 7-30).

TABLE 7-30. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	5 (20)	3 (12)	13 (52)	4 (16)	**25**
Shrub	9 (25)	7 (19)	19 (53)	1 (3)	**36**
Tree	12 (27)	1 (2)	25 (57)	6 (14)	**44**
Total count	**1 (4)**	**3 (14)**	**13 (59)**	**5 (23)**	**22**

7.10.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-31).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Illawarra-Shoalhaven Subtropical Rainforest and outlined below and described in Appendix 2 (Section 11.8).

TEC 8: Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 127 [99 genera]

Trees:
- 35% (n = 44)

Shrubs:
- 28% (n = 36)

Herbaceous:
- 20% (n = 25)

Climbers/Vines:
- 17% (n = 22)

Fire Response

Resprouters:
- 55% (n = 70)

Obligate seeders:
- 21% (n = 27)

Facultative seeders:
- 11% (n = 14)

Unknown:
- 13% (n = 16)

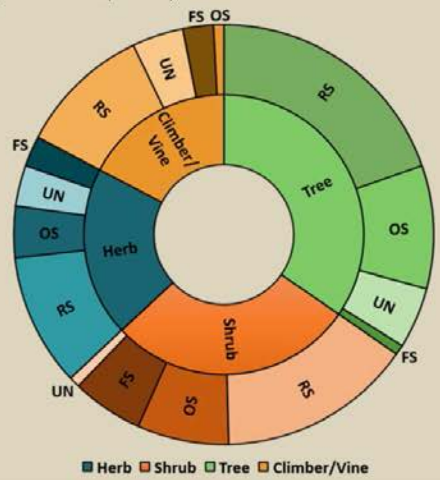
Life History and Fire Response

Resprouters (RS):
- Higher proportion of herbaceous species (52%), shrubs (53%), climbers/vines (59%) and trees (57%)

Obligate seeders (OS):
- Ranged from 4% of climbers/vines to 27% of trees

Facultative seeders (FS):
- Ranged from 2% of trees to 19% of shrubs

For each life form:
- High proportion of unknown (UN) fire responses (3 -23% of species)

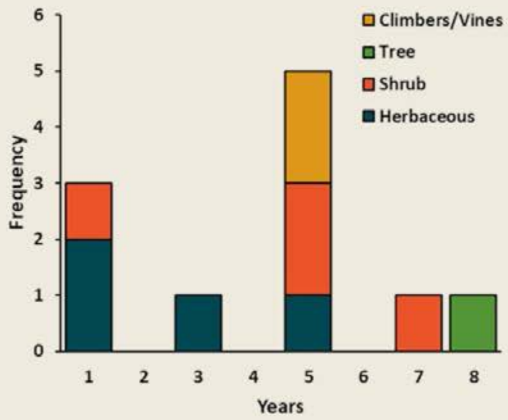


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- > 25 years (fire should be avoided)

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-14 years
- Herbaceous = 2-10 years
- Climbers/vines = 10 years
- Trees = 16 years



[1]Obligate seeders and facultative seeders

Table 7-31. Priority areas 1 and 2 Illawarra-Shoalhaven Subtropical Rainforest: Variables influencing regenerative potential

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (20-40)	2706.9	14.1	2.8[a]	1.8-10	2.9	2-5	41.8	37.3-47.6	1281.1	0-7009.3
2 (0-20)	4823.4	25.1	3.3[b]	1.7-10	2.8	2-5	40.5	37.3-46.6	2700.1	400-6937.6
3 (40-60)	6659.2	34.7	2.6	1.7-10	3.8	2-5	41.7	37.3-47.6	1664.2	0-6937.6
4 (20-40)	2849.0	14.8	2.2	1.4-5	4.5	2-5	41.7	37.3-47.3	843.9	0-2640.1
5 (0-20)	2163.2	11.3	2.3	1.4-3.3	4.6	2-5	41.5	37.3-47.6	252.4	0-640.3

Finer scale analysis of NSW fire data: Priority area 1[a] = 30.8 years (8.3 – 50 years); Priority area 2[b] = 31.3 (7.1 – 50 years)

See Figure 7-13 for distribution of each priority area

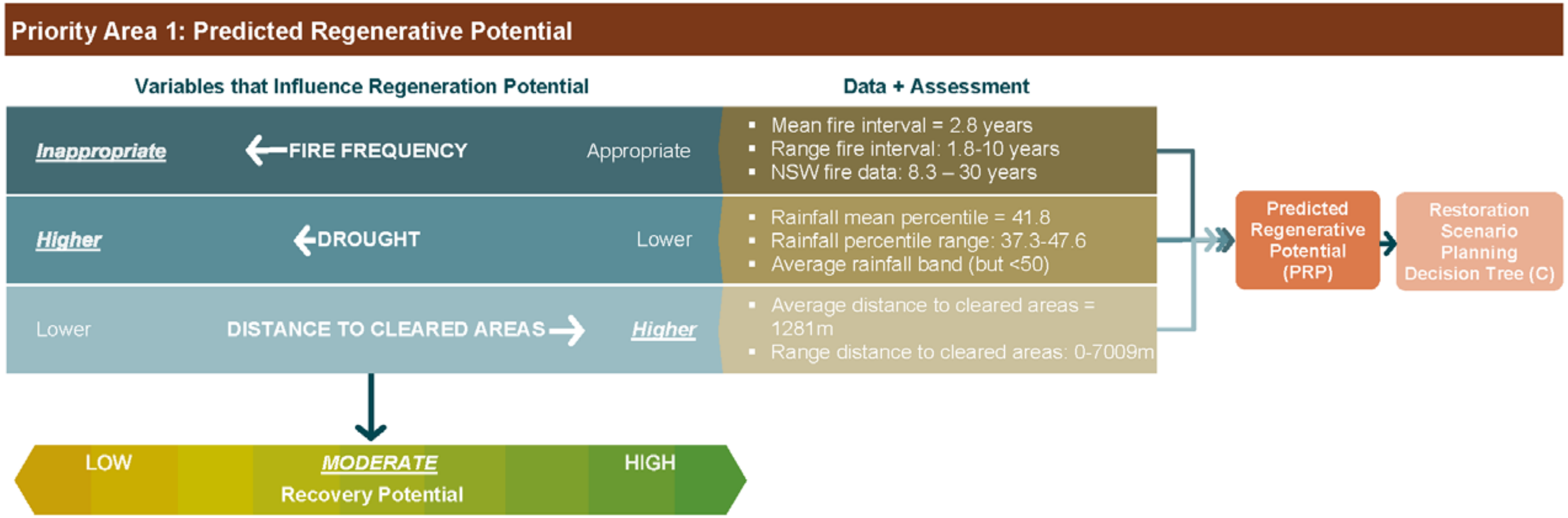
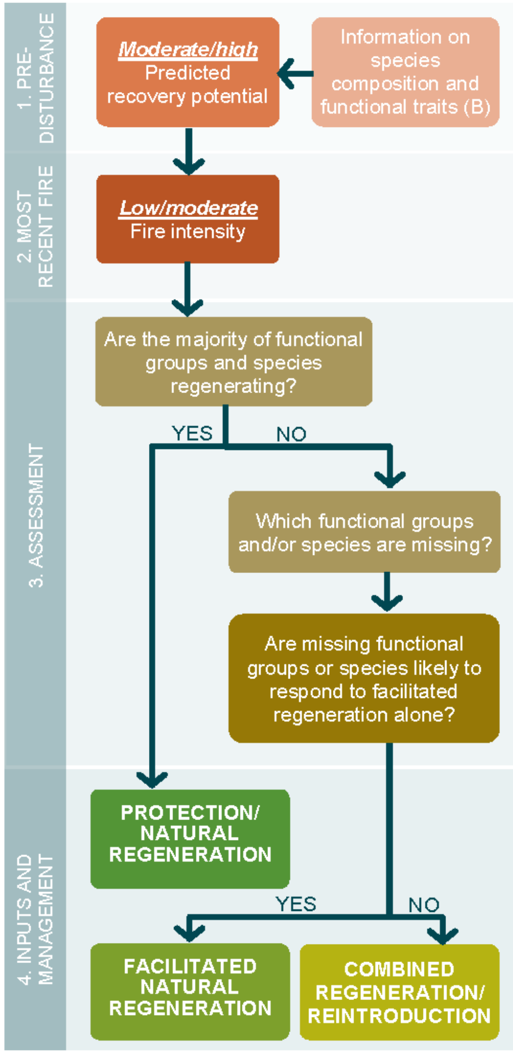


TABLE 7-32. RESTORATION APPROACHES FOR ILLAWARRA-SHOALHAVEN SUBTROPICAL RAINFOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Quarrying • Inappropriate fire regimes • Grazing • Rubbish dumping	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Ageratina adenophora* (Crofton Weed) • *Ageratum riparia* (Mistflower) • *Cinnamonum camphora* (Camphor Laurel) • *Delairea odorata* (Cape Ivy) • *Hedychium gardnerianum* (Ginger Lily) • *Ligustrum spp.* (Privet) • *Olea europaea ssp. cuspidata* (African olive) • *Solanum mauritianum* • *Tradescantia fluminensis* • *Lantana camara* • *Araujia sericifera* (Moth Vine)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-33. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-33).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Illawarra-Shoalhaven Subtropical Rainforest

FIGURE 7-12. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR ILLAWARRA-SHOALHAVEN SUBTROPICAL RAINFOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-31 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

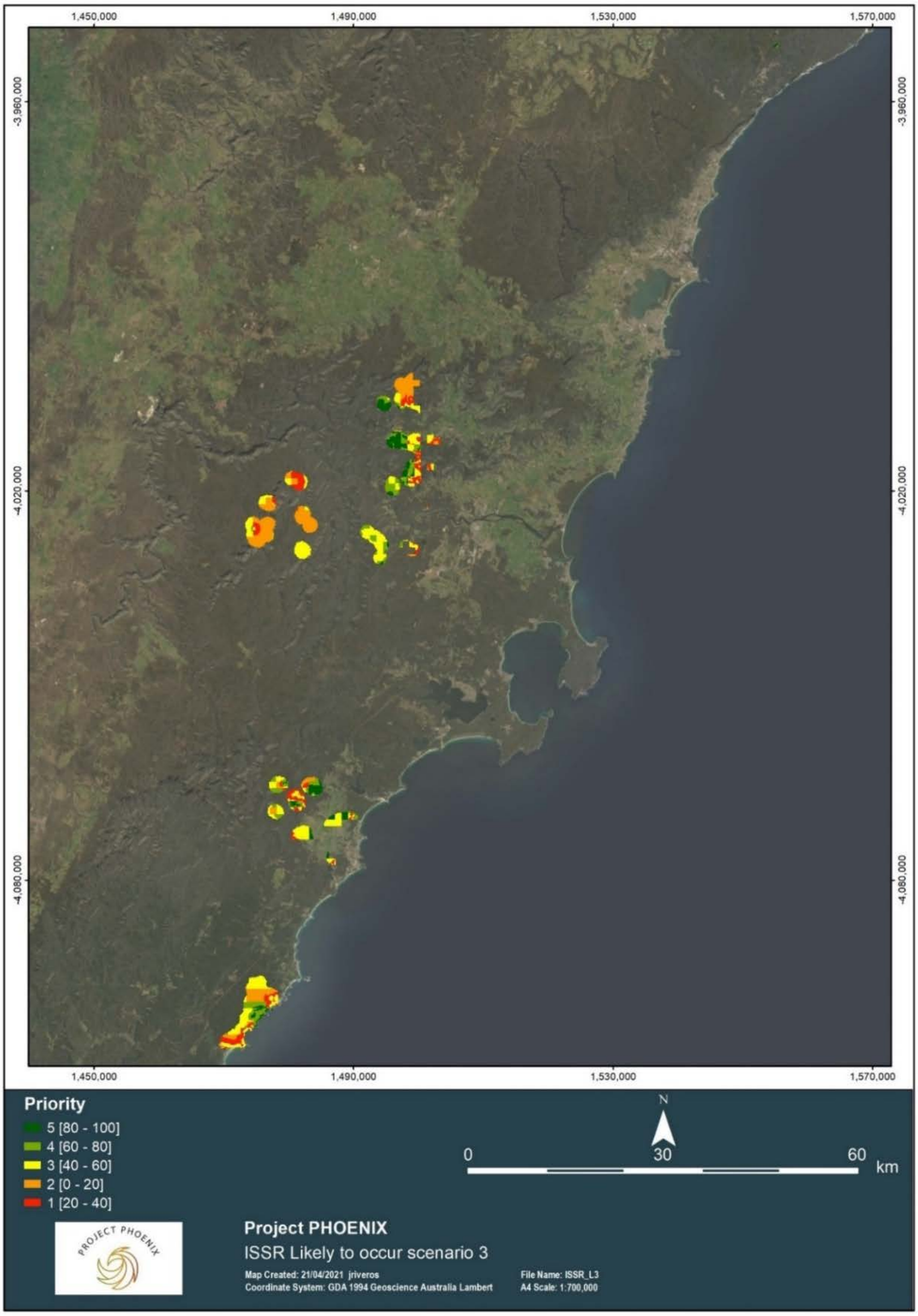


FIGURE 7-13. THE MEAN FIRE INTERVAL (MEANFI) FOR THE ILLAWARRA-SHOALHAVEN SUBTROPICAL RAINFOREST AND SURROUNDING AREA BASED ON THE NSW FIRE HISTORY DATA. WHITE POLYGONS DESIGNATE THE BOUNDS OF THE TEC AND RELATE TO THE AREAS IN FIGURE 7-13 (ABOVE).

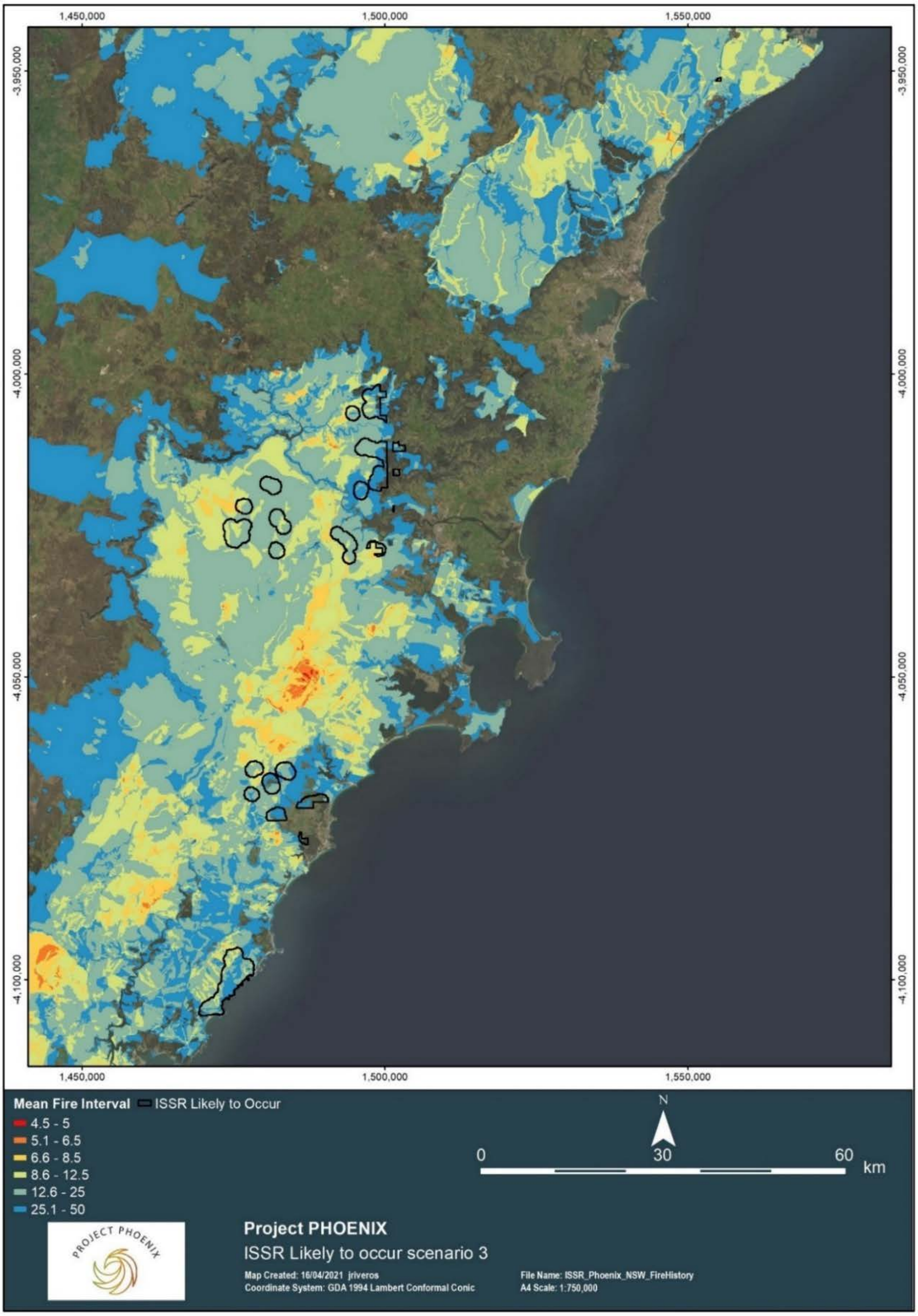


TABLE 7-33. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE ILLAWARRA-SHOALHAVEN SUBTROPICAL RAINFOREST OF THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Abutilon oxycarpum var. oxycarpum*	S	OS	S	
TEC species list	*Acacia maidenii*	T	OS	S	
TEC species list	*Aphanopetalum resinosum*	C	OS	T	
TEC species list	*Arthropteris tenella*	H	OS	UN	
TEC species list	*Asplenium australasicum*	H	OS	T	
TEC species list	*Cinnamomum oliveri*	T	OS	UN	
TEC species list	*Citronella moorei*	T	OS	UN	
TEC species list	*Croton verreauxii*	S/T	OS	UN	
TEC species list	*Cryptocarya microneura*	T	OS	UN	
TEC species list	*Dendrocnide excelsa*	T	OS	S	
TEC species list	*Ehretia acuminata*	T	OS	T	
TEC species list	*Ehretia acuminata var. acuminata*	T	OS	T	
TEC species list	*Elaeocarpus kirtonii*	T	OS	UN	
TEC species list	*Hibiscus heterophyllus*	S/T	OS	S	
TEC species list	*Hibiscus heterophyllus subsp. heterophyllus*	S/T	OS	S	
TEC species list	*Litsea reticulata*	T	OS	UN	
TEC species list	*Marsdenia flavescens*	S	OS	UN	
TEC species list	*Microsorum scandens*	H	OS	UN	
TEC species list	*Plectranthus parviflorus*	S	OS	S	
TEC species list	*Podocarpus elatus*	T	OS	UN	
TEC species list	*Polyosma cunninghamii*	T	OS	UN	
TEC species list	*Pyrrosia rupestris*	H	OS	UN	
TEC species list	*Sarcomelicope simplicifolia subsp. simplicifolia*	S/T	OS	T	
TEC species list	*Sloanea australis*	T	OS	UN	
TEC species list	*Stellaria flaccida*	H	OS	S	
TEC species list	*Streblus brunonianus*	S/T	OS	T	
TEC species list	*Symplocos thwaitesii*	S/T	OS	T	
TEC species list	*Acronychia oblongifolia*	S/T	FS	T	
TEC species list	*Adiantum formosum*	H	FS	UN	
TEC species list	*Alectryon subcinereus*	S/T	FS	T	
TEC species list	*Breynia oblongifolia*	S	FS	S	
TEC species list	*Cissus hypoglauca*	C	FS	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Commelina cyanea*	H	FS	UN	
TEC species list	*Eustrephus latifolius*	C	FS	UN	
TEC species list	*Myrsine howittiana*	S/T	FS	UN	
TEC species list	*Pandorea pandorana*	C	FS	S	
TEC species list	*Pittosporum revolutum*	S	FS	UN	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Pseuderanthemum variabile*	H	FS	S	
TEC species list	*Syzygium australe*	S/T	FS	T	
TEC species list	*Wilkiea huegeliana*	S/T	FS	UN	
Fire-affected species	*Acacia trachyphloia*	S	OS	UN	Yes
Fire-affected species	*Acacia yalwalensis*	S	OS	UN	Yes
Fire-affected species	*Cestichis reflexa*	H	OS	UN	
Fire-affected species	*Epacris gnidioides*	S	OS	UN	Yes
Fire-affected species	*Grevillea baueri subsp. asperula*	S	OS	S	Yes
Fire-affected species	*Hakea dohertyi*	S	OS	C	Yes
Fire-affected species	*Philotheca scabra subsp. latifolia*	S	FS	S	Yes
Fire-affected species	*Eucalyptus sturgissiana*	T	RS	C	Yes
Fire-affected species	*Leptospermum subglabratum*	S	UN	UN	Yes
Fire-affected species	*Prostanthera tallowa*	S	UN	UN	Yes

7.11 TEC 9: Turpentine-Ironbark Forest of the Sydney Basin Bioregion

7.11.1 Description

The Turpentine-Ironbark Forest in the Sydney Basin Bioregion consists of a *Syncarpia glomulifera* (turpentine) dominated canopy with other eucalypt species, a shrub and small tree mid-storey and a herb and grass ground cover.[85] It occurs up to 750m above sea level in areas with 800–1100mm/year rainfall.[86–88] Plant species of regional conservation significance include *Acacia pubescens* (Downy Wattle), *Eucalyptus benthamii* (Camden White Gum) and *Grammitis stenophylla* (Narrow-leaf Finger Fern).[89]

7.11.2 Fire response traits

In the Turpentine-Ironbark Forest, there are 103 plant species representing 75 different genera. Of these plant species, 51% (n = 52) are resprouters, 31% (n = 32) are facultative seeders and 17% (n = 17) are obligate seeders, with 2% (n = 2) having an unverified fire response (Table 7-34). Herbaceous species make up 40% (n = 41) of all plant species present, shrubs make up 31% (n = 32), trees make up 18% (n = 19) and climbers/vines make up 11% (n = 11) (Table 7-34).

TABLE 7-34. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

NUMBER (AND %) OF EACH FIRE RESPONSE					
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	6 (15)	9 (22)	24 (58)	2 (5)	**41**
Shrub	10 (31)	17 (53)	5 (16)	0 (0)	**32**
Tree	0 (0)	1 (5)	18 (95)	0 (0)	**19**
Total count	**1 (10)**	**5 (45)**	**5 (45)**	**0 (0)**	**11**

7.11.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-35).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Turpentine-Ironbark Forest and outlined below and described in Appendix 2 (Section 11.9).

TEC 9: Turpentine-Ironbark Forest of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 103 [75 genera]

Trees:
- 18% (n = 19)

Shrubs:
- 31% (n = 32)

Herbaceous:
- 40% (n = 41)

Climbers/Vines:
- 11% (n = 11)

Fire Response

Resprouters:
- 51% (n = 52)

Obligate seeders:
- 17% (n= 17)

Facultative seeders:
- 31% (n = 32)

Unknown:
- 2% (n = 2)

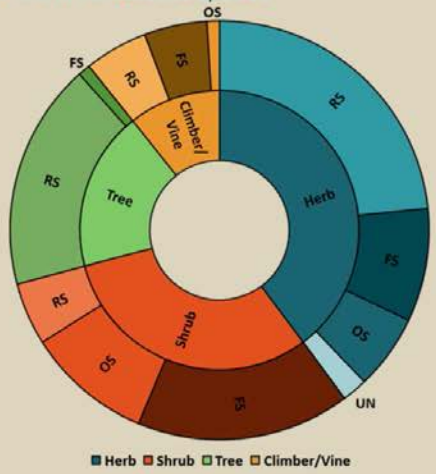
Life History and Fire Response

Resprouters (RS):
- Higher proportion of herbaceous species (58%) and trees (95%)

Obligate seeders (OS):
- Ranged from 10% of climbers/vines to 31% of shrubs

Facultative seeders (FS):
- Higher proportion of shrubs (53%) and climbers/vines (45%)

Unknown fire response (UN):
- 5% of herbaceous species

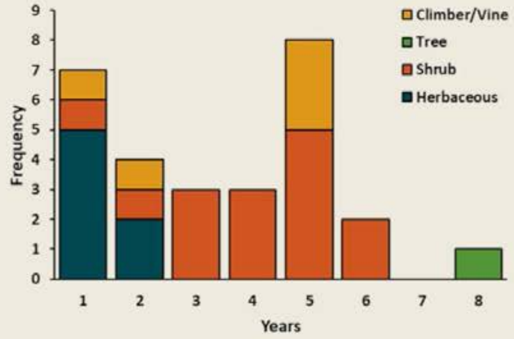


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 11-22 years[2]

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-12 years
- Herbaceous = 2-4 years
- Climbers/vines = 2-10 years
- Trees = 16 years



[1]Obligate seeders and facultative seeders

[2]74

TABLE 7-35. PRIORITY AREAS 1 AND 2 TURPENTINE–IRONBARK FOREST: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	69.2	5.6	2.4[a]	2.1-3.8	4.8	3-5	41	38.4-43.8	244.7	0-509.9
2 (60-80)	1.4	0.1	2.1[b]	2.1-2.1	5.0	5-5	43.1	43.1-43.1	468	400-538.5
3 (40-60)	727.4	59.2	2.8	2.1-3.8	3.8	3-5	41.8	37.7-45.8	1145.5	0-5578.5
4 (20-40)	286.2	23.3	2.6	2-3.8	3.3	2-5	41.5	37.7-45.9	283.9	0-1140.2
5 (0-20)	144.2	11.7	2.4	2-3.3	3.4	2-4	40.1	37.7-45.8	1395.2	223.6-2701.9

Finer scale analysis of NSW fire data: Priority area 1[a] = 23.6 years (8.3 – 50 years); Priority area 2[b] = 19.8 (16.7 – 25 years)

See Figure 7-15 for distribution of each priority area

Priority Area 1: Predicted Regenerative Potential

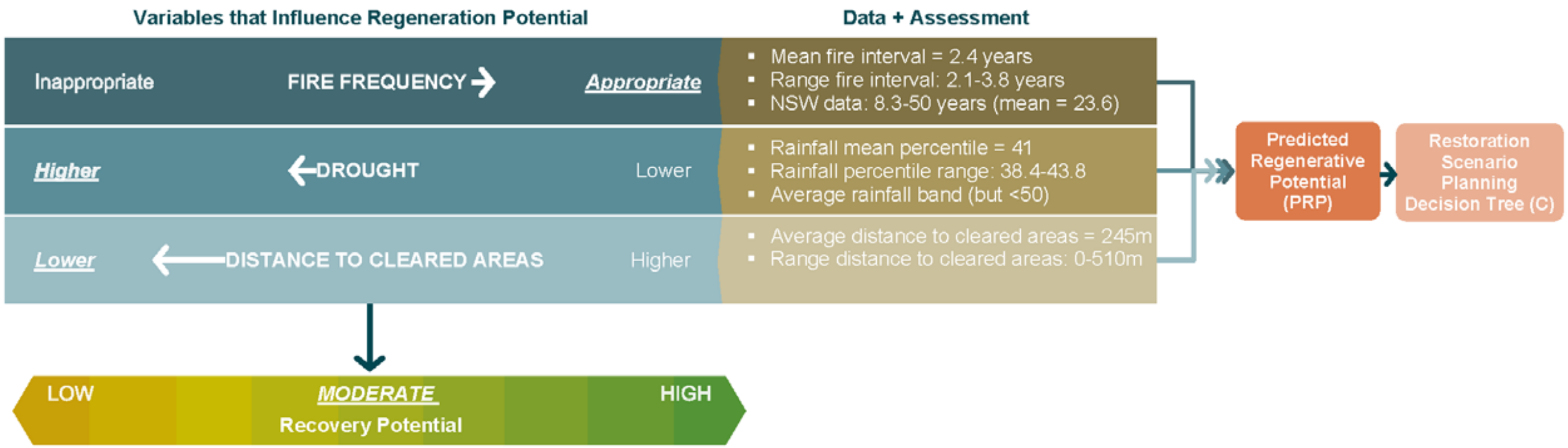
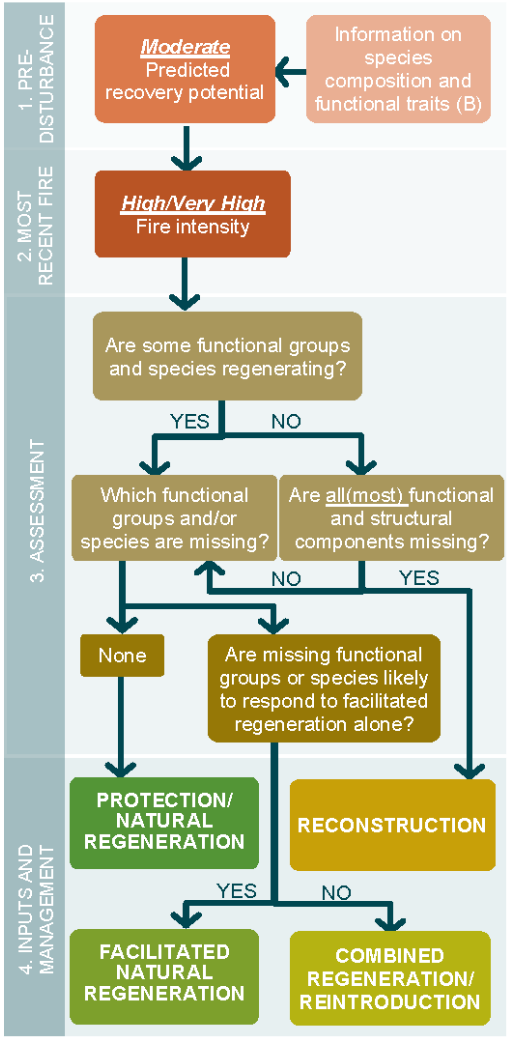


TABLE 7-36. RESTORATION APPROACHES FOR TURPENTINE–IRONBARK FOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural, and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Urban runoff contributing to increased nutrient load • Grazing • Recreational activities • Dieback and pathogens e.g., myrtle rust	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Araujia sericifera* (Moth Vine) • *Asparagus aethiopicus* • *Asparagus asparagoides* (Bridal Creeper) • *Chrysanthemoides monilifera* (Boneseed) • *Ehrharta erecta* (Panic Veldtgrass) • *Hedera helix* (English Ivy) • *Lantana camara* • *Ligustrum spp.* (Privet) • *Ochna serrulata* (Mickey Mouse Plant) • *Paspalum dilatatum* (Paspalum) • *Phytolacca octandra* (Inkweed) • *Sida rhombifolia* (Paddy's Lucerne)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and facultative seeders are listed in Table 7-37. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-37).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Turpentine-Ironbark Forest

FIGURE 7-14. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION TURPENTINE-IRONBARK FOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-35 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

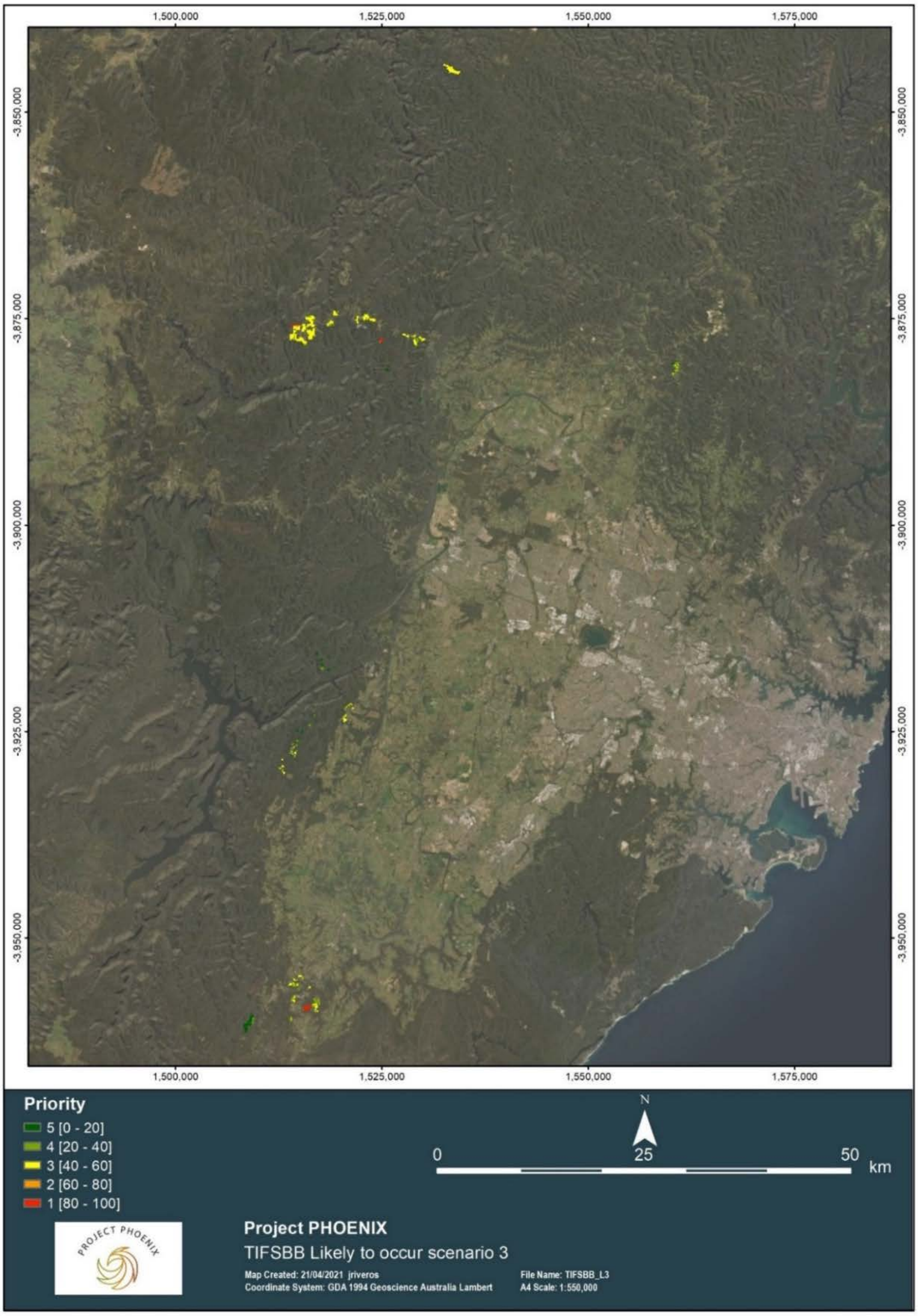


TABLE 7-37. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE TURPENTINE-IRONBARK FOREST IN THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia decurrens*	S	OS	S	
TEC species list	*Acacia falcata*	S	OS	S	
TEC species list	*Acacia parramattensis*	S	OS	S	
TEC species list	*Acacia stricta*	S	OS	S	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Clematis aristata*	C	OS	S	
TEC species list	*Daviesia genistifolia*	S	OS	S	
TEC species list	*Dodonaea triquetra*	S	OS	S	
TEC species list	*Einadia nutans*	H	OS	UN	
TEC species list	*Einadia polygonoides*	H	OS	UN	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Kunzea ambigua*	S	OS	S	
TEC species list	*Opercularia hispida*	H	OS	UN	
TEC species list	*Pomaderris lanigera*	S/T	OS	S	
TEC species list	*Pomax umbellata*	S	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Trema aspera*	S/T	OS	S	
TEC species list	*Acacia implexa*	S	FS	S	
TEC species list	*Acacia longifolia*	S	FS	S	
TEC species list	*Acacia myrtifolia*	S	FS	S	
TEC species list	*Billardiera scandens*	S	FS	S	
TEC species list	*Breynia oblongifolia*	S	FS	S	
TEC species list	*Clematis glycinoides*	C	FS	S	
TEC species list	*Commelina cyanea*	H	FS	UN	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Dianella caerulea*	H	FS	T	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Elaeocarpus reticulatus*	S/T	FS	T	
TEC species list	*Exocarpos cupressiformis*	S/T	FS	UN	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Homalanthus stillingiifolius*	S	FS	UN	
TEC species list	*Indigofera australis*	S	FS	S	
TEC species list	*Kennedia rubicunda*	C	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Lasiopetalum parviflorum*	S	FS	S	
TEC species list	*Leucopogon juniperinus*	S	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Oxalis exilis*	H	FS	S	
TEC species list	*Ozothamnus diosmifolius*	S	FS	S	
TEC species list	*Pandorea pandorana*	C	FS	S	
TEC species list	*Pittosporum revolutum*	S	FS	UN	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Platylobium formosum*	S	FS	S	
TEC species list	*Polyscias sambucifolia*	S	FS	S	
TEC species list	*Pseuderanthemum variabile*	H	FS	S	
TEC species list	*Senecio hispidulus*	H	FS	S	
TEC species list	*Sporobolus creber*	H	FS	UN	
TEC species list	*Zieria smithii*	S	FS	S	
Fire-affected species	*Tetratheca ericifolia*	S	FS	S	
Fire-affected species	*Leptospermum macrocarpum*	S	RS	C	Yes

7.12 TEC 10: Illawarra and South Coast Lowland Forest and Woodland

7.12.1 Description

The Illawarra and South Coast Lowland Forest and Woodland occurs less than 350m above sea level within 30km of the New South Wales south coast from north of Wollongong to Moruya.[68,90] The annual rainfall will range from 1150mm to 1400mm per year with temperatures between 5°C and 25°C.[68] At a local scale, this community varies with aspect, with more mesic elements on south facing slopes. *Eucalyptus* or *Angophora* trees dominate the canopy with a main canopy foliage cover of more than 10 per cent and *E. tereticornis* always present in the mature tree canopy.[90] Characteristic species include *Cheilanthes sieberi* (mulga fern), *Dianella longifolia* (flax lily), *Entolasia stricta* (wiry panic) and *Lagenophora stipitata* (blue bottle daisy).[90]

7.12.2 Fire response traits

In the Illawarra and South Coast Lowland Forest and Woodland, there are 77 plant species representing 55 different genera. Of these plant species, 62% (n = 48) are resprouters, 25% (n = 19) are facultative seeders and 13% (n = 10) are obligate seeders, with none having an unverified fire response (Table 7-38). Herbaceous species make up 51% (n = 39) of all plant species present, shrubs make up 25% (n = 19), trees make up 14% (n = 11) and climbers/vines make up 10% (n = 8) (Table 7-38).

TABLE 7-38. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS)) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE			
LIFE FORM	OS	FS	RS	TOTAL COUNT
Herbaceous	2 (5)	11 (28)	26 (67)	**39**
Shrub	8 (42)	4 (21)	7 (37)	**19**
Tree	0 (0)	1 (9)	10 (91)	**11**
Climber/Vine	0 (0)	3 (38)	5 (62)	**8**
Total count	**10**	**19**	**48**	**77**

7.12.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-39).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Illawarra and South Coast Lowland Forest and Woodland and outlined below and described in Appendix 2 (Section 11.10).

TEC 10: Illawarra and South Coast Lowland Forest and Woodland

Community Characteristics

Number of species:
- 77 [55 genera]

Trees:
- 14% (n = 11)

Shrubs:
- 25% (n = 19)

Herbaceous:
- 51% (n = 39)

Climbers/Vines:
- 10% (n = 8)

Fire Response

Resprouters:
- 62% (n = 48)

Obligate seeders:
- 13% (n= 10)

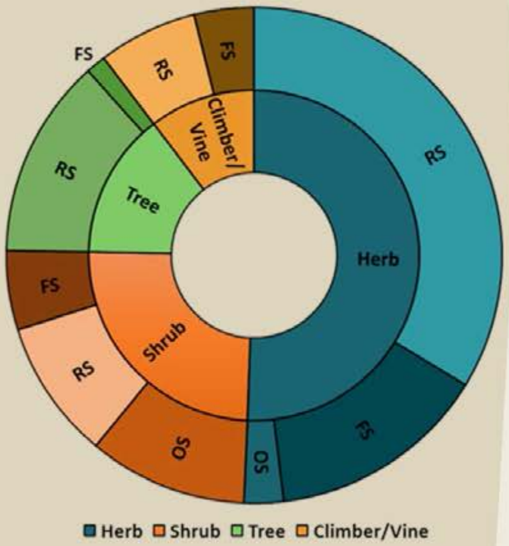
Facultative seeders:
- 25% (n = 19)

Life History and Fire Response

Resprouters (RS):
- Ranged from 37% of shrubs to 91% of trees

Obligate seeders (OS):
- Higher proportion of shrubs (45%)

Facultative seeders (FS):
- Higher proportion of herbaceous species (28%) and climbers/vines (38%)

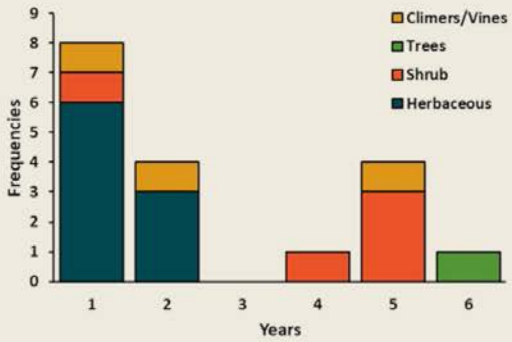


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 15 years (normally low intensity fire)

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-10 years
- Herbaceous = 2-4 years
- Climbers/vines = 2-10 years
- Trees = 12 years



[1]Obligate seeders and facultative seeders

TABLE 7-39. PRIORITY AREAS 1 AND 2 ILLAWARRA AND SOUTH COAST LOWLAND FOREST AND WOODLAND: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	146.2	8.1	3.2[a]	1.9-3.3	4.7	3-5	46.4	45.7-47.3	155.9	0-538.5
2 (60-80)	0.7	0	3.3[b]	3.3-3.3	5	5-5	47.3	47.3-47.3	519.3	500-538.5
3 (40-60)	993.6	55.1	2.3	1.5-5	3.3	2-5	44.5	38.3-47.6	104	0-316.2
4 (20-40)	519.9	28.8	2.3	1.5-3.8	3	2-4	43.3	38.3-47.5	254.6	0-1005
5 (0-20)	1	8	2.3	1.7-2.6	2.5	2-4	43.7	38.3-46.6	517.1	141.4-1019.8

Finer scale analysis of NSW fire data: Priority area 1[a] = 48.2 years (25 – 50 years); Priority area 2[b] = 50.0 (50 – 50 years)

See Figure 7-16 for distribution of each priority area

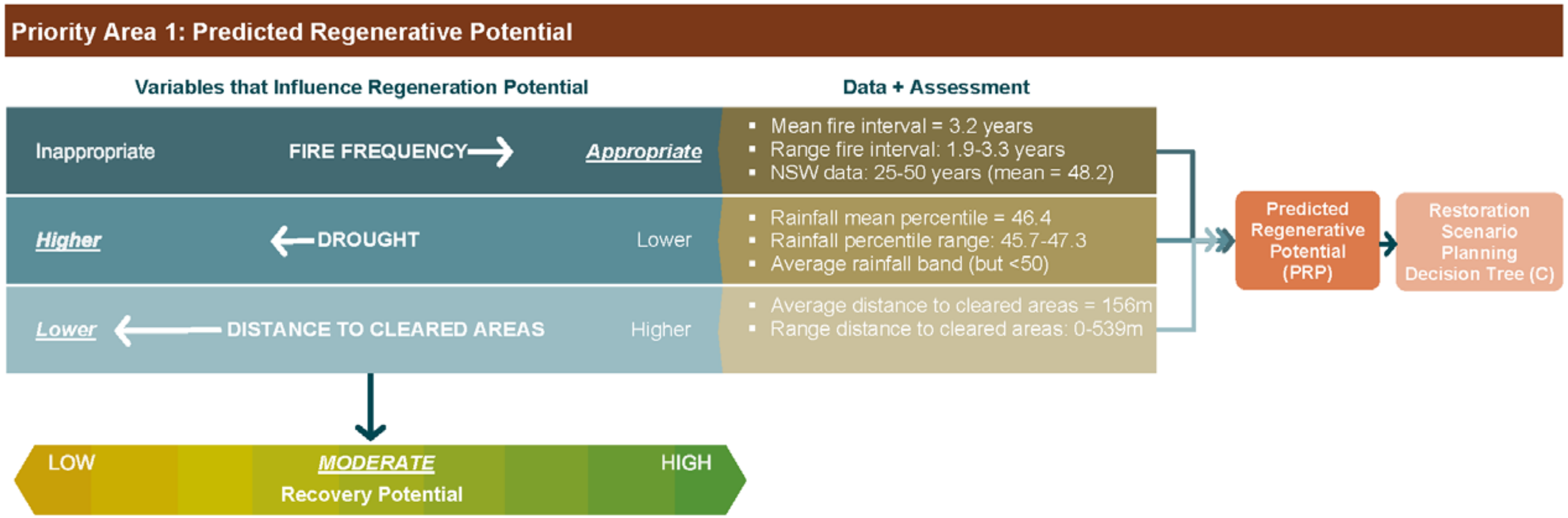
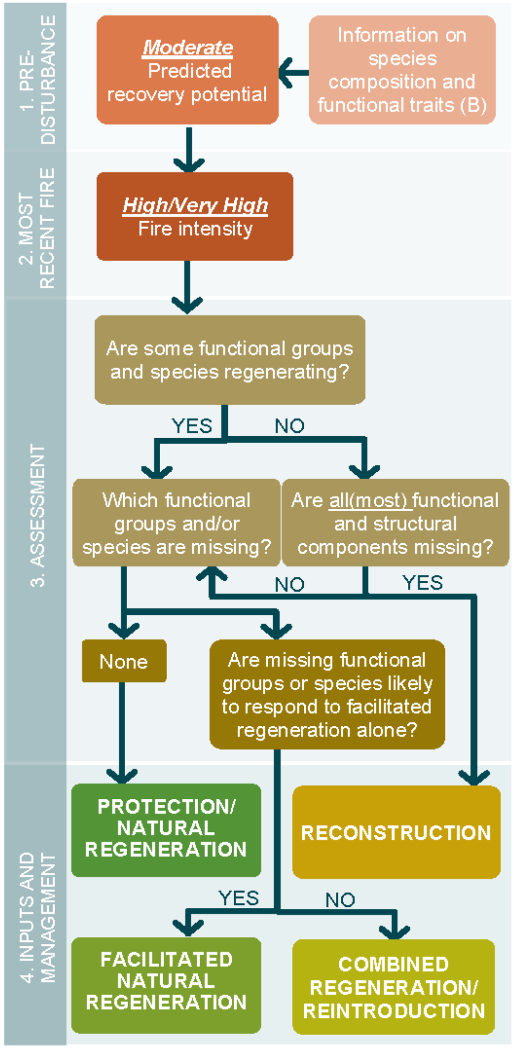


TABLE 7-40. RESTORATION APPROACHES FOR ILLAWARRA AND SOUTH COAST LOWLAND FOREST AND WOODLAND



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnant patches** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Introduced animals including feral cats (*Felis catus*), feral honeybees, rats, mice and European Red Fox (*Vulpes vulpes*) • Grazing • Logging and timber removal • Climate change • Quarrying	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Asparagus spp.* • *Axonopus fissifolius* • *Cenchrus clandestinum* (Kikuyu) • *Chrysanthemoides monilifera subsp. rotundata* (Boneseed) • *Eragrostis curvula* (African lovegrass) • *Lantana camara* • *Ligustrum spp.* (Privet) • *Lycium ferocissimum* (African boxthorn) • *Oleus europaea subsp.cuspidata* (African olive) • *Rubus fruticosus* (Blackberry) • *Senecio madagascarensis* • *Ulex europaeus* (Gorse)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-41. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-41).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Illawarra and South Coast Lowland Forest and Woodland

Figure 7-15. The distribution of priority areas for management intervention for Illawarra and South Coast Lowland Forest and Woodland. Red areas represent priority area 1 and orange areas priority area 2. See Table 7-39 above for assessment variables in each priority area.

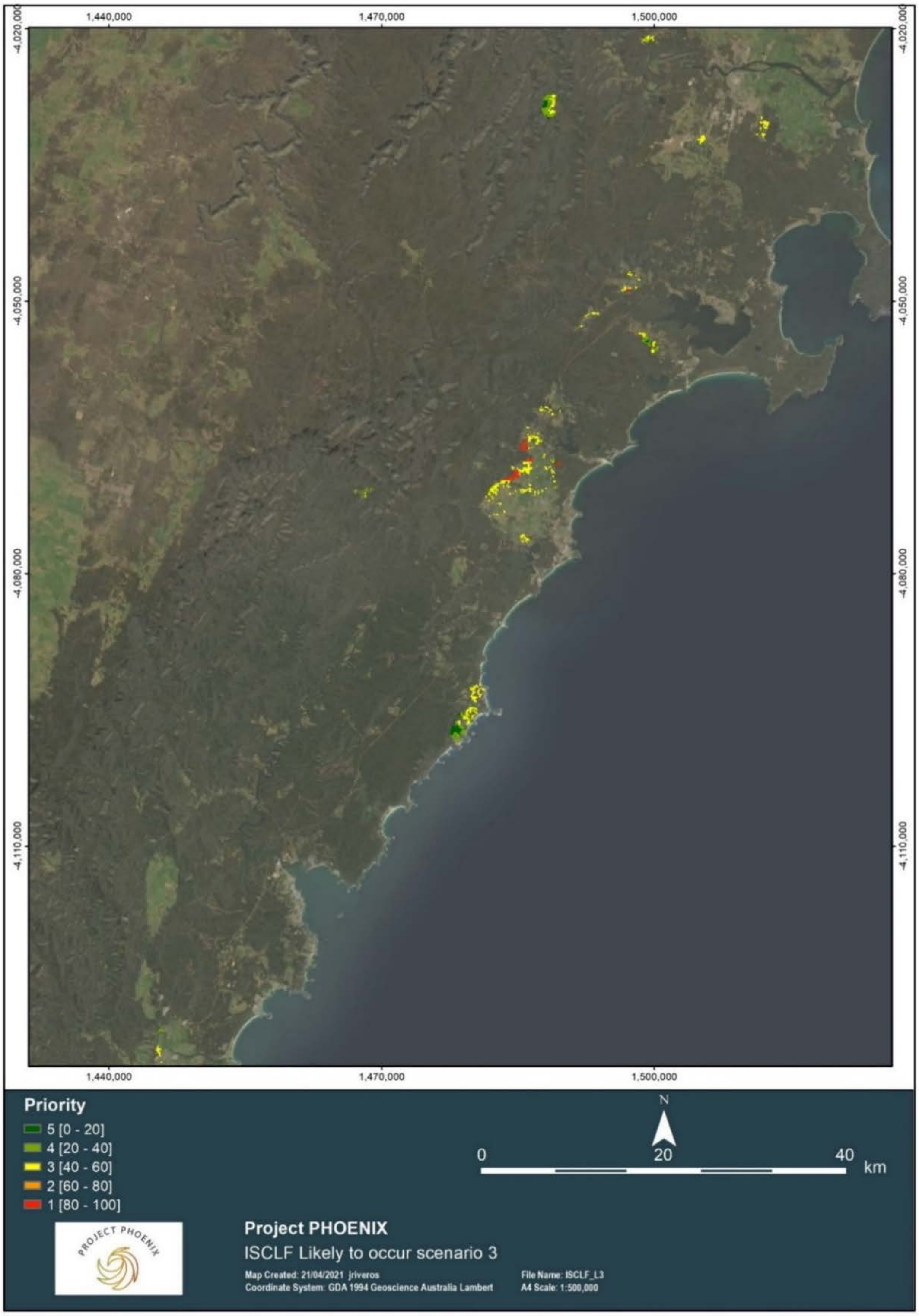


FIGURE 7-16. THE MEAN FIRE INTERVAL (MEANFI) FOR THE ILLAWARRA AND SOUTH COAST LOWLAND FOREST AND WOODLAND AND SURROUNDING AREA BASED ON THE NSW FIRE HISTORY DATA. WHITE POLYGONS DESIGNATE THE BOUNDS OF THE TEC AND RELATE TO THE AREAS IN FIGURE 7-16 (ABOVE). THE INSERT REPRESENTS THE FIRE INTERVAL VARIATION WITHIN A 10 X 10KM GRID THAT RESULTS IN AN UNDERESTIMATE OF MEAN FIRE INTERVAL FOR TECS WHEN A COARSER RESOLUTION IS USED.

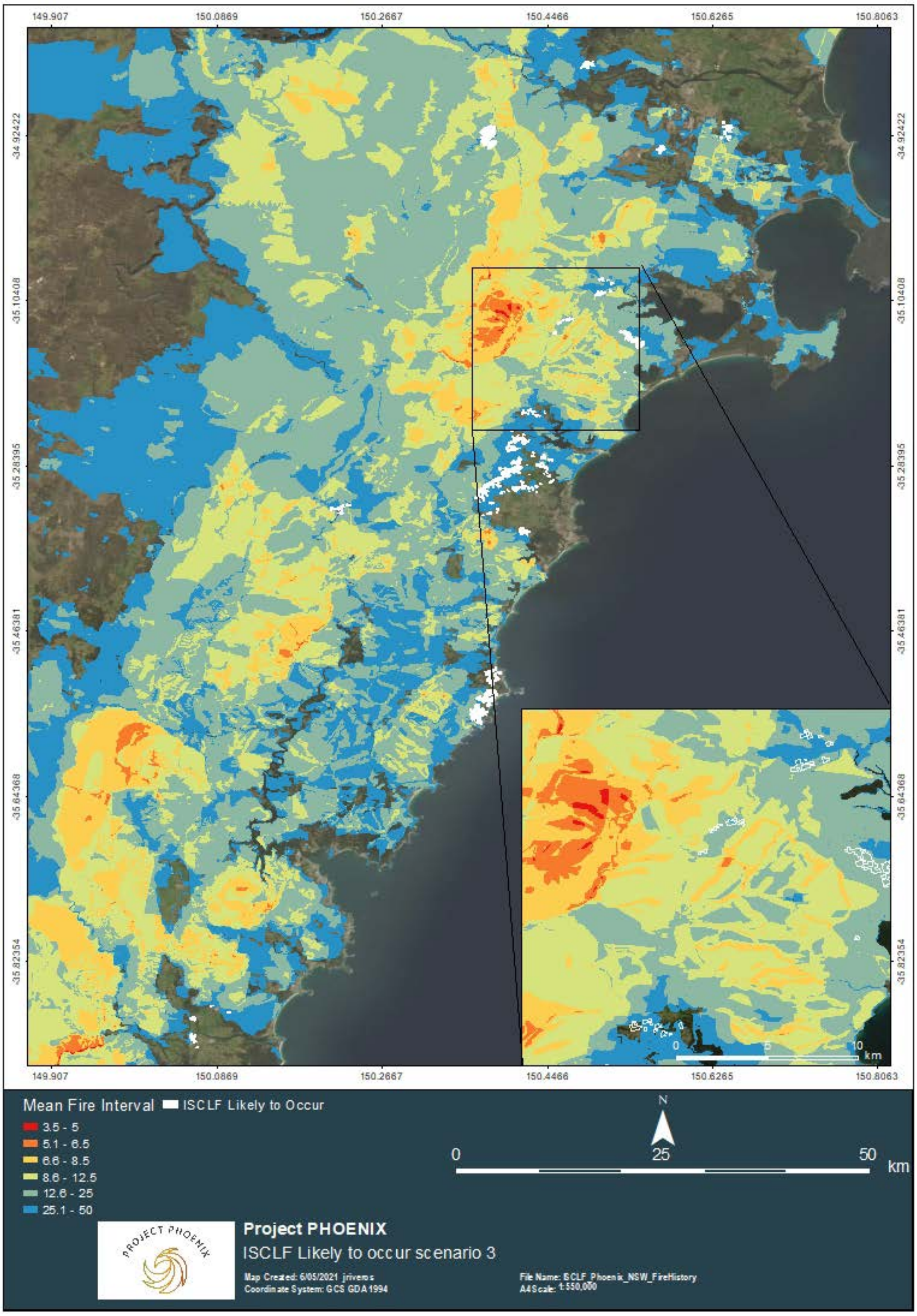


TABLE 7-41. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE ILLAWARRA AND SOUTH COAST LOWLAND FOREST AND WOODLAND TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia falcata*	S	OS	S	
TEC species list	*Acacia maidenii*	S	OS	S	
TEC species list	*Acacia mearnsii*	S	OS	S	
TEC species list	*Acacia stricta*	S	OS	S	
TEC species list	*Daviesia genistifolia*	S	OS	S	
TEC species list	*Dodonaea viscosa var angustifolia*	S	OS	UN	
TEC species list	*Geranium solanderi*	H	OS	UN	
TEC species list	*Plectranthus parviflorus*	S	OS	S	
TEC species list	*Pultenaea villosa*	S	OS	S	
TEC species list	*Stellaria flaccida*	H	OS	S	
TEC species list	*Acacia implexa*	S	FS	S	
TEC species list	*Allocasuarina littoralis*	T	FS	T	
TEC species list	*Boronia polygalifolia*	H	FS	S	
TEC species list	*Commelina cyanea*	H	FS	UN	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Desmodium rhytidophyllum*	H	FS	S	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Gahnia radula*	H	FS	UN	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Hibbertia aspera*	S	FS	S	
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Kennedia rubicunda*	C	FS	S	
TEC species list	*Leucopogon juniperinum*	S	FS	S	
TEC species list	*Tricoryne elatior*	H	FS	T	
TEC species list	*Veronica calycina*	H	FS	T	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
TEC species list	*Wahlenbergia stricta subsp. stricta*	H	FS	S	
Fire-affected species	*Acacia yalwalensis*	S	OS	UN	Yes
Fire-affected species	*Eucalyptus sturgissiana*	T	RS	C	Yes

7.13 TEC 11: Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain

7.13.1 Description

The Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain occurs in the South West Swan region of Western Australia between Holocene dunes. It is heavily influenced by the water regime and typically requires being water logged in winter and retaining surface soil with high moisture levels in the summer.[91] Common native plant species include *Acacia rostellifera* (Summer-scented Wattle), *Ficinia nodosa* (Knotted Club Rush) and *Xanthorrhoes preissii* (Grass tree).

7.13.2 Fire response traits

In the Sedgelands in Holocene Dune Swales, there are 75 plant species representing 61 different genera. This species list is indicative and the assemblage of species will likely vary between patches of this community as vegetation composition changes with age and proximity to the water table.[92] Of these plant species, 25% (n = 19) are obligate seeders, 21% (n = 16) are resprouters and 16% (n = 12) are facultative seeders, with 37% (n = 28) having an unverified fire response (Table 7-42). Herbaceous species make up 52% (n = 39) of all plant species present, shrubs make up 35% (n = 26), climbers/vines make up 8% (n = 6) and trees make up 5% (n = 4) (Table 7-42).

TABLE 7-42. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE)

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	7 (18)	6 (15)	10 (26)	16 (41)	**39**
Shrub	9 (35)	4 (15)	4 (15)	9 (35)	**26**
Tree	0 (0)	2 (50)	1 (25)	1 (25)	**4**
Climber/Vine	3 (50)	0 (0)	1 (17)	2 (33)	**6**
Total count	**19**	**12**	**16**	**28**	**75**

7.13.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-43).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Sedgelands in Holocene Dune Swales and outlined below and described in Appendix 2 (Section 11.11).

TEC 11: Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain

Community Characteristics

Number of species:
- 75 [61 genera]

Trees:
- 5% (n = 4)

Shrubs:
- 35% (n = 26)

Herbaceous:
- 52% (n = 39)

Climbers/Vines:
- 8% (n = 6)

Fire Response

Resprouters:
- 21% (n = 16)

Obligate seeders:
- 25% (n= 19)

Facultative seeders:
- 16% (n = 12)

Unknown:
- 37% (n = 28)

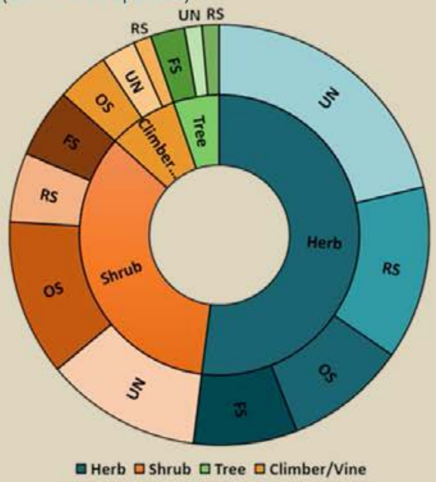
Life History and Fire Response

Resprouters (RS):
- Ranged from 15% of shrubs to 26% of herbaceous species

Obligate seeders (OS):
- Higher proportion of shrubs (35%) and climbers/vines (50%)

Facultative seeders (FS):
- Higher proportion of and trees (50%)

For each life form:
- High proportion of unknown (UN) fire responses (25-41% of species)

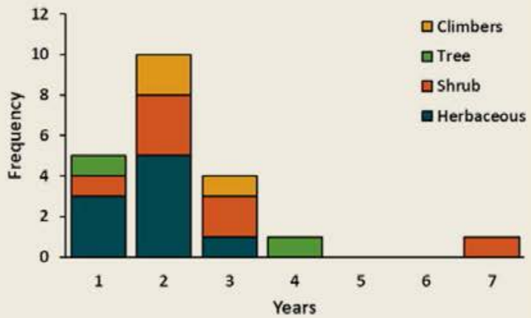


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 20 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-14 years
- Herbaceous = 2-6 years
- Climbers/vines = 4-6 years
- Trees = 2-8 years



[1]Obligate seeders and facultative seeders

TABLE 7-43. PRIORITY AREAS 1 AND 2 SEDGELANDS IN HOLOCENE DUNE SWALES: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	1125.9	39.3	3.7	2-4	4.7	3-5	26.4	25.6-26.8	372	0-1104.5
2 (60-80)	1333.8	46.6	3.3	2-4	4	2-5	26.1	25.6-26.8	459.7	0-1392.8
3 (40-60)	117.3	4.1	3.8	2-5	2.7	2-5	25.6	16.4-26.8	548.1	141.4-1216.6
4 (20-40)	91.2	3.2	5	5-5	3	3-3	16.4	16.4-16.4	701	400-1100
5 (0-20)	196	6.8	16	16-16	3	3-3	21.1	19.5-21.5	204.4	0-412.3

See Figure 7-18 for distribution of each priority area

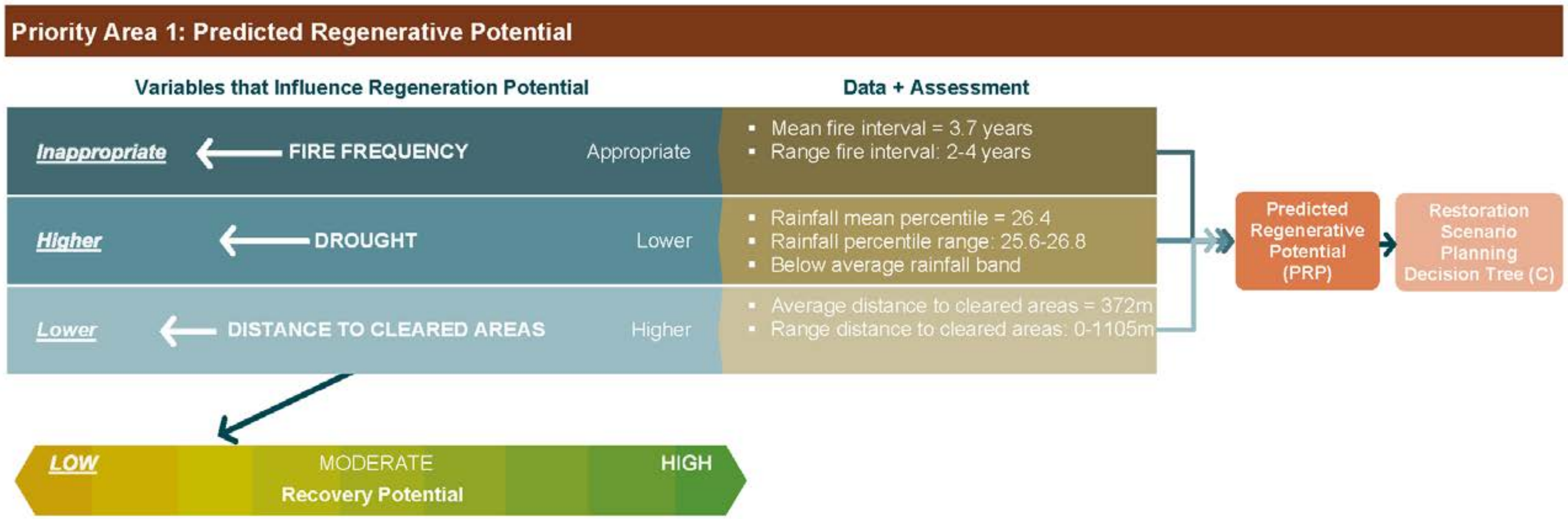
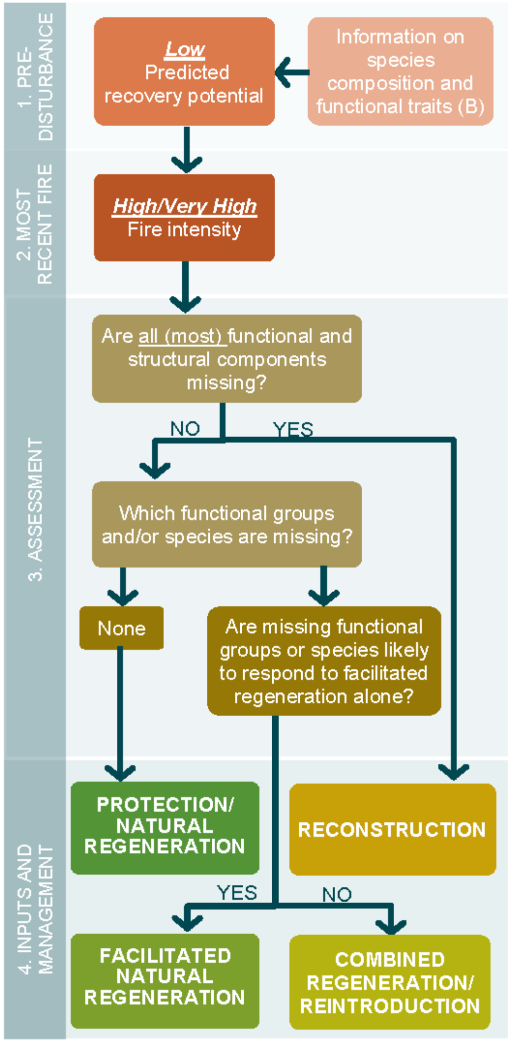


TABLE 7-44. RESTORATION APPROACHES FOR SEDGELANDS IN HOLOCENE DUNE SWALES



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Declining water levels and water quality • Invasion and establishment of weed species • Inappropriate fire regimes • Recreational activities (mainly unauthorised vehicle access) • Grazing by introduces herbivores • Rubbish dumping	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Asparagus asparagoides* (Bridal Creeper) • *Cortaderia selloana* (Pampas Grass) • *Euphorbia terracina* (Geraldton Carnation Weed) • *Gomphocarpus fruticosus* (Cottonbush) • *Juncus acutus* (Sharp Rush) • *Pelargonium capitatum* (Rose Pelargonium) • *Trachyandra divaricata* (Dune Onion Weed)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and facultative seeders are listed in Table 7-45. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-45).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Sedgelands in Holocene Dune Swales

FIGURE 7-17. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR SEDGELANDS IN HOLOCENE DUNE SWALES. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-43 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

TABLE 7-45. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS (OS) AND FACULTATIVE SEEDERS (FS)) FROM THE SEDGELANDS IN HOLOCENE DUNE SWALES OF THE SOUTHERN SWAN COASTAL PLAIN TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia lasiocarpa*	S	OS	S	
TEC species list	*Acacia pulchella*	S	OS	S	
TEC species list	*Adriana quadripartita*	S	OS	UN	
TEC species list	*Alyogyne huegelii*	S	OS	UN	
TEC species list	*Anthocercis littorea*	S	OS	S	
TEC species list	*Austrostipa flavescens*	H	OS	S	
TEC species list	*Cassytha racemosa*	C	OS	S	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Daucus glochidiatus*	H	OS	UN	
TEC species list	*Geranium retrorsum*	H	OS	UN	
TEC species list	*Kennedia prostrata*	C	OS	S	
TEC species list	*Muehlenbeckia adpressa*	C	OS	S	
TEC species list	*Opercularia hispidula*	H	OS	UN	
TEC species list	*Opercularia vaginata*	H	OS	S	
TEC species list	*Phyllanthus calycinus*	S	OS	C	
TEC species list	*Pimelea argentea*	S	OS	S	
TEC species list	*Samolus repens*	H	OS	S	
TEC species list	*Spyridium globulosum*	S	OS	S	
TEC species list	*Templetonia retusa*	S	OS	S	
TEC species list	*Acacia rostellifera*	S	FS	S	
TEC species list	*Acacia saligna*	S	FS	S	
TEC species list	*Conostylis candicans subsp. candicans*	H	FS	UN	
TEC species list	*Eucalyptus gomphocephala*	T	FS	UN	
TEC species list	*Gahnia trifida*	H	FS	UN	
TEC species list	*Lachnagrostis filiformis*	H	FS	UN	
TEC species list	*Leucopogon parviflorus*	S	FS	S	
TEC species list	*Melaleuca rhaphiophylla*	S/T	FS	C	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Stackhousia monogyna*	H	FS	S	
TEC species list	*Tricoryne elatior*	H	FS	T	
TEC species list	*Xanthorrhoea preissii*	T*	FS	UN	

*Structurally tree (T), but monocot

7.14 TEC 12: Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland

7.14.1 Description

The Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland is typically found 30km from the coast less than 20m above sea level.[93] Typical soils are unconsolidated sediments (incl alluvium deposits) and peaty soils (organosols).[93,94] Its structure varies from woodland to forest, influenced by the soils, tidal history and disturbance regimes but is characterised by a sparse *Casuarina glauca* (swamp oak, swamp she-oak) canopy.[93]

7.14.2 Fire response traits

In the Coastal Swamp Oak Forest, there are 170 plant species representing 136 different genera. This species list is indicative and the assemblage of species will likely vary between patches of this community as vegetation composition changes with age and proximity to the water table.[93] Of these plant species, 36% (n = 61) are resprouters, 17% (n = 29) are obligate seeders and 12% (n = 20) are facultative seeders, with 35% (n = 60) having an unverified fire response (Table 7-46). Herbaceous species make up 49% (n = 83) of all plant species present, trees make up 18% (n = 31), climbers/vines make up 17% (n = 29) and shrubs make up 16% (n = 27) (Table 7-46).

Table 7-46. The number and per cent of each fire response (obligate seeder (OS), facultative seeder (FS), resprouter (RS), unknown) of each life form (herbaceous, shrub, tree, climber/vine)

	Number (and %) of each fire response				
Life form	OS	FS	RS	Unknown	Total count
Herbaceous	13 (16)	7 (8)	24 (29)	39 (47)	**83**
Shrub	3 (11)	5 (18)	15 (56)	4 (15)	**27**
Tree	2 (7)	5 (16)	14 (45)	10 (32)	**31**
Climber/Vine	11 (38)	3 (10)	8 (28)	7 (24)	**29**
Total count	**29**	**20**	**61**	**60**	**170**

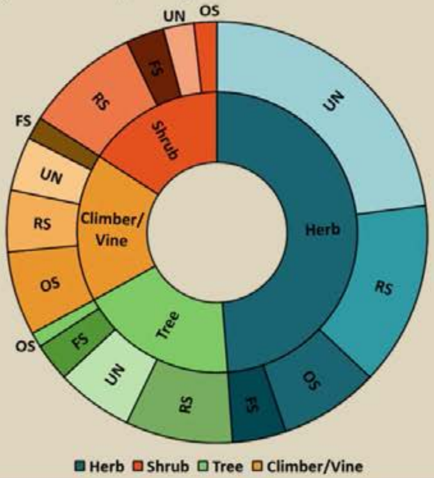
7.14.3 GIS analysis

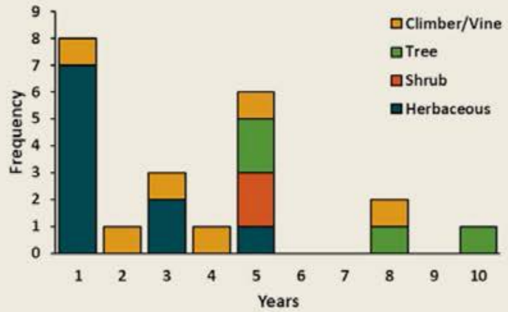
We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-47).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Coastal Swamp Oak Forest and outlined below and described in Appendix 2 (Section 11.12).

TEC 12: Coastal Swamp Oak (Casuarina Glauca) Forest of New South Wales and South East Queensland

Community Characteristics	Fire Response	Life History and Fire Response	Primary Juvenile Periods for Fire Sensitive Species
Number of species: • 170 [136 genera] **Trees:** • 18% (n = 31) **Shrubs:** • 16% (n = 27) **Herbaceous:** • 49% (n = 83) **Climbers/Vines:** • 17% (n = 29)	**Resprouters:** • 36% (n = 61) **Obligate seeders:** • 17% (n= 29) **Facultative seeders:** • 12% (n = 20) **Unknown:** • 35% (n = 60)	**Resprouters (RS):** • Higher proportion of shrubs (56%) and trees (45%) **Obligate seeders (OS):** • Ranged from 7% of trees to 38% of climbers/vines **Facultative seeders (FS):** • Ranged from 8% of trees to 18% of climbers/vines **For each life form:** • High proportion of unknown (UN) fire responses (15-47% of species)	**The frequency of primary juvenile periods for sensitive species[1] of different life forms** **General recommendation for fire free interval:** • > 15 years • Can withstand intervals of 6-7 years (low intensity fire) **Minimum fire interval based on primary juvenile period:** • Shrubs = 10 years • Herbaceous = 2-10 years • Climbers/vines = 2-16 years • Trees = 10-20 years





[1]Obligate seeders and facultative seeders

TABLE 7-47. PRIORITY AREAS 1 AND 2 COASTAL SWAMP OAK FOREST: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	3565.9	21.0	2.7[a]	1.4-16.7	4.5	2-5	41.4	35.7-48.5	302.6	0-1140.2
2 (60-80)	8550.2	50.3	2.8[b]	1.4-16.7	3.5	2-5	43.2	35.5-48.5	374.4	0-3420.5
3 (40-60)	4590.6	27.0	3.8	1.4-16.7	3.2	2-5	42.8	31.5-48.3	1009.9	0-3401.5
4 (20-40)	298.6	1.8	11.5	3.3-50	3.3	2-5	44.5	36.4-68.3	829.5	0-2102.4
5 (0-20)	6.2	0	22.2	12.5-25	2.5	2-4	47.6	44.9-48.5	220.9	0-447.2

Finer scale analysis of NSW fire data: Priority area 1[a] = 33.1 years (5.6 – 50 years); Priority area 2[b] = 31.4 (5.0 – 50 years)

See Figure 7-19 for distribution of each priority area

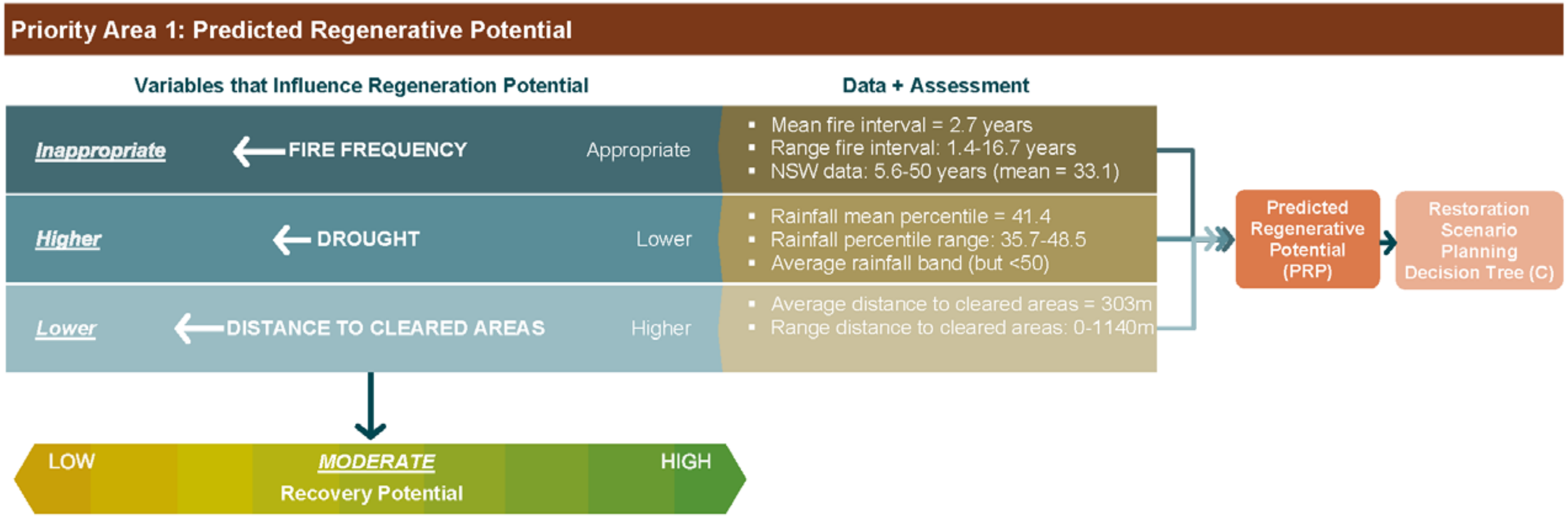
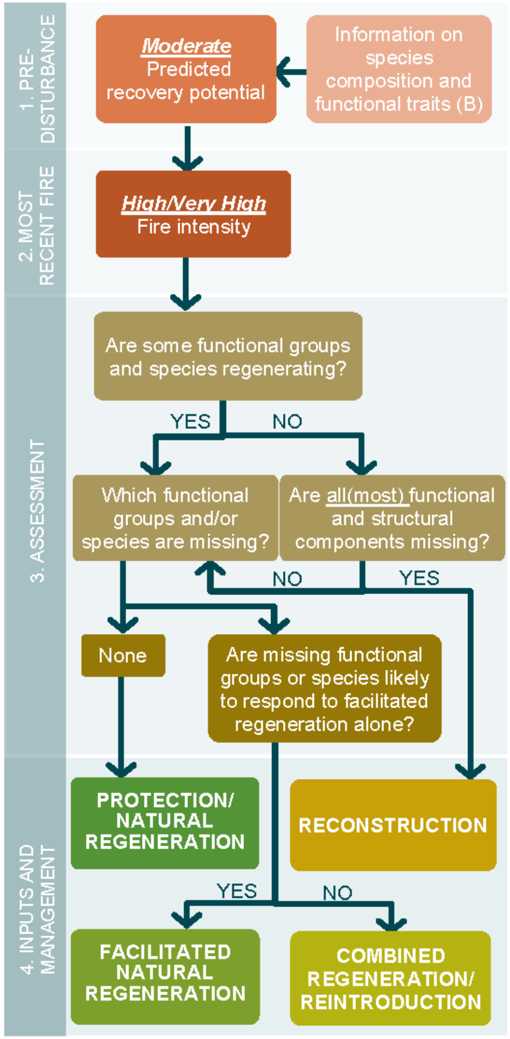


TABLE 7-48. RESTORATION APPROACHES FOR COASTAL SWAMP OAK FOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnant patches** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural, and urban development • Invasion and establishment of transformer weed species • Invasive fauna • Inappropriate fire regimes • Grazing • Changes in hydrology • Recreational activities • Climate change	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Cinnamonum camphora* (Camphor Laurel) • *Ipomeoa spp.* • *Ligustrum lucidum* (Large-leaved Privet) • *Ligustrum sinense* (Small-leaved Privet) • *Pennisetum spp.* (Feather Grasses and Mission Grasses) • *Schefflera actinophylla* (Umbrella Tree) • *Senna pendula* (Winter Senna)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-49. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-49).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Coastal Swamp Oak Forest

Figure 7-18. The distribution of priority areas for management intervention for Coastal Swamp Oak Forest. Red areas represent priority area 1 and orange areas priority area 2. See Table 7-47 above for assessment variables in each priority area.

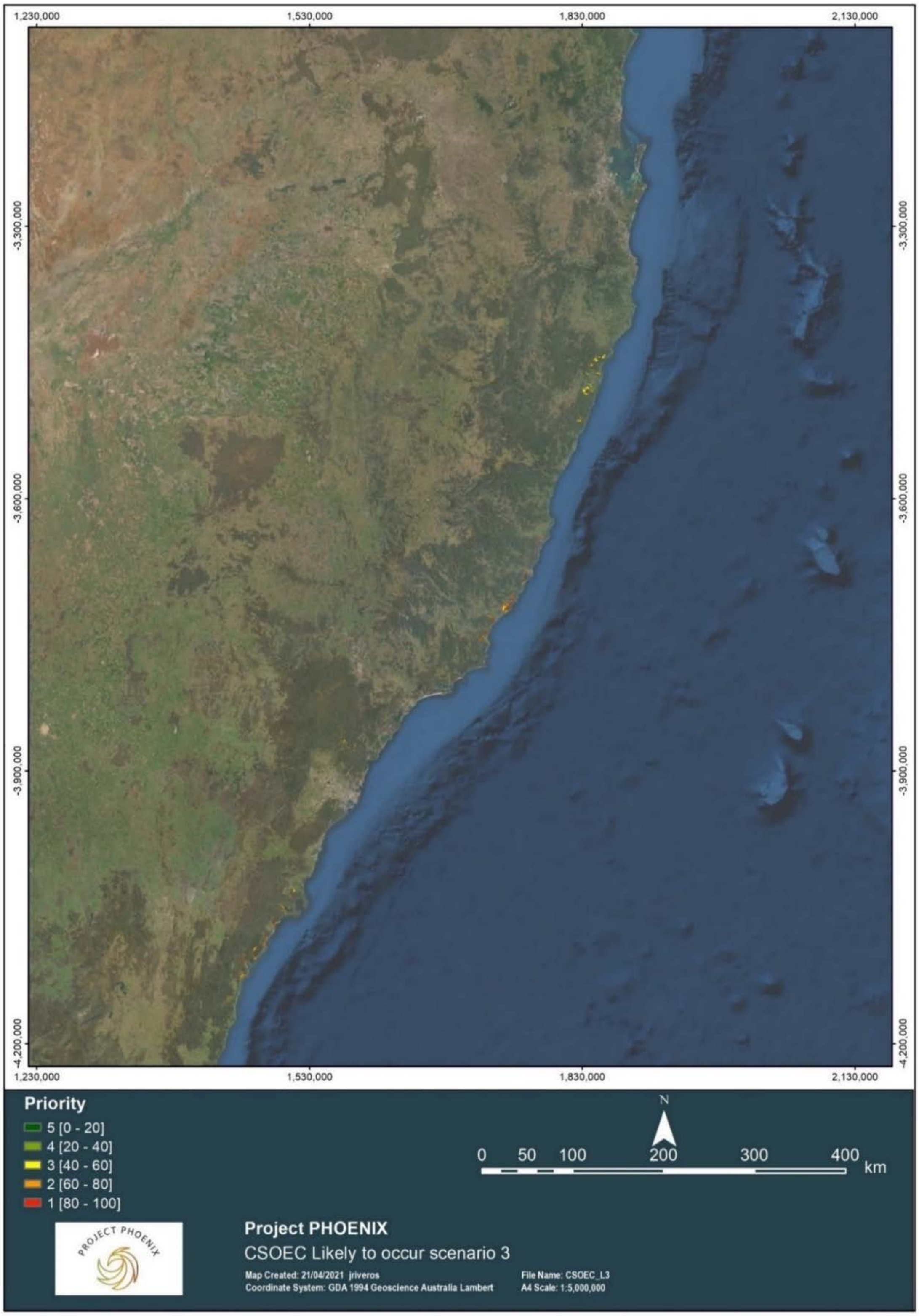


TABLE 7-49. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE COASTAL SWAMP OAK (*CASUARINA GLAUCA*) FOREST OF NEW SOUTH WALES AND SOUTH EAST QUEENSLAND TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia maidenii*	C	OS	S	
TEC species list	*Acacia venulosa*	S	OS	S	
TEC species list	*Amyema cambagei*	C	OS	UN	
TEC species list	*Apium prostratum*	H	OS	UN	
TEC species list	*Archontophoenix cunninghamiana*	T	OS	T	
TEC species list	*Asperula asthenes*	H	OS	UN	
TEC species list	*Asplenium australasicum*	C	OS	T	
TEC species list	*Austromyrtus dulcis*	H	OS	UN	
TEC species list	*Cassytha glabella subsp. glabella*	C	OS	S	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Cyperus polystachyos*	H	OS	UN	
TEC species list	*Dendrobium linguiforme*	C	OS	S	
TEC species list	*Einadia hastata*	H	OS	UN	
TEC species list	*Elaeodendron australe*	S/T	OS	UN	
TEC species list	*Enchylaena tomentosa var. glabra*	H	OS	UN	
TEC species list	*Haloragis exalata subsp. exalata*	H	OS	S	
TEC species list	*Lobelia anceps*	H	OS	UN	
TEC species list	*Notothixos subaureus*	C	OS	T	
TEC species list	*Platycerium bifurcatum*	C	OS	T	
TEC species list	*Platycerium superbum*	C	OS	T	
TEC species list	*Psilotum nudum*	C	OS	T	
TEC species list	*Pyrrosia confluens*	C	OS	UN	
TEC species list	*Pyrrosia rupestris*	C	OS	UN	
TEC species list	*Rhagodia spp.*	S	OS	UN	
TEC species list	*Samolus repens*	H	OS	S	
TEC species list	*Solanum americanum*	H	OS	UN	
TEC species list	*Solanum prinophyllum*	H	OS	UN	
TEC species list	*Syzygium hodgkinsoniae*	T	OS	T	
TEC species list	*Tetragonia tetragonioides*	H	OS	UN	
TEC species list	*Acacia melanoxylon*	S	FS	S	
TEC species list	*Aegiceras corniculatum*	S	FS	V	
TEC species list	*Avicennia marina*	S/T	FS	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Breynia oblongifolia*	S	FS	S	
TEC species list	*Commelina cyanea*	H	FS	UN	
TEC species list	*Cupaniopsis anacardioides*	T	FS	S	
TEC species list	*Dianella caerulea*	H	FS	T	
TEC species list	*Eucalyptus grandis*	T	FS	C	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Goodenia ovata*	H	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Melaleuca linariifolia*	S/T	FS	C	
TEC species list	*Melaleuca quinquenervia*	T	FS	C	
TEC species list	*Pandorea pandorana subsp. pandorana*	C	FS	S	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Sarcocornia quinqueflora*	H	FS	UN	
TEC species list	*Syzygium moorei*	T	FS	S	
TEC species list	*Villarsia exaltata*	H	FS	T	
TEC species list	*Viola banksii*	H	FS	UN	
Fire-affected species	*Acacia trachyphloia*	S	OS	UN	Yes
Fire-affected species	*Acacia yalwalensis*	S	OS	UN	Yes
Fire-affected species	*Boronia subulifolia*	S	OS	UN	Yes
Fire-affected species	*Zieria caducibracteata*	S/T	OS	UN	Yes

7.15 TEC 13: Alpine Sphagnum Bogs and Associated Fens

7.15.1 Description

The Alpine Sphagnum Bogs and Associated Fens are found in New South Wales, the Australian Capital Territory, Victoria and Tasmania in alpine, sub-alpine and montane landscapes.[95] They require a water table near the surface either through a good source of ground water with an impeded drainage system[96] which allows a peat soil structure to form, typical of this TEC.[97] Bogs and fens are two distinct components included in the TEC. The bogs are characterised by *Sphagnum spp*., the most common one being *Sphagnum cristatum* (Sphagnum moss).[9,8] The fens are often surrounded by or near the bogs with either less or no *Sphagnum spp.*, containing open, shallow water pools.[95]

7.15.2 Fire response traits

In the Alpine Sphagnum Bogs and Associated Fens, there are 57 plant species representing 40 different genera. This species list is indicative and the assemblage of species will likely vary between patches of this community as vegetation composition changes with age and proximity to the water table.[99] Of these plant species, 51% (n = 29) are resprouters, 18% (n = 10) are obligate seeders and 18% (n = 10) are facultative seeders, with 14% (n = 8) having an unverified fire response (Table 7-50). Herbaceous species make up 79% (n = 45) of all plant species present and shrubs make up 21% (n = 12) (Table 7-50).

TABLE 7-50 .THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB)

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	6 (13)	7 (16)	24 (53)	8 (18)	**45**
Shrub	4 (33)	3 (25)	5 (42)	0 (0)	**12**
Total count	**10**	**10**	**29**	**8**	**57**

7.15.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-51).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Alpine Sphagnum Bogs and Associated Fens and outlined below and described in Appendix 2 (Section 11.13).

TEC 13: Alpine Sphagnum Bogs and Associated Fens

Community Characteristics

Number of species:
- 57 [40 genera]

Shrubs:
- 21% (n = 12)

Herbaceous:
- 79% (n = 45)

Fire Response

Resprouters:
- 51% (n = 29)

Obligate seeders:
- 18% (n= 10)

Facultative seeders:
- 18% (n = 10)

Unknown:
- 14% (n = 8)

Life History and Fire Response

Resprouters (RS):
- High proportion of herbaceous species (53%) and shrubs (42%)

Obligate seeders (OS):
- Ranged from 13% of herbaceous species to 33% of shrubs

Facultative seeders (FS):
- Ranged from 16% of herbaceous species to 25% of shrubs

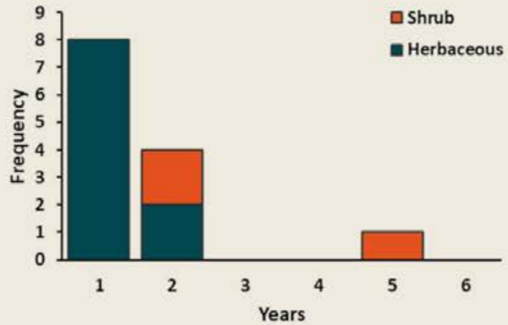
For each life form:
- Low proportion of unknown (UN) fire responses (0-18% of species)

Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- > 20 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-10 years
- Herbaceous = 2-4 years



[1]Obligate seeders and facultative seeders

TABLE 7-51. PRIORITY AREAS 1 AND 2 ALPINE SPHAGNUM BOGS AND ASSOCIATED FENS: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	10186.5	1.6	10.7	3-17	4.9	2-5	53.4	36.6-57.5	1352.1	0-2640.1
2 (60-80)	73269.8	11.6	11.8	2-50	4.0	2-5	45.7	32.7-57.7	2947.7	0-12903.5
3 (40-60)	124987.1	19.8	13.4	2-50	3.2	2-5	43.5	31.9-57.7	4839.6	0-22073.1
4 (20-40)	168807.1	26.7	28.6	2-50	4.2	2-5	45.8	30.5-57.7	3699.5	0-15572.4
5 (0-20)	255243.4	40.4	26.2	2-50	3.2	2-5	46.1	31.9-57.7	4913.2	0-15041.6

See Figure 7-20 for distribution of each priority area

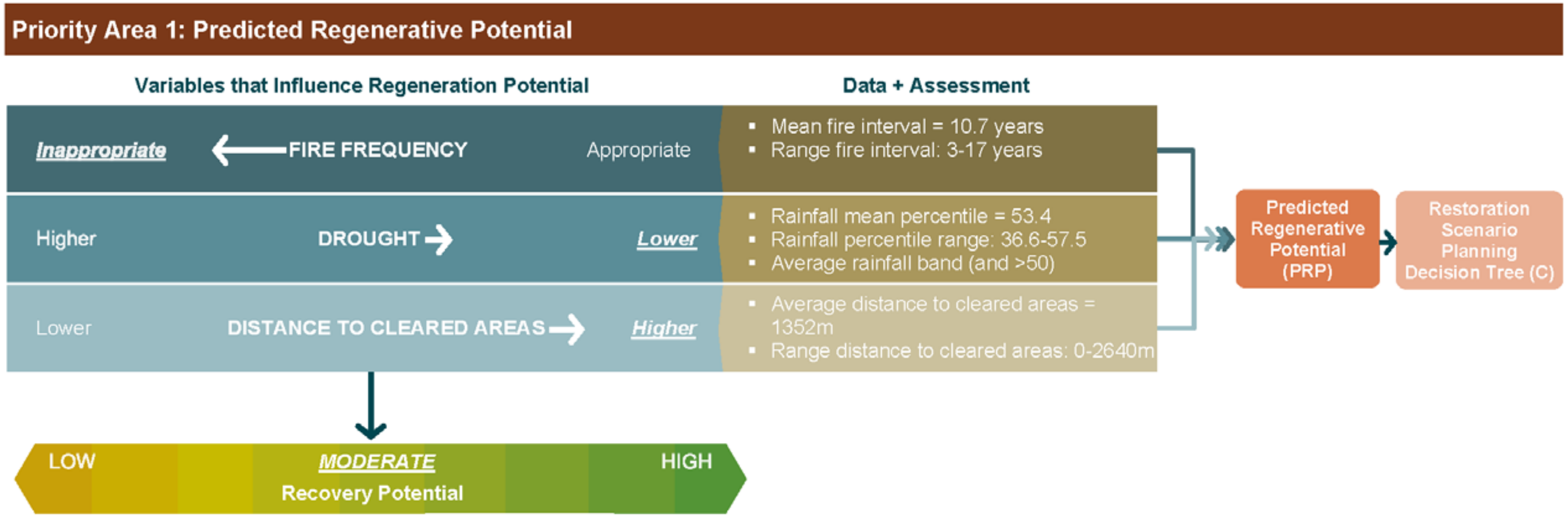
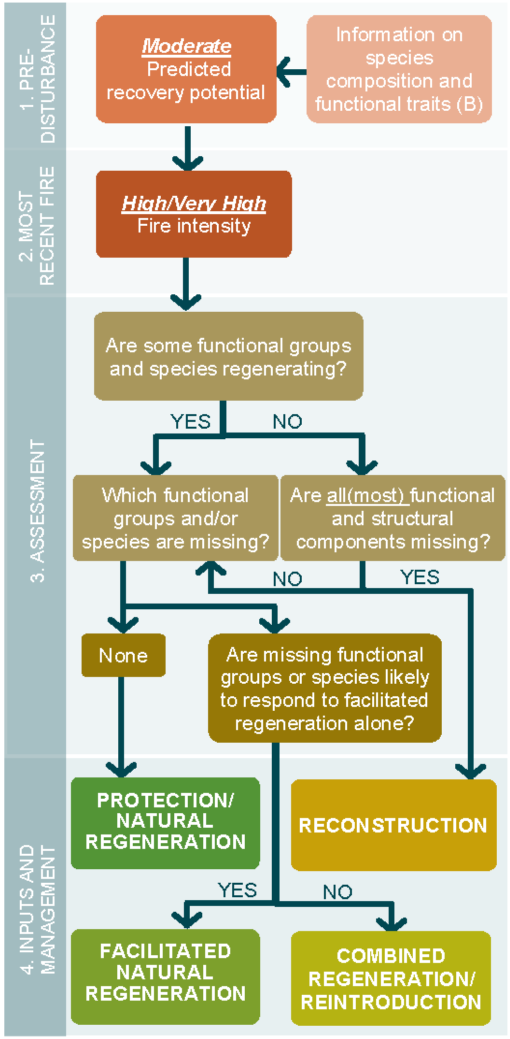


TABLE 7-52. RESTORATION APPROACHES FOR ALPINE SPHAGNUM BOGS AND ASSOCIATED FENS



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Inappropriate fire regimes • Grazing • Climate change • Invasion and establishment of transformer weed species • Recreational activities • Clearing from rural, agricultural and urban development • *Sphagnum* harvesting	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Anthoxanthum odoratum* (Sweet Vernal Grass) • *Holcus lanatus* (Yorkshire Fog) • *Pilosella spp. or Hieracium spp.* (Hackweed) • *Juncus effuses* (Soft Rush) • *Salix spp.* (Willows)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-53. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-53).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Alpine Sphagnum Bogs and Associated Fens

FIGURE 7-19. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR ALPINE SPHAGNUM BOGS AND ASSOCIATED FENS. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-51 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

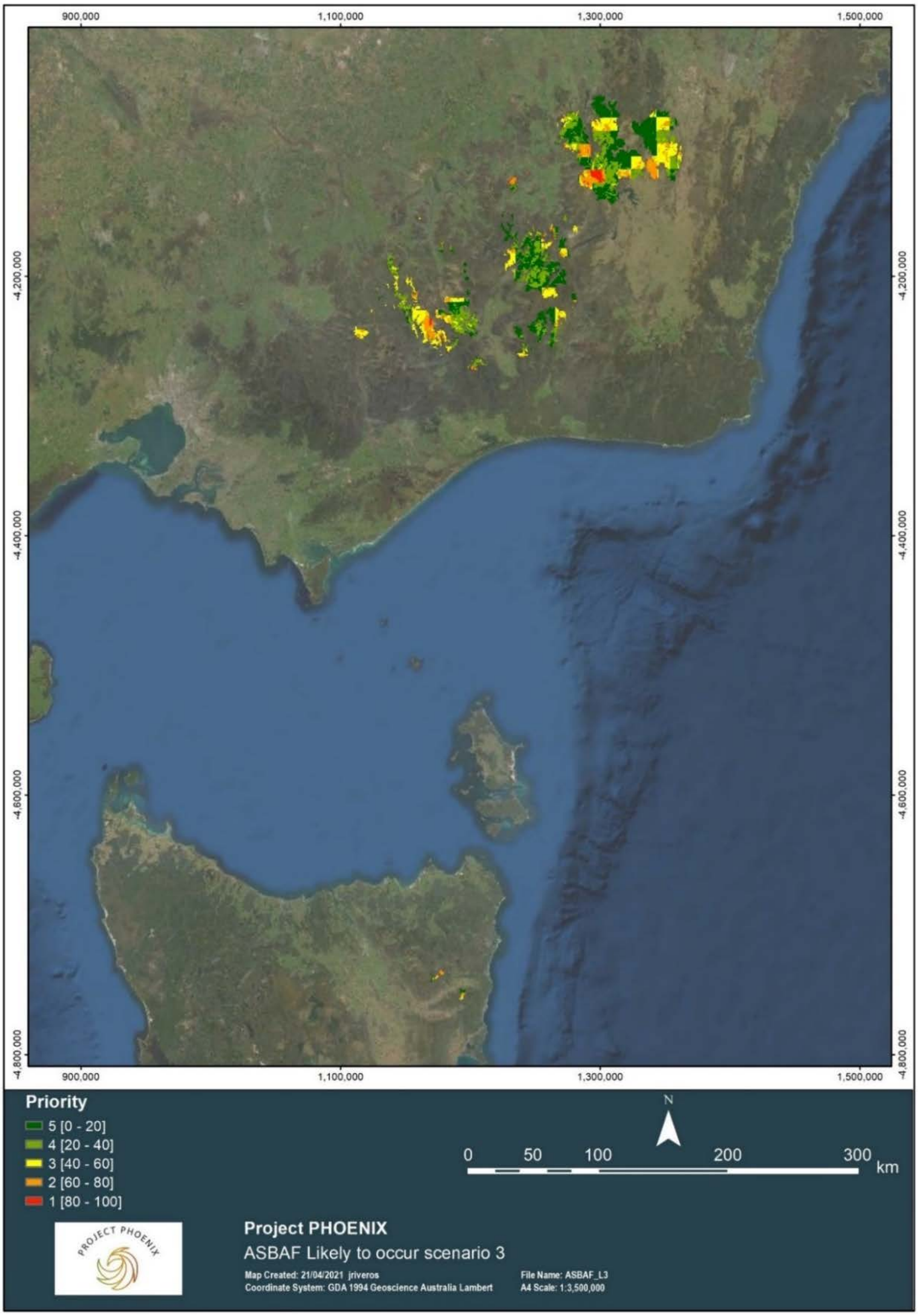


TABLE 7-53. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM ALPINE SPHAGNUM BOGS AND ASSOCIATED FENS TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Carpha alpina*	H	OS	UN	
TEC species list	*Celmisia saxifraga*	H	OS	UN	
TEC species list	*Gonocarpus micranthus*	H	OS	S	
TEC species list	*Isolepis crassiuscula*	H	OS	UN	
TEC species list	*Nertera granadensis*	H	OS	UN	
TEC species list	*Oreomyrrhis ciliata*	H	OS	S	
TEC species list	*Ozothamnus rodwayi*	S	OS	T	
TEC species list	*Richea continentis*	S	OS	S	
TEC species list	*Richea scoparia*	S	OS	UN	
TEC species list	*Richea victoriana*	S	OS	UN	
TEC species list	*Acaena novae-zelandiae*	H	FS	UN	
TEC species list	*Epilobium gunnianum*	H	FS	T	
TEC species list	*Lepidosperma filiforme*	H	FS	UN	
TEC species list	*Luzula modesta*	H	FS	S	
TEC species list	*Myriophyllum pedunculatum*	H	FS	UN	
TEC species list	*Olearia algida*	S	FS	T	
TEC species list	*Oxylobium ellipticum*	S	FS	S	
TEC species list	*Ozothamnus hookeri*	S	FS	UN	
TEC species list	*Poa costiniana*	H	FS	S	
TEC species list	*Pratia surrepens*[5]	H	FS	UN	
Fire-affected species	*Acacia phasmoides*	S	OS	S	Yes
Fire-affected species	*Deyeuxia talariata*	H	OS	T	Yes
Fire-affected species	*Gentiana baeuerlenii*	H	OS	UN	
Fire-affected species	*Grevillea burrowa*	S	OS	UN	Yes
Fire-affected species	*Grevillea jephcottii*	S	OS	UN	Yes
Fire-affected species	*Prostanthera walteri*	S	OS	S	Yes
Fire-affected species	*Grevillea ramosissima subsp. hypargyrea*	S	FS	S	Yes
Fire-affected species	*Monotoca rotundifolia*	S	FS	S	Yes
Fire-affected species	*Tetratheca ericifolia*	S	FS	S	
Fire-affected species	*Eucalyptus stellulata*	T	RS	T	Yes
Fire-affected species	*Lomandra confertifolia subsp. leptostachya*	H	RS	UN	Yes
Fire-affected species	*Luzula flaccida subsp. Long Anther (K.L.Wilson 828 et al.)*	H	RS	S	Yes
Fire-affected species	*Olearia stenophylla*	S	RS	UN	Yes
Fire-affected species	*Celmisia longifolia*	H	UN	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Cryptandra speciosa subsp. speciosa*	S	UN	UN	Yes
Fire-affected species	*Eucalyptus phoenix*	T	UN	UN	Yes
Fire-affected species	*Grevillea pachylostyla*	S	UN	UN	Yes
Fire-affected species	*Grevillea polychroma*	S	UN	UN	Yes
Fire-affected species	*Leptospermum jingera*	S	UN	UN	Yes
Fire-affected species	*Leptospermum namadgiense*	S	UN	UN	Yes
Fire-affected species	*Olearia sp. Rhizomatica (I.R.Telford 11549)*	S	UN	UN	Yes
Fire-affected species	*Pomaderris helianthemifolia*	S	UN	UN	Yes
Fire-affected species	*Viola improcera*	H	UN	UN	Yes

7.16 TEC 14: Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion

7.16.1 Description

The Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion occurs in New South Wales, predominantly in the Castlereagh area on tertiary sands and gravel, but also at the Agnes Banks on tertiary alluvium with aeolian sands.[100] Annual rainfall is typically 700-900mm,[66] occurring at altitudes up to 200m above sea level. The structure is typically a low woodland with a 15m average high canopy, sclerophyll shrub mid-layer and a patchy sedge and grass ground cover [66,68]

7.16.2 Fire response traits

In the Castlereagh Scribbly Gum and Agnes Banks Woodlands, there are 206 plant species representing 124 different genera. Of these plant species, 48% (n = 98) are resprouters, 38% (n = 78) are facultative seeders and 13% (n = 27) are obligate seeders, with 1% (n = 3) having an unverified fire response (Table 7-54). Herbaceous species make up 46% (n = 94) of all plant species present, shrubs make up 45% (n = 93), trees make up 6% (n = 12) and climbers/vines make up 3% (n = 7) (Table 7-54).

TABLE 7-54. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

NUMBER (AND %) OF EACH FIRE RESPONSE					
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	5 (5)	27 (29)	59 (63)	3 (3)	**94**
Shrub	19 (20)	48 (52)	26 (28)	0 (0)	**93**
Tree	0 (0)	0 (0)	12 (100)	0 (0)	**12**
Climber/Vine	3 (43)	3 (43)	1 (14)	0 (0)	**7**
Total count	**27**	**78**	**98**	**3**	**206**

7.16.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-55).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Castlereagh Scribbly Gum and Agnes Banks Woodlands and outlined below and described in Appendix 2 (Section 11.14).

TEC 14: Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 206 [124 genera]

Trees:
- 6% (n = 12)

Shrubs:
- 45% (n = 93)

Herbaceous:
- 46% (n = 94)

Climbers/Vines:
- 3% (n = 7)

Fire Response

Resprouters:
- 48% (n = 98)

Obligate seeders:
- 13% (n= 27)

Facultative seeders:
- 38% (n = 78)

Unknown:
- 1% (n = 3)

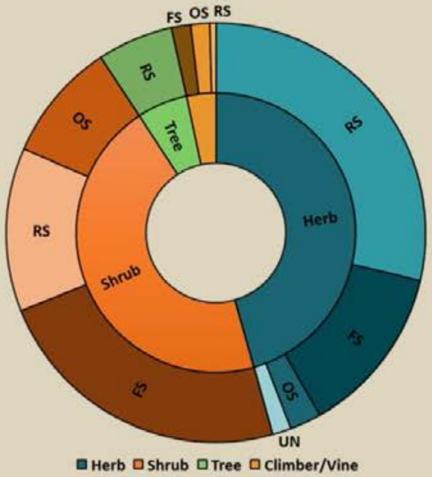
Life History and Fire Response

Resprouters (RS):
- Higher proportion of herbaceous species (63%) and trees (100%)

Obligate seeders (OS):
- Ranged from 5% of herbaceous species to 43% of climbers/vines

Facultative seeders (FS):
- Higher proportion of shrubs (52%) and climbers/vines (43%)

For each life form:
- Low proportion of unknown (UN) fire responses (0-3% of species)

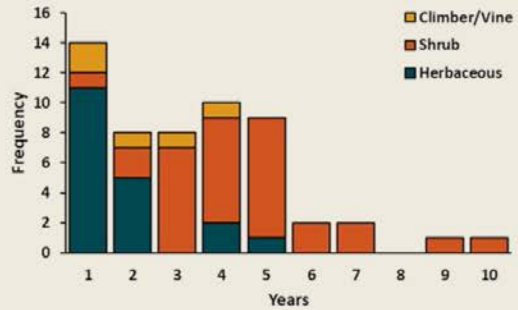


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 6- 20 years
- 6-20 years for Castlereagh Scribbly Gum Woodland (NSW DEC, 2005)
- 7-25 years for Agnes Banks Woodland (NSW DEC, 2005)

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-20 years
- Herbaceous = 2-10 years
- Climbers/vines = 2-8 years



[1]Obligate seeders and facultative seeders

TABLE 7-55. PRIORITY AREAS 1 AND 2 CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	146.7	16.5	2.2[a]	1.7-5.6	4	4-4	44.1	44-44.8	130.7	0-223.6
2 (60-80)	261.5	29.4	2.3[b]	1.7-5.6	3.6	3-4	44.2	43.5-45.2	166.8	0-360.6
3 (40-60)	284.6	32.0	2.4	1.7-5.6	3.6	2-4	44.2	43.5-44.8	295.5	0-640.3
4 (20-40)	194.4	21.9	2.3	1.7-16.7	3.5	3-5	44.1	43.5-44.8	428	0-860.2
5 (0-20)	1.0	0.1	1.7	1.7-1.7	3	3-3	44	44-44	467.4	412.3-509.9

Finer scale analysis of NSW fire data: Priority area 1[a] = 40.8 years (16.7 – 50 years); Priority area 2[b] = 45.2 (16.7 – 50 years)

See Figure 7-21 for distribution of each priority area

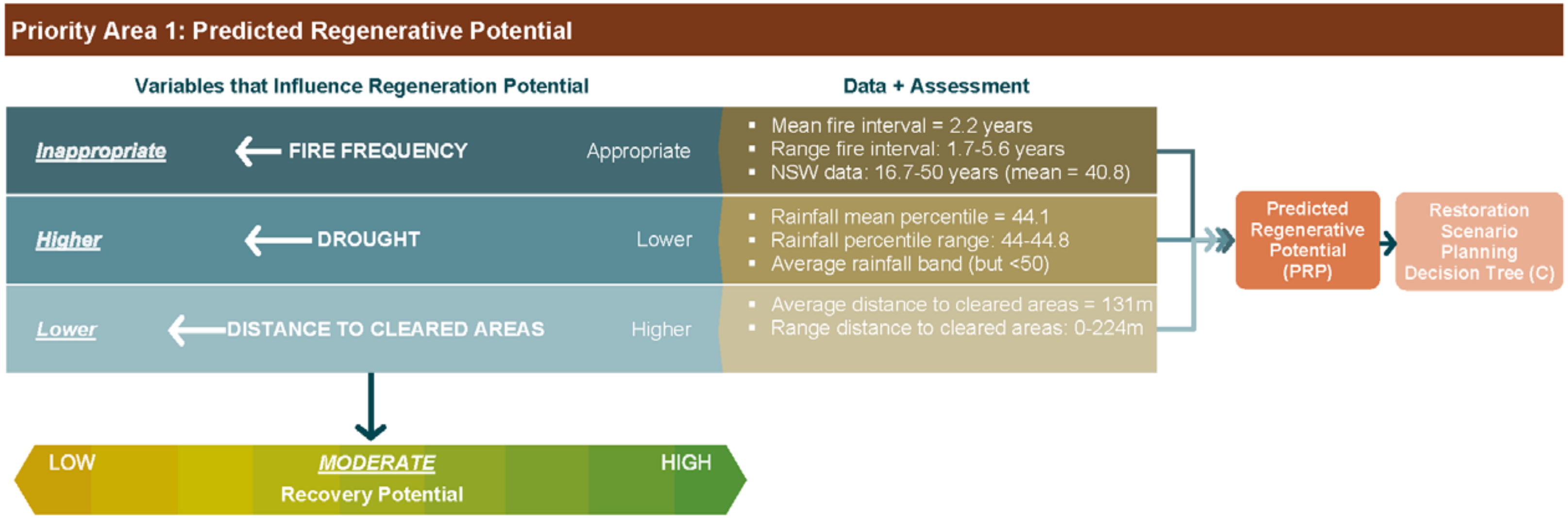
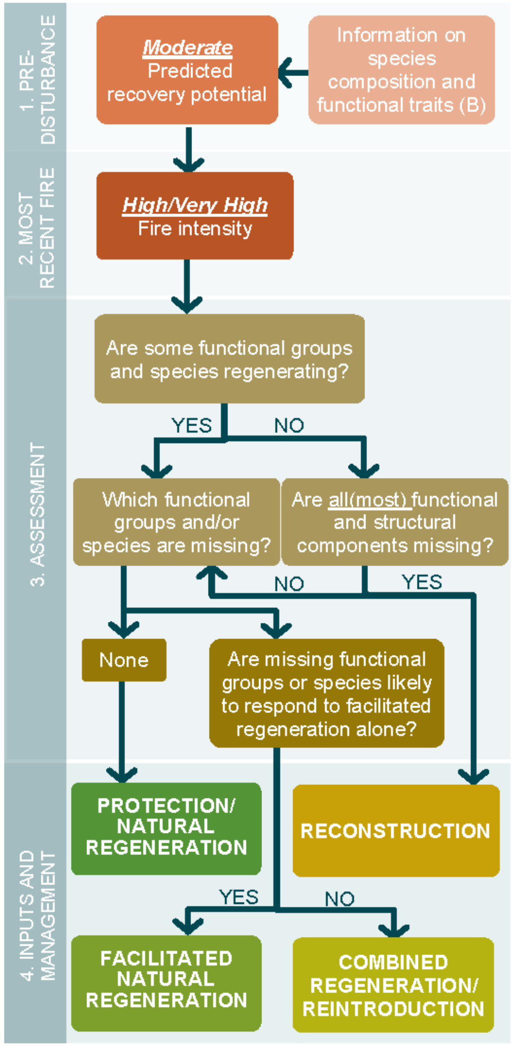


TABLE 7-56. RESTORATION APPROACHES FOR CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Phytophthora dieback (*Phytophthora cinnamomic*) infestation • Changes in hydrology • Invasive fauna including domestic pigs and feral introduced species • Climate change	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Acacia baileyana* (Cootamundra Wattle) • *Andropogon virginicus* (Whisky Grass) • *Araujia sericifera* (Moth Vine) • *Asparagus spp.* (Asparagus) • *Cenchrus clandestinus* (Kikuyu) • *Chloris gayana* (Rhodes Grass) • *Ehrharta erecta* (Panic Veldt Grass) • *Eragrostis curvula* (African Lovegrass) • *Grevillea robusta* (Silky Oak) • *Hyparrhenia hirta* (Coolatai Grass) • *Hypochaeris radicata* (Flat Weed)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-57. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-57).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Castlereagh Scribbly Gum and Agnes Banks Woodlands

FIGURE 7-20. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-55 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

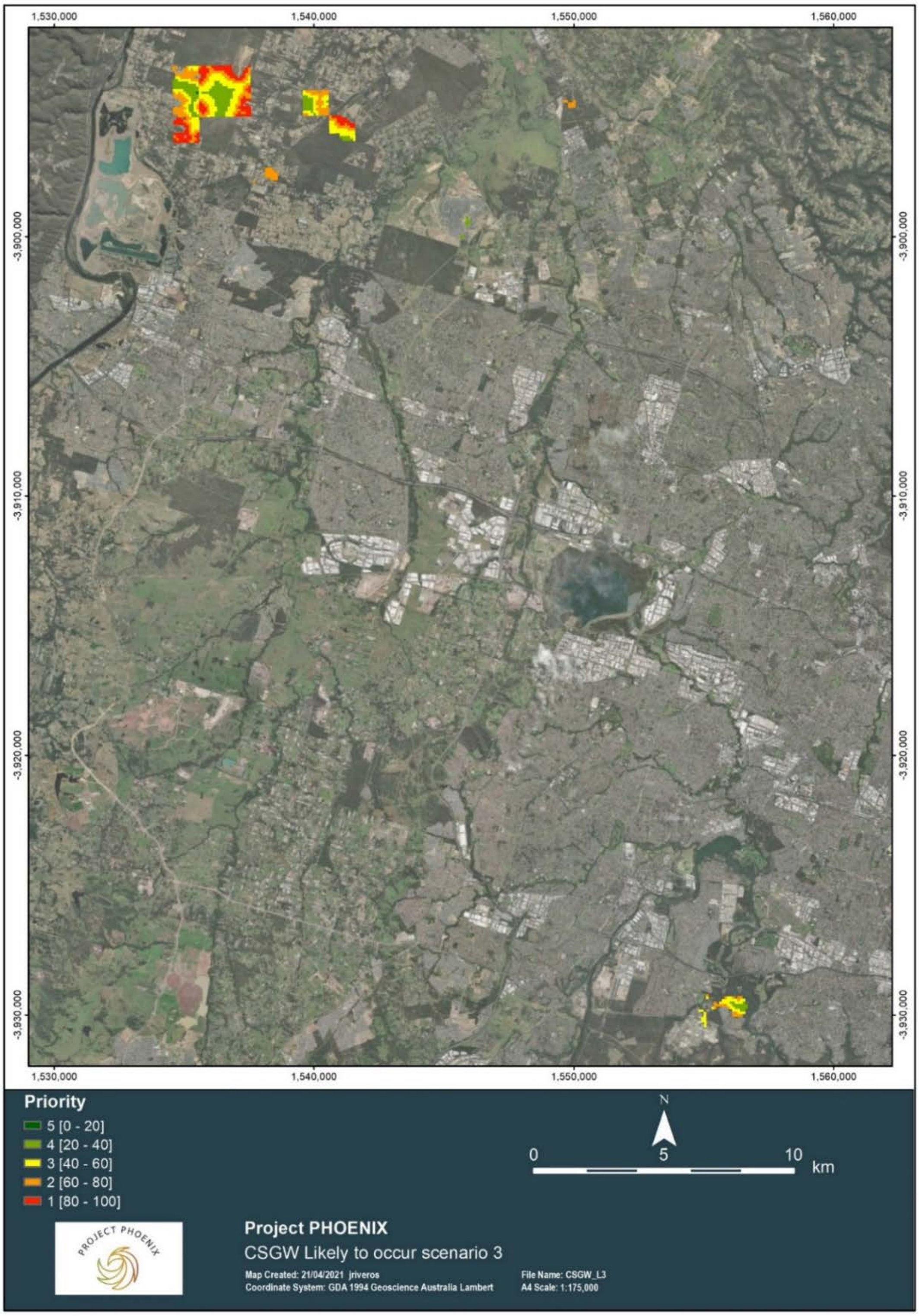


TABLE 7-57. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia decurrens*	S	OS	S	
TEC species list	*Acacia falcata*	S	OS	S	
TEC species list	*Acacia linifolia*	S	OS	S	
TEC species list	*Cassytha glabella*	C	OS	UN	
TEC species list	*Cassytha pubescens*	C	OS	S	
TEC species list	*Cuscuta australis*	C	OS	S	
TEC species list	*Dillwynia floribunda*	S	OS	S	
TEC species list	*Dillwynia parvifolia*	S	OS	UN	
TEC species list	*Dillwynia tenuifolia*	S	OS	S	
TEC species list	*Gonocarpus micranthus*	H	OS	S	
TEC species list	*Grevillea juniperina subsp. juniperina*	S	OS	UN	
TEC species list	*Hakea dactyloides*	S	OS	C	
TEC species list	*Hakea sericea*	S	OS	C	
TEC species list	*Hovea longifolia*	S	OS	S	
TEC species list	*Kunzea ambigua*	S	OS	S	
TEC species list	*Lagenophora gracilis*	H	OS	UN	
TEC species list	*Lobelia purpurascens*	H	OS	UN	
TEC species list	*Micromyrtus minutiflora*	S	OS	UN	
TEC species list	*Olearia microphylla*	S	OS	S	
TEC species list	*Persoonia lanceolata*	S	OS	S	
TEC species list	*Persoonia nutans*	S	OS	S	
TEC species list	*Pimelea linifolia subsp. collina*	S	OS	S	
TEC species list	*Pomax umbellata*	S	OS	S	
TEC species list	*Poranthera ericifolia*	H	OS	S	
TEC species list	*Pultenaea parviflora*	S	OS	S	
TEC species list	*Pultenaea villosa*	S	OS	S	
TEC species list	*Stackhousia viminea*	H	OS	T	
TEC species list	*Acacia brownii*	C	FS	S	
TEC species list	*Acacia elongata*	S	FS	S	
TEC species list	*Acacia longifolia*	S	FS	S	
TEC species list	*Acacia myrtifolia*	S	FS	S	
TEC species list	*Acacia ulicifolia*	S	FS	S	
TEC species list	*Billardiera scandens*	S	FS	S	
TEC species list	*Boronia polygalifolia*	H	FS	S	
TEC species list	*Bossiaea heterophylla*	S	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Bossiaea rhombifolia*	S	FS	S	
TEC species list	*Brachyloma daphnoides*	S	FS	S	
TEC species list	*Centrolepis strigosa subsp. strigosa*	H	FS	T	
TEC species list	*Chrysocephalum apiculatum*	H	FS	S	
TEC species list	*Conospermum taxifolium*	S	FS	S	
TEC species list	*Cyanthillium cinereum*	H	FS	T	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Dillwynia glaberrima*	S	FS	S	
TEC species list	*Dillwynia sericea*	S	FS	S	
TEC species list	*Drosera spatulata*	H	FS	T	
TEC species list	*Epacris microphylla*	S	FS	S	
TEC species list	*Euryomyrtus ramosissima subsp. ramosissima*	S	FS	UN	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Gompholobium glabratum*	S	FS	S	
TEC species list	*Gompholobium huegelii*	S	FS	S	
TEC species list	*Gompholobium minus*	S	FS	S	
TEC species list	*Gompholobium pinnatum*	S	FS	S	
TEC species list	*Gonocarpus tetragynus*	H	FS	S	
TEC species list	*Gonocarpus teucrioides*	H	FS	S	
TEC species list	*Goodenia bellidifolia subsp. bellidifolia*	H	FS	S	
TEC species list	*Grevillea parviflora subsp. parviflora*	S	FS	S	
TEC species list	*Grevillea sericea*	S	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Harmogia densifolia*	S	FS	S	
TEC species list	*Hibbertia aspera*	S	FS	S	
TEC species list	*Hibbertia fasciculata*	S	FS	S	
TEC species list	*Hibbertia serpyllifolia*	S	FS	S	
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Hypericum japonicum*	H	FS	S	
TEC species list	*Isopogon anemonifolius*	S	FS	C	
TEC species list	*Isopogon anethifolius*	S	FS	C	
TEC species list	*Kunzea capitata*	S	FS	S	
TEC species list	*Lachnagrostis filiformis*	H	FS	UN	
TEC species list	*Laxmannia gracilis*	H	FS	S	
TEC species list	*Leptospermum arachnoides*	S	FS	C	
TEC species list	*Leptospermum continentale*	S	FS	C	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Leptospermum parvifolium*	S	FS	T	
TEC species list	*Leptospermum polygalifolium*	S	FS	C	
TEC species list	*Leptospermum squarrosum*	S	FS	C	
TEC species list	*Lomandra obliqua*	H	FS	S	
TEC species list	*Melichrus procumbens*	S	FS	S	
TEC species list	*Melichrus urceolatus*	S	FS	S	
TEC species list	*Micromyrtus ciliata*	S	FS	UN	
TEC species list	*Mirbelia rubiifolia*	S	FS	S	
TEC species list	*Mitrasacme polymorpha*	H	FS	S	
TEC species list	*Monotoca scoparia*	S	FS	S	
TEC species list	*Olax stricta*	S	FS	S	
TEC species list	*Opercularia diphylla*	H	FS	S	
TEC species list	*Petrophile pedunculata*	S	FS	C	
TEC species list	*Petrophile sessilis*	S	FS	C	
TEC species list	*Philotheca myoporoides*	S	FS	S	
TEC species list	*Philotheca salsolifolia subsp. salsolifolia*	S	FS	S	
TEC species list	*Phyllanthus hirtellus*	S	FS	T	
TEC species list	*Pimelea linifolia subsp. linifolia*	S	FS	S	
TEC species list	*Platysace ericoides*	S	FS	S	
TEC species list	*Poa sieberiana*	H	FS	UN	
TEC species list	*Pultenaea tuberculata*	S	FS	S	
TEC species list	*Ricinocarpos pinifolius*	S	FS	S	
TEC species list	*Schoenus apogon*	H	FS	S	
TEC species list	*Senecio hispidulus*	H	FS	S	
TEC species list	*Solenogyne gunnii*	H	FS	S	
TEC species list	*Sphaerolobium vimineum*	S	FS	S	
TEC species list	*Stylidium graminifolium*	H	FS	S	
TEC species list	*Thysanotus tuberosus*	H	FS	T	
TEC species list	*Trachymene incisa subsp. incisa*	H	FS	S	
TEC species list	*Tricoryne elatior*	H	FS	T	
TEC species list	*Wahlenbergia communis*	H	FS	S	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
TEC species list	*Wahlenbergia stricta subsp. stricta*	H	FS	S	

7.17 TEC 15: Natural Temperate Grassland of the South Eastern Highlands

7.17.1 Description

The Natural Temperate Grassland of the South Eastern Highlands occurs in New South Wales and the Australian Capital Territory, up to 1200m above sea level. It is characterised by native perennial tussock grasses, up to 1m high, with no or few trees.[101] The vegetation structure can be variable and is classified into eight different associations, listed in the approved conservation advice.[102] Common dominant grasses include *Austrostipa scabra* (slender speargrass), *Bothriochloa macra* (red grass) and *Poa sieberiana* (snowgrass).[102]

7.17.2 Fire response traits

In the Natural Temperate Grassland, there are 224 plant species representing 140 different genera. Of these plant species, 42% (n = 93) are resprouters, 24% (n = 53) are obligate seeders and 17% (n = 39) are facultative seeders with 17% (n = 39) having an unverified fire response (Table 7-58). Herbaceous species make up 83% (n = 186) of all plant species present, shrubs make up 15% (n = 34) and climbers/vines make up 2% (n = 4) (Table 7-58). There are no tree species in the Natural Temperate Grassland.

TABLE 7-58. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	42 (22)	29 (16)	78 (42)	37 (20)	**186**
Shrub	10 (29)	9 (27)	13 (38)	2 (6)	**34**
Climber/Vine	1 (25)	1 (25)	2 (50)	0 (0)	**4**
Total count	**53**	**39**	**93**	**39**	**224**

7.17.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-59).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Natural Temperate Grassland and outlined below and described in Appendix 2 (Section 11.15).

TEC 15: Natural Temperate Grassland of the South Eastern Highlands

Community Characteristics

Number of species:
- 224 [140 genera]

Shrubs:
- 15% (n = 34)

Herbaceous:
- 83% (n = 186)

Climbers/Vines:
- 2% (n = 4)

Fire Response

Resprouters:
- 42% (n = 93)

Obligate seeders:
- 24% (n= 53)

Facultative seeders:
- 17% (n = 39)

Unknown:
- 17% (n = 39)

Life History and Fire Response

Resprouters (RS):
- Highest proportion of herbaceous species (42%), shrubs (38%) and climbers/vines (50%)

Obligate seeders (OS):
- Ranged from 22% of herbaceous species to 29% of shrubs

Facultative seeders (FS):
- Ranged from 16% of herbaceous species to 27% of shrubs

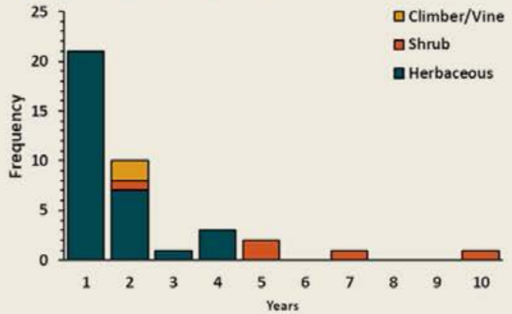
For each life form:
- Low proportion of unknown (UN) fire responses (0-20% of species)

Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- For grassy/herbaceous <10 years (less depending on species, site productivity and historical fire regime)
- 10-20 years for shrub layer

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-20 years
- Herbaceous = 2-8 years
- Climbers/vines = 4 years



[1]Obligate seeders and facultative seeders

TABLE 7-59. PRIORITY AREAS 1 AND 2 NATURAL TEMPERATE GRASSLAND: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	10524	18.9	3.3[a]	1.6-16.7	4.8	2-5	43.9	38.3-55	2242	0-5140
2 (60-80)	11186	20.0	4.1[b]	1.6-25	4	2-5	44.2	37.4-56.6	1866	0-9235
3 (40-60)	9834	17.6	5.7	1.6-50	3.4	2-5	44.1	36.1-56.6	2366	0-9908
4 (20-40)	15563	27.9	20.6	2.4-50	3.7	2-5	43.7	34.6-55	1664	0-13376
5 (0-20)	8690	15.6	30.5	1.9-50	3.3	2-5	42.9	38.3-54.1	3828	0-14169

Finer scale analysis of NSW fire data: Priority area 1[a] = 31.2 years (5.6 – 50 years); Priority area 2[b] = 31.4 (5 – 50 years)

See Figure 7-22 for distribution of each priority area

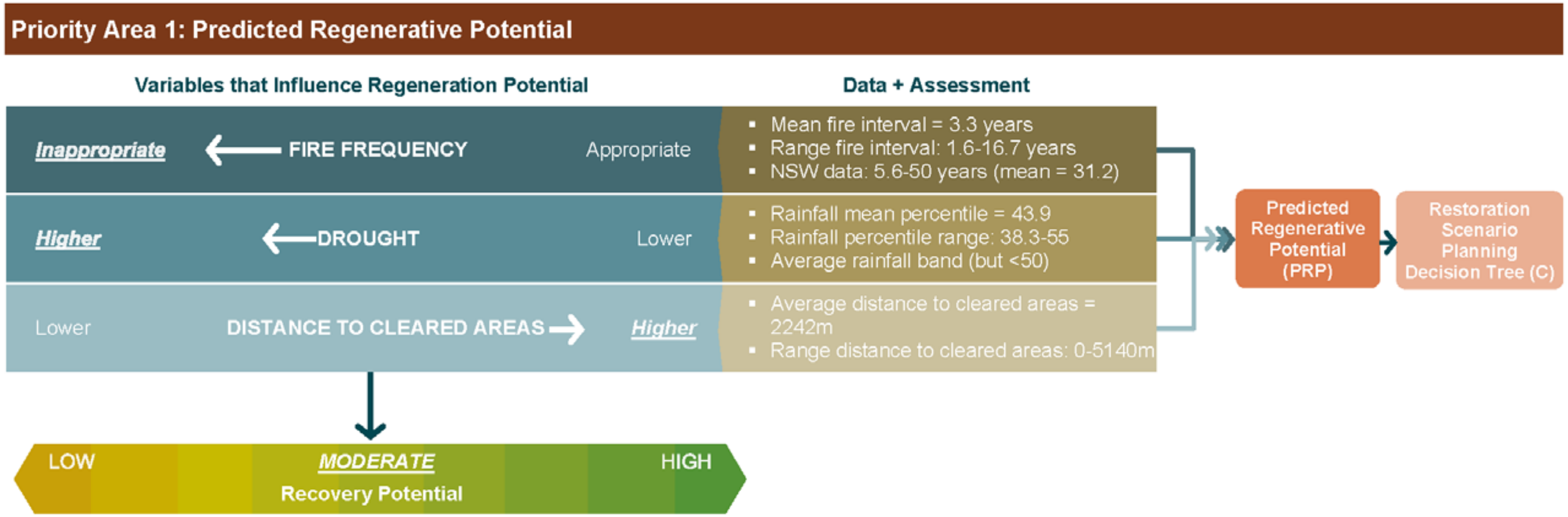
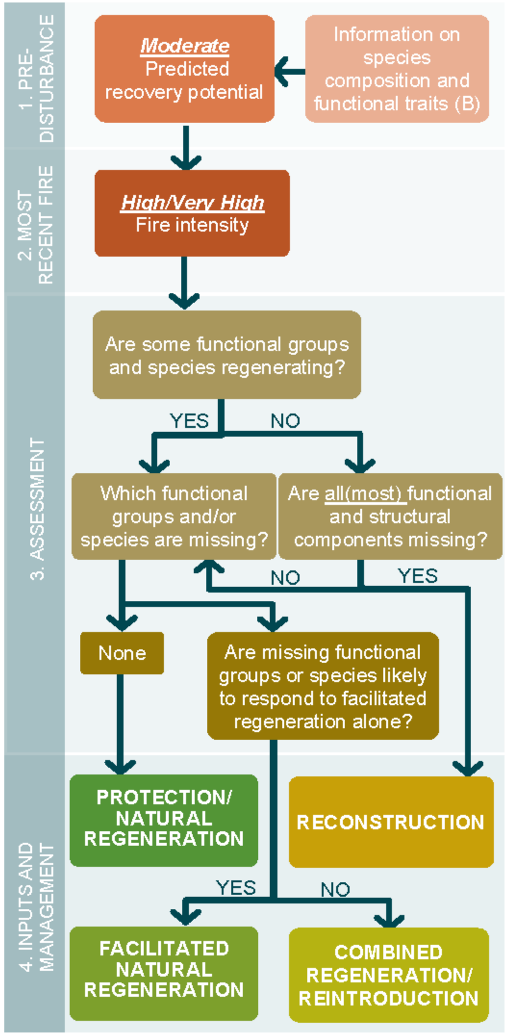


TABLE 7-60. RESTORATION APPROACHES FOR NATURAL TEMPERATE GRASSLAND



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Grazing • Nutrient enrichment • Invasive fauna including European rabbit (*Oryctolagus cuniculus*), feral cats (*Felis cattus*), European red fox (*Vulpes vulpes*) and feral pigs (*Sus scrofa*) • Climate change	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Aira spp.* (Hair Grasses) • *Avena spp.* (Wild Oats) • *Briza spp.* • *Bromus spp.* • *Crataegus monogyna* (English Hawthorn) • *Eragrostis curvula* (African Lovegrass) • *Hordeum spp.* (Barley Grasses) • *Hypericum perforatum* • *Lycium ferocissimum* (African Boxthorn) • *Nassella spp.* • *Phalaris aquatica* • *Rosa rubiginosa* (Sweet Briar) • *Rubus fruticosus* (Blackberry) • *Vulpia spp.* (Rat's Tail Fescue)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-61. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-61).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Natural Temperate Grassland

FIGURE 7-21. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR NATURAL TEMPERATE GRASSLAND. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-59 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

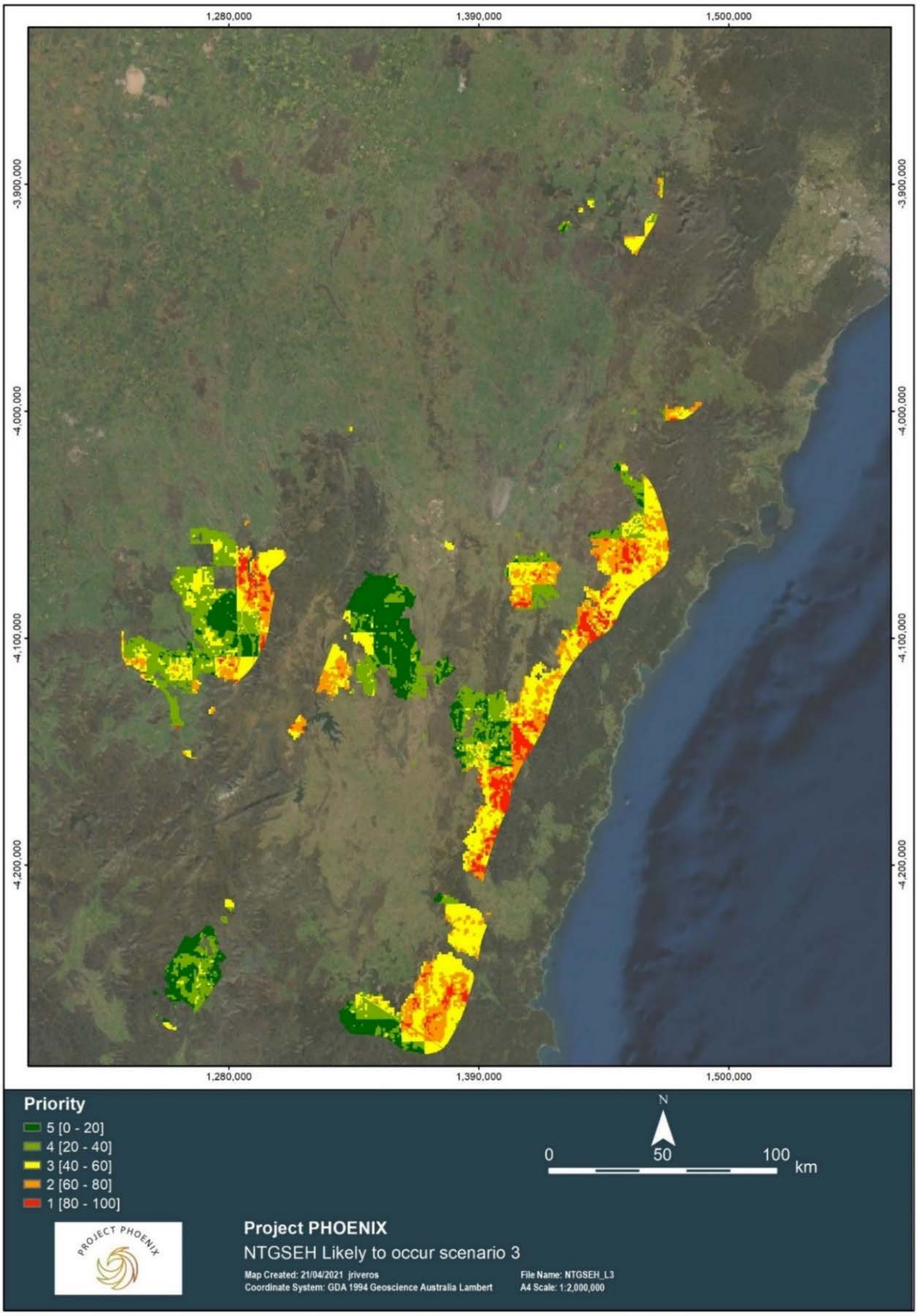


TABLE 7-61. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE NATURAL TEMPERATE GRASSLAND OF THE SOUTH EASTERN HIGHLANDS TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. FAS = FIRE-AFFECTED SPECIES. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Ajuga australis*	H	OS	UN	
TEC species list	*Ammobium alatum*	H	OS	T	
TEC species list	*Banksia marginata*	S	OS	C	
TEC species list	*Boerhavia dominii*	H	OS	UN	
TEC species list	*Brachyscome aculeata*	H	OS	S	
TEC species list	*Brachyscome decipiens*	H	OS	UN	
TEC species list	*Brachyscome ptychocarpa*	H	OS	UN	
TEC species list	*Calotis glandulosa*	H	OS	T	
TEC species list	*Calotis lappulacea*	H	OS	UN	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Chenopodium glaucum*	H	OS	UN	
TEC species list	*Craspedia variabilis*	H	OS	UN	
TEC species list	*Crassula helmsii*	H	OS	T	
TEC species list	*Cullen microcephalum*	H	OS	S	
TEC species list	*Cullen tenax*	H	OS	S	
TEC species list	*Daviesia genistifolia*	S	OS	S	
TEC species list	*Dodonaea procumbens*	S	OS	S	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Epacris petrophila*	S	OS	UN	
TEC species list	*Euphrasia collina*	H	OS	S	
TEC species list	*Euphrasia orthocheila*	H	OS	UN	
TEC species list	*Eutaxia diffusa*	S	OS	UN	
TEC species list & FAS	*Gentiana bredboensis*	H	OS	UN	Yes
TEC species list	*Geranium antrorsum*	H	OS	S	
TEC species list	*Gingidia harveyana*	H	OS	T	
TEC species list	*Gonocarpus micranthus*	H	OS	S	
TEC species list	*Grevillea juniperina*	S	OS	UN	
TEC species list	*Isoetopsis graminifolia*	H	OS	UN	
TEC species list	*Isotoma fluviatilis*	H	OS	T	
TEC species list	*Kennedia prostrata*	C	OS	S	
TEC species list	*Lawrencia spicata*	H	OS	UN	
TEC species list	*Lepidium hyssopifolium*	H	OS	S	
TEC species list	*Levenhookia dubia*	H	OS	T	
TEC species list	*Mentha diemenica*	H	OS	UN	
TEC species list	*Mirbelia oxylobioides*	S	OS	S	
TEC species list	*Muehlenbeckia axillaris*	S	OS	UN	
TEC species list	*Opercularia hispida*	H	OS	UN	
TEC species list	*Oreomyrrhis argentea*	H	OS	S	
TEC species list	*Oreomyrrhis eriopoda*	H	OS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Podolepis hieracioides*	H	OS	UN	
TEC species list	*Polygala japonica*	H	OS	T	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Pultenaea subspicata*	S	OS	S	
TEC species list	*Ranunculus lappaceus*	H	OS	T	
TEC species list	*Ranunculus pimpinellifolius*	H	OS	S	
TEC species list	*Rulingia prostrata*	S	OS	UN	
TEC species list	*Scleranthus diander*	H	OS	UN	
TEC species list	*Sebaea ovata*	H	OS	UN	
TEC species list	*Sida corrugata*	H	OS	UN	
TEC species list	*Thesium australe*	H	OS	T	
TEC species list	*Trachymene humilis*	H	OS	UN	
TEC species list	*Triptilodiscus pygmaeus*	H	OS	UN	
TEC species list	*Xerochrysum bracteatum*	H	OS	S	
TEC species list	*Bossiaea riparia*	S	FS	S	
TEC species list	*Brachyloma daphnoides*	S	FS	S	
TEC species list	*Caesia calliantha*	H	FS	T	
TEC species list	*Centrolepis strigosa*	H	FS	T	
TEC species list	*Chrysocephalum apiculatum*	H	FS	S	
TEC species list	*Chrysocephalum semipapposum*	H	FS	S	
TEC species list	*Cryptandra amara*	S	FS	S	
TEC species list	*Daviesia mimosoides*	S	FS	S	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Drosera peltata*	H	FS	T	
TEC species list	*Epacris microphylla*	S	FS	S	
TEC species list	*Galium gaudichaudii*	H	FS	UN	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Gompholobium minus*	S	FS	S	
TEC species list	*Gonocarpus tetragynus*	H	FS	S	
TEC species list	*Goodenia bellidifolia*	H	FS	S	
TEC species list	*Hakea microcarpa*	S	FS	C	
TEC species list	*Haloragis heterophylla*	H	FS	S	
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Hypericum japonicum*	H	FS	S	
TEC species list	*Laxmannia gracilis*	H	FS	S	
TEC species list	*Leucochrysum albicans*	H	FS	UN	
TEC species list	*Lobelia pedunculata*	H	FS	UN	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Melichrus urceolatus*	S	FS	S	
TEC species list	*Pimelea curviflora*	H	FS	UN	
TEC species list	*Podolepis jaceoides*	H	FS	UN	
TEC species list	*Rutidosis leptorrhynchoides*	H	FS	UN	
TEC species list	*Scleranthus biflorus*	H	FS	S	
TEC species list	*Stackhousia monogyna*	H	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Stellaria angustifolia*	H	FS	S	
TEC species list	*Stellaria pungens*	H	FS	S	
TEC species list	*Stylidium graminifolium*	H	FS	S	
TEC species list	*Swainsona recta*	H	FS	S	
TEC species list	*Thysanotus tuberosus*	H	FS	T	
TEC species list	*Tricoryne elatior*	H	FS	T	
TEC species list	*Utricularia dichotoma*	H	FS	T	
TEC species list	*Veronica calycina*	H	FS	T	
TEC species list	*Zornia dyctiocarpa*	H	FS	S	
Fire-affected species	*Acacia covenyi*	S	OS	UN	Yes
Fire-affected species	*Acacia hamiltoniana*	S	OS	UN	Yes
Fire-affected species	*Acacia olsenii*	S	OS	UN	Yes
Fire-affected species	*Acacia phasmoides*	S	OS	S	Yes
Fire-affected species	*Acacia trachyphloia*	S	OS	UN	Yes
Fire-affected species	*Asterolasia trymalioides subsp. areniticola*	S	OS	S	Yes
Fire-affected species	*Boronia anemonifolia subsp. wadbilligensis*	S	OS	S	Yes
Fire-affected species	*Boronia subulifolia*	S	OS	UN	Yes
Fire-affected species	*Callitris oblonga subsp. corangensis*	S/T	OS	C	Yes
Fire-affected species	*Correa lawrenceana var. genoensis*	S	OS	UN	Yes
Fire-affected species	*Darwinia taxifolia subsp. macrolaena*	S	OS	S	Yes
Fire-affected species	*Deyeuxia talariata*	H	OS	T	Yes
Fire-affected species	*Epacris gnidioides*	S	OS	UN	Yes
Fire-affected species	*Eucalyptus fraxinoides*	T	OS	C	Yes
Fire-affected species	*Eucalyptus paliformis*	T	OS	T	Yes
Fire-affected species	*Eucalyptus stenostoma*	T	OS	T	Yes
Fire-affected species	*Gentiana baeuerlenii*	H	OS	UN	
Fire-affected species	*Grevillea acanthifolia subsp. paludosa*	S	OS	S	Yes
Fire-affected species	*Grevillea baueri subsp. asperula*	S	OS	S	Yes
Fire-affected species	*Grevillea jephcottii*	S	OS	UN	Yes
Fire-affected species	*Grevillea juniperina subsp. villosa*	S	OS	UN	Yes
Fire-affected species	*Grevillea molyneuxii*	S	OS	S	Yes
Fire-affected species	*Leptospermum thompsonii*	S	OS	S	Yes
Fire-affected species	*Nematolepis elliptica*	S	OS	UN	Yes
Fire-affected species	*Nematolepis rhytidophylla*	S	OS	UN	Yes
Fire-affected species	*Persoonia mollis subsp. budawangensis*	S	OS	S	Yes
Fire-affected species	*Philotheca myoporoides subsp. brevipedunculata*	S	OS	S	Yes
Fire-affected species	*Prostanthera monticola*	S	OS	S	Yes

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Prostanthera saxicola var. montana*	S	OS	S	Yes
Fire-affected species	*Pultenaea baeuerlenii*	S	OS	UN	Yes
Fire-affected species	*Pultenaea parrisiae*	S	OS	S	Yes
Fire-affected species	*Styphelia psiloclada*	S	OS	S	Yes
Fire-affected species	*Zieria caducibracteata*	S/T	OS	UN	Yes
Fire-affected species	*Zieria murphyi*	S	OS	S	Yes
Fire-affected species	*Boronia deanei subsp. deanei*	S	FS	UN	Yes
Fire-affected species	*Chrysocephalum apiculatum subsp. stoloniferum*	H	FS	S	Yes
Fire-affected species	*Grevillea irrasa subsp. didymochiton*	S	FS	S	Yes
Fire-affected species	*Grevillea ramosissima subsp. hypargyrea*	S	FS	S	Yes
Fire-affected species	*Monotoca rotundifolia*	S	FS	S	Yes
Fire-affected species	*Philotheca scabra subsp. latifolia*	S	FS	S	Yes
Fire-affected species	*Tetratheca ericifolia*	S	FS	S	
Fire-affected species	*Baloskion longipes*	H	RS	UN	Yes
Fire-affected species	*Callistemon forresterae*	S	RS	UN	Yes
Fire-affected species	*Callistemon subulatus*	S	RS	C	Yes
Fire-affected species	*Dillwynia stipulifera*	S	RS	S	Yes
Fire-affected species	*Eucalyptus baeuerlenii*	T	RS	T	
Fire-affected species	*Eucalyptus deuaensis*	T	RS	UN	Yes
Fire-affected species	*Eucalyptus gregsoniana*	T	RS	T	Yes
Fire-affected species	*Eucalyptus olsenii*	T	RS	UN	Yes
Fire-affected species	*Eucalyptus stellulata*	T	RS	T	
Fire-affected species	*Eucalyptus sturgissiana*	T	RS	C	Yes
Fire-affected species	*Eucalyptus triflora*	T	RS	UN	Yes
Fire-affected species	*Genoplesium vernale*	H	RS	UN	Yes
Fire-affected species	*Grevillea epicroca*	S	RS	UN	Yes
Fire-affected species	*Grevillea imberbis*	S	RS	UN	Yes
Fire-affected species	*Grevillea renwickiana*	S	RS	T	Yes
Fire-affected species	*Hibbertia praemorsa*	S	RS	UN	Yes
Fire-affected species	*Leionema coxii*	S	RS	UN	Yes
Fire-affected species	*Lomandra confertifolia subsp. leptostachya*	H	RS	UN	Yes
Fire-affected species	*Luzula flaccida subsp. Long Anther (K.L.Wilson 828 et al.)*	H	RS	S	Yes
Fire-affected species	*Olearia stenophylla*	S	RS	UN	Yes
Fire-affected species	*Persoonia procumbens*	S	RS	UN	Yes
Fire-affected species	*Plinthanthesis rodwayi*	H	RS	UN	Yes
Fire-affected species	*Prasophyllum caricetum*	H	RS	UN	Yes
Fire-affected species	*Schoenus evansianus*	H	RS	UN	Yes
Fire-affected species	*Telopea mongaensis*	S	RS	UN	Yes

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Telopea mongaensis x Telopea oreades*	S	RS	UN	
Fire-affected species	*Trachymene scapigera*	H	RS	UN	Yes
Fire-affected species	*Astrotricha sp. Deua (R.O.Makinson 1647)*	S	UN	UN	Yes
Fire-affected species	*Brachyscome riparia*	H	UN	UN	Yes
Fire-affected species	*Brachyscome salkiniae*	H	UN	UN	Yes
Fire-affected species	*Caladenia oreophila*	H	UN	UN	Yes
Fire-affected species	*Caladenia osmera*	H	UN	UN	Yes
Fire-affected species	*Celmisia longifolia*	H	UN	UN	
Fire-affected species	*Cryptandra speciosa subsp. speciosa*	S	UN	UN	Yes
Fire-affected species	*Daviesia suaveolens*	S/T	UN	UN	Yes
Fire-affected species	*Dillwynia crispii*	S	UN	UN	Yes
Fire-affected species	*Grevillea neurophylla subsp. fluviatilis*	S	UN	UN	Yes
Fire-affected species	*Grevillea pachylostyla*	S	UN	UN	Yes
Fire-affected species	*Grevillea parvula*	S	UN	UN	Yes
Fire-affected species	*Grevillea polychroma*	S	UN	UN	Yes
Fire-affected species	*Grevillea rhyolitica subsp. semivestita*	S	UN	UN	Yes
Fire-affected species	*Hibbertia singularis*	S	UN	UN	Yes
Fire-affected species	*Kunzea juniperoides subsp. pernervosa*	S	UN	UN	Yes
Fire-affected species	*Leionema ceratogynum*	S	UN	UN	Yes
Fire-affected species	*Leptospermum crassifolium*	S	UN	UN	Yes
Fire-affected species	*Leptospermum deuense*	S	UN	UN	Yes
Fire-affected species	*Leptospermum glabrescens*	S/T	UN	UN	Yes
Fire-affected species	*Leptospermum namadgiense*	S	UN	UN	Yes
Fire-affected species	*Leptospermum subglabratum*	S	UN	UN	Yes
Fire-affected species	*Olearia sp. Rhizomatica (I.R.Telford 11549)*	S	UN	UN	Yes
Fire-affected species	*Persoonia brevifolia*	S	UN	UN	Yes
Fire-affected species	*Pomaderris gilmourii var. gilmourii*	S	UN	UN	Yes
Fire-affected species	*Pomaderris helianthemifolia*	S	UN	UN	Yes
Fire-affected species	*Pomaderris helianthemifolia subsp. hispida*	S	UN	UN	Yes
Fire-affected species	*Pomaderris oblongifolia*	S	UN	UN	Yes
Fire-affected species	*Prostanthera porcata*	S	UN	UN	Yes
Fire-affected species	*Prostanthera tallowa*	S	UN	UN	Yes
Fire-affected species	*Pultenaea rodwayi*	S	UN	UN	Yes
Fire-affected species	*Viola improcera*	H	UN	UN	Yes
Fire-affected species	*Westringia cremnophila*	S	UN	UN	Yes

7.18 TEC 16: Robertson Rainforest in the Sydney Basin Bioregion

7.18.1 Description

The Robertson Rainforest in the Sydney Basin Bioregion occurs only in New South Wales in the Southern Highlands, 500–800m above sea level on basalt and basanite soils.[103] The canopy layer is typically low and dense with characteristic species including *Acacia melanoxylon* (Blackwood), *Doryphora sassafras* (Sassafras), *Polyosma cunninghamii* (Featherwood) and *Quintinia sieberi* (Possumwood). It often has a dense herbaceous and fern ground cover including species such as *Asplenium flabellifolium* (Necklace Fern), *Microsorum pustulatum subsp. pustulatum* (Kangaroo Fern) and *Urtica incisa* (Stinging Nettle).[103]

7.18.2 Fire response traits

In the Robertson Rainforest, there are 147 plant species representing 116 different genera. Of these plant species, 42% (n = 61) are resprouters, 28% (n = 41) are obligate seeders and 21% (n = 31) are facultative seeders, with 10% (n = 14) having an unverified fire response (Table 7-62). Herbaceous species make up 44% (n = 65) of all plant species present, shrubs make up 22% (n = 33), climbers/vines make up 19% (n = 28) and trees make up 14% (n = 21) (Table 7-62).

TABLE 7-62. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	25 (38)	11 (17)	22 (34)	7 (11)	**65**
Shrub	4 (12)	11 (33)	16 (49)	2 (6)	**33**
Tree	6 (28)	2 (10)	11 (52)	2 (10)	**21**
Climber/Vine	6 (21)	7 (25)	12 (43)	3 (11)	**28**
Total count	**41**	**31**	**61**	**14**	**147**

7.18.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-63).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Robertson Rainforest and outlined below and described in Appendix 2 (Section 11.16).

TEC 16: Robertson Rainforest in the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 147 [116 genera]

Trees:
- 14% (n = 21)

Shrubs:
- 22% (n = 33)

Herbaceous:
- 44% (n = 65)

Climbers/Vines:
- 19% (n = 28)

Fire Response

Resprouters:
- 42% (n = 61)

Obligate seeders:
- 28% (n= 41)

Facultative seeders:
- 21% (n = 31)

Unknown:
- 10% (n = 14)

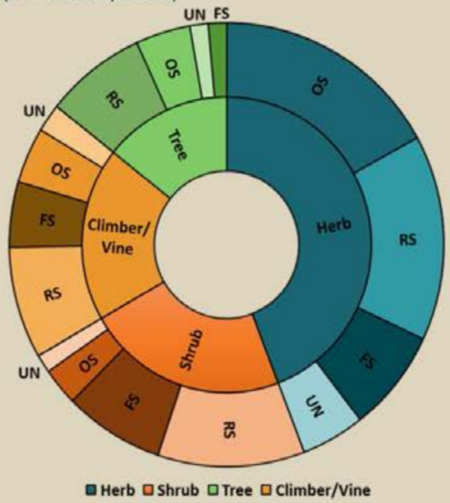
Life History and Fire Response

Resprouters (RS):
- Close to half of all shrubs (49%), climbers/vines (43%) and trees (52%)

Obligate seeders (OS):
- Higher proportion of herbaceous species (38%) and trees (28%)

Facultative seeders (FS):
- Ranged from 10% of trees to 33% of shrubs

For each life form:
- Low proportion of unknown (UN) fire responses (6-11% of species)

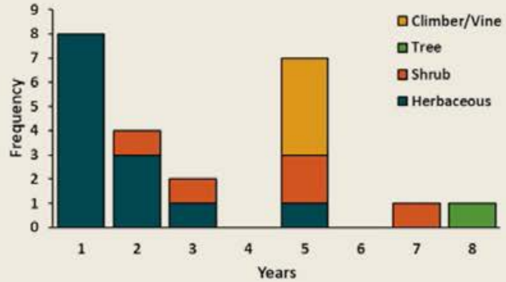


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- > 25 years (fire should be avoided)

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-14 years
- Herbaceous = 2-10 years
- Climbers/vines = 10 years
- Trees = 16 years



[1]Obligate seeders and facultative seeders

Table 7-63. Priority areas 1 and 2 Robertson Rainforest: Variables influencing regenerative potential

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (20-40)	150.9	5.2	7.2[a]	2.2-16.7	2.4	2-3	38.6	37.6-39.2	221.5	0-500
2 (0-20)	215.1	7.4	2.2[b]	2.2-2.2	2	2-2	38.7	37.9-39.2	1170.6	400.0-2051.8
3 (40-60)	961.9	33	4.7	2.2-5.0	4	2-5	41.3	38.1-42.2	1091.5	0-2308.7
4 (60-80)	812.0	27.9	3.8	2.3-5.0	4.6	4-5	40.5	38.3-42.2	762.3	0-2158.7
5 (80--100)	775.1	26.6	2.8	2.3-5.0	4.6	4-5	39.8	38.3-41.5	211.4	0-600

Finer scale analysis of NSW fire data: Priority area 1[a] = 25.6 years (12.5 – 50 years); Priority area 2[b] = 18.2 (12.5 – 50 years)

See Figure 7-23 for distribution of each priority area

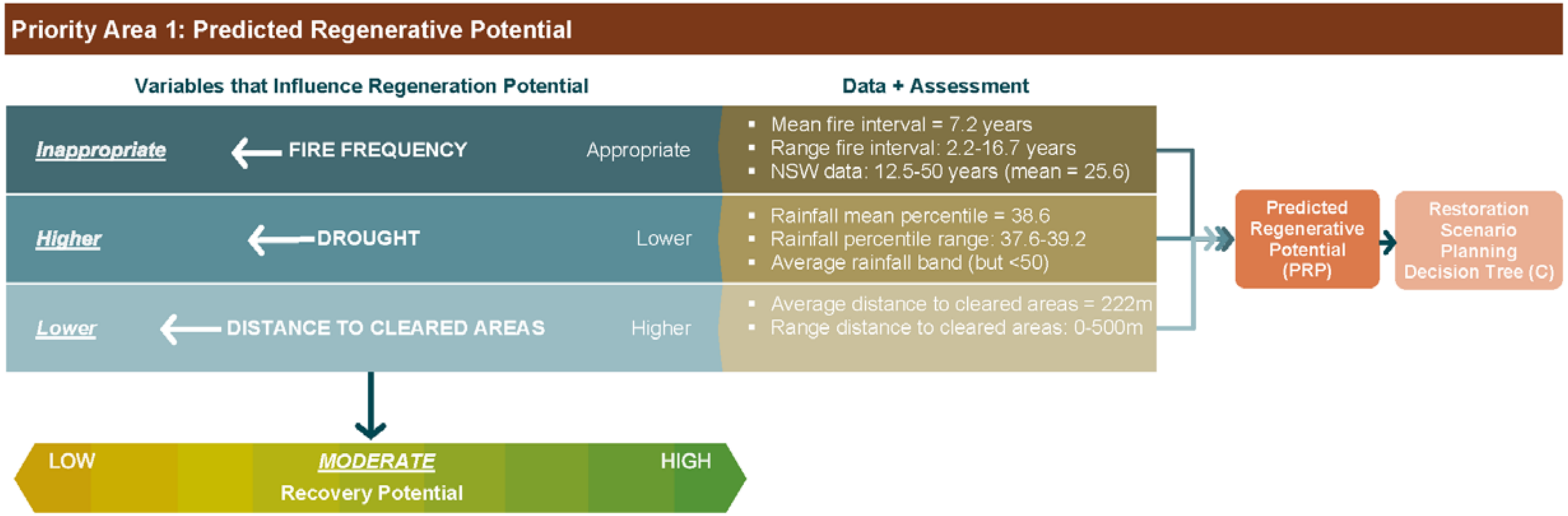
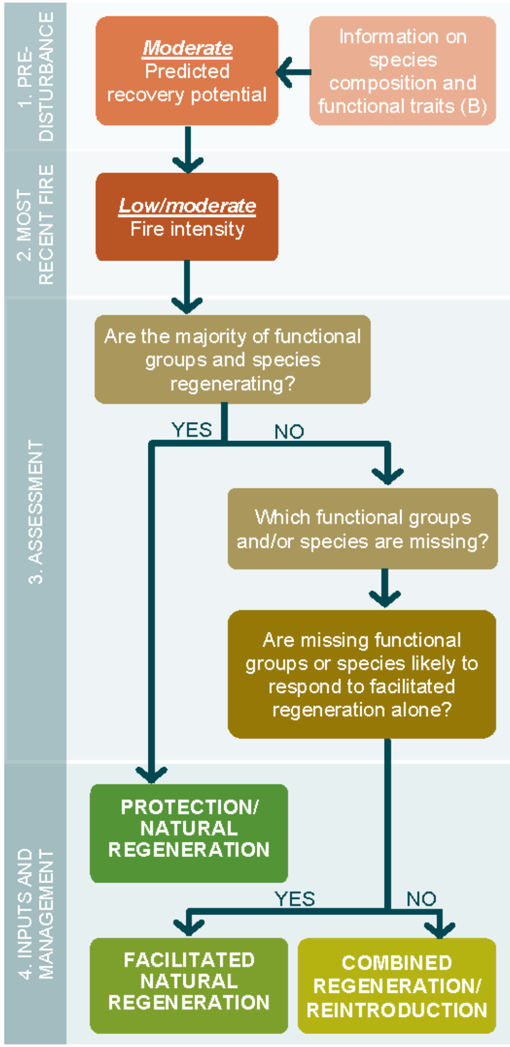


TABLE 7-64. RESTORATION APPROACHES FOR ROBERTSON RAINFOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal (especially transformer weeds) to facilitate regeneration**	• **Weed removal (especially transformer weeds)** • **Facilitate recovery of fire sensitive species**	• **Build buffers around rainforest remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Invasive fauna including European rabbits (*Oryctolagus cuniculus*), feral pigs (*Sus scrofa*), goats (*Capra hircus*), feral cats (*Felis catus*), feral dogs (*Canis lupus familiaris*) and European red fox (*Vulpes vulpes*) • Inappropriate fire regimes • Grazing • Climate change	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Asparagus asparagoides* (Bridal Creeper) • *Berberis vulgaris* (Barberry) • *Crataegus spp.* (Hawthorn) • *Genista spp.* • *Nassella neesiana* (Chilean Needle Grass) • *Nassella trichotoma* • *Pyracantha spp.* (Firethorn) • *Rapistrum rugosum* (Turnip Weed) • *Rumex acetosella* (Sheep's Sorrel) • *Senecio madagascariensis* • *Ulex europaeus* (Gorse)	**Weed removal** (see Facilitated regeneration) **Reintroduction:** • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-65. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-65).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Robertson Rainforest

FIGURE 7-22. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR ROBERTSON RAINFOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-63 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

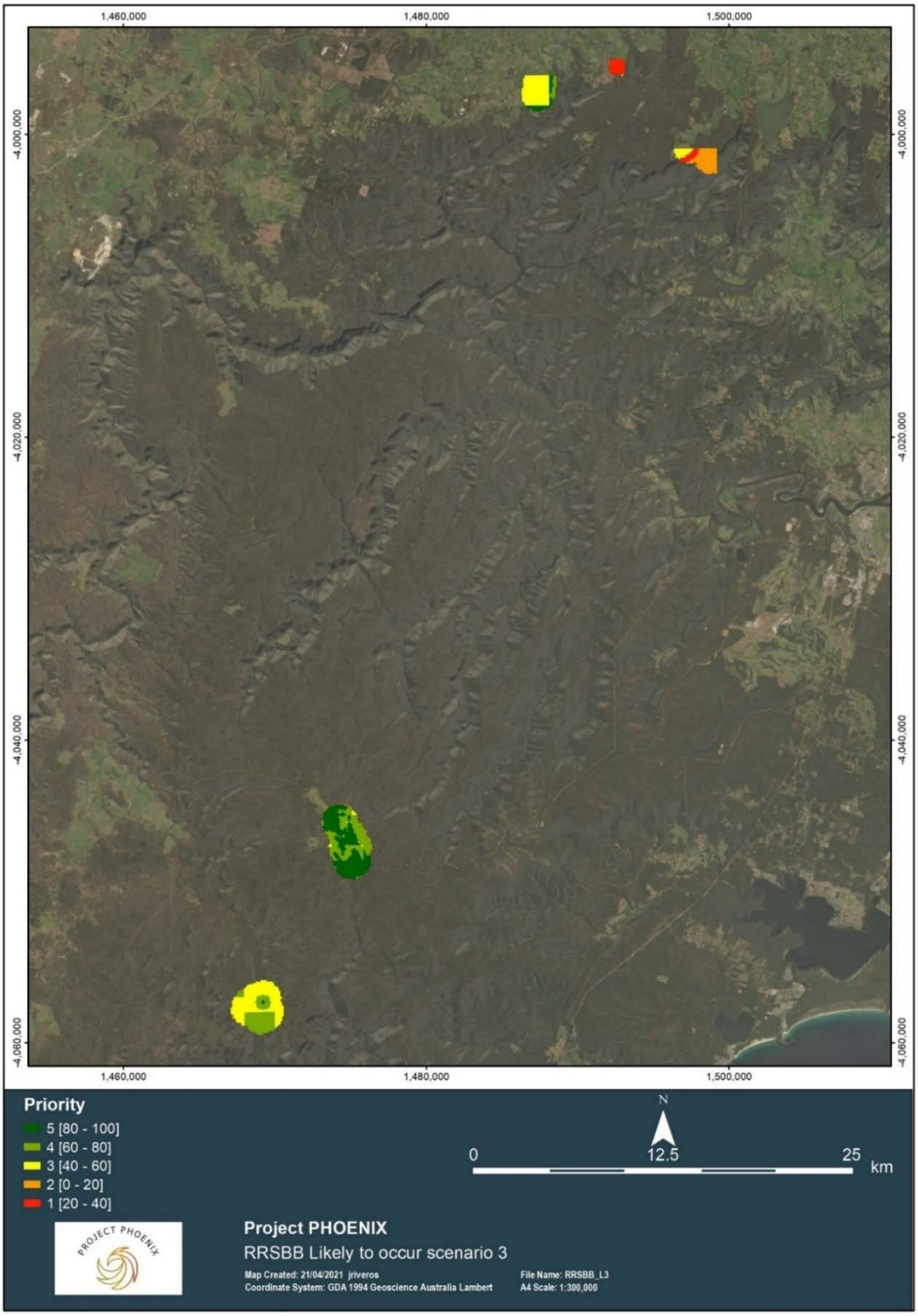


Figure 7-23. The mean fire interval (meanFI) for Robertson Rainforest and surrounding area based on the NSW fire history data. White polygons designate the bounds of the TEC and relate to the areas in Figure 7-23 (above).

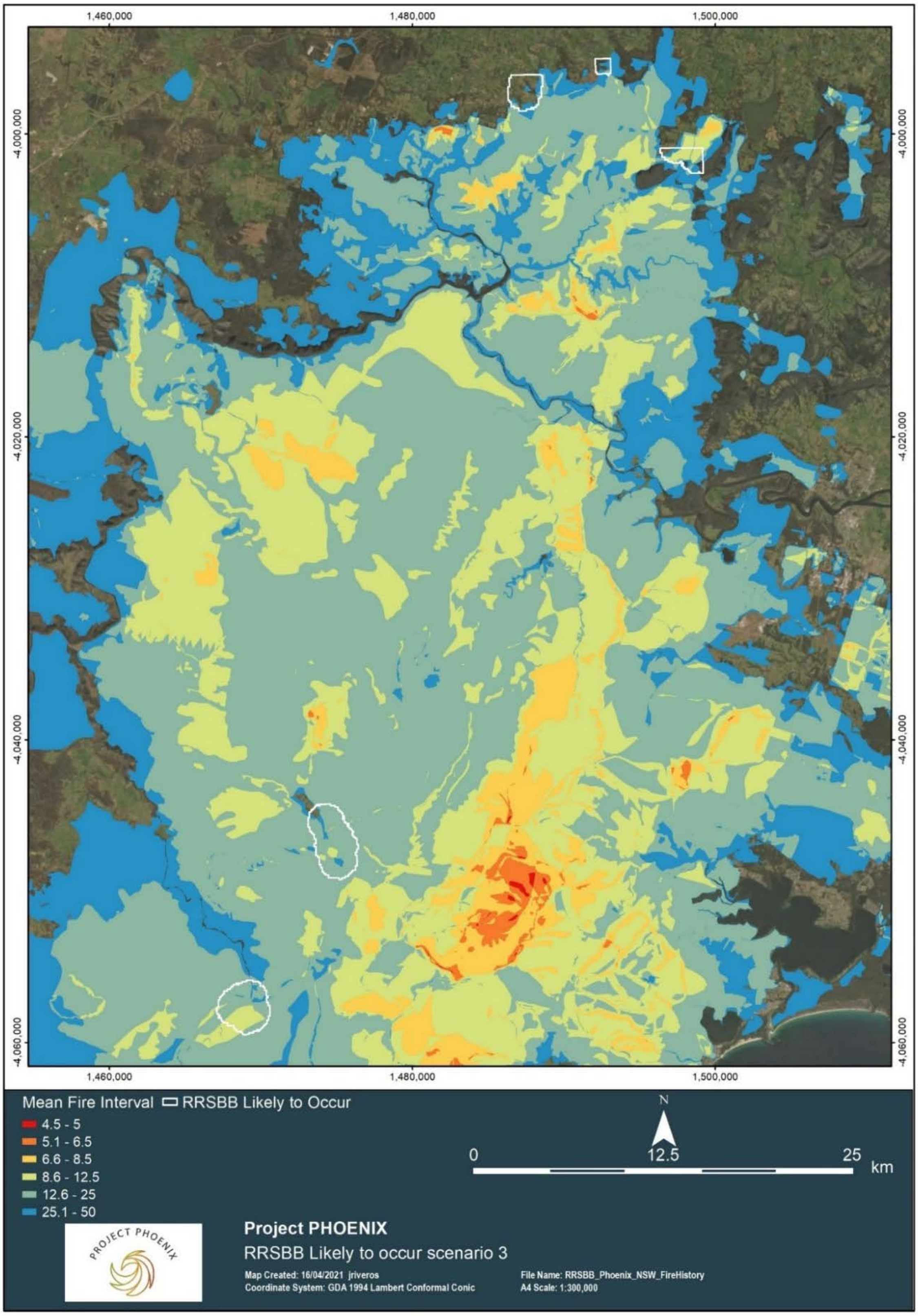


TABLE 7-65. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE ROBERTSON RAINFOREST IN THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia mearnsii*	S	OS	S	
TEC species list	*Amyema congener*	C	OS	UN	
TEC species list	*Aphanopetalum resinosum*	C	OS	T	
TEC species list	*Arthropteris tenella*	H	OS	UN	
TEC species list	*Asplenium attenuatum*	H	OS	T	
TEC species list	*Asplenium australasicum*	C	OS	T	
TEC species list	*Asplenium flaccidum*	H	OS	T	
TEC species list	*Austrocynoglossum latifolium*	H	OS	S	
TEC species list	*Citronella moorei*	T	OS	UN	
TEC species list	*Clematis aristata*	C	OS	S	
TEC species list	*Dendrobium pugioniforme*	C	OS	S	
TEC species list	*Dendrocnide excelsa*	T	OS	S	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Elaeocarpus kirtonii*	T	OS	UN	
TEC species list	*Fieldia australis*	C	OS	UN	
TEC species list	*Galium leiocarpum*	H	OS	UN	
TEC species list	*Grammitis billardieri*	H	OS	UN	
TEC species list	*Hymenophyllum cupressiforme*	H	OS	T	
TEC species list	*Hymenophyllum flabellatum*	H	OS	T	
TEC species list	*Hypolepis glandulifera*	H	OS	UN	
TEC species list	*Microsorum pustulatum subsp. pustulatum*	H	OS	UN	
TEC species list	*Microsorum scandens*	H	OS	UN	
TEC species list	*Ozothamnus ferrugineus*	S/T	OS	UN	
TEC species list	*Plantago debilis*	H	OS	S	
TEC species list	*Plectorrhiza tridentata*	H	OS	UN	
TEC species list	*Polyosma cunninghamii*	T	OS	UN	
TEC species list	*Polyphlebium venosa*	H	OS	T	
TEC species list	*Polyscias murrayi*	T	OS	UN	
TEC species list	*Pyrrosia rupestris*	H	OS	UN	
TEC species list	*Ranunculus lappaceus*	H	OS	T	
TEC species list	*Ranunculus plebeius*	H	OS	UN	
TEC species list	*Senecio quadridentatus*	H	OS	T	
TEC species list	*Sigesbeckia orientalis*	H	OS	S	
TEC species list	*Sloanea australis*	T	OS	UN	
TEC species list	*Solanum aviculare*	H	OS	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Solanum prinophyllum*	H	OS	UN	
TEC species list	*Solanum pungetium*	H	OS	UN	
TEC species list	*Stellaria flaccida*	H	OS	S	
TEC species list	*Symplocos thwaitesii*	S/T	OS	T	
TEC species list	*Tasmannia insipida*	S	OS	UN	
TEC species list	*Urtica incisa*	H	OS	S	
TEC species list	*Acacia melanoxylon*	S	FS	S	
TEC species list	*Acronychia oblongifolia*	S/T	FS	T	
TEC species list	*Alectryon subcinereus*	S/T	FS	T	
TEC species list	*Cassinia trinerva*	S	FS	UN	
TEC species list	*Cissus hypoglauca*	C	FS	UN	
TEC species list	*Clematis glycinoides*	C	FS	S	
TEC species list	*Coprosma quadrifida*	S	FS	T	
TEC species list	*Cyathea leichhardtiana*	T	FS	T	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Elaeocarpus reticulatus*	H	FS	T	
TEC species list	*Eustrephus latifolius*	C	FS	UN	
TEC species list	*Geranium homeanum*	H	FS	UN	
TEC species list	*Hedycarya angustifolia*	S	FS	UN	
TEC species list	*Hibbertia scandens*	C	FS	S	
TEC species list	*Histiopteris incisa*	H	FS	T	
TEC species list	*Hydrocotyle laxiflora*	H	FS	UN	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Myrsine howittiana6*	S/T	FS	UN	
TEC species list	*Ozothamnus diosmifolius*	S	FS	S	
TEC species list	*Pandorea pandorana*	C	FS	S	
TEC species list	*Parsonsia brownii*	C	FS	UN	
TEC species list	*Passiflora cinnabarina*	C	FS	S	
TEC species list	*Pittosporum revolutum*	S	FS	UN	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Polyscias sambucifolia*	S	FS	S	
TEC species list	*Polystichum proliferum*	H	FS	UN	
TEC species list	*Prostanthera lasianthos*	S	FS	S	
TEC species list	*Pseuderanthemum variabile*	H	FS	S	
TEC species list	*Senecio minimus*	H	FS	T	
TEC species list	*Viola hederacea*	H	FS	S	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
Fire-affected species	*Acacia hamiltoniana*	S	OS	UN	Yes
Fire-affected species	*Boronia subulifolia*	S	OS	UN	Yes

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
Fire-affected species	*Darwinia taxifolia subsp. macrolaena*	S	OS	S	Yes
Fire-affected species	*Epacris gnidioides*	S	OS	UN	Yes
Fire-affected species	*Eucalyptus fraxinoides*	T	OS	C	Yes
Fire-affected species	*Grevillea baueri subsp. asperula*	S	OS	S	Yes
Fire-affected species	*Leptospermum thompsonii*	S	OS	S	Yes
Fire-affected species	*Persoonia mollis subsp. budawangensis*	S	OS	S	Yes
Fire-affected species	*Prostanthera saxicola var. montana*	S	OS	S	Yes
Fire-affected species	*Zieria caducibracteata*	S/T	OS	UN	Yes
Fire-affected species	*Philotheca scabra subsp. latifolia*	S	FS	S	Yes
Fire-affected species	*Dillwynia stipulifera*	S	RS	S	Yes
Fire-affected species	*Eucalyptus gregsoniana*	T	RS	T	Yes
Fire-affected species	*Eucalyptus triflora*	T	RS	UN	Yes
Fire-affected species	*Schoenus evansianus*	H	RS	UN	Yes
Fire-affected species	*Telopea mongaensis*	S	RS	UN	Yes
Fire-affected species	*Agonis ericoides*	S	UN	UN	Yes
Fire-affected species	*Leptospermum crassifolium*	S	UN	UN	Yes

7.19 TEC 17: Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion

7.19.1 Description

The Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion occurs only in New South Wales on the Southern Highlands plateau often on clay soils.[104] It often occurs 470–830m above sea level with annual rainfall of 900–1400mm.[105] The vegetation structure has a eucalypt dominated tree canopy and herbaceous understorey but variation does occur due to rainfall, exposure and disturbances (including weed invasion, clearing and grazing). Characteristic species include *Eucalyptus globoidea* (white stringybark), *Eucalyptus piperita* (Sydney peppermint), *Eucalyptus radiata* (narrow-leaved peppermint), *Hardenbergia violacea* (purple coral pea, waraburra), *Lomandra longifolia* (spiny-head mat-rush, basket grass) and *Poa labillardierei* (common tussock-grass).[105]

7.19.2 Fire response traits

In the Southern Highlands Shale Forest, there are 101 plant species representing 59 different genera. Of these plant species, 45% (n = 46) are resprouters, 35% (n = 35) are facultative seeders and 17% (n = 17) are obligate seeders with 3% (n = 3) having an unverified fire response (Table 7-66). Herbaceous species make up 40% (n = 41) of all plant species present, shrubs make up 32% (n = 32), trees make up 23% (n = 23) and climbers/vines make up 5% (n = 5) (Table 7-66).

TABLE 7-66. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	7 (17)	13 (32)	19 (46)	2 (5)	**41**
Shrub	9 (28)	17 (53)	6 (19)	0 (0)	**32**
Tree	0 (0)	2 (9)	20 (87)	1 (4)	**23**
Climber/Vine	1 (20)	3 (60)	1 (20)	0 (0)	**5**
Total count	**17**	**35**	**46**	**3**	**101**

7.19.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-67).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Southern Highlands Shale Forest and Woodland and outlined below and described in Appendix 2 (Section 11.17).

TEC 17: Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 101 [59 genera]

Trees:
- 23% (n = 23)

Shrubs:
- 32% (n = 32)

Herbaceous:
- 40% (n = 41)

Climbers/Vines:
- 5% (n = 5)

Fire Response

Resprouters:
- 45% (n = 46)

Obligate seeders:
- 17% (n= 17)

Facultative seeders:
- 35% (n = 35)

Unknown:
- 3% (n = 3)

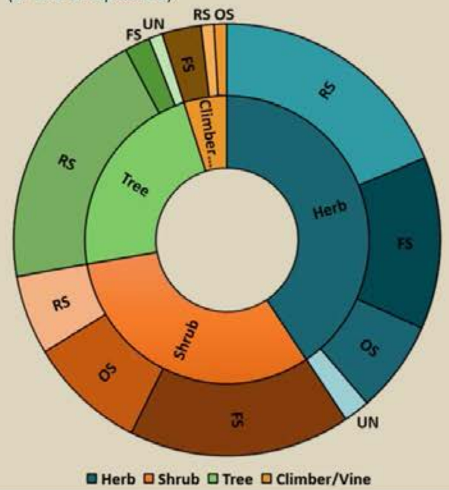
Life History and Fire Response

Resprouters (RS):
- Highest proportion and trees (87%) followed by herbaceous species (46%)

Obligate seeders (OS):
- Range from 17% of herbaceous species to 28% of shrubs

Faculative seeders (FS):
- Higher proportion of shrubs (53%) and climbers/vines (60%)

For each life form:
- Low proportion of unknown (UN) fire responses (0-5% of species)

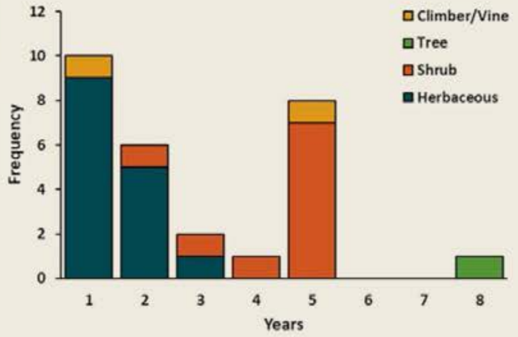


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 10-20 years

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-10 years
- Herbaceous = 2-6 years
- Climbers/vines = 2-10 years
- Trees = 16 years



[1]Obligate seeders and facultative seeders

Table 7-67. Priority areas 1 and 2 Southern Highlands Shale Forest and Woodland: Variables influencing regenerative potential

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	111.1	5.7	4	1.9-4.5	5	4-5	39.2	38.3-39.4	474.9	0-1063
2 (60-80)	1140.8	58.6	3.8	1.9-4.5	3.6	2-5	38.6	36.1-40.2	241.3	0-2879.2
3 (40-60)	525.3	27	4	1.9-4.5	3.1	2-4	38.7	36.1-40.2	511.4	0-3733.6
4 (20-40)	94.8	4.9	4.2	2.2-16.7	2.8	2-4	39.4	37.9-40.2	2139.3	0-3328.7
5 (0-20)	75.0	3.9	16.7	16.7-16.7	2.5	2-4	39.8	37.6-40.2	161.7	0-360.6

Finer scale analysis of NSW fire data: Priority area 1[a] = 40.2 years (16.6 – 50 years); Priority area 2[b] = 41.3 (10 – 50 years)

See Figure 7-25 for distribution of each priority area

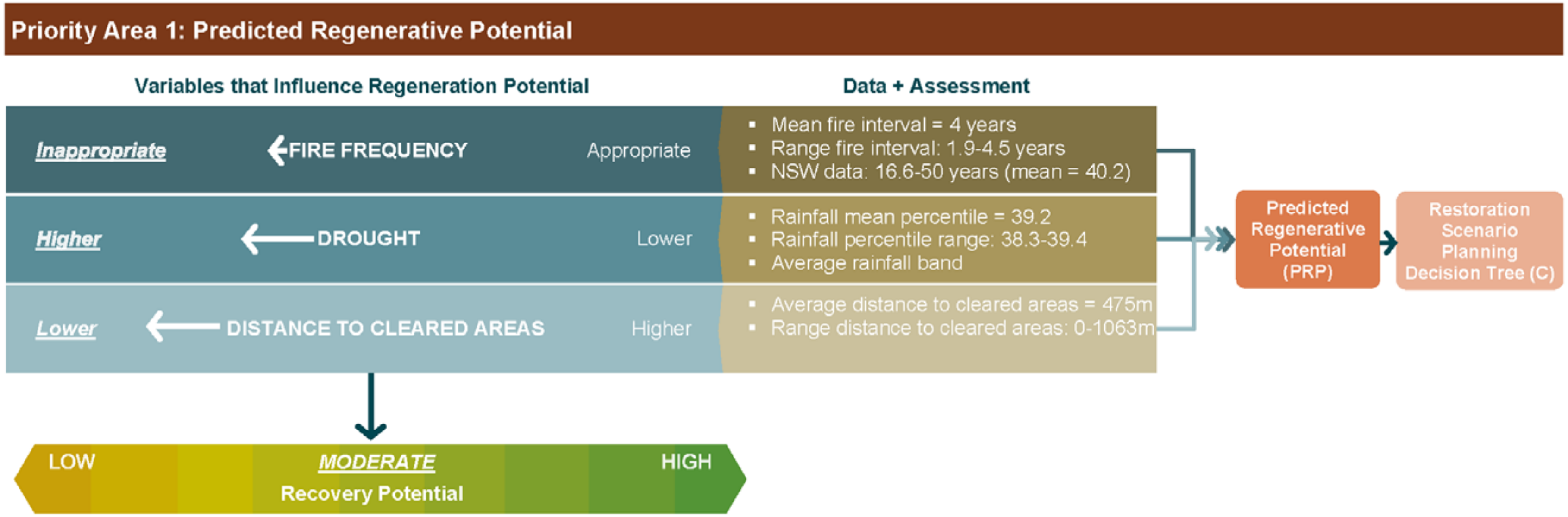
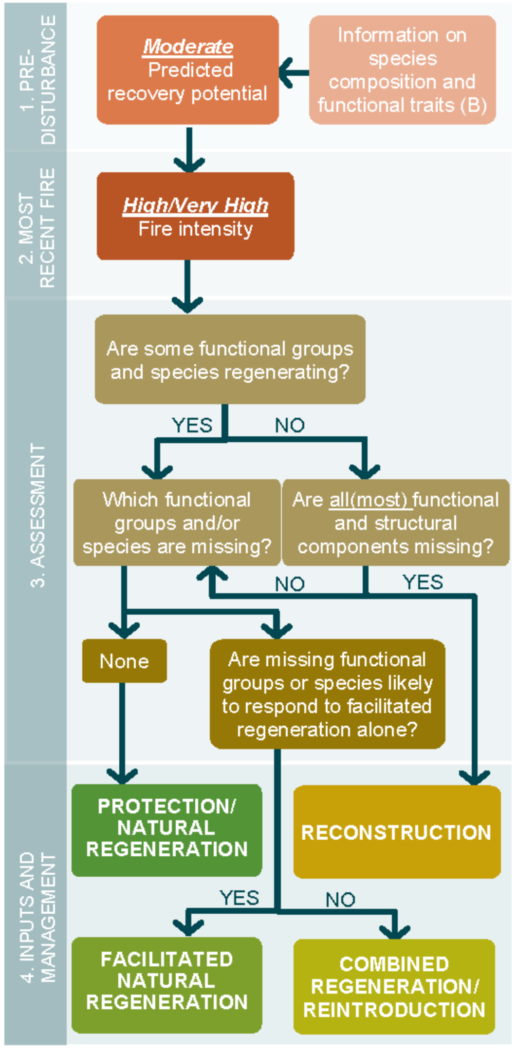


TABLE 7-68. RESTORATION APPROACHES FOR SOUTHERN HIGHLANDS SHALE FOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnant patches** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Invasion and establishment of transformer weed species • Inappropriate fire regimes • Invasive fauna including European rabbit (*Oryctolagus cuniculus*), feral honeybees, feral deer, noisy miners (*Manorina melanocephala*), European red fox (*Vulpes vulpes*), feral cats (*Felis catus*), feral pigs (*Sus scrofa*) • Grazing • Climate change	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Berberis vulgaris* (Barberry) • *Delairea odorata* (Cape Ivy) • *Cytisus scoparius* (Scotch Broom) • *Eragrostis curvula* (African Lovegrass) • *Genista monspessulana* (Montpellier Broom) • *Hedera helix* (English Ivy) • *Ligustrum spp.* (Privet) • *Olea europaea sp. cuspidata* (African Olive) • *Prunus laurocerasus* • *Tradescantia fluminensis* • *Ulex europaeus* (Gorse)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-69. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-69).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Southern Highlands Shale Forest and Woodland

FIGURE 7-24. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR SOUTHERN HIGHLANDS SHALE FOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-67 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA

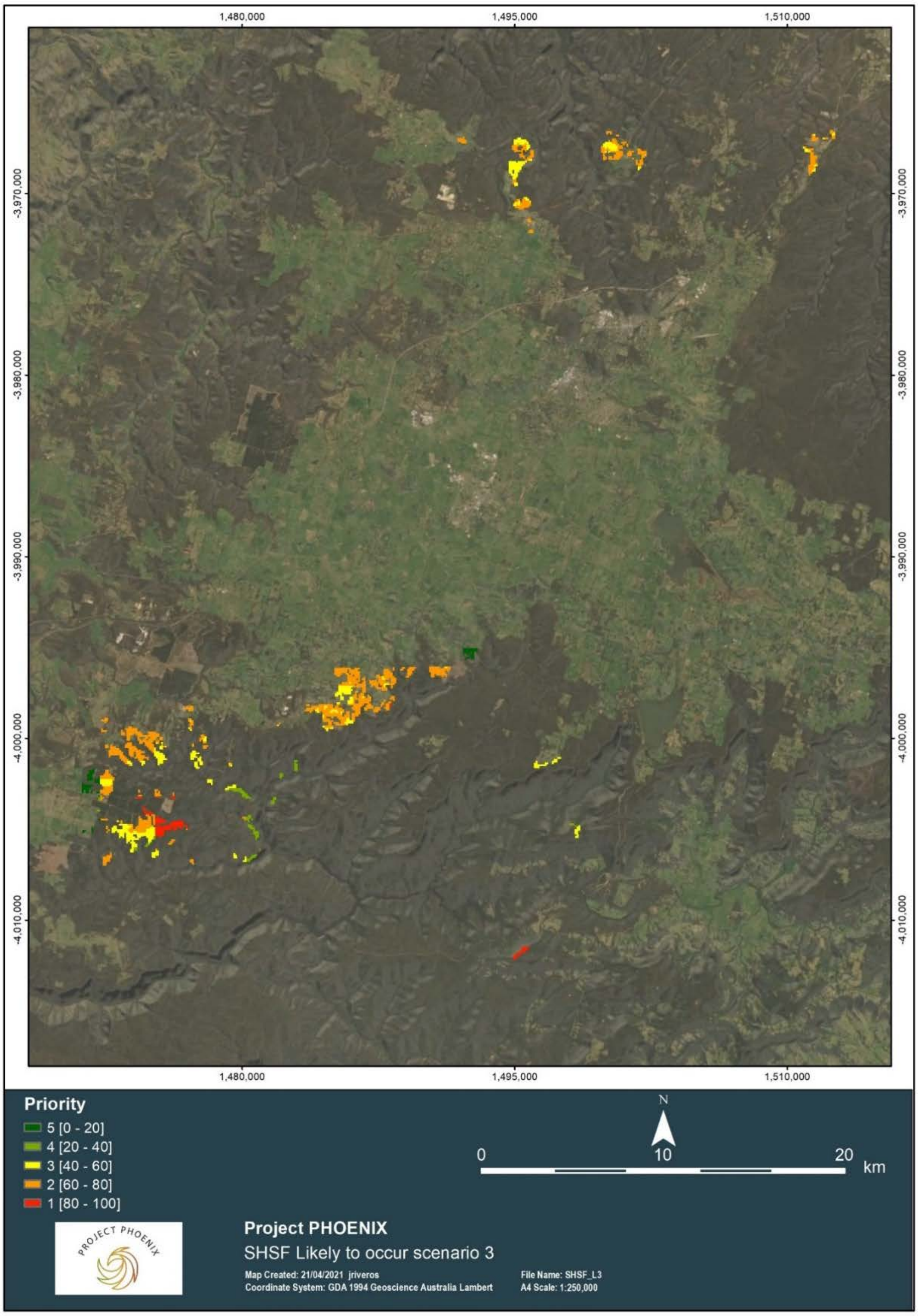


TABLE 7-69. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE SOUTHERN HIGHLANDS SHALE FOREST AND WOODLAND IN THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia binervata*	S	OS	S	
TEC species list	*Acacia decurrens*	S	OS	S	
TEC species list	*Acacia mearnsii*	S	OS	S	
TEC species list	*Acacia parramattensis*	S	OS	S	
TEC species list	*Acacia stricta*	S	OS	S	
TEC species list	*Cassinia aculeata*	S	OS	S	
TEC species list	*Clematis aristata*	C	OS	S	
TEC species list	*Coronidium elatum*	H	OS	UN	
TEC species list	*Einadia nutans*	H	OS	UN	
TEC species list	*Geranium solanderi*	H	OS	UN	
TEC species list	*Olearia microphylla*	S	OS	S	
TEC species list	*Plectanthus parviflorus*	H	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Pultenaea blakelyi*	S	OS	S	
TEC species list	*Pultenaea flexilis*	S	OS	S	
TEC species list	*Stackhousia viminea*	H	OS	T	
TEC species list	*Xerochrysum bracteatum*	H	OS	S	
TEC species list	*Acacia falciformis*	S	FS	S	
TEC species list	*Acacia implexa*	S	FS	S	
TEC species list	*Acacia longifolia*	S	FS	S	
TEC species list	*Acacia melanoxylon*	S	FS	S	
TEC species list	*Acacia rubida*	S	FS	S	
TEC species list	*Billardiera scandens*	S	FS	S	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Dichelachne crinita*	H	FS	UN	
TEC species list	*Dichondra spp.*	H	FS	UN	
TEC species list	*Dillwynia ramosissima*	S	FS	S	
TEC species list	*Eucalyptus elata*	T	FS	T	
TEC species list	*Eustrephus latifolius*	C	FS	UN	
TEC species list	*Exocarpos cupressiformis*	S/T	FS	UN	
TEC species list	*Geranium homeanum*	H	FS	UN	
TEC species list	*Gonocarpus tetragynus*	H	FS	S	
TEC species list	*Goodenia ovata*	H	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Hibbertia scandens*	C	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Hypericum gramineum*	H	FS	S	
TEC species list	*Indigofera australis*	S	FS	S	
TEC species list	*Leptospermum polygalifolium*	S	FS	C	
TEC species list	*Leucopogon juniperinus*	S	FS	S	
TEC species list	*Leucopogon lanceolatus*	S	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Melaleuca linariifolia*	S/T	FS	C	
TEC species list	*Opercularia diphylla*	H	FS	S	
TEC species list	*Ozothamnus diosmifolius*	S	FS	S	
TEC species list	*Pittosporum undulatum*	T	FS	T	
TEC species list	*Poa sieberiana*	H	FS	UN	
TEC species list	*Podolobium ilicifolium*	S	FS	S	
TEC species list	*Senecio hispidulus*	H	FS	S	
TEC species list	*Senecio minimus*	H	FS	T	
TEC species list	*Stackhousia monogyna*	H	FS	S	
TEC species list	*Viola hederacea*	H	FS	S	
TEC species list	*Zieria smithii*	S	FS	S	
Fire-affected species	*Grevillea molyneuxii*	S	OS	S	Yes
Fire-affected species	*Zieria murphyi*	S	OS	S	Yes
Fire-affected species	*Tetratheca insularis*	S	FS	S	
Fire-affected species	*Prostanthera tallowa*	S	UN	UN	Yes

7.20 TEC 18: Shale Sandstone Transition Forest of the Sydney Basin Bioregion

7.20.1 Description

The Shale Sandstone Transition Forest of the Sydney Basin Bioregion is endemic to New South Wales, to the west of Sydney, on shale and weathered sandstone substrate soils. It typically occurs less than 200m above sea level with annual rainfall of 800–1100mm.[68] The vegetation structure is typically tall to open forest or woodland with mixed eucalypt species dominated canopy and sclerophyll shrub and herbaceous understorey.[106] The main tree species include Forest Red Gum (*Eucalyptus tereticornis*), Grey Gum (*E. punctata*), stringybarks (*E. globoidea*, *E. eugenioides*) and ironbarks (*E. fibrosa* and *E. crebra*). Characteristic species vary based on location but typically include *Bursaria spinosa* (blackthorn), *Kunzea ambigua* (tick bush), *Lepidosperma laterale* (saw sedge) and *Solanum prinophyllum* (forest nightshade).[106]

7.20.2 Fire response traits

In the Shale Sandstone Transition Forest, there are 139 plant species representing 93 different genera. Of these plant species, 55% (n = 77) are resprouters, 25% (n = 35) are facultative seeders and 19% (n = 26) are obligate seeders with 1% (n = 1) having an unverified fire response (Table 7-70). Herbaceous species make up 51% (n = 71) of all plant species present, shrubs make up 28% (n = 39), trees make up 17% (n = 24) and climbers/vines make up 4% (n = 5) (Table 7-70).

TABLE 7-70. THE NUMBER AND PER CENT OF EACH FIRE RESPONSE (OBLIGATE SEEDER (OS), FACULTATIVE SEEDER (FS), RESPROUTER (RS), UNKNOWN) OF EACH LIFE FORM (HERBACEOUS, SHRUB, TREE, CLIMBER/VINE).

	NUMBER (AND %) OF EACH FIRE RESPONSE				
LIFE FORM	OS	FS	RS	UNKNOWN	TOTAL COUNT
Herbaceous	9 (13)	17 (24)	44 (62)	1 (1)	**71**
Shrub	16 (41)	15 (38)	8 (21)	0 (0)	**39**
Tree	0 (0)	1 (4)	23 (96)	0 (0)	**24**
Climber/Vine	1 (20)	2 (40)	2 (40)	0 (0)	**5**
Total count	**26**	**35**	**77**	**1**	**139**

7.20.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-71).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Shale Sandstone Transition Forest and outlined below and described in Appendix 2 (Section 11.18).

TEC 18: Shale Sandstone Transition Forest of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 139 [93 genera]

Trees:
- 17% (n = 24)

Shrubs:
- 28% (n = 39)

Herbaceous:
- 51% (n = 71)

Climbers/Vines:
- 4% (n = 5)

Fire Response

Resprouters:
- 55% (n = 77)

Obligate seeders:
- 19% (n= 26)

Facultative seeders:
- 25% (n = 35)

Unknown:
- 1% (n = 1)

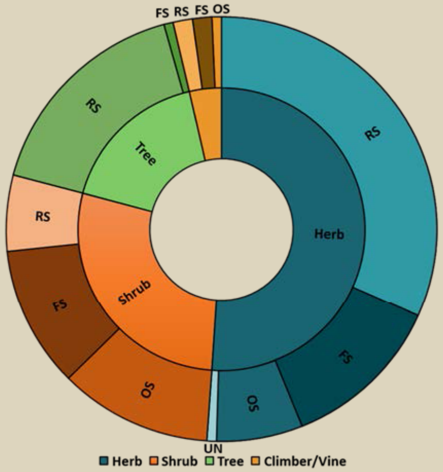
Life History and Fire Response

Resprouters (RS):
- High proportion of herbaceous species (62%) and trees (96%)

Obligate seeders (OS):
- Highest proportion of shrubs (41%)

Facultative seeders (FS):
- Approx. 1/3 of shurbs (38%) and 1/4 of herbaceous species (24%)

For each life form:
- Low proportion of unknown (UN) fire responses (0-1% of species)

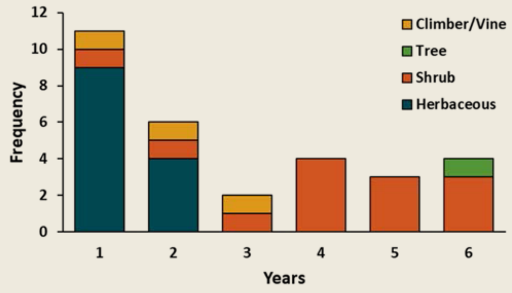


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 13-20 years[2]

Minimum fire interval based on primary juvenile period:
- Shrubs = 2-12 years
- Herbaceous = 2-4 years
- Climbers/vines = 2-6 years
- Trees = 12 years



[1]Obligate seeders and facultative seeders
[2]Hammil *et al.*[74]

Table 7-71. Priority areas 1 and 2 Shale Sandstone Transition Forest: Variables influencing regenerative potential

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	18.9	1.4	2.4	2.4-2.4	4.5	3-5	38.5	37.7-39.9	131	0-400
2 (40-60)	948.0	71.3	2.6	1.9-6.3	3.4	2-5	40.3	37.7-45.9	114.6	0-300
3 (20-40)	354.5	26.7	2.6	1.9-6.3	3.1	2-5	41.1	37.7-45.9	197.5	0-583.1
4 (0-20)	8.2	0.6	2.3	1.9-3.3	2.8	2-3	39.9	37.6-45.8	936.8	141.4-1565.2

Finer scale analysis of NSW fire data: Priority area 1[a] = 23.4 years (12.5 – 25 years); Priority area 2[b] = 35.3 (5.6 – 50 years)

See Figure 7-26 for distribution of each priority area

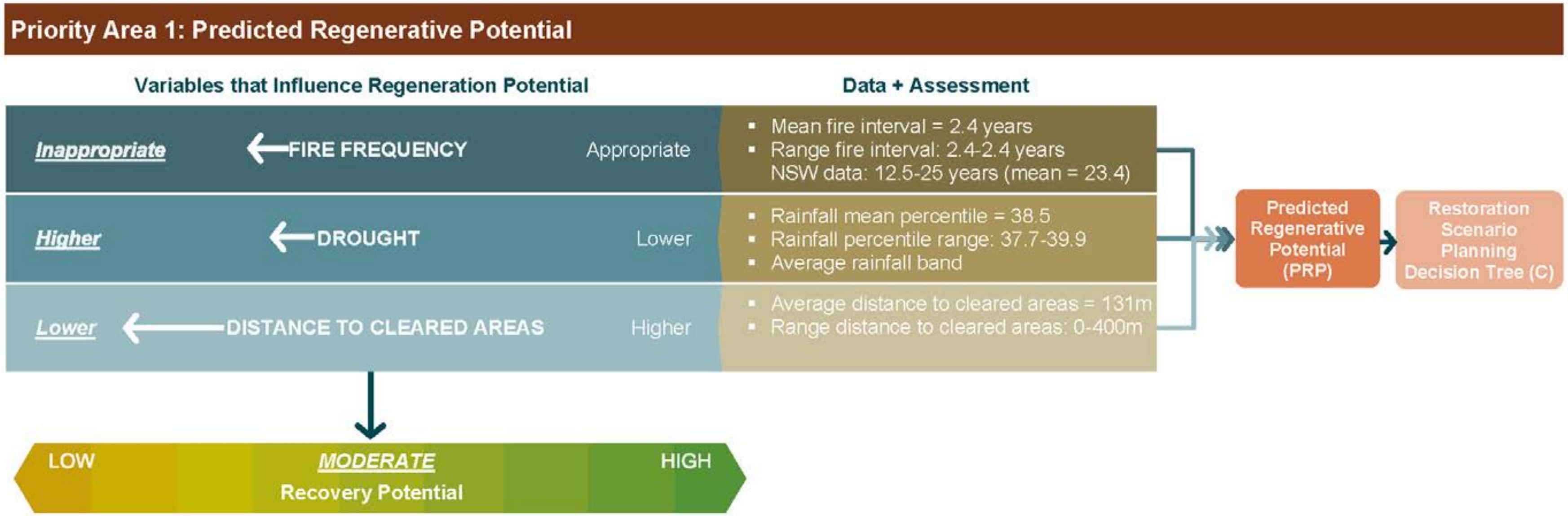
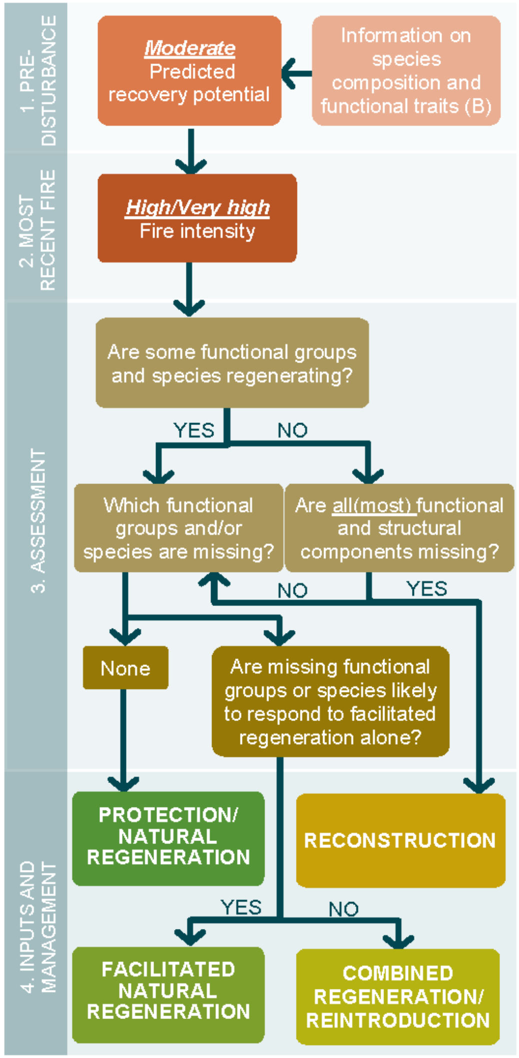


TABLE 7-72. RESTORATION APPROACHES FOR SHALE SANDSTONE TRANSITION FOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Underscrubbing from mowing and grazing by livestock • Invasion and establishment of weed species • Inappropriate fire regimes • Hydrological change • Recreational activities • Invasion of introduced deer • Increased nutrients, erosion and sedimentation	**Manage threats** (see Protection) **Weed removal**. Key weeds include: • *Araujia hortorum* (Moth Vine) • *Cirsium vulgare* (Spear Thistle) • *Delairea odorata* (Cape Ivy) • *Hyparrhenia hirta* (Coolatai Grass) • *Ligustrum lucidum* (Broad-leafed Privet) • *Ligustrum sinense* (Small-leafed Privet) • *Myrsiphyllum asparagoides* (Bridal Sreeper) • *Olea europaea subsp. cuspidata* (African Olive)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species (obligate seeders and to a lesser extent facultative seeders) are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-73. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-73).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Shale Sandstone Transition Forest

FIGURE 7-25. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR SHALE SANDSTONE TRANSITION FOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-71 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

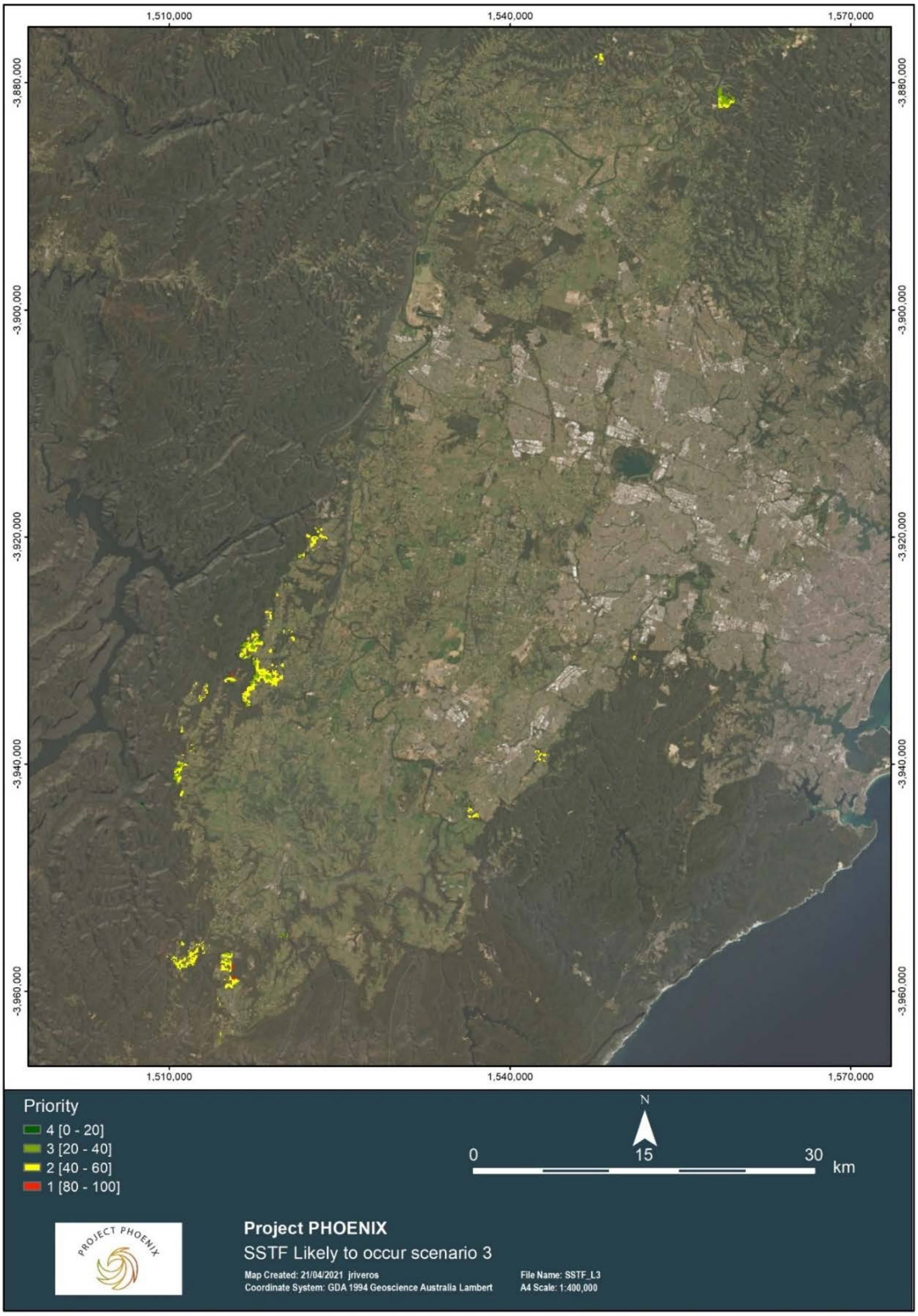


TABLE 7-73. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE SHALE SANDSTONE TRANSITION FOREST OF THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia decurrens*	S	OS	S	
TEC species list	*Acacia falcata*	S	OS	S	
TEC species list	*Acacia parramattensis*	S	OS	S	
TEC species list	*Calotis dentex*	H	OS	S	
TEC species list	*Cassytha glabella*	C	OS	UN	
TEC species list	*Centella asiatica*	H	OS	S	
TEC species list	*Dillwynia tenuifolia*	S	OS	S	
TEC species list	*Dodonaea triquetra*	S	OS	S	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Epacris purpurascens var. purpurascens*	S	OS	S	
TEC species list	*Euchiton sphaericus*	H	OS	UN	
TEC species list	*Hakea sericea*	S	OS	C	
TEC species list	*Kunzea ambigua*	S	OS	S	
TEC species list	*Lagenophora gracilis*	H	OS	UN	
TEC species list	*Olearia microphylla*	S	OS	S	
TEC species list	*Persoonia acerosa*	S	OS	S	
TEC species list	*Persoonia bargoensis*	S	OS	S	
TEC species list	*Persoonia glaucescens*	S	OS	S	
TEC species list	*Persoonia hirsuta*	S	OS	S	
TEC species list	*Plantago debilis*	H	OS	S	
TEC species list	*Pomaderris brunnea*	S	OS	S	
TEC species list	*Pomax umbellata*	S	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Pultenaea villosa*	S	OS	S	
TEC species list	*Solanum prinophyllum*	H	OS	UN	
TEC species list	*Solanum pungetium*	H	OS	UN	
TEC species list	*Acacia implexa*	S	FS	S	
TEC species list	*Acacia myrtifolia*	S	FS	S	
TEC species list	*Allocasuarina littoralis*	T	FS	T	
TEC species list	*Billardiera scandens*	S	FS	S	
TEC species list	*Breynia oblongifolia*	S	FS	S	
TEC species list	*Cyanthillium cinereum*	H	FS	T	
TEC species list	*Daviesia ulicifolia*	S	FS	S	
TEC species list	*Dianella caerula*	H	FS	T	
TEC species list	*Dichondra repens*	H	FS	UN	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Exocarpos cupressiformis*	S/T	FS	UN	
TEC species list	*Geranium homeanum*	H	FS	UN	
TEC species list	*Glycine clandestina*	C	FS	S	
TEC species list	*Gonocarpus tetragynus*	H	FS	S	
TEC species list	*Grevillea parviflora subsp. parviflora*	S	FS	S	
TEC species list	*Hardenbergia violacea*	C	FS	S	
TEC species list	*Helichrysum scorpioides*	H	FS	S	
TEC species list	*Hibbertia aspera subsp. aspera*	S	FS	S	
TEC species list	*Hibbertia diffusa*	S	FS	S	
TEC species list	*Indigofera australis*	S	FS	S	
TEC species list	*Laxmannia gracilis*	H	FS	S	
TEC species list	*Leucopogon juniperinus*	S	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Opercularia diphylla*	H	FS	S	
TEC species list	*Opercularia varia*	H	FS	S	
TEC species list	*Oxalis exilis*	H	FS	S	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Ozothamnus diosmifolius*	S	FS	S	
TEC species list	*Phyllanthus hirtellus*	S	FS	T	
TEC species list	*Pimelea curviflora var. curviflora*	H	FS	UN	
TEC species list	*Pimelea linifolia subsp. linifolia*	S	FS	S	
TEC species list	*Poa sieberiana*	H	FS	UN	
TEC species list	*Polyscias sambucifolia*	S	FS	S	
TEC species list	*Pseuderanthemum variabile*	H	FS	S	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
Fire-affected species	*Acacia clunies-rossiae*	S	OS	UN	Yes
Fire-affected species	*Banksia paludosa subsp. astrolux*	S	OS	C	Yes
Fire-affected species	*Grevillea aspleniifolia*	S	OS	S	Yes
Fire-affected species	*Tetratheca ericifolia*	S	FS	S	Yes
Fire-affected species	*Acrophyllum australe*	S	RS	UN	Yes
Fire-affected species	*Callistemon subulatus*	S	RS	C	Yes
Fire-affected species	*Grevillea kedumbensis*	S	RS	UN	Yes
Fire-affected species	*Olearia cordata*	S	RS	UN	Yes
Fire-affected species	*Veronica brownii*	H	RS	UN	Yes
Fire-affected species	*Epacris pilosa*	S	UN	UN	Yes
Fire-affected species	*Epacris sprengelioides*	S	UN	UN	Yes

7.21 TEC 19: Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion

7.21.1 Description

The Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion occurs only in New South Wales on predominantly Tertiary alluvium derived clay-rich, or Wianamatta Shale derived soils.[107,108] It has an average annual rainfall of 800–1000mm and occurs below 100m above sea level.[68] The vegetation structure ranges from an open forest to a low woodland which is dominated by Melaleuca decora (paperbark) and Eucalyptus fibrosa (broad-leaved ironbark).[68,108] The understorey is dense and often dominated by *Lissanthe strigosa* (peach heath) and *Melaleuca nodosa* (prickly-leaved paperbark), with a sparse ground layer commonly including *Entolasia stricta* (wiry panic) and *Lobelia purpurascens* (whiteroot).[108]

7.21.2 Fire response traits

In the Cooks River/Castlereagh Ironbark Forest, there are 99 plant species representing 71 different genera. Of these plant species, 52% (n = 51) are resprouters, 26% (n = 26) are facultative seeders and 21% (n = 21) are obligate seeders with 1% (n = 1) having an unverified fire response (Table 7-74). Herbaceous species make up 51% (n = 50) of all plant species present, shrubs make up 33% (n = 33), trees make up 12% (n = 12) and climbers/vines make up 4% (n = 4) (Table 7-74).

Table 7-74. The number and per cent of each fire response (obligate seeder (OS), facultative seeder (FS), resprouter (RS), unknown) of each life form (herbaceous, shrub, tree, climber/vine).

	Number (and %) of each fire response				
Life form	OS	FS	RS	Unknown	Total count
Herbaceous	9 (18)	17 (34)	24 (48)	0 (0)	**50**
Shrub	8 (24)	7 (21)	18 (55)	0 (0)	**33**
Tree	1 (8)	2 (17)	8 (67)	1 (8)	**12**
Climber/Vine	3 (75)	0 (0)	1 (25)	0 (0)	**4**
Total count	**21**	**26**	**51**	**1**	**99**

7.21.3 GIS analysis

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas (see Table 7-75).

Details of the application of the conceptual model and restoration scenario decision tree for priority areas 1 and 2 of the Cooks River/Castlereagh Ironbark Forest and outlined below and described in Appendix 2 (Section 11.19).

TEC 19: Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion

Community Characteristics

Number of species:
- 99 [71 genera]

Trees:
- 12% (n = 12)

Shrubs:
- 33% (n = 33)

Herbaceous:
- 51% (n = 50)

Climbers/Vines:
- 4% (n = 4)

Fire Response

Resprouters:
- 52% (n = 51)

Obligate seeders:
- 21% (n= 21)

Facultative seeders:
- 26% (n = 26)

Unknown:
- 1% (n = 1)

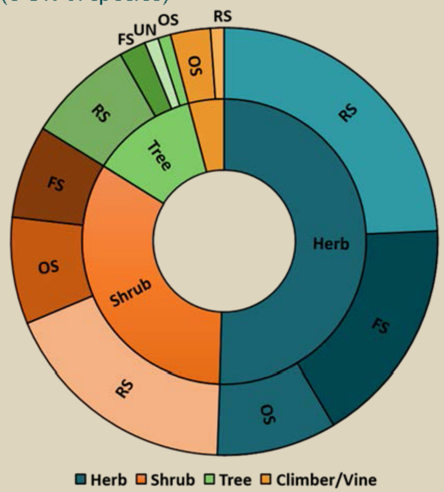
Life History and Fire Response

Resprouters (RS):
- Highest proportion of herbaceous species (48%), shrubs (55%) and trees (67%)

Obligate seeders (OS):
- Most climbers (75%) and almost a quarter of shrubs (24%)

Faculative seeders (FS):
- Ranged from 17% of trees to 34% of herbaceous species

For each life form:
- Low proportion of unknown (UN) fire responses (0-8% of species)

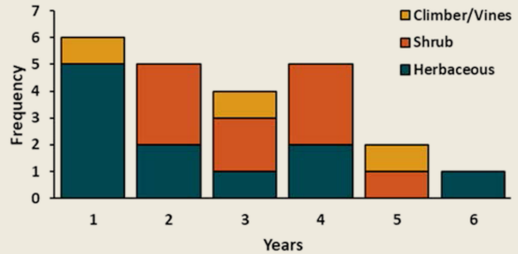


Primary Juvenile Periods for Fire Sensitive Species

The frequency of primary juvenile periods for sensitive species[1] of different life forms

General recommendation for fire free interval:
- 11-20 years[2]

Minimum fire interval based on primary juvenile period:
- Shrubs = 4-10 years
- Herbaceous = 2-12 years
- Climbers/vines = 2-10 years



[1]Obligate seeders and facultative seeders
[2]Hammil *et al.*[74]

TABLE 7-75. PRIORITY AREAS 1 AND 2 COOKS RIVER/CASTLEREAGH IRONBARK FOREST: VARIABLES INFLUENCING REGENERATIVE POTENTIAL

Priority Area	Area (ha)	Percent in each priority class	Mean fire interval (years)	Range fire interval (years)	Mean fire intensity	Range fire intensity	Mean rainfall percentile	Range rainfall percentile	Mean distance to cleared areas (m)	Range distance to cleared areas (m)
1 (80-100)	80.5	74.1	6.4[a]	3.8-16.7	3.8	2-5	44.5	43.5-45.2	360.9	0-707.1
2 (60-80)	24.9	22.9	6.3[b]	6.3-6.3	3	3-3	43.3	43.3-43.3	136.5	0-282.8
3 (40-60)	1.0	0.9	6.3	6.3-6.3	3	3-3	43.3	43.3-43.3	212	141.4-282.8
4 (0-20)	2.2	2	50	50-50	4	4-4	45.2	44.8-45.5	50	0-100

Finer scale analysis of NSW fire data: Priority area 1[a] = 32.2 years (25 – 50 years); Priority area 2[b] = 50 (50 – 50 years)

See Figure 7-27 for distribution of each priority area

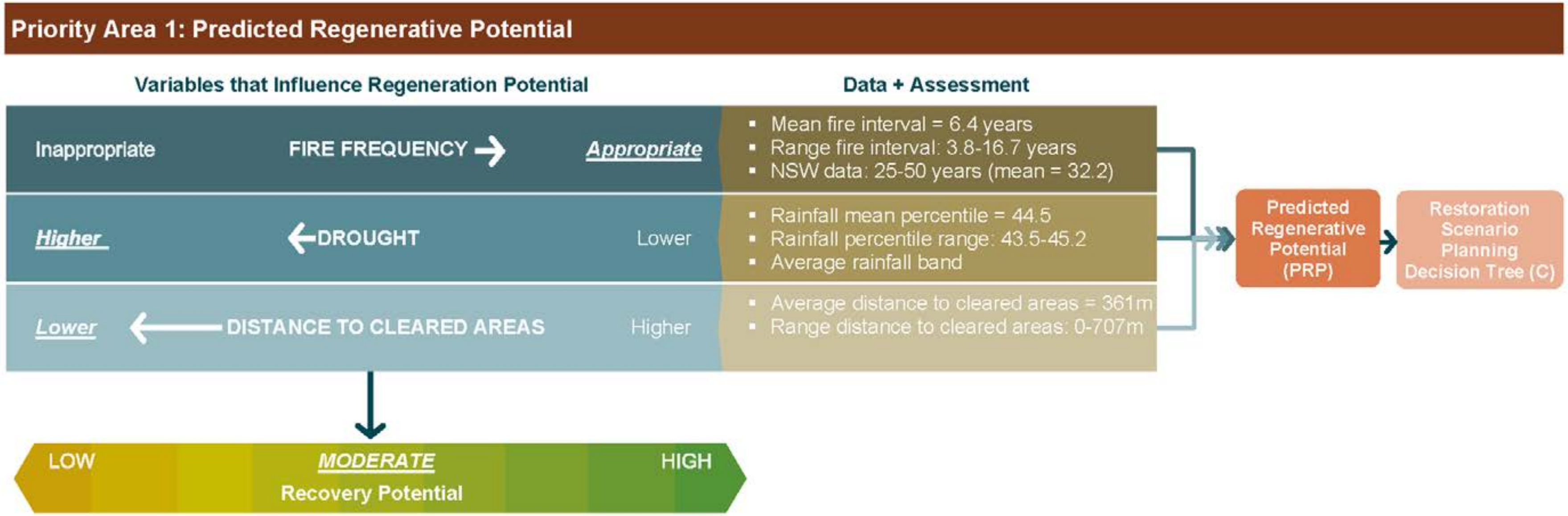
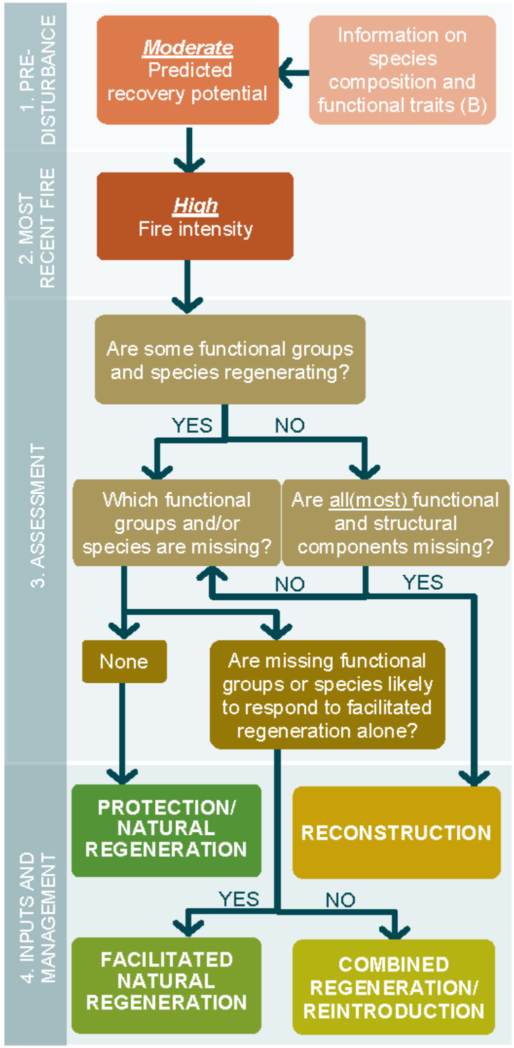


TABLE 7-76. RESTORATION APPROACHES FOR COOKS RIVER/CASTLEREAGH IRONBARK FOREST



RESTORATION APPROACH	PROTECTION/ NATURAL REGENERATION	FACILITATED NATURAL REGENERATION	COMBINED REGENERATION / REINTRODUCTION	RECONSTRUCTION
GOAL	• **Manage threats**	• **Weed removal to facilitate regeneration**	• **Weed removal** • **Facilitate recovery of fire sensitive species**	• **Build buffers around remnants** • **Extend the spatial extent of current patches** • **Improve connectivity between remnants**
DETAILS AND/OR TARGET SPECIES	**Manage threats** • Clearing from rural, agricultural and urban development • Fragmentation • Invasion and establishment of weed species • Inappropriate fire regimes • Increased nutrient loads and pollution runoff • Clay/shale extraction • Potentially impacted by Phytophthora dieback	**Manage threats** (see Protection) **Weed removal.** Key weeds include: • *Araujia sericifera* (Moth Vine) • *Asparagus aethiopicus* (Ground Asparagus) • *Asparagus asparagoides* (Bridal Creeper) • *Cenchrus clandestinus* (Kikuyu) • *Cestrum parqui* (Green Cestrum) • *Cynodon dactylon* (Common Couch) • *Ehrharta erecta* (Panic Veldt Grass) • *Juncus spp.* (Rushes) • *Ochna serrulata* (Mickey Mouse Bush) • non-native *Rubus spp.* • *Typha spp.* (Cattail)	**Weed removal** (see Facilitated regeneration) **Reintroduction**: • Site assessments are required to evaluate and quantify missing species and/or functional groups • Fire sensitive species are more likely to be affected by inappropriate fire regimes • Obligate seeders and Facultative seeders are listed in Table 7-77. • Due to the extent of impact, fire affected taxa may require management intervention in terms of seed and/or seedling addition (see Table 7-77).	• Requires broad seed inputs • Conservation planning can identify where in the landscape these are positioned to maximise benefits to biodiversity, genetic connectivity and as protection from future fire events

Spatial distribution of priority areas for Cooks River/Castlereagh Ironbark Forest

FIGURE 7-26. THE DISTRIBUTION OF PRIORITY AREAS FOR MANAGEMENT INTERVENTION FOR COOKS RIVER/CASTLEREAGH IRONBARK FOREST. RED AREAS REPRESENT PRIORITY AREA 1 AND ORANGE AREAS PRIORITY AREA 2. SEE TABLE 7-75 ABOVE FOR ASSESSMENT VARIABLES IN EACH PRIORITY AREA.

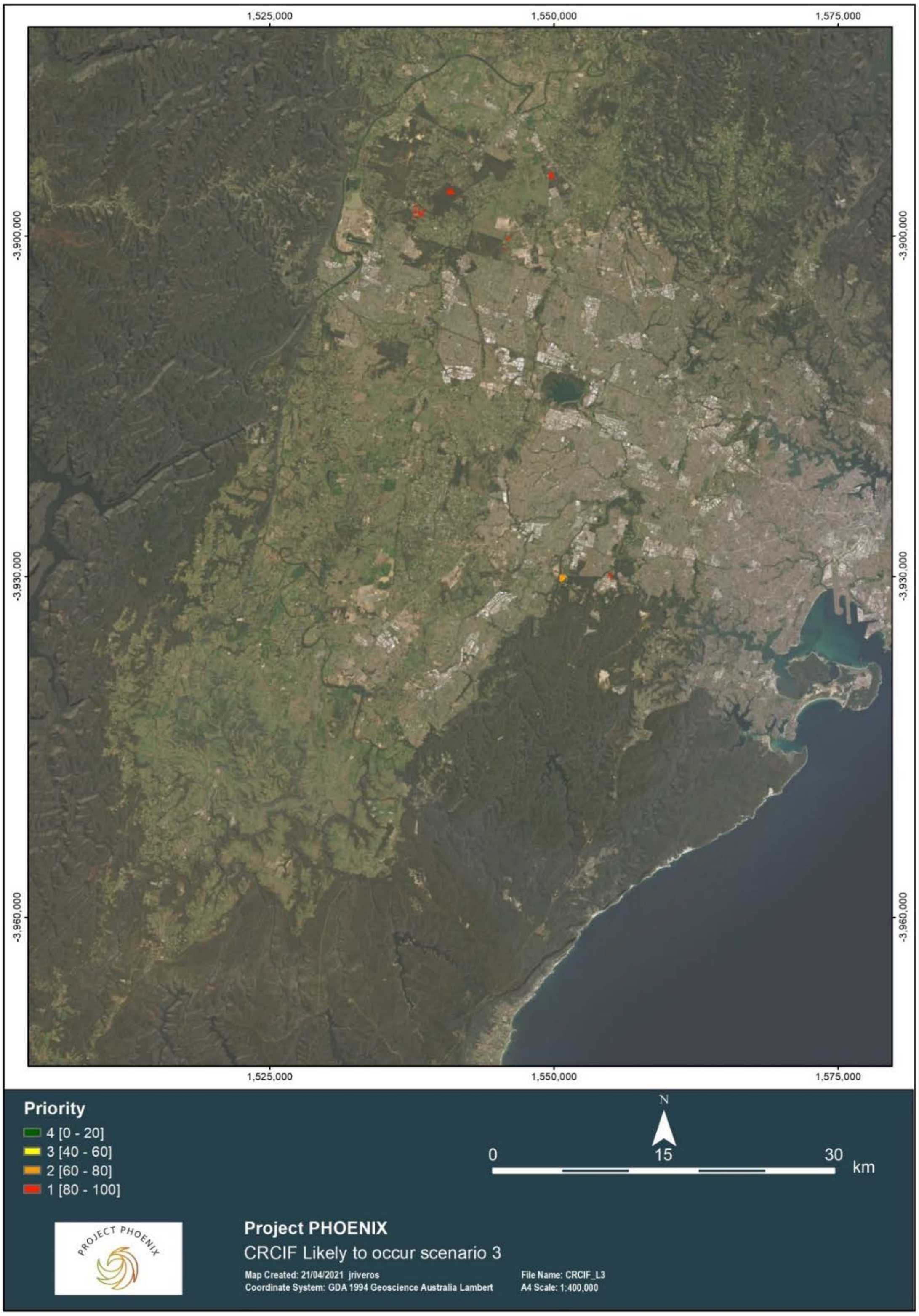


TABLE 7-77. A LIST OF THE FIRE SENSITIVE SPECIES (OBLIGATE SEEDERS AND FACULTATIVE SEEDERS) FROM THE COOKS RIVER/CASTLEREAGH IRONBARK FOREST OF THE SYDNEY BASIN BIOREGION TEC SPECIES LIST AND THE FIRE-AFFECTED SPECIES WITHIN THE TEC 'LIKELY TO OCCUR' BOUNDARY. LIFE FORM: HERBACEOUS (H), SHRUB (S), TREE (T), CLIMBER/VINE (C). SEED STORAGE: SOIL (S), TRANSIENT (T), CANOPY (C), UNKNOWN (UN).

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Acacia binervia*	C	OS	S	
TEC species list	*Acacia decurrens*	H	OS	S	
TEC species list	*Acacia falcata*	S/T	OS	S	
TEC species list	*Calotis cuneifolia*	H	OS	UN	
TEC species list	*Cassinia arcuata*	S	OS	UN	
TEC species list	*Cassytha glabella forma glabella*	S	OS	S	
TEC species list	*Dillwynia parvifloria*	T	OS	UN	
TEC species list	*Dillwynia sieberi*	S	OS	S	
TEC species list	*Dillwynia tenuifolia*	S	OS	S	
TEC species list	*Einadia nutans*	H	OS	UN	
TEC species list	*Einadia trigonos*	H	OS	S	
TEC species list	*Hakea sericea*	H	OS	C	
TEC species list	*Kunzea ambigua*	S	OS	S	
TEC species list	*Lobelia purpurascens*	S	OS	UN	
TEC species list	*Olearia microphylla*	S	OS	S	
TEC species list	*Persoonia nutans*	H	OS	S	
TEC species list	*Pomax umbellata*	H	OS	S	
TEC species list	*Poranthera microphylla*	H	OS	S	
TEC species list	*Prostanthera scutellarioides*	C	OS	S	
TEC species list	*Pultenaea villosa*	H	OS	S	
TEC species list	*Stackhousia viminea*	C	OS	T	
TEC species list	*Acacia elongata*	H	FS	S	
TEC species list	*Acacia pubescens*	S	FS	S	
TEC species list	*Allocasuarina littoralis*	H	FS	T	
TEC species list	*Billardieria scandens*	H	FS	S	
TEC species list	*Boronia polygalifolia*	H	FS	S	
TEC species list	*Cyanthillium cinereum*	H	FS	T	
TEC species list	*Daviesia ulicifolia*	S/T	FS	S	
TEC species list	*Dichondra repens*	H	FS	UN	
TEC species list	*Echinopogon ovatus*	H	FS	S	
TEC species list	*Exocarpos cupressiformis*	T	FS	UN	
TEC species list	*Glycine clandestina*	S	FS	S	
TEC species list	*Gonocarpus tetragynus*	S	FS	S	
TEC species list	*Goodenia bellidifolia*	H	FS	S	
TEC species list	*Hibbertia aspera*	S	FS	S	

IDENTIFICATION SOURCE	SCIENTIFIC NAME	LIFE FORM	FIRE RESPONSE	SEED STORAGE	MANAGEMENT INTERVENTION (EXPERT PANEL)
TEC species list	*Hibbertia serpyllifolia*	H	FS	S	
TEC species list	*Hypericum gramineum*	S	FS	S	
TEC species list	*Laxmannia gracilis*	H	FS	S	
TEC species list	*Leucopogon juniperinus*	H	FS	S	
TEC species list	*Lomandra longifolia*	H	FS	S	
TEC species list	*Opercularia diphylla*	H	FS	S	
TEC species list	*Oxalis perennans*	H	FS	UN	
TEC species list	*Ozothamnus diosmifolius*	T	FS	S	
TEC species list	*Pimelea linifolia subsp. linifolia*	H	FS	S	
TEC species list	*Podolobium ilicifolium*	H	FS	S	
TEC species list	*Rhytidosporum procumbens*	S	FS	S	
TEC species list	*Wahlenbergia gracilis*	H	FS	S	
Fire-affected species	*Grevillea kedumbensis*	S	RS	UN	
Fire-affected species	*Veronica brownii*	H	RS	UN	Yes

8 GIS METHODS

8.1 Caveats and data limitations

Our GIS spatial models were based on the best available information (and data layers) to enable a national approach to be implemented. However, states vary in the resolution and availability of the data so that a different set of layers may have been used if this was completed on a state-by-state basis. One of the layers where this was most obvious was for fire history where application of a national standardised approach required the use of the fire history layer with a $10km^2$ grid resolution.

For TECs where there was fine scale variation in fire history within the grid, areas with frequent fires brought the average for the cell down so that it was much lower than the actual fire history experienced by the areas within the TEC. To overcome this limitation, we cross checked our model results with finer scale modelling ($1km^2$ grid size) of the fire history for TECs within NSW. These results and comparison with the NSW mean fire interval data are discussed throughout our TEC analysis.

8.2 Threatened Ecological Communities (TEC)

To determine which of the nationally listed TECs were burnt (and the extent of the TEC burnt) we used the generalised distribution maps of the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (*EPBC Act 1999*) listed threatened Ecological Communities https://www.environment.gov.au/science/erin/databases-maps/ecnes. This was then intersected with the National Indicative Aggregated Fire Extent Dataset (NIAFED) within the Preliminary Analysis Area (PAA) as devised by the Bushfire Recovery Expert Panel to provide the area and extent of each TEC that was in the fire scar.

8.3 Fire extent

Fire extent was derived from the National Indicative Aggregated Fire Extent Dataset (NIAFED) within the Preliminary Analysis Area (PAA) as devised by the Bushfire Recovery Expert Panel. This was represented by a raster at 10,000m resolution.

8.4 Model choice

8.4.1 Fire history — mean fire interval (weighting 5 in the GIS model)

Given the importance of fire history to regenerative potential, mean fire interval was included in the GIS model and given an overall weighting of 5. Mean interval was used to characterise fire history because species are likely to respond long-term to this variable[109] and it can be directly related to life history and fire response traits of the species within a community. The score for each fire interval category was assigned for each TEC based on species composition and information available on primary and secondary juvenile periods.

Fire history data were available for the period 2003 to 2018 (Australia-wide) and for the period 1969 to 2002 (NSW only). For this data, mean interval was based on the average interval (year) between known historical fire seasons. To ensure consistency and enable a national model to be applied mean fire interval data was only available at a $10km^2$ resolution.

To assign fire interval category scores in each TEC, we examined the maturity time (primary juvenile period) of obligate seeder species sensitive to frequent fire and facultative seeders (while also considering the secondary juvenile period of resprouting species). Where available, we also included information on the senescence time of species sensitive to infrequent fire to assess the maximum appropriate fire intervals.

To define the minimum fire intervals for species persistence we also include an assessment of seed production, which is estimated as two times the primary juvenile period.[15,110] For seed bank replenishment, an additional three years is usually recommended to allow time for the establishment of seedbank reserves.[111]

The scoring categories for the GIS model for mean fire interval were:

- highly inappropriate (10)
- inappropriate (8)
- inappropriate for some species (4)
- appropriate for some, but not all species (2) and
- acceptable for most species (1),

with an overall weighing of 5 for fire interval in the model.

These scores were assigned based on the best available information on fire response and maturity times of species within a TEC and recognise that no one fire interval will be suitable for all species. For frequent fire (the most common scenario in our data), repeated fire intervals below the recommended minimum will likely result in the loss of species, and/or result in shifts in species composition or abundance to favour more fire-resistant species. We therefore use mean fire interval to predict areas with an inappropriate fire history and prioritise where intervention may be required to maintain species composition representative of the TEC.

We recognise that variation in inter-fire intervals is required to accommodate the requirements of all co-occurring species[112,113] but focus this analysis on identifying and predicting areas within a TEC that are likely in greatest need of conservation intervention.

An important limitation of the data included in this model is that only species for which enough data on fire response and life history is known are considered in calculation of the appropriate fire intervals. This may result in a bias in the assessment of appropriate fire intervals towards species with more quantitative data on life history and fire response traits.

TABLE 8-1. SUMMARY OF MEAN FIRE INTERVAL RANGES AND ASSOCIATED RATINGS FOR EACH GIS MODEL SCORE

1. UPLAND BASALT EUCALYPT FORESTS OF THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–3	Highly inappropriate
8	3–6	Inappropriate
4	6–12	Inappropriate for some species
2	12–25	Appropriate for some, but not all species
1	25–35	Acceptable for most species
4	35–50	Acceptable for most species
8	>50	Inappropriate

2. EASTERN STIRLING RANGE MONTANE HEALTH AND THICKET		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–5	Highly inappropriate
8	5–15	Inappropriate
4	15–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	25–35	Acceptable for most species

3. TEMPERATE HIGHLAND PEAT SWAMPS ON SANDSTONE		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–5	Highly inappropriate
8	5–15	Inappropriate
4	15–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	25–50	Acceptable for most species

4. NEW ENGLAND PEPPERMINT (*EUCALYPTUS NOVA-ANGLICA*) GRASSY WOODLANDS		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–4	Highly inappropriate
8	4–8	Inappropriate for some species
4	8–12	Appropriate for some, but not all species
2	12–25	Appropriate for most species
1	25–50	Acceptable for most species, but could be too long for short-lived species

5. LOWLAND RAINFOREST OF SUBTROPICAL AUSTRALIA		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–10	Highly inappropriate
8	10–20	Inappropriate
4	20–30	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

6. LOWLAND GRASSY WOODLAND IN THE SOUTH EAST CORNER BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–3	Inappropriate
8	3–6	Inappropriate for some species
4	6–12	Appropriate for some, but not all species
2	12–25	Appropriate for most species
0	25–50	Acceptable for most species

7. SILURIAN LIMESTONE POMADERRIS SHRUBLAND OF THE SOUTH EAST CORNER AND AUSTRALIAN APS BIOREGIONS		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–3	Highly inappropriate
8	3–6	Inappropriate
4	6–12	Inappropriate for some species
2	12–25	Appropriate for some, but not all species
0	25–50	Acceptable for most species

8. Illawarra–Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–10	Highly inappropriate
8	10–20	Inappropriate
4	20–30	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

9. TURPENTINE–IRONBARK FOREST OF THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–8	Highly inappropriate
8	8–12	Inappropriate
4	12–16	Inappropriate for some species
2	16–24	Appropriate for some, but not all species
1	25–50	Acceptable for most species

10. ILLAWARRA AND SOUTH COAST LOWLAND FOREST AND WOODLAND ECOLOGICAL COMMUNITY		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–5	Highly inappropriate
8	5–10	Inappropriate
4	10–15	Inappropriate for some species
2	15–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

11. SEDGES IN HOLOCENE DUNE SWALES OF THE SOUTHERN SWAN COASTAL PLAIN		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–4	Highly inappropriate
8	4–8	Inappropriate
4	8–12	Inappropriate for some species
2	12–25	Appropriate for some, but not all species
4	25–50	Acceptable for most species

12. COASTAL SWAMP OAK (*CASUARINA GLAUCA*) FOREST OF NSW AND SE QLD ECOLOGICAL COMMUNITY		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–6	Highly inappropriate
8	6–100	Inappropriate
4	10–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Inappropriate for some species due to canopy closure

13. ALPINE SPHAGNUM BOGS AND ASSOCIATED FENS		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–4	Highly inappropriate
8	4–8	Inappropriate
4	8–10	Inappropriate for some species
2	10–20	Appropriate for some, but not all species
1	20–50	Acceptable for most species

14. CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS OF THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–8	Highly inappropriate
8	8–15	Inappropriate
4	15–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

15. NATURAL TEMPERATE GRASSLAND OF THE SOUTH EASTERN HIGHLANDS		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–4	Highly inappropriate
8	4–8	Inappropriate
4	8–10	Inappropriate for some species
2	10–20	Appropriate for some, but not all species
1	20–50	Acceptable for most species

16. ROBERTSON RAINFOREST IN THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–10	Highly inappropriate
8	10–20	Inappropriate
4	20–30	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

17. SOUTHERN HIGHLANDS SHALE FOREST AND WOODLAND IN THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–8	Highly inappropriate
8	8–15	Inappropriate
4	15–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

18. SHALE SANDSTONE TRANSITION FOREST OF THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–8	Highly inappropriate
8	8–12	Inappropriate
4	12–18	Inappropriate for some species
2	18–25	Appropriate for some, but not all species
1	25–50	Acceptable for most species

19. COOKS RIVER/CASTLEREAGH IRONBARK FOREST OF THE SYDNEY BASIN BIOREGION		
SCORE	MEAN FIRE INTERVAL (YEARS)	RATING
10	1–6	Highly inappropriate
8	6–12	Inappropriate
4	12–20	Inappropriate for some species
2	20–30	Appropriate for some, but not all species
1	30–50	Acceptable for most species

8.4.2 Precipitation (average rainfall percentile over 5 years, all quarters and for April to September) (weighting 3)

Average rainfall in the pre-fire period may influence the innate ability of a community to regenerate post-fire by reducing seed production, seed viability and resprouting capacity (see Figure 2-1). Rainfall was assessed using three-monthly rainfall percentile gridded data from the Bureau of Meteorology (2020) for the five-year period prior to 2019 (2015–2019); for this analysis, we used all quarters combined (annual rainfall, all months), and then the two quarters (6 months) representing April to September. The score for each rainfall percentile category was assigned according to the classification of the Bureau of Meteorology (BOM) ratings (http://www.bom.gov.au/climate/data-services/), including the BOM lowest on record category in <10, and highest on record category in >90:

TABLE 8-2. THE GIS SCORES ASSOCIATED WITH DIFFERENT RAINFALL PERCENTILES

SCORE	RAINFALL PERCENTILES	RATING
10	<10	Very much below average
8	10–30	Below average
2	30–70	Average
0	70–90	Above average
4[1]	>90	Very much above average

[1]Due to erosion risk very much above average rainfall has a higher score than above average rainfall

The two precipitation scenarios (April to September rainfall and annual rainfall) were used to account for the TECs within the climate classification systems that have the highest rainfall during the cooler months (SW Western Australia, South Australia and some of western Victoria).[115,116] Furthermore, despite year to year variability, in recent decades there has been a trend towards declining winter rainfall in the southern temperate zone[1,17,118] which, by influencing annual growth[119] may reduce the inherent regenerative potential of species within vegetation communities. These seasonal shifts can be masked by annual averages, especially if there is a corresponding increase in large summer rainfall events. We compared the model results for each TEC based on both precipitation scenarios, but chose the final model based on whether the community experiences winter dominant or more uniform rainfall (see Table 8-3).

TABLE 8-3. A SUMMARY OF THE TECS ACCORDING TO PRECIPITATION MODEL CHOICE. MODEL 3 IS THE ANNUAL RAINFALL, WHILE MODEL 4 IS THE WINTER DOMINANT RAINFALL

THREATENED ECOLOGICAL COMMUNITY (TEC)	FINAL MODEL CHOICE: ANNUAL (A) OR WINTER (W) RAINFALL	STATE (REGION/ AREA)	COMMUNITY TYPE
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	A	NSW	Wet sclerophyll forest
Eastern Stirling Range Montane Heath and Thicket	W	WA	Heathland
Temperate Highland Peat Swamps on Sandstone	A	NSW	Peatland
New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands	A	NSW, QLD	Grassy woodland
Lowland Rainforest of Subtropical Australia	A	NSW, QLD	Rainforest
Lowland Grassy Woodland in the South East Corner Bioregion	A	NSW, VIC	Grassy woodland
Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions	A	VIC	Shrubland
Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion	A	NSW	Rainforest
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	A	NSW	Wet/dry sclerophyll forest
Illawarra and south coast lowland forest and woodland ecological community	A	NSW	Grassy woodland/dry sclerophyll forest
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	W	WA	Sedgeland
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	A	QLD, NSW	Coastal floodplain forest
Alpine Sphagnum Bogs and Associated Fens	A	ACT, NSW, TAS, VIC	Peatland
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	A	NSW	Grassy woodland/dry sclerophyll forest
Natural Temperate Grassland of the South Eastern Highlands	A	ACT, NSW	Grassland
Robertson Rainforest in the Sydney Basin Bioregion	A	NSW	Rainforest
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	A	NSW	Grassy woodland/dry sclerophyll forest
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	A	NSW	Dry sclerophyll forest
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	A	NSW	Dry sclerophyll forest

8.4.3 Proximity to cleared areas as a proxy for weed load (weighting 2)

Competition from weeds (non-native species) can reduce the regenerative capacity of individual species and vegetation communities following disturbance. This reduced recovery potential may necessitate the implementation of restoration interventions such as facilitated regeneration in combination with seed inputs.

In our model we use distance to cleared areas as a proxy for weed load with an overall model weighting of 2. Weed species vary in dispersal traits (i.e. wind dispersal and animal dispersal vs no active dispersal mechanism) and therefore potential dispersal distance (and the shape of dispersal curves). The scoring for our GIS model reflects a general leptokurtic dispersal of propagules, such that the closest areas (1–100m) were assigned much higher scores for potential weed load (10) compared to areas further away (e.g. 1000–2500m = 2; see Table 8-4). We recognise that the composition of weeds in each TEC (and their life history and dispersal traits) will likely vary, but this generic scoring provides a consistent means of assessing potential weed load across different vegetation communities.

TABLE 8-4. THE SCORES FOR THE GIS MODEL ACCORDING TO DISTANCE TO THE CLEARED AREAS AND THE GENERAL DISPERSAL RATING

SCORE	DISTANCE TO CLEARED AREAS (M)	DISPERSAL RATING
10	<100	High dispersal zone
8	100–250	Moderate dispersal zone
6	250–500	Low dispersal zone
4	500–1000	Infrequent dispersal
2	1000–2000	Long distance dispersal
1	>2000	Rare long-distance dispersal

8.4.4 Fire intensity (weighting 3)

Fire intensity is an important component of fire regime and will influence the recovery of both individual species and the community following fire. Sclerophyll forests and woodlands of the southern and eastern regions of Australia are associated with infrequent, high-intensity fire regimes.[120]

Fire severity is known to affect both mortality and post-fire recovery of species in different ways. Repetition of low intensity fires may lead to decline of species with a heat cue for germination, while repetition of high severity fires may impact structural habitat elements. Lignotubers will survive most fires from about five years of age, though they may be killed by intense fire in dry soil conditions.

In the GIS model, fire intensity was included as a stand-alone raster at 1000m resolution. Fire intensity was rated using values from 2 (low) and 3 (medium) to 4 (high) and 5 (very high) intensity and the 1000m cells were rated according to the modal (i.e. most frequent) intensity value in that cell.

For the fire intensity data, we tailored the scoring for each community type. For Sclerophyll vegetation types, very high was given a higher score as detrimental but high was a lower score (these types of communities can cope, and often need, high intensity fire). For Rainforest types, any fire of medium intensity and above can be detrimental (they are not fire-prone communities), so these fires were given higher scores.

TABLE 8-5. THE SCORES ASSOCIATED WITH DIFFERENT FIRE INTENSITY RATING FOR SCLEROPHYLL VEGETATION TYPES

SCORE	FIRE INTENSITY VALUE	RATING
10	5	Very high
4	4	High
2	3	Medium
1	2	Low

TABLE 8-6. THE SCORES ASSOCIATED WITH DIFFERENT FIRE INTENSITY RATINGS FOR RAINFOREST

SCORE	FIRE INTENSITY VALUE	RATING
10	5	Very high
8	4	High
4	3	Medium
2	2	Low

TABLE 8-7. A SUMMARY OF THE TECS ACCORDING TO FIRE INTENSITY MODEL CHOICE. S = SCLEROPHYLL AND R = RAINFOREST

THREATENED ECOLOGICAL COMMUNITY (TEC)	SCLEROPHYLL (S) OR RAINFOREST (R) INTENSITY SCORING	COMMUNITY TYPE
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	S	Wet sclerophyll forest
Eastern Stirling Range Montane Heath and Thicket	S	Heathland
Temperate Highland Peat Swamps on Sandstone	S	Peatland
New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands	S	Grassy woodland
Lowland Rainforest of Subtropical Australia	R	Rainforest
Lowland Grassy Woodland in the South East Corner Bioregion	S	Grassy woodland
Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions	S	Shrubland
Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion	R	Rainforest
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	S	Wet/dry sclerophyll forest
Illawarra and south coast lowland forest and woodland ecological community	S	Grassy woodland/dry sclerophyll forest
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	S	Sedgeland
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	S	Coastal floodplain forest
Alpine Sphagnum Bogs and Associated Fens	S	Peatland
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	S	Grassy woodland/dry sclerophyll forest
Natural Temperate Grassland of the South Eastern Highlands	S	Grassland
Robertson Rainforest in the Sydney Basin Bioregion	R	Rainforest
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	S	Grassy woodland/dry sclerophyll forest
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	S	Dry sclerophyll forest
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	S	Dry sclerophyll forest

8.5 Model outputs and limitations

It is important to recognise that restoration priority comparisons are relative within a TEC and are to be considered within TECs. For example, a high priority scoring within a TEC is higher relative to the other areas of that TEC and is not directly comparable to the high priority regions of other TECs. This is due to the scaling of the model results within a TEC. We also recognise that there are subtleties in the model data: (a) that it is likely not all one community type (it will be patchy and potentially mix or grade into different vegetation communities); and (b) that the priority coding is a prediction that needs to be tested through site assessments. Hence these model outputs need to be used a tool for prioritising site assessment and planning potential seed needs post-fire and not as a definitive predictive tool of the post-fire community.

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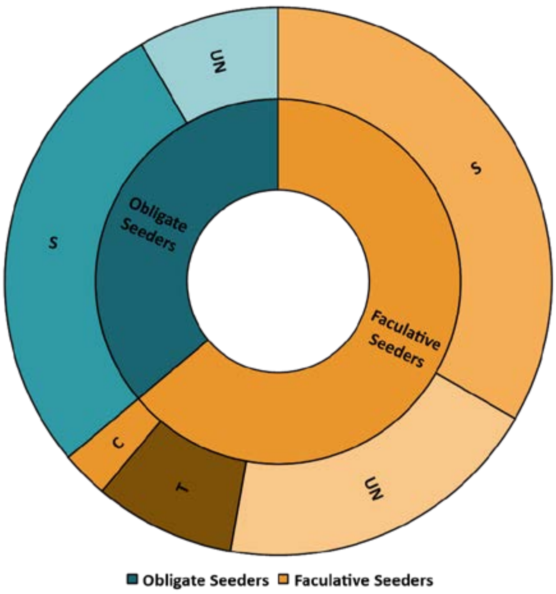
10 APPENDIX 1 — DESCRIPTION OF SEED STORAGE FOR SPECIES IN EACH TEC

The definitions for each seed storage categories are as follows:

- Canopy (C) = seed is stored in serotinous cones on the plant for a number of years and are released due to a stimulus (e.g. heat of a fire or smoke)[121]
- Soil (S) = seed lays dormant for decades (to centuries) in the soil and are stimulated to germinate after fire due to the heat or chemicals[122]
- Transient (T) = seed bank disperses and depletes after a couple months[123]
- Viviparous (V) = seeds germinate whilst still on the plant to minimise the dormancy stage before dispersing[124]

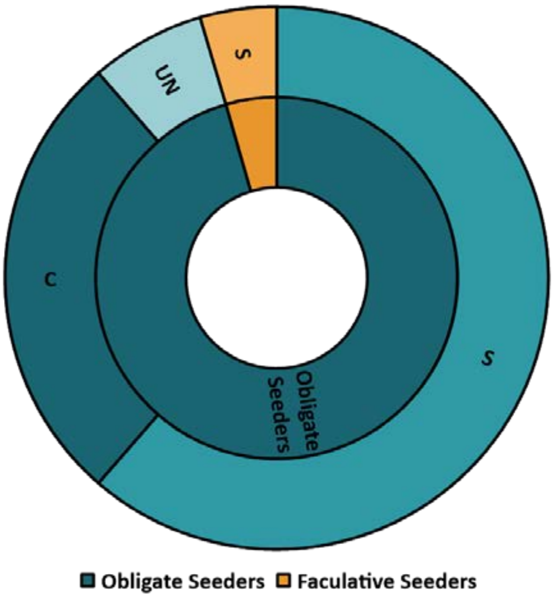
10.1 TEC 1: Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion

- Most obligate seeders have a soil-stored seed bank
- Mix of soil-storage, canopy and transient storage in facultative seeders
- Higher proportion of unknown seed storage in facultative seeders



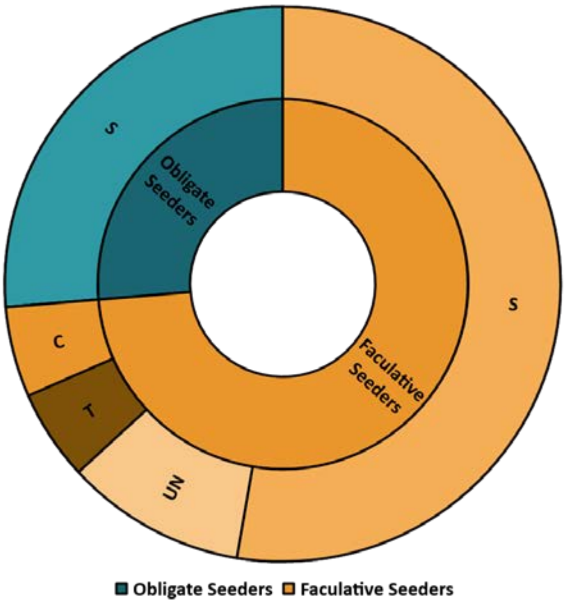
10.2 TEC 2: Eastern Stirling Range Montane Heath and Thicket

- Most obligate seeders have either a soil-stored or canopy stored seed bank



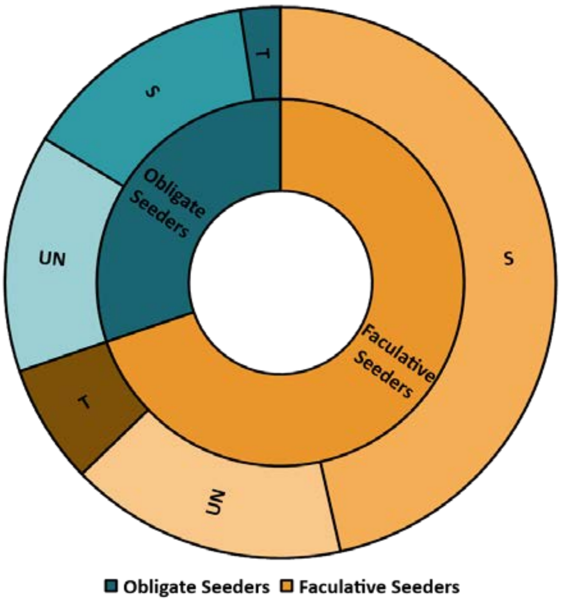
10.3 TEC 3: Temperate Highland Peat Swamps on Sandstone

- The majority of obligate seeders and facultative seeders have a soil-stored seed bank



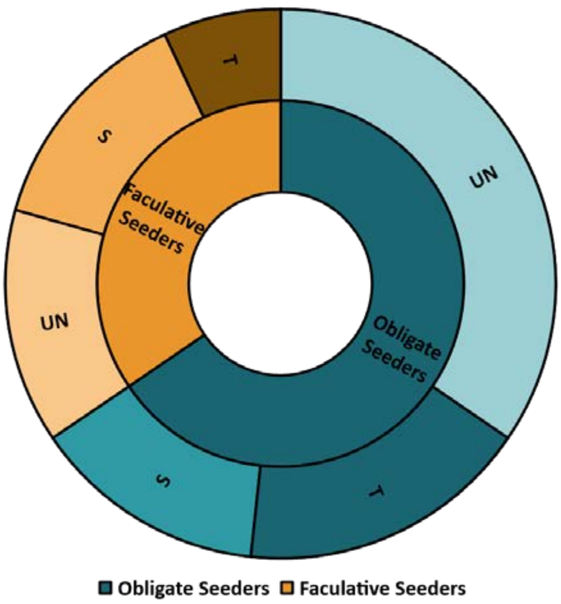
10.4 TEC 4: New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands

- Most obligate seeders and facultative seeders have a soil-stored seed bank
- Substantial proportion of unknown seed storage in obligate and facultative seeders



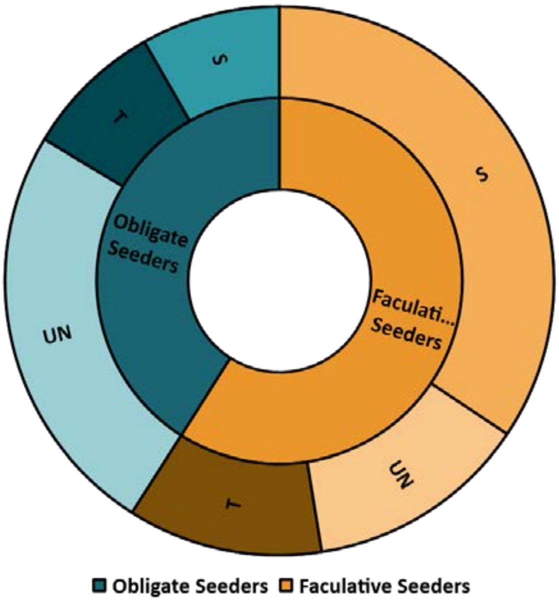
10.5 TEC 5: Lowland Rainforest of Subtropical Australia

- High proportion of unknown seed storage for both groups
- Most obligate seeders have a transient seed bank and facultative seeders have a soil-stored seed bank



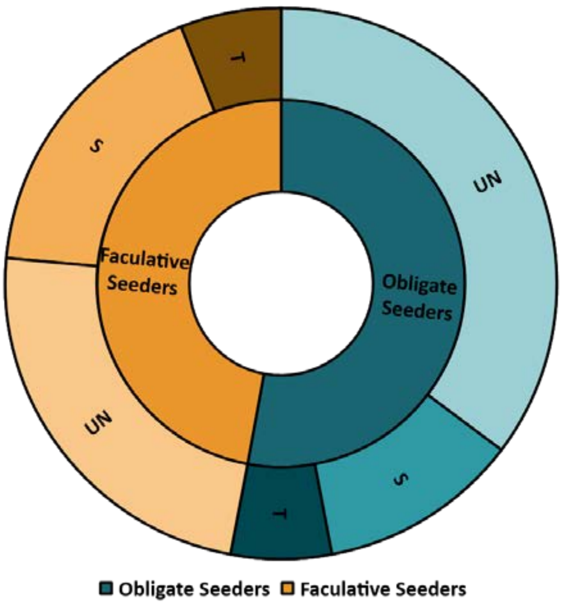
10.6 TEC 6: Lowland Grassy Woodland in the South East Corner Bioregion

- Most facultative seeders have a soil-stored seedbank, followed by transient seed bank
- Seed storage unknown for most obligate seeders. Of the known responses, obligate seeders have similar proportions of transient and soil-stored seed banks



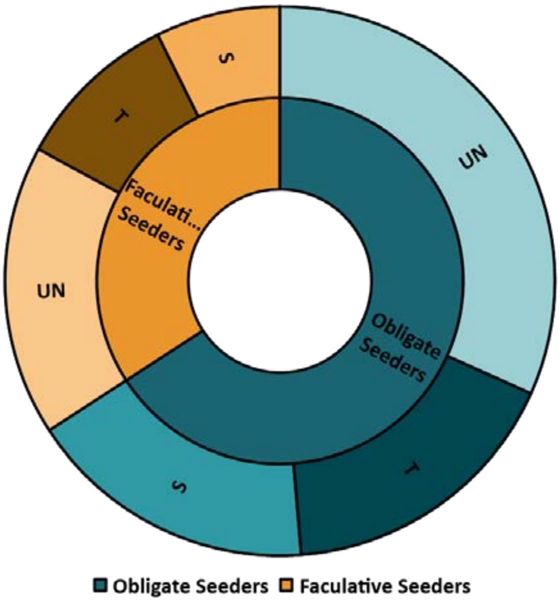
10.7 TEC 7: Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions

- High proportion of unknown seed storage for both obligate and facultative seeders
- Of the known responses, more obligate seeders and facultative seeders have a soil-stored seed bank compared to transient seed storage



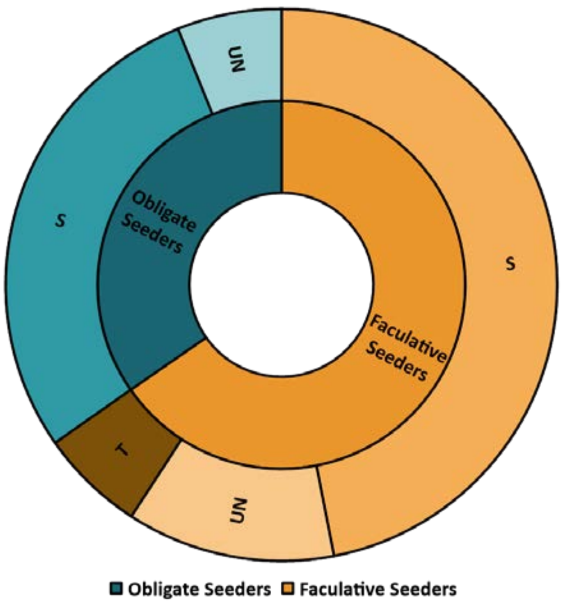
10.8 TEC 8: Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion

- High proportion of unknown seed storage for obligate seeders
- For the obligate seeders with known seed storage, there are similar proportions of soil storage and transient seed storage
- Slightly higher proportion of transient, compared to soil storage for facultative seeders



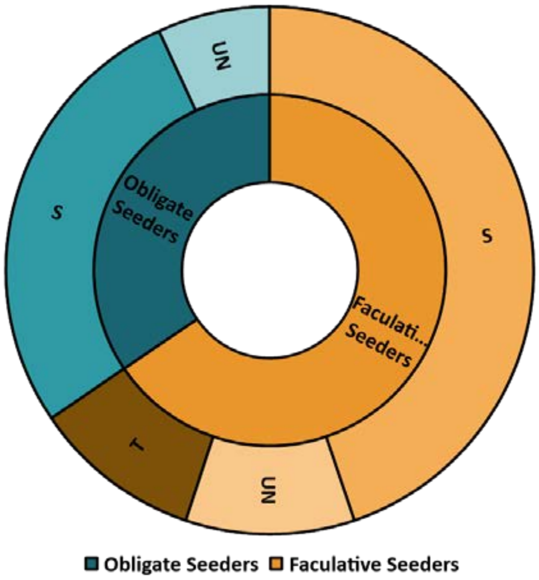
10.9 TEC 9: Turpentine-Ironbark Forest of the Sydney Basin Bioregion

- Most obligate seeders and facultative seeders have a soil-stored seed bank



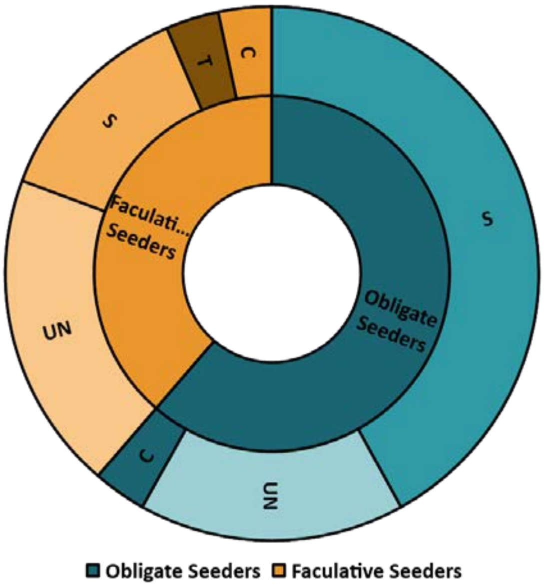
10.10 TEC 10: Illawarra and South Coast Lowland Forest and Woodland

- Most obligate seeders and facultative seeders have a soil-stored seed bank
- Presence of transient seed bank in facultative seeders
- Generally low proportion of unknown seed storage



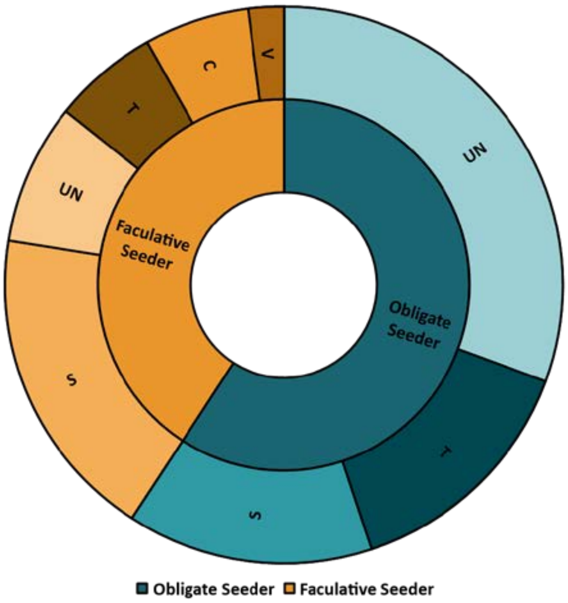
10.11 TEC 11: Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain

- Most obligate seeders have a soil-stored seed bank, with a small proportion of canopy stored seed
- Highest proportion of unknown seed storage in facultative seeders, followed by soil storage, with a smaller proportion of transient and canopy stored seed



10.12 TEC 12: Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland

- Highest proportion of obligate seeders have an unknown seed storage, with similar proportion of transient and soil-stored seed banks for the species with known storage
- Highest proportion of soil stored seed for facultative seeders, with smaller proportions of transient, canopy and unknown seed storage

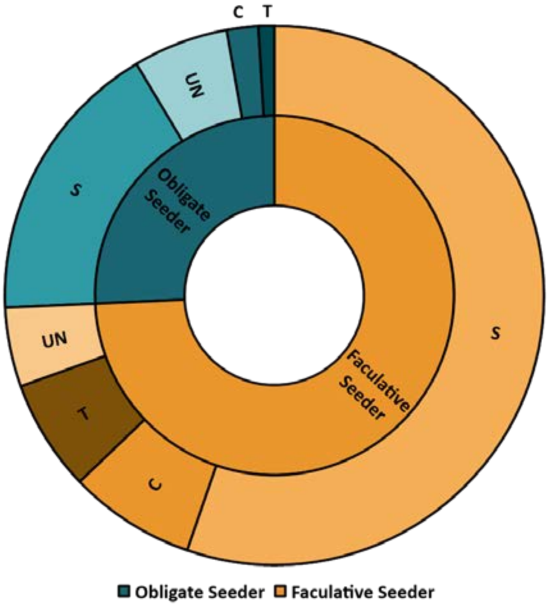


10.13 TEC 13: Alpine Sphagnum Bogs and Associated Fens

- Unknown seed storage was highest for both obligate seeders and facultative seeders
- The next highest proportion was soil-stored and transient seed banks for both obligate seeders and facultative seeders

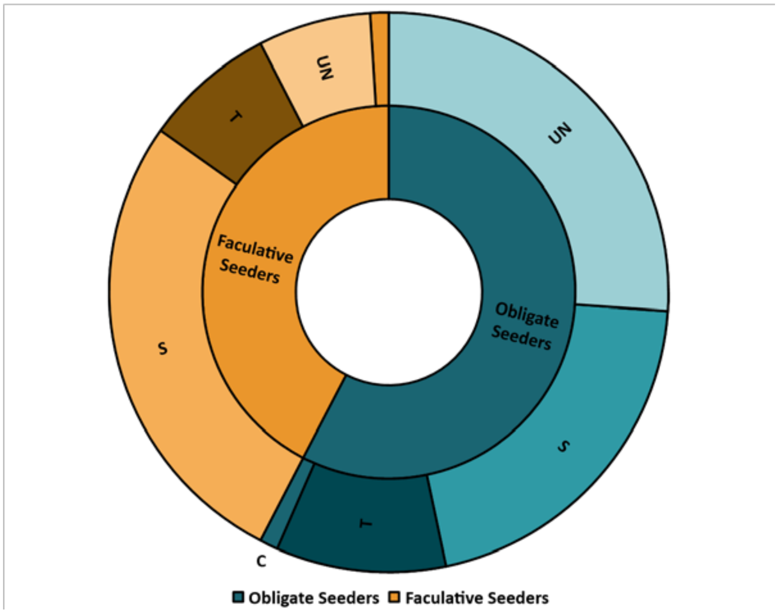
10.14 TEC 14: Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion

- The majority of obligate seeders and facultative seeders have a soil-stored seed bank, with a lower proportion of canopy-stored and transient seed banks



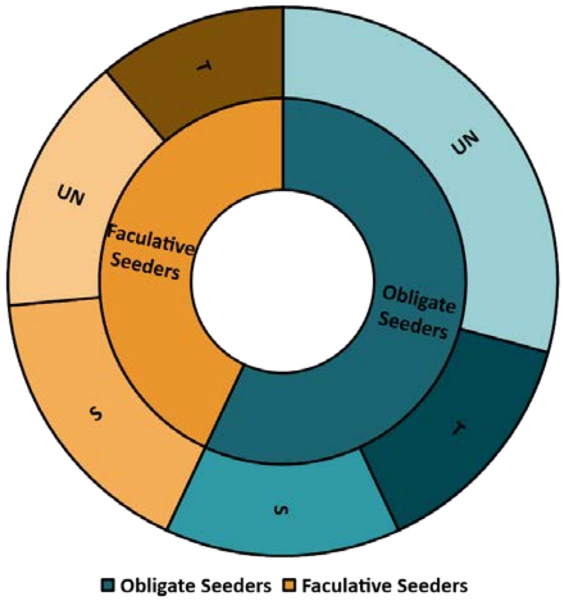
10.15 TEC 15: Natural Temperate Grassland of the South Eastern Highlands

- High proportion of unknown seed storage for obligate seeders, followed by soil stored and transient seed banks.
- Most facultative seeders had a soil-stored seed bank followed by transient seed storage



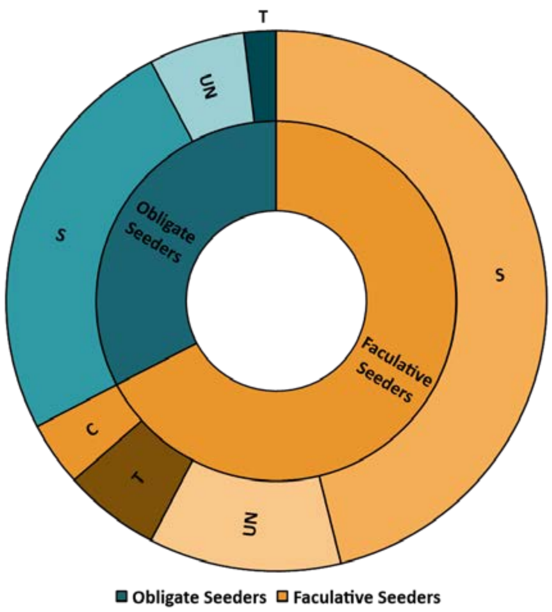
10.16 TEC 16: Robertson Rainforest in the Sydney Basin Bioregion

- Most obligate seeders had unknown seed storage, followed by transient and soil stored seed banks
- For facultative seeders, the highest proportion was soil stored, followed by unknown and transient seed storage



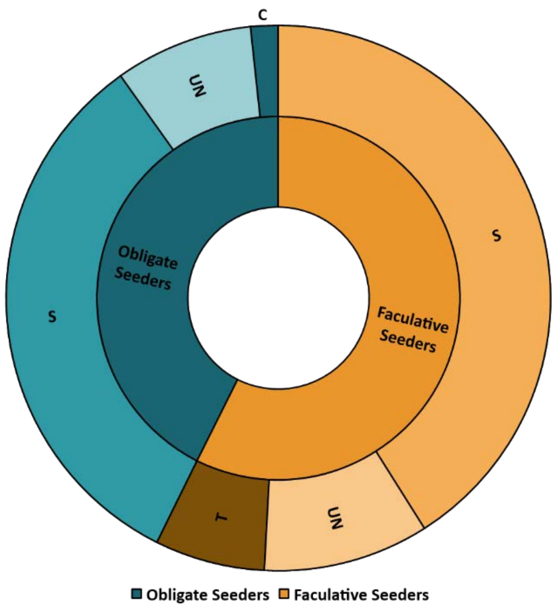
10.17 TEC 17: Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion

- Most obligate seeders and facultative seeders have a soil-stored seed bank



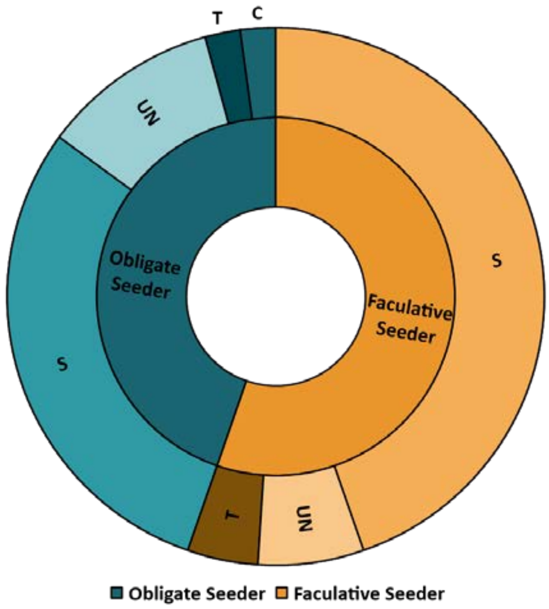
10.18 TEC 18: Shale Sandstone Transition Forest of the Sydney Basin Bioregion

- Most obligate seeders and facultative seeders have a soil-stored seed bank



10.19 TEC 19: Cooks River/Castlereagh Ironbark Forest of Sydney Basin Bioregion

- Most obligate seeders and facultative seeders have a soil-stored seed bank



11 APPENDIX 2 — DESCRIPTIONS OF THE APPLICATION OF THE CONCEPTUAL MODEL AND DECISION TREE TO EACH TEC

11.1 TEC 1: Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion

11.1.1 GIS analysis — likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-3)

Predicted regenerative potential

- Priority area 1 is small and represents only 1.1% of the fire scar, with this area covering 747ha of the 'likely to occur' area of Upper Basalt Eucalypt Forest. The average fire interval within this area is 2.8 years (range 2.3–5.6 years), which is very likely inappropriate for most fire sensitive species within this community. However, the mean fire interval was more appropriate when considered using the finer scale fire mapping from the NSW fire interval data. The NSW indicated a mean of 23.5 years for this area with a range of 8.3 to 50 years.
- The average rainfall percentile for the five years before the fire event was 42.6, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 38.3).
- The average distance to cleared areas was 545m, but this ranged from 0 (directly adjacent to cleared areas) to 1702m (distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <200m, with intermediate weed loads in patches where the distance to the cleared areas is between 500-1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.8), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-3)

Predicted regenerative potential

- Priority area 1 represents 11.5% of the fire scar and covers an area of 8001ha of the 'likely to occur' area of Upper Basalt Eucalypt Forest. The average fire interval within this area is 4.1 years, which is likely inappropriate for most fire sensitive species within this community. However, within this area, fire history is more variable and ranges from 1.9–16.7 years. In addition, the mean fire interval was more appropriate when considered using the finer scale fire mapping from the NSW fire interval data. The NSW indicated a mean of 24.1 years for this area with a range of 7.1 to 50 years. It is therefore only in the lower interval areas that fire history would be inappropriate.
- The average rainfall percentile for the five years before the fire event was 40.5, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 36.1).
- The average distance to cleared areas was over 2.5km (2766m), but this ranged from 0 (directly adjacent to cleared areas) to 9765m (distant to cleared areas). Generally, lower weed loads are expected in patches where the distance is >1000m, as weeds predominately enter via long-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 4.4), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if all functional groups and species are missing.
- If the answer is yes, then the management action required is: **reconstruction** (see Table 7-4 for details). This scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If the answer is no, non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**.

However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?

- If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-4).
- If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-4). Fire-affected species (see Table 7-5) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary juvenile periods are likely to be most vulnerable and should be assessed first.

- **Reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.2 TEC 2: Eastern Stirling Range Montane Heath and Thicket

11.2.1 GIS analysis — likely to occur Model 4 (L4)

Based on the scale of the fire history data available (10km^2), the whole area of the fire scar for this TEC was scored with the same fire interval (8 years). Consequently, all four priority bands would be assessed as having an inappropriate historical fire frequency. Differences in the assessment of priority areas is therefore based on variation in fire intensity and distance to cleared areas. This means that — due to the inappropriate fire history — priority areas 3 and 4 may require further assessment to determine if intervention is required to facilitate post-fire recovery; this is especially relevant for the small area (1ha) within priority band 3, which is further from cleared areas, but which had a mean fire interval of 8 and experienced a high fire intensity (4) in the most recent fire.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-7)

Predicted regenerative potential

- Priority area 1 is the largest of the four priority areas (542 ha) and represents over 63.6% of the fire scar of the Eastern Stirling Range Montane Heath and Thicket TEC. The average fire interval within this area is 8 years, which is likely inappropriate for most fire sensitive species within this community. Fire intervals of 9–10 years are considered to be at the lower bounds of risk for species persistence.[71]

- The average rainfall percentile for the five years before the fire event was 41.1, which is within the broad average rainfall band (30–70), but below the 50th percentile. The variation within this priority area was low (range of rainfall percentiles = 41–41.3).
- The average distance to cleared areas was 3972m and ranged from 3036–5171m. Given the distance to cleared areas, lower weed loads are expected.
- Taking all these factors into consideration, this priority area would have a ***low predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.9), but this did vary from low to very high (range = 2 – 5).

Priority area 2 (see Table 7-7)

Predicted regenerative potential

- Priority area 2 represents 15.1% of the fire scar and covers an area of 128ha of the 'likely to occur' area of Eastern Stirling Range Montane Heath and Thicket. The average fire interval within this area is 8 years, which is likely inappropriate for most fire sensitive species within this community.
- The average rainfall percentile for the five years before the fire event was 41.1, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was little variation in rainfall percentiles within this priority area (range rainfall mean percentile = 41–41.3).
- The average distance to cleared areas was over 4km (4047m), and this ranged from 2741 to 5080m. Generally, due to the reduced likelihood of long-distance weed dispersal with increasing distance, lower weed loads are expected in patches where the distance is >1000m.
- Taking all these factors into consideration, this priority area would have a ***low predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 4.4), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if all (or most) functional groups and species are missing.
- If the answer is yes, then the management action required is: **reconstruction** (see Table 7-8 for details). Even with the assessment of a low predicted recovery potential, this scenario of no regeneration is probably unlikely. It would, however, need to be verified by on-ground assessments.

- If the answer is no, non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-8). Yet weed loads are likely to be generally low in patches more distant to cleared areas.
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-8). Fire-affected species (see Table 7-9) may also be targeted for reintroduction following site assessments and ground truthing. Shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- **Reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - established insurance populations to reduce the risk of *Phytopthora*.

11.3 TEC 3: Temperate Highland Peat Swamps on Sandstone

11.3.1 GIS analysis — likely to occur Model 4 (L4)

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. However, both data sets illustrate that the fire intervals are likely too short to be appropriate for the fire sensitive species in this community. This, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-11)

Predicted regenerative potential

- Priority area 1 is small and represents 3.4% of the fire scar, with this area covering 44.6ha of the ‘likely to occur’ area of Temperate Highland Peat Swamps. The average fire interval within this area is 3.1 years (national data), with fire interval ranging from 2.3–5.6 years. In comparison, the NSW data indicated that fire interval ranged from 8.3–25 years. Using both data sets, the fire history of this area is likely inappropriate for some fire sensitive species within this community, especially in the lower range.

- The average rainfall percentile for the five years before the fire event was 45.2, which is within the broad average rainfall band (30–70), but below the 50th percentile (range = 43.8–46).
- The average distance to cleared areas was 180m, but this ranged from 0 (directly adjacent to cleared areas) to 361m. Generally, higher weed loads are expected in patches where the distance is <100m, with moderate dispersal in patches where the distance to the cleared areas is between 100–250m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.7), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-11)

Predicted regenerative potential

- Priority area 2 is larger representing 14.3% of the fire scar, with this area covering 188.5ha of the 'likely to occur' area of Temperate Highland Peat Swamps. The average fire interval within this area is 2.8 years (national data), with fire interval ranging from 1.8–4.2 years. In comparison, the NSW data indicated that fire interval ranged from 8.3–50 years. Using both data sets, the fire history of this area is likely inappropriate for some fire sensitive species within this community, especially in the lower range of fire intervals.
- The average rainfall percentile for the five years before the fire event was 45.3, which is within the broad average rainfall band (30–70), but below the 50th percentile (range = 41.8–46.8).
- The average distance to cleared areas was 227m, but this ranged from 0 (directly adjacent to cleared areas) to 854m. Generally, higher weed loads are expected in patches where the distance is <100m, with moderate dispersal in patches where the distance to the cleared areas is between 100–250m. Lower dispersal is expected in area where the distance to cleared areas is 250–500m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 4.3), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-12 for details). However, given community composition and fire history, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments. if some functional groups and species are regenerating.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-12).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-12). Fire-affected species (see Table 7-13) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- For Temperate Highland Peat Swamps, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnant patches.

  Given the specific habitat requirements of the Temperate Highland Peat Swamps, these areas could be identified through analysis of the areas immediately around current patches and from the distribution of historical records of this TEC.

11.4 TEC 4: New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands

11.4.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution.

However, both data sets illustrate that the fire intervals are likely either too short (National fire history) or too long (NSW fire history) to be appropriate for the fire sensitive species in this community. This, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-15)

Predicted regenerative potential

- Priority area 1 is small and represents only 1.2% of the fire scar, with this area covering 145ha of the 'likely to occur' area of New England Peppermint Grassy Woodland. The average fire interval within this area is 2.0 years, which is very likely inappropriate for some fire sensitive species within this community. Within this area, fire frequency is consistently high with fire interval ranging from 1.5–3.8 years. In comparison, the finer scale NSW data indicated that fire interval ranged from 6.3–50 years (mean 18.4 years). Using both data sets, the fire history of this area is patchy and likely inappropriate for some fire sensitive species in areas in the lower range.
- The average rainfall percentile for the five years before the fire event was 39.8, which is within the broad average rainfall band (30–70), but below the 50th percentile.
- The average distance to cleared areas was 1288m, but this ranged from 0 (directly adjacent to cleared areas) to 2625m (distant to cleared areas). Generally, lower weed loads are expected in patches where the distance to cleared areas is >1000m, as weeds predominately enter via long-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.8), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-15)

Predicted regenerative potential

- Priority area 2 represents approximately half of the fire scar (50.4%) and covers an area of 4435ha of the 'likely to occur' area of New England Peppermint Grassy Woodland. The average fire interval within this area is 2.2 years, which is likely inappropriate for some fire sensitive species within this community. However, within this area, fire history is more variable and fire interval ranges from 1.5–6.7 years. Using the finer scale NSW data, the fire interval ranged from 6.3–50 years (mean 23.3 years). Using both data sets, the fire history of this area is patchy and likely inappropriate for some fire sensitive species in areas in the lower range.

- The average rainfall percentile for the five years before the fire event was 40.7, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 37.8).
- The average distance to cleared areas was 3526m, but this ranged from 0 (directly adjacent to cleared areas) to 9213m (distant to cleared areas).
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 4.3), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all (most) functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-16 for details). However, given community composition, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-16).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-16). Fire-affected species (see Table 7-17) may also be targeted for reintroduction following site assessments and ground truthing.
- For New England Peppermint Grassy Woodland, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch/remnant size and
  - improved connectivity between remnants.

11.5 TEC 5: Lowland Rainforest of Subtropical Australia

11.5.1 GIS analysis

11.5.1.1 Spatial extent and 'Likely to occur' vs 'May occur'

Threatening processes such as land clearing and habitat degradation have resulted in a reduction in geographic extent of Lowland Rainforest, so that remnant populations are often small and fragmented[77]. This means that the spatial extent of Lowland Rainforest (based on structure and floristic composition) is likely smaller that the extent mapped for both the 'likely to occur' and 'may occur' scenarios (see Figure 7-10 for details on mapping of the spatial extent for may occur and likely to occur areas).

Even within these areas where Lowland Rainforest is likely to occur, variation in underlying geology and drainage, precipitation and disturbance history (including fire)[77] will determine the bounds of this TEC and may result in transitions to sclerophyll dominated communities. As such, fire is an important driver of rainforest extent across the landscape, with frequent fire reducing the extent of fire sensitive rainforest species.

Given the lower flammability of the interior of Lowland Rainforest patches, inappropriate fire regimes are likely to be a threat to the rainforest margins, especially in fragmented landscapes. In this scenario, repeated burning is likely to change species composition and/or structure and result in a transition to more fire-tolerant sclerophyll communities away from the rainforest core. This means that Lowland Rainforest and sclerophyll dominated forest are likely both represented within the areas identified in the fire scar for this TEC.

The GIS modelling of fire recovery potential for the Lowland Rainforest community identified two distinct groupings:

1. areas more likely to be Lowland Rainforest communities due to longer average inter-fire periods (average inter-fire period > 25 years) and
2. areas more likely to be Sclerophyll-dominated forest due to shorter (<6 year) average inter-fire periods.

More detailed assessment of the fire history of priority areas 1 and 2 using the higher resolution NSW data alone supports this general assessment but found larger minimum fire intervals more reflective of rainforest: in priority area 1 fire interval ranged from 25–50 years, while for priority area 2 fire interval ranged from 12.5–50 years.

Restoration scenarios for this TEC will only focus on the first group, which are the areas where the fire history aligns with existence of a fire sensitive Lowland Rainforest.

11.5.1.2 Likely to occur Model 3 (L3)

These priority areas (Priority area 1 and 2) were chosen because their historical fire regimes indicate the presence of a rainforest community. The more frequently burnt communities (indicated by Priority areas 3, 4 and 5) are likely sclerophyll-dominated forest that may require management intervention to assist recovery from the 2019–20 fires. However, here we focus on restoration scenario planning for Lowland Rainforest; while recognising that the true spatial extent of these communities would need to be verified with on-ground assessments.

By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for priority area 1 was slightly longer, and for priority area 2 was slightly shorter, than using the National fire history data with coarser resolution. In this case, both data sets illustrate that the fire intervals are likely to be appropriate for the fire sensitive species in this community. However, due to the patchy nature of historical fires across the TEC, there is still the need for site assessments to understand if management intervention is required.

Priority area 1 (see Table 7-19)

Predicted regenerative potential

- Priority area 1 represents 20.4% of the fire scar and covers 6230ha of the 'likely to occur' area of Lowland Rainforest. The average fire interval within this area is 35 years, which is likely appropriate for most species within fire-sensitive rainforest communities. There is, however, variation in fire history across this area (range = 3.6–50 years). The areas with a more frequent fire history may be sclerophyll-dominated patches within the rainforest matrix or may represent rainforest margins. On-ground assessment will be required to determine the finer scale spatial extent of different community types and the potential need for intervention within this area. The finer scale NSW fire interval data aligns with the general model (mean = 37.7 years, range 5.6–50 years).
- The average rainfall percentile for the five years before the fire event was 38.8, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 32.5).
- The average distance to cleared areas was 1306m, but this ranged from 0 (directly adjacent to cleared areas) to 4836m (distant to cleared areas). This indicates that this priority area likely contains rainforest patches of different sizes within a cleared landscape matrix. Lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally lower across this area (mean = 2.7), but there were areas that experienced high fire intensity (range = 2–5). These high fire intensity areas may correspond to more sclerophyll dominated patches and/or represent the rainforest margins which tend to contain a higher proportion of sclerophyll species.

Priority area 2 (see Table 7-19)

Predicted regenerative potential

- Covering 5663ha, this area represents 18.5% of the fire scar for the 'likely to occur' area of Lowland Rainforest. The average fire interval within this area is 39 years, which is likely appropriate for most species within fire-sensitive rainforest communities. There is, however, variation in fire history across this area (range = 3.9–50 years). These areas may be sclerophyll-dominated patches within the rainforest matrix or areas corresponding to the rainforest margins. This indicates the need for on-ground assessment to determine the fine scale spatial extent of different community types and the potential need for intervention. The finer scale NSW fire interval data aligns with the general model (mean = 36.4 years, range 5.0–50 years).
- The average rainfall percentile for five years before the fire event was 41.9, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall = 32.2).
- The average distance to cleared areas was 1682m, but these ranged from 0 (directly adjacent to cleared areas) to 5045m (distant to cleared areas). Patches more proximate to cleared areas are likely to have higher weed loads, with lower weed loads in patches where the distance is >1000m so that weeds predominately enter via long-distance dispersal. The greater average distance to cleared areas in priority area 2 (1682 vs 1306m) may indicate a lower average weed load, which contributed to the lower ranking of conservation priority.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally lower across this area (mean = 2.7), but there were areas that experienced high fire intensity (range = 2–5). These high fire intensity areas may correspond to more sclerophyll dominated patches and/or represent the rainforest margins which tend to contain a higher proportion of sclerophyll species.

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if the majority of functional groups and species are regenerating.
- If the answer is yes, then the management action required is: **protection/natural regeneration** (see Table 7-20 for details).

- If the answer is no, then non-regenerating groups and/or species need to be identified. Following identification of these species, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these rainforest species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-20).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) from the Lowland Rainforest community are likely to be most vulnerable and may require reintroduction (see Table 7-20). Fire-affected species (see Table 7-21) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- Although this is an unlikely scenario for management within burnt rainforest patches, **reconstruction** could be used to extend the extent of Lowland Rainforest beyond its current distribution to provide additional conservation benefits including:
  - creation of rainforest, buffers
  - increased patch size and
  - improved connectivity between remnants.

11.6 TEC 6: Lowland Grassy Woodland in the South East Corner Bioregion

11.6.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. However, both data sets illustrate that the fire intervals are spatially variable and could be either too short (or too long) to be appropriate for the fire sensitive (or fire dependent) species in this community. This, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-23)

Predicted regenerative potential

- Priority area 1 is small and represents only 3% of the fire scar, with this area covering 264ha of the 'likely to occur' area of Lowland Grassy Woodland. The average fire interval within this area is 2.5 years, which is likely inappropriate for some fire sensitive species within this community. Within this area, fire frequency is consistently high with fire interval ranging from 1.9–5.6 years.

In comparison, the NSW data indicated a higher fire interval (range = 10–50 years), which is more appropriate for this community. Using both data sets, the fire history of areas with more frequent fire may be inappropriate for some fire sensitive species within this community, but this requires further mapping to identify these more frequently burnt areas.

- The average rainfall percentile for the five years before the fire event was 43.8, which is within the broad average rainfall band (30–70), but below the 50th percentile.
- The average distance to cleared areas was 330m, but this ranged from 0 (directly adjacent to cleared areas) to 2283m (distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <200m, with intermediate weed loads in patches where the distance to the cleared areas is between 500–1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.8), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-23)

Predicted regenerative potential

- Priority area 2 represents approximately half of the fire scar (50.4%) and covers an area of 4435ha of the 'likely to occur' area of Lowland Grassy Woodland. The average fire interval within this area is 3.4 years, which is likely inappropriate for some fire sensitive species within this community. However, within this area, fire history is more variable and fire interval ranges from 1.4–16.7 years. In comparison, the NSW data indicated a higher fire interval (range = 7.1–50 years), which is more appropriate for this community. Using both data sets, the fire history of areas with more frequent fire may be inappropriate for some fire sensitive species within this community, but this requires further mapping to identify these more frequently burnt areas.
- The average rainfall percentile for the five years before the fire event was 44.4, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 38.5).
- The average distance to cleared areas was 261m, but this ranged from 0 (directly adjacent to cleared areas) to 4968m (distant to cleared areas).
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally moderate to high across this area (mean = 3.8), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-24 for details). However, given community composition, this scenario of no regeneration is unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-24).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-24). Fire-affected species (see Table 7-25) may also be targeted for reintroduction following site assessments and ground truthing.
- For Lowland Grassy Woodlands, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.7 TEC 7: Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions

11.7.1 GIS analysis — Likely to occur Model 3 (L3)

For this TEC, the small area of the fire scar (31.8 ha) and uniform mean fire interval, fire intensity and rainfall percentile meant that only two priority areas were identified from the GIS analysis. The two areas were differentiated based on mean distance to cleared areas and identified as higher (closer to cleared areas) and lower (further from cleared areas) priority.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-27)

Predicted regenerative potential

- Priority area 1 is small and represents 26.4% of the fire scar, with this area covering 8.4ha of the 'likely to occur' area of Silurian Limestone Pomaderris Shrubland. The average fire interval within this area is 50 years, which is very likely appropriate for fire sensitive species within this community. However, Moorrees (2010) state that this TEC was burnt in 2003.
- The average rainfall percentile for the five years before the fire event was 42.8, which is within the broad average rainfall band (30–70), but below the 50th percentile.
- The average distance to cleared areas was 773m, and this ranged from 500–1030m. Generally, higher weed loads are expected in patches where the distance is <200m, with intermediate weed loads in patches where the distance to the cleared areas is between 500-1000m. Lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate to high predicted recovery potential***.

Most recent fire

- Fire intensity was medium (moderate) across this area (mean = 3).

Priority area 2 (see Table 7-27)

Predicted regenerative potential

- Priority area 2 represents the majority of the fire scar (73.6%), with this area covering 23.4ha of the 'likely to occur' area of Silurian Limestone Pomaderris Shrubland. The average fire interval within this area is 50 years, which is very likely appropriate for fire sensitive species within this community. However, Moorrees (2010) state that this TEC was burnt in 2003.
- The average rainfall percentile for the five years before the fire event was 42.8, which is within the broad average rainfall band (30–70), but below the 50th percentile.
- The average distance to cleared areas was 1516m, and this ranged from 943–2088m. Lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate to high predicted recovery potential***.

Most recent fire

- Fire intensity was medium (moderate) across this area (mean = 3).

Assessment

- For both priority areas 1 and 2 (higher and lower priority), site assessments are required to evaluate community recovery and if the majority of functional groups and species are regenerating.
- If the majority of groups and species are regenerating, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-28).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-28). Fire-affected species (see Table 7-29) may also be targeted for reintroduction following site assessments and ground truthing.
- For Silurian Limestone Pomaderris Shrubland, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires and
  - extending the spatial extent of current patches.

11.8 TEC 8: Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion

11.8.1 GIS analysis — Likely to occur Model 3 (L3)

These priority areas (Priority area 1 and 2) were chosen because their historical fire regimes indicate the presence of a rainforest community. The more frequently burnt communities (indicated by Priority areas 3, 4 and 5) are likely sclerophyll-dominated forest that may require management intervention to assist recovery from the 2019–20 fires. However, here we focus on restoration scenario planning for Rainforest patches; while recognising that the true spatial extent of these communities would need to be verified with on-ground assessments.

By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for the priority areas longer than using the National fire history data with coarser resolution. Due to the patchy nature of historical fires across the TEC, we suggest the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-19)

Predicted regenerative potential

- Priority area 1 represents 14.1% of the fire scar and covers 2707ha of the 'likely to occur' area of the Illawarra-Shoalhaven Subtropical Rainforest. Using the national model, the average fire interval within this area is 2.8 years (range 1.8–10 years) which, if accurate would be highly inappropriate for most within fire-sensitive rainforest communities. However, using the finer resolution NSW data, the average fire interval was 30.8 years (range = 8.3 -50), which is more appropriate for this vegetation type. The more frequent burnt areas identified by the finer resolution data may be sclerophyll-dominated patches within the rainforest matrix or may represent rainforest margins. On-ground assessment will be required to determine the finer scale spatial extent of different community types and the potential need for intervention within this area.
- The average rainfall percentile for the five years before the fire event was 41.8, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 37.3).
- The average distance to cleared areas was 1281m, but this ranged from 0 (directly adjacent to cleared areas) to 7009m (distant to cleared areas). This indicates that this priority area likely contains rainforest patches of different sizes within a cleared landscape matrix. Lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally lower across this area (mean = 2.9), but there were areas that experienced high fire intensity (range = 2–5). These high fire intensity areas may correspond to more sclerophyll dominated patches and/or represent the rainforest margins which tend to contain a higher proportion of sclerophyll species.

Priority area 2 (see Table 7-19)

Predicted regenerative potential

- Covering 4823ha, this area represents 25.1% of the fire scar for the 'likely to occur' area of Illawarra-Shoalhaven Subtropical Rainforest. The average fire interval within this area is 3.3 years using the national data, which, if accurate, is likely inappropriate for most species within fire-sensitive rainforest communities. Fire interval using the NSW data was higher (average 31.3 years), and ranged from 7.1–50 years, which is more appropriate for this community.

More frequently burnt areas may be sclerophyll-dominated patches within the rainforest matrix or areas corresponding to the rainforest margins. This indicates the need for on-ground assessment to determine the fine scale spatial extent of different community types and the potential need for intervention.

- The average rainfall percentile for five years before the fire event was 40.5, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall = 37.3).
- The average distance to cleared areas was 2700m, but these ranged from 0 (directly adjacent to cleared areas) to 6938m (distant to cleared areas). Lower weed loads are expected in patches where the distance is >1000m as weeds predominately enter via long-distance dispersal. The greater average distance to cleared areas in priority area 2 (2700 vs 1281m) may indicate a lower average weed load, which contributed to the lower ranking of conservation priority.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally lower across this area (mean = 2.8), but there were areas that experienced high fire intensity (range = 2–5). These high fire intensity areas may correspond to more sclerophyll dominated patches and/or represent the rainforest margins which tend to contain a higher proportion of sclerophyll species.

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if the majority of functional groups and species are regenerating.
- If the answer is yes, then the management action required is: **protection/natural regeneration** (see Table 7-20 for details).
- If the answer is no, then non-regenerating groups and/or species need to be identified. Following identification of these species, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these rainforest species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-20).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) from the Illawarra-Shoalhaven Subtropical Rainforest community are likely to be most vulnerable and may require reintroduction (see Table 7-20). Fire-affected species (see Table 7-21) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.

- Although this is an unlikely scenario for management within burnt rainforest patches, **reconstruction** could be used to extend the extent of Illawarra-Shoalhaven Subtropical Rainforest beyond its current distribution to provide additional conservation benefits including:
  - creation of rainforest, buffers
  - increased patch size and
  - improved connectivity between remnants.

11.9 TEC 9: Turpentine-Ironbark Forest of the Sydney Basin Bioregion

11.9.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority areas 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. The National fire history indicates a fire interval that is too short for fire sensitive species, but the NSW fire history data indicates that it is more appropriate (mean = 23.6 years, range 8.3–50). This inconsistency, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-35)

Predicted regenerative potential

- Priority area 1 is small and represents only 5.6% of the fire scar, with this area covering 69ha of the 'likely to occur' area of Turpentine-Ironbark Forest. The average fire interval within this area is 2.4 years (range 2.1–3.8 years), which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 8.3 and 50 years, which is more appropriate for this community type.
- The average rainfall percentile for the five years before the fire event was 41, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 38.4).
- The average distance to cleared areas was 245m, but this ranged from 0 (directly adjacent to cleared areas) to 510m (more distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <200m, with intermediate weed loads in patches where the distance to the cleared areas is between 500–1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.8), but this did vary from medium to very high (range = 3–5).

Priority area 2 (see Table 7-35)

Predicted regenerative potential

- Priority area 2 represents 0.1% of the fire scar and covers an area of 1.4ha of the 'likely to occur' area of Turpentine-Ironbark Forest. The average fire interval within this area is 2.1 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 16.7 and 25 years, which is more appropriate for this community type.
- The average rainfall percentile for the five years before the fire event was 43.1, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was no variation within this priority area.
- The average distance to cleared areas was 468m and ranged from 400 to 538m (both distant to cleared areas). Generally, intermediate weed loads are expected in patches where the distance to the cleared areas is between 500–1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was very high across this area (mean = 5) and did not vary across the priority area.

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all (most) functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-36 for details). However, given community composition and fire history, this scenario of no regeneration is unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-36).

- If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-36). Fire-affected species (see Table 7-37) may also be targeted for reintroduction following site assessments and ground truthing.

- For the Turpentine–Ironbark Forest in the Sydney Basin Bioregion, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires and to protect the core remnants from additions threats and encroachment
  - increased patch/remnant size and
  - improved connectivity between remnants.

11.10 TEC 10: Illawarra and South Coast Lowland Forest and Woodland

11.10.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority areas 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. The National fire history indicates a fire interval that is too short for fire sensitive species, but the NSW fire history data indicates that it is appropriate (and in some cases may be too long for species that require fire to regenerate). This inconsistency, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-39)

Predicted regenerative potential

- Priority area 1 is small and represents only 8.1% of the fire scar, with this area covering 146ha of the 'likely to occur' area of Illawarra and south coast lowland forest and woodland. Based on the national data the average fire interval within this area is 3.2 years (range 1.9–3.3 years), which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 25 and 50 years, which is more appropriate for this community type.
- The average rainfall percentile for the five years before the fire event was 46.4, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 45.7).

- The average distance to cleared areas was 156m, but this ranged from 0 (directly adjacent to cleared areas) to 539m (more distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <200m, with intermediate weed loads in patches where the distance to the cleared areas is between 500–1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.7), but this did vary from medium to very high (range = 3–5).

Priority area 2 (see Table 7-39)

Predicted regenerative potential

- Priority area 2 represents 0.0% of the fire scar and covers an area of 0.7ha of the 'likely to occur' area of Illawarra and south coast lowland forest and woodland. The average fire interval within this area is 3.3 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher at 50 year, which may even be too long for species dependent on fire for recruitment.
- The average rainfall percentile for the five years before the fire event was 47.3, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was no variation within this priority area.
- The average distance to cleared areas was 519m and ranged from 500 to 539m (both distant to cleared areas). Generally, intermediate weed loads are expected in patches where the distance to the cleared areas is between 500-1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was very high across this area (mean = 5) and did not vary across the priority area.

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all (most) functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-40 for details). However, given community composition and fire history, this scenario of no regeneration is unlikely but needs to be verified by on-ground assessments.

- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-40).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-40). Fire-affected species (see Table 7-41) may also be targeted for reintroduction following site assessments and ground truthing.
- For the Illawarra and South Coast Lowland Forest and Woodland, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires and to protect the core remnants from additions threats and encroachment
  - increased patch/remnant size and
  - improved connectivity between remnants.

11.11 TEC 11: Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain

11.11.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority areas 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. However, this same framework could be used to assess restoration scenarios for priority areas 3 and 4 which have an inappropriate fire history for this community type (average fire interval <10 years).

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-43)

Predicted regenerative potential

- Priority area 1 represents only 39.3% of the fire scar, with this area covering 1126ha of the 'likely to occur' area of Sedgelands in Holocene Dune Swales. The average fire interval within this area is 3.7 years, which is very likely inappropriate for some fire sensitive species within this community. Within this area, fire frequency history varied between low and high with fire interval ranging from 2–4 years.

- The average rainfall percentile for the five years before the fire event was 26, which is within the below average rainfall band (10–30), and below the 50th percentile. There was some variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 25.6).
- The average distance to cleared areas was 372m, but this ranged from 0 (directly adjacent to cleared areas) to 1105m (distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <500m, with intermediate weed loads in patches where the distance to the cleared areas is between 500-1000m.
- Taking all these factors into consideration, this priority area would have a ***low predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.7), but this did vary from medium to very high (range = 3–5).

Priority area 2 (see Table 7-43)

Predicted regenerative potential

- Priority area 2 represents 46.6% of the fire scar and covers an area of 13334ha of the ‘likely to occur’ area of Turpentine-Ironbark Forest. The average fire interval within this area is 3.3 years, which is likely inappropriate for some fire sensitive species within this community. Similar to the Priority area 1, within this area, fire frequency history was generally high with fire interval ranging from 2–4 years.
- The average rainfall percentile for the five years before the fire event was 26.1, which is within the below average rainfall band (10–30), and below the 50th percentile. Similar to Priority area 1, there was some variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 25.6).
- The average distance to cleared areas was 460m but this ranged from 0 (directly adjacent to cleared areas) to 1393m (distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <500m, with low weed loads in patches where the distance to the cleared areas is between 1000-2000m.
- Taking all these factors into consideration, this priority area would have a ***low predicted recovery potential***.

Most recent fire

- Fire intensity was high across this area (mean = 4), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating.
- If the answer is no (most to all functional and structural components are missing), then the management action required is: **reconstruction** (see Table 7-44 for details). This scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If the answer is yes and some regeneration is occurring, non-regenerating groups and/or species need to be identified (which functional groups and/or species are missing?). If most functional groups and/or species are present (most to none missing), then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-44)
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-44). Fire-affected species (see Table 7-45) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- **Reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.12 TEC 12: Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland

11.12.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. The National fire history indicates a fire interval that is too short for fire sensitive species, but the NSW fire history data indicates that it is more appropriate. This inconsistency, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-47)

Predicted regenerative potential

- Priority area 1 represents only 21% of the fire scar, with this area covering 3566ha of the 'likely to occur' area of Coastal Swamp Oak Forest. The average fire interval within this area is 2.7 years which is very likely inappropriate for some fire sensitive species within this community. Within this area, fire frequency history varied between low and high with fire interval ranging from 1.4–16.7 years.
- The average rainfall percentile for the five years before the fire event was 41.4, which is within the broad average rainfall band (30–70), but below the 50th percentile (range = 35.7–48.5).
- The average distance to cleared areas was 303m, but this ranged from 0 (directly adjacent to cleared areas) to 1140m (distant to cleared areas). Generally, lower weed loads are expected in patches where the distance is 250–500m, with infrequent weed loads in patches where the distance to the cleared areas is between 500–1000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.5), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-47)

Predicted regenerative potential

- Priority area 2 is larger representing 50.3% of the fire scar, with this area covering 8550ha of the 'likely to occur' area of Coastal Swamp Oak Forest. The average fire interval within this area is 2.8 years which is very likely inappropriate for some fire sensitive species within this community. Similar to the Priority area 1, within this area, fire frequency history varied between low and high with fire interval ranging from 1.4–16.7 years.
- The average rainfall percentile for the five years before the fire event was 43.2, which is within the broad average rainfall band (30–70), but below the 50th percentile (range = 35.5–48.5).
- The average distance to cleared areas was 374m, but this ranged from 0 (directly adjacent to cleared areas) to 3421m (very distant to cleared areas). Generally, lower weed loads are expected in patches where the distance is 250-500m, with intermediate weed loads in patches where the distance to the cleared areas is between 500-1000m. Only rare long distanced dispersal will occur where the distance to cleared area is >2000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 3.5), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-48 for details). However, given community composition and fire history, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments. if some functional groups and species are regenerating.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-48).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-48). Fire-affected species (see Table 7-49) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- For Coastal Swamp Oak Forests, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnant patches.

11.13 TEC 13: Alpine Sphagnum Bogs and Associated Fens

11.13.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as they were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-51)

Predicted regenerative potential

- Priority area 1 is small and represents only 1.6% of the fire scar, with this area covering 10187ha of the 'likely to occur' area of Alpine Sphagnum Bogs and Associated Fens. The average fire interval within this area is 10.7 years, which is very likely inappropriate for some fire sensitive species within this community. Within this area, the fire frequency ranges from 3–17 years.
- The average rainfall percentile for the five years before the fire event was 53.4, which is within the broad average rainfall band (30–70), and above the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 36.6).
- The average distance to cleared areas was 1352m, but this ranged from 0 (directly adjacent to cleared areas) to 2640m (distant to cleared areas). Generally, lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal. At distances >2000m, weed loads are even lower with only rare long-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.9), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-51)

Predicted regenerative potential

- Priority area 2 is also small and represents only 11.6% of the fire scar and covers an area of 73270ha of the 'likely to occur' area of Alpine Sphagnum Bogs and Associated Fens. The average fire interval within this area is 11.8 years, which is likely inappropriate for some fire sensitive species within this community. However, within this area, fire history is more variable and fire interval ranges from 2–50 years.
- The average rainfall percentile for the five years before the fire event was 45.7, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 32.7).
- The average distance to cleared areas was 2948m, but this ranged from 0 (directly adjacent to cleared areas) to 12904m (distant to cleared areas).
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally moderate to high across this area (mean = 4.0), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-52 for details). However, given community composition, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-52).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-52). Fire-affected species (see Table 7-53) may also be targeted for reintroduction following site assessments and ground truthing.
- For Alpine Sphagnum Bogs and Associated Fens, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.14 TEC 14: Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion

11.14.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as they were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. However, this same framework could be used to assess restoration scenarios for priority areas 3, 4 and 5 which have an inappropriate fire history for this community type (average fire interval <5 years).

By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. This, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-55)

Predicted regenerative potential

- Priority area 1 is small and represents only 16.5% of the fire scar, with this area covering 147ha of the 'likely to occur' area of Castlereagh Scribbly Gum and Agnes Banks Woodlands. The average fire interval within this area is 2.2 years, which is very likely inappropriate for most fire sensitive species within this community. Within this area, fire history is consistently high with fire interval ranging from 1.7–5.6 years.
- The average rainfall percentile for the five years before the fire event was 44.1, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was very little variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 44).
- The average distance to cleared areas was 131m, but this ranged from 0 (directly adjacent to cleared areas) to 224m (somewhat distant to cleared areas). Generally, moderate weed loads are expected in patches where the distance is 100–250m.
- Taking all these factors into consideration, this priority area would have a ***low predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 4) and it did not vary.

Priority area 2 (see Table 7-55)

Predicted regenerative potential

- Priority area 2 represents 29.4% of the fire scar and covers an area of 262ha of the 'likely to occur' area of Castlereagh Scribbly Gum and Agnes Banks Woodlands. The average fire interval within this area is 2.3 years, which is likely inappropriate for most fire sensitive species within this community. However, within this area, fire history varied the same as the Priority area 1 from 1.8–5.6 years.
- The average rainfall percentile for the five years before the fire event was 44.2, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 43.5).

- The average distance to cleared areas was 167m, but this ranged from 0 (directly adjacent to cleared areas) to 361m (distant to cleared areas). Generally, moderate weed loads are expected in patches where the distance is 100–250m, with lower weed loads at distances between 250-500m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 3.6), but this did vary from moderate to high (range = 3–4).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if all (or most) functional groups and species are missing.
- If the answer is yes, then the management action required is: **reconstruction** (see Table 7-56 for details). This scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If the answer is no, non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-56).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-56). Fire-affected species (see Table 7-57) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.
- **Reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.15 TEC 15: Natural Temperate Grassland of the South Eastern Highlands

11.15.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as they were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. However, this same framework could be used to assess restoration scenarios for priority areas 4 and 5 which have an inappropriate fire history for this community type (average fire interval >20 years).

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-59)

Predicted regenerative potential

- Priority area 1 is relatively small and represents only 18.9% of the fire scar, with this area covering 10524ha of the 'likely to occur' area of Natural Temperate Grassland. The average fire interval within this area is 3.3 years, which is likely inappropriate for some fire sensitive species within this community. Within this area, fire frequency varied from low to very high with fire interval ranging from 1.6–16.7 years.
- The average rainfall percentile for the five years before the fire event was 43.9, which is within the broad average rainfall band (30–70) but is below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 38.3).
- The average distance to cleared areas was 2242m, but this ranged from 0 (directly adjacent to cleared areas) to 5140m (very distant to cleared areas). Generally, lower weed loads are expected in patches where the distance is >1000m as weeds would predominately arrive via longer-distance dispersal. At distances >2000m, weed loads are even lower with only rare long-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.8), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-59)

Predicted regenerative potential

- Priority area 2 is a similar size and represents only 20% of the fire scar and covers an area of 11186ha of the 'likely to occur' area of Natural Temperate Grassland. The average fire interval within this area is 4.1 years, which is likely inappropriate for some fire sensitive species within this community. However, within this area, fire history is more variable and fire interval ranges from 1.6–25 years.

- The average rainfall percentile for the five years before the fire event was 44.2, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile = 37.4).
- The average distance to cleared areas was 1866m, but this ranged from 0 (directly adjacent to cleared areas) to 9235m (distant to cleared areas).
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally moderate to high across this area (mean = 4), but this did vary from low to very high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-60 for details). However, given community composition, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-60).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-60). Fire-affected species (see Table 7-61) may also be targeted for reintroduction following site assessments and ground truthing.
- For Natural Temperate Grassland, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnants.

11.16 TEC 16: Robertson Rainforest in the Sydney Basin Bioregion

11.16.1 GIS analysis — Likely to occur Model 3 (L3)

These priority areas (Priority area 1 and 2) were chosen because their historical fire regimes (and fire intensity) indicate the presence of a rainforest community. The more frequently burnt communities (indicated by Priority areas 3, 4 and 5) are likely sclerophyll-dominated forest that may require management intervention to assist recovery from the 2019–20 fires. However, here we focus on restoration scenario planning for Rainforest patches; while recognising that the true spatial extent of these communities would need to be verified with on-ground assessments.

By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for priority areas 1 and 2 were longer than using the National fire history data with coarser resolution. In this case, both data sets illustrate that the fire intervals are likely to be appropriate for some species in this community. However, due to the patchy nature of historical fires across the TEC, there is still the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-63)

Predicted regenerative potential

- Priority area 1 represents 5.2% of the fire scar and covers 151ha of the 'likely to occur' area of the Robertson Rainforest. Using the national model, the average fire interval within this area is 7.2 years (range 2.2-16.7 years) which, if accurate would be highly inappropriate for most within fire-sensitive rainforest communities. However, using the finer resolution NSW data, the average fire interval was 25.6 years (range = 12.5 -50), which is more appropriate for this vegetation type, but at the lower end of tolerance. On-ground assessment will be required to determine the finer scale spatial extent of different community types and the potential need for intervention within this area.
- The average rainfall percentile for the five years before the fire event was 38.6, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas (37.6–39.2).
- The average distance to cleared areas was 221m, but this ranged from 0 (directly adjacent to cleared areas) to 500m. This indicates that this priority area likely contains rainforest patches of different sizes within a cleared landscape matrix. Moderate /higher weed loads are expected in patches where the distance is 200–5000m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally lower across this area (mean = 2.4).

Priority area 2 (see Table 7-63)

Predicted regenerative potential

- Covering 215ha, this area represents 7.4% of the fire scar for the 'likely to occur' area of Robertson Rainforest. The average fire interval within this area is 2.2 years using the national data, which, if accurate, is likely inappropriate for most species within fire-sensitive rainforest communities. Fire interval using the NSW data was higher (average 18.2 years), and ranged from 12.5–50 years, which still frequent for rainforest. However, more frequently burnt areas may be sclerophyll-dominated patches within the rainforest matrix or areas corresponding to the rainforest margins. This indicates the need for on-ground assessment to determine the fine scale spatial extent of different community types and the potential need for intervention.
- The average rainfall percentile for five years before the fire event was 38.7, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas (range = 37.9–39.2).
- The average distance to cleared areas was 1171m, but these ranged from 400 to 2051m. Lower weed loads are expected in patches where the distance is >1000m as weeds predominately enter via long-distance dispersal.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally low across this area (2).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate if the majority of functional groups and species are regenerating.
- If the answer is yes, then the management action required is: **protection/natural regeneration** (see Table 7-64 for details).
- If the answer is no, then non-regenerating groups and/or species need to be identified. Following identification of these species, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these rainforest species?
  - If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-64).

- If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) from the Robertson Rainforest community are likely to be most vulnerable and may require reintroduction (see Table 7-64). Fire-affected species (see Table 7-65) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.

- Although this is an unlikely scenario for management within burnt rainforest patches, **reconstruction** could be used to extend the extent of Robertson Rainforest beyond its current distribution to provide additional conservation benefits including:
  - creation of rainforest, buffers
  - increased patch size and
  - improved connectivity between remnants.

11.17 TEC 17: Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion

11.17.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority area 1 and 2 as they were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. However, both data sets illustrate that the fire intervals are likely either too short (National fire history) or too long (NSW fire history) to be appropriate for the fire sensitive species in this community. This, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-67)

Predicted regenerative potential

- Priority area 1 is small and represents only 5.7% of the fire scar (111.1 ha). The average fire interval within this area is 4 years, which is very likely inappropriate for most fire sensitive species within this community. Within this area, fire history is consistently high with fire interval ranging from 1.9–4.5 years. The finer scale NSW data indicates a longer fire interval (16.6–50 years) — indicating the need for site assessments to enable on-ground truthing.
- The average rainfall percentile for the five years before the fire event was 39.2, which is within the broad average rainfall band (30–70), but below the 50th percentile. Rainfall was consistently low (38.3–39.4).

- The average distance to cleared areas was 474m, but this ranged from 0 (directly adjacent to cleared areas) to 1063m (distant to cleared areas). Generally, low to moderate weed loads are expected in patches where the distance is <500m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally very high across this area (mean = 5) and it did not vary.

Priority area 2 (see Table 7-67)

Predicted regenerative potential

- Priority area 2 represents 58.6% of the fire scar and covers an area of 1141ha of the 'likely to occur' area of Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion. The average fire interval within this area is 3.8 years (range 1.9-4.5 years). The finer scale NSW data indicates a longer fire interval (10–50 years) — indicating the need for site assessments to enable on-ground truthing.
- The average rainfall percentile for the five years before the fire event was 38.6, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas, with a lower percentile of precipitation in some areas (rainfall mean percentile range = 36.1–40.2).
- The average distance to cleared areas was 241m, but this ranged from 0 (directly adjacent to cleared areas) to 2879m (distant to cleared areas). Generally, moderate weed loads are expected in patches where the distance is 100–250m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high across this area (mean = 3.6), but this did vary from moderate to high (range = 2–5).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all functional and structural components are missing, then the management action required is: **reconstruction** (see Table 7-68 for details). However, given community composition and fire history, this scenario of no regeneration is probably unlikely but needs to be verified by on-ground assessments. if some functional groups and species are regenerating.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If the majority of functional groups and/or species are present, then the management action required is: **protection/natural regeneration**.

However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?

- If yes, then the management action required is**:** **facilitated regeneration**. For this community this may include identification and removal of key weeds (see Table 7-68).
- If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see Table 7-68). Fire-affected species (see Table 7-69) may also be targeted for reintroduction following site assessments and ground truthing. Trees and shrubs with longer primary periods are likely to be most vulnerable and should be assessed first.

- For Southern Highlands Shale Forest and Woodland, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires
  - increased patch size and
  - improved connectivity between remnant patches.

11.18 TEC 18: Shale Sandstone Transition Forest of the Sydney Basin Bioregion

11.18.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority areas 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. The National fire history indicates a fire interval that is too short for fire sensitive species, but the NSW fire history data indicates that it is more appropriate (mean = 23.4 years, range 12.5–25). This inconsistency, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

11. Priority area 1 (see

Table 7-71)

Predicted regenerative potential

- Priority area 1 is small and represents only 1.4% of the fire scar, with this area covering 19ha of the ‘likely to occur’ area of Shale Sandstone Transition Forest. The average fire interval within this area is 2.4 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 12.5 and 25 years (mean = 23.4), which is more appropriate for this community type.

- The average rainfall percentile for the five years before the fire event was 38.5, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was variation within these priority areas (range = 37.7–39.9).
- The average distance to cleared areas was 131m, but this ranged from 0 (directly adjacent to cleared areas) to 400m (more distant to cleared areas). Generally, higher weed loads are expected in patches where the distance is <200m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally high to very high across this area (mean = 4.5), but this did vary from medium to very high (range = 3–5).

12. Priority area 2 (see

Table 7-71)

Predicted regenerative potential

- Priority area 2 represents 71.3% of the fire scar and covers an area of 948ha of the 'likely to occur' area of Shale Sandstone Transition Forest. The average fire interval within this area is 2.6 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 5.6 and 50 years (mean = 35.3), which is more appropriate for this community type, but still contains some areas where fire has been frequent.
- The average rainfall percentile for the five years before the fire event was 40.3, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was no variation within this priority area.
- The average distance to cleared areas was 114.6m and ranged from 0 to 300m. Generally, higher weed loads are expected in patches where the distance to the cleared areas is <200m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was moderate/high across this area (mean = 3.4) and ranged from 2-5.

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all (most) functional and structural components are missing, then the management action required is: **reconstruction** (see **Error! Reference source not found.** for details). However, given community composition and fire history, this scenario of no regeneration is unlikely but needs to be verified by on-ground assessments.

- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see **Error! Reference source not found.**).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see **Error! Reference source not found.**). Fire-affected species (see Table 7-73) may also be targeted for reintroduction following site assessments and ground truthing.
- For the Shale Sandstone Transition Forest of the Sydney Basin Bioregion, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires and to protect the core remnants from additions threats and encroachment
  - increased patch/remnant size and
  - improved connectivity between remnants.

11.19 TEC 19: Cooks River/Castlereagh Ironbark Forest of Sydney Basin Bioregion

11.19.1 GIS analysis — Likely to occur Model 3 (L3)

We focus on analysis of priority areas 1 and 2 as there were assessed as having the greatest need for intervention based on fire history, fire intensity and distance to cleared areas. By including analysis of the finer scale data from the NSW fire history we identified that the fire intervals for all priority areas were longer than using the National fire history data with coarser resolution. The National fire history indicates a fire interval that is too short for fire sensitive species, but the NSW fire history data indicates that it is more appropriate (mean = 32.3 years, range 25-50). This inconsistency, combined with the patchy nature of historical fires across the TEC, indicates the need for site assessments to understand if management intervention is required.

Restoration scenario planning decision tree for priority areas 1 and 2

Priority area 1 (see Table 7-75)

Predicted regenerative potential

- Priority area 1 is small and represents a large proportion of the fire scar (74%), with this area covering 80.5ha of the 'likely to occur' area of Cooks River/Castlereagh Ironbark Forest. The average fire interval within this area is 6.4 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher, between 25 and 50 years (mean = 32.2), which is more appropriate for this community type.
- The average rainfall percentile for the five years before the fire event was 44.5 (range 43.5-45.2), which is within the broad average rainfall band (30–70), but below the 50th percentile.
- The average distance to cleared areas was 361m, but this ranged from 0 (directly adjacent to cleared areas) to 707m (more distant to cleared areas). Generally, moderate weed loads are expected in patches where the distance to the cleared areas is between 200–500m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was generally moderate to high across this area (mean = 3.8), but this did vary from low to very high (range = 2–5).

Priority area 2 (see Table 7-75)

Predicted regenerative potential

- Priority area 2 represents 22.9% of the fire scar and covers an area of 25ha of the 'likely to occur' area of Cooks River/Castlereagh Ironbark Forest. The average fire interval within this area is 6.3 years, which is likely inappropriate for some fire sensitive species within this community. The NSW indicates that the fire intervals are much higher at 50 years, which is more appropriate for this community type, and may actually be too long for species that recruit after fire.
- The average rainfall percentile for the five years before the fire event was 43.3, which is within the broad average rainfall band (30–70), but below the 50th percentile. There was no variation within this priority area.
- The average distance to cleared areas was 136.5m and ranged from 0 to 283m. Generally, higher weed loads are expected in patches where the distance to the cleared areas is <200m.
- Taking all these factors into consideration, this priority area would have a ***moderate predicted recovery potential***.

Most recent fire

- Fire intensity was moderate across this area (3).

Assessment

- For both priority areas 1 and 2 (Likely to occur), site assessments are required to evaluate community recovery and if some functional groups and species are regenerating. If the answer is no, and all (most) functional and structural components are missing, then the management action required is: **reconstruction** (see **Error! Reference source not found.** for details). However, given community composition and fire history, this scenario of no regeneration is unlikely but needs to be verified by on-ground assessments.
- If regeneration is occurring, then non-regenerating groups and/or species need to be identified. If most functional groups and/or species are present, then the management action required is: **protection/natural regeneration**. However, if non-regenerating groups and/or species are identified, local specialist knowledge should be used to address the question: can facilitated regeneration alone assist post-fire recovery for these species?
  - If yes, then the management action required is**: facilitated regeneration**. For this community this may include identification and removal of key weeds (see **Error! Reference source not found.**).
  - If no, then a combined **regeneration/reintroduction** approach should be considered. Fire-sensitive species (obligate seeders and facultative seeders) are likely to be most vulnerable and may require reintroduction (see **Error! Reference source not found.**). Fire-affected species (see Table 7-77) may also be targeted for reintroduction following site assessments and ground truthing.
- For the Cooks River/Castlereagh Ironbark Forest, **reconstruction** could be used to extend the extent of this community beyond its current distribution to provide additional conservation benefits including:
  - creation of buffers for future fires and to protect the core remnants from additions threats and encroachment
  - increased patch/remnant size and
  - improved connectivity between remnants.