IDENTIFICATION AND CONSERVATION OF FIRE SENSITIVE ECOSYSTEMS AND SPECIES OF THE SOUTH COAST NATURAL RESOURCE MANAGEMENT REGION.

Department of Environment and Conservation
Our environment, our future

SOUTHCOAST NATURAL RESOURCE MANAGEMENT INC.

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Identification and Conservation of Fire Sensitive Ecosystems and Species of the South Coast Natural Resource Management Region

Sarah Barrett, Sarah Comer, Nathan McQuoid, Meghan Porter, Cameron Tiller and Deon Utber

Executive Summary

Southern Prospects, the South Coast Strategy for Natural Resource Management, identified that the South Coast region has many fire sensitive ecosystems occurring on public and private land; that inappropriate fire regimes were a significant threatening process impacting on biodiversity; and that more information was required to adequately manage and conserve these systems. This project identifies a preliminary list of 80 fire sensitive systems and collates information on their ecological attributes that will directly assist their management. Many of these systems characteristise the landscape of the South Coast region in terms of their endemism, species richness and restricted distribution. The identification of ecosystem sensitivity was a product of the Ecodistrict perspective and was based upon the disturbance response of vegetation communities and habitat development to meet the requirements of fauna.

Fire sensitive systems were defined as those systems vulnerable to long term loss of species diversity, vegetation structure and habitat value as a result of too frequent, intense or extensive fire or to inappropriate season of fire. These primarily included vegetation systems dominated by serotinous obligate seeder species such as mallet woodlands, shrublands and mallee over *Melaleuca* shrublands, as well as transitional woodlands, granite communities, wetland and riparian systems, peat and organic soil systems, cryptogram communities, and systems with refugial fauna and other short range endemic species.

General recommendations and guidelines for South Coast fire sensitive systems were developed as well as ecological management guidelines for individual systems. Key fire sensitive species for each system were identified and their response to fire and maturation times documented where known. Fire sensitive plant species included dominant structural species, in particular serotinous obligate seeder species, with long maturation or recovery periods, species sensitive to intense or extensive fire, short range endemics and relictual species. Monitoring guidelines were developed to inform adaptive management.

Past and present fire management practices and relevant fire management policy were reviewed and the fire history of remnant vegetation in the region was mapped. An analysis of the fire history, with an emphasis on specific reserves, in a GIS environment allowed some general observations to be made on the fire regimes in the last 33 years (1975-2008). The cause of fire for the eastern and more remote parts of the region has been predominantly wildfire with a greater incidence of prescribed fire in western parts of the region and areas of greater public use. The greatest proportion of area in the reserves assessed had a fire frequency of 1 to 2 fires in the 30 year period. The Fitzgerald River National Park (FRNP) and Great Western Woodland (GWW) had greater areas with no fire recorded for the study period. Of concern for the regeneration of serotinous obligate seeder species, was the high percentage of the

Stirling Range National Park (SRNP) (16%) and Cape Arid National Park (CANP) (12%) that had experienced three fires in the study period. The area burnt annually across the region and the incidence of fire between 1975 and 2008 showed an upward trend in this period. This trend was less marked for individual reserves with the exception of the GWW where the area burnt annually appears to be increasing.

Fire ecology literature and related environmental issues relevant to the South Coast region were reviewed. Ecological studies based in the region are summarised in this report and along with expert knowledge and the collation of fire response data used to identify fire sensitive systems. From the literature review, knowledge gaps and research priorities were identified and included:

- Population and seed bank dynamics of key functional plant taxa in relation to fire;
- Chronosequence (space-for-time) studies to investigate the effect of fire regime on community species composition and structure;
- The effect of fire regime including patch size and fire history diversity on the habitat and population dynamics of key fauna species;
- Leaf litter ecology and fungal diversity and in relation to fire regime;
- Fuel load (biomass), flammability and risk of ignition in priority South Coast systems in relation to time since fire.

This report is designed to assist future land management and planning within the South Coast region in that it provides land managers with a preliminary list of fire sensitive systems and the key components within these systems that can be used to assess and monitor ecosystem health in relation to fire.

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1 INTRODUCTION

The South Coast of Western Australia occurs within one of the 34 globally recognised biodiversity hotspots (Mittermeier *et al*. 2005), and contains a diverse range of species and landscapes. The South Coast Natural Resource Management (NRM) region encompasses the southern and eastern extent of the Southwest Botanical Region (Hopper and Gioia 2004). The diversity of landforms, soils and a extended history of isolation have resulted in a diverse flora with a notably high level of endemism, with areas of intense floristic richness found between Ravensthorpe and the Stirling Range. It also includes wet sclerophyll karri and tingle forest, dry sclerophyll forest of jarrah and marri, significant areas of the Goldfields or Transitional Woodlands (Great Western Woodlands), granite 'islands' both mainland and off-shore, extensive kwongan shrub and heathlands, wetlands and salt-lake chains.

For many of the taxa and ecosystems and found in the South Coast region, both threatened and common, inappropriate fire regimes are a key threat to the diversity, viability and long term conservation of communities, habitats and populations.

The South Coast Regional NRM (Inc) Strategy "Southern Prospects 2004-2009" identified the need for investment in an assessment of fire history and ecological responses to fire in the many high priority ecosystems that characterise the NRM region. The Strategy provides management action targets to address issues of strategic importance across its themes. The Biodiversity Theme Management Action Target, MAT B14, is "to develop and implement appropriate fire management regimes to protect high priority South Coast ecosystems". Its related management action is "to develop partnerships between fire planning and control organisations and ecologists". This report aims to identify those South Coast ecosystems and taxa considered sensitive to some fire regimes, usually frequent or infrequent fire, and those ecosystems and taxa for which different aspects of fire such as intensity, scale or patchiness are perceived to be a threat. The list of fire-sensitive ecosystems, referred to as 'systems' hereafter in this document, is preliminary and should be added to in the future with improvements in knowledge.

Aim of the report and guidelines:

> ***To provide landscape managers and ecologists with a synthesis of information on the fire ecology and fire sensitivity of taxa and systems on the South Coast, and thereby facilitate improved fire management outcomes for biodiversity conservation.***

This report provides South Coast landscape managers and ecologists with the basic information required to guide fire management that is specifically directed at conservation of South Coast biodiversity, and outlines simple protocols for monitoring to improve understanding of the fire responses of the biota. In addition after analysis of the existing literature, research areas that will further inform fire management of South Coast taxa and ecosystems have been identified. While the report aims to inform decision making for fire management at both planning and operational levels, it does not provide information on how fire suppression, mitigation measures or the use of planned fire is implemented. The information provided here should be used in the context of broader fire management objectives.

The report specifically provides:

- A review of fire-related literature (published and unpublished) of relevance to the South Coast systems;
- A preliminary list of high priority fire sensitive systems in the South Coast NRM region;
- A review of past and current fire management practices and plans including planned fire and wildfire suppression;
- An analysis of planned and wildfire history, including frequency, extent and ignition sources;
- Information on ecological responses to fire (taxa and systems) including maturation and habitat development times, and identifies gaps in this information;
- Recommendations for fire ecology research to address knowledge gaps;
- Ecological considerations for fire management of sensitive systems and monitoring protocols; and
- A review of ecological fire management in relation to National, State and regional legislation and regulations

A workshop was held in March 2009 to access expert opinion on the identification and fire management of fire sensitive systems, research and monitoring.

1.1 Fire, policy and legislation

State legislation concerning land management including the *CALM Act 1985* and the *Wildlife Conservation Act 1950* do not specifically address fire management and its place in maintaining biodiversity. Existing State legislation relevant to fire concerns itself with the prevention of, preparedness for and response to, unplanned fire. The primary State Acts pertinent to fire management are the *Bush Fires Act 1954* and the *Emergency Management Act 2005*; neither of which requires any specific outcome for the use of fire in land management or biodiversity conservation.

The Department of Environment and Conservation (DEC) has developed Policy Statement 19 – Fire Management to provide a bridge between legislation and operational practice and to provide guidance in managing fire on land managed by the Department. The Policy statement provides direction on the use of fire to maintain biodiversity and to minimise the risk and consequence of unplanned fire. It also provides guidance on the Department's role in detecting and responding to unplanned fires when they do occur. The Policy provides a commitment to create new knowledge concerning fire management. The Policy statement is supported by a statement of rationale and fire management principles that underlie the Policy direction.

The DEC Code of Practice for Fire Management recognizes the relationship between fire management and biodiversity and provides a framework for fire management procedures and practice. Its purpose is to ensure the efficient, effective and safe management of fire to achieve land management objectives and to protect the range of associated values. The Code applies to lands managed by the Department, and to

Unallocated Crown Land and Unmanaged Reserves for the purpose of fire preparedness. It also applies to agents acting on behalf of the Department. The Code links to the Conservation and Land Management Act 1985 and the Wildlife Conservation Act 1950. There are also links to the Environment Protection and Biodiversity Conservation Act 1999, which the Department has interpreted through Policy 19. The Code states that the application of planned fire needs to be ecologically appropriate to the local environment and have the outcomes monitored and recorded. More information on relevant National, State and Regional legislation and regulations is provided in Appendix II.

Fire Management Principles have also been developed by DEC which provide guidance on the fire ecology paradigms that underlie Departmental policy and practice. There are a set of general principles (contained in Policy Statement 19) that apply to fire management in all the environments of Western Australia (WA) and more specific principles for some of the larger biospheres such as spinifex grasslands and tropical savannas. Draft principles are currently being prepared for south coast heathlands.

At an operational level the Department has a series of Fire Operation Guidelines (FOG) which until recently largely pertained to tactical level on-ground operations and best practice fire management procedures. To assist land managers in making informed fire management decisions concerning species or ecosystems with specific fire regime requirements the department has developed a series of Fire Management Guidelines (FMG). These guidelines provide an overview of the ecology of the ecosystem or species, threatening processes, distribution and habitat information and outline fire management recommendations. The recommendations provide broad objectives with regards to either planned or unplanned fire and list strategies or management actions in order to achieve conservation specific objectives.

1.2 Fire and related environmental issues

There can be very significant interactions between fire and other types of disturbance including invasion by non-native plants and animals, plant diseases, grazing, fragmentation and climate change (Hobbs 2003), and on a smaller scale other forms of habitat modification such as scrub-rolling (Gosper *et al.* in press). Fire can mitigate or facilitate these threatening processes. For example, fire, grazing and climatic variability can interact in a number of ways to determine the state of the vegetation in a given area and post fire regeneration success. On the South Coast the interaction between fire and Phytophthora dieback caused by the plant pathogen *Phytophthora cinnamomi* can cause gross changes in susceptible plant communities (Moore 2005). The limited published literature as well as unpublished information on these interactions is summarised in Appendix III.

2 LITERATURE REVIEW

A review of the general fire ecology literature most relevant to the South Coast is presented in tabular form in Section 2. South Coast fire ecology literature and studies are reviewed and the main research findings are summarised in Appendix I.

These reviews were used to identify critical knowledge gaps and assist in the identification of fire sensitive systems on the South Coast and the formulation of ecological guidelines for these systems.

Table 1. A review of selected fire ecology literature relevant to South Coast ecosystems		
Issue	**Comment**	**Ref Nos**
Biogeographical perspective / Landscape ecology	Within a landscape the heterogeneity of soils and topography interacting with fire regime can have a strong effect on the diversity of the biota. Increasing fire frequency in unproductive environments is likely to reduce plant diversity and animal diversity, while in more productive environments increased fire frequency may increase plant diversity.	[1, 2] [3, 4]
Pre-European fire regimes	Fire has been part of the landscape in Southwest Western Australia for some 250 million years and with modern vegetation types for at least 30 million years. Aboriginal people used fire in their environment commencing sometime during the last 60,000 years and this has probably involved different fire regimes to that which occurred previously.	[1] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14]
Plant fire response obligate seeders	Obligate seeders are killed by fire that causes 100% canopy scorch or girdles the stem at or near ground level and germinate either from seed stored in the soil or on the plant in woody capsules (serotinous species). For obligate seeders the time required to re-establish seed banks after germination is critical, if a second lethal fire occurs before a population has produced sufficient seed it may decline or become locally extinct. The juvenile period (time to first flowering after germination) of obligate seeders can be used to estimate minimum fire intervals and provide a biological basis for quantifying fire frequency. Inter-fire recruitment may play a critical role in population maintenance in the absence of fire.	[15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33]
Obligate seeders: soil-stored seed	While there has been considerable research into serotinous species, relatively little is known of the demography, seed bank dynamics and post-fire seedling establishment of non-serotinous species. While many species appear to have persistent soil seed banks with fire-related dormancy, others have transient seed banks.	[6] [15] [26] [34] [35] [36] [37] [38] [39]
Obligate seeders: canopy stored seed	A critical ecological difference between serotinous species and those with a soil-stored seed bank is that serotinous species largely persist for the life of the plant, while soil-stored seed may remain viable long after the parent has died. Serotinous species often have longer juvenile periods than species with soil-stored seed banks. Obligate seeders with canopy stored seed are at most risk from very short inter-fire periods as all adults die and all seeds die or germinate after the first fire, and a second fire occurring before the seed bank has developed could lead to population extinction. Those species that depend on fire for seed release and successful germination are also at risk from very long periods of fire exclusion because a) the parent plants, and hence the seed bank, may be extirpated before the next fire or b) if the next fire is high intensity, it may destroy the seed bank.	[15] [16] [17] [18] [20] [21] [23] [26] [28] [30] [31] [32] [33] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60]
Plant fire response: resprouters	Plants may be classified as resprouters if a significant number of established plants can survive 100% canopy scorch or stem girdling at or near ground level. Resprouter species are generally long-lived plants and have the ability to resprout from either epicormic buds on the stem or base, from rootstock buds (lignotubers) below the ground, from perrenating organs such as corms, bulbs, rhizomes and tubers, or from a terminal or apical bud. Many resprouters are also capable of recruitment from seed and are termed facultative seeder-sprouters. Resprouters can have canopy-stored or persistent or transient soil-stored seed banks but typically the seed bank size is reduced in comparison with obligate seeders.	[15] [17] [18] [22] [26] [40] [43] [55] [59] [61] [62] [63] [64] [65] [66]

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Issue	Comment	Ref Nos
Post-fire ephemerals	Post-fire ephemerals are adapted to exploit transiently non-limiting habitat resources such as increased nutrients immediately after fire. Some (monocarpic) species complete their life-cycle within the 6-8 months post-fire; polycarpic species commence reproduction in the second season after and survive for several seasons. The abundance of fire ephemeral species varies considerably between vegetation systems and in response to climatic consideration and other disturbance regimes e.g. weeds.	[6] [25] [67] [68]
Resprouter to seeder ratio	There is evidence to show that resprouter:seeder ratios vary among different habitats, change in predictable ways along productivity gradients and may also relate to the natural frequency of fires. There are a higher proportion of reseeders in the southern kwongan compared with the northern kwongan and southwest forests.	[5] [26] [40] [50] [69] [70] [71] [72] [73] [74]
Fire response: fauna (general)	Levels of fire response include an individual's response, population response and response of biota to temporal and spatial fire regimes. Many South Coast fauna are sensitive to particular fire regimes at the individual or population level. There is generally a poor understanding of the impacts of fire regime on populations and habitat, and the scale of mosaic optimal for specific taxa. The impact of fire on fauna is generally directly proportional to the scale and intensity of the fire with large and intense wildfires having a greater immediate and long term impact than low intensity, patchy fires.	[15] [22] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85]
Fire sensitive fauna: Specific taxa	A number of South Coast fauna taxa are considered highly sensitive to inappropriate fire regimes, and many of these have a requirement for long fire intervals either due to low fecundity or their requirement for late seral stage habitat. While some fauna species are resilient to fire, for many of the fauna species on the South Coast, it is the lack of mobility and capacity to escape fire, or highly fragmented habitat that leads to them being categorised as fire sensitive. These include the Western Ground Parrot, Gilbert's Potoroo, Noisy Scrub-bird and Moggridgea sp. Stirling Range. Species such as the Western Trout Minnow may be susceptible to significant change in habitat parameters from fire. References and more detailed information for species specific responses are provided in Appendix VII.	[5] [83] [84] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97]
Fire driven extinction	Most of the fire-driven extinctions reported in the literature involve elimination of obligate seeders, in particular serotinous species, by frequent fire regimes or regimes that combine high frequency, intensity and season. Other fire regimes associated with decline and extinction, particularly of woody species, include low fire frequency, high intensity fire and repeated fires with poor vertical penetration of heat. However, rates of decline may be slower in resprouters and less easy to observe.	[15] [17] [22] [26] [41] [60] [98] [99] [100] [101] [102] [103]
Plant longevity	Fire ecology studies have been strongly biased towards the early seral stage and little is known about the structure, floristics and fire behaviour of longer unburnt vegetation or the longevity of standing plants.	[15] [40] [43] [45] [49] [104] [105] [106]
Fire and rarity	An analysis of fire response of threatened flora in SW WA showed that 66% were seeders and 33% resprouters, a higher ratio than found in most other habitats. There is some evidence that areas which burn less frequently than the surrounding landscape may act as refugia for more fire sensitive taxa or communities. Inappropriate fire regimes have the potential to	[36] [44] [102] [107] [108] [109] [110] [111] [112] [113] [114] [115]

Table 1. A review of selected fire ecology literature relevant to South Coast ecosystems

Issue	Comment	Ref Nos
	increase the extinction vulnerability of many rare species. However, as many of these species only regenerate following fire, fire may be required at some stage of their lifecycle.	
Fire regimes and plants: interval	Fire interval or the time between fires has a significant influence on biodiversity. Recovery after fire and the rate of accumulation of biomass appears to be not only related to rainfall but the proportion of seeder and resprouting species present. Areas high in resprouters may recover quickly after fire to reach pre-fire biomass levels in 10-20 years whereas seeder biomass continues to increase for up to 50 years and possibly beyond. Useful fire regime indicators include climatic data, historical fire regimes and biological indicators such as regeneration strategy, floristic and structural changes, and post-fire biomass accumulation rates.	[5] [6] [11] [14] [72] [104] [114] [115] [116] [117] [118] [119] [120] [121] [122] [123] [124] [125] [126] [127] [128] [129] [130]
Fire interval: fauna	Life history characteristics of individual species will dictate suitable fire intervals for the maintenance of viable populations. For fauna, key factors affected by fire interval are food resources, habitat cover and breeding habitat. For some species the structural attributes that are required for optimal habitat may not develop until decades, or even centuries after fire (for example hollows in Salmon Gums and Wandoo). For most South Coast fauna the relationship between fire interval, fire patchiness and habitat suitability is poorly understood. Limited work has been done on the relationships between fire interval and the threatened birds of the Two Peoples Bay Manypeaks area, and documenting the native plant species used as a food resource by Carnaby's Black-Cockatoo.	[22] [75] [76] [78] [83] [93] [94] [120] [131] [132] [133] [134] [135] [136] [137]
Fire regimes and plants: intensity	Plants respond differently to high versus low intensity fire. Intense fires may damage epicormic buds or lignotubers thereby causing death of resprouter species or consume viable seed in the soil or canopy. Fire with poor vertical heat penetration may fail to trigger the germination of hard coated reseeder species. Low intensity fire may fail to trigger the opening of woody fruits on serotinous species.	[6] [17] [20] [40] [126] [136] [137] [138] [139]
Season of fire (including impact on geophytes)	Season of burn may have a considerable impact on obligate seeder species and seedling regeneration may be more successful after autumn burns as seedlings can establish during the wetter winter months. Geophytes, in particular orchid species, are vulnerable to fire regimes that can lead to depletion of carbohydrate reserves in the bulb or tuber. While some orchids may be killed during their winter –spring growing season, research is needed to better understand the effect of season of fire on orchid ecology. Flowering of certain orchid species is be stimulated by summer fire. Enhanced flowering of geophytes after fire leads to increased reproductive potential in the early years after fire.	[6] [15] [18] [140] [141] [142] [143] [144] [145] [146] [147]
Fire regime: Spatial and	The maintenance of fire mosaics has been advocated in Australia, particularly for fauna conservation. However, there is little data on what is the optimal size of mosaics or the actual proportion of habitat required to be in the early, mid or late	[6] [17] [61] [98] [124] [126] [127] [134] [147]

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temporal variability	seral stage. Sustained invariant fire regimes are considered unlikely to maintain full biodiversity. Variability in fire regimes, aims to ensure that one group of species do not dominate while others decline to extinction. Scale-related issues for fauna i.e. recolonisation, habitat variability are poorly defined etc	[148] [149]
Organic soils and peat systems	Local organic-rich systems can be permanently altered or disrupted by fire regimes that remove organic matter. Organic and peat systems are susceptible to fire because of their restricted, shallow and often ephemeral nature as well as the presence of readily flammable littoral vegetation and organic substrates, potentially losing soil thousands of years old. Regular and homogenous burning regimes can reduce the ability of moister parts of the landscape to edaphically control fire. Organic and peat systems are highly susceptible to post-fire weed invasion. The presence of organic-rich systems that are relictual in nature in south-west WA is arguably the result of a long-term absence of inappropriate fire. In a drying climate, soils may dry out to a great depth and therefore are more flammable and vulnerable to summer or autumn fires.	[17] [93] [150] [151]
Wetland and riparian system	Fire in wetlands and riparian systems may impact on water quality and riparian habitat value. Impacts of inappropriate fire on wetland dependent fauna should be considered. Wetland areas can be permanently altered or disrupted by fire regimes that remove organic matter. The use of surfactants and foams near wetlands during fire management activities can have adverse impacts on water quality and fauna. High intensity fires in surrounding vegetation have the potential to overwhelm the edaphic barriers and burn into the riparian zones.	[79] [150] [151] [152] [153]
Granite outcrops	The spread of fire on granite outcrops may be impeded allowing for the persistence of longer unburnt vegetation; granite outcrops may therefore provide refugial opportunities for fire-sensitive species. A high ratio of seeders to resprouters has been documented for granite outcrop vegetation in the Southwest, with 60% seeder species compared with 40% resprouters. Fire may have been a less significant selective force in the evolution of granite endemic taxa compared with kwongan taxa.	[36] [68] [123] [154] [155] [156] [157] [158] [159]
Fungi	Fungal response to fire in the forest systems follows a successional model similar to plants, with soil conditions post-fire dictating fungal groups present. Mycorrhizal fungi are significantly affected by fire, with long unburnt areas supporting higher numbers of mycorrhizal roots than more recently burnt areas. For other vegetation systems of the South Coast the fungi and their response is generally poorly known.	[160] [161] [162] [163] [164]
Mycophagy	Mycophageous mammals may be impacted by changes in food availability post fire, although effects on South Coast mammals are not well understood. Research has suggested that hypogeous ectomycorrhizal fungi may be influenced by fire in the short term in *Eucalyptus* forests. The interdependence of the nature of the fire induced spatial mosaic of these food resources and the interaction with the natal and foraging territories of dependent fauna is poorly known.	[162] [163] [165]
Leaf litter and fauna	A wide range of fauna species are dependent on well developed leaf litter, which may require many years to develop to functional levels after fire. This is likely to vary in different South Coast systems, and is not documented in terms of	[79] [136] [166] [167]

Table 1. A review of selected fire ecology literature relevant to South Coast ecosystems

Issue	Comment	Ref Nos
	successional development in relationship to fire risk. Specific examples of South Coast fauna with requirements for well developed litter layers include the Noisy Scrub-bird (associated invertebrate food resource), Malleefowl, *Lerista viduata* and burrowing frogs.	
Plant functional types / key life cycle processes / fire response patterns	Plant functional types are based on shared plant traits that result in assemblages of taxa responding similarly to a particular disturbance regime. Grouping species according to key life cycle processes and fire response patterns may be useful in predicting long-term changes in plant community composition under known fire regimes. These responses must also be placed in an environmental context as factors such as climate and predation will influence life cycle processes.	[6] [16] [22] [61] [69] [95] [129] [168] [169] [170] [171] [172]
Area management planning	Management plans for national parks and other reserves provide recommendations regarding zoning, wildfire suppression, pre-suppression activities (e.g. use of buffers and firebreaks) and prescribed burning. Fire management strategies may provide a greater level of detail with regard to fire ecology and biodiversity.	[112] [173] [171-184]
Species management plans	Recovery plans for individual threatened species document fire responses and ecology where known and make recommendations for appropriate fire management.	[100] [101] [136] [174] [175] [188-193] [176] [177]
Scrub-rolling and burning	Scrub-rolling followed by burning is a widely used management tool in the South Coast Region for the creation of fuel reduction buffers that aims to provide a degree of protection to large areas of vegetation from the impacts of wildfires. However, areas that are scrub-rolled and burnt may alter in vegetation structure and composition with the greatest impact being on serotinous obligate seeders and this should be considered in the planning process.	[6] [50] [178] [179]
Fire retardants and foams	Information on the environmental affects of fire suppressants and retardants predominantly concerns biota from a range of functional groups in north America. There is limited knowledge of the impact of fire retardants and foams on the biota, with limited work on effects of use on seedling recruitment, seedling establishment in relation to soil nutrient status, invertebrates and community composition. Although not specific to the South Coast evidence suggests that terrestrial vegetation may be impacted by use of retardants and aquatic systems affected by the use of foams. In addition use of retardants may favour weed recruitment post fire.	[151] [177] [180] [181] [182] [183] [184] [185] [186] [187] [188] [189] .
Fire and plant disease	Phytophthora dieback caused by the plant pathogen *Phytophthora cinnamomi* is a prime threat to South Coast plant communities. Research has demonstrated that fire in *P. cinnamomi* infested communities has the potential to increase both the severity and extent of disease and impinge on the regeneration capabilities of susceptible species. Any soil movement during fire management and suppression activities may result in the introduction or spread of soil-borne pathogens such as *P. cinnamomi*, therefore strict disease hygiene is essential. Interactions between fire and aerial canker disease are less well understood.	[6] [15] [40] [102] [105] [190] [191] [192] [193] [194] [195] [196]
Fire and grazing	Few studies have investigated the interaction between fire and grazing. Seedlings are susceptible to damage and mortality	[6] [19] [22] [108] [109]

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	by grazing after fire with palatable species being more affected. Grazers, both vertebrate and invertebrate, are often selective and can alter species abundances and floristic composition. Grazing pressure varies with season and vegetation composition and may be greater with isolated small burns.	[191] [197] [198] [199] [200] [201] [202] [203] [204]
Fire and weeds	The relationship between disturbance regimes such as fire and the establishment of weeds has been recognized in ecosystems world-wide. The timing and location of fire may enhance or mitigate weed invasion, depending on the resilience of the existing community, the fire regime and weed traits. Weeds may alter flammability characteristics at a site leading to more frequent or intense fires and prevent the regeneration of native perennial species. Weed invasion is enhanced by other forms of disturbance including grazing and nutrient addition. Immediately after fire there may be an opportunity to implement weed control actions. The strategic use of fire, informed by the relative responses of available native and exotic taxa, may potentially assist restoration of weed-invaded ecosystems.	[1] [19] [40] [197] [200] [205]
Fire and feral animals	Following fire the risk of predation is increased due to reduced cover, greater access for predators and reduced protection for native fauna. Many native fauna may be weakened or injured following an intense fire and more vulnerable to predation.	[6] [80] [93] [136] [206] [207] [208]
Fire and fragmentation	Fire can become extremely rare events in fragmented systems due to lack of continuous vegetation cover and the absence of active fire management. Fragmented landscapes are vulnerable to any fire regimes because a key mechanism of post-fire recovery, i.e. recolonisation, is diminished in fragmented landscapes. Fire frequency may increase where fire is used in the surrounding landscape. Fragmented vegetation is frequently also under threat from a range of processes such as altered hydrology, grazing, weeds, disease and reduced pollinator interactions.	[6] [154] [197] [200] [209] [210] [211]
Fire and salinity / altered hydrology	The impact of fire in areas affected by salinity has not been well investigated. Fire is not required to regenerate succulent shrubs and salt bush but may stimulate a release of seed from woody species and other taxa that may persist in mildly salt-affected land. However, fire may trigger a more rapid or temporal rise in groundwater level and further impede the rate or success of regeneration of seedlings.	[6]
Fire and climate change	The possibility of altered fire regimes as a result of climate change is recognized world-wide. Climatic models predict an increase in the frequency and intensity of wildfires. These changes will be coupled with predicted shifts in species distribution and phenology. Populations that exist near their fire frequency extinction threshold are at most risk of substantial effects from changes in fire regime due to climate change.	[6] [40] [199] [212] [213] [214]
Fire and islands	Many of the South Coast islands provide significant refuge for island endemics and are also important habitat for breeding seabirds. The Recherché Archipelago contains over 100 islands; important islands near Albany are Bald Island, Breaksea and Eclipse. The impact of fire on island endemics, and breeding seabird colonies are poorly documented.	[156] [215] [216] [217] [218] [219] [220] [195]

3 SOUTH COAST ECODISTRICTS AND THEIR RELATIONSHIP TO FIRE.

Conserving the nature of complex Mediterranean-type ecosystems such as those of the South Coast region of Western Australia is a challenge. The first order for the effective conservation of such intricate systems is understanding how the landscape and biota developed – particularly vegetation systems, and most importantly the disturbance responses of the biota. The use of a systematic methodology is a productive way to help attain this understanding. The eco-district analysis (McQuoid 2009, in prep) provides a useful methodology. It identifies the region's natural patterns in terms of related areas by the criteria of oldest to youngest of geology, climate, drainages, soils and vegetation systems. It contextualises the physiographical patterning of landscape units and vegetation communities, and supports the contemplation of biological and structural responses. This method is designed to help identify fire sensitive systems and develop more holistic management recommendations for these systems. It addresses the foundations for the presence of the biota, its distribution patterns and the physical forces that support its existence.

The Ecodistrict classification was considered to be more useful for the purposes of this project however, there is considerable overlap of the larger Ecodistricts described below with the IBRA biogeographical classification (Jarrah Forest 2, Esperance Sandplain 1, Esperance Sandplain 2, Mallee 2 and Coolgardie subregions). For example, the Esperance Sandplain east and west Ecodistricts are largely equivalent to the Esperance Sandplain IBRA regions, but the Ecodistricts pick up the subtle changes within the IBRA regions by recognising the Marine Plain and Greenstone Range as separate ecological units.

3.1 Geology, climate, drainage, soils and vegetation

The geology of the South Coast is elaborate with five major systems and several minor derivatives present. These systems vary greatly in developmental age from Achaean gneiss to more recent Quaternary limestone. However, the more recent weathering, drainage development and soil metamorphology from these geological systems has provided the mosaic of substrates, which in combination with hydrology, is the primary determinate of the vegetation complexity.

The climate of the South Coast region is Mediterranean, varying west to east and greatly south to north (Fig.1). In the Stirling Range, the orographic effect of the hills often results in summit cloud cover and the annual average rainfall at the summit of Bluff Knoll is approximately 1200mm with additional moisture derived from mist. Just to the north at Borden around 20 kilometres away, the rain shadow effect results in an average rainfall of approximately 400mm, a particularly sharp gradient.

Drainage systems and patterns across the region are largely modest river systems draining southwards while some systems drain internally into lakes. The river drainage systems have developed different depositional soils types over time and the vegetation systems reflect the high local variation and often-dynamic nature of these systems. The largest catchment is the Pallinup system which supports woodland trees otherwise absent to the region. The Pabelup suite of wetlands of the Fitzgerald River

National Park is mostly a freshwater system typified by flat-topped yate (yate – *Eucalyptus occidentalis*) and paperbark woodlands. In the east calcareous saline lakes dot the landscape with saltbush low shrubs the predominant vegetation of their damp soils, surrounded by woodland and mallee shrubland systems.

This extremely ancient landscape has largely been without significant soil development or acute disturbance for many millions of years. The soils are a series of reworked substrates that have been variously eroded and deposited in different places by fluvial and aeolian mechanisms. They vary enormously often over very short distances from alkaline coastal systems and sandy plains through neutral gravels and alluvial loams to acid sands and duplex sand/clay systems.

The vegetation and flora have a range of reproductive and survival strategies. These adaptations and characteristics include regenerative lignotuberous, adventitious roots, plant longevity, symbiotic relationships, sand blanketing thicket systems and winter/cold adapted seed germination triggers (Bell *et al*. 1984). These adaptations have seen the loss of many of the key survival mechanisms of new world disturbance opportunist flora with greatly reduced dispersal facility and intolerance for modest soil nutrients and frequent disturbance (Hopper 2009).

Infrequent disturbance events including extreme heat (Groom *et al*. 2004), frost, flood, hail and storms as well as fire, trigger regeneration responses that are ultimately successful so long as the intervals and timing allow regeneration and development to mature seral successional stages. However, at a landscape level, population dynamics and the resilience of species to fire is poorly understood. Fire is a major disturbance factor with the potential to become more influential with the increasing impact of climate change (Carey 2002; Burrows and Wardell-Johnson 2003). Plant community structure may vary significantly with fire interval.

Climate change has implications for South Coast systems in terms of the seasonality and intensity of rainfall. A steady decline in rainfall has been observed in the western half of the region, in contrast, the rainfall in the east appears to have increased slightly over the past 50 years in association with the influence of decaying tropical cyclones. In a drying climate many of the denser shrubland systems will become more flammable for longer periods each year leading to a change in the dynamic equilibrium of these systems. Increased incidence of wildfires from lightning ignition may also be a consequence of climate change. These systems include banksia shrublands and moort and mallet eucalypt woodland systems. These systems that are sensitive to frequent fire are interspersed with more resilient mallee shrubland. The consequence of wildfires in a drying climate is likely to be significantly affected by the grain size and extent of the existing fire induced vegetation structural mosaic.

The region also has island vegetation communities, predominantly in the Recherché Archipelago, which in comparison with adjacent mainland communities are somewhat depauperate in plant species. This includes the apparently almost complete loss of Proteaceous taxa from the Recherché Archipelago islands with only four species from the Proteaceae recorded compared with 87 in nearby Cape Arid National Park (CANP). This raises questions about the reasons for the loss and whether fire intervals during the 12,000 or so years since separation may play a role. Long unburnt (> 50 years since last fire) plant communities on the mainland such as those in the northwestern corner of Fitzgerald River National Park (FRNP) may help provide clues to vegetation patterning and disturbance frequencies over time, as the Proteaceous component, in particular banksias and hakeas, appears to be declining in these communities. However, there may be other less obvious reasons for the loss of Proteaceous constituents of island communities, including whether they existed much at all on the old shoreline.

3.2 The 15 Ecodistricts

The Ecodistricts assign the region into the following 15 discrete areas. They are based on physical and biological patterns as layers developed over ecological time from the oldest to newest: geology, climatic history, drainage patterns, major soil systems, and native vegetation communities (Fig 1).

1. **Forest Mosaic**. The extreme south western corner of the region where the wettest forests on deepest organic soils contain significant mixtures of relictual Gondwanan plants and animals including karri and tingle, red-flowering gum, frogs and trapdoor spiders. The mosaic of this Ecodistrict also contains several classes of wetlands from estuaries to winter wet swamps

2. **Albany Fraser Coastal.** The coastal granite features of West Cape Howe, Albany to Manypeaks, the Bremer peninsulas, and Esperance to Point Malcolm. This Ecodistrict contains vegetation communities similar in structure and often taxa, including many that are endemic, localised or restricted. These include particular mallet and mallee systems as well as kwongan heathlands.

3. **Albany Fraser Inland West.** A visible western zone of the South Coast region that includes low sub-coastal granite hills, inland to the Porongurup Range and Mounts Barker, Lindesay, and Frankland. A significant although scattered Ecodistrict, it contains wetter forest and woodland habitats and occurrences of many locally endemic plants, relictual communities related to climatic conditions, and rare and threatened animals. Note: The Ecodistrict map is not sufficiently detailed to show the western occurrences of this district e.g. Mt Lindesay and the numerous granite islands that occur with the western Forest Mosaic.

4. **Albany Fraser Inland East.** A mosaic of inland hills of the Esperance area and includes sub-coastal features as well as Mounts Ridley, Ney and Burdett to the north of Esperance. The laterised sheets surrounding the hills are included in this Ecodistrict. This Ecodistrict is similar to Albany Fraser Inland West in that it also contains many localised endemic plants although it is appreciably more arid with shrubbier plant communities. Inland it is further surrounded by the Mallee Lakes Ecodistrict of internal drainages on Eocene sediments.

5. **Albany Fraser Island.** The granite island system that includes all offshore islands except Red Island, (a quartzite feature) off the central Barrens coast. These islands support vegetation systems commonly exclusive in nature and important habitat for mammals, some endemic and relictual species no longer found on the adjacent mainland and marine animals which require land for parts of their lives.

6. **Marine Plain.** A western manifestation of the Eocene sediments between Albany and Ravensthorpe, this district has coordinated drainage systems that have formed linear alluvial and breakaway colluvial soils that in addition to the several duplex soils support a range of exclusive vegetation communities including kwongan shrublands and mallet and moort woodlands. The impact of the drainage system's erosive and development forces in carving through the substrate have created new landscapes that support a great diversity of habitats and vegetation.

7. **Greenstone Range.** The Ravensthorpe Range and nearby associated hills. These are unique on the South Coast and their geological difference, metamorphic relationship with the adjoining quartzite system, a unique nodular limestone presence, and proximity to three additional Ecodistricts make it one of the most intense occurrences of plant diversity in south-western Australia, with woodland, mallet, mallee and heath communities. It intriguingly has outliers of the goldfield floral elements and contains intense mineralisation and as such is subject to exploration and mining activity.

8. **Quartzite Range.** One of the most dramatic landforms of the South Coast are the omnipresent Stirling Range, Barrens and Russell Range/Mt Ragged. These metamorphosed sedimentary rocks that began as old river deltas in a prehistoric ocean floor have resisted weathering better than the surrounding geology to remain standing as jagged low mountains. The mountain thicket, heaths and mallee-heath vegetation contain many of the endemic plants and plant communities found in the South Coast region. The Barrens and Mt Ragged have distinctive wave cut benches surrounding the seaward sides of their bases.

9. **Esperance Sandplain West.** The western division of the dominant Esperance plain is typified by its coordinated drainages and junction with the Yilgarn Block, which dips south under it. It runs from an Ecodistrict junction at East Mt Barren and the Jerdacuttup Fault at Culham Inlet east to the eastern divide of the Lort River drainage system. It comprises kwongan heathlands, *Banksia* and mallee shrubland and wetland chains including the Lake Shaster system.

10. **Esperance Sandplain East.** The eastern division of the Esperance plain to the east of the Lort River drainage is typified by its uncoordinated or very short coastal drainage and junction with the Albany Fraser province that underlies it. Mallee and *Banksia* shrubland dominate with interspersed kwongan heath, and wetland palusplain and freshwater systems.

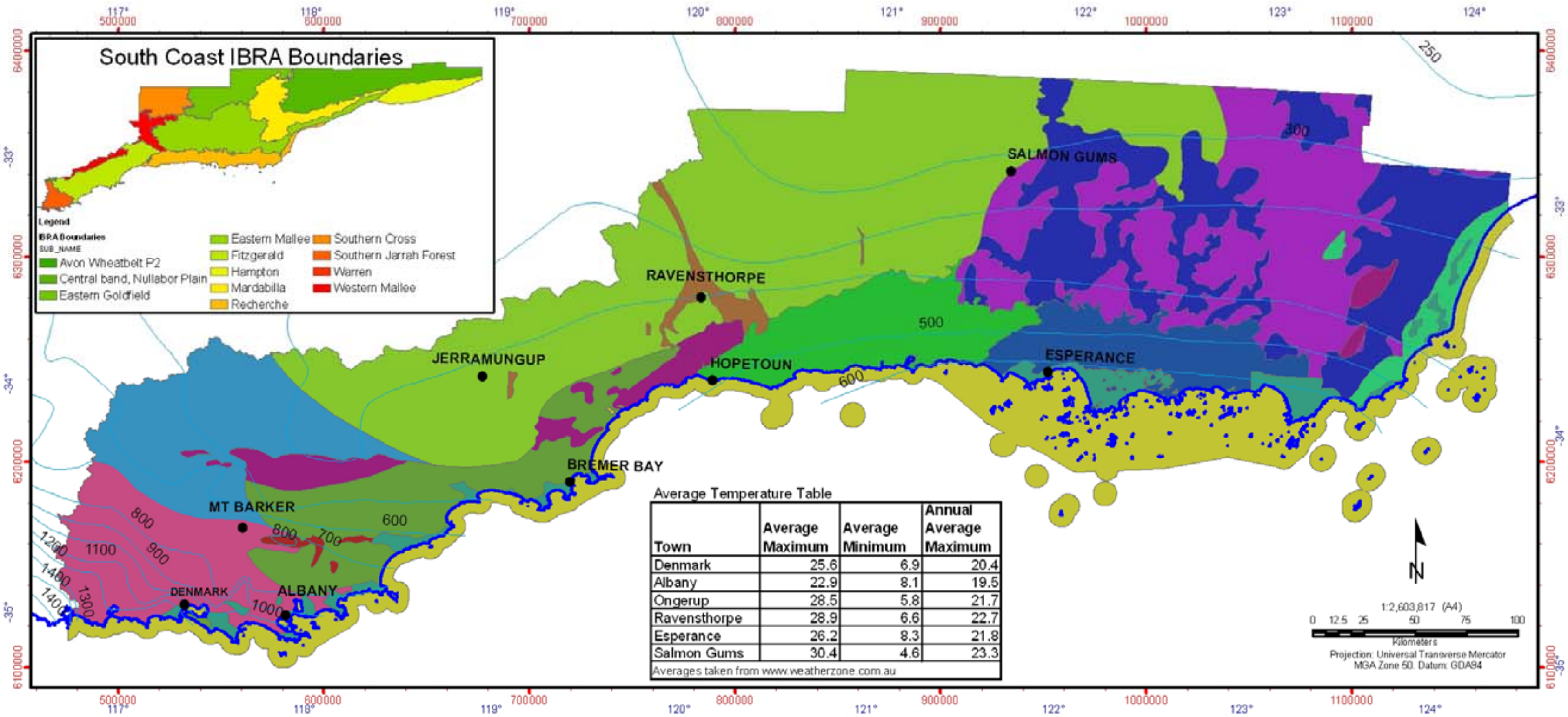
11. **Northwest Mosaic.** Wetter climates in the west give rise to coordinated drainage systems, often fresh, as well as slightly less diverse vegetation types than the Yilgarn Block East. It includes woodlands of jarrah, marri, wandoo, brown mallet, york gum, yate and swamp sheoak; as well as shrubland, kwongan heathlands and wetlands both fresh and saline.

12. **Yilgarn Block East.** A complex mix of soil systems underlying a climatic transition zone supporting as many different vegetation types, including tall woodlands of morrel and salmon gum, woodlands of many species of mallet, mallee and *Banksia* shrubland and rich kwongan heathlands. This Ecodistrict is largely intact with little human interaction in its eastern sections.

13. **Mallee Lakes.** A mosaic eco-district inland from Esperance comprising the paleo-drainages marine sediment systems and their internal lake drainages. This Ecodistrict is similar to the marine plain Ecodistrict further west although it lacks it's relatively large coordinated drainages. It is dominated by mallee woodlands and shrubland, mallet woodlands and scattered kwongan heathlands on calcareous sandy soils.

14. **Nuytsland.** A linear coastal and sub-coastal Ecodistrict that extends along the coast of the western Great Australian Bight from just south of Israelite Bay west to Point Malcolm. It is typified by the recent Pliocene shoreline and Aeolian limestone, sand dunes and linear saline lake systems with *Acaci*a and mallee shrubland and kwongan heathlands. It forms the fine coastal corridor that extends the southwestern botanical district to its easternmost

15. **Coastal Dynamic**. A narrow strip of the most recently formed landscape units of Aeolian limestone, dunes, swales and estuary edges. These support woodlands of peppermint, *Melaleuca*, yandil (*Eucalyptus cornuta*), yate and mallet; and shrubland of *Hakea*, peppermint, *Spyridium* and wattle, and often an understorey of restiods and annuals. These vegetation systems are able to withstand more frequent disturbance having adapted to these recent and more dynamic landscape units. Note: This unit is not mapped.



Town	Average Maximum	Average Minimum	Annual Average Maximum
Denmark	25.6	6.9	20.4
Albany	22.9	8.1	19.5
Ongerup	28.5	5.8	21.7
Ravensthorpe	28.9	6.6	22.7
Esperance	26.2	8.3	21.8
Salmon Gums	30.4	4.6	23.3

Averages taken from www.weatherzone.com.au

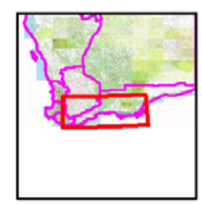
Figure 1 - South Coast Ecodistricts

Legend

- Towns
- WA Isohyets
- WA Coast

South Coast Eco-Districts

- Albany Fraser Coastal
- Albany Fraser Inland East
- Albany Fraser Inland West
- Albany Fraser islands
- Esperance Sandplain - East
- Esperance Sandplain - West
- Forest Mosaic
- Greenstone Range
- Mallee Lakes
- Marine Plain
- North West Mosaic
- Nuytsland
- Quartzite Range
- Yilgarn Block East



Graticule shown at 1 degree intervals
Grid shown at 100000 metre intervals

Produced by MP
Under the Direction of
Keiran McNamara
Director General, Department of
Environment and Conservation

Produced at 14:20pm, on June 25, 2009

Department of Environment and Conservation
Our environment, our future

4 FIRE-SENSITIVE SYSTEMS

While many organisms have developed adaptations for living with fire it must be considered that the biota may not be adapted to fire *per se* but rather to a particular range of fire regimes. Some plant communities may be relatively resilient to fire based on biological and physical traits that have enabled them to persist in a fire prone environment, while others are less so.

In this project we have identified systems that are sensitive to particular fire regimes that result in permanent loss of species diversity, vegetation structural characteristics and habitat value. Such fire sensitive systems can also be described as 'fire regime dependent' ecosystems. The identification of ecosystem sensitivity is described within the Ecodistrict concept, based upon the disturbance response of vegetation communities and the development of habitat. Fire evading or fire-intolerant biota which may have persisted in refugial sites on the climatically buffered South Coast with the onset of increasing aridity in the Tertiary are also considered.

For some flora and ecological communities the threat imposed by inappropriate fire regimes may be direct, dependent on the life history strategies of particular taxa and the constituent species within communities. For some fauna the relationship between appropriate fire and habitat is somewhat more complex, and is likely to include the development and maintenance of habitat during intervals between fires. Many of the region's fire sensitive fauna have been shown to require a component of at least some old, structurally complex, long unburnt vegetation to maintain critical habitat.

Key aspects of any fire regime are fire frequency, intensity, spatial extent and season and the sensitivity of any system to fire is based on traits that render the system sensitive to any one or combination of these parameters.

4.1 Fire sensitivity - flora

Plant traits such as the ability to regenerate from a seed bank or resprout after fire are useful in predicting long-term changes in plant community composition after fire (Keith *et al.* 2007). Fire sensitive traits used to identify fire sensitive plant taxa include long juvenile period, thin bark, crowns close to the fuel bed, serotiny, and limited dispersal capability (Burrows *et al.* 1999).

Obligate seeders are readily killed by fire and germinate either from seed stored in the soil or on the plant in woody capsules (serotinous species). For obligate seeders, in particular serotinous seeder species, the time required to re-establish seed banks after germination is critical, if a second fire occurs before a population has produced sufficient seed it may decline or become locally extinct. Obligate seeders with a soil-stored seed bank may have large seedbanks capable of surviving a sequence of frequent fires. The juvenile period (time to first flowering after germination, usually based on flowering of 50% of a population) of obligate seeders can be used to estimate minimum fire intervals and provide a biological basis for quantifying fire frequency (Burrows *et al.* 1999). For example, Burrows and Friend (1998) classify fire frequency based on the juvenile period of the slowest maturing fire vulnerable species as ‘high’ (fire frequency is less than twice the juvenile period), ‘moderate’ (2-4 times), ‘low’ (4-6 times) and ‘very low’ (more than 6 times) the juvenile period.

Plants may be classified as resprouters if a significant number of established plants can survive 100% canopy scorch. Resprouter species are generally long-lived plants and have the ability to resprout from either epicormic buds on the stem, from rootstock buds (lignotubers) below the ground, corms, bulbs, rhizomes and tubers or from a terminal bud. Many resprouters are also capable of recruitment from seed and are termed facultative seeder-sprouters. Inter-fire recruitment where seed germinates and plants establish in the absence of fire may play a critical role in population maintenance for seeder and facultative seeder-sprouter species also, particularly where fire is absent for long periods.

There is evidence to show that the resprouter to seeder ratio varies among different habitats, changes in predictable ways along productivity gradients and may also relate to the natural frequency of fires (Huston 2003). For example, there are a higher proportion of reseeders in granite, montane communities and southern shrubland or kwongan compared with the northern kwongan and southwest forests, suggestive of less frequent fire regimes (Cowling and Lamont 1985a; Lamont and Markey 1995; Hassell 2001; Burrows and Wardell-Johnson 2003). In some plant communities on islands of the Recherché Archipelago there are no resprouters (Comer and Barrett unpublished data). In areas subjected to greater fire frequencies, fire sensitive species are usually confined to areas of unusual habitat, burnt less frequently than the surrounding landscape (Burrows and Wardell-Johnson 2003). Fire may have been a less significant selective force in the evolution of systems with high proportions of obligate seeder species (Yates *et al*. 2003b).

Key aspects of any fire regime are fire frequency, intensity and season. Plants respond differently to high versus low intensity fire. Intense fires may damage epicormic buds or lignotubers thereby causing death of resprouter species or consume viable seed in the soil or canopy. Intense fires in semi-arid woodlands can kill mature trees and it may take over 100 years for these woodlands to recover structurally. Intense fires can also destroy the soil structure of peat swamps. The presence of organic-rich systems that are relictual in nature in south-west WA is arguably the result of a long-term absence of inappropriate fire (Horwitz *et al*. 2003). Low intensity fire may fail to trigger the opening of woody fruits of serotinous species. Season of burn may have a considerable impact on obligate seeder species and seedling regeneration may be more successful after autumn burns as seedlings can establish during the wetter winter months. Fire interval, or the time between fires, may have a greater influence on biodiversity than fire intensity (Morrison 2002). Recovery after fire and the rate of accumulation of biomass are influenced by the proportion of seeder and resprouter species present. Areas high in resprouters may recover quickly after fire to reach pre-fire fuel levels in 10-20 years whereas seeder biomass continues to increase for up to 50 years and possibly beyond (Specht 1981).

Most of the fire-driven plant extinctions reported in the literature involve elimination of obligate seeders, in particular serotinous species in Western Australia, by frequent fire regimes (Gill and Bradstock 1995). However, rates of decline may be slower in resprouters and less easy to observe (Whelan *et al*. 2002). A critical ecological difference between serotinous species and those with a soil-stored seed bank is that serotinous species only persist for the life of the plant, while soil-stored seed may remain viable long after the parent has died. Serotinous species often have longer juvenile periods than species with soil-stored seed banks. Obligate seeders with canopy stored seed are at most risk from short inter-fire periods. Although there has been considerable research into serotinous species, relatively little is known of the demography, seed bank dynamics and post-fire seedling establishment of non-serotinous species. While many species appear to have persistent soil seed banks with fire-related dormancy, others can have transient seed banks and may be more vulnerable to frequent fire (Meney *et al*. 2001). It is apparent that systems and taxa that require disturbance to regenerate are also among those most affected by disturbance. Disturbance timing and frequency has great influence on species composition and the development of structure and habitat.

Woodland systems including moort and mallet woodlands are good examples of systems particularly sensitive to fire interval for both the creation and maintenance of the system, and for the development of structures suitable for fauna habitat such as hollows. The moorts and mallets, forms of eucalypts enemic to southwest Australia, are obligate seeding, usually small to medium trees that often form dense single age, and single or few species stands. Typical moort and mallet stands form following lethal disturbance where replacement plants grow first with mostly leguminous understorey pioneer plants, and over time develop again into mostly even age, species-poor stands. Several moort and mallet systems are inherently localised or restricted in occurrence and size, which together with their sensitivity to fire frequencies under 50 or so years makes them vulnerable to severe alteration, diminishment and loss (McQuoid pers. comm.). Other systems with dominant serotinous seeder species sensitive to frequent fire are Proteaceous mallee-shrubland and heath, *Allocasuarina* shrubland and mallee over *Melaleuca* systems.

4.2 Fire sensitivity - fauna

It is widely recognised that responses of fauna to wildfire are complex and varied, and that there is a difficulty in predicting the response of a single taxon or members of a community to a particular wildfire event, which in itself may be variable in terms of its impact on fauna habitat (Burrows *et al*. 1999; Whelan *et al*. 2002; Burbidge 2003). Many species of fauna are sensitive to fire due to their specialised habitat requirements, low fecundity or poor dispersal capacity or mobility. In addition, Clarke (2008) points out that some of the premises on which traditional fire management are based do not necessarily encompass the needs of fauna or result from robust scientific study; these being '(i) pyrodiversity supports biodiversity, (ii) organisms are more likely to cope with disturbance regimes with which they are familiar in an evolutionary sense, (iii) that we can use our knowledge of plant responses to fire as a basis for determining representativeness of seral stages in the landscape, and (iv) that burning over represented age classes or seral stages in particular vegetation types is reliable in producing under represented age classes'. Conversely, many species show great resilience to diverse fire regimes, benefiting from fire induced habitat regeneration or increased availability of food resources following fire (Burbidge 2003; Friend and Wayne 2003), and also benefiting from the reduced risk of large-scale, intense wildfire that is created by a mosaic of habitat age.

There has been limited research into the fire response of the fauna of the South Coast region, and in this work a number of species have been identified as fire sensitive either at the organism response level (e.g. Honey Possum *Tarsipes rostratus* that are sensitive to large and intense wildfires and frequent fires) or at the habitat level (e.g. Western Ground Parrot *Pezoporus wallicus flaviventris* that have a requirement for long unburnt habitat for breeding but younger vegetation for feeding). Included in the latter is the response of food or breeding habitat to inappropriate fire regimes, which are largely unknown. Optimal fire regime and patch size is unknown for most species in the South Coast region, although it is generally accepted that for most large scale intense wildfire is detrimental to population viability. A number of species found on the South Coast are considered to be post-fire opportunists, and generally flexible in terms of habitat and dietary requirements and breeding periods. Examples include the Quenda *Isoodon obesulus*, Ash-grey Mouse *Pseudomys albocinereus* and various species of Honeyeaters (Chapman 1985; Friend 1993; Chapman and Newbey 1994; Everhaardt 2003). Specific examples of fauna considered sensitive to particular fire regimes include the Noisy Scrub-bird *Atrichornis clamosus*, Western Ground Parrot and *Moggridgea* sp Stirling Range (Burbidge *et al*. 2007; Comer *et al*., 2009, Framenau *et al*. 2008; Gilfillan *et al*. in press). Appendix VII provides a summary of South Coast fauna species considered sensitive to fire to some degree, and where known the observed or hypothesised response to fire of the organism and habitat. In addition, specific species or functional groups are included in the descriptions of fire-sensitive systems where they are known to occur (Appendix V).

In attempting to design ecological fire management guidelines for 'sensitive' fauna in the South Coast region a number of factors should be taken into consideration, including information on population conservation status, distribution and the specific taxons' habitat requirements where known. Additional threatening processes may impact on individuals that survive a fire disturbance event, for example through increased predation, lack of food resources, lack of suitable habitat for reproduction or through the increased vulnerability of habitat to erosion events. Thus the capacity of populations to persist will also depend on both their immediate response to fire regimes**,** their resilience to post-fire pressures and their capacity to recolonise suitable habitat.

In general, species of note in terms of fire sensitivity are late successional species, species associated with fire sensitive habitats, which exist in discrete dispersed populations, have low fecundity or dispersal capacity and threatened or restricted species.

The following points should be considered in designing fire regimes for conservation of fauna on the South Coast:

1. Fire frequency, patch size and scale are a key to understanding fire response and persistence of fauna.

2. For small vertebrate fauna the post-fire response patterns can be predicted from their shelter, food and breeding requirements. Consideration of these factors and the suite of animals present will improve conservation outcomes.

3. Fire sensitive fauna species may have highly specific requirements for post-fire seral stages and burning regimes. Ultimately these will be the organisms which should guide introduced fire intervals.

4. Opportunities to fill research gaps should be taken, in particular understanding relationships between fauna life history characteristics, habitat characteristics (including nesting, breeding and food resources) and response to fire regime factors such as fire intensity and mosaic grain size.

5 IDENTIFICATION OF HIGH PRIORITY FIRE SENSITIVE SYSTEMS, INFORMATION ON PRIORITY SYSTEMS AND THREATENED TAXA WITHIN SYSTEMS AND THEIR RELATIONSHIP WITH FIRE

Based on the literature review, the fire sensitivity attributes discussed above in Sections 4 and the collation of information on fire responses in the South Coast region, 80 fire-sensitive systems were identified in consultation with local experts and land managers (Appendix IV**)**. Many of these systems, however, share characteristics and species across Ecodistricts. This list is preliminary in nature and may be added to or subtracted from as additional knowledge is gained. The 'precautionary principle' has been applied, as from the literature review it is clear that our knowledge of ecosystem function and fire responses is far from complete. Therefore, some systems have been listed where it was considered that a threat is posed by inappropriate fire based on ecosystem characteristics but with limited empirical or other supporting data.

Inappropriate (usually frequent) fire regimes have the potential to have long-term adverse impacts on species persistence, floristic diversity, community structure and fauna habitat values in these sensitive systems. Objectives and outcomes in relation to fire management must demonstrate how these systems will be benefited or that ecosystem processes are maintained to ensure the persistence of individual elements, alpha and beta diversity, structural integrity and habitat values.

The following criteria were used to characterise fire sensitive systems on the South Coast:

- Plant structural formations dominated by serotinous seeder species
- A high diversity of serotinous seeder species
- Forests, woodlands and other systems sensitive to intense fires
- Refugial habitat including wetlands and granite systems
- Relictual fauna
- Fauna sensitive to frequent, intense or extensive fire or requiring specific fire regimes
- Geographically restricted communities, and
- Species sensitive to additional threatening processes interacting with fire, including plant disease and feral animals.

Woody plant communities containing a high proportion of species capable of resprouting generally indicates a moderate frequency of fire rather than a high or low frequency (Burrows *et al*. 1999). Systems that were considered to be able to persist under a relatively broad range of fire regime variables (scale, interfire period, seasonality and intensity) included peppermint *Agonis flexuosa* woodlands and coastal shrubland in the Coastal Dynamic Ecodistrict and woodlands (e.g. Jarrah *Eucalyptus marginata*, Marri *Corymbia calophylla*, Sheoak *Allocasuarina* spp) on laterite and sand over laterite in the Forest Mosaic and Northwest Mosaic. While fire sensitive flora species occur within these systems and require consideration, overall they comprise a higher proportion of resprouters. In addition, some fauna species occurring in these systems may have specific fire regime requirements, but do not occur in the sensitive vegetation systems outlined in this report. The habitat requirements of these fauna species should be considered separately. Systems such as salt-lakes dominated by succulents were considered to be at lower risk due to their very low flammability. It was beyond the scope of this project to identify all systems considered to be relatively resilient to fire.

The majority of vegetation systems identified as sensitive were those dominated by serotinous seeder species which are vulnerable to too frequent fire. In addition, several wetland and riparian systems with dominant resprouters species were identified as sensitive to intense fires as were drier woodlands systems e.g. Transitional woodlands. Other systems sensitive to intense fire included peat and organic soil communities, cryptogram communities and those habitats with refugial fauna species.

Appendix V briefly describes each system in terms of vegetation structure, the Eco-district where it occurs and key structural and fire sensitive species are highlighted as well as the response to fire and rate of maturation of fire sensitive species where known. The comprehensiveness of these species lists varies considerably between systems and according to the authors' knowledge and available information and are not complete lists. Detailed descriptions of the vegetation of each system were beyond the scope of this project given the region's floral diversity and lack of sufficiently detailed vegetation mapping. However, Fig. 2 shows how mapping of the Ravensthorpe Range (Craig *et al*. 2008) can be used to identify fire sensitive systems.

The fire sensitive flora species documented in this report are largely dominant overstorey and shrub species from the families dominated by serotinous species, the Proteaceae and Myrtaceae. Species with longer juvenile periods are typically those with canopy-stored seed and these are often taller, thicket forming or key-stone species that provide habitat for fauna (Burrows *et al*. 2008a). In addition short range endemic flora including Threatened flora that are vulnerable to stochastic environmental disturbance such as fire have been included.

Fire sensitive fauna include late successional species, species associated with fire sensitive habitats, fauna with limited dispersal capacity, relictual invertebrates and threatened or short range endemic species.

Information on the response to fire of Threatened and Priority flora is provided in Appendix VI Threatened fauna in Appendix VII. Case studies and observations on fire sensitive mallet, moort and woodland ecosystems are provided in Appendix VIII.

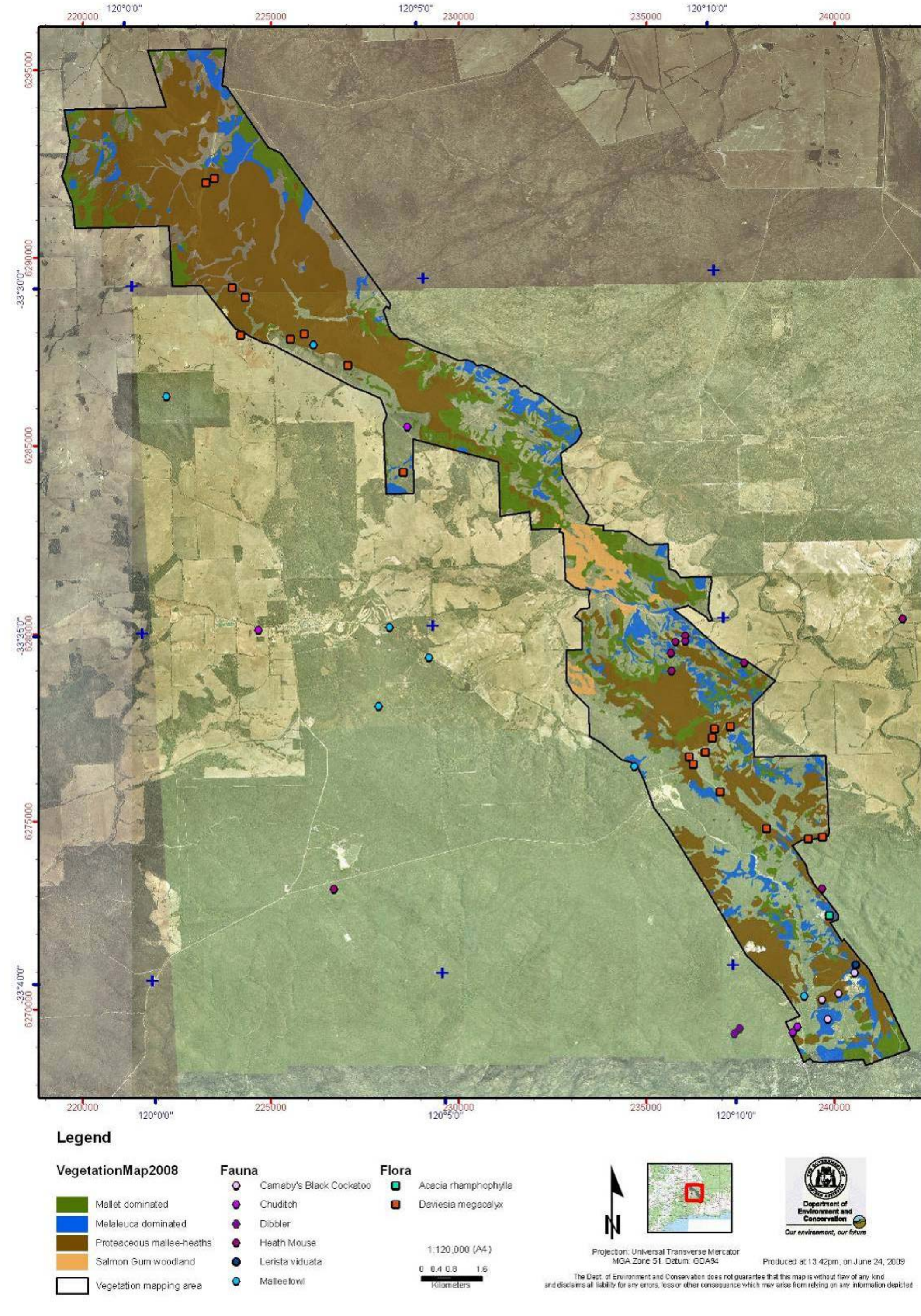


Figure 2. **Ravensthorpe Range vegetation units and species sensitive to fire (adapted from Craig et al. 2008).**

In Appendix V, plants are classified as either obligate seeders with a canopy or soil-stored seed bank, resprouters, or facultative resprouter / seeders. Maturation times for fire sensitive species, using post-fire recovery and flowering (where time to first flowering is based on 50% of a population flowering), are classified as rapid (< 3 years), medium (4 - 6 years) and slow (>6) (adapted from Hassell 2001). 'Slow recovery' species are typically reseeders that were emergent or dominant species and individuals of these probably have a greater structural influence within the vegetation (Hassell 2001). It should be noted that the recovery times as described are only based on the commencement of rebuilding plant reserves and flowering and seed production. The time needed for the establishment of seed banks and reserves sufficient to ensure survival from subsequent fires is considerably greater. A minimum tolerable fire interval period of twice the juvenile period of the slowest maturing seeder species in a community has been recommended (Gill and Nicholls 1989; Burrows and Wardell-Johnson 2003; Burrows *et al.* 2008a). In fire sensitive habitats this may be increased to 3-4 times the juvenile period for fire sensitive species (Shedley 2007). The relationship between time since fire and seedbanks is not necessarily linear. For example, a slow growing species such as *Hakea corymbosa* may take 20 years to replace its seed bank with viable seed numbers fluctuating with time (Lamont 1985) while *Banksia nutans* plants at over 40 years in the Fitzgerald River National Park were still increasing their canopy seed bank (Wooller *et al*. 2002). Consequently, a precautionary approach would be to sample canopy seed banks of slow maturing serotinous obligate seeders prior to application of prescribed fire, rather than rely on simple rules of thumb or extrapolation from data from other locations or seasons (see Appendix V).

Observations of inter-fire recruitment or senescence were not included in the database but would be a useful addition for ongoing data collection.

These responses have been compiled from the authors' observations in the South Coast region, the observations of other botanists, from published and unpublished South Coast and Southwest data as well as from the DEC Fire Response Database. The full database for this project gives locational data and sources. While much of the data has been recorded from the South Coast and from the relevant Ecodistrict, other data has come from outside the region and therefore all responses and maturation times should be regarded as indicative only. In addition responses may vary across the region and between years.

Limitations to simple fire response systems should be acknowledged as ecotypic factors, climate and fire intensity can produce variable fire response (Clarke and Knox 2002). The primary juvenile period for any species may also vary considerably across a geographic region and also between fire events depending on factors such as the annual rainfall in the subsequent years after fire (Shedley 2007), soils and competition with co-occurring plant species. Whelan *et al*. (2002) notes that fire-response patterns are site and fire-specific and that it is important to consider also life-cycle processes that produce patterns of fire response.

Recommendations for the management of these systems are provided in Section 10 below, systems with shared characteristics are treated together.

6 INFORMATION ON PAST AND CURRENT FIRE MANAGEMENT PRACTICES AND PLANS INCLUDING PLANNED FIRE AND WILDFIRE SUPPRESSION

6.1 Past Practices

Prior to 2000, fire management was primarily driven by Departmental policy (e.g. Policy Statement No 19) and the Fire Operations Manual which continue to guide fire management today.

Wildfire Suppression

With the formation of the Department of Conservation and Land Management in 1986 this element of fire management was specifically guided within Regions and Districts by the preparation of an annual Wildfire Response Plan.

The first priority for wildfire suppression was and still is based upon the protection of life and property values as prescribed in the DEC Corporate Plan (2007). The South Coast region was divided into three zones of response according to the significance of life and property values and the capacity to respond to individual fire events. Zone A is largely coastal extending about 100 km inland, and encompasses areas of high public use with a ready response capability by DEC and Bush Fire Brigade resources. Zone C has a low degree of public use and a low response capability. It includes remote woodlands and salt lakes north west and north east of Esperance and the Nullarbor Plain to the east. Zone B occurs between Zone C and Zone A and has an intermediate degree of public use; fires can be responded to in a limited fashion. Wildfires have been managed (when fire behaviour conditions allowed) by direct attack within the A and B zones, in particular adjacent to built up areas within the agricultural landscape. However, there was historically limited use of direct attack on wildfires in Zone C and as a result large areas of the landscape within Zone C often burnt extensively. Initial wildfire suppression response on Unallocated Crown Land (UCL) has been the legislative responsibility of local government with assistance from the Fire and Emergency Services Authority (FESA)

Planned use of fire

With the formation of the Department of Conservation and Land Management in 1986 planned fire operations were driven by Departmental policy, the CALM Act (1984), management plans and Interim Management Guideline documents. Other Government Agencies and local community input was sourced through the establishment of Fire Working Groups for selected National Parks. These groups ensured that local knowledge on values, weather patterns and fire (both wildfire and planned fire) were incorporated into planned activities by the Department of Conservation and Land Management. The development of burn prescriptions were developed by internal planning processes which were then discussed with the Fire Working Groups. Planned fire operations were generally focussed upon the creation and maintenance of low fuel zones that would assist in limiting the potential extent of wildfires. These areas generally constituted “buffers” around the perimeter and strategic firebreaks within key reserves, as well as firebreaks adjacent to recreation sites and other high value sites and structures within reserves. These low fuel zones had some ability to provide longer term protection to internal portions of reserves. Initiatives using planned fire within broad landscapes were made in the late 1980’s and early 1990's using aircraft and ground based perimeter lighting techniques. These initial attempts were never fully progressed into regular operational activities due to limitations on the required additional funding and resources. However, staff within the Esperance District in the 1990’s continued to refine the technique of ground based wind driven strips, with approvals drawn from Interim Management Guidelines and burn prescriptions. These operations proved to be very successful and on a number of occasions resulted in very strategic outcomes for the containment of wildfires.

6.2 Present Practices

Current practices continue to be guided by Policy Statement No 19 and additionally the Code of Practice for Fire Management (2008), Fire Management Guidelines, Fire Operations Guidelines Manual, Management Plans, the Good Neighbour Policy (2007) and more recently the Draft Regional Fire Management Plan (2009). The same system of zoning is used with Zone A now having an increased fire suppression capacity, some sound but limited suppression in Zone B and still a reactionary suppression in Zone C based on values at risk. Zone A has an annual fire protection program; Zone B and C have a limited annual protection program. The potential impact of Phytophthora dieback is recognised in each zone with the greatest impact in the higher rainfall Zone A. More information on the interactions between Phytophthora dieback and fire is provided in Appendix III.

Wildfire Suppression

In recent years there has been an increased allocation of ground and aerial resources to deal with major wildfire events. Increasingly wildfires are being contained by direct attack methods as conditions allow across all of the Wildfire response zones defined within the South Coast region. However, in Zone C there may still be limited intervention depending on the values at risk, the availability of resources, existing DEC commitments and the remoteness of the area. Some fires (once evaluated) may also be left to run their course in the anticipation that they will be naturally contained if old fires scars are present and or areas of less flammable vegetation such as the Transitional Woodlands and Salt lake systems. In addition, much of this area is UCL where fire mitigation measures, excluding wildfire suppression, have been the responsibility of DEC.

The need for increased intervention in wildfires in Zone B and C has been recognised due to the presence of localised, highly significant biodiversity assets and increased fuel loadings within the landscape and drier seasonal conditions. This multi-decadal drought condition may be a reflection of long term climate changes.

The potential for ‘remote’ fires to travel significant distances and impact on the assets associated with the settled districts and utility corridors such as major highways contributed to the decision to increase the region’s suppression capability. The potential for significant adverse impacts on biodiversity and life and property values without early intervention were recognised e.g. the Lake Tay fire of 2003. This fire, which started in a remote area approximately 100 km north-east of Ravensthorpe, was left to run its course for several days during which time it spread significantly and ultimately threatened the town of Ravensthorpe, the biodiversity of the Ravensthorpe Range and the Bandalup corridor. Deliberate containment of large fires will enable extensive tracts of landscapes to remain unaffected by wildfire, enabling them to act as refugia and sources for recolonisation of burnt areas. It will also provide protection to populations of threatened species. An undesirable situation could develop if all fires are contained to relatively small areas and there is limited capacity to carry out strategic prescribed burning. This would result in extensive contiguous areas of even aged or long unburnt vegetation, carrying high fuels loads that will burn with very high intensity under wildfire conditions with a limited likelihood of containment by direct fire suppression operations. This is not a desirable outcome for biodiversity as it reduces diversity across vegetation types and increases the risk of very large areas burning in a single event.

In many cases suppression of wildfires involves burning of large blocks of country to achieve containment. Lack of access tracks (e.g. in Great Western Woodlands), inaccessible terrain, extreme fire behaviour, cost and resource availability and the risk of introducing Phytophthora dieback or disturbing environmentally sensitive areas limits the opportunity to implement direct-attack strategies (building fireline using earth moving machinery directly on the fire edge).

Sustainable and ecologically acceptable wildfire risk mitigation may be achieved in some remote areas by establishing and maintaining a mosaic of fire ages across the landscape to minimise the likelihood of single wildfire events burning large areas. If a mosaic of fire ages can be created in the landscape, as well as strategic firebreaks from which indirect attack can be implemented, there will be more opportunity to prevent large contiguous areas from burning.

Planned use of fire

The use of planned fire is guided by the Principles of Fire Management, the Regional Fire Management Plan, Area Management Plans, Interim Management Guidelines and Fire Management Guidelines with local area community input being derived through Fire Working Groups and community workshops. These deliberations result in the development of an annual Regional and District Master Burn Plan. The Master Burn Planning Manual (April 2009) outlines the principles used in determining an appropriate fire regime. This includes using life history attributes to identify the range of inter-fire periods suitable for key species within particular systems. It identifies limitations to burning conditions in terms of season and fire intensity as well as limitations to the spatial extent of any individual fire. The Master Burn Planning Process identifies Condition Burning Areas (CBA) for areas that require either exclusion from fire or require burning in a particular way. There are eight types of CBA’s four of which are relevant to the South Coast:

1. Fire Exclusion – Reference Area: An area from which fire has been deliberately excluded to provide a reference site for scientific studies of the effects of fire on the environment. Areas selected should be broadly representative of the landscape within which they are located. These areas have value for scientific study because they are long unburnt.

2. Scientific Study Area: Is an area in which scientific study is being undertaken and for the period of that study is not to be burnt or burnt as per the study requirements.

3. Fire Exclusion – Habitat: An Area identified as having special value as fauna or flora habitat due to its vegetation structure, species composition, seral stages, niche values or location.

4. Specified Management Regime: Is an area identified in a gazetted Management Plan or Draft Management Plan that has been assigned a specific fire regime for a specified purpose.

In recent years there has been a significant step towards the development of Fire Management Strategies (e.g. the Draft Stirling Range Fire Management Strategy (Barrett *et al.* 2006)) for key reserves which considers biodiversity as well as life and property values, past fire history and for the first time and most importantly life history attributes of key flora and fauna species.

Low fuel zones are being increasingly established through the fuel reduction of strategic strips which can be established either by utilising modified hand or aerial lighting techniques, using the scrub rolling technique and/or establishing slashed breaks in strategic areas. The establishment of these low fuel zones facilitates the more extensive use of planned fire across the landscape using either aerial ignition or wind-driven strips. This will assist in the creation of mosaics across the landscape in order to protect biodiversity values and reduce the size and intensity of wildfire events. These low fuel zones through a sound fire management planning process should be strategically located to avoid sensitive ecosystems and aim to protect the more fire sensitive systems. The adverse impact of creating and maintaining these strategically located low fuel areas, for example the possible reduction of populations of reseeder species, must be carefully weighed against the potential impact of large scale intense wildfires. Similarly, the effectiveness of low fuel zones in reducing the impact of wildfire should be monitored and evaluated

7 ANALYSIS OF PLANNED AND WILDFIRE HISTORY

Fire history records were collated for the South Coast region from information sources that included the Department of Environment and Conservation, Gondwana Link and Alison O'Donnell (UWA PhD student provided data from the Lake Johnson area). Fire history records were reasonably complete for the conservation reserve system, but less consistently so for areas of remnant vegetation in other reserves or on private property. For this reason much of the analysis was not able to be completed at the Ecodistrict level. An estimate of the completeness of the records was made and approximately 66 percent of the remnant vegetation in the region had good fire history records for the 33-year period 1975 to 2008.

The level of accuracy of fire recording is variable, with some fire scars digitised from satellite imagery (e.g. O'Donnell) providing good representation of the fire patchiness while others are less accurately plotted and are unlikely to reflect patchiness if present in a particular fire event. The accurate recording of fire boundaries is significant in terms of mosaic or patch sizes for fauna recolonisation and for understanding post fire recruitment patterns in ecosystems. It is essential therefore that fire history maps for key conservation areas are updated from remote sensing (see Section 9 General Recommendations and Guidelines). The level of recording of the cause and season of fire is also patchy with many records lacking these attributes. It is possible that this data could be found on paper fire records, but it was beyond the scope of this project to collate this information.

The Northwest Mosaic and Coastal Dynamic Ecodistricts were not included in the analysis. The raw data used for the analysis is presented in Appendix IX, as this is the first attempt at an analysis on this scale, some caution should be used when interpreting the data, maps and graphs presented

7.1 Cause of Fire

An analysis of cause of fire by Ecodistrict (Fig 3) shows that the majority of fires (>70%) were wildfires in the Albany-Fraser Inland East, Albany-Fraser Islands, Esperance Sandplain East and West, Mallee Lakes and Nuytsland Ecodistricts. Wildfire, as defined for this study, was unplanned fire mainly due to lightning strike but also included arson and escapes from private property.

In the remaining seven Ecodistricts, prescribed burning formed a significant component of all fires, in the order of 40 to 70 %. High percentages of prescribed fire (71%) in the Yilgarn East Ecodistrict may be largely attributable to 71% prescribed fire in the Fitzgerald River National Park (FRNP); similarly for the Quartzite Ecodistrict the 78% identified may be due to prescribed fire primarily in the Stirling Range National Park (SRNP). More regular prescribed burning in the forested areas contributes to high levels of prescribed fire in the Forest Mosaic and Albany Fraser West Ecodistricts.

Overall there was a trend of increasing proportion of wildfire over prescribed fire from west to east and in more remote and less populated areas.

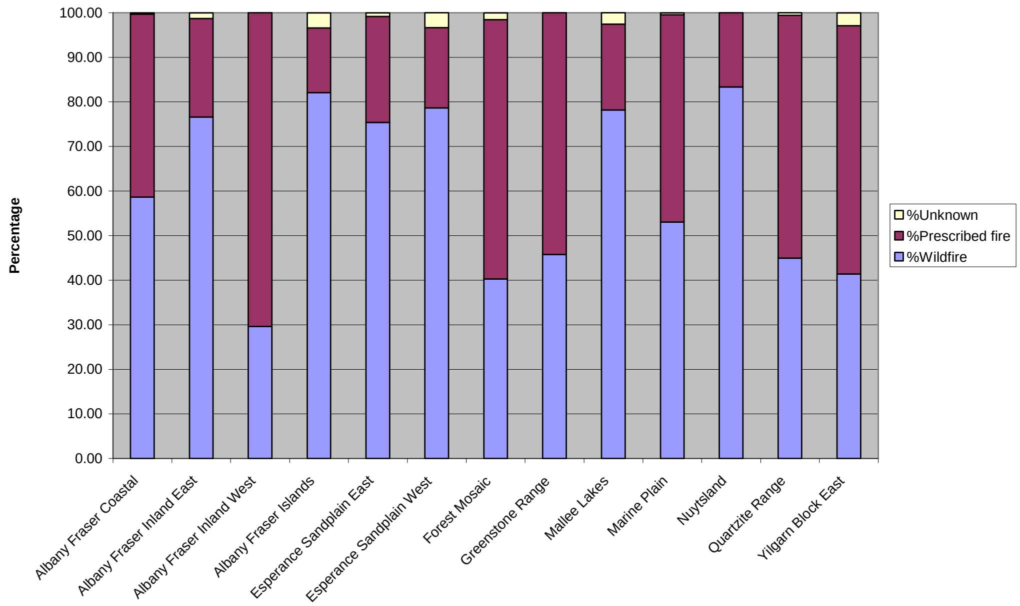


Figure 3. **Fire events (%) by cause of fire for 13 Ecodistricts in the South Coast region 1975-2008. (Note: Some fires recorded as prescribed may have originated from arson)**

7.2 Season of fire

The seasonal breakdown of fire by Ecodistrict indicated that the majority of fires occurred over summer and autumn with a smaller proportion (< 25%) occurring in spring. The exceptions were the Forest Mosaic and Albany Fraser West Ecodistricts where more than 30% of fires occurred in spring (Fig 4). This was probably associated with a greater incidence of prescribed burning in spring in these Ecodistricts. The season of fire was unknown for a considerable proportion of fires across Ecodistricts but particularly so for the Albany Fraser Inland and Mallee Lakes Ecodistricts.

7.3 Fuel Age Distribution

The fuel age distribution was examined for the region as a whole (Fig. 5) as well as for some of the larger DEC managed reserves in the region (Cape Arid National Park-CANP, FRNP, SRNP, Two-Peoples Manypeaks - 2PB-MP) (Figs 6-10) as well as the section of the Great Western Woodlands (GWW) occurring within the region. In the future, this analysis would ideally be extended to other major reserves in the region.

The fuel age distribution for the region as whole has major peaks at 20, 11 and 1 year-old fuel and therefore an uneven distribution across age groups. This uneven distribution applied for the major parks and areas analysed across the region. CANP had a distribution characterised by predominantly younger fuels (e.g. a 6 year-old peak of almost 140,000 ha) with a smaller peak of 19 year-old fuel and a relatively small proportion (<40,000 ha) of old (> 35 year-old) vegetation. The SRNP was also characterised by predominantly younger (<14 year old) fuels, and relatively less >35 year-old vegetation (10,000 ha). Similarly, 2PB-MP had a ‘young’ (< 10 year-old) fuel age distribution with peaks in 4, 6 and 9 year old fuel. The fuel age in the FRNP was more evenly distributed but with a major peak in 20 year-old fuel (>70,000 ha), there was also a smaller peak in > 35 years vegetation (>50,000 ha). In contrast, the GWW had an ‘old’ fuel age distribution dominated by > 35 year-old fuel (almost 4.5 million ha).

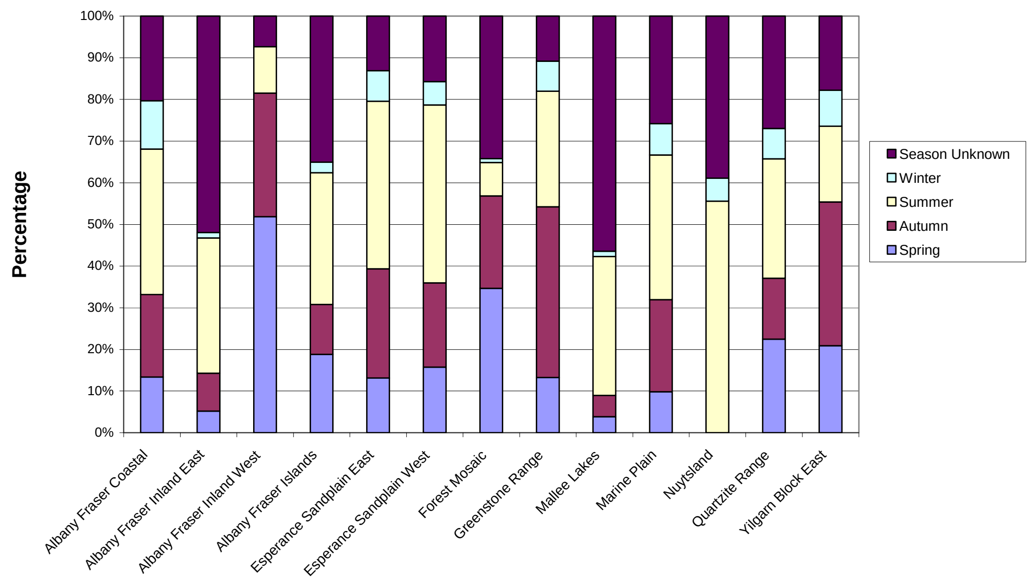


Figure 4. **Fire events (%) by season for 13 Ecodistricts in the South Coast region 1975– 2008.**

The concentration of fuel ages as seen above into a relatively small number of age classes may have implications for fauna species that need a diversity of fuel ages. However, the optimal habitat requirements in terms of fire age diversity for most fauna species on the South Coast are unknown (see Section 8, Recommendations for fire ecology research).

The CANP, SRNP and 2PB-MP distributions roughly approximate the shape of the ‘optimal age structure’ modelled by Tolhurst and Friend (2003) and McCarthy (2001) with a greater proportion of fuels in the younger age group. In terms of conservation outcomes, this may be a desirable state for e.g. forest systems where regular low intensity burning may reduce the incidence of damaging intense fire. However, the above parks and much of the South Coast region contains banksia shrublands, heath and other systems sensitive to frequent fire and therefore require longer fire intervals. In addition, older vegetation can be burnt to create younger seral stages but older vegetation cannot be created from younger. The age structure of these models may therefore be detrimental for conservation outcomes. Most fire age distribution models have been based on fire responses in forested areas compared with, for example, heath and transitional woodland systems where fire intervals in the order of 50 to 300 years may be desirable.

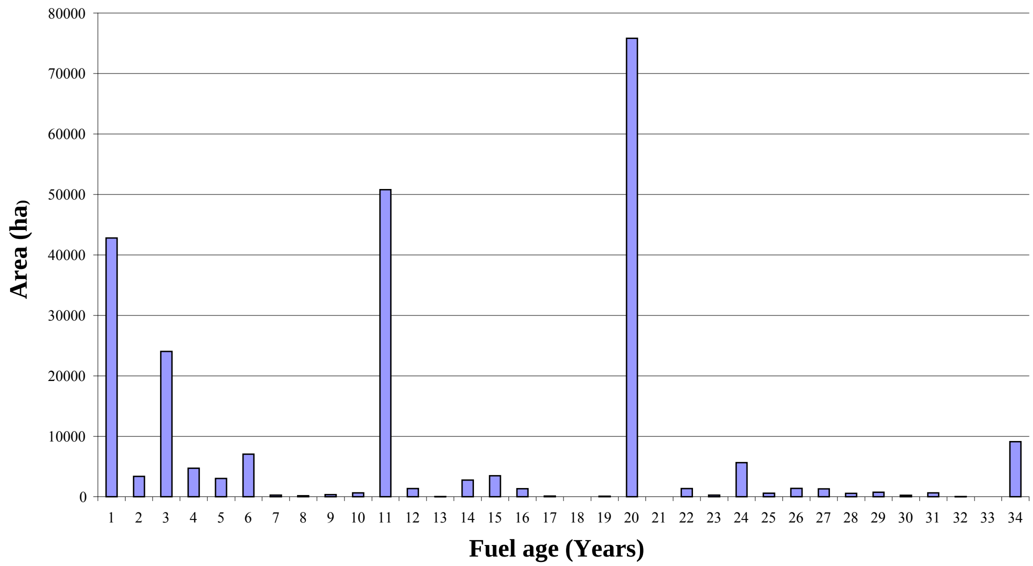


Figure 5. Fuel Age Distribution South Coast region.

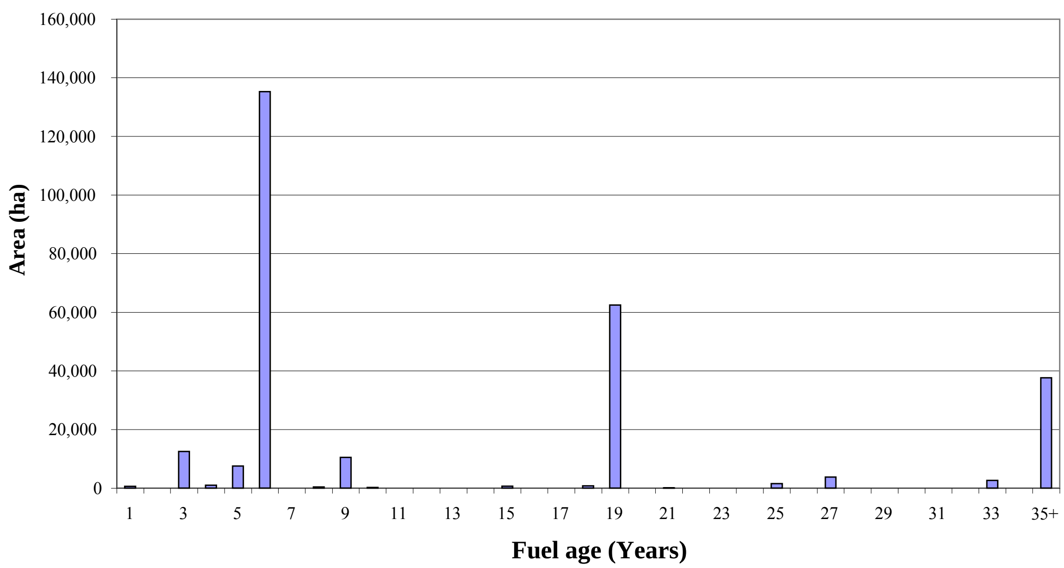


Figure 6. Fuel age distribution Cape Arid National Park.

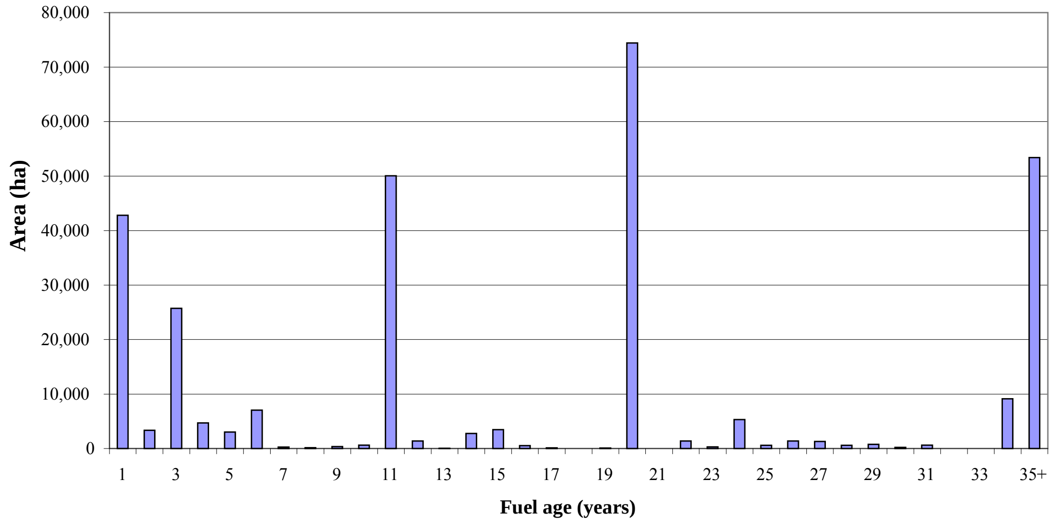


Figure 7. Fuel age distribution Fitzgerald River National Park.

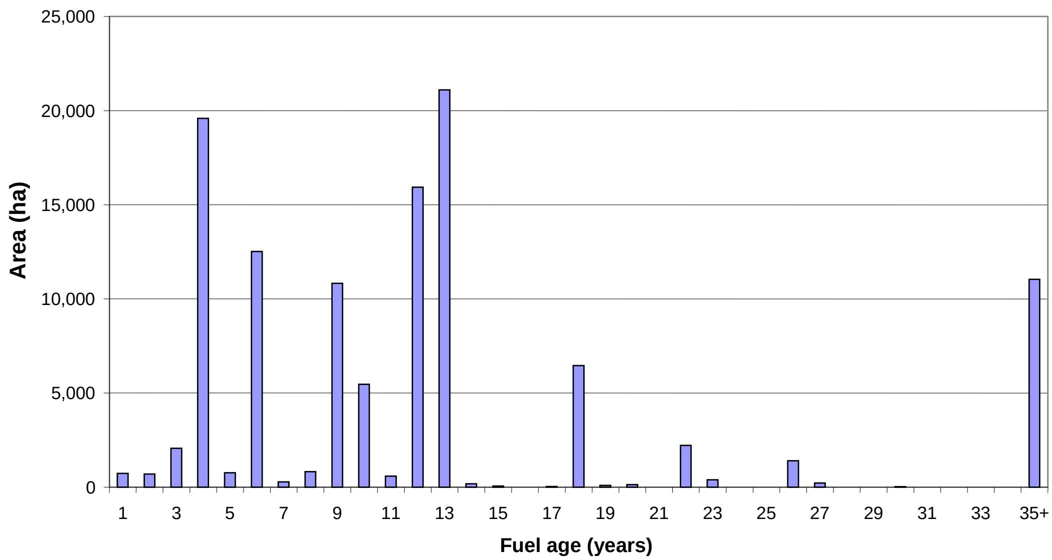


Figure 8. Fuel age distribution Stirling Range National Park.

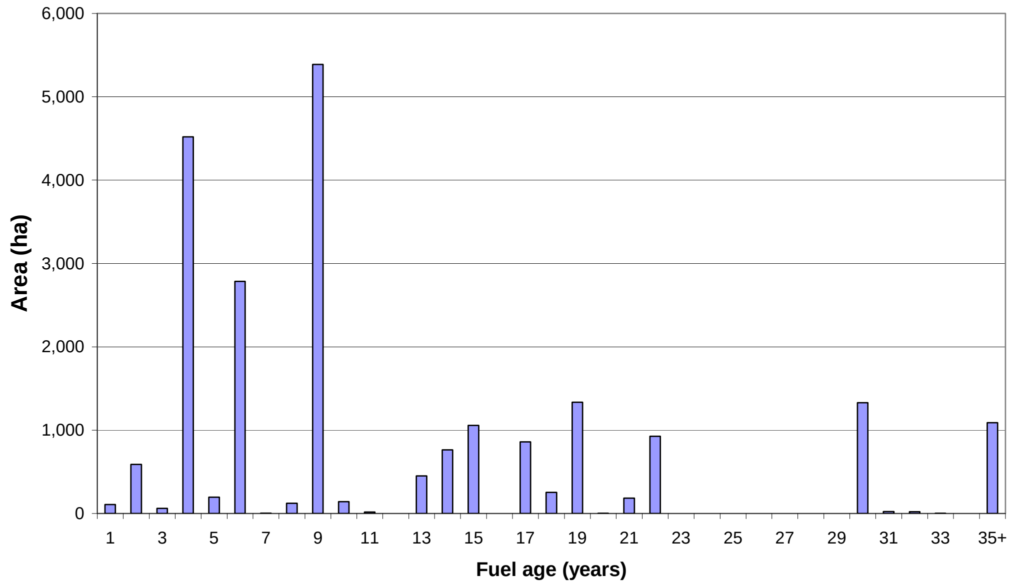


Figure 9. Fuel age distribution Two-Peoples Bay - Manypeaks

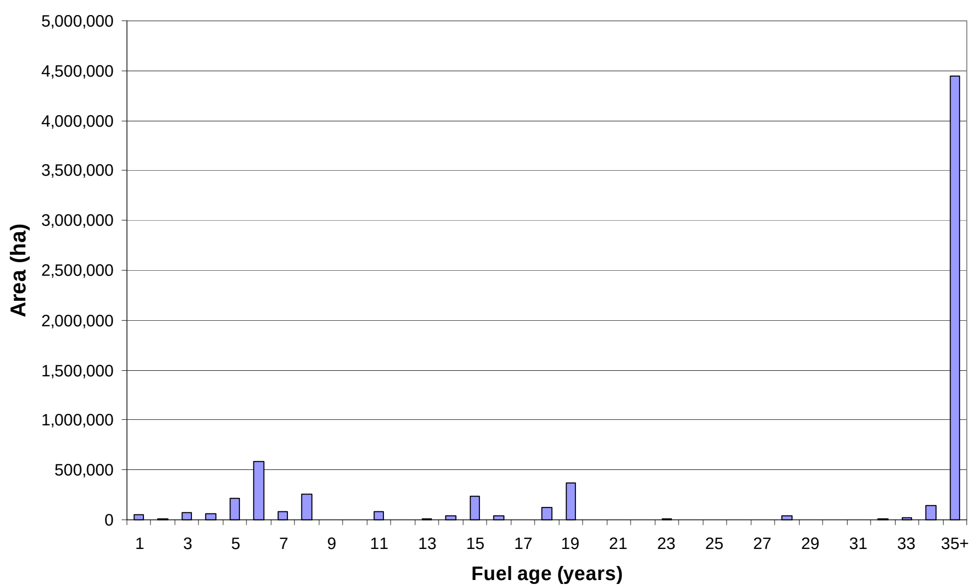


Figure 10. Fuel age distribution of Great Western Woodlands within South Coast NRM region.

7.4 Fire frequency

Fire frequency was analysed for the major parks across the project area and the section of the GWW within the region. The study period ranged from 29 to 32 years for CANP, SRNP and 2PB-MP, 38 years for FRNP and 47 years for the GWW. More than two thirds of the total area of these reserves and UCL were in the 1 to 2 fire frequency category with the exception of the GWW (36%). Less than 15% of the area of CANP, SRNP and 2PB-MP had no fire recorded in the 30 year period compared with 17% of FRNP over 38 years and 61% of GWW over 47 years (Figs 11-15).

Of some concern for systems to vulnerable to frequent fire are areas where there have been three or more fires, the majority of which were intense large scale fires or 'stand-replacement' fires, within the last 30 or so years. This comprised 16 % of the SRNP, 12% of CANP, and > 8% of 2PB-MP. For example, much of the eastern Stirling Range burnt in 1972, 1991 and 2000. There were considerably lower percentages of area in the > 3 category in the FRNP (3% in a 38 year period), and GWW (1.4% in a 47 year period).

Of additional concern are areas that have burnt four times or more in the last 32 years in CANP (Fig. 16). For example, approximately 5000ha (almost 2%) has burnt four or more times in the past 33 years in the area to the southeast of Mt Arid, with intervals of eight, seven and thirteen years between fires. Existing survey areas sites in CANP (Fig. 15) provide an excellent opportunity to understand the impacts of fire frequency and interval on the structure of specific systems. In this case, the proteaceous heaths rich in serotinous seeder species such as *Banksia* and *Hakea* may have been altered by the two short return intervals i.e. eight followed by seven years. Therefore re-surveying historical monitoring or survey sites can provide an important insight into plant community responses (see Section 8, Recommendations for fire ecology research). Similarly, frequency data across the region can be used for chronosequence studies in a range of fire sensitive systems.

A fire frequency of 2 in a $\pm$ 30 year study period for these reserves may also have an adverse impact e.g. on serotinous species, depending on the actual interval between these fires e.g. 30 years versus 10, and further interrogation of the GIS data will allow some determination of fire history return intervals for areas with multiple fires recorded in the study period.

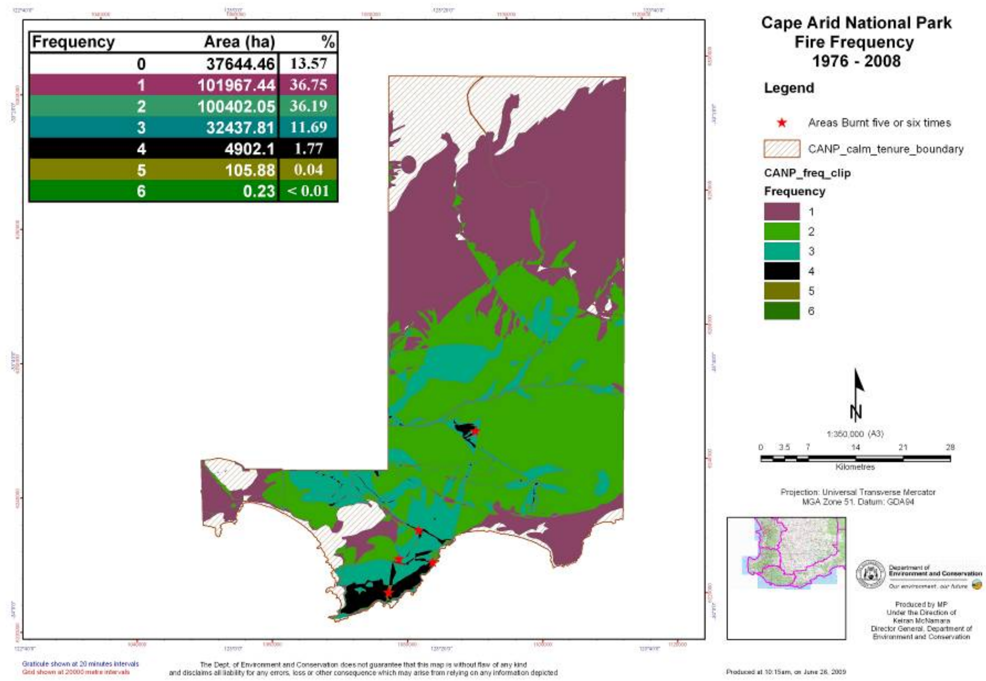


Figure 11. **Fire frequency Cape Arid National Park 1976-2008.**

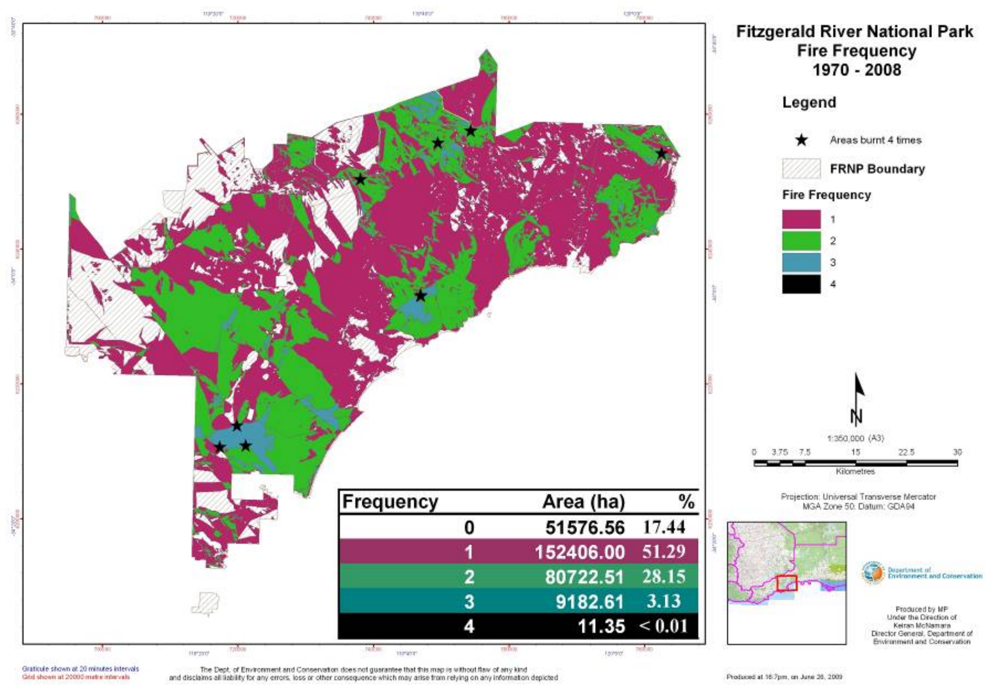


Figure 12. **Fire frequency Fitzgerald River National Park 1970-2008.**

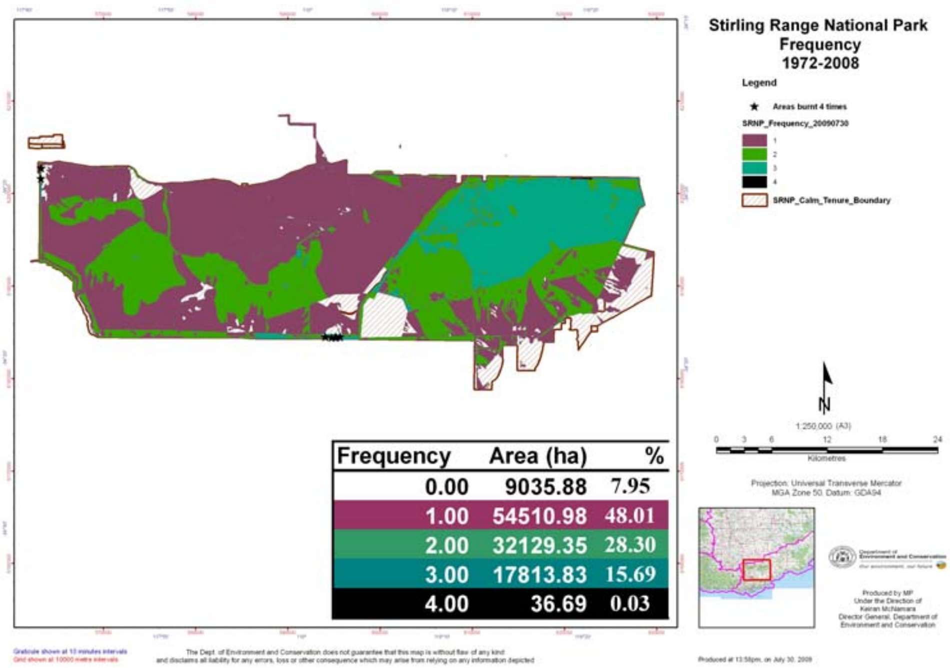


Figure 13. **Fire frequency Stirling Range National Park 1979-2008.**

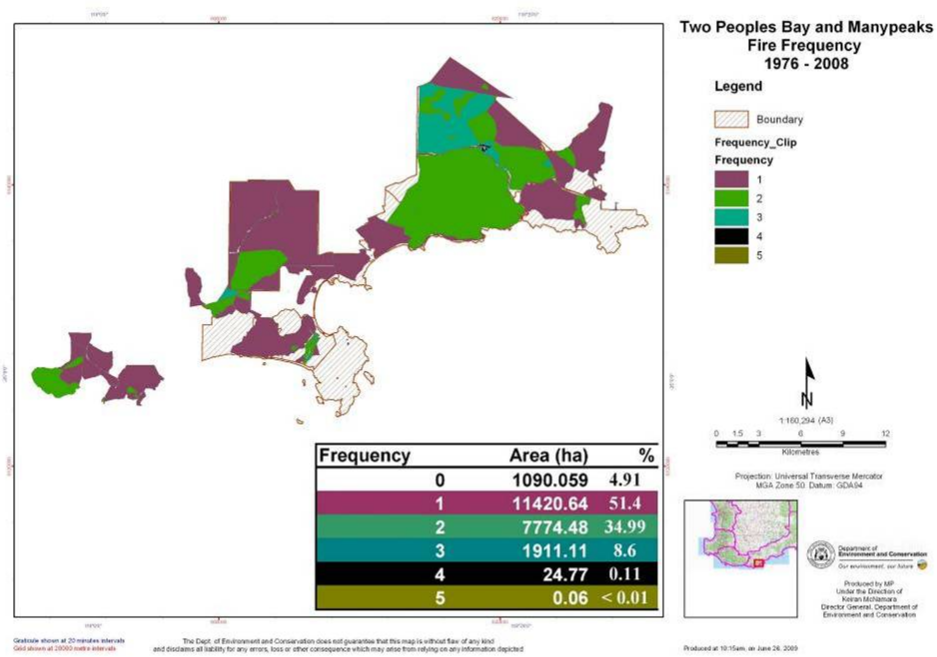


Figure 14. **Fire frequency Two-Peoples Bay - Manypeaks 1976-2008.**

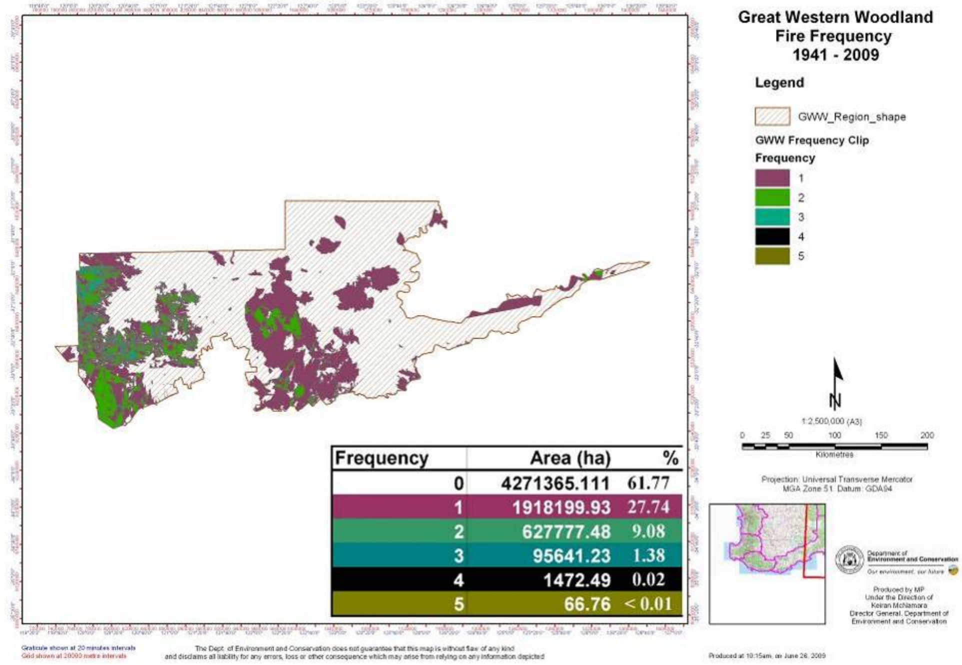


Figure 15 Fire frequency Great Western Woodlands within SCNRM region 1941-2008.

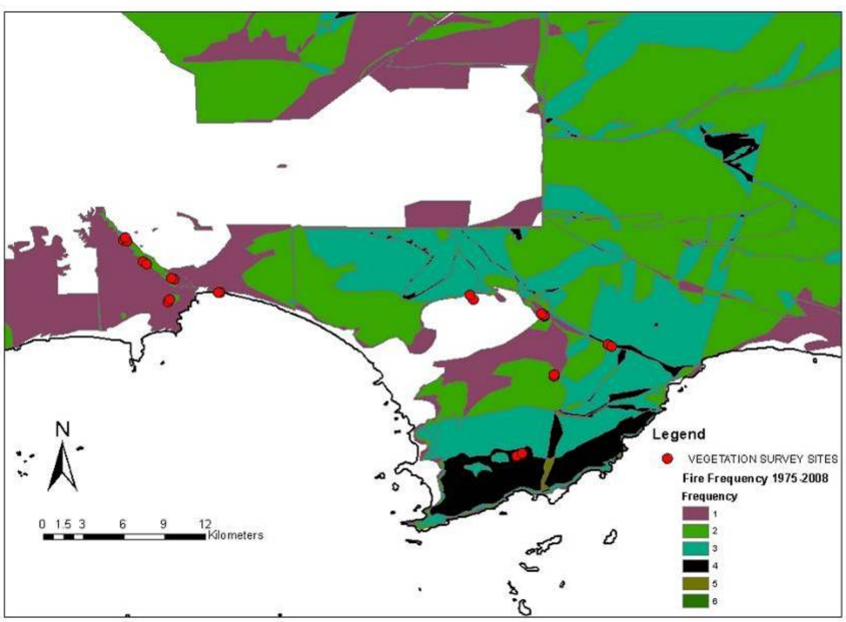


Figure 16 Areas with a fire frequency of four or higher, Cape Arid National Park.

7.5 Area burnt annually

The number of fires and the total area burnt annually across the South Coast region are presented in Fig. 17. Overall there was an upward trend in both incidence and area. These area statements do not include unburnt areas within fire scar boundaries that can be identified by using remote sensing to capture fire boundaries.

The area burnt each year from 1975 to 2008 in CANP, FRNP, SRNP, 2PB-MP, the Forest Mosaic Ecodistrict and GWW (Figs 18-23) does not show a clear trend and the 33-year period of analysis may have been insufficient for this purpose. For the national parks assessed, there was a relatively even and intermittent distribution of fire activity over the period with occasional large spikes in fire activity at intervals e.g. FRNP: 120,000 ha burnt in 1989, CANP: >120,000 ha in 1982 and 2003, and 2PB-MP: 9,000 ha in 1979. In contrast, the GWW showed a trend towards an increase in area burnt over the period with some 300,000 ha burnt in 1975, 400,000 ha in 1990 and almost 600,000 ha burnt in 2003. Interestingly, the 1961 Rodger Royal Commission refers to very extensive fires, possibly in the order of 1,000,000 ha, in the Balladonia area in 1961 which is outside and east of the South Coast region.

The SRNP demonstrated a more regular occurrence (<10 years interval) of large fires events in the park and again some trend towards an increase in area burnt with 25,000 ha burnt in 1983, >25,000 ha in 1991 and almost 35,000 ha in 2000.

The Forest Mosaic had the most regular pattern of fire with in the order of 20-50,000 ha burning annually with a major spike of 100,000 ha in 2002.

Investigation of the relationship between climate and fire events in this period would be a useful and informative exercise as well as an evaluation of trends in all Ecodistricts.

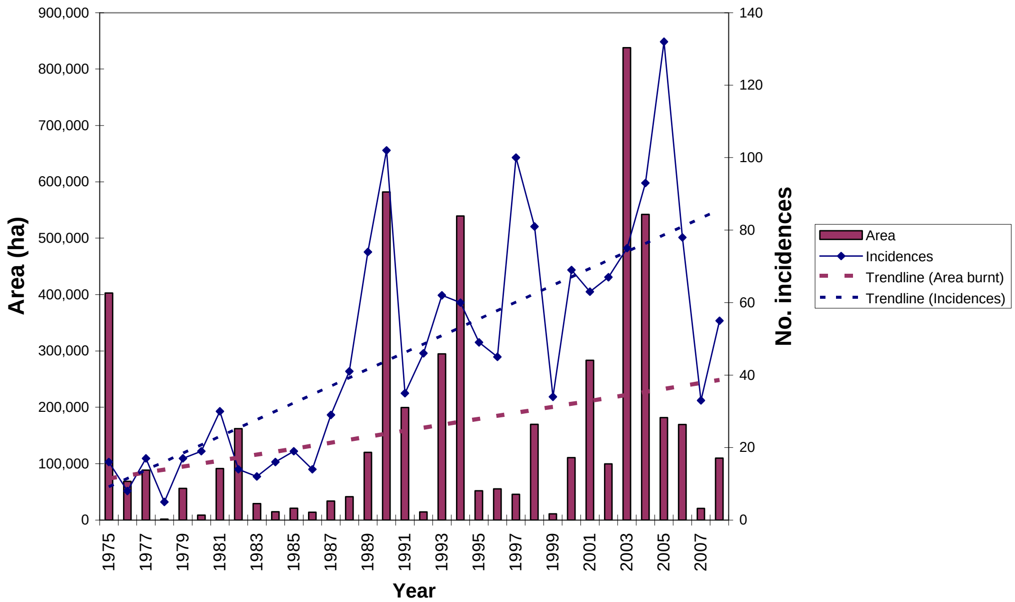


Figure 17. **Area (ha) and incidence of fire per annum, South Coast region 1975-2008.**

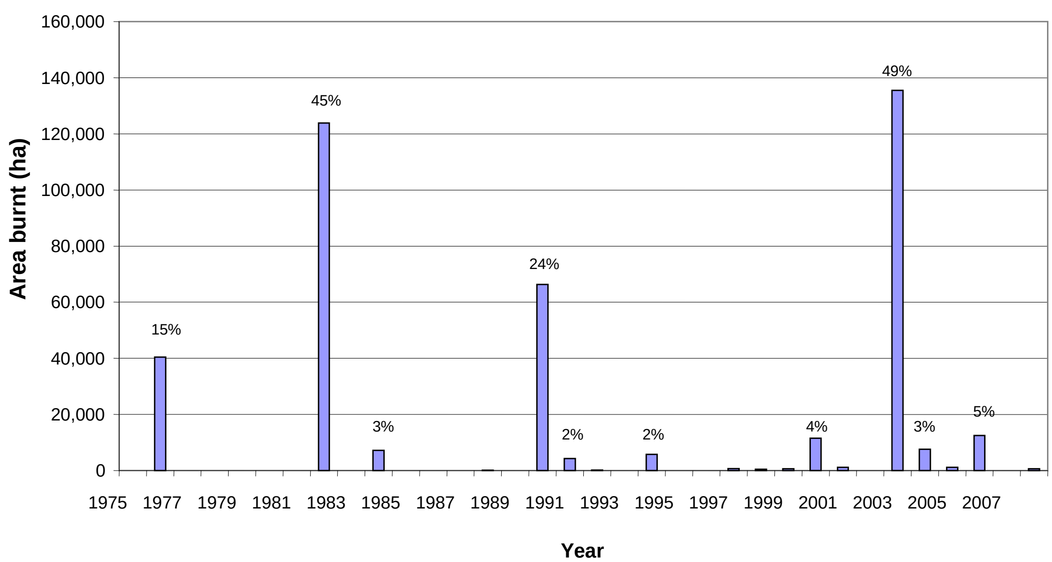


Figure 18. **Area (ha) and percentage of park burnt per annum 1975-2008 Cape Arid National Park.**

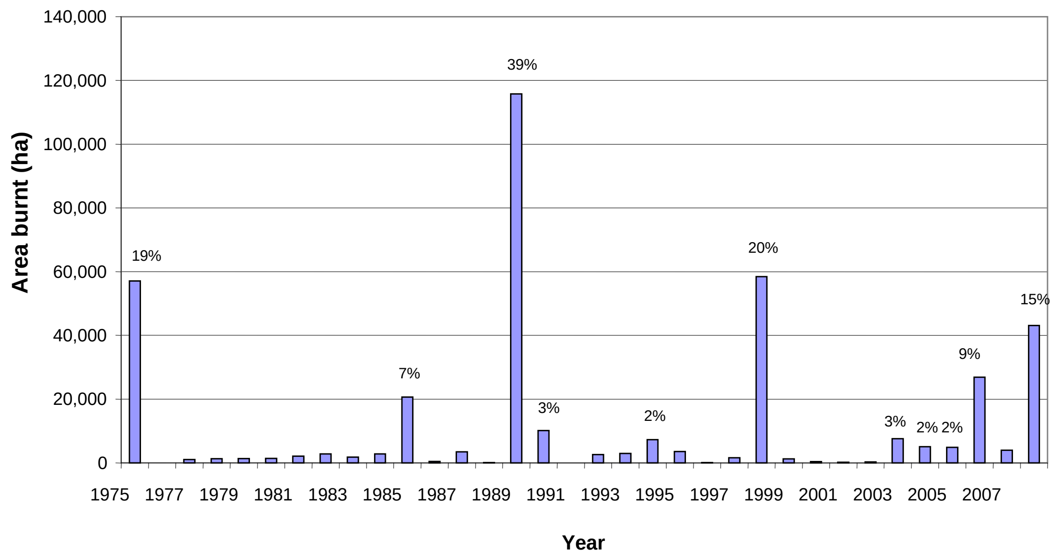


Figure 19. **Area (ha) and percentage of park burnt per annum 1975-2008 Fitzgerald River National Park.**

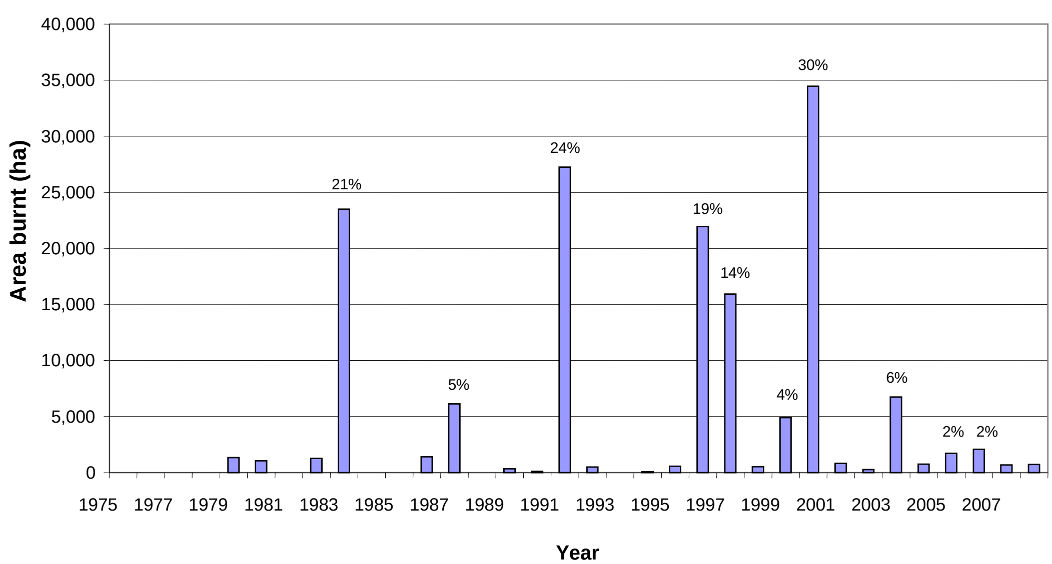


Figure 20. **Area (ha) and percentage of park burnt per annum 1975-2008 Stirling Range National Park.**

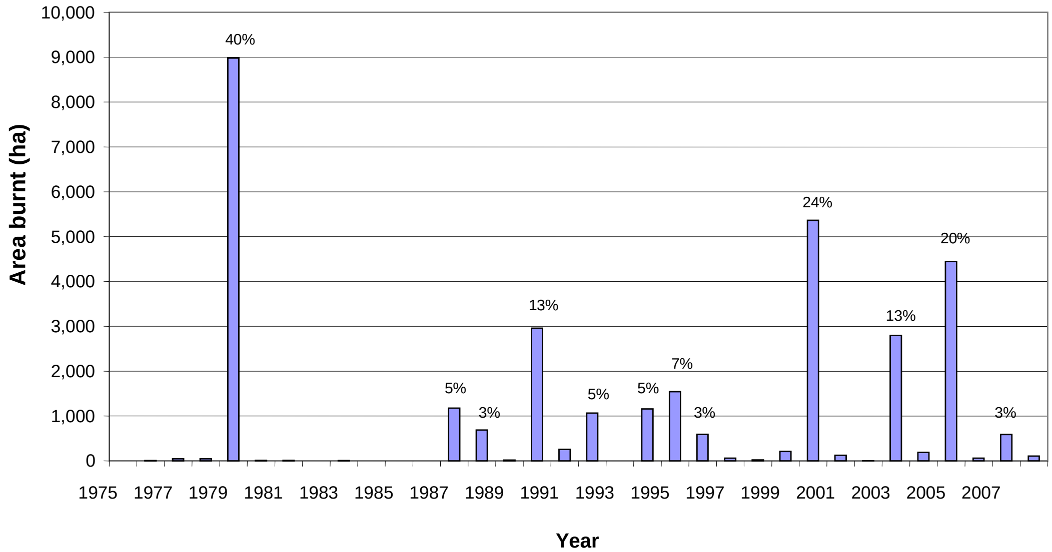


Figure 21. Area (ha) and percentage of park burnt per annum 1975-2008 Two-Peoples Bay – Manypeaks.

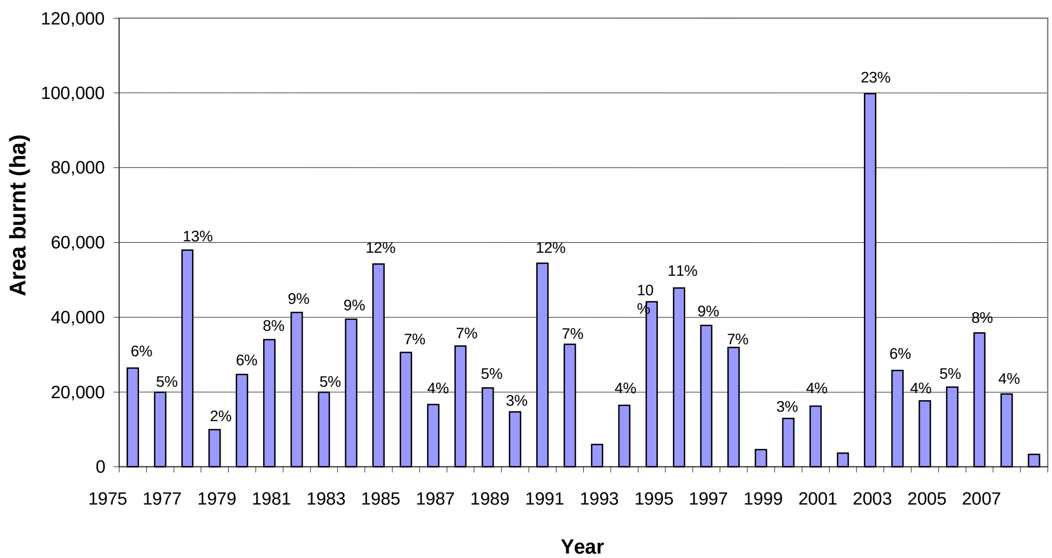


Figure 22. Area (ha) and percentage of DEC estate burnt per annum 1975-2008 Forest Mosaic Ecodistrict.

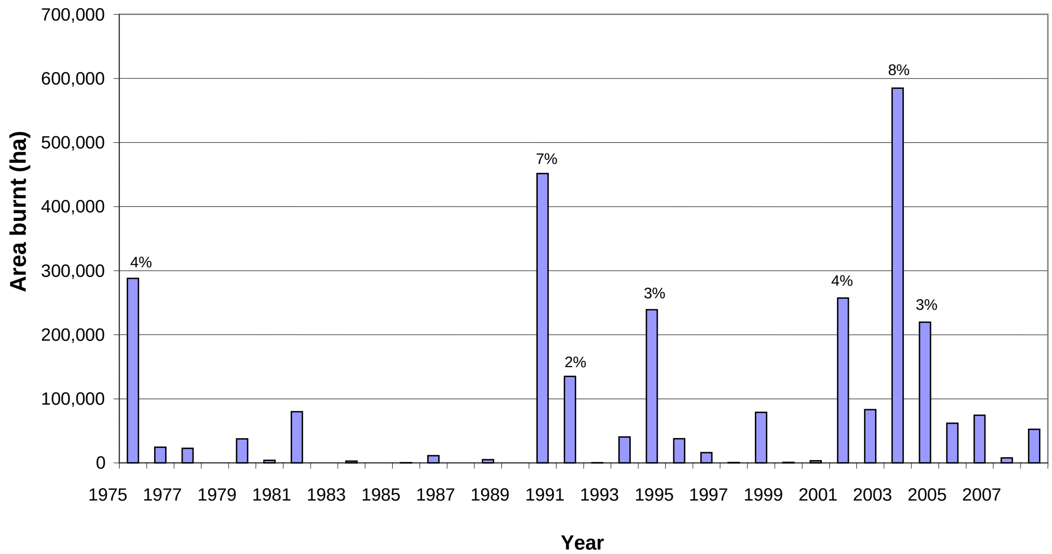


Figure 23. Area (ha) and percentage of total area burnt per annum 1975-2008 Great Western Woodlands within the South Coast NRM region.

Fire history maps for CANP, FRNP, SRNP, 2PB-MP and GWW are included in Appendix X. Long unburnt areas can be identified from these maps and used as benchmark reference monitoring sites for fire-sensitive systems (see Section 12). These maps give an indication of the diversity of fire ages present and the grain size of the fire mosaic currently present in the landscape. For example CANP and to a lesser extent SRNP shows little diversity of fire history currently compared with FRNP which has a relatively wide range of fuel ages.

A major research question (Section 8) is to establish if diversity in age structure equates to diversity in conservation value in fire sensitive and other systems. It must also be remembered that pockets of unburnt vegetation potentially persist in recently burnt areas that have not been accurately mapped (using satellite imagery) as yet, and that long unburnt areas may not contain the same range of habitats or occurrence of species and community types in the same proportion as more frequently burnt areas.

8 RECOMMENDATIONS FOR FIRE ECOLOGY RESEARCH TO ADDRESS KNOWLEDGE GAPS

Following on from the literature review, outcomes of the March workshop and the knowledge gaps identified by the authors of this report, the following topics were identified as priority areas of fire ecology research in the South Coast region:

1. Population and seed bank dynamics of key functional plant taxa in relation to fire
   - When do key serotinous species commence and reach peak seed production, how much seed is required to maintain viable populations? What is the effect of habitat and climate on seed production?
   - What is the longevity of seed banks of key reseeder species with soil or canopy-stored seed banks? What species or species groups may have transient or short-lived seed banks? What is the impact of fire intensity on seedbanks?
   - What is the role of inter-fire recruitment in maintaining plant populations in different systems? Can senescence cause local extinctions? What causes the recruitment failure observed in key serotinous seeders?
   - Investigate pre-dispersal and post-dispersal factors such as grazing and climate that influence the recruitment of re-seeder species.
   - Investigate mallet ecology, stand age and the effect of fire on pure versus mixed stand composition. How does serotiny vary between eucalypt species and what are the environmental conditions required for eucalypt seedling establishment?

2. Chronosequence (space-for-time) studies in key systems to investigate the effect of fire regime on plant community composition and structure
   - Has fire permanently modified systems or have species become locally extinct due to altered fire regimes? What aspect of fire regime is most influential for species persistence?
   - Compare reseeder to resprouter ratios across climate and productivity gradients and between mainland and island systems

3. The effect of fire regime on the habitat and population dynamics of key fauna species
   - Does diversity in age structure equate to diversity in fauna conservation values?
   - What is an appropriate patch scale for burning in different ecosystems?
   - What is the effect of fire regime and time since last fire on vegetation structure, plant density, leaf litter and hollow development?
   - What is the fire response of key fauna species including short range endemic and threatened invertebrates? How valid is the indicator species concept? For example, how does the use of fire exclusion for Gilbert's Potoroo impact on other species in the ecosystem?

4. The effect of fire on fungal diversity and leaf litter ecology

- How does fungal diversity and soil microbial succession relate to fire regime?
- How does fire affect hypogeal fungi as a food source for the Potoroo or the reintroduction of the Woylie into its former habitat?
- What is the relationship between fungal diversity and plant community susceptibility to *Phytophthora cinnamomi*?
- What is the effect of fire regime on the impact and spread of *P. cinnamomi*?

5. Fuel load, flammability and risk of ignition in priority South Coast systems in relation to time since fire
   - At what time after fire will a plant community carry fire from lightning, wildfire spotting or planned ignition and what are natural ignition scenarios for a range of systems across the region?
   - What are the acceptable prescribed fire conditions and thresholds for the introduction of fire to sensitive systems e.g. Transitional woodlands?
   - How effective are low fuel buffers and wind-driven strips in reducing the impact of wild-fire for selected vegetation types?
   - Investigate "fuel" loads in relation to time since fire in key systems such as ground parrot habitat, moort and mallet woodland, woodlands and *Banksia* shrublands. What is the fuel load and flammability of mature systems and how does fuel load relate to community composition, structure and time since fire?
   - Validate predicted impacts of climate change by modelling fuel dynamics and ignition; how will climate change impact on fire behaviour?
   - What is the impact of machine tracking, slashing and soil disturbance on vegetation, soil stored seedbanks, geophytes and habitat values?

9 GENERAL RECOMMENDATIONS AND GUIDELINES

1 Inappropriate fire regimes have the potential to have long-term adverse impacts on species diversity, community structure and fauna habitat values in sensitive systems. Some fauna species may be fire sensitive, but do not occur in sensitive vegetation systems as outlined in this report. Objectives and outcomes in relation to fire management of fire sensitive systems must demonstrate how these ecosystems will be benefited.

2 Consider vegetation community response type and identify fire sensitive and non-sensitive communities, key fire sensitive and structural species and the reproductive status of species prior to the use of planned fire.

3 Accurately map the fire-sensitive ecosystems of the South Coast as identified in this report.

4 Identify keystone or key functional taxa for priority fire sensitive systems and investigate life history and response to fire of key components of ecosystem with emphasis on data deficient species and systems as identified in Appendix V.

5 Establish monitoring database for the South Coast. Systematic data collection and databasing of fire response, juvenile periods and time to senescence on a local area basis is essential to fill information gaps and to determine the longest and shortest juvenile periods for each system. Given the extent of the region, its floristic diversity and community heterogeneity, data cannot be extrapolated from one Ecodistrict to another.

6 Complete fire history mapping project across the region on all remnant vegetation and collect data systematically on an ongoing basis. Ensure that boundaries are accurately plotted for both historical and new fire events and include details of fire behaviour, cause, season and management actions taken in response to fires (backburning, chained strips etc). Ensure that fire history maps for key conservation areas are updated from remote sensing so that fire 'patchiness' is captured in recording system. Undertake further GIS analysis including fire frequency and fuel age distribution on an Ecodistrict basis and for other significant reserves

7 Ensure monitoring opportunities to gather ecological data are identified and resourced on a priority basis after wildfire and planned fires.

8 It is mandatory to consider the presence of Phytophthora dieback and the potential to increase the impact or spread of the pathogen after fire or to introduce the pathogen during fire management activities.

9 Avoid burning entire remnants by not edging and burning off cell boundaries, and ensure the preservation of adequate refugia values of unburnt vegetation.

10 Evaluate the overall impact of machine tracking and soil disturbance on vegetation, soil stored seedbanks, geophytes and habitat values prior to using these techniques.

11 Consider the impact of low intensity burning where serotinous re-seeder species are present as if fire intensity is insufficient, yet adult plants are killed, dehiscence of woody fruits may not be achieved, resulting in lack of recruitment.

12 Consider potential adverse effects of foams (FOG 76) and retardants in proximity to wetlands and riparian systems in wildfire suppression activities.

13 Map and assess existing vegetation survey (plot and relevee) data for the South Coast region, and identify those with value for fire ecology research and monitoring; resurvey key plots. Identify where baseline monitoring needs to be established for fire monitoring purposes.

14 Document available fuel loading, fuel consumed, fire intensity statistics and correlate to post-fire regenerations response in both wildfire and prescribed fire situations for vegetation associations of interest.

15 Incident management teams dealing with wildfire incidents on the South Coast should access knowledge within the region to ensure adequate management of fire regime specific systems and Phytophthora hygiene. Establish Environmental Officer position within team where appropriate. Information on biodiversity values must be packaged to make it readily available to fire management personnel in a systematic way to avoid over-reliance on the availability of local expert knowledge.

16 Fire management personnel given opportunities to receive training and ongoing support in the management of fire sensitive systems.

17 Fire Exclusion Reference Areas for benchmarking purposes should be established across the South Coast in areas representative of the habitat diversity in the region. Fire sensitive systems should be a priority for establishing such sites. Long unburnt remnants offer vital analogues for the investigation of system development and identification of similar vegetation types at different ages allows for their comparison.

18 Facilitate education and information exchange between fire management bodies, the community and nature conservation personnel regarding biodiversity values, fire sensitive species and communities including long unburnt areas.

19 Good communication between nature conservation personnel and fire managers is critical to ensure that management of fire sensitive systems is successful.

20 Early intervention should be considered where feasible in high value remote areas e.g. Great Western Woodlands.

10 SPECIFIC ECOLOGICAL CONSIDERATIONS FOR THE MANAGEMENT OF FIRE SENSITIVE SYSTEMS AND TAXA

This section gives a brief description of the fire sensitive systems identified, the Ecodistricts in which they occur, their key ecological attributes and key points to be considered in relation to fire management. It also identifies what components of the system could potentially be monitored or incorporated into adaptive management experimentation depending on priorities and resources.

10.1 Forest

Tingle forest, karri forest (including outlying karri) and associated invertebrates (Forest Mosaic)

The tingle forest is dominated by three locally endemic large eucalypts: red tingle *Eucalyptus jacksonii***,** Rate's tingle *E. brevistylis* and yellow tingle *E. guilfoylei* (Fig. 24). Tingle forest has a patchy distribution restricted to an area between Walpole and Denmark with an annual rainfall of up to 1400 mm. Many plant and invertebrate species are Gondwanan relicts including spider species such as *Moggridgea* and *Chasmocephalon*. Orchid species richness is high. The three species of tingle grow in association with karri *Eucalyptus diversicolor*, jarrah *E. marginata* and marri *Corymbia calophylla*. From a seedling, karri and red tingle may take from 15 and 25 years, respectively, to reach reproductive maturity while taking 100-150 years to reach structural maturity.

Karri forest is more widespread, however important outlying populations occur in the Porongurup Range (Fig. 25) and Albany area. These forests systems are considered to be sensitive to intense fire due to the presence of refugial species and the impacts of intense fire on tingle, Rate's tingle may be vulnerable to frequent fire also.

- Consider presence of refugial invertebrate species, the impact of fire upon invertebrate populations and species richness and abundance and the retention of long unburnt refugia

- Consider importance of litter layer on ecosystem function and biodiversity, assess litter layer depth and composition

- Consider the impact of hollow butting as a result of intense fire (in particular on red tingle which has a weak lignotuber) due to fire entering the tree at the interface of the trunk and roots. Removal of litter and duff from base of individual trees before prescribed fire may reduce this impact.

- Rate's tingle, red tingle and karri may decrease with frequent intense fire. Patchy low intensity fire may be an acceptable fire regime for maintaining pockets of deep litter and structural diversity in this ecotype.

- Consider soil moisture in tingle forest in relation to retention of unburnt patches and a percentage of the humic profile and the reduction of hollow butting,

- Retain riparian zones and seeps

- Consider impact of season of fire on geophytes

- More detailed information may be found in DEC Fire Management Guideline No. E2 (Tingle Forest) and No. S11 (Geophytes)

- Karri with its smooth bark can be less fire sensitive than tingle because it does not carry the fire up its trunk into the canopy as tingle does. Determine whether "Epiphytic Cryptogams of the Karri Forest" Priority Ecological Community is present.

Monitoring options:

- Monitor relictual taxa eg invertebrates, monitor crown recovery, litter build up in relation to time since fire.
- Monitor germination and subsequent survival of eucalypt species in relation to fire intensity and canopy effect, recruitment in the absence of fire.
- Monitor the number of large tree collapses
- see Appendix V for flora and fauna species to assess and monitor

10.2 Woodlands

Stable Landscape woodlands - Wandoo and Transitional Woodlands, Lake Johnson Woodlands, Salt-lake fringing woodlands (NW Mosaic, Yilgarn East, Greenstone, Mallee Lakes) Dynamic landscape woodlands – York Gum, Swamp Yate Woodlands, Riverine Yate and Flooded Gum Woodland, (Forest Mosaic, Marine Plain, Esperance Sandplains)

Although structurally similar, woodlands can be grouped on their large functional differences into those occurring on either stable or dynamic landscapes. 'Stable' woodlands occur on the old weathered landscapes and are therefore poorly adapted to frequent disturbance. These include 'Transitional' (occurring between the inland arid and wet forest regions) woodlands e.g. salmon gum *E. salmonophloia* (Figs 26-27) and Wandoo woodlands.

'Dynamic' woodlands occur where there is relatively frequent ground disturbance eg river valleys and swamps and therefore they may be more resilient to more frequent disturbance. Yate *Eucalyptus occidentalis* woodlands occur across the region in swamp or riverine habitat. Flooded gum *E. rudis* is restricted to the Forest Mosaic and Northwest Mosaic Districts and york gum *E. loxophleba* to the Northwest Mosaic District. Under severe conditions fire will burn through riparian zones and wetlands.

Plant community structure is the critical aspect of woodland systems in terms of providing habitat for a range of fauna. Late seral stage habitats in woodland may take a long time (>100 years) to develop. Suitable hollows in trees and in dead wood on the ground may take over 150 years to form. The understorey component of woodlands is typically sparse but the well developed leaf blanket layer provides additional habitat. Western occurrences of woodlands exist in a highly fragmented landscape while eastern occurrences occur in a more contiguous vegetated landscape. This directly influences fire behaviour, spread and extent.

- Woodlands are sensitive to moderate to high intensity fire which will kill mature plants. Flame residence time is an important factor. There can be a significant build up of litter around the tree base which may increase fire intensity and flame height. Some of the smooth bark woodland species can be killed by very mild fire by girdling the collar (Armstrong, pers.comm). Trees may survive low intensity scorch and recover by producing epicormic buds. Epicormic regrowth can be considerably slower than for example jarrah or marri.

- Woodlands may take 100 years or more to regain the mature woodland structure where mature trees have been killed.

- Juvenile trees of many woodland species such as wandoo and salmon gum may be killed by even medium intensity fire.

- Even where trees are not killed outright, considerable limb death may occur and it may take decades for canopy to recover fully, hollow butts on the ground may also be damaged or created. Recovery by basal coppicing can also be unreliable.

- Fire may further damage or kill trees already under stress in areas affected by salinity, altered hydrology or insect damage.

- In fragmented landscapes consider other threatened processes that may be facilitated by fire, for example weeds, salinity, acid sulphate processes and feral animals

- Fragmented remnants may have a long fire-free history and have great reference value

- Older trees provide important nesting habitat for hollow dependant birds, bats and other fauna.

- Recruitment of *Santalum* species eg sandalwood (*Santalum spicatum*) and quandong (*S. acuminatum*) after fire is highly stochastic.

- Chenopods are usually obligate seeders with no effective post-fire seed bank, short-range dispersal and very low flammability.

- Granite outcrops and their surrounds within woodland systems may act as refugia for mesic-adapted species

- Identify ecosystems not considered to be fire sensitive within woodland systems and consider appropriate management

- The information base is limited for the South Coast region but Avon region knowledge is applicable.

Monitoring options:

- Monitor recruitment and stems per ha, tree size, presence of and size of logs, leaf blanket depth, species composition

- In riverine and wetland habitat monitor water quality, weed invasion

- See Appendix V for key species to monitor

10.3 Mallet woodlands

Mallet (Marine Plain, Yilgarn East, Northwest Mosaic, Greenstone, Coastal Dynamic, Mallee Lakes) Moort low forest (Marine Plain, Yilgarn East, Mallee Lakes)

Mallet and moort woodlands (Figs 28-31) are fire sensitive because they are killed by low to moderate intensity fire due to their thin bark and rely on canopy-stored seed for regeneration. There are some 38 mallet and moort taxa excluding intergrades and hybrids in the South Coast region. They occur on specific soil types and many mallet and moort species are short-range endemics eg Corackerup moort *E. vesiculosa*. Individual mallet and moort stands are usually not extensive and typically can occupy a very restricted area eg less than 1 ha. Mallet and moort stands provide a diversity of structure that is important in providing habitat for a range of fauna. Mallet and moort woodlands develop slowly to maturity over decades if fire is excluded. The gradual thinning of dense post-fire regeneration of eucalypt and leguminous species transforms maturing mallet and moort woodlands into even aged stands of typically one to three taxa with a sparse understorey and a well developed leaf litter layer. Some mallet and moort species also occur as scattered plants with mallee eucalypts. Plant dimensions are strongly influenced by nutrient and water availability with stands many decades old typically having stem diameters of only a few centimetres. There is little evidence of recruitment in the absence of fire.

On offshore islands moort and mallet trees achieve considerably higher stature than in more frequently burnt mainland systems.

- Where any management intervention is being considered the distribution of mallet and moort woodlands should be mapped.

- Mallet woodlands are composed of *Eucalyptus* species without lignotubers that are killed by fire and reliant on canopy-stored seed for regeneration, maturation times are typically long eg 12 years to first flowering for brown mallet *E. astringens*.

- Long unburnt mallet and moort forest (eg 100 years plus) tend to show fewer signs of senescence than other communities dominated by obligate seeders. Species richness may be lower in long-unburnt vegetation, but soil seed banks of understorey species appear to be long-lived and seed will germinate after long intervals between fires, and canopy *Eucalyptus* spp. also appear very long-lived.

- Mallet woodlands are unlikely to burn under mild conditions but intense fire will cause mortality of the *Eucalyptus* overstorey.

- Successful recruitment may be dependent on adequate rainfall in early years after fire, seedling mortality may be high. Spring fire is likely to reduce recruitment due to summer drought mortality and seed harvesting by invertebrates. Scrub-rolling and burning has been observed to result in recruitment failure.

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- Pure mallet stands should be considered for exclusion from chained and burnt strips.

- A well-developed leaf litter layer is characteristic of mature mallet woodland taking many years to form and provides important reptile habitat.

- Fauna associated with long-unburnt mallet woodland include Mallee-fowl and hollow nesting mammals (e.g. Red-tailed Phascogale, birds and bats). Fauna is vulnerable to predation in recently burnt areas. Uniformly burnt stands at early seral stages are unsuitable for many fauna species.

- Consider patch size for habitat requirements, connectivity with other habitat, presence of long unburnt habitat.

Monitoring options:

- Monitor leaf litter accumulation, species composition, tree size and hollow formation, recruitment and stems per ha

- See Appendix V for key *Eucalyptus* species to monitor

10.4 Proteaceous Mallee-shrubland

Banksia and Hakea dominated mallee-heath and low woodland, Proteaceous mallee-heath (Forest Mosaic, Marine Plain, Esperance Sandplains), *Eucalyptus pleurocarpa / E. falcata* mallee shrubland (Yilgarn East, Greenstone),

Transitional mallee-shrubland (Yilgarn East, Mallee-Lakes) *E. decipiens / E. falcata* mallee shrubland (North-west Mosaic)

Mallee-shrubland and mallee-heath communities (Figs 32-33) are highly species rich and structurally diverse and prominent in the Marine Plain, Esperance Sandplain, Greenstone and Yilgarn East Ecodistricts. Key structural components of these include members of the Proteaceae, in particular species from the genera *Banksia* and *Hakea*, many of these dominants are obligate seeder serotinous species. These communities include species highly susceptible to *Phytophthora cinnamomi*.
Transitional mallee-shrubland occurs in more arid parts of the region within a mosaic of woodland. Sandalwood *Santalum spicatum* and quandong *S. acuminatum* are also fire sensitive species.

- Serotinous obligate seeders are dominant in many of these mallee-heath systems.

- Assess canopy seed store for key serotinous obligate seeders.

- Frequent fire may cause plant population extinctions in species that are slow to mature.

- Successful recruitment of seeder species may be dependent on adequate rainfall in early years after fire, seedling mortality may be high.

- The mallee component of these systems appear to be resilient to frequent and intense fires, however recruitment appears to be sporadic and is poorly understood.

- Long fire-free intervals may lead to decline of some members of the Proteaceae and community change through expansion of *Allocasuarina huegeliana* woodlands (Maher 2007); these changes require monitoring.

- Consider patch size for habitat requirements, connectivity with other habitat, presence of long unburnt habitat.

- Consider habitat for species with low dispersal ability and ground dwelling species (e.g. Dibbler, Western Ground Parrot, Western Heath Mouse, Western Bristlebird, trapdoor spiders).

- Consider impact on food resources.

- Consider presence of Phytophthora dieback within 400 mm isohyet and the potential to increase impact or spread of pathogen after fire or to introduce pathogen during fire management activities.

- Scrub-rolling (± burning) is likely to have detrimental impacts on populations of serotinous re-seeder species.

Monitoring options:

- Monitor species composition, fuel loads, community structure, changes in densities of Proteaceous component over time.

- See Appendix V for key species to assess and monitor.

10.5 Mallee over Melaleuca

Mallee over Melaleuca (Greenstone, Yilgarn East), Melaleuca Thickets (Greenstone, Coastal Dynamic)

Mallee over *Melaleuca* systems (Fig 34). are a prominent feature of the Ravensthorpe Range and Yilgarn East Ecodistricts. The *Melaleuca* dominated mid-storey forms a dense canopy and includes many serotinus seeder species killed by fire. The mallee component of these systems appear to be resilient to frequent and intense fires, however recruitment appears to be relatively sporadic. The mode of regeneration of many *Melaleuca* species has not been determined. Several species endemic to the Ravensthorpe Range occur within this system.

Other dominant serotinous seeder *Melaleuca* systems include *Melaleuca thapsina* thickets, a feature of the Ravensthorpe Range, *Melaleuca lanceolata* thicket or low forest and *Melaleuca nesophila* thicket in the Coastal Dynamic and Island Ecodistricts.

- The dominant *Melaleuca* understorey includes *Melaleuca* species killed by fire that rely on canopy-stored seed for regeneration.

- Assess canopy seed store for serotinous obligate seeders, see Appendix V for key species to assess and monitor, see vegetation of the Ravensthorpe Range (Craig *et al*. 2008) for description of vegetation units.

- Successful recruitment of seeder species may be dependent on adequate rainfall in early years after fire, seedling mortality may be high.

- Investigate and document fire response of dominant *Melaleuca* species.

- Document maturation times of fire sensitive species.

- This system is slow to regain structural characteristics of mature vegetation.

- The mallee component of these systems appear to be resilient to frequent and intense fires, however seedling recruitment appears to be sporadic.

- *Melaleuca stramentosa* is a thicket forming obligate seeding *Melaleuca* restricted to quartzite derived soils of the southern Ravensthorpe Range. Its thicket-forming habit is likely a product of favourable climatic conditions following fire, and very long fire frequency intervals.

- *Melaleuca sp*. Kundip (G.F. Craig 6020) is a very restricted thicket-forming obligate seeding *Melaleuca* on quartzite derived soils in the Kundip area. It occurs predominantly under mallet and moort eucalypts, as well in one location as a component of mallee understorey. It requires very long fire intervals to maintain its place, characterising structure and habitat value in the landscape.

Monitoring options

- Monitor community structure, fuel loads, germination and survival of re-seeder *Melaleuca* species, recruitment and survival of mallee species.

10.6 Granite shrubland and fringing Eucalyptus or Allocasuarina woodlands

Includes relictual and endemic invertebrate fauna, cryptogram and *Borya* communities (Mt Lindesay, coastal and inland Albany-Fraser granites, Yilgarn East granites)

Granite outcrop systems (Fig. 35) are associated with more mesic environments as a result of their water-harvesting ability and therefore provide refugial opportunities for fire-sensitive species. A higher ratio of seeders to resprouters has been documented for granite outcrop vegetation in the Southwest. Granite communities are typically sensitive to fire and frequent fire is detrimental. However, in large depositional sandy systems, rock sheoak *Allocasuarina huegeliana* and wilywurrwer *Acacia lasiocalyx* are more resilient to frequent disturbance. Long unburnt granite communities are unlikely to pose a risk to other assets due to their position in the landscape. Inter-fire recruitment is a feature of granite plant communities and seedlings can readily germinate in open areas with survival dependent on adequate summer rainfall. Granite monadnocks and outcrops are characterised by a high number of endemic species including several threatened flora and short-range endemic invertebrates.

- Assess canopy seed store for serotinous obligate seeders which are frequently dominant in these communities.

- Granite communities are frequently characterised by endemic flora including threatened flora e.g. the granite banksia (*Banksia verticillata*) and fauna species. Several threatened vertebrate species are associated with granite outcrops (e.g. Noisy Scrub-bird, Gilbert's Potoroo *Potorous gilberti*, Quokka *Setonix brachyurus*, Western Ringtail Possum *Pseudocheirus occidentalis*, Western Whipbird (heath subspecies) *Psophodes nigrogularis nigrogularis*).

- Successful recruitment may depend on adequate rainfall in early years after fire, seedling mortality may be high.

- Rabbits may be common on granite outcrops and affect post-fire regeneration and survival.

- Consider presence of refugial invertebrate species.

- Cryptograms (lichens, algae and mosses), gnamma and *Borya* communities (Fig. 36) are considered to be fire intolerant with no beneficial effect of fire apparent.

- Run-off and ponding of water may predispose susceptible plant species to Phytophthora dieback, consider the potential to increase impact or spread of pathogen after fire.

- Coastal granite communities in particular may be affected by aerial canker which may affect population viability and vigour.

- For further information see DEC Fire Management Guideline No. E5 Granite outcrops.

Monitoring options:

- Monitor germination and survival of fire sensitive species, refugial invertebrates, fire sensitive fauna, cryptograms and *Borya*, grazing impacts.

- see Appendix V for key species to assess and monitor.

10.7 Spongelite shrubland and mallet woodlands

Spongelite breakaways (Fig. 37) and exposures are a relatively rare feature in the Marine Plan Ecodistrict. Where the soil is skeletal an open low heath forms which may have associated endemic flora. A laterised gravel layer typically covers the spongelite. In wet winters water-logging may occur, although skeletal soils dry out rapidly over summer. Mallet and moort eucalypts can be common on breakaways. Inter-fire recruitment is a feature of open spongelite plant communities and seedlings can readily germinate in open areas with survival dependent on adequate summer rainfall.

- Spongelite communities are typically high in re-seeder plants eg *Verticordia*, including endemic species such as *Verticordia helichrysantha*, *V. longisylis*, *V. crebra* and *V. fastigiata*.

- Successful recruitment may be dependent on adequate rainfall in early years after fire, seedling mortality may be high.

- Assess canopy seed store for serotinous obligate seeders eg *Calothamnus* spp which may be dominant in these communities.

- Assess fire response of dominant species and document maturation times where unknown times.

- Soil structure is fragile, avoid disturbance.

- These are naturally open, sparse communities that are likely to experience infrequent fire.

- Long unburnt spongelite communities are unlikely to pose a risk to surrounding vegetation due to their open nature.

- Consider potential refugial nature of spongelite systems.

- Mallet or moort communities associated with breakaways are composed of eucalypts killed by fire and reliant on canopy-stored seed for regeneration, maturation times are typically long. The associated leaf blanket provides important habitat.

Monitoring options:

- Monitor germination and survival of fire sensitive species, soil condition.

- see Appendix V for key species to assess and monitor.

10.8 Montane thicket and mallee-thickets Quartzite Ecodistrict

Stirling Range, Russell Range, Barrens

The vegetation of the quartzite mountains systems (Figs 38a, 38b) of the South Coast is characterised by a dense thicket, mallee thicket or mallee-heath. Vegetation structure is strongly influenced by altitude and aspect. These quartzite ranges are refugial in nature and characterised by high numbers of endemic and threatened taxa including invertebrate species many of which are fire sensitive. Growth rates of plant communities on mountain summits and upper slopes may be considerably lower than in lowland systems. Many mountain endemic species in the Stirling Range National Park (SRNP) have long juvenile periods, several longer than 10 years. Frequent fire has resulted in population declines. The higher rainfall associated with these mountains along with presence of highly susceptible plant communities predisposes them to Phytophthora dieback which has had a disastrous impact on montane communities in the SRNP, and fire has been shown to exacerbate this impact (Figs. 39a, 39b).

- Key structural components of quartzite systems include members of the Proteaceae, in particular species from the genera *Banksia, Isopogon* and *Petrophile*, many of these dominants are serotinous obligate seeder species.

- Frequent fire causes local extinctions in plant species that are slow to mature.

- Dominant structural species, including species with soil-stored seed banks, may have long juvenile periods rendering them vulnerable to frequent fire.

- The thicket structure may take decades to form after fire at higher elevations.

- Assess canopy seed store for serotinous obligate seeders.

- Assess fire response of dominant species and document maturation times where unknown times.

- Soil structure is skeletal and fragile.

- Consider affect of site altitude, exposure and aspect on plant growth.

- Consider impact of grazing post fire.

- Consider refugial nature of mountain systems.

- Consider presence of short-range endemic invertebrates (Figs 40-41).

- Consider presence of Phytophthora dieback and the potential to increase impact or spread of pathogen after fire or to introduce pathogen during fire management activities.

Monitoring options:

- Monitor seed banks, germination and survival of key serotinous seeder species, monitor Phytophthora dieback.

- see Appendix V for key species to assess and monitor.

10.9 Banksia shrubland, heaths and Proteaceous palusplain heath

Marine Plain, Esperance Sandplain, Nuytsland, Forest Mosaic, Greenstone, Yilgarn East and Coastal Dynamic Eco-Districts

Kwongan (shrubland) and heath communities (Figs 42-43) are highly diverse and a feature of the nutrient poor sand-plains of the Marine Plain, Forest Mosaic, Esperance Sandplain, Yilgarn East and Nuytsland Eco-districts. Key structural components of these include members of the Proteaceae e.g. the genera *Banksia, Hakea* and *Lambertia*, many of which are obligate serotinous seeder species. These communities are typically highly susceptible to Phytophthora dieback. Pockets of fire-sensitive Cypress *Callitris* spp. occur within these shrublands and are considered to be refugial in nature.

- Serotinous obligate seeders are dominant in *Banksia* shrubland and Proteaceous palusplain heath.

- Frequent fire may cause local extinctions in plant species that are slow to mature.

- Assess canopy seed store for obligate seeders.

- Recruitment of seeder species may vary considerably between years depending upon rainfall in the early years after fire.

- Decline of some members of the Proteaceae may occur with long fire-free interval and requires monitoring.

- Consider patch size for habitat requirements, connectivity with other habitat, presence of long unburnt habitat.

- Consider habitat for species with low dispersal ability and ground dwelling species eg Dibbler, Ground Parrot, Western Bristlebird, trapdoor spiders.

- Consider impact of fire on food resources for nectarivorous fauna.

- Consider presence of Phytophthora dieback and the potential to increase its impact or its spread after fire, or to introduce pathogen during fire management activities.

- Scrub-rolling followed by burning may have detrimental impacts on populations of serotinous seeder species.

- Sandy soils are vulnerable to weed invasion and grazing by herbivores in fragmented remnants eg road verges after fire..

- Refer to DEC Fire Management Guidelines for Cypress *Callitris* spp. (Fig 44).

Monitoring options:

- Monitor seed banks, germination and survival of key serotinous seeder species, monitor Phytophthora dieback.

- See Appendix V for key species to assess and monitor.

10.10 Allocasuarina shrubland: Yilgarn East, Greenstone

Allocasuarina shrublands are a feature of the Ravensthorpe Range (Greenstone) and Yilgarn East Eco-districts. Several of these vegetation units are dominated by serotinous obligate seeder species eg *Allocasuarina acutivalvis*. The response of other *Allocasuarina* species is unknown. These shrublands typically occupy small areas and occur on shallow soils over rocky substrates.

- Several of dominant *Allocasuarina* species in these shrublands are killed by fire and rely on canopy stored seed for regeneration.

- Assess canopy-stored seed.

- Successful recruitment may be dependent on adequate rainfall in early years after fire, seedling mortality may be high.

- The leaf blanket provides important reptile and ground-dwelling bird habitat.

Monitoring options:

- Monitor seed banks, germination and survival of re-seeder *Allocasuarina* species.

- See Appendix V for key species to assess and monitor, document fire response and juvenile period of dominant *Allocasuarina* species.

10.11 Wetlands and damplands

Peat swamps and organic soils, seasonally wet heath-sedgeland and fringing Banksia shrubland, Wattie *Taxandria juniperina* low forest, Paperbark woodlands, *Baumea* sedgeland (Forest Mosaic, Marine Plain, Esperance Sandplains)

Organic-rich soils and peat lands are generally restricted to coastal plains in the southwest and open heath plains on the South Coast where they are associated with small and localised wetland systems. These systems develop over very long time periods of thousands of years. Organic soils and other seasonal wetlands (Figs 46-47) are susceptible to fire invasion because of their restricted distribution, shallow and often ephemeral nature as well as the presence of readily flammable littoral vegetation and organic substrates. Loss of fringing and catchment vegetation due to fire events can result in altered hydrology and water quality within wetland systems. Wattie *Taxandria juniperina* is a serotinous re-seeder, forms a low forest in permanently wet swamps while paperbark woodlands usually occupy seasonally wet drainage depressions. Wetland dependent fauna may be susceptible to fire disturbance in these systems.

- Organic soils and wetlands are sensitive to fire due to the presence of readily flammable littoral vegetation and organic substrates, potentially losing soil thousands of years old.

- Removal of peat holds consequences for the nutrient status and water retention capacity of remaining soil and may be compounded by erosion to render soil unsuitable for seedling establishment over time.

- Local organic-rich systems can be permanently altered or disrupted by frequent hot fire or any regime that systematic removes organic matter.

- Indicators of soil loss or damage are exposed roots where the fire has consumed organic soil from around the roots of shrubs and trees; long-term cracked soil where deep organic soils have shrunk from the heat of the fire; remnant pedestals where fire has consumed organic soil around Restionaceae and failed to completely burn the soil; burnt edges where shallow organic soils upslope of the wetland were consumed by fire.

- Regular and homogenous burning regimes can reduce landscape heterogeneity by reducing the ability of moister parts of the landscape to edaphically control fire; prescribed burning should not over-ride edaphic controls.

- Dominant re-sprouter species may fail to resprout after hot fires due to lignotuber damage.

- Many dominant rushes (Restionaceae) are killed by fire and rely on soil-stored seed for recruitment.

- Fringing *Banksia* shrubland may contain serotinous re-seeder species (e.g. *Banksia quercifolia* and *B. occidentalis*) that are vulnerable to frequent fire and highly susceptible to Phytophthora dieback which can be prevalent in these moist systems.

- *Taxandria juniperina* is a serotinous obligate seeder species and the dominant component of *T. juniperina* low forests.

- Intense fire can damage the structure of paperbark (*Melaleuca preissiana, M. rhaphiophylla, M. cuticularis*) woodlands.

- Feral pigs can cause significant soil disturbance after fire in wetland systems.

- Fire can lead to an exacerbation of acid sulphate soils.

- Wet areas are vulnerable to weed invasion, especially after fire.

- Several bird (e.g. Australasian Bittern *Botaurus poicilloptulus*, Black Bittern *lxobrychus flavicollis*, Buff-banded rail *Gallirallus philippensis*, Rufous Night Heron *Nycticorax caledonicus)*, frog and crustacean species are dependant on wetland reed and rush habitat; several bird species nest in trees overhanging watercourses.

- Fire retardant chemicals and fire suppressant foams may have on water quality and aquatic biota as both have been found to be toxic to algae, invertebrates and fish.

- For further information see DEC Fire Management Guidelines No. E1 Organic-Rich Soils (Peatlands), No. E3 Habitat Protection (Birds) within Reeds and Rushes.

Monitoring options:

- Monitor soil structure, recovery of resprouter species vulnerable to intense fire, serotinous species, wetland fauna (i.e. bird, frog and crustacean species).

- see Appendix V for key species to assess and monitor.

Fig. 24 Rate's tingle (*Eucalyptus brevistylis*) showing hollow-butting after intense summer fire near Mt Frankland.

Fig.25. Prolific germination of introduced dolichos creeper (*Dolichos lignosus*) after 2007 fire in the Porongurup karri forest.

Fig. 26 Salmon gum (*E. salmonophloia*) woodland, resprouting from basal lignotuber in foreground. It may take more than 100 years for mature woodland structure to develop after intense fire.

Fig 27. Stand of juvenile Salmon gum (*E. salmonophloia*) that has recruited in the absence of fire in canopy gap where mature tree fell over.

Fig. 28 Mature mallet woodland with short-range endemic mallet species, *Eucalyptus melanophitra* from Corackerup area.

Fig. 29 Dense 30+ year-old mallet (*Eucalyptus densa*) stand, Frank Hann National Park, showing narrow stem diameters (2-5 cm) in centre of stand.

Fig. 30 Moort (*Eucalyptus utilis*) stand in 30+ year-old vegetation with sparse understorey and dense litter layer, Middle Island, Recherche Archipelago.

Fig. 31 Dense seedling regrowth (*E. utilis, Pimelea clavata*) three years after 2006 fire, Middle Island.

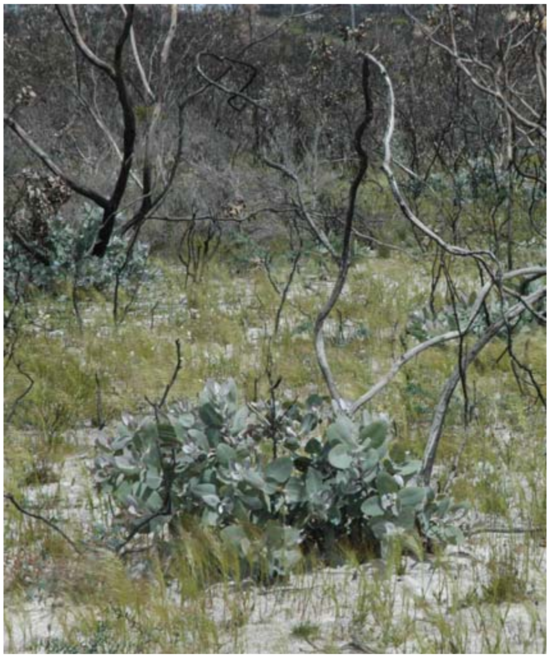

Fig. 32 Proteaceous mallee-heath: *Eucalyptus pleurocarpa* resprouts from lignotuber, dominant serotinous *Banksia* and *Hakea* species are killed by fire and regenerate from canopy-stored seed.

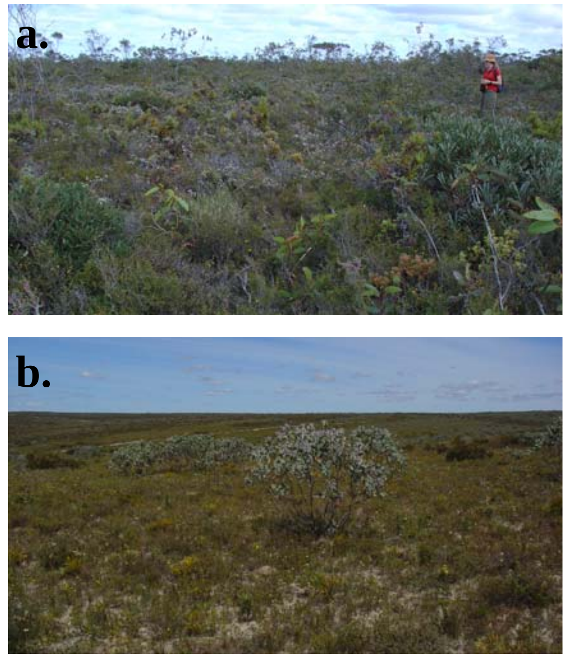

Fig. 33 a) & b) Proteaceous mallee-heath, FRNP: the Western Ground Parrot uses (a) 20-year-old habitat for roosting and nesting, but will utilise (b) six-year-old vegetation for feeding.

Fig. 34 Mallee over *Melaleuca* systems: serotinous obligate seeder species feature in understorey.

Fig. 35 Granite outcrops provide refugial habitat for fire sensitive species such as the granite banksia (*Banksia verticillata*) which has a 10-year juvenile period.

Fig. 36 Fire intolerant *Borya*, cryptogram and gnamma communities on granite outcrop.

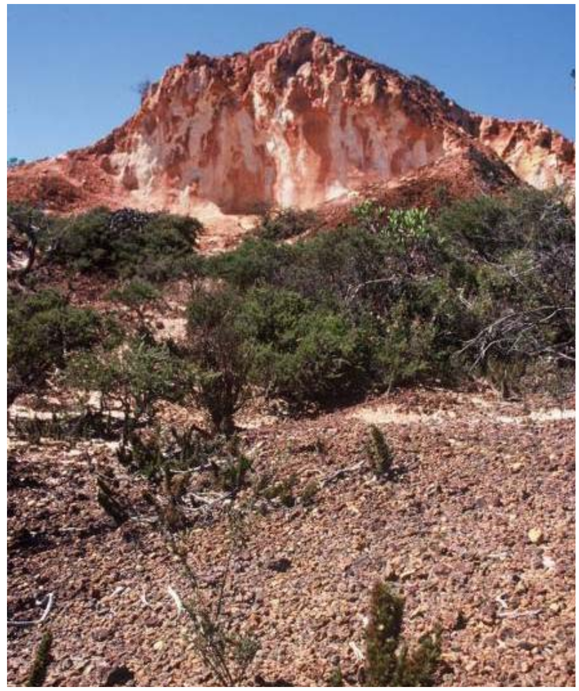

Fig. 37 Spongelite outcrop with characteristic shallow soils, obligate seeders and endemic species.

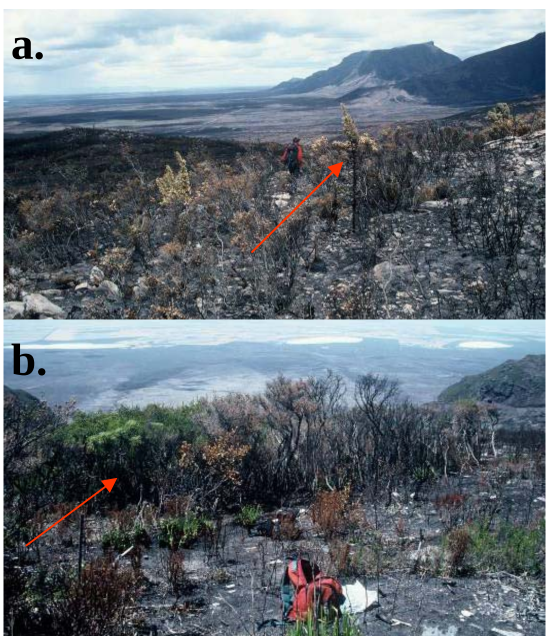

Fig. 38 a) & b) Fire in 1991 and 2000 in the Stirling Range National Park caused dramatic reductions in populations of endemic serotinous obligate seeder species such as *Banksia anatona* (a) and *B. montana* (b).

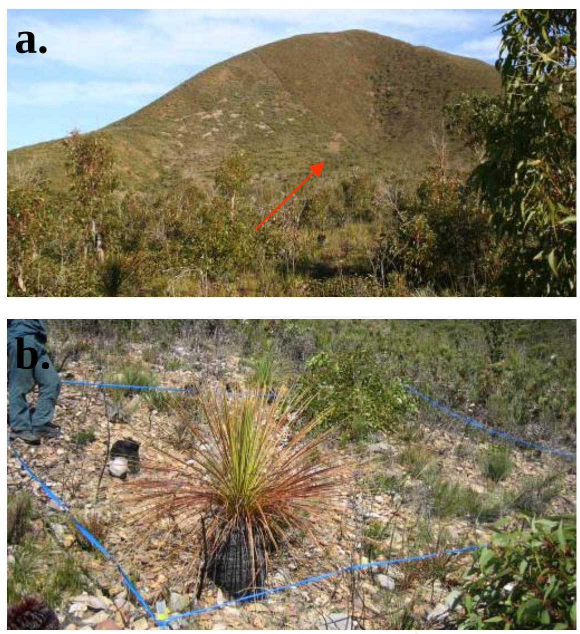

Fig 39 a) & b) Increased impact of Phytophthora dieback after fire with significant declines of Proteaceae, Epacridaceae, Papillionaceae and Xanthorrhoeaceae documented, Stirling Range National Park.

Fig 40 Inappropriate fire regimes threatens many short-range endemic species with poor dispersal capabilities such as the Rhytidid snail, Stirling Range National Park.

Fig. 41 The trapdoor spider *Moggridgea* construct short tunnels (often in trees) from which they can ambush prey. These tunnels, and the spider within, are extremely vulnerable to inappropriate fire.

Fig. 42 *Banksia* shrubland: Regeneration of serotinous reseeder, *Banksia speciosa,* Cape Arid National Park.

Fig. 43 Loss of *Banksia speciosa* in foreground vegetation from short (< 10 years) fire interval, Cape Arid National Park. Line of *B. speciosa* shrubland visible in background.

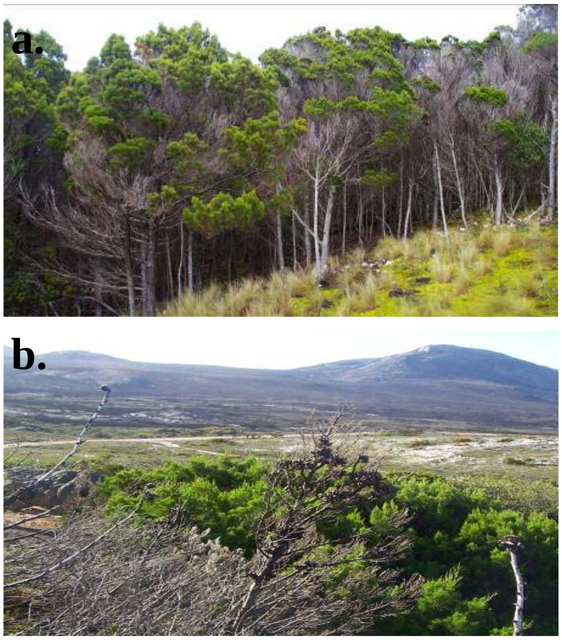

Fig. 44 a) & b) *Callitris preissii* is a serotinous reseeder killed by fire. In 100+-year-old stands, Bald Island, trees reach heights of 10 – 12 m with stem diameters of 40-50 cm, contrasting with shrubbier mainland stands.

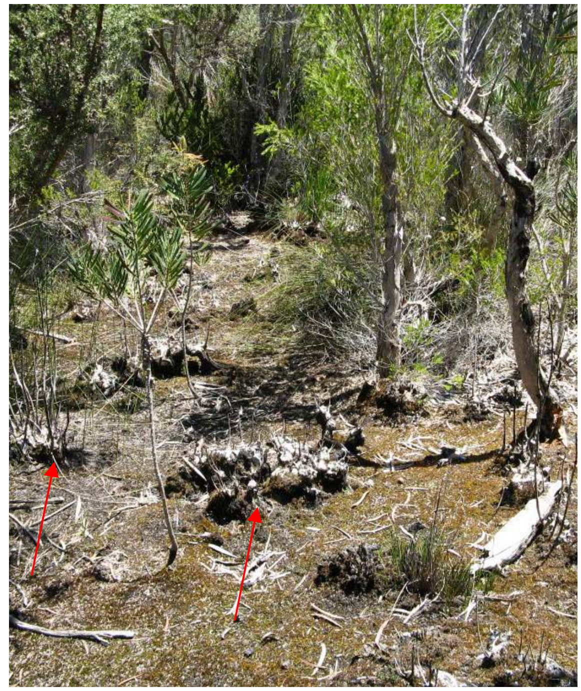

Fig 45 Intense fire can kill resprouters such as the wetland species *Callistemon glauca* and *Homalospermum firmum* .

Fig. 46. Fire in riparian zones may affects aquatic and terrestrial habitat for birds, frogs and crustaceans and water quality.

Fig. 47. Organic-rich systems can be permanently altered by hot fires that remove organic matter.

11 RECOMMENDATIONS FOR MONITORING PROTOCOLS

Pre and post-fire monitoring should align to management objectives for biodiversity conservation (DEC 2007). The level and type of monitoring will be determined by what information is needed to manage specific fire sensitive species and ecosystems. Monitoring procedures may therefore vary considerably and standardisation is difficult.

Monitoring programs and techniques used will depend upon available resources, skills and budget. More comprehensive monitoring may only be feasible at selected sites.

Monitoring programs need to be built into fire prescriptions, adequate resources identified and a commitment made to implement monitoring programs, document the results in accessible formats and use the results to inform future fire management activities using the principles of adaptive management. A monitoring program requires a working document with a clear outline of procedures.

Training is required for operational, fire management, rangers and other field-based personnel to enable them to recognise fire sensitive plant species and systems and assess their function and health, age and reproductive capability in order to conduct basic monitoring.

Monitoring may be conducted at the landscape, site or species level. At the landscape level for example, fire history may be documented and mapped including fire interval, patchiness of fire, area burnt, season, source of ignition, fire management actions applied and climatic data. At the site level data may be collected from quadrats, transects or water bodies. Fire behaviour should be documented in relation to monitoring sites. At the species level key flora or fauna species may be identified based on functional groups, life history attributes, conservation status, and dominant structural components and population demography monitored pre and post fire.

Guide to development of monitoring programs

- Identify existing baseline data or monitoring where present, identify information gaps i.e. what information is required to manage sensitive systems eg fire responses and maturation times of *Melaleuca* species.

- It is essential to formulate the questions that monitoring will address prior to commencement of monitoring program.

- Record information systematically, document methodology, and recommend monitoring interval.

- Ensure consistency between monitoring events and personnel.

- Vouchering of specimens at an appropriate institution (eg WA Herbarium, WA Museum) is desirable where fire responses are being added to a database. Use system of field herbaria and or photographs to assist identification.

- Map fire boundaries accurately, include information on source of ignition, fire behaviour and intensity, climatic conditions during fire.

- Integrate monitoring with other biodiversity monitoring e.g. threatened species, Western Shield.

- Link monitoring to relevant climate data and fire history to understand before and after response.

- Monitor fauna response and food resources where appropriate.

- Monitor senescence and population decline in longer unburnt vegetation.

- Monitor the impact and spread of Phytophthora dieback pre and post-fire.

- Document aims, methodology and results of monitoring in stable and accessible formats for future use.

- Consultation (with Flora Conservation Officers, Research Scientists, Statisticians etc) about the experimental design of monitoring programs is important to ensure maximum usefulness of the data collected and that the monitoring question is being addressed by the data collection program.

- Where appropriate and possible, apply statistical techniques (power analysis, repetition, etc) to determine the robustness of apparent trends in monitoring data.

Potential monitoring techniques:

- Permanent monitoring quadrats:
- Quadrat size will depend on habitat and species densities eg 10x10 m for shrubland, Document all species present, abundance and fire regeneration strategy (See Appendix XI for an example**).** Abundance can be scored using frequency or foliage cover**,** cover categories should conform to those of National Vegetation Information System (NVIS) (2003) (Appendix XI**)**
- or
- Document abundance and reproductive status of selected fire sensitive species. Quantify seed banks eg number of cones/ fruits of serotinous species
- After fire, monitor number of seedlings of selected species at pre-determined intervals (especially prior to the onset of summer drought and again prior to the commencement of winter) until established. Similar methodology could be applied to monitor canopy seed banks and mortality in long unburnt vegetation.
- Document fire responses where unknown.
- Document juvenile period both time to first flowering and time to the setting of the first viable seed.

- Relevee (non permanent, un-marked but GPSed plot)
- Within fixed area, count number of dead stags of selected fire sensitive species and count seedling recruitment to give parent to seedling ratio. Continue to monitor at fixed intervals until established.

  or

  Randomly select stags of target species on a transect, count regeneration in a plot based around stag (eg. 1 x 1 m). The scale of sampling would need to be determined based on the size of the mature plants and dispersal mechanisms (i.e. for some winged seeded species the location of parent plants is only a rough guide as to where recruitment is likely to occur).

- Photo-monitoring: GPS and mark fixed monitor points, record direction of photo, take photos pre and post-fire and at fixed intervals thereafter.

- Monitor crown cover using digital cover photography, spherical densitometer or fish-eye photography, (MacFarlane *et al*. 2007)

- Fauna monitoring will require specific techniques for individual species however all observations of fauna activity and recolonisation in relation to fire are valuable.

12 CONCLUSIONS

This document provides land managers with the means to better understand and conserve fire sensitive ecosystems by the identification of these systems, their key component species and the provision of ecological guidelines for sensitive systems.

Fire sensitive systems were identified using an Ecodistrict approach in consultation with local experts and land managers based upon a literature review, fire sensitivity attributes and the collation of information on fire responses of component species. Fire sensitive systems included vegetation types dominated by serotinous obligate seeder species such as mallet woodlands, Proteaceous shrublands and mallee over *Melaleuca* shrublands, as well as transitional woodlands, granite communities, wetland and riparian systems, peat and organic soil systems, cryptogram communities, and systems with refugial fauna and other short range endemic species. Key fire sensitive species, their response to fire and maturation times for each system have been identified where known and should be used to help determine optimal fire regimes in sensitive systems.

The 'precautionary principle' was adopted in identifying sensitive systems, as from the literature review, it is clear that our knowledge of ecosystem function and fire responses is far from complete and research priorities to aid our understanding of sensitive systems have been identified in response to these knowledge gaps. Ongoing data collection and monitoring can further inform the adaptive management process.

The use of GIS systems to collate and analyse accurate fire history data is critical to give a clear assessment of the past and current impacts of prescribed and unmanaged fire and to guide the decision making process in relation to fire management. An analysis of the fire history of remnant vegetation in a GIS environment has allowed some general observations to be made on the cause, seasonality, distribution, frequency and scale of fires in the last 33 years (1975-2008). The cause of fire for the eastern and more remote parts of the region has been predominantly wildfire with an increased use of prescribed fire in western parts and in areas of greater public use. This concurs with past and current fire management practises, as outlined in this report, of reduced fire intervention in more remote areas of the region.

Cape Arid, Stirling Range and Two-Peoples Bay – Manypeaks National Parks tended to have a 'young' fuel age distribution in comparison with the 'older' fuel age distribution of the Great Western Woodland. The greatest proportion of area in the reserves assessed had a fire frequency of one to two fires in the 30-year study period. The Fitzgerald River National Park and Great Western Woodland had larger areas that had no fire recorded for the study period. Of concern for serotinous seeder species, was the high percentage of the Stirling Range National Park (16%) and Cape Arid National Park (12%) that had experienced three fires in 34 and 32 years, respectively. The area burnt annually across the region between 1975 to 2008 shows a trend towards an increase in fire incidence and the area burnt. The trend was less marked for individual reserves assessed with the exception of the Great Western Woodland where the area burnt annually appears to be increasing.

Systematic data collection and monitoring of the fire responses and life history attributes of components of these South Coast systems is critical and the key to understanding optimal fire regimes for achieving conservation outcomes.

13 GLOSSARY

Aeolian	**Produced by wind**
Aerial canker	**Stem rot disease caused by aerially dispersed fungi**
Benchmark	**A reference mark (e.g. vegetation quadrat) to which other values can be referred**
Bradysporous	**Having hard seed cases that require fire to open seed case and release seed for germination. Comes from Greek word 'brady' meaning 'slow' in this case referring to the slow release of spores.**
Chronosequence study	**A study using e.g. vegetation of a range different ages or fire histories to compare the effect of age on floristics, compared with a longitudinal study that follows vegetation succession directly through time.**
Communities	**A dynamic system of plants living in association with one another and their environment**
Coppice	**The regrowth of a tree from the point of removal of a stem, usually at ground level, takes advantage of an established root system.**
Cryptogams	**A general term for plans reproducing by spores or without flowers or true stems, for example lichens and mosses.**
Dendrochronology	**The study of climatic or other environmental factors through the dating and interpretation of the annual growth rings of trees.**
Drainage depression	**A shallow gently sloping depression formed by sheet erosion**
Edaphic	**Relating to the physical, chemical or biological characteristics of soil.**
Endemic	**A plant or animal naturally restricted to a particular region**
Epicormic	**Arising from a dormant bud especially following injury to the plant above the bud**
Fire interval	**Time between two consecutive fires**
Geophyte	**A land plant with dormant underground parts such as bulbs, tubers or rhizomes**
Geosporous	**Having a soil seed bank**
Gimlet	**Usually refers to *Eucalyptus salubris*, a smooth, shiny barked tree**
Gnamma	**A rock hole capable of holding water formed by weathering**
Greenstone	**Zones of metamorphosed mafic and ultra-mafic (igneous rocks low in silica, high in dark coloured mafic minerals e.g. iron and magnesium) volcanic sequences with associated sedimentary rocks that occur within Archaean and Proterozoic (Pre-Cambrian) cratons between granite and gneiss bodies.**
Hollow-butting	**Formation of tree hollows due to removal of heartwood by intense fire.**
Inter-fire recruitment	**Seedling recruitment in the absence of fire**
Juvenile period	**Time to first flowering for a plant species killed by fire that regenerates from seed**
Kwongan	**The diverse heathlands and shrublands of Western Australia**
Leaf litter layer	**Includes the layer of humus, leaf and twig litter covering the soil**
Lignotuber	**A dense woody swelling at the base of a shrub or tree where the plants stores food and buds, serves as a reservoir for growth hormones and contains adventitious buds which can produce coppice shoots if older stems are removed or damaged**
Littoral	**Relating to shallow waters**
Marine Plain	**Marine sediments from the Tertiary Period**
Mycorrhizal association	**An association of fungal hyphae with plant roots, the plant receives nutrients and the fungi sugars**
Mallet	**Species of *Eucalyptus* that are killed by fire and regenerate from seed, typically single-stemmed in appearance**
Mesic	**Requiring a large amount of water for survival**
Metamorphology	**Transformation of igneous or sedimentary through heating, pressure or water action**
Monadnock	**A mountain or rocky mass that has resisted erosion and stands isolated in an essentially level area, also called 'inselberg'.**
Moort	**Species in *Eucalyptus* sect. *Bisectae*, subsect. *Glandulosae*, ser *Erectae*,**

	suprasp. *Latae*, includes *E. platypus* ssp *platypus, E. platypus* ssp *congregata, E. utilis, E. nutans,* All are killed by fire and regenerate from seed, typically single-stemmed in appearance.
Obligate seeder	**Plants that are killed by fire and must re-establish through germination and establishment of seedlings.**
Palusplain	**Seasonally water-logged flat**
Pliocene	**The last geological epoch of the Tertiary Period, commenced about 5 mya and finished with beginning of Pleistocene epoch. Climatic conditions were unstable undergoing wide fluctuations.**
Proterozoic	**That section of the Pre-Cambrian Era following the Azoic Period**
Quaternary	**The most recent period of the most recent geological (Cainozoic) Era commencing between 1.5-1.8 mya. Consists of Pleistocene and Recent Epochs**
Recruitment	**Regeneration of plants by means of seed bank germination and seedling establishment**
Refugia	**Areas that provide habitat for species that may have been more widespread in the geological past under different e.g. wetter climatic conditions.**
Reseeder	**Plants that are killed by fire and re-establish through germination and establishment of seedlings.**
Resprouter	**Plants that survive fire as individuals, typically have massive deeply penetrating root systems**
Rhizome	**An underground stem**
Riparian	**Requiring free water or very moist conditions such as is found along the banks of a stream or lake; living on or adjacent to a water course or lake.**
Senescence	**The condition of old ages that applies to plants**
Scrub-rolling	**A process of mechanically rolling over vegetation to facilitate prescribed burning under more controlled conditions.**
Seral	**The plant or animal community at a particular time during a succession**
Serotinous	**A seed case that requires heat from a fire to open or release the non-dormant seed. Actual meaning is "late in developing" or in this case releasing seed.**
Short-range endemic	**A plant or animal geographically restricted to a range of typically less than 100 km^2**
Skeletal soil	**Shallow soil over rock**
Spongelite	**Soft sedimentary rock formed under an inland sea over 36 mya in the Tertiary Period, featuring the fossils of sea sponges**
Sporangia	**The case in which fungal spores form**
Stochastic	**Produced at random rather than by a cause**
Swamp	**A low wet areas covered by shrubs or trees adapted to excessive moisture**
Transitional woodlands	**Eucalypt woodlands situated in the Transitional Rainfall Zone, between the high rainfall forest of the Southwest and low rainfall inland Australia, with an annual rainfall of 300 – 800 mm. More recently described as the Great Western Woodlands. Includes Avon Wheatbelt and Mallee IBRA regions.**
Transitional mallee shrublands	**Mallee shrublands situated in the Transitional Rainfall Zone described for transitional woodlands.**
Wetland	**A low lying area inundated or permanently covered by shallow water**
Yilgarn	**The Large Pre-Cambrian granite - gneiss shield or craton forming most of the WA landmass**

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APPENDIX I. A REVIEW OF SOUTH COAST REGION FIRE ECOLOGY STUDIES

1 FOREST MOSAIC ECODISTRICT

The fire ecology of forest ecosystems of the Southwest has been relatively well studied and findings are applicable to plant associations within the Forest Mosaic District in the western end of the South Coast region.

The ratio of resprouters to re-seeders, including trees, woody shrubs and perennial herbs, in the drier upland sites of the jarrah forest and wandoo woodlands was found to be approximately 75:25 (Burrow and Wardell-Johnson 2003), considerably higher than other areas in the South Coast region (e.g. 48% resprouters Fitzgerald River National Park). The proportion of taxa in different fire response categories differs between community types in the same region with higher proportions (60%) of seeders in the karri forest compared with heath or dune communities in the Walpole Nornalup National Park (Yates *et al.* 2003a). In habitats less prone to fire, the proportion of obligate seeders is typically high, varying from 50-80% whereas in frequently burnt communities it may be as low as 8% (Burrows and Wardell-Johnson 2003). Within the forest, communities with high proportions of obligate seeders usually occur in habitats that are moist, carry sparse fuels, or are natural barriers to fire and include riparian zones, granite outcrops, valleys, swamps and wet sclerophyll forest such as karri and tingle.

Mean annual rainfall and temporal and spatial variability in landscape flammability are significant factors affecting the distribution of fire regime sensitive species (Burrows *et al.* 2008). Fire sensitive species are usually confined to areas of unusual habitat that may be burnt less frequently than surrounding landscape. Threatened flora and fire sensitive taxa are often associated with these habitats (Burrows and Wardell-Johnson 2003). White's gum (*Eucalyptus virginea*) is a restricted relictual eucalypt near Mt Lindesay with a thin bark, sparse regeneration and shows severe hollow butting of mature trees; it is confined to margins of granite outcrops, and steep-sided streams. Similarly, brown mallet (*E. astringens*) is confined to lateritic breakaways and bullich (*E. megacarpa*) occupies wetter areas thus avoiding frequent fire (Burrows and Wardell-Johnson 2003). The vulnerability of a local endemic in a fire prone environment is likely to reflect differences in the prevailing adaptations of the dominant species, most species including fire vulnerable local endemics have some capacity to survive in relation to fire. However, jarrah and marri dominate in forested ecosystems because they have both a greater capacity to regenerate and survive fire from a seedling stage and a greater capacity to access water from deeply weathered profiles.

Of 639 plants species surveyed in the jarrah forest and associated ecosystems, 97% of understorey species reached flowering age within three years and all by five years (Burrows *et al.* 2008). There was variation within species with plants at the drier end of their range taking longer to mature. Resprouter species in almost all life form categories flowered sooner than re-seeders. Fire sensitive species with longer juvenile periods mostly occurred in low rainfall zones or in habitat less prone to fire such as riparian zones or swamps or rock outcrops. Species with longer juvenile periods were mostly those with canopy-stored seed. Only 1-2% of species relied on canopy-stored seed compared with 25-30% soil-stored seeders. Notably, the former are often threatened taxa, have a limited distribution or are taller, thicket forming or key-stone species providing habitat for fauna.

Longer juvenile periods were documented for species in the drier (< 750 mm) eastern jarrah forest compared with the wetter western forest. Sustained frequent burning at 3-4 years resulted in a significant decrease in abundance of two obligate seeder species, *Crowea angustifolia* and *Acacia browniana*, these also declined in long unburnt sites although seed probably persisted in the soil (Burrows and Wardell-Johnson 2003). Other species that increased in regularly burnt plots included *Corymbia calophylla, E. marginata, Hovea elliptica* and *Taxandria parviceps*. Species with relatively long juvenile periods *included Lambertia rariflora, Hakea oleifolia, H. lasianthoides, Banksia seminuda, Melaleuca viminea, M. ringens* and *Taxandria juniperina*, these species can take 6-8 years to flower after fire.
Most forest eucalypts such as karri, red tingle, yellow tingle, marri and wandoo will take advantage of post-fire conditions to regenerate prolifically from seed (Burrows and Wardell-Johnson 2003). From a seedling karri may take 15-20 years to become reproductively mature while red tingle takes at least 25 years, structural maturity takes considerably longer and can be in the order of 100-150 years. In contrast, yellow tingle flowers within 8 years of establishment. The response of juvenile eucalypts may vary from that of mature trees, moderate intensity fires will kill small juvenile wandoo.

The Tingle Mosaic near Walpole occurs within the higher rainfall karri forest. The responses of three locally endemic tingle species (*E. brevistylis, E. jacksonii* and *E. guilfoylei*) as well as three regional species (*E. marginata, E. diversicolor* and *Corymbia calophylla*) were studied within the Tingle Mosiac (Wardell-Johnson 2000). While eucalypts are largely resprouters rather than obligate seeders, they may very considerably in their sensitivity to fire. There was little evidence of broad-scale purely even-aged stands suggesting that old-growth forest in this area consists of several cohorts of regeneration within a stand, which is generally true for karri forest also (Bradshaw and Rayner 1997a & 1997b). While no species were strictly fire sensitive and all re-sprouted from crown epicormics after 100% leaf scorch, the quantity and type of regeneration in relation to gaps created by dead trees varied between species. The very low levels of regeneration of *E. brevistylis* following fire and the high proportion of stems of *E. jacksonii* that were hollow butted may be factors associated with narrow endemism of these species and their vulnerability to fire. The interaction between seed availability, intense fires and subsequent rainfall may be critical in the long-term survival of these species. It was considered that *E. brevistylis* and *E. jacksonii* were likely to decrease in abundance under a regime of more frequent fire associated with climate change. In contrast, *C. calophylla*, *E. marginata* and *E. guilfoylei* may become more abundant with increased fire frequency. The build up of biomass around the stems of karri, red tingle and Rates tingle can be very high, and while no more sensitive to fire than jarrah or marri; under dry conditions mature plants can be killed (Burrows and Wardell-Johnson 2003).

A space-for-time substitution study of floristic patterns in relation to disturbance history in the karri forest demonstrated the resilience of karri forest to fire (Wardell-Johnson *et al*. 2004; 2007). Time-since-fire influenced species richness and floristic composition more than the number of recent past fires because of a high proportion of ephemerals associated with the immediate post-fire period. This was in contrast to the more species-rich but drier and nutrient-poor adjoining jarrah forest, where the number of past fires is more influential. Long-lived shrubs with soil stored seed were dominant numerically and in understorey biomass in comparison with neighbouring vegetation types. Under the current climatic regime it was concluded that karri forest communities are likely to undergo less long-term change in floristic patterns following disturbance than adjoining vegetation types.

A DEC monitoring project in karri / tingle forest in the Nuyts Wilderness near Walpole after an intense wildfire in 2001 has collected post-fire data for plants, vertebrates, invertebrates and stand structure (DEC 2008a). At four years post-fire crown condition of mature karri and tingle had stabilised although isolated tree mortality continued. Karri, red tingle and marri had regenerated vigorously, where the overstorey was damaged, with saplings to 5m. At five years post-fire the normal suite of bird species had established and quokka had established in all suitable habitat within the burn area. Results to date indicate that long-term fire exclusion can result in severe fire impacts on forest ecosystems and that large scale high intensity fire can have undesirable outcomes including simplification of plant population structure and depletion of seed banks. Tingle and karri forest contain a high proportion of short range relict invertebrates. Post-fire monitoring of arthropod litter invertebrates since December 2001 compares species composition between burnt (wildfire and prescribed) and long unburnt tall wet forests. Understanding the effects of a single intense wildfire on invertebrate biodiversity aims to assist in the development of ecologically appropriate fire regimes.

A one-year study of litter invertebrates, spring 1996, in Walpole-Nornalup National Park (jarrah, tingle and karri forest) showed that taxonomic composition and unique species richness varied between sites with different fire histories (van Heurck *et al.* 2000). Some invertebrate groups peaked in long unburnt while others peaked in more recently burnt sites. For example, long unburnt (30 years) jarrah forest had the greatest overall number of unique species with highest richness of wasps, bees and ants while one-month-old forest was highest in unique spiders and beetles. Thirty-three % of morpho-species were only trapped in sites unburnt for more than 29 years and 44% in sites less than 12 years-old. The distribution of relict taxa suggests that sites with different plant composition and fire ages have their own unique relict invertebrate communities. The authors suggested that a complete regional biodiversity should be conserved by maintaining a mosaic of fire regimes which included refugial microhabitats.

Another DEC project, the Walpole fine grain mosaic burning trial (DEC 2008a) aims to investigate the hypothesis that fire diversity can benefit biodiversity at a landscape scale as well as reducing the occurrence of large, damaging and homogenising wildfires. The study is investigating the effects of a fine grain fire mosaic on fire regime specific plant taxa, geophytes, fire regime specific fauna, reptile, bird, invertebrate and vascular plant assemblages, fungi and cryptograms. The study to date has shown that fine grain patch-burning is operationally feasible in forest area while benefits to biodiversity have not been fully assessed.

Peat and organic soils

Wetlands with peat soils are widespread but relatively rare and tend to be concentrated in the higher rainfall Forest Mosaic Ecodistrict. Shallower layers of organic rich soils are more common across the region. The presence of organic-rich systems that are relictual in nature in south-west WA is arguable the result of a long-term absence of the types of fires that will burn soils in particular parts of the landscape (Horwitz *et al.* 2003). Endemic, relictual and often restricted species depend on moist refugial habitats provided for by fine scale hydrological patterns and seasonally wet and swampy habitats. These moist areas are regionally significant for the retention of vulnerable species particularly through extended drought. Specific sites where the Gondwanan element may be found include high rainfall areas, topographically high South Coastal areas with frequent cloud cover, areas adjacent to granites, areas of impeded groundwater flow producing winter wet swamps, streams with extensive fresh headwater swamps and year round flow, areas that can harvest water from fog or cloud e.g. tingle forest and South Coast dunes and heath; areas with southern or southwest aspect e.g. wet valley floors, areas of intact forest canopy, springs or cave-streams or other expressions of interstitial or groundwater (Horwitz *et al.* 2003).

Some of the best developed soils in southwest WA occur in and adjacent to small and localized wetlands, often restricted to depressions in coastal aeolian sand hills, and on the South Coast to open heath plains. Organic soils and wetlands are susceptible to fire invasion because of their restricted distribution, shallow and often ephemeral nature as well as the presence of readily flammable littoral vegetation and organic substrates, potentially losing soil thousands of years old (Horwitz *et al.* 2003). Removal of peat holds consequences for nutrient status and water retention capacity of remaining soil and may be compounded by erosion to render soil unsuitable for seedling establishment over time Keith (1996). Local organic-rich systems can be permanently altered or disrupted by frequent hot fire or a regime that systematic removes organic matter (Horwitz *et al.* 2003).

Indicators of soil loss or damage include are exposed roots where the fire has consumed organic soil from around the roots of shrubs and trees; long-term cracked soil where deep organic soils have shrunk from the heat of the fire; remnant pedestals where fire has consumed organic soil around Restionaceae and failed to completely burn the soil; burnt edges where shallow organic soils upslope of the wetland were consumed by fire (Horwitz *et al.* 2003). Thus fire removes organic matter and changes soil structure, organic soils may be exposed to more severe drying making them more vulnerable to fire and loss of fibric material.

Regular and homogenous burning regimes can reduce landscape heterogeneity by reducing the ability of moister parts of the landscape to edaphically control fire; prescribed burning should not over-ride edaphic controls. With regular burning loss of organic soils may therefore be higher than for infrequent (even intense) wildfire. In a drying climate, soils may dry out to a great depth and therefore are more flammable and vulnerable to summer or autumn fires.

An additional issue with regard to fire suppression is the impact that fire retardant chemicals and fire suppressant foams may have on water quality and aquatic biota as both have been found to be toxic to algae, invertebrates and fish (Horwitz *et al.* 2003).

2 MARINE PLAIN AND ESPERANCE SANDPLAINS ECODISTRICTS: BANKSIA SHRUBLAND / MALLEE SHRUBLAND

The Marine Plain, Esperance Sandplain and Nuytsland Ecodistricts are characterised by kwongan (shrubland) and mallee-heath communities, key structural components of these include members of the Proteaceae, in particular species from the genera *Banksia* and *Hakea*, many of these dominants are obligate seeding serotinous species. While the northern kwongan has been the subject of many studies, relatively little is known about the population dynamics of South Coast kwongan communities other than a small number of ecological (e.g. van der Moezel *et al.* 1984; Bennett 1987; McCaw 1997; Chapman and Newbey 1994; Hassell 2001) and species studies (e.g. Witkowski *et al.* 1991; McCaw and Smith 1992; Wooller *et al.* 2002, McCaw 2008).

The ecology of southern species growing under different climatic conditions may be expected to differ from their northern counterparts (Witkowski *et al*. 1991). The abundance of *Banksia* species with lignotubers (resprouters) is much reduced in the southern sandplains compared with their northern counterparts with about twice as many obligate re-seeders on the South Coast (Lamont and Markey 1995; Cowling and Lamont 1985a). This difference has been attributed to a greater fire frequency in northern heathlands and milder temperatures with a longer growing season on the South Coast (Lamont and Markey 1995). Such conditions are likely to have resulted in long-lived plants with a longer juvenile period and a slower accumulation of canopy stored seed (Wooller *et al.* 2002).

The seed bank dynamics of three co-occurring South Coast endemic species: *Banksia baxteri, B. speciosa* and *B. coccinea* were studied in relation to plant age and inter-fire establishment near Hopetoun (Marine Plain Ecodistrict) (Witkowski *et al*. 1991). Seed storage per annum was found to increase exponentially with plant age in *B. speciosa* and *B. baxteri* whereas storage peaked at 16 years for *B. coccinea*. The build up of a viable seed bank with time occurred at a slower rate than for non-resprouting banksias in the northern sandplains. Inter-fire establishment was only significant in *B. coccinea* which showed a lower degree of serotiny than the other two species. Even limited recruitment between fires may be critical when fire intervals are variable (Enright *et al.* 1998). There was minimal mortality in 21-year old *B. speciosa* and *B. baxteri* with no indication of senescence and cone and seed production had not peaked at this age; in addition healthy 40-year old trees were observed. In contrast 50% of 21-year-old *B. coccinea* were dead. The study suggested that *B. coccinea* has a shorter life span the other two species and may be adapted to shorter fire intervals. It was suggested that fire intervals of greater than 20 years could lead to its demise although inter-fire establishment could ensure its survival if environmental conditions for this were suitable.

In contrast, McCaw (1997a) in a study of *B. coccinea* across its range, found that the longevity of *B. coccinea* may exceed 45 years in the absence of disturbance by fire or severe infection by aerial canker fungi. Mature *B. coccinea* were the same age as other dominant shrub species. Despite this considerable age, there was successful initial recruitment of seedlings after fire.

Wooller *et al.* (2002) studied the regeneration of three non-resprouting *Banksia* endemic to the South Coast (*B. baxteri, B. nutans* and *B. baueri*) in relation to fire interval over a 20-year period in the western end of the Fitzgerald River National Park (FRNP). *B. baueri* and *B. nutans* (low shrubs) took six years to commence flowering after fire and *B. baxteri* (upright shrub) five years. A small proportion of B nutans and B. baueri flowered initially and it took 20 years for 50% of individuals to flower. Only at a site unburnt for 40 years, did all *B. nutans* flower. In *B. baxteri*, once flowering started, a large proportion flowered each year and there was a decline in flowering in older sites. Cones accumulated fastest in *B baxteri* and slowest in *B. nutans* with *B baueri* intermediate between the two. After about 20-30 years, most of the annual seed increment of *B baxteri* appeared to replace seed released from the canopy. *B. nutans* plants over 40 years old were still increasing their canopy seed bank. All three species were extinguished from an area burnt twice with a nine-year fire interval. No inter-fire recruitment was recorded for the three species, and *B. baxteri* is known to have minimal seed release in the absence of fire (McCaw and Smith 1992). Seedling densities were lowest for *B. baxteri* and it was suggested that this may account for its more rapid growth and accumulation of infructescences.

Age to first flowering and fertile fruiting of *B baxteri* and *B. coccinea* were studied in a longitudinal study at a single site in lowland mallee-heath near the southern boundary of the Stirling Range National Park, after fires in autumn 1989 and spring 1990 (McCaw 2008). Plants from the 1989 cohort began flowering by 5 years and more than 90% flowered by eight years. Fertile cones were observed on 50% of *B. baxteri* plants by 7 years, fertile cones were first observed on *B. coccinea* at 7 years and it took more than 10 years for 95% of plants to fruit. In contrast, only 60% of the 1990 cohort of *B. baxteri* had flowered at 8-years old while only 30% of *B coccinea* had flowered at 9-years old, 45% of *B. coccinea* individuals died without flowering. The extended juvenile period for the spring burnt cohort of these species was attributed to drought conditions from 1994 to 1996. The spring cohort was slower to develop fertile cones for both species and only 40% of *B. coccinea* developed fertile cones. The study demonstrated the considerable variation in age to flowering and fruiting that may occur between years or across the geographic range of a species resulting from climatic or other environmental factors. The time to first flowering for the autumn 1989 cohort of *B. baxteri* (McCaw 2008) is similar to that reported by Wooller (2002) but is considerably longer than that of Witkowski *et al.* (1991) and this may reflect the coastal influence at Hopetoun or particularly good growing seasons in the late 1970s early 1980s.

The genus *Hakea* is another group within the Proteaceae characterized by canopy-stored seed. There have been few studies of the fire ecology of *Hakea* with the exception of Lamont *et al* (1999) who investigated the recovery of 11 Hakea species (resprouting and non-resprouting) north and east of Perth, as well as four South Coast *Banksia* species near Hopetoun, from fire. The greatest influence on final plant densities (survivors after second summer) was the number of initial seedlings/parent and this varied considerable with species. Seedling densities were in turn largely a function of seeds available per plant at the time of fire. Patterns of seedling survival had a secondary role on densities. Mortality was primarily due to summer drought with minimal herbivory and this study suggested that there were considerable differences between species in their drought susceptibility. Plant community recovery appeared to be essentially haphazard and the study indicated that post-fire communities may differed demographically, floristically, structurally and functionally from the pre-fire community. For example, in the *Banksia* study, *B. speciosa* was almost twice its pre-fire density by the third winter after fire while *B. baxteri* was only 12%, *B. coccinea* 16% and *B. pulchella* 76%. Seedling survival did not correlate consistently with seed size but there was tendency for the largest seedlings to survive best and the seedlings of non-sprouters tended to survive better than resprouters. It was concluded by the authors that making predictions of post-fire community dynamics based on pre-fire numbers was purely conjectural.

Hassell (2001) studied the fire ecology of the FRNP by looking at historical evidence, the fire age requirements of selected biota, the post-fire recovery of individual species and charcoal levels in an estuarine core. Biological Survey sites (Chapman and Newbey 1987) burnt in the 1989 FRNP fire were monitored (1990-97) to determine post-fire regeneration strategy and the estimated recovery period of 249 species based on growth and / or the commencement of flowering (Hassell 2001). Vegetation includes Marine Plain shrublands and mallee heath, Yate (*E. occidentalis*) woodland, coastal dune communities and granitic upland units. Of the 249 species, resprouters were 7.8%; resprouters/seeder 40.8% and seeders 51.4%, thus the proportion recorded as commonly recovering from seed was 92.2% compared with 48.6% resprouter. Monocots had less seeders than dicots (30.8% versus 58.4%), and more resprouters (15.4% versus 5.3%) and resprouter / seeders (53.8% versus 36.3%). 'Rapid' recovery was defined as recovery and flowering in 1-4 years, 'medium' within 5-9 year and 'slow' within 10 years or more. While the number of slow recovery species was less (9-10%) than rapid or medium, the majority of these were emergents or dominants and individuals of these probably have a greater influence within the vegetation.

Slow recovery species were mainly seeders that were at most risk from short fire intervals. In general monocots recovered faster than dicots and comprised 55% of rapid recovery species. Applied to the FRNP as a whole it was estimated that approximately 157 (9% of 1748) species were slow recovery species at risk from short fire intervals and at least 20 years should be allowed for their full reproductive potential to be reached. Many resprouters had some capacity to re-seed e.g. *Banksia gardneri*. Seedlings of resprouters took longer to mature and flower than resprouts of the same species. Thus, even if resprouters survive short-interval fires; species dispersal, the potential to increase or stabilize population size and the potential for new genetic combinations are impaired (Hassell 2001). Individuals of several resprouters were killed by fire suggesting that a proportion of most species can be killed by fire even if the species has the ability to resprout under some conditions. Factors such as fire intensity, stem and bark thickness (Lamont 1985), fire resident time, fuel type, age and vigour of individual, depth of soil and root system (Whelan 1995) will influence ability to resprout. Recovery from the 1989 fires indicated that the vegetation had high inertia i.e. high resistance to change in species numbers and composition, and little fluctuation without disturbance, there is a slow change in the dominance of slow growing seeder species as they mature and become emergent (Hassell 2001).

A succession of change in vegetation structure induced by the length of fire interval was recognized, However, the vegetation formations of the FRNP have not had intervals consistently short (which tends to produce sedgeland) or consistently long enough to produce forest formations such as on off-shore islands and fall into an intermediate group. The effect season of fire on vegetation was considered to be relatively minor. The range of vegetation fire ages suggested that the most common fire interval was not less than 30-50 years. Areas with fire intervals of 80-100+ years were woodlands, shrubland with or without mallee, chenopod/succulent associations, and rocky or coastal locations. The high level of species richness in the FRNP appeared to be associated with 'intermediate' fire intervals. Short intervals reduce species number and long intervals are also associated with lower species richness (Hassell 2001), this is in accordance with 'intermediate disturbance hypothesis' of Keith (1996).

Studies of the fire ecology of lowland plant communities of the Stirling Range are limited to a single on-going study by McCaw (1997b) in one mallee-heath community on the southern edge of the SRNP. The project assessed the fire response and juvenile periods of species in this community after two experimental burns in vegetation burnt 20 years previously. A fire response database was compiled for this mallee-heath community as part of this study. Species with primary juvenile periods of six years or more included *Petrophile squamata, P. phyllicoides, Isopogon tripartitus* and *Hakea crassifolia* ssp *pandanicarpa* and *Hakea corymbosa*. In the case of *Hakea crassifolia* ssp *pandanicarpa,* 40% of individuals had flowered by 7 years and 67% had fruited by age 10. Of the species studies, 48% showed vegetative recovery compared with 80% for the northern kwongan (Bell *et al.* 1984). Twenty-nine percent had a canopy-stored seed bank compared with 8% at Badgingarra.

Unpublished studies Marine Plain Ecodistrict

Pre and post-fire monitoring to assess the regeneration of six dominant serotinous re-seeder species (*Banksia lemmaniana, B. heliantha, B. baueri, B. oreophila* and *Hakea pandanicarpa* ssp *crassifolia*) was conducted in the south-eastern end of the Fitzgerald River National Park, 20 months after a spring prescribed burn in 2006 and a previous fire interval of 17 years (Barrett and Freebury 2008 unpublished report). Vegetation varied from mallee-heath on sandy gravely soils to 'Barren's thicket' on quartzite, sites were either near coastal (all species) and or 8 km inland (*B. lemmaniana, H. pandanicarpa* ssp *crassifolia*). After the fire, the juvenile to parent ratios were 2:1 for *H. pandanicarpa* ssp *crassifolia,* 3:1 for coastal *B. lemanniana,* 7:1 for inland *B. lemanniana,* 5:1 for *B. heliantha,* 6 :1 for *B. oreophila* and 7: 1 for *Banksia baueri.* The juvenile to parent ratio was lower for inland compared with coastal populations of *B. lemanniana* but was similar for both populations of *H. pandanicarpa* ssp *crassifolia.* Overall, low levels of seedling mortality were observed, being most apparent in *B. heliantha.* Despite what appeared to be low numbers of cones or fruits per plant pre-fire, regeneration may have been adequate to replace pre-fire numbers. However, further monitoring was considered necessary to assess densities following mortality and thinning in subsequent summers.

In Cape Arid National Park, the magnitude of the seed bank of the most fire-sensitive species was assessed across different fire-aged habitats to assist land managers in the selection of appropriate fire intervals for biodiversity conservation outcomes (Cochrane *et al.* 2009 unpublished). Using a combination of field and laboratory techniques, on-plant fruit load, seed to follicle ratio and seed viability for three co-occurring obligate seeding *Banksia* species: *Banksia speciosa* R.Br.*, B. nutans* R.Br. and *B. pulchella* R.Br was quantified. Reproductive data and fruiting material were gathered from paired monitoring plots established in 8, 13 and 24 year old vegetation communities. A bi-directional temperature gradient plate was used to create germination temperature profiles for each species in order to assess temperature constraints on recruitment as a vulnerability predictor for climate warming.

Time since fire influenced plant height and reproductive output for all three species. Eight years post-fire a proportion of plants of all species had flowered and fruited. There was a positive relationship between numbers of fruiting cones per plant and fire age, although many flowering spikes did not set fruit even at 24 years post-fire. There was no consistent trend between plant age and mean cone dimensions, mean follicles per cone or in mean seeds per cone for any species. Although cones can carry two seeds per follicle the seed to follicle ratios calculated demonstrated that very few follicles had a full complement, mostly due to seed predators. Using a germination test, we found no significant difference in seed quality or mean germination time for the different aged stands. Field and laboratory data was used to show a positive relationship between our estimate of mean viable seeds per plant and time since fire, which ranged from less than 10 viable seeds per plant at 8 years post-fire to more than 100 viable seeds per plant for *B. speciosa* at 24 years of age. Neither *B. pulchella* nor *B. nutans* produced seed quantities comparable to *B. speciosa*. For all measurements there was considerable variability in reproductive output between the two 24 year old vegetation communities.

The authors considered that measuring total seed production rather than flowering or fruit formation is the most relevant management tool for decision support when choosing ecologically sound burning regimes aimed at ensuring plant population persistence. Although fire parameters, post-fire seed and seedling predation and climatic conditions will impact on post-fire recruitment success, the quantity of seeds produced by each species is one of the major factors most likely to cause threat to their survival if fire frequencies are too short. Without sufficient seeds for adult replacement local population extinction of obligate seeding, serotinous species can occur. Increasingly arid conditions and drought associated with a changing climate will impact on regeneration, survival, time to reproductive maturity and level of flower and seed production.

3 ALBANY-FRASER ECODISTRICTS

There have been no specific studies of granite outcrop ecology within the South Coast region; however parallels can be drawn from other granite outcrop studies in the Southwest. The spread of fire on granite outcrops may be impeded allowing for the persistence of longer unburnt vegetation (Yates *et al.* 2003a); granite outcrops may therefore provide refugial opportunities for fire-sensitive species. A higher ratio of seeders to resprouters has been documented for granite outcrop vegetation in the Southwest, with 60% seeder species compared with 40% resprouters (Yates *et al.* 2003a).

Muir (1985) noted that 34% of threatened flora were associated with granite outcrops or breakaways despite the low area these habitat types occupy in the landscape and queried whether fire been instrumental in creating their rarity. A study of two successive fires 13 years apart on granite outcrop vegetation in the eastern wheatbelt documented dramatic differences in species composition over the period with a significant post-fire flush of annuals and geophytes and a significant decline in the endemic serotinous re-seeder species *Hakea petiolaris* ssp *trichophylla* after the second fire (Yates *et al.* 2003b). Post fire seedling densities varied within and between species following the two fires.

A comparative study of the granite endemic *Verticordia staminosa* ssp *staminosa* and the rare endemic occurred each winter with germination and survival being considerably higher in wet winters (Yates *et al.* 2004). In contrast, for the fire prone kwongan species *V. fimbrilepis* ssp *fimbrilepi*s, some recruitment occurred each winter but was considerably higher after a fire. On the South Coast, significant and ongoing inter-fire recruitment has been recorded for the threatened granite endemics *Banksia verticillata*, *Isopogon uncinatus* and *Grevillea maxwellii* (Monks *et al*. 1994; Barrett and Cochrane 2007; Barrett unpublished data). Yates *et al.* (2003b) conclude that fire has been a more significant selective force in the evolution of kwongan taxa than granite endemic taxa.

4 QUARTZITE ECODISTRICT

The quartzite ranges of the Stirling Range National Park are characterized by high numbers of endemic and threatened taxa many of which are fire sensitive with long juvenile periods, three Threatened or Priority Ecological communities occur on these mountain summits and slopes (Barrett 1999, 2004). Previous studies have suggested that there is a clear dichotomy in the fire sensitivity of species occupying the wet gullies and thickets of upland areas and those occupying the seasonally dry lowland mallee-heath with the upland areas requiring longer fire-free intervals of 25 years or more (York-Main and Gaull 1993, Friend and William 1993, Barrett 1996). Slow growth rates observed on mountain tops suggest that the time for many species to reach maturity in this community may be considerably higher (>20 years) than lowland plant communities (Barrett 1996). The recent fire history of the Stirling Range National Park, Park with extensive fire in 1987, 1991, 1996, 1997, 2000 and 2003, suggest that high frequency, intense fires constitute the greatest risk for driving population decline and extinction in a landscape already extensively infested by Phytophthora dieback (Barrett *et al.* 2006). In particular, fire in 2000 burnt almost one third of the park in two separate wildfires. The eastern section of the Park had been burnt only nine years previously in 1991.

Following the spring 2000 fire, a chronosequence study of the fire ecology of the Eastern Stirling Range Montane Heath and Thicket TEC was initiated and is ongoing (Yates and Barrett unpublished data) in vegetation burnt in various combinations of fire intervals. The ratio of seeders to resprouters was very high with only 29% resprouters compared with 71% reseeders documented (Barrett pers. comm.), suggestive of the greater sensitivity of this community to fire. Of the resprouters present, 38% were facultative seeder-sprouters. Very long juvenile periods of 9-10 years have been documented for several fire-sensitive threatened taxa endemic to this TEC (*Andersonia axilliflora, Banksia montana, Persoonia micranthera*). Populations of serotinous species such as *Banksia montana* underwent dramatic declines while two populations of *Banksia brownii* were rendered extinct as a result of a nine-year fire interval. Grazing impacts on regenerating vegetation in the TEC have been significant after the 2000 fire reducing growth reproduction and survival of affected species.

The Montane Mallee Thicket TEC is also characterized by a high number of endemic, fire sensitive species (Barrett 2004). Monitoring of the threatened taxa *Banksia brownii* and *Lambertia fairallii* after fires in 1991 and 2000 showed a dramatic reduction in population densities. Mean densities of *B. brownii* in quadrats fell from 2.3 / m^2 pre-fire to 0.05 / m^2 post-fire while densities of *L. fairallii* fell from 7.5 / m^2 to 0.1 / m^2 (Barrett 2005) while a population of *L. fairallii* was rendered extinct. Assessment of cone or fruit production at various times since fire in this community indicates that considerable fire-free intervals are required to enable seed banks to be replenished. At seven years after fire *B. solandri, B. brownii, B. concinna, B. oreophila, I. latifolius* and *L. fairallii* all had less than one fruit per plant while at 12 years mean cone production was 0.6 for *B. brownii*.

A Draft Fire Management Strategy for the Stirling Range NP (Barrett *et al.* 2006), recommends that demographic processes and life history attributes be used to identify fire sensitive species within each fire 'cell' and to determine the minimal tolerable fire frequency for these species. It also identifies threatened species and ecological communities and recommends that the core mountain areas (corresponding to occurrences of this community) be designated as "no planned burn" areas for the duration of the Master Burn Plan. There have been no studies of the fire ecology of other quartzite ranges.

5 GREENSTONE ECODISTRICT

The fire ecology of the Greenstone Ecodistrict is limited to single study by Bennett (1987) which followed the post-fire recovery of one vegetation type on quartz rich granite soils after an autumn prescribed burn in 1981. The ratio of resprouters to seeders 58:42 suggesting that the natural fire frequency of this vegetation type is intermediate between jarrah forest or the fire prone shrubland (75% resprouters) of the northern kwongan (66% resprouters) and the arid regions of the Great Sandy Desert (24% resprouters). The vegetation composition after fire did not change markedly. However, the proportion of seedlings surviving up to the first summer was very low and therefore it was considered that densities would be reduced compared to pre-fire levels due to summer drought and heat. Overall, shaded seedlings had 25% survival compared with 11% in the open. Of the species present, 8% showed no regeneration by the first summer after fire.

Several plant species, including short range endemics from Bandalup Hill some 40 km east of Ravensthorpe, are the subject of a current PhD Thesis (Brian Vincent UWA) into their life history characteristics, demography and reproductive biology. Research into the obligate seeder *Stachystemon vinosus* (Euphorbiaceae) indicated that *S. vinosus* relies on a soil seed bank established between fires in order to survive the next fire. However the study showed that *S. vinosus* was not totally dependent on fire as plant density in burnt areas was half that of unburnt areas, indicating that a substantial proportion of the population was derived from inter-fire recruitment (Vincent *et al*.a submitted. The considerable variation in plant sizes in both burnt and unburnt areas indicated that recruitment occurred over a prolonged period, as opposed to a single pulse of recruitment following fire and resulted in stands of populations with a relatively uniform size. In addition there was substantial size overlap between plants in burnt and unburnt areas indicating that, although fire had stimulated recruitment, seeds in unburnt areas had germinated over the same time period. Hence the regeneration niche of S. *vinosus* was dependent on recruitment from seed and germination that may be stimulated by various environmental factors, which include the breaking of dormancy. A similar pattern of recruitment has been discovered for another south-western Australian Euphorbiaceae species - *Beyeria cockertonii* (Vincent *et al.*b submitted). This pattern contrasts with the general model of population dynamics that occurs in ecosystems were fire is the predominant form of disturbance. The authors concluded that further investigation into the inter-fire population dynamics of species in similar environments is therefore warranted.

A vegetation survey of the Ravensthorpe Range (Craig *et al.* 2008) identified vegetation units sensitive to fire based on fire response. These were units where serotinous seeder species were dominant and included mallet woodland systems, Proteaceous mallee heath and shrubland, mallee over *Melaleuca* units and *Allocasuarina* shrubland.

6 YILGARN EAST ECODISTRICT

Transitional Woodlands

Lightening-caused wildfire is common in the semi-arid woodlands of this area much of which is Unallocated Crown Land (UCL), although significant reserves include Frank Hann and Peak Charles National Parks. Typically, intervention for fire management in this more remote region has been minimal and the incidence of human-caused ignition is low (McCaw *et al* 2006). The recent history of large intense fires in landscapes where eucalypt woodlands are interspersed with sandplain shrubland appears incompatible with the persistence of mature eucalypts woodlands. There are considerable concerns re the impact of frequent, repeated fire on the structure of eucalypt woodlands which are a unique and ecologically important part of this landscape. Fire-induced change from woodland to mallee-heath east of Lake King was recorded by Hopkins and Robinson (1981), 40 years after the last recorded fire there was no indication of a return to a single-trunked woodland habit and it was estimated that at least 100 years was required for a return to woodland. Anecdotal information suggests that fire has had significant impacts on salmon gum woodland structure due to poor regeneration after major wildfire events (McKenzie pers. Comm.; McQuoid pers. comm.) while the the conversion of eucalypt woodland to mallee was noted by Beard (1973) also,

The responses of salmon gum (*E. salmonophloia*) woodland to landscape-scale disturbances caused by fire, floods, windstorms and drought were examined in unfragmented landscapes by Yates *et al.* (1994). Their study sites included Salmon Gum woodland within the South Coast region near Peak Charles that was burnt in a wildfire in 1991. Sites disturbed by fire, flood or storm during 1991-92 displayed adult tree mortality and extensive seedling establishment confirming the importance of landscape scale disturbance. Seedlings were absent or rare in undisturbed woodland. Rates of seedling mortality were lower at Peak Charles in the first year after fire compared with 'storm recruits'. While the authors suggest that seedling recruitment is rare in the absence of recruitment, patches of juvenile trees have been observed in woodland west of Norseman as well as near Salmon Gums by the authors of this report. These have established in gaps in the canopy where mature trees have died, and this, as well as the uneven aged nature of many stands, suggests that some inter-disturbance recruitment may occur. The conditions required for successful inter-disturbance recruitment is unclear.

While most woodland species have some ability to survive crown scorch and resprout from basal or epicormic shoots, many individuals are killed or do not achieve full crown replacement. More information is required as to when bark thickness is sufficient to protect cambial cells from fires of low to moderate intensity and the impact of these fires on adult mortality (Shedley 2007). In particular smooth barked eucalypts such as Wandoo, Salmon Gum and Gimlet (*E. salubris*) are sensitive to fire.

While there have been no studies of the effect of fire intensity on such woodland species in the South Coast region, research by Burrows *et al.* (1990) is applicable to woodlands in the North-West Mosaic and Yilgarn East Ecodistricts. Moderate intensity fire was found to cause significant damage to Wandoo trees and killed 89% of trees less than 10 cm diameter and 43% of trees in the 10-20 cm diameter range. Moderate intensity fire completely scorched all crowns, burnt down large trees to hollow butts and caused dry sides on most trees greater than 10 cm diameter due to cambial death (Burrows *et al.* 1990). Even low intensity fire killed 63% of small Wandoo trees less than 10 cm diameter with clumps of saplings particularly susceptible. While larger trees can resprout from epicormic growth after 100% scorch this was considerably slower than jarrah or marri at the same location. Coppice growth in Salmon Gum woodlands was found to be poor or non-existent, few trees had epicormic shoots nine months after high intensity fire and by 22 months only 50 % of adults had survived and were resprouting.

Until recently, there had been no comprehensive study of the fire ecology of transitional woodlands. However, a current PhD study in the Lake Johnston region aims to examine 'natural' temporal and spatial patterns of fire and how these patterns influence vegetation type (Alison O'Donnell unpublished), some preliminary findings are summarised below. The major hypothesis is that frequent fires have induced structural change in eucalypt woodlands from single stemmed to multi-stemmed shrubland. The project has created a database of fire history information from aerial photos and satellite imagery (1972-2005) for the Lake Johnston area to investigate fire patterns and their impacts on vegetation distribution and structure. In order to validate the fire history database and to more accurately define dates of pre-1985 fires, the stand age structure of *Callitris preissii* and *C. canescens*, both serotinous obligate seeders, were examined as stand age may be used as a proxy measure of time since fire. Stem sections and standard dendrochronology techniques confirm that *Callitris* stand age is a strong proxy measure of time since fire (O'Donnell *et al.* in press). There is anecdotal evidence that fire spread is largely dictated by previous scars, vegetation distribution and natural barriers such as lakes. The major questions posed by the study are: Do fires preferentially occur in certain vegetation types? What effect does this have on the distribution of plant communities? Has the proportion of vegetation types changed since the 1960s? Are the proportions of vegetation types more or less homogenous since the 1960s? Is fire-induced structural change self-perpetuating? Is fire in mallee shrubland occurring too frequently for recruitment? Can high intensity fires change the structure of eucalypt woodlands?

Analysis of fire scar data for the Lake Johnson 1:250,000 map sheet indicates that the age class distribution of vegetation is highly skewed. Forty-seven percent of the landscape has been burnt within the last 20 years, mostly by several, very large fires ignited by lightening. Only 17 % of the vegetation falls within 20-70 year age class, while 36% of the area has been unburnt for more than 70 years. The spatial distribution of the high fire activity area is strongly biased towards the southern and western parts of the area, possibly reflecting greater lightening or a difference in fuel conditions. Thirty-two percent of the study area has been burnt two or more times during the past 70 years. The data suggests that fires are preferentially occurring over previously burnt areas rather than long unburnt areas. The consequences for biodiversity and ecosystem function of repeated burning by large high intensity fires include: declines in fire sensitive plant species with long juvenile periods such as *Callitris, Hakea* and some woodland eucalypts; loss of mature eucalypt woodland and associated habitat components such as hollows and coarse woody debris; potential decline in vegetation cover leading to increased vulnerability to wind erosion; declines in carbon stocks in long-lived woody vegetation.

Modelling based on empirical fire interval data (1940-2007) shows that fire interval in this region is dependent on vegetation type. The typical fire interval length for woodland is 414 years, considerably longer than that of Mallee (63 years) and Shrubland (47 years) (O'Donnell *et al*. 2008). Fire regimes in woodlands are independent of fuel age with a relatively constant low probability of burning despite increases in fuel age. Fire regimes in Mallee show some age dependency with a linear growth in the probability of burning with fuel age. Fire regimes in Shrubland show moderate age dependency and exponential growth in the probability of burning with fuel age. All vegetation types showed a reduced probability of burning (less than an age independent regime) following fire for 25 years for Shrubland, 33 years for Mallee and 49 years for Woodland.

Transitional Mallee-shrubland and heath

The dominance of obligate-seeding species in the mallee flora suggests that these communities have evolved in an environment which experiences a lower fire frequency (van der Moezel and Bell 1984). Post-fire regeneration is slow in this semi-arid climate and a period of 50-100 years may be required for complete recovery to the dominant vegetation type of low mallee woodland formation with a dense understorey. Older areas have a taller more open tree canopy, a tall sparse shrub layer and an herbaceous ground cover. Studies across semi-arid mallee in southern Australia suggest that recruitment need only occur every few centuries since eucalypts may live for around 200 years (Bradstock and Cohn 2002). Recruitment of mallee seedlings is affected by season, rabbit grazing, and competition from mature eucalypts, lignotuber growth and rainfall. Other resprouting woody species such as *M. uncinata* follow broadly similar patterns of survivorship, regrowth maturation and seedling establishment. Mosses and lichens that form extensive crusts in gaps in bare soil appear mainly in long unburnt areas, the cryptogram layer may inhibit the establishment of vascular plants in long-unburnt mallee. There is little evidence of inter-fire recruitment, whether establishment is limited by release of seed from dormant seed banks, competition with established plants or grazing is unclear. Post-fire conditions lead to a temporary reduction in competition and predator / grazer satiation (Bradstock and Cohn 2002).

Being the only canopy dominant gymnosperm, *Callitris* are unique in semi-arid ecosystems of Southwest and *Callitris* patches are likely to be an important refuge for fire sensitive species. Recent declines in *C. collumellaris* due to inadequate recruitment in northern Australia highlight the need for careful management (Flaherty 2007). *Callitris* trees are extremely long-lived up to 250 years) and slow growing with a juvenile period of 10 to 20 years. There have been few studies of *Callitris* populations in WA despite the fact that it is a prominent genus in semi-arid areas (Flaherty 2007). *Callitris preissii* populations persist as patches of mature trees within semi-arid heathlands of southern WA despite periodic large wildfires in this flammable landscape. In the Lake Johnson area, no consistent evidence was found to suggest that edaphic factors account for this patchiness (Flaherty 2007). The extremely low flammability of *C. preissii* litter may partly explain why populations frequently avoid being burnt (Flaherty 2007). *C. preissii* patches were found in areas with fire return intervals as little as 10 years. The low flammability of *C. preissii* litter compared with co-occurring species is likely to play a vital role in altering small scale fire spread patterns and allowing population cores to escape being burnt. In those patches that do burn, the high degree of serotiny and accumulation of canopy seed facilitate post fire seedling establishment.

In the absence of fire, few recently recruited juveniles were recorded and together with fire history, competition for water and nutrients is likely to be an important factor affecting growth rates and the size-class distribution of *C. preissii*. The large cone crop shows that *C. preissii* has a high degree of serotiny although there was considerable variability between sites. Variability in age estimates at a site burnt six years previously suggested that seedling emergence may be delayed for a number of years after seed is released from cones on fire-killed trees which could be linked to with periods of below average rainfall. Inter-fire recruitment in *Callitris* has been reported for some species. However, Flaherty (2007) considered that this would account for only a small proportion of seedling establishment in the Lake Johnston area.

Callitris may be a relict of dry rainforest prior to the dominance of dry sclerophyll angiosperms and the co-existence of these serotinous obligate reseeders with more flammable angiosperms is problematical (Bradstock and Cohn 2002). It is hypothesized that the major functional groups in mallee communities are in tension and competition for resources may lead to dominance of one group over the other. Where fire is excluded *Callitris* may dominate over eucalypts, with frequent fire *Callitris* may be eliminated (Hobbs 2002). *Callitris verrucosa* patches were shown to reduce incoming fire intensity from adjacent eucalypt dominated vegetation under moderate intensity but not high intensity conditions (Cohn *et al*. 2008). Therefore under low to moderate intensity fire a feedback loop allows co-existence of fire tolerant and fire sensitive species, under extreme conditions there is no feedback and co-existence is difficult to regain.

Santalum spicatum (Sandalwood) is another prominent member of transitional as well as more mesic southern mallee shrubland. *Santalum spicatum* (sandalwood) and its relative, *S. acuminatum* (quondong) are obligate seeders that are highly sensitive to fire and may be substantially damaged, or killed by even a mild fire (Anderson 2005). Both species are therefore dependant upon the existing soil seed bank for their survival. Germination may be limited or absent if the seed bank that exists in the leafy humus below the shrub is also consumed by fire. With the decline or absence of key seed dispersal species in the critical body-weight range (50g-5kg) such as the woylie or burrowing bettong in sandalwood or quondong habitat, seed dispersal may now be restricted to vectoring by the emu or by means of surface water movement. Germination under these circumstances depends upon the seed lodging in a situation conducive to its growth and survival. Seed dispersal may also be reduced or absent if emus have been reduced in numbers by drought or control measures. Recruitment in a fire-damaged population of *Santalum spicatum* or *S. acuminatum* may therefore be very limited or non-existent (Anderson 2005).

At least a 100 years may be required for successful establishment (Hassell 2001). Sandalwood is very slow growing, seed loses viability quickly and the species has a short-lived (< 2 years) soil seed bank. The *Acacia* hosts (e.g. *Acacia acuminata*) may take at least four years to support sandalwood by which time the seed bank may be have lost viability. The presence of sufficient numbers of sandalwood for commercial harvest on European arrival indicates that fire intervals where it occurred were at least 100 years. Population extinctions following wildfires have been observed in the arid zone at Plumridge Lakes (Anderson pers. comm.). Coppicing (resprouting) of *S. spicatum* has been observed following fire or physical injury in the Phillips River valley near Ravensthorpe, this appears to occur in protected habitats where soil moisture levels are maintained over a longer period of the year (G. Woodall *pers comm.* 2004).

In more southerly Tallerack (*Eucalyptus pleurocarpa*) mallee-heath, serotinous obligate seeders are the dominant component of mature communities and comprised on average 52% of all vegetation point intercepts in mature plots at Lake Magenta Nature Reserve (Gosper *et al* in press), serotinous obligate seeders contribute the greatest bulk of the tallest shrub layer in this community.

Sheoak (*Allocasuarina huegeliana*) woodland on granitic soils is a feature of the Yilgarn eco-district. A. huegeliana can reproduce successfully without fire for at least 63 years although the majority of juvenile plants die in their early years leaving a minority to grow through to senescence (Muir 1985, Maher 2007).

7 ALBANY FRASER ISLAND ECODISTRICT

The islands of the Recherché Archipelago are in general much less frequently burnt than comparable mainland sites and provide ‘long unburnt’ reference sites for some mainland plant communities. Long-term quantitative studies of vegetation on Middle Island commenced after fire in the early 1970s (Weston 1985). Evidence suggests that the lightening–induced fire in 1972-73 was the first major bushfire on Middle Island since one at the beginning of the 1800s and that long-term fire exclusion does not necessarily alter floristic composition or richness of southwestern communities. Lack of fire gives a good example of temporal rarity, the fire ephemeral *Alogyne hakeifolia* was recorded in 1802 soon after a fire and next after fire in 1973, while contributing 25% of the canopy in 1975, it had disappeared by 1979 (Yates et al 2003a).

With a 100-170 year fire interval mainland shrub-sized species form forest formations, a structure completely different to the mainland with mono-specific stands of coastal moort (*E. utilis*), *E. angulosa* and *E. conferruminata*; these species have a mallee habit on the mainland indicating that the fire intervals in mallee shrubland on the South Coast are less than 170 years. Similarly, on Bald Island near Albany *E. conferruminata* and *Callitris preissii* form forest formations to 15 m due to long fire-free intervals of up to 140 years.

Low closed forests of the serotinous seeder species *Melaleuca lanceolata* are dominant on several islands on the South Coast including Long, Middle, Mondrain and Woody Islands in the Recherché Archipelago and Bald Island near Albany (Yates et al 2003a). *C. preissii* has been recorded on the granite peaks of Sandy Hook, Long, Mondrain and Middle Islands. *Callitris* and *M. lanceolata* communities are rare on the adjacent mainland where fire has been more frequent. On the South Coast mainland, *M. lanceolata* is restricted to small areas on the seaward edge of coastal granites.

Bald Island is thought to have avoided the influence of Aboriginal burning for some thousands of years. The age and structure of *Callitris preissii* on Bald Island varies considerably from groves of large mature tress through to thickets of sapling-sized trees that may have regenerated following episodic disturbance events (McCaw 1997c). Growth increment cores taken from large trees indicate ages of at least 100 years and in some cases up to 140 years. No young seedlings of *C. preissii* were observed even in open areas adjacent to large trees and grazing by quokka has been suggested as a factor limiting regeneration on Bald Island (McCaw 1997c).

The resprouter to seeder ratios documented in woodland and shrubland on Recherché Archipelago islands is extremely low compared with mainland plant communities. For example in shrubland vegetation on the lower slopes of Flinders Peak on Middle Island all species recorded in quadrats were re-seeders (Comer and Barrett unpublished data). Sedges were conspicuous by their absence. The lack of resprouter species may suggest that fire has been a less significant factor in the evolution of the Island flora.

APPENDIX II. A REVIEW OF FIRE POLICY WITH REGARDS TO FIRE ECOLOGY PROVISIONS

The formal protection of biodiversity within the State's legislative framework is achieved through the Conservation and Land Management Act 1984 and the Wildlife Conservation Act 1950. These acts provide for the management of the State's Conservation Reserve System and the protection of wildlife at the species level. At a National level, biodiversity at the level of species and ecosystems is protected through the Environment Protection and Biodiversity Conservation Act 1999. These acts to varying degrees recognize that fire can have adverse affect on biodiversity but there is no direct mention within the legislation that refers to the maintenance of fire regimes to maintain ecosystems or species. This can be attributed to the lack of broad scale information on specific fire regime requirements for the majority of ecosystems and species in Western Australia and the South Coast region. However, it is also unlikely that specific fire regimes at a species or ecosystem level can be legislated. It is more tenable that legislation requires that fire regimes are developed for fire sensitive species or ecosystems based on sound scientific information where available. It is then the role of policy, guidelines and management plans to enact these legislative requirements.

However, the absence of direct legislation governing the impact of inappropriate fire on biodiversity has not stopped the development of other policy instruments. In recent years, State government policy and guidelines have been developed to minimize the impacts of inappropriate fire regimes and the risk of large scale wildfires on biodiversity values. The Department of Environment and Conservation's Policy Statement No. 19 states that the Department will manage "prescribed fire and wildfires on lands managed by the Department to protect and promote the conservation of biodiversity and natural values… also promote fire management that protects biodiversity on lands not managed by the Department."

To support the implementation of this policy, the Department has developed a Code of Practice for Fire Management that outlines a framework for fire management procedures and practice. The code primarily sets out a framework for the Department's operational role in fire management of prescribed and unplanned fire. The code also states the Department's responsibilities in minimizing negative impacts of fire and fire management activities on biodiversity values including monitoring of prescribed burn outcomes, undertaking post fire studies and restoration and conducting research into the effects of fire on flora, fauna and ecosystems. Outlined in the code are a number of environmental principles that state that fire regimes and management activities will be appropriate to maintain the vigor and diversity in populations of species and communities of the State's flora and fauna and that the Department will undertake measures to promote the re-establishment of the ecological processes after a wildfire event.

At an operational level the Department has a series of guidelines which until recently largely pertained to on-ground operations and best practice fire management. Over the past few years guidelines have been developed specifically for fire sensitive ecosystems and species. These guidelines provide and overview of the ecology of the ecosystem or species, threatening processes, distribution and habitat information and outline fire management recommendations. The recommendations provide broad objectives with regards to either planned or unplanned fire and list strategies and management actions in order to achieve the objectives.

Ecosystem and species guidelines compliment the Master Burn Planning Manual which has a section that provides some guidance of how to determine fire regimes based on the life strategies of specific species. The manual includes a process for defining Condition Burning Areas to meet specific objectives based on the protection of a set of values or to achieve a specific objective. Included in these eight Conditional Burning Areas are the following categories:

- Fire Exclusion – reference area: An area from which fire has been deliberately excluded to provide a reference site for scientific studies of the effects of fire on the environment. Areas selected should be broadly representative of the landscape within which they are located. A reference area may be in the order of less than 500ha and should have value for scientific study because it is long unburnt.
- Scientific Study Area: An area in which scientific study is being undertaken and for the period of that study is not to be burnt or may be burnt as per the study requirements.
- Fire Exclusion – Habitat: An Area identified as having special value as fauna or flora habitat due to its vegetation structure, species composition, seral stages, niche values or location.
- Specified Management Regime: An area identified in a gazetted Management Plan or Draft Management Plan that has been assigned a specific fire regime for a specified purpose.

These categories can provide protection to fire sensitive ecosystems or species provided that adequate information exists to define and locate them.

APPENDIX III. INFORMATION ON RELATED ENVIRONMENTAL ISSUES

The interactions between fire and other types of disturbance and habitat modification including invasion by non-native plants, disease, grazing, fragmentation, and climate change can be very significant (Hobbs 2003). For example, fire, grazing and climatic variability can interact in a number of ways to determine the state of the vegetation in a given area and post fire regeneration success. The limited published as well as unpublished information on these interactions is summarised below.

1 SCRUB ROLLING AND BURNING

Scrub-rolling followed by burning is a widely used management tool in the South Coast Region for the creation of fuel reduction buffers to reduce the likelihood of unplanned wildfires into or out of reserves and to facilitate prescribed burning operations.

Research in mallee-heath vegetation in Lake Magenta Nature Reserve (Yilgarn East Eco-district) recorded 90% fewer recruits of serotinous obligate seeders in rolled and burnt compared to solely burnt plots and a 44% decrease in their species richness (Gosper *et al*. in press. Plots had been burnt at intervals after rolling that ranged from 33 days to over a year. Recruits of obligate seeding shrubs and fire ephemeral herbs with soil-stored seed banks increased by 166% in rolled plots while resprouters showed little difference between treatments. The conclusions from this study were that scrub-rolling and burning were likely to significantly alter vegetation structure and composition with the greatest impact being on serotinous obligate seeders. While rolling and burning may be preferable to mineral earth firebreaks, pre-rolling impacts assessments should be used to minimize detrimental impacts (Gosper *et a*l. in press). These assessments should identify sensitive species, communities and in particular threatened, priority or narrow-range endemics that are serotinous seeders. Where feasible populations may then be excluded from scrub-rolling or the landscape as a whole managed to favour these species and populations.

2 FIRE AND PLANT DISEASE

The interaction between plants, fungal pathogens and fire is poorly understood (Keith *et al* 2002). While timing and occurrence of fire as a germination cue may offer a means of escape from disease for species with a soil seed bank, it is unlikely to provide viable management options for those with canopy or transient seed banks.

Phytophthora dieback

Phytophthora dieback caused by the plant pathogen *Phytophthora cinnamomi* is one of the foremost threatening processes for the flora and plant communities of the South Coast Region. Survey and assessment of the health of mountain plant communities in the Stirling Range National Park (SRNP) in the 1990s suggested that there was a higher impact of *P. cinnamomi* in more recently burnt areas (Barrett 1996). A study in 2006 examined for the first time, the effect of fire on the expression of *P. cinnamomi* in four plant communities of the SRNP (Moore 2005). The incidence of disease was consistently higher in recently burnt sites and declines in species richness and abundance were identified across all plant communities surveyed. The incidence of disease declined with time since last burnt. Increased severity of disease in recently burnt and infested sites was particularly pronounced for *X. platyphylla* and the dominant Proteaceous component of the plant communities. While fire promoted recruitment of some members of the Epacridaceae, Papilionaceae and Myrtaceae, numerous species of Epacridaceae and Papilionaceae also suffered serious declines in recently burnt infested sites. An increase in species richness and abundance from the Myrtaceae was documented in recently burnt sites irrespective of *P. cinnamomi* impact.

The presence of *P. cinnamomi* increased the incidence of percentage bare ground within quadrats. Leaf litter was considered to have important roles for reducing the incidence and severity of *P. cinnamomi* and in reducing conditions favourable to the pathogen. Leaf litter on steeper slopes appears to help control erosion/runoff in periods of heavy rainfall and assist in seedling establishment. It was identified that soil temperatures in recently burnt sites were up to 9.6 ^{o}C warmer than soil beneath leaf litter and canopy cover (long-unburnt sites). Soil moisture contents at two recently burnt sites were significantly greater in spring than at the paired longer-unburnt sites. Sporangial production was significantly higher in soil extract collected from a 7-day-old fire and soil microbial activity was significantly reduced when compared to the comparable long-unburnt soil.

This study demonstrated that fire in *P. cinnamomi* infested communities has the potential to increase both the severity and extent of disease in native plant communities, and impinge on the regeneration capabilities of susceptible species. The findings have important implications for *P. cinnamomi* and fire management within the SRNP and other South Coast plant communities.

Wild-fire or prescribed burning will also change the hydrology of a catchment with potential for increased surface and sub-surface flow in the early years after fire and consequently increased opportunities for disease establishment and spread. Fire is considered to pose a significant threat to the spread of *P. cinnamomi* outside of currently infested catchments boundaries in the Bell Track area of the Fitzgerald River National Park (Massenbauer 2009)
The proportion of the catchment burnt is predicted to directly affect both hydrological and animal vectoring of *P. cinnamomi*.

Any soil movement during firebreak maintenance or construction may result in the spread of soil-borne pathogens such as *P. cinnamomi*, therefore strict disease hygiene is essential. Similarly the maintenance and construction of cut-off drains may redirect water to create conditions more favourable for the pathogen (Shedley 2007). Water used for fire suppression activities also provides potential for the introduction of *P. cinnamomi*.

Aerial Canker
Aerial canker causing fungi including *Cryptodiaporthe melanocraspeda, Botryosphaeria* spp. and *Zythiostroma* spp. Have had and continue to have a significant impact on Proteaceous shrubland associations on the South Coast causing significant population decline e.g. *Banksia coccinea* (Cheyne Beach), *Banksia*

verticillata (Gull Rock, Torndirrup), *Lambertia orbifolia* ssp *orbifolia* (Narrikup) *Hakea trifurcata* (Betty's Beach). Investigations by Bathgate and Shearer (1995) indicated a direct relationship between increasing stand age in *Banksia coccinea* and the severity of aerial canker disease caused by *Cryptodiaporthe melanocraspeda*, they identified aerial canker in all stands over 14 years. However, McCaw (1997a) found that most of the stands examined across the species range (Hopetoun to SRNP to Waychinnicup) exceeding 20 years of age had only low levels of limb dieback caused by aerial canker fungi. Both studies suggest that while limb dieback is uncommon in stands five years old or younger, the severity of disease in older stands may vary considerably (McCaw 1997). Bathgate and Shearer (1995) also identified the adverse effect of aerial canker on seed production in *B. coccinea*, the overall condition of *B. coccinea* stands within an area should be considered in relation to burning regimes (McCaw 1997a).

3 FIRE AND GRAZING

The impact of post-fire herbivory on recruitment to plant populations has received little attention (Whelan *et al*. 2002). Seedlings are most susceptible to damage and mortality by grazing after fire with the more palatable species being more affected. Grazers, both vertebrate and invertebrate, are often selective and can alter species composition. Grazing pressure varies with season and vegetation composition and may be greater with small patchy burns but will depend on the total grazing pressure (Shedley 2007). Grazing by vertebrate and invertebrate grazers has been shown to affect post-fire vegetation development in *Banksia* woodland in WA and grazing by grasshoppers affected regeneration of canopy and understorey trees (Whelan and Main 1979). Post-fire herbivory influences seedling survivorship, species composition, density and height. Grazing by Quokka (*Setonix brachyurous*), has been implicated in the failure of tree species to regenerate following fire on Rottnest Island (Hobbs 2003). Large areas previously covered by *Callitris preissii, Melaleuca lanceolata* or *Acacia rostillifera* are now covered by heath, this is thought to be a combination of fire and grazing by Quokkas grazing preferentially on seedlings and resprouts of these three tree species. Trampling by livestock alters soil structure which in turn can affect the ability of dominant woodland tree species to regenerate after fire (Hobbs 2003). In fragmented reserves and remnants of the wheatbelt there is increasing anecdotal evidence that the total grazing pressure has increased, most likely from increased kangaroo numbers (Shedley 2007). Preferential grazing of *Acacia acuminata* and *Allocasuarina huegeliana* has been observed with predicted significant impacts on native vegetation structure.

There has been no specific study of the interaction between fire and grazing on the South Coast. However, on-going monitoring of threatened flora and TECs provides evidence of significant grazing impacts (Barrett 2008; Barrett unpublished data). Within the Stirling Range Montane Heath and Thicket TEC (Barrett 2000), there is widespread evidence of grazing by rabbits and/or quokka (*Setonix brachyurus*) after a major fire in 2000. This has had a significant impact on plant health, regeneration, reproduction and survival of several threatened species (*Banksia montana, Leucopogon gnaphalioides, Latrobea colophona* and *Persoonia micranthera*) as well as other members of the TEC. Anecdotal evidence suggests rabbit numbers have increased after fires in 1991 and 2000. Post-fire grazing has also reduced the growth and delayed reproduction, effectively increasing the juvenile period of lowland species in the SRNP e.g. *Banksia anatona*.

Rabbit populations have also been frequently observed around granite outcrops and monadnocks e.g. Porongurups, Mt Manypeaks (Barrett 1996). Grazing by Western Grey Kangaroo has reduced growth and caused mortality of the threatened flora *Grevillea maxwellii* (Barrett and Cochrane 2007) and *Banksia ionthocarpa* ssp *ionthocarpa* (Barrett and Cochrane 2004, Barrett unpublished data). The sandplains of the South Coast provide ideal habitat for rabbit populations as well as native grazers. Monitoring following fire in 1989 in the FRNP showed that grazing, presumably by kangaroos, can have a significant effect on the year's flower and seed crop (Hassell 2001).

4 FIRE AND OTHER FERAL ANIMALS

There has been no systematic study of the interaction of fire and feral animals in the South Coast region. Following fire the risk of predation is increased due to greater access for predators and reduced protection for native fauna (Shedley 2007). Many native fauna may be weakened following a fire due to lack of food or greater distances travelled to obtain food resources as well as increased exposure to weather. Feral fox and cat numbers require control where there are threatened flora populations up to one year prior to prescribed burn and at least two years after (Shedley 2007). Similarly, rabbits need to be controlled before and after burning. The interaction between fire and feral pigs in peatland and swamp environments is also significant with pigs causing gross soil disturbance (Bain pers. comm.)

5 FIRE AND INVASIVE PLANT SPECIES

The relationship between disturbance regimes such as fire and the establishment of weeds has been recognized in ecosystems world-wide (Burrows and Wardell-Johnson 2003, Prober *et al.* 2009) however, there has been no systematic study of the interaction of fire and weeds in the South Coast region. Logging and associated burning in the jarrah forest caused a short-term increase in weed abundance (Burrows and Wardell-Johnson 2003). Small remnants, road verges and boundaries with farmland or town-sites and some riparian areas and wetlands are most prone to weed invasion. The incidence of fire may enhance weed invasion while weeds in turn may lead to more frequent or intense fires and weeds may prevent the regeneration of native perennial species (Hobbs 2003). In Kings Park, frequent recurrent burns prior to World War 2 lead to the replacement of native understorey by South African veldt grass (*Ehyrharta calycina*) and bulbous weeds, thus fire lead to a loss of biodiversity with no significant impact on the frequency of large wildfires (Hopper 2003). In York gum / Jam (*E. loxophleba* / *Acacia acuminata*) woodland in Southwest WA, a strong negative correlation was found between the survival of seedlings of *E. loxophleba* and the cover of non-native annuals following fire (Hobbs and Atkins 1991). However, it is likely that the impact of weeds is greatest in highly disturbed areas (Hobbs 2003) while some vegetation types are not invaded to weeds to any great extent e.g. low nutrient soils. Weed invasion is enhanced by other forms of disturbance including grazing and nutrient addition.

While fire is often considered to increase ecosystem invasibility, Prober et al. (2009) showed in eastern Australia that the strategic use of fire, informed by the relative responses of available native and exotic taxa, may potentially assist restoration of weed-invaded temperate eucalypt woodlands. The dominant native grass Austrodanthonia caespitosa and native forbs were resilient to repeated fires, and target exotic annuals and perennials were suppressed differentially by autumn and spring fires.

Immediately after fire there may be an opportunity to implement weed control before germinating weeds increase sufficiently in cover to limit weed control measures, thus providing an effective one-off control and reduce the need for a staggered follow-up program. Weed introduction and dispersal may also occur as a result of soil dispersal during the construction of firebreaks (Shedley 2007). Weed –fire interactions on the South Coast are readily apparent in road-side and other disturbed remnants, particularly on sandy soils. Weed germination and growth has been prolific in the Porongurup National Park following wild-fire in 2006 (Barrett pers. comm.).

Shedley (2007) outlines several factors to be considered to determine whether there is any benefit in burning a weedy reserve. These include the direct the weed species present and the extent and spatial pattern of invasion, response of weed species to fire, whether resources are available to control weeds post-burn, the accessibility for weed control and control methods required and likelihood of re-invasion.

6 FIRE AND FRAGMENTATION

Fire can become almost eliminated from fragmented systems due to lack of continuous vegetation cover and the absence of fire management (Hobbs 2003, Parsons & Gosper submitted). In many cases the remaining vegetation is already under threat due to range of processes such as altered hydrology, grazing, disease and reduced pollinator interactions. Fire frequency may also increase where fire is used in the surrounding landscape e.g. stubble burning. However, small reserves are less likely to be ignited by lightening being smaller targets and provide an opportunity to retain long unburnt areas (Shedley 2007). Although these reserves may burn completely if accidentally ignited, this may be an acceptable risk to take. While fire may encourage regeneration from seed, this may be prevented in the fragmented system because of degradation of the seed-bed by grazing and competition from weeds. Fire management should aim to avoid having an isolated reserve being burnt out completely in a single fire as this may lead to local extinctions of species that have poor survival and dispersal mechanisms (Shedley 2007).

A comparison of fire regimes in Wheatbelt remnants showed that fire was infrequent in small remnants (mean return interval 339 yrs), more frequent in large remnants (69 yrs) and most frequent in uncleared areas (40 years) (Parsons and Gosper submitted). On this basis it was considered that mallefowl are unlikely to be threatened by too frequent fire within the Wheatbelt compared with the adjoining continuously vegetated landscape where fires are more frequent and extensive. Fires in small remnants were also found to burn only a small portion of the remnant in many cases, in contrast to the widely held view that small remnants are likely to burn in their entirety.

The suppression of fire in smaller remnants may have an adverse effect on the survival of some rare species (e.g. Yates and Ladd 2004) where fire resulted in a greater recruitment of seedlings compared with the sporadic emergence in the absence of fire.

7 SALINITY AND ALTERED HYDROLOGY

There have been no studies of the interaction of fire and salinity in the South Coast region. The impact of fire in areas affected by salinity has not been well investigated (Shedley 2007). Fire is not required to regenerate succulent shrubs and salt bush but may stimulate a release of seed from woody species such as *Melaleuca* and *Allocasuarina* and other taxa that may persist in mildly salt-affected land. However, fire may trigger a more rapid rise in groundwater level and further impede the regeneration of seedlings and coppice growth. The risk of high seedling mortality after fire requires serious consideration (Shedley 2007).

8 CLIMATE CHANGE

There is considerable evidence that climate change is occurring in southwest WA where average rainfall has decreased since the early 1970s and the possibility of altered fire regimes as a consequence is recognized world-wide (Burrows and Wardell-Johnson 2003). Climate change has serious implications for South Coast systems in terms of the seasonality and intensity of rainfall. A steady decline in rainfall has been observed in the western half of the region over the past 40 years. However, in contrast, the rainfall in the east appears to have increased slightly in association with the influence of decaying tropical cyclones and therefore climate change will have different implications for western and eastern areas of the South Coast.

The most significant consequence of a drying climate is most probably the reduced opportunities for successful recruitment of plants, and as such the strong possibility that vegetation community compositions and structures will change greatly. This will lead to a loss and alteration of habitat and in the character and possibly diversity of the South Coast region ecosystem. Climatic models predict an increase in the frequency and intensity of wildfires with a decreased window of opportunity for prescribed burning. Coupled with predictions in shifts in species distributions, phenology and nutrient cycling there is a need to develop ecologically-based management strategies in addition to fuel reduction burning (Penman *et al* 2008). An increase in fire frequency may be the more significant outcome of increasing CO_2 levels and this is likely to be a function of reduction in fire extinguishment than significant increases in fire intensity (Cary 2002). Therefore populations that exist near their fire frequency extinction threshold are at most risk of substantial effects from climate change. Increases in fire intensity may not be as biologically significant. A reduction in annual rainfall will also probably slow post-fire plant recovery and growth reproduction and recruitment (Burrows and Wardell-Johnson 2003). Juvenile periods may lengthen increasing the minimum tolerable interval between fires therefore a cautious approach with respect to frequency and scale of prescribed burning is warranted with ongoing monitoring of the response of plant communities to fire (Burrows and Wardell-Johnson 2003). Dendrochronological studies using *Callitris* species have considerable potential for use in climate change reconstructions as shown by Sgherza (2006). Chronological studies may be used to provide a historical context for projected climate change scenarios and to investigate natural variability in rainfall and regional rainfall anomalies.

APPENDIX IV. PRELIMINARY LIST OF FIRE SENSITIVE SYSTEMS AND LISTING CRITERIA BY ECODISTRICT

Preliminary list of Fire Sensitive systems	Listing criteria	
Albany Fraser Coastal	**Primary**	**Secondary**
Granite communities: shrubland, fringing woodland and gully systems; Waychinnicup to Walpole (Habitat for Noisy Scrub-birds, Gilberts Potoroo, Moggridgea 'Two Peoples Bay')	Refugial habitat, short range endemic invertebrates, Threatened species	Likely high seeder: sprouter ratio (including serotinous seeders) vulnerable to frequent fire
Granite communities and fringing mallee shrubland, Cape Knob headland	Refugial habitat	Likely high seeder: sprouter ratio
Granite communities and fringing mallee shrubland, Doubtful Island headland	Refugial habitat	Likely high seeder: sprouter ratio
Granite communities and fringing woodland and shrubland and gully systems, Cape le Grand - Mt Arid coastal hills	Refugial habitat, short range endemic invertebrates, Threatened species	Likely high seeder: sprouter ratio (including serotinous seeders) vulnerable to frequent fire
Albany Fraser Inland West	**Primary**	**Secondary**
Mt Lindesay-Little Lindesay Granite Complex **TEC** and fringing woodlands and relictual invertebrates (includes, Mt Soho, Mt Frankland, Soho Hills, un-named hills)	Refugial habitat, short range endemic invertebrates, Threatened species	Likely high seeder: sprouter ratio (including serotinous seeders) vulnerable to frequent fire
Porongurup Granite community, fringing woodlands and relictual invertebrates	Refugial habitat, short range endemic invertebrates, Threatened species	Interaction of fire and weeds
Albany Fraser Inland East	**Primary**	**Secondary**
Granite shrubland and fringing eucalypt woodland: Mt Ney, Mt Burdett, Mt Ridley, Mt Buraminya	Priority flora	Likely high seeder: sprouter ratio
Northwest Mosaic	**Primary**	**Secondary**
Yilgarn West brown mallet woodland	Dominant serotinous seeder vulnerable to frequent fire	
Yilgarn West wandoo woodland	Intense fire impacts on woodland structure and habitat values	Interaction of fire, altered hydrology, weeds, feral animals, grazing
Yilgarn West riverine and wetland woodland	Intense fire impacts on woodland structure and habitat values	Intense fire removes organic soil
Yilgarn West *Eucalyptus falcata* -. *E decipiens* mallee shrubland	Dominant serotinous seeders vulnerable to frequent fire	Possible decline due to senescence in long unburnt remnants

Preliminary list of Fire Sensitive systems	Listing criteria	
Forest Mosaic	**Primary**	**Secondary**
Tingle forest[1]	Intense fire impacts on forest structure and tree integrity	Relictual invertebrate species
Reedia swamps **TEC** and other peaty swamps	Intense fire removes peat and organic soils	Interaction of fire and feral pigs; threatened frog species
Karri forest and relictual invertebrates and epiphytic cryptograms[2]	Intense fire impacts on forest structure	Relictual invertebrate species
Porongurup karri forest and other karri outliers	Interaction of fire and weeds	Relictual invertebrate species
Woodland over Hakea shrubland (*H. ferruginea, H. lasiantha*) on impeded drainage	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Open Low *Allocasuarina fraseriana - Eucalyptus staeri* woodland in association with *Banksia coccinea* thicket **PEC**	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Coastal Proteaceous (*Hakea elliptica, Banksia formosa*) thicket on laterite	Dominant serotinous seeders vulnerable to frequent fire	
Riparian woodlands (*Eucalyptus rudis, E. patens, E. occidentalis*)	Intense fire impacts on woodland structure and habitat values	Interaction of fire, altered hydrology, weeds, feral animals, grazing
Taxandria juniperina low forest	Dominant serotinous seeder vulnerable to frequent fire	Intense fire removes organic soil
Paperbark woodlands	Intense fire impacts on woodland structure and habitat values	Intense fire removes organic soil
Seasonally wet heath and sedgeland and fringing *Banksia* shrubland	Dominant serotinous seeders vulnerable to frequent fire	Intense fire removes organic soil. Interaction of fire and Phytophthora
Quarram grasslands **PEC**	In the absence of fire, grassland encroached on by woody shrubs	
Baumea sedgeland (habitat for Australasian Bittern, Little Bittern)	Intense fire impacts on reed and rush nesting habitat	
Eucalyptus ficifolia - Beaufortia sparsa plain community, Walpole	Intense fire impacts on community structure	
Quartzite	**Primary**	**Secondary**
Montane Heath and Thicket of the Eastern Stirling Range **TEC** and relictual invertebrates	Dominant serotinous seeders vulnerable to frequent fire, relictual invertebrates, high seeder:sprouter ratio	Interaction of fire and Phytophthora dieback, grazing

1 Includes Sphagnum communities of the Tingle Forest PEC

2 Includes Epiphytic Cryptogams of the Karri forest PEC

Preliminary list of Fire Sensitive systems	Listing criteria	
Montane Mallee Thicket **PEC** and relictual invertebrates, SRNP	Dominant serotinous seeders vulnerable to frequent fire, relictual invertebrates	Interaction of fire and Phytophthora dieback, grazing
Mallee heath and *Banksia* shrubland SRNP lower slopes	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Coyanerup wetland suite **PEC**, SRNP	Intense fire removes organic soil	Threatened flora, relictual invertebrates
Proteaceous dominated 'Barrens Thicket' FRNP and relictual invertebrates[3]	Dominant serotinous seeders vulnerable to frequent fire	Relictual invertebrates
Eucalyptus conferruminata, E. mcquoidii low woodland over *Hakea cucullata* on Quartzite Schist, Quoin Head, 2-Bump Hill, Marshes Beach FRNP	Dominant serotinous seeders vulnerable to frequent fire	
Melaleuca sp Kundip mallet over Heath **PEC**	Dominant serotinous seeders vulnerable to frequent fire	
Russell Range mixed thicket complexes **TEC**	Dominant serotinous seeders vulnerable to frequent fire	
Banksia lemmaniana and *Melaleuca stramentosa* thicket	Dominant serotinous seeders vulnerable to frequent fire	
Coastal dynamic	**Primary**	**Secondary**
Coastal Mallet woodland and shrubland (*Eucalyptus utilis, Melaleuca nesophila, Melaleuca lanceolata*)	Dominant serotinous seeders vulnerable to frequent fire	
Estuarine woodland and shrubland (*Eucalyptus occidentalis* x *utilis, Melaleuca nesophila*)	Dominant serotinous seeders vulnerable to frequent fire	
Banksia praemorsa coastal shrubland	Dominant serotinous seeders vulnerable to frequent fire	
Marine Plain	**Primary**	**Secondary**
Moort low forest	Dominant serotinous seeders vulnerable to frequent fire	Fire impacts on litter layer and habitat values
Eucalyptus nutans mallet woodland	Dominant serotinous seeder vulnerable to frequent fire	
Mallet woodlands and shrublands on spongelite	Dominant obligate seeders vulnerable to frequent fire	
Banksia shrublands (e.g. *Banksia baxteri* , *B. baueri, B. coccinea, B. nutans*)	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Mallee over *Banksia - Hakea* shrubland	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback

3 Includes Eucalyptus acies mallee heath TEC and relictual invertebrates

Preliminary list of Fire Sensitive systems	Listing criteria	
Albany Blackbutt (*Eucalyptus staeri*) mallee-heath on deep sand **PEC** (Pallinup sandplain)	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Albany Blackbutt (*Eucalyptus staeri*) mallee-heath on lateritic ridges **PEC** (Pallinup sandplain)	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Tallerack (*Eucalyptus pleurocarpa*) mallee-heath on heavy soils **PEC**	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Tree mallee shrubland (*Eucalyptus acies / E. goniantha/ E. doratoxylon)* on spongelite **PECs**	Dominant serotinous seeders vulnerable to frequent fire	
Porongurup wet ironstone Heath **PEC**	Dominant serotinous seeders vulnerable to frequent fire	
Swamp yate woodlands in seasonally inundated clay basins (**PEC**) / Riverine yate woodland	Intense fire impacts on woodland structure and habitat values	Interaction of fire, altered hydrology, weeds, grazing
Wandoo woodland	Intense fire impacts on woodland structure and habitat values	Interaction of fire and salinity, weeds, feral animals
Baumea sedgeland, habitat for Australasian Bittern, Little Bittern	Intense fire impacts on reed and rush nesting habitat	
Eucalyptus brandiana woodland-mallee mix	Dominant serotinous seeder vulnerable to frequent fire	
Greenstone	**Primary**	**Secondary**
Salmon gum woodland	Intense fire impacts on woodland structure and habitat values	
Eucalyptus purpurata mallet woodland **PEC**	Dominant serotinous seeder vulnerable to frequent fire	Threatened flora
Eucalyptus pleurocarpa - *E. falcata* mallee shrublands (Proteaceous)[4]	Dominant serotinous seeders vulnerable to frequent fire	
Allocasuarina shrublands	Dominant serotinous seeders vulnerable to frequent fire	
Melaleuca thapsina thicket	Dominant serotinous seeder vulnerable to frequent fire	
Banksia cirsioides heath	Dominant serotinous seeders vulnerable to frequent fire	
Moort and mallet woodlands	Dominant serotinous seeders vulnerable to frequent fire	Fire impacts on litter layer and habitat values
Mallee over *Melaleuca* shrubland	Dominant serotinous seeders vulnerable to frequent fire	

4 Includes Banksia laevigata-B. lemanniana Proteaceous Thicket PEC

Preliminary list of Fire Sensitive systems	Listing criteria	
Heath on komatiite **PEC**	Dominant obligate seeders vulnerable to frequent fire	Threatened flora
Yilgarn East	**Primary**	**Secondary**
Transitional woodlands (including *Eucalyptus extensa, E. salmonophloia, E. spathulata, E. urna)*	Intense fire impacts on woodland structure and habitat values	
Granite communities and fringing sheoak (*Allocasuarina huegeliana*) woodland	Dominant seeders vulnerable to frequent fire	Refugial habitat
Yilgarn East moort and mallet woodlands	Dominant serotinous seeders vulnerable to frequent fire	Fire impacts on litter layer and habitat values
Lake Johnson woodlands	Intense fire impacts on woodland structure and habitat values	
Salt Lakes fringing woodland (*E. salicola, E. alipes*)	Intense fire impacts on woodland structure and habitat values	
Bremer Range System including *Allocasuarina* thickets on greenstone ridges (**PEC**)	Dominant serotinous seeders vulnerable to frequent fire	
Upland *Eucalyptus occidentalis* woodland	Intense fire impacts on woodland structure and habitat values	Interaction of fire, altered hydrology, insect damage
Mallee (*E. pleurocarpa*) over *Banksia - Hakea* shrubland	Dominant serotinous seeders vulnerable to frequent fire	Interaction of fire and Phytophthora dieback
Transitional mallee-shrubland and heath	Dominant serotinous seeders vulnerable to frequent fire	Impact on habitat values.
Peak Charles - Peak Eleanora granite community and fringing woodland	Dominant seeders vulnerable to frequent fire	Refugial habitat
Mallee over *Melaleuca* shrubland (also Greenstone)	Dominant serotinous seeders vulnerable to frequent fire	
Esperance Sandplain west	**Primary**	**Secondary**
Banksia shrubland and Proteaceous palusplain heath (*B. speciosa, Hakea* spp)[5]	Dominant serotinous seeders vulnerable to frequent fire. Impact on habitat values.	Interaction of fire and Phytophthora dieback
Swamp and riverine yate woodlands including paperbark woodland	Intense fire impacts on woodland structure and habitat values	Intense fire removes organic soil
Esperance Sandplain east	**Primary**	**Secondary**
Banksia shrubland and Proteaceous palusplain heath	Dominant serotinous seeders vulnerable to frequent fire, Western Ground Parrot habitat	Interaction of fire and Phytophthora dieback

Preliminary list of Fire Sensitive systems	Listing criteria	
Swamp and riverine yate woodland (including paperbark woodland)	Intense fire impacts on woodland structure and habitat values	Intense fire removes organic soil
Nuytsland	**Primary**	**Secondary**
Banksia shrubland	Dominant serotinous seeders vulnerable to frequent fire	
Mallee Lakes	**Primary**	**Secondary**
Ridley system mallet woodland	Dominant serotinous seeders vulnerable to frequent fire	
Salmon gum in clay depressions	Intense fire impacts on woodland structure and habitat values	
Mallee lakes mallee shrubland	Dominant serotinous seeders vulnerable to frequent fire	
Islands	**Primary**	**Secondary**
Granite community and fringing woodlands and shrubland, important reference systems	High seeder: sprouter ratio (including serotinous seeders) vulnerable to frequent fire	Refugial habitat

5 Includes Scrub Heath on deep sand with Banksia and Lambertia, on Esperance Sandplain PEC

APPENDIX V. VEGETATION STRUCTURE AND SELECTED COMPONENT PLANT SPECIES OF FIRE-SENSITIVE SYSTEMS ACCORDING TO ECODISTRICTS.

The following component species lists are not comprehensive lists and their level of detail varies considerably between systems.

The response to fire and rate of maturation rates of flora species is documented where known. Selected fire sensitive species are highlighted in **bold**, these include obligate reseeders, in particular serotinous species, as well as structural species sensitive to high intensity fire, short range endemics and significant fauna.

Plants are classified as obligate seeders with a canopy (OSC) or soil-stored seed bank (OSS), basal resprouters (RS), epicormic resprouters (RS ep) or facultative resprouter / seeders (RS / OSC or OSS). Maturation times for plant species, based on post-fire recovery and first flowering, are classified as rapid (< 3 years), medium (4 - 6 years) and slow (>6) (adapted from Hassell 2001). First flowering is defined as time to first flowering of 50% of a population where this data is available. Fire responses and maturation times should be regarded as indicative only.

Unpublished data sources were Sarah Barrett, Karlene Bain, Sarah Comer, Anne Cochrane, Emma Adams, Nathan McQuoid, Gil Craig, Roger Hearn, Jannine Liddelow, Carl Gosper, Ted Middleton, Libby Sandiford (personal observations); McCaw (1997b), DEC NatureMap, DEC Fire Response Database.
Published sources were Anderson (2005), Burrows *et al*. (2008), Collins *et al*. (2008), Hassell (2001), George and Pieroni (2002), Gosper *et al.* (in press), Kavanagh and Pieroni (2006), Marriot and Olde (1995 a, b), Meney and Pate (1999), Taylor and Hopper (1988), Young (2006).

ALBANY FRASER COASTAL ECODISTRICT

ALBANY FRASER COASTAL			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Shrubland / Fringing Open Woodland			
Granite and fringing communities and gullies (western)	**Trees**		
	Eucalyptus cornuta	RS ep	
	Eucalyptus conferruminata	OSC	
	Eucalyptus megacarpa	RS ep /OSC	
	Shrubs		
	Acacia sulcata ssp. sulcata	OSS	
	Andersonia sprengelioides	OSS	rapid
	Andersonia setifolia	OSS	
	Anthocercis viscosa	RS	
	Banksia verticillata	OSC	slow
	Banksia formosa	OSC	medium
	Calothamnus quadrifidus	RS	
	Calytrix sp. Esperance	OSS?	
	Chamelaucium forrestii ssp. orarium	OSS?	
	Darwinia citriodora	OSS	rapid
	Daviesia horrida	RS	
	Dodanaea ceratocarpa	RS	
	Eutaxia myrtifolia	OSS	rapid
	Gastrolobium bilobum	OSS	rapid
	Gastrolobium brownii		
	Gastrolobium coriaceum	OSS	
	Hakea drupaceae	OSC	
	Hakea elliptica	OSC	slow
	Isopogon formosus	OSC	rapid to medium
	Leucopogon altissimus	OSS	
	Melaleuca diosmifolia	OSC	slow
	Melaleuca lanceolata	OSC	slow
	Prostanthera verticllaris	OSS	
	Ricinocarpus glaucus	OSS	rapid
	Sphenotoma drummondii	OSS	slow
	Taxandria marginata	RS/ OSC	
	Thomasia discolor	OSS	
	Thryptomene saxicola	RS/OSC	
	Verticordia plumosa	OSS	
	Ferns		
	Asplenium aethiopicum	Fern	
	Cryptograms		
	Rock pool communities /Gnammas		

ALBANY FRASER COASTAL			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Noisy Scrub-bird, Western Whipbird, Quokka, Western Ringtail Possum, Gilbert's Potoroo, relictual invertebrate communities		
Granite shrubland /Mallee heath			
Doubtful Island headland	**Mallee**		
	Eucalyptus retusa	RS	
	Eucalyptus cuspidata	RS	
	Eucalyptus retusa x cornuta	RS	
	Eucalyptus retusa x cuspidata	RS	
	Eucalyptus decipiens subsp adesmo.	RS	
	Eucalyptus notactites	RS	
	Shrubs		
	Grevillea sp. 'nivea'	OSS	
	Thryptomene saxicola	RS/OSC	
	Agonis flexuosa	RS/OSC	
	Hakea victoria	OSC	
	Banksia dryandroides	OSC	
	Cryptograms		
Granite shrubland / Mallee heath			
Cape Knob headland	**Mallee**		
	Eucalyptus retusa	RS	
	Eucalyptus retusa x cornuta	RS	
	Eucalyptus cornuta	RSE	
	Eucalyptus decipiens subsp. adesmo.	RS	
	Eucalyptus notactites	RS	
	Shrubs		
	Anthocercis viscosa	RS	
	Calothamnus quadrifidus	RS	
	Kunzea baxteri	OSC	
	Agonis flexuosa	OSC/RS	
	Banksia violaceae	OSC	
	Cryptograms		
	Rock pool communities		
Shrubland / Fringing Open Woodland			
	Trees		
	Allocasuarina trichodon	OSC	
	Callitris preissii	OSC	slow
	Eucalyptus cornuta	RS ep	
	Eucalyptus conferruminata	OSC	slow
	Eucalyptus doratoxylon	RS ep	
	Eycalyptus sweedmaniana	RS	
	Eucalyptus utilis	OSC	slow

ALBANY FRASER COASTAL			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Granite and fringing communities and gullies (Cape le Grand / Mt Arid Coastal hills)	**Shrubs**		
	Acacia myrtifolia	OSS	
	Agonis baxteri	RS	
	Allocasuarina campestris	?OSC	
	Anthocercis viscosa ssp. caudata	?OSS	
	Banksia armata var. ignicida	OSC	
	Bossiaea dentata	OSS	
	Calothamnus quadrifidus	RS	
	Calothamnus villosus	OSC	
	Dillwynia pungens	OSS	
	Dodanaea ceratocarpa	RS	
	Dodanaea viscosa	OSS	
	Eutaxia myrtifolia	OSS	rapid
	Gastrolobium bilobum	OSS	rapid
	Goodenia scapigera	OSS	
	Grevillea concinna ssp. concinna	OSS	
	Grevillea oligantha	OSS	
	Hakea clavata	OSC	
	Hakea drupaceae	OSC	
	Kunzea baxteri	OSS	
	Lambertia echinata ssp. echinata	OSC	
	Leptospermum sericeum	?OSC	
	Leucopogon interruptus	OSS	
	Melaleuca elliptica	RS/OSC	medium
	Melaleuca fulgens	RS	
	Melaleuca globiferra	R/OSC	
	Mirbelia dilatata	OSS	rapid
	Taxandria callistachys		
	Taxandria marginata	RS/OSC	
	Thryptomene australis	OSC	
	Herbs		
	Anigozanthos gabrielae	Annual	rapid
	Cryptograms		
	Rock pool communities /Gnammas		
	Invertebrate communities		
	Fauna		
	Tammar, wetlands may support bittern, Rock Wallabies		

ALBANY FRASER INLAND WEST ECODISTRICT

ALBANY FRASER INLAND WEST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Shrublands			
Mt Lindesay-Little Lindesay Granite Complex TEC (and Mt Frankland, Mt Roe, Soho Hills, un-named hills)	**Trees**		
	Eucalyptus cornuta	RS ep	
	Eucalyptus virgineae	RS	
	Eucalyptus megacarpa	RS ep / OSC	
	Shrubs		
	Acacia sulcata ssp. sulcata	OSS	
	Andersonia hammerslyeana	OSS	medium
	Andersonia sprengelioides	OSS	rapid
	Andersonia setifolia	OSS	
	Andersonia virolens	OSS	rapid
	Banksia formosa	OSC	medium
	Borya longioscapa	RS/OSS	
	Cryptandra congesta		
	Grevillea fuscolutea	OSS	
	Calothamnus quadrifidus	RS	
	Calothamnus sp. Mt Lindesay	RS/OSC	medium - slow
	Calytrix sp. Esperance	OSS	
	Chamelaucium forrestii ssp. forrestii	OSS	
	Darwinia citriodora	OSS	rapid
	Dodanaea ceratocarpa	RS	
	Eutaxia myrtifolia	OSS	rapid
	Gastrolobium bilobum	OSS	rapid
	Gastrolobium brownii	OSS	rapid
	Gastrolobium coriaceum	OSS	
	Hemigena humilis		
	Hemigena podlyarina		
	Isopogon formosus	OSC	rapid to medium
	Lasiopetalum sp. Denmark	OSS	rapid to medium
	Leucopogon sp. Southern granite		
	Olearia paucidentata	OSS	
	Ricinocarpus glaucus	OSS	rapid
	Sphenotoma drummondii	OSS	slow
	Taxandria conspicua		
	Taxandria marginata		
	Thryptomene saxicola	RS/OSC	

ALBANY FRASER INLAND WEST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Verticordia endlicheriana var. angustifolia		
	Verticordia plumosa	OSS	
	Herbs		
	Laxamnnia grandiflora spp brendae		
	Ferns		
	Asplenium aethiopicum	Fern	
	Cryptograms		
	Rock pool communities		
	Fauna		
	Western Ringtail Possum, Carnaby's Cockatoo, Baudin's Cockatoo, Quokka, relictual invertebrates		
Porongurup Granite	**Trees**		
	Eucalyptus megacarpa	RS ep / OSC	
	Eucalyptus cornuta	RS ep	
	Shrubs		
	Acacia heteroclita ssp. valida	OSS	
	Asterolasia sp. Kalgan	OSS	
	Gastrolobium subcordatum	OSS	
	Hibbertia porongurupensis	OSS	
	Sphenotoma drummondii	OSS	slow
	Taxandria marginata	RS /OSC	
	Thryptomene saxicola	RS/OSC	
	Villarsia calthifolia	OSS	rapid
	Cryptograms		

ALBANY FRASER INLAND EAST ECODISTRICT

ALBANY FRASER INLAND EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Shrubland / Fringing Open Woodland			
Granites outcrops, sheet granite and fringing communities - Mt Burdett, Mt Ridley, Mt Buraminya	**Trees**		
	Allocasuarina huegeliana	OSC	slow
	Mallee		
	Eucalyptus lehmannii	RS	
	Eucalyptus tetraptera	RS	
	Shrubs		
	Acacia acuminata	OSS	medium to slow
	Acacia bidentata		
	Acacia erinacea		
	Acacia fragilis		
	Acacia glaucissima		
	Acacia pinguiculosa ssp. teretifolia	OSS	
	Acacia tryptycha		
	Allocasuarina campestris	OSC	
	Allocasuarina scleroclada	RS	
	Beaufortia schaueri	OSC	
	Baeckea crassifolia subsp.. icosandra		
	Banksia armata subsp.. ignicida	OSS	
	Boronia baeckeacea subsp.. patula		
	Boronia sp..		
	Calothamnus quadrifidus	RS	
	Calothamnus tuberosus		
	Chamelaucium ciliatum		
	Dodonaea ceratocarpa	RS	
	Dodonaea caespitosa		
	Exocarpos sparteus		
	Gastrolobium bilobum	OSS	
	Gastrolobium involutum		
	Gastrolobium parviflorum		
	Granitites intangendus		
	Grevillea anethifolia		
	Grevillea concinna subsp.. lehamanniana		
	Grevillea plurijuga subsp.. superba		
	Hakea bicornata		
	Hakea clavata	OSC	
	Hakea commutata		
	Hakea laurina	OSC	

ALBANY FRASER INLAND EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Hakea preissii		
	Keraudrenia sp..		
	Labichea lanceolata subsp.. brevifolia		
	Lasiopetalum rosmarinifolium		
	Leptospermum incanum		
	Lasiopetalum indutum		
	Leucopogon conostephioides		
	Melaleuca bromelioides		
	Melaleuca elliptica	RS/OSC	medium
	Melaleuca eximia		
	Melaleuca fulgens		
	Melaleuca glaberimma	OSC	
	Melaleuca podiocarpa		
	Melaleuca glena		
	Melaleuca eleuterostachya		
	Micromyrtus elobata		
	Micromyrtus imbricata		
	Mirbelia microphylla		
	Persoonia teretifolia		
	Phebalium lepidotum		
	Petrophile fastigiata		
	Phyllanthus calycina		
	Prostanthera carrickiana		
	Santalum acuminatum	OSS	
	Thryptomene australis	OSC	
	Herbs		
	Borya constricta		
	Borya sp..		
	Cyanicula deformis		
	Caladenia discoidea		
	Pterostylis sanguinea		
	Diuris affin pulchella		
	Pterostylis recurva		
	Eriochilus scaber		
	Cryptograms		
	Cladia ferdinandii		

NORTHWEST MOSAIC ECODISTRICT

NORTHWEST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Woodland			
Wandoo woodland	**Trees**		
	Corymbia calophylla	RS	
	Eucalyptus marginata	RSep	
	Eucalyptus wandoo	RS/ep/OSC	
	Shrubs		
	Acacia spp		
	Gastrolobium spinosum	OSS	rapid
	Gastrolobium parviflorum	OSS	medium
	Hakea lissocarpha	RS	
	Thomasia foliosa		
Riverine and wetland woodland	**Trees**		
	Eucalytpus occidentalis	RS ep / OSC	
	Eucalytpus rudis	RS ep	
	Eucalyptus decipiens	RS ep	
	Melaleuca preissiana	RS ep / OSC	
	Melaleuca rhaphiophylla	RS ep/ OSC	
	Banksia littoralis	RS ep	
	Shrubs		
	Melaleuca viminea	OSC	medium
	Callistachys lanceolatum	OSS	
	Fauna		
	Tammar and Brush Wallaby, potential habitat for Brush & Red-tailed Phascogale. May also be used by cockatoos. Possibly Heath Mouse		
Mallee woodland/ shrubland			
E. falcata , E decipiens mallee shrubland	**Mallee**		
	Eucalyptus decipiens	RS	
	Eucalyptus falcata	RS	
	Eucalyptus decipiens x falcata	RS	
	Eucalyptus orthostemon	RS	
	Shrubs		
	Adenanthos cygnorum	OSS	
	Allocasuarina acuaria		
	Allocasuarina lehmanniana	OSC	
	Banksia arctotidis	RS	
	Banksia acuminata	RS	

NORTHWEST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia alliacea	OSC	
	Banksia armata	RS	
	Banksia brunnea	OSC	medium
	Banksia fraseri	RS	
	Banksia attenuata	RS	
	Bnaksia grandis	RS	
	Banksia lepidorrhiza	RS	
	Banksia meisnerii	OSC	medium
	Banksia mucronulata sp. retrorsa	OSC	
	Banksia nivea ssp. nivea	OSC	
	Banksia pellaeifolia	RS	
	Banksia porrecta	?RS	
	Banksia sessilis	OSC	medium
	Banksia sphaerocarpa ssp. sphaerocarpa	RS	
	Banksia tenuis	OSC	
	Calothamnus gracilis	RS	
	Calothamnus huegelii		
	Calothamnus quadrifidus	RS	
	Calothamnus sanguineus	RS	
	Petrophile media		
	Petrophile serruriae	OSC	medium
	Gastrolobium spinosum	OSS	rapid
	Hakea cucullata	OSC	medium to slow
	Hakea trifurcata	OSC	slow
	Hakea undulata	OSC	rapid
	Isopogon attentuatus	RS	
	Isopogon buxifolius	OSC	
	Isopogon heterophyllus	?OSC	
	Isopogon formosus	OSC	rapid to medium
	Xanthorrhoea platyphylla	RS	
Mallet			
Yilgarn West Brown mallet - Brown mallet woodlands with grassy understoreys in the Tambellup area	**Mallet**		
	Eucalyptus astringens	OSC	
	Eucalyptus garderni	OSC	

FOREST MOSAIC ECODISTRICT

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Open - Closed Forest			
Tingle	**Trees**		
	Allocasuarina decussata	RS ep	
	Eucalyptus brevistylis	RS ep /OSC	
	Eucalyptus diversicolor	RS ep/ OSC	slow
	Eucalyptus guilfoylei	RS ep/ OSC	slow
	Eucalyptus jacksonii	RS ep / OSC	slow
	Hakea lasianthoides	OSC	medium
	Hakea oleifolia	OSC	medium
	Hibbertia furfuracea	RS	
	Trymalium odaritissimum	OSS	rapid
	Acacia pentadenia	OSS	medium to slow
	Leucopogon verticillatus	RS	
	Lepidosperma effusem	RS	
	Petrophile diversifolia	OSC	medium
	Fauna		
	Relictual & threatened invertebrates, Quokka, Carnaby's and Baudin's Cockatoo, Chuditch, Western Ringtail Possum		
Karri forest and relictual invertebrates	**Trees**		
	Eucalyptus diversicolor	RS ep/ OSC	slow
	Allocasuarina decussata	RS/ ep	
	Corymbia calophylla	RS/ ep	
	Banksia seminuda	OSC	medium to slow
	Eucalyptus megacarpa	RS ep / OSC	
	Shrubs		
	Acacia browniana	OSS	rapid
	Acacia pentadenia	OSS	medium to slow
	Banksia grandis	RS	
	Choralaena quercifolia	OSS	rapid
	Hibbertia furfuracea	RS	
	Leucopogon verticillatus	RS	
	Paraserianthes lophantha	**OSS**	**rapid**
	Persoonia longifolia	RS	
	Trymalium odaritissimum	OSS	rapid
	Lepidosperma effusem	RS	
	Cryptograms		
Forest			
	Trees		

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Porongurup Range Karri Forest - Occurs on granite, red clay-loam on the mid-upper slopes of the Porongurup Range. PEC (P1)	**Eucalyptus diversicolor**	RS ep/ OSC	slow
	Trymalium odaritissimum	OSS	rapid
	Paraserianthes lophantha	OSS	rapid
	Shrubs		
	Mirbelia dilata	OSS	rapid
	Herbs /grasses		
	Apium prostratum ssp. phillipi	OSS	rapid
	Cryptograms		
	Invertebrate communities		
	Porongurup Moggridgea, Neohomogona, Velvet worm		
	Fauna		
	Baudin's & Carnaby's Cockatoo, Western Ringtail Possum, translcoation site NSB		
Karri outlier Manypeaks, Redmond	**Trees**		
	Eucalyptus diversicolor	RS ep/ OSC	slow
	E. goniantha subsp. goniantha	RS	
Woodland			
Riparian woodlands	**Trees**		
	Eucalyptus patens	RS ep	
	Eucalyptus occidentalis	RS ep / OSC	
	Eucalyptus rudis	RS ep	
Paperbark woodlands (drainage depressions)	**Trees**		
	Melaleuca cuticularis	RS ep/OSC	
	Melaleuca preissiana	RS ep/OSC	
	Melaleuca rhaphiophylla	RS /OSC	
	Shrubs		
	Gastrolobium sericeum		
	Melaleuca pauciflora	RS	
	Melaleuca lateritia	RS	
	Sedge		
	Baumea spp		
	Gahnia trida	RS	
	Lepidosperma effusem	RS	
Open Woodland			
	Trees		
	Allocasuarina fraseriana	RS ep	
	Eucalyptus marginata	RS ep	
	Eucalyptus staeri	RS ep	

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
E. marginata / E.staeri / A. fraseriana over Hakea spp on impeded drainage	**Shrubs**		
	Banksia biterax	OSC	medium
	Banksia brownii	OSC	medium to slow
	Banksia formosa	OSC	medium
	Banksia mucronulata	OSC	medium
	Banksia obovata	OSC	medium
	Banksia serra	OSC	medium
	Banksia squarrosa	OSC	medium
	Daviesia spinossisima		
	Gastrolobium coriaceum	OSS	
	Grevillea fasiculata	OSS	
	Grevillea trifida	OSS	
	Hakea amplexicaulis	RS	
	Hakea cucullata	OSC	medium to slow
	Hakea ceratophylla	RS	
	Hakea ferruginea	OSC	medium to slow
	Hakea lasiantha	OSC	slow
	Hakea trifurcata	OSS	medium to slow
	Hakea tuberculata	OSC	medium to slow
	Lambertia uniflora	OSC	medium to slow
	Leptomeria squarrulosa	OSS	
	Pultenaeae verruculosa	OSS	
	Taxandria parviceps	RS	
	Xanthorrhoea platyphylla	RS	
Open woodland over heathland			
Open Low Allocasuarina fraseriana - Eucalytpus staeri woodland in association with Banksia coccinea thicket PEC	**Trees**		
	Allocasuarina fraseriana	RS ep	
	Eucalyptus staeri	RS ep	
	Shrubs		
	Andersonia pinaster	OSS	medium
	Banksia attenuata	RS / OSC	
	Banksia coccinea	OSC	medium to slow
	Banksia nutans	OSC	slow
	Conospermum teretifolium	RS	
	Franklandia fucifolia	RS	
	Gompholobium scabrum	OSS	
	Jacksonia spinosa	OSS	
	Latrobea brunonis	OSS	
	Leucopogon flavescens	OSS	
	Leucopogon glabellus	OSS	
	Leucopogon gracilis	OSS	

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Leucopogon obovatus	OSS	
	Leucopogon rubricaulis	?OSS	
	Melaleuca thymoides	RS	
	Phyllota barbata	OSS	
	Petrophile acicularis	OSC	
	Petrophile rigida	RS	
	Fauna		
	Western Ringtail (Two Peoples Bay, Bayonet Head), Western Whipbird (heath Subspecies) , Western Bristlebird		
Mallee-thicket			
Coastal Proteaceous thicket (laterite)	**Mallee**		
	Corymbia calophylla	RS ep	
	Eucalyptus marginata	RS ep	
	Shrubs		
	Banksia formosa	OSC	medium
	Bossiaea linophylla	OSS	rapid
	Hakea elliptica	OSC	slow
Heathland			
Eucalyptus ficifolia / Beaufortia sparsa plain community	**Mallee**		
	Eucalyptus ficifolia	RS ep	
	Shrubs		
	Acacia myrtifolia	OSS	rapid
	Adenanthos obovatus	RS	
	Beaufortia sparsa	RS	
	Homalospermum firmum	RS	
Closed forest			
Wattie forest	**Trees**		
	Taxandria juniperina	OSC	medium to slow
Shrubland over closed sedgeland			
Reedia swamps TEC and other peaty swamps	**Shrubs**		
	Acidonia microcarpa	OSS	medium
	Aotus intermedia	OSS	
	Astartea scoparia	RS	
	Callistemon glaucum	RS	
	Cosmelia rubra	RS	
	Homalospermum firmum	RS	
	Kunzea ericifolia	OSC	
	Melaleuca densa	OSC?	
	Melaleuca microphylla	RS ep	
	Melaleuca viminea	OSC	

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Sphaerolobium spp		
	Sphenotoma gracile	OSS	
	Taxandria juniperina	OSC	
	Taxandria linearifolia	RS / OSC	
	Sedges		
	Baumea spp		
	Empodisma gracillimum	RS	
	Gahnia decomposita	RS	
	Juncus spp		
	Lepidosperma tetraquetrum	RS	
	Leptocarpus tenax	RS	
	Reedia spathacea	RS	
	Schoenus multiglumis		
	Tremulina tremula	OSS	
	Herbs		
	Cephalotus follicularis	**RS**	
	Organic-rich soils		
	Fauna		
	Little Bittern, Australasian Bittern, Hydromys, Spicospina flamocaerulea, relictual invertebrates, Quokka, native fish		
Shrubland- Heathland - Sedgeland			
Seasonally wet heath-sedgeland and fringing Banksia shrubland	**Shrubs**		
	Acidonia microcarpa	OSS	medium
	Aotus intermedia	OSS	
	Banksia littoralis	RS	
	Banksia occidentalis	OSC	medium
	Banksia quercifolia	OSC	medium
	Banksia seminuda	OSC	medium to slow
	Beaufortia sparsa	RS	
	Callistachys lanceolatum / sp South Coast	OSS	
	Hakea linearis	RS	
	Hakea tuberculata	OSC	medium
	Hakea sulcata	OSC	medium
	Hypocalymma ericifolium	OSS	
	Isopogon axillaris	RS	
	Kunzea ericifolia	OSC	
	Leptocarpus tenax	RS	
	Melaleuca densa	OSC?	
	Melaleuca incana	RS	
	Melaleuca pauciflora	RS	
	Meleluca spathulata	RS	

FOREST MOSAIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca viminea	OSC	medium to slow
	Pericalymma spongicaule	OSC	
	Petrophile phyllicoides	OSC	slow
	Rhadinothamnus anceps	OSS	rapid
	Sphaerolobium spp		
	Sphenotoma gracile	OSS	
	Taxandria angustifolia	RS	
	Taxandria fragrans	RS	
	Sedges / Rushes		
	Evandra aristata	RS / OSS	
	Leptocarpus tenax	RS	
	Meeboldina spp		
	Schoenus spp		
	Tremulina tremula	OSS	
	Herbs		
	Cephalotus follicularis	RS	
	Organic-rich soils		
Grassland			
Southwest Coastal grassland (Quarram grassland) PEC	**Trees**		
	Agonis flexuosa	RS ep/ OSC	
	Shrubs		
	Exocarpus odoratus	OSS	rapid
	Hakea oleifolia	OSC	medium
	Hakea prostrata	RS	
	Myoporum oppositifolium	OSS	rapid
	Pimelea clavata	OSS	rapid
	Grasses		
	Austrodanthonia occidentalis	RS	
	Austrostipa flavescens	OSS	rapid
	Dichelachne crinita		
	Microlaena stipioides	RS	
	Poa drummoniana	RS	
	Poa porphryoclados		
Sedgelands			
Baumea	**Sedges**		
	Baumea articulata		
	Habitat for Australasian Bittern, little Bittern		

QUARTZITE ECODISTRICT

QUARTZITE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Thicket			
Montane Thicket of the Eastern Stirling Range TEC	**Shrubs**		
	Allocasuarina decussata	RS ep	
	Andersonia axilliflora	OSS	slow
	Beaufortia anisandra	OSC	slow
	Banksia biterax	OSC	
	Banksia brownii	OSC	slow
	Banksia concinna	OSC	slow
	Banksia montana	OSC	slow
	Banksia solandri	OSC	slow
	Banksia oreophila	OSC	slow
	Calothamnus crassus	RS / OSC	
	Darwinia collina	OSS	slow
	Hakea florida	RS	
	Isopogon latifolius	OSC	slow
	Kunzea montana	OSS	slow
	Leucopogon gnaphalioides	OSS	slow
	Persoonia micranthera	OSS	slow
	Sphenotoma sp. Stirling	OSS	medium
	Taxandria floribunda	OSC	
	Invertebrate communities		
	Fauna		
	Quokka		
Thicket/ Mallee Thicket			
Montane Mallee Thicket PEC	**Mallee**		
	Eucalyptus doratoxylon	RS	
	Eucalytus ligulata ssp. stirlingica	RS	
	Eucalyptus marginata	RS	
	Eucalyptus talyuberlup	OSC?	
	Shrubs		
	Aotus genistoides	OSS	
	Adenanthos filifolius	OSS	
	Beaufortia anisandra	OSC	slow
	Banksia brownii	OSC	slow
	Banksia concinna	OSC	slow
	Banksia rufa ssp. pumilo	OSC	medium
	Banksia foliolata	OSC	
	Banksia`grandis	RS	

QUARTZITE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia hirta	OSC	medium
	Banksia oreophila	OSC	
	Bankisa plumosa ssp. denticulata	OSC	medium
	Banksia solandri	OSC	slow
	Calothamnus crassus	RS / OSC	
	Hakea ambigua	OSC	medium
	Hakea lasiantha	OSC	slow
	Kunzea montana	OSS	slow
	Lambertia fairallii	OSC	slow
	Leucopogon atherolepis	OSS	
	Leucopogon lasiophyllus	OSS	
	Isopogon baxteri	OSC	medium
	Isopogon latifolius	OSC	slow
	Sphenotoma sp. Stirling	OSS	medium
	Taxandria floribunda	OSC	
	Invertebrate communities		
Coyanerup Wetland Suite PEC (peat soil)	**Mallee**		
	Allocasuarina decussata	RS ep	
	Eucalyptus megacarpa	RS ep / OSC	
	Shrubs		
	Astartea sp. staminodes	OSS?	
	Taxandria linearifolia	RS	
	Homalaspermum firmum	RS	
	Sedges		
	Xyris exilis	OSS	medium
	Organic-rich soil		
	Invertebrate communities		
Proteaceous 'Barrens Thicket' FRNP (Barrens, Eyre range etc)	**Shrub mallee**		
	Eucalyptus acies	RS	
	Eucalyptus acies x preissiana	RS	
	Eucalyptus burdettiana	RS	
	Eucalyptus coronata	RS	
	Eucalyptus decurva	RS	
	Eucalyptus lehmannii subsp. parallela	RS	
	Eucalyptus sepulcralis	RS	
	Eucalyptus redunca	RS	
	Eucalyptus preissiana	RS	
	Shrubs		
	Acacia argutifolia		
	Adenanthos ellipticus	OSS	medium
	Adenanthos ellipticus x cuneatus	OSS	

QUARTZITE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Adenanthos labilliardierei	OSS	
	Adenanthos oreophilus	OSS	
	Adenanthos venosus	RS	
	Agonis baxteri (obtusissima)	RS	
	Banksia baueri	OSC	slow
	Banksia heliantha	OSC	
	Banksia lemanniana	OSC	slow
	Banksia oreophila	OSC	
	Banksia plumosa ssp. plumosa	OSC	
	Calothamnus macrocarpus	RS	
	Calothamnus pinifolius	OSC	
	Calothamnus sp. Kundip	**OSC**	
	Calothamnus validus		
	Calothamnus villosus	OSC?	
	Gonocarpus hispidus	OSS	
	Hakea hookeriana	OSC	
	Hakea victoria	OSC	
	Kunzea similis spp similis	OSS	
	Grevillea coccinea	OSS	
	Grevillea infundibularis	OSS	medium
	Grevillea aff nudiflora	OSS	
	Grevillea infundibularis x aff nudiflora	OSS	
	Grevillea coccinea ssp. lanata	OSS	
	Grevillea fistulosa	OSS	
	Leptospermum conferetum	OSC	
	Melaleuca citrina	RS	
	Melaleuca nesophila	OSC	
	Monotoca aristata		
	Pityrodia exserta		
	Verticodia pityrhops	OSS	slow
Russell Range mixed thicket complexes TEC	**Mallee**		
	Eucalyptus doratoxylon	RS ep	
	Shrubs		
	Adenanthos oreophilus	OSS	
	Banksia armata var. ignicida	OSC	
	Banksia media	OSC	
	Banksia obovata	OSC	medium
	Banksia prolata ssp. archeos	OSC	
	Beaufortia aff schaueri		
	Darwinia sp. Mt Ragged	OSS	
	Daviesia grossa		

QUARTZITE			
Proposed Priority fire sensitive systems	Component Species (Key sensitive species in bold)	Fire response	Post-fire recovery and flowering
	Daviesia teretifolia	RS/OSS	
	Dillwynia pungens	OSS	
	Grevillea concinna ssp. lemanniana	OSS	
	Grevillea oligantha	OSS/RS	
	Grevillea pauciflora ssp. axatilis	OSS	
	Grevillea plurijuga ssp. plurijuga	OSS/RS	
	Hakea drupaceae	OSC	
	Hakea erecta		
	Hakea laurina	OSC	medium
	Hakea pandanicarpa ssp. pandanicarpa	OSC	
	Hakea pycnoneura		
	Hakea scoparia ssp. trycheria	OSC	
	Hakea verrucosa	OSC	
	Isopogon sp. Fitzgerald		
	Isopogon formosus	OSC	rapid
	Kunzea baxteri	OSS	
	Labichea lanceolata	RS	
	Leucopogon apiculatus	OSS	
	Melaleuca fulgens	RS?	
	Melaleuca pentagona ssp raggedensis	OSC?	
	Melaleuca undulata	OSC	
	Melaleuca uncinata	RS	
	Melaleuca viminea	OSC	medium
	Petrophile squamata ssp. northern	OSC	
	Petrophile teretifolia		
	Short range - relictual invertebrates		
Mallee heath / Banksia shrublands			
SRNP lower slopes: Mallee heath / Banksia shrublands	**Mallee**		
	Eucalyptus pachyloma	RS ep	
	Eucalyptus buprestium	RS ep	
	Eucalyptus decipiens	RS	
	Eucalyptus preissiana	RS ep	
	Eucalyptus marginata	RS ep	
	Eucalytpus ligulata ssp. stirlingica	RS ep	
	Eucalytpus kalganensis	RS ep	
	Eucalyptus erectifolia	RS ep	
	Eucalyptus talyuberlup	OSC?	
	Shrubs		
	Adenanthos pungens	OSS	
	Banksia aculeata	OSC	slow
	Banksia arctotidis	RS?	medium
	Banksia baxteri	OSC	medium to slow

QUARTZITE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia blechnifolia	RS	
	Banksia brunnea	OSC	medium
	Banskia calophylla	RS/OSC	
	Banksia coccinea	OSC	medium to slow
	Banksia grandis	RS	
	Banksia mucronulata	OSC	medium
	Banksia nutans	OSC	slow
	Banksia obovata	OSC	medium
	Banksia oreophila	OSC	medium to slow
	Banksia plumosa ssp. denticulata	OSC	medium
	Banksia sessilis	OSC	medium
	Beaufortia anisandra	OSC	medium to slow
	Beaufortia cyrodonta	OSC	medium
	Beaufortia schaueri	OSC	
	Calothamnus affinis	OSC	medium
	Calothamnus sanguineus	RS	
	Conospermum dorrienii	OSS	
	Darwinia meeboldii	OSS	medium
	Darwinia oxylepis	OSS	medium
	Daviesia crenulata	OSS	
	Grevillea pulchella	OSS	
	Hakea ambigua	OSC	medium
	Hakea baxteri	OSC	
	Hakea corymbosa	OSC	slow
	Hakea cucullata	OSC	medium to slow
	Hakea denticulata	OSC?	
	Hakea ferruginea	OSC	medium to slow
	Hakea lehmanniana	RS?	
	Hakea crassifolia ssp. pandanicarpa	OSC	slow
	Hakea ruscifolia	RS	
	Hakea trifurcata	OSC	slow
	Hakea undulata	OSC	slow
	Hibbertia helianthemoides	OSS	
	Isopogon baxteri	OSC	medium
	Kunzea montana	OSS	medium to slow
	Lambertia ericifolia	OSC	medium
	Leucopogon mollis	OSS	
	Melaleuca pungens	OSC	
	Petrophile anceps	OSC	
	Petrophile carduacea	OSC	
	Petrophile longifolia	OSC	
	Petrophile serruriae	OSC	medium to slow

QUARTZITE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Petrophile squamata	OSC	slow
	Stirlingia tenuifolia	OSS	medium
	Taxandria spathulata	RS/OSC	
Low Woodland			
Quartzite Schizt, Quoin Head, Marshes, Two Bump	**Trees**		
	Eucalyptus conferruminata	OSC	slow
	Eucalyptus mcquoidii	OSC	slow
	Eucalyptus redunca	RS	
	Shrubs		
	Hakea cucullata	OSC	medium to slow
Mallet /heath			
Melaleuca sp Kundip Mallet over Heath PEC	**Trees**		
	Eucalyptus cernua	OSC	slow
	Eucalyptus astringens subsp. 'kundip'	OSC	slow
	Eucalyptus clivicola	OSC	slow
	Eucalyptus pileata	RS	
	Eucalyptus platypus	OSC	slow
	Shrubs		
	Calothamnus pinifolius	OSC	
	Daviesia emarginata	RS/OSS	
	Daviesia pachyphylla	RS/OSS	
	Gastrolobium racemosum	OSS	
	Melaleuca bracteosa		
	Melaleuca sp. Kundip	OSC	
	Melaleuca stramentosa	OSC	
	Melaleuca haplantha	OSC	
	Melaleuca rigidifolia	OSC	
	Melaleuca pauperiflora	OSC	
	Melaleuca undulata	OSC	
	Pultenaea craigiana	OSS?	
	Fauna		
	Tammar, Dibbler, Chuditch, Western Whipbird, Lerista viduata, Malleefowl, Brush-Wallaby, Relictual invertebrates, Crested Bellbird, Shy Heathwren, Carnaby's Cockatoo		
Thicket			
Melaleuca stramentosa / Banksia lemanniana	**Shrubs**		
	Banksia lemmaniana	OSC	slow
	Melaleuca stramentosa	OSC	

COASTAL DYNAMIC ECODISTRICT

COASTAL DYNAMIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Mallet woodland / shrubland			
Coastal Mallet - Melaleuca shrubland	**Trees**		
	Callitris preissii	OSC	slow
	Eucalyptus utilis	OSC	slow
	Eucalyptus megacornuta	OSC	slow
	Eucalyptus platypus	OSC	slow
	Shrubs		
	Calothamnus quadrifidus	RS	
	Melaleuca nesophila	OSC	
	Melaleuca lanceolata	OSC	slow
	Chamelaucium axillare	OSS	
	Cryptograms		
	Invertebrate communities		
Woodland/ shrubland			
Estuarine woodland - Melaleuca shrubland	**Trees**		
	Eucalyptus cuspidata		
	Eucalyptus occidentalis	RSep/OSC	
	Eucalyptus occidentalis x utilis	OSC	
	Melalaueca nesophila	OSC	
	Agonis flexuosa	OSC	
	Shrubs		
	Acacia cyclops	OSS	
	Acacia littorea	OSS	
	Kennedia nigricans	OSS	
	Spryidium globulosum	OSS	
	Thomasia sp.		
	Waterbirds, aquatics		
Shrubland			
Banksia praemorsa shrubland	**Shrubs**		
	Acacia littorea	OSS	
	Acrotriche cordata		
	Adenanthos sericeous	OSS	
	Banksia praemorsa	**OSC**	medium
	Banksia sessilis	OSC	medium
	Jacksonia horrida		
	Melaleuca thymoides	RS	
	Pultenaeae heteroclita		

COASTAL DYNAMIC			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Spyridium globulosum	OSS	rapid
	Templetonia retusa	OSS	medium
	Sedges		
	Desmocladus flexuosa		
	Lepidosperma 'dense'		

MARINE PLAIN

MARINE PLAIN			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Woodland			
Wandoo woodland	**Trees**		
	Eucalyptus wandoo	RS ep / OSC	
	Eucalyptus occidentalis	RS ep / OSC	
	Shrubs (incomplete sp list)		
	Hakea lissocarpha	RS	
Riverine Flooded gum	**Trees**		
	Eucalyptus rudis	RS ep	
Swamp Yate woodlands in seasonally inundated clay basins PEC/ Riverine Yate woodland	**Trees**		
	Banksia littoralis	RS ep	
	Eucalyptus decipiens	RS	
	Eucalyptus occidentalis	RS ep / OSC	
	Melaleuca cuticularis	RS ep	
	Melaleuca preissiana	RS ep	
	Shrubs		
	Banksia dyandroides	OSC	
	Hakea denticulata	OSC	
	Hakea nitida	RS	
	Kunzea recurva	OSS/RS	rapid to medium
	Melaleuca suberosa	RS	
	Pericalymma ellipticum	RS	
	Petrophile squamata	OSC	slow
	Sedges /grasses		
	Anarthria laevis	RS	
	Gahnia trifida	RS	
Moort forest			
Moort low forest	**Trees**		
	Eucalyptus annulata	RS	
	Eucalyptus platypus ssp platypus	OSC	slow
	Eucalyptus praetermissa	OSC	slow
	Eucalyptus vesiculosa	OSC	slow
	Eucalyptus melanophitra	OSC	slow
	Eucalyptus newbyii	OSC	slow
	Eucalytpus redacta	OSC	slow
	Shrubs		

MARINE PLAIN			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Acacia glaucoptera	OSS	rapid
	Melaleuca acuminata	OSC	medium
Mallet Woodland			
Eucalyptus nutans mallet woodland	**Trees**		
	Eucalyptus anceps	RS	
	Eucalyptus nutans	OSC	slow
	Eucalyptus ocidentalis	RS ep/OSC	
	Shrubs		
	Acacia cyclops	OSS	
	Acacia glaucoptera	OSS	rapid
	Hakea laurina	OSC	slow
	Melaleuca undulata	OSC	
	Melaleuca subfalcata		
	Rhadinothamnus rudis		
	Fauna		
	Western Whipbird, Chuditch Red-tailed phascogale		
Woodland/ mallee			
Eucalyptus brandiana woodland/mallee mix	**Eucalyptus brandiana**	OSC	slow
	data deficient		
Mallet woodland / shrubland			
Mallet woodlands and shrublands on spongelite	**Trees**		
	Allocasuarina trichodon	OSC	slow
	Eucalyptus melanophitra	OSC	slow
	Eucalyptus astringens ssp. redacta	OSC	slow
	Eucalyptus praeterissima	OSC	slow
	Eucalyptus arborella	OSC	slow
	Shrubs		
	Banksia armata	RS	
	Banksia ionthocarpa ssp. ionthocarpa	OSC	slow
	Banksia laevigata ssp. laevigata	OSC	slow
	Calothamnus quadridus	RS	
	Calothamnus robustus	OSC?	
	Kunzea pauciflora	OSS	medium
	Verticordia fastigiata	OSS	
	Verticordia helicrysantha	OSS	medium
	Verticordia crebra	OSS	rapid
	Vericorida longistylis	OSS?	
Shrubland			

MARINE PLAIN			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Banksia shrublands	**Shrubs**		
	Banksia attenuata	RS/OSC	
	Banksia baueri	OSC	slow
	Banksia baxteri	OSC	slow
	Banksia coccinea	OSC	medium to slow
	Banksia dryandoides	OSC	medium
	Banksia lemanniana	OSC	medium to slow
	Banksia media	OSC	medium to slow
	Banksia nutans	OSC	slow
	Banksia obovata	OSC	medium
	Banksia violacea	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Conospermum distichium	RS/OSS	medium
	Daviesia incrassata spp. reversifolia	RS/OSS	
	Hakea victoriae	OSC	medium to slow
	Hakea corymbosa	OSC	slow
	Isopogon trilobus	OSC	medium to slow
	Lambertia inermis	OSC	medium
	Melaleuca striata	RS	
	Petrophile ericifolia	OSS	
	Petrophile phyllicoides	OSC	slow
	Petrophile teretifolia	RS/OSC	medium
	Stirlingia tenuifolia	RS/OSS	medium
Mallee Shrublands			
Banksia / Hakea dominated mallee-heath	**Mallee**		
	Eucalyptus decipiens	RS ep	
	Eucalyptus decurva	RS	
	Eucalyptus falcata	RS	
	Eucalyptus marginata	RS ep	
	Eucalyptus staeri	RS ep	
	Eucalyptus pleurocarpa	RS ep	
	Eucalyptus tetraptera	RS	
	Shrubs		
	Allocasuarina trichodon	OSC	slow
	Allocasuarina microstachys	RS	
	Banksia attenuata	RS	
	Banksia baueri	OSC	slow
	Banksia brunnea	OSC	medium
	Banksia dryandoides	OSC	medium
	Banksia drummondii	OSC	medium
	Banksia falcata	OSC	medium to slow

MARINE PLAIN			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia media	OSC	medium to slow
	Banksia mucronulata	OSC	medium to slow
	Banksia plumosa ssp. plumosa	OSC	medium to slow
	Banksia tenuifolia ssp tenuifolia	RS	
	Banksia violaceae	OSC	medium to slow
	Beaufortia anisandra	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Beaufortia schaueri	OSC	medium
	Calothamnus pinifolius	OSC	
	Calothamnus robustus	OSC?	
	Grevillea fasiculata	OSS	medium
	Hakea baxteri	OSC	
	Hakea corymbosa	OSC	slow
	Hakea cucullata	OSC	medium to slow
	Hakea ferruginea	OSC	slow
	Hakea lehmanii	RS	
	Hakea marginata	RS	
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
	Hakea trifurcata	OSC	slow
	Hakea tuberculata	OSC	
	Isopogon baxteri	OSC	medium
	Isopogon buxifolius	OSC	slow
	Isopogon cuneatus	OSC	
	Isopogon formosus	OSC	rapid to medium
	Isopogon trilobus	OSC	medium to slow
	Lambertia citrina	OSC	
	Lambertia inermis	OSC	medium
	Lambertia uniflora	OSC	medium to slow
	Melaleuca suberosa	RS	
	Melaleuca violaceae		
	Petrophile divaricata	OSC	
	Petrophile ericifolia	OSC	medium
	Petrophile phyllicoides	OSC	slow
	Petrophile serrurieae	OSC	medium to slow
	Petrophile squamata	OSC	slow
	Taxandria spathulata	RS/OSC	
	Xanthorrhoea platyphylla	RS	

MARINE PLAIN			
Mallee Shrublands			
Albany Blackbutt (*Eucalyptus staeri*) mallee-heath on deep sand PEC (Pallinup sandplain)	**Mallee**		
	Eucalytpus staeri	RS ep	
	Shrubs		
	Banksia attenuata	RS ep/ OSC	
	Banksia baueri	OSC	slow
	Banksia baxteri	OSC	medium to slow
	Banksia mucronulata ssp. mucronulata	OSC	medium to slow
	Banksia nutans ssp. nutans	OSC	slow
	Banksia plumosa ssp. plumosa	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Hakea baxteri	OSC	
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
	Lambertia inermis	OSC	medium
Albany Blackbutt (*Eucalyptus staeri*) mallee-heath on lateritic ridges PEC (Pallinup sandplain)	**Mallee**		
	Eucalytpus staeri	RS	
	Eucalytpus decurva	RS	
	Shrubs		
	Banksia baxteri	OSC	medium to slow
	Banksia falcata	OSC	medium to slow
	Banksia mucronulata ssp. mucronulata	OSC	medium to slow
	Banksia nutans ssp. nutans	OSC	slow
	Banksia obovata	OSC	medium to slow
	Banksia plumosa ssp. plumosa	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Hakea baxteri	OSC	
	Hakea cucullata	OSC	medium to slow
	Hakea corymbosa	OSC	slow
	Hakea ferruginea	OSC	slow
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
	Hakea trifurcata	OSC	slow
	Lambertia inermis	OSC	medium
	Melaleuca striata	RS	
	Petrophile divaricata	OSC	
	Taxandria spathulata	RS/OSC	
	Xanthorrhoea platyphylla	RS	
Mallee Shrublands			
Tallerack (*Eucalyptus pleurocarpa*) mallee-heath on heavy soils PEC	**Mallee**		
	Eucalyptus bupestrium	RS ep	
	Eucalyptus decurva	RS ep	
	Eucalyptus pleurocarpa	RS ep	
	Eucalyptus uncinatus	RS ep	
	Shrubs		

	MARINE PLAIN		
	Banksia mucronulata ssp. mucronulata	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Hakea cucullata	OSC	medium to slow
	Hakea denticulata	OSC	
	Hakea nitida	RS	
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
	Isopogon trilobus	OSC	medium to slow
	Melaleuca spathulata	RS	
	Melaleuca suberosa	RS	
	Melaleuca subtrigona	RS	
	Petrophile crispata		
	Petrophile squamata	OSC	slow
	Regelia inops		
Tree Mallee Shrubland			
Tree mallee shrubland (Eucalyptus acies / E. goniantha/ E. doratoxylon) on spongelite PECs	**Trees**		
	Eucalyptus acies	RS	
	Eucalyptus doratoxylon	RS	
	Eucalyptus gonaiantha	RS	
	Eucalyptus lehamanii	RS	
	Shrubs		
	Banksia mucronulata	OSC	medium to slow
	Banksia serra	OSC	medium
	Beaufortia empetrifolia	OSC	medium
	Calothamnus robustus	?OSC	
	Hakea cucullata	OSC	medium to slow
	Hakea elliptica	OSC	slow
	Hakea lasiantha	OSC	slow
	Calothamnus robustus	?OSC	
Wet heath			
Porongurup Wet Ironstone Heath PEC	**Shrubs**		
	Hakea cucullata	OSC	medium to slow
	Hakea lasiocarpha	OSC	
	Hakea tuberculata	OSC	
	Hakea oldfieldii	?OSC	
	Hakea sulcata	OSC	
	Petrophile squamata	OSC	slow
	Kunzea recurva	OSS/RS	rapid to medium
	Melaleuca violacea		
	Melaleuca suberosa	RS	
Sedgelands			
Baumea sedgelands, habitat for Australasian Bittern, little Bittern	**Sedges**		
	Baumea articulata		

GREENSTONE ECODISTRICT

GREENSTONE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Woodland			
Salmon Gum Woodland	**Trees**		
	Eucalyptus salmonophloia	RS ep, OSC	slow
	Eucalyptus phenax	RS ep	
	Shrubs		
	Acacia glaucoptera	OSS	rapid
	Grevillea huegellii	RS/OSS	
	Lasiopetalum compactum		
	Senna artesmoides ssp filifolia	OSS	
Mallet woodland			
Ravensthorpe Moort and Mallet woodland	**Trees**		
	Eucalyptus cernua	OSC	slow
	Eucalyptus clivicola	OSC	slow
	Eucalyptus dielsii	OSC	slow
	Eucalyptus extensa	OSC	slow
	Eucalyptus gardneri ssp. Ravensthorpensis	OSC	slow
	Eucalyptus lehmanii ssp. parallela	RS	
	Eucalyptus megacornuta	OSC	slow
	Eucalyptus platypus ssp. congregata	OSC	slow
	Eucalyptus platypus ssp. platypus	OSC	slow
	Eucalyptus purpurata	OSC	slow
	Eucalyptus salubris	OSC	slow
	Shrubs		
	Beaufortia orbifolia	OSC	
	Beyeria sp. Ravensthorpe	OSS	
	Exocarpus aphyllus	OSS	
	Gastrolobium parviflorum	OSS	
	Grevillea patentiloba ssp. platypoda	OSS	
	Hakea commutata	OSC	
	Hakea laurina	OSC	slow
	Hakea obtusa	OSC	
	Hakea verrucosa	OSC	
	Isopogon polycephalus	RS	
	Melaleuca acuminata	OSC	medium
	Melaleuca cucullata	OSC?	
	Melaleuca eleuterostachya		
	Melaleuca hamata	RS	
	Melaleuca haplantha	OSC?	

GREENSTONE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca pauperiflora spp pauperiflora	OSC	
	Melaleuca sp. Gorse	OSC	
	Melaleuca teuthidoides		
	Melaleuca thapsina	OSC	
	Melaleuca torquata		
	Melaleuca undulata	OSC	
	Siegfriedia darwinioides	OSS	rapid to medium
	Spyridium glaucum	OSS	rapid to medium
	Pultenaea calycina ssp. proxaena	OSS	
Mallee Shrubland			
Eucalyptus pleurocarpa / E. falcata Proteaceous shrublands	**Mallee**		
	Eucalyptus falcata	RS	
	Eucalyptus pleurocarpa	RS	
	Shrubs		
	Acacia durabilis	OSS	
	Acacia heterochroa	OSS?	
	Banksia cirsioides	OSC	medium to slow
	Banksia corvijuga	OSC	
	Banksia foliosissima	OSC	
	Banksia heliantha	OSC	
	Banksia laevigata ssp. laevigata	OSC	
	Banksia lemanniana	OSC	slow
	Banksia pallida	OSC	slow
	Beaufortia schaueri	OSC	medium to slow
	Beaufortia orbifolia	OSC	
	Calothamnus quadrifidus	RS	
	Grevillea coccinea	OSS	
	Hakea cygna ssp. cygna	OSC	
	Hakea laurina	OSC	slow
	Hakea marginata	RS	
	Hakea multilineata	OSC	medium to slow
	Hakea obtusa	OSC	
	Hakea pandanicarpa spp crassifolia	OSC	slow
	Hakea subsulcata	OSC	slow
	Hakea verrucosa	OSC	
	Isopogon polycephalus	RS	
	Kunzea cincinnata		
	Kunzea similis ssp. mediterraneae	OSS	
	Lasiopetalum sp. Desmond N McQuoid 653	OSS?	
	Melaleuca rigidifolia	OSC	
	Melaleuca thapsina	OSC	

GREENSTONE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Petrophile glauca	OSC	slow
	Petrophile seminuda	RS/OSC	medium
	Santalum acuminatum	OSS	slow
	Taxandria spathulata	RS/OSC	
	Fauna		
	Heath mouse, Western Whipbird, Malleefowl, Tammar & Brush Wallaby, Carnaby's Cockatoo		
Mallee over Melaleuca Shrubland			
Mallee over *Melaleuca* units	**Mallee**		
	Eucalyptus spp		
	Shrubs		
	Exocarpus aphylla	OSS	
	Gastrolobium parviflorum	OSS	medium
	Grevillea huegellii	OSS?	
	Grevillea pectinata	RS/OSS	
	Grevillea oligantha	RS/OSS	
	Hakea commutata	OSC	
	Hakea verrucosa	OSC	
	Kunzea cincinnata		
	Melaleuca acuminata		
	Melaleuca cliffortoides	RS	
	Melaleuca coronicarpa	OSC	
	Melaleuca cucullata	OSC?	
	Melaleuca eleuterostachya		
	Melaleuca glaberrima	OSC	
	Melaleuca hamata	RS	
	Melaleuca lateriflora ssp. lateriflora	RS/OSC	
	Melaleuca pauperiflora spp pauperiflora	OSC	
	Melaleuca sp. Gorse	OSC	
	Melaleuca pentagona		
	Melaleuca pomphostoma		
	Melaleuca rigidifolia		
	Melaleuca societatis	OSC	
	Melaleuca teuthidoides		
	Melaleuca torquata		
	Melaleuca undulata	OSC	
	Sanatalum acuminatum	OSS	slow
	Siegfriedia darwinioides	OSS	rapid to medium
Mallee shrublands			
	Trees		
	Eucalytpus kessellii	RS	

GREENSTONE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Eucalyptus indurata	RS	
Magnesite mallee shrublands	**Shrubs**		
	Beyeria sp. Ravensthorpe	OSS	
	Lissanthe pleurandroides	OSS?	
	Melaleuca haplantha	OSC?	
	Pulenaea calycina ssp. proxaena	OSS	
Shrubland			
Allocasuarina shrublands	**Shrubs**		
	Acacia pinguiculosa	OSS	
	Allocasuarina acutivalvis ssp. acutivalvis	OSC	
	Allocasuarina campestris	OSC	
	Allocasuarina huegeliana	OSC	medium to slow
	Allocasuarina hystericosa	RS	
	Allocasuarina spinosissima	OSC ?	
	Allocasuarina scleroclada	RS	
	Calothamnus quadrifidus	RS/OSC	
	Hakea verrucosa	OSC	
	Kunzea cinncinata		
	Kunzea strigosa		
	Leptospermum maxwellii		
	Melaleuca hamata	RS	
	Verticordia oxylepis	OSS	
	Santalum acuminatum	OSS	slow
Melaleuca thicket			
Melaleuca thapsina thicket	**Shrubs**		
	Banksia laevigata ssp. laevigata	OSC	
	Beaufortia orbifolia	OSC	
	Melaleuca thapsina	OSC	
Heath			
Banksia cirsioides heath	**Shrubs**		
	Allocasuarina acutivalvis ssp. acutivalvis	OSC	
	Banksia cirsiodes	OSC	medium to slow
	Banksia erythrocaephala	RS	
	Banksia lemanniana	OSC	slow
	Beaufortia schaueri	OSC	medium to slow
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
Heath on Komatiite PEC	**Shrubs**		
	Acacia ophiolithica	OSS	
	Beyeria cockertonii	OSS	
	Calothamnus quadrifidus	RS /OSC	
	Hakea verrucosa	OSC	

GREENSTONE			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca cliffortioides	RS	
	Grevillea fastigiata	OSS	
	Grevillea oligantha	OSS	
	Philotheca gardneri spp Ravesnthorpe		

YILGARN EAST ECODISTRICT

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Woodlands			
Lake Johnson woodlands	**Trees**		
	Eucalyptus urna	OSC	slow
	Eucalyptus platypus subsp congregata	OSC	slow
	Eucalyptus longicornis	RSep	
	Eucalyptus melanoxylon	RSep	
	Eucalyptus salmonophloia	RS ep, OSC	slow
	Eucalyptus sp. dendrosheath	OSC	slow
	Eucalyptus ravida	OSC	slow
	Eucalyptus salubris	OSC	slow
	Eucalyptus transcontinentalis	RSep	
	Shrubs		
	Acacia spp		
	Davieisa nematophylla		
	Eremophila spp		
	Melaleuca pauperiflora	OSC	
	Melaleuca halmaturorum		
	Melaleuca sheathiana	OSC	
	Melaleuca spp		
Upland yate woodland	**Trees**		
	Eucalyptus occidentalis	RSep/OSC	
Salt Lakes fringing woodland	**Trees**		
	Eucalyptus alipes	OSC	slow
	Eucalyptus salicola	OSC	slow
	Eucalyptus kumarlensis	OSC	slow
	Eucalyptus angustissima	RS	
	Shrubs		
	Atriplex spp		
	Frankenia spp		
Woodland / Low forest			
Transitional Woodlands (Eucalyptus extensa, E. salmonophloia, E. spathulata, E. urna)	**Trees**		
	Eucalyptus extensa	OSC	slow
	E. longicornis	RS ep	
	E. loxophleba	RS	
	E. loxophleba x spathulata		
	E. occidentalis	RS ep/OSC	
	Eucalyptus phenax	RS ep	

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	E. platypus ssp platypus	OSC	slow
	E. salmonophloia	RS ep/OSC	slow
	E. spathulata	OSC	slow
	E. urna	OSC	slow
	E. wandoo	RS ep/OSC	
	E. sp mallet	OSC	slow
	E. sp. aff uncinata	RS	
	E. oleosa	RS	
	E. occidentalis x platypus	OSC	slow
	Shrubs		
	Acacia spp		
	Choretrum glomeratum		
	Grevillea spp		
	Hakea commutata	OSC	
	Hakea preissii	OSC	
	Eremophila spp		
	Melaleuca acuminata	RS	
	Melaleuca hamata	RS	
	Melaleuca spp		
	Santalum acuminatum	OSS	slow
	Senna artesmoides ssp. filifolia	OSS	
	Chuditch, Malleefowl, Carnaby's Cockatoo. Possibly Numbat? Likely to be SRE invertebrates		
Mallet / moort woodland			
Yilgarn East moort and mallet woodlands	**Trees**		
	Eucalyptus annulata	RS	
	Eucalyptus calyerup	OSC	slow
	Eucalyptus densa	OSC	slow
	Eucalyptus platypus ssp. platypus	OSC	slow
	Eucalyptus spathulata	OSC	slow
	Eucalyptus platypus subsp. congregata	OSC	slow
	Eucalyptus forrestiana	OSC	slow
	Eucalyptus dolichoryncha	OSC	slow
	Eucalyptus stoatei	OSC	slow
	E. salmonophloia	RS ep/ OSC	slow
	E. urna	OSC	slow
	Shrubs		
	Acacia spp		
	Melaleuca undulata	OSC	
Woodland/shrubland			
	Trees		

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Peak Charles / Eleanora Granite woodland / shrubland	**Callitris preissii**	OSC	slow
	Eucalyptus salmonophloia	Rsep/OSC	slow
	Shrubs		
	Acacia incongesta		
	Allocasuarina campestris	OSC	
	Anthocercis genistoides	OSS	rapid
	Calothamnus quadrifidus	RS/OSC	
	Dodonaea pinifolia	RS	
	Drummondita hassellii	OSS	
	Exocarpus sparteus	OSS	
	Gastrolobium acrocaroli		
	Labichea stellata		
	Melaleuca fulgens	RS?	
	Santalum acuminatum	OSS	slow
	Santalum spicatum	OSS	slow
	Cryptograms		
Woodland/ thickets			
Bremer Range PEC - Woodland / Allocasuarina thickets on greenstone ridges	**Trees**		
	Allocasuarina huegeliana	OSC	slow
	Callitris columellaris	OSC	slow?
	Callitris glaucophylla	OSC	slow?
	Eucalyptus diptera	OSC	slow
	Eucalyptus dundasii	OSC	slow
	Eucalyptus eremophila	RS	slow
	Eucalyptus extensa	OSC	slow
	Eucalyptus georgei ssp. georgei	OSC	slow
	Eucalyptus livida	RS	
	Eucalyptus longicornis	RS ep	
	Eucalyptus melanoxylon	RS ep	
	Eucalyptus oleosa	RS ep	
	Eucalypyus protensa	OSC	slow
	Eucalyptus ravida	OSC	slow
	Eucalyptus rhomboidea	OSC	slow
	Eucalyptus salubris	OSC	slow
	Eucalyptus salmonophloia	RS ep, OSC	slow
	Eucalyptus sp. dendrosheath	OSC	slow
	Eucalyptus tenuis	OSC	slow
	Eucalyptus transcontinentalis	RS ep	
	Eucalyptus urna	OSC	slow
	Eucalyptus incerata	RS	
	Eucalyptus cerasiformis	RS	

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Shrubs		
	Acacia acuminata	OSS	medium
	Acacia duriuscula		
	Allocasuarina acutivalvis	OSC	medium to slow
	Allocasuarina campestris	OSC	
	Allocasuarina helmsii		
	Allocasuarina globosa		
	Calothamnus asper		
	Calothamnus quadrifidus	RS/OSC	
	Davieisa argillaceae		
	Dodanaea stenozyga		
	Exocarpus aphyllus	OSS	
	Grevillea acuaria	OSS	
	Grevillea huegellii	RS/OSS	
	Grevillea oncogyne	OSS	
	Grevillea pectinata	RS/OSS	
	Hakea commutata	OSC	
	Hakea multilineata	OSC	medium to slow
	Hakea scoparia	OSC	rapid to medium
	Melaleuca cordata	RS/OSC	
	Melaleuca eleuterostachya		
	Melaleuca lanceolata	OSC	
	Melaleuca lateriflora	RS/OSC	
	Melaleuca pauperiflora	OSC	
	Melaleuca pentagona	RS	
	Melaleuca phoidophylla		
	Melaleuca hamata	RS	
	Olearia muelleri		
	Pittosporum angustifolium		
	Thryptomene kochii		
Woodland			
Sheoak woodland / granite outcrop communities	**Trees**		
	Allocasuarina huegeliana	OSC	slow
	Eucalyptus occidentalis	RS ep / OSC	
	Santalum spicatum	OSS	slow
	Shrubs		
	Acacia acuminata	OSS	medium to slow
	Acacia lasiocalyx	OSS?	
	Calothamnus quadrifidus	RS/OSC	
	Callistemon phoeniceus		
	Callitris preissii	OSC	slow

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Callitris roei	OSC	slow
	Calytrix tetragona	OSS?	
	Dodanaea ceratocarpa	RS	
	Hakea lissocarpha	RS	
	Hypocalymma angustifolium	RS	
	Hakea laurina	OSC	slow
	Hakea preissii	OSC	
	Hakea verrucosa	OSC	
	Melaleuca acuminata	RS	
	Melaleuca coccinea		
	Melaleuca elliptica	RS/OSC	medium
	Melaleuca hamata	RS	
	Melaleuca penicula		
	Santalum acuminatum	OSS	slow
	Thryptomene australis	OSC	rapid
	Verticordia spp		
	Herbs		
	Borya spp		
	Cryptograms		
	Invertebrates		
	Fauna		
	Tammar, Brush Wallaby		
Mallee-heath			
Mallee heath (including E. pleurocarpa) Banksia / Hakea dominant	**Mallee**		
	Eucalyptus spp		
	Eucalyptus pleurocarpa	RS	
	Shrubs		
	Acacia drewiana spp minor	OSS	
	Acacia unifillis	OSS	
	Acacia aemula ssp. muricata	OSS	medium
	Acacia chrysocephala	OSS	medium
	Acacia shuttleworthii	OSS	
	Acacia rostellata	OSS	medium
	Acacia gonophylla	OSS	medium
	Banksia arctotidis	RS	
	Banksia brunnea	OSC	medium
	Banksia calyei	OSC	slow
	Banksa cirsioides	OSC	medium to slow
	Banksia erythrocephala	RS	
	Banksia falcata	OSC	medium to slow
	Banksia media	OSC	medium to slow

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia nivea ssp. nivea	OSC	medium
	Banksia pallida	OSC	slow
	Banksia pilostylis	OSC	medium to slow
	Banksia pteridifolia	RS	
	Banksia rufa ssp. chemelocarpa	RS	
	Banksia violacea	OSC	slow
	Banksia xylothemelia	RS	
	Beaufortia micrantha var.. micrantha	OSC	medium to slow
	Beaufortia schaueri	OSC	medium to slow
	Callitris drummondii	OSC	
	Callitris preissii	OSC	slow
	Calothamus gracilis	RS	
	Daviesia audax	OSS	
	Daviesia abnormis	RS	
	Daviesia emarginata	OSS	
	Daviesia incrassata	OSS	
	Davieisa lancifolia	RS	
	Daviesia pachyphylla	RS/OSS	
	Daviesia sarrissa	OSS	
	Daviesia teretifolia	RS/OSS	
	Gastrolobium crassifolium	RS	
	Gastrolobium latifolium	OSS	
	Gastrolobium spinosum	OSS	rapid
	Gompholobium confertum	OSS	
	Gompholobium knightianum	OSS	
	Gompholobium marginatum	OSS	
	Grevillea cagiana	OSS	
	Grevillea dolichopoda	OSS	medium
	Grevillea oligantha	OSS	slow
	Grevillea patentiloba	OSS	medium
	Grevillea pectinata	RS/OSS	
	Hakea cinerea	OSC	
	Hakea commutata	OSC	
	Hakea corymbosa	OSC	slow
	Hakea crassifolia ssp. pandanicarpa	OSC	slow
	Hakea cygna subsp.. cygna	OSC	
	Hakea ferruginea	OSC	slow
	Hakea horrida	OSC	
	Hakea incrassata	RS	
	Hakea laurina	OSC	slow
	Hakea nitida	RS	
	Hakea obliqua	OSC	

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Hakea strumosa	OSC	
	Hakea trifurcata	OSC	slow
	Hakea verrucosa	OSC	
	Isopogon buxifolius	OSC	slow
	Isopogon sp. Fitzgerald		
	Isopogon teretifolius	RS	
	Lambertia inermis	OSC	medium
	Leptospermum spinescens	RS	
	Leucopogon concinnus		
	Leucopogon conostephoides	OSS	medium
	Leucopogon corynocarpus		
	Leucopogon gibbosus	OSS	
	Leucopogon minutifolius		
	Melaleuca subfalcata		
	Melaleuca pulchella	RS	
	Melaleuca suberosa	RS	
	Persoonia striata	RS/OSS	
	Petrophile squamata	OSC	slow
	Pultenaea brachyphylla	OSS	
	Taxandria spathulata	RS/OSC	
	Xanthorrhoea platyphylla	RS	
	Animals – Western Whipbird		
Mallee			
Transitional mallee-shrublands / heath	**Mallee**		
	Eucalyptus eremophila	RS	
	Eucalyptus dissimulata	RS	
	Eucalyptus kessellii	RS	
	Eucalyptus forrestiana	OSC	slow
	Eucalytpus leptocalyx	RS	
	Eucalyptus spp		
	Shrubs		
	Acacia fragilis		
	Acacia resinomarginea		
	Acacia stereophylla		
	Allocasuarina acutivalvis	OSC	
	Allocasuarina campestris	OSC	
	Allocasuarina corniculata		
	Allocasuarina helmsii		
	Allocasuarina microstachys	RS	
	Allocasuarina scleroclada	RS	
	Banksia cirsioides	OSC	medium to slow
	Banksia lullfitzii	RS	

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Banksia elderiana	RS	
	Banksia laevigata subsp. fuscolutea	OSC	medium to slow
	Banksia media	OSC	slow
	Banksia purdieana	?OSC	
	Beaufortia micrantha var. micrantha	OSC	medium to slow
	Beaufortia schaueri	OSC	medium to slow
	Callitris preissii	OSC	slow
	Calothamnus gracilis	RS	
	Calothamnus quadrifidus	RS/OSC	
	Eremophila spp		
	Exocarpus aphyllus	OSS	
	Gastrolobium spinosum	OSS	
	Grevillea huegellii	RS/ OSS	
	Grevillea oncogyne	OSS	
	Grevillea cagiana	OSS	
	Grevillea concinna	OSS	
	Grevillea excelsior	OSS	
	Grevillea hookeriana	OSS	
	Grevillea incrassata		
	Grevilea rufa		
	Grevillea didymobotyra		
	Grevillea integrifolia		
	Grevillea teretifolia		
	Hakea cygna ssp. cygna	OSC	
	Hakea commutata	OSC	
	Hakea falcata	OSC	medium to slow
	Hakea laurina	OSC	slow
	Hakea multilineata	OSC	medium to slow
	Hakea crassifolia spp pandanicarpa	OSC	slow
	Hakea roei		
	Hakea subsulcata	OSC	slow
	Isopogon gardneri		
	Isopogon scabriusculus		
	Leptospermum roei		
	Melaleuca acuminata	OSC	medium
	Melaleuca calycina	OSC	medium to slow
	Melaleuca cordata	RS/OSC	
	Melaleuca pungens	OSC	medium
	Melaleuca pauperiflora spp pauperiflora	OSC	
	Melaleuca sapientes	OSC	
	Melaleuca subfalcata		

YILGARN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca undulata	OSC	
	Petrophile seminuda	RS/OSC	
	Petrophile stricta		
	Thryptomene appressa		
	Thryptomene kochii		
	Fauna		
	Malleefowl		
Mallee over Melaleuca Shrubland			
Mallee Shrubland	**Mallee**		
	Eucalyptus spp	RS	
	Shrubs		
	Gastrolobium parviflorum	OSS	medium
	Grevillea huegelii	OSS	
	Grevillea pectinata	RS/OSS	
	Hakea commutata	OSC	
	Hakea verrucosa	OSC	
	Melaleuca cordata	RS/OSC	
	Melaleuca cornicarpa	OSC?	
	Melaleuca cucullata	OSC?	
	Melaleuca eleuterostachya		
	Melaleuca hamata	RS	
	Melaleuca lateriflora ssp. lateriflora	RS	
	Melaleuca pauperiflora spp pauperiflora	OSC	
	Melaleuca sapientes	OSC	
	Melaleuca societatis	OSC	
	Melaleuca teuthidoides		
	Melaleuca torquata		
	Melaleuca undulata	OSC	
	Sanatalum acuminatum	OSS	slow

ESPERANCE SAND PLAIN WEST ECODISTRICT

ESPERANCE SANDPLAIN WEST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Banksia Shrublands / Mallee shrublands			
Banksia shrublands/Proteaceous paluspalin heath	**Mallee**		
	Eucalyptus spp		
	Shrubs		
	Banksia baueri	OSC	slow
	Banksia baxteri	OSC	medium to slow
	Banksia brunnea	OSC	medium
	Banksia cirsioides	OSC	medium
	Banksia coccinea	OSC	medium to slow
	Banksia media	OSC	medium to slow
	Banksia nutans	OSC	slow
	Banksia obtusa	OSC	
	Banksia obovata	OSC	medium
	Banksia pilostylis	OSC	medium to slow
	Banksia pulchella	OSC	slow
	Banksia speciosa	OSC	medium to slow
	Banksia violacea	OSC	
	Beaufortia empetrifolia	OSC	medium
	Beaufortia micrantha	OSC	medium to slow
	Beaufortia schaueri	OSC	
	Callitris drummondii	OSC	
	Callitris preissii	OSC	slow
	Callitris roei	OSC	slow
	Calothamnus gracilis	RS	
	Conospermum distichium	RS/OSS	
	Conospermum teretifolium	RS	
	Davieisa teretifolia	RS/OSS	
	Lambertia inermis	OSC	medium
	Hakea commutata		
	Hakea corymbosa	OSC	slow
	Hakea cinerea	OSC	
	Hakea laurina	OSC	
	Hakea marginata	RS	
	Hakea nitida	RS	
	Hakea sulcata	OSC	
	Hakea trifurcata	OSC	slow
	Isopogon polycephalus	RS	
	Isopogon trilobus	OSC	medium to slow

ESPERANCE SANDPLAIN WEST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca brevifolia	?OSC	
	Melaleuca pulchella	RS	
	Melaleuca subfalcata	?	
	Melaleuca striata	RS	
	Melaleuca thapsina	OSC	
	Petrophile fastigiata	OSC?	
	Petrophile phyllicoides	OSC	slow
	Petrophile seminuda	RS/OSC	
	Petrophile seorsiflora		
	Petrophile squamata	OSC	slow
	Petrophile teretifolia	RS/OSC	
	Phymatocarpus maxwellii	OSC	
	Santalum acuminatum	OSS	slow
	Stirlingia anaethifolia	OSS	rapid
	Verticordia vicinella	OSS?	
	Xanthorrhoea playtphylla	RS	
Woodland			
Swamp Yate woodlands, RiverineYate woodland including paperbark	**Trees**		
	Eucalyptus occidentalis	RS ep /OSC	
	Melaleuca cuticularis	RS ep	
	Shrubs		
	Melaleuca thapsina	OSC	

ESPERANCE SAND PLAIN EAST ECODISTRICT

ESPERANCE SANDPLAIN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Banksia Shrublands / Mallee shrublands			
Banksia shrublands/Proteaceous palusplain heath	**Mallee**		
	Eucalyptus captiosa	RS	
	Eucalyptus extrica	RS	
	Eucalyptus goniantha notac	RS	
	Eucalyptus insularis	RS	
	Eucalyptus ligulata ssp ligulata	RS	
	Eucalyptus litorea	RS	
	Eucalyptus micranthera	RS	
	Eucalyptus tetragona	RS	
Banksia shrublands/Proteaceous palusplain heath	**Shrubs**		
	Adenanthos cuneatus	RS	
	Agonis baxteri	RS	
	Allocasuarina lehmanniana	OSC	
	Allocasuarina sclerocalda	RS	
	Allocasuarina trichodon	OSC	
	Banksia alliaceae	OSC	
	Banksia armata	RS	
	Banksia armata var. ignicida	OSC	
	Banksia media	OSC	medium to slow
	Banksia nivea	OSC	
	Banksia nutans	OSC	slow
	Banksia obovata	OSC	medium
	Banksia obtusa	OSC	
	Banksia occidentalis	OSC	medium
	Banksia petiolaris	OSC	medium
	Banksia pilostylis	OSC	medium to slow
	Banksia prolata ssp. prolata	OSC	
	Banksia pulchella	OSC	slow
	Banksia repens	RS	
	Banksia speciosa	OSC	medium to slow
	Banksia tenuis	OSC	
	Banksia violacea	OSC	
	Beaufortia empetrifolia	OSC	medium
	Beaufortia micrantha	OSC	medium to slow
	Beaufortia schaueri	OSC	
	Callitris drummondii	OSC	
	Callitris preissii	OSC	slow

ESPERANCE SANDPLAIN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Callitris roei	OSC	slow
	Calothamnus gracilis	RS	
	Conospermum distichium	RS/OSS	
	Conospermum teretifolium	RS	
	Conothamnus aureus	RS	
	Davieisa teretifolia	RS/OSS	
	Lambertia inermis	OSC	medium
	Melaleuca suberosa	RS	
	Grevillea coccinea	OSS	
	Grevillea pauciflora	OSS	
	Hakea commutata	OSC	
	Hakea corymbosa	OSC	slow
	Hakea cinerea	OSC	
	Hakea laurina	OSC	medium
	Hakea marginata	RS	
	Hakea obliqua	OSC	
	Hakea nitida	RS	
	Hakea ruscifolia	RS	
	Hakea scoparia ssp trycherica	OSC	
	Hakea sulcata	OSC	
	Hakea trifurcata	OSC	slow
	Hakea tuberculata	OSC	
	Isopogon formosus	OSC	rapid to medium
	Isopogon heterophyllus	?OSC	
	Isopogon polycephalus	RS	
	Isopogon trilobus	OSC	medium to slow
	Isopogon sp Fitzgerald		
	Isopogon sp. Ravesnthorpe		
	Jacksonia spinosa	OSS	
	Jacksonia viscosa		
	Macrozamia dyeri	RS	
	Melaleuca acuimnata	OSC	medium
	Melaleuca calycina	RS	
	Melaleuca cucullata	OSC	
	Melaleuca elliptica	OSC	medium
	Melaleuca fulgens	RS?	
	Melaleuca glaberrima	OSC	
	Melaleuca globiferra	RS/OSC	
	Melaleuca incana ssp. tenella	OSC	
	Melaleuca pauperiflora	OSC	
	Melaleuca pentagona	RS/OSC	
	Melaleuca pulchella	RS	

ESPERANCE SANDPLAIN EAST			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca subfalcata		
	Melaleuca scabra	RS/OSC	
	Melaleuca societatis	OSC	
	Melaleuca striata	RS	
	Melaleuca suberosa	RS	
	Melaleuca thapsina	OSC	
	Melaleuca thymoides	RS	
	Melaleuca tuberculata		
	Petrophile fastigiata	OSC?	
	Petrophile phyllicoides	OSC	slow
	Petrophile squamata	OSC	slow
	Petrophile teretifolia	OSC	medium to slow
	Phymatocarpus maxwellii	OSC	
	Santalum acuminatum	OSS	slow
	Stirlingia anaethifolia	OSS	rapid
	Taxandria callistachys	RS	
	Taxandria conspicua ssp. abrupta	RS?	
	Taxandria spathulata	RS/OSC	
	Xanthorrhoea playtphylla	RS	
	Sedges		
	Gahnia sp. L	RS?	
Woodland			
Swamp Yate woodlands, RiverineYate woodland	**Trees**		
	Eucalyptus occidentalis	RS ep / OSC	
	Melaleuca cuticularis	RS ep	
	Shrubs		
	Melaleuca incana ssp tenella	OSC	
	Melaleuca thapsina	OSC	

NUYTSLAND ECODISTRICT

NUYTSLAND			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Banksia shrublands			
Banksia shrublands	**Mallee**		
	Eucalyptus surgens	**RS**	
	Eucalyptus spp		
	Shrubs		
	Acacia carnosula		
	Acacia glaucoptera	OSS	
	Acacia gonophylla	OSS	
	Acacia mutabilis ssp angustifolia	OSS	
	Acacia mutabilis ssp. mutabilis	OSS	
	Acacia myrtifolia	OSS	
	Allocasuarina helmsii		
	Allocasuarina preissii		
	Allocasuarina scleroclada	RS	
	Acacia oswaldii		
	Adeanthos cuneatus	RS	
	Adenanthos dobsonii		
	Adenanthos eyri	OSS	
	Adenanthos forrestii	RS	
	Agonis baxteri	RS	
	Banksia epica	OSC	
	Banksia media	OSC	medium to slow
	Banksia nutans	OSC	slow
	Banksia obtusa	OSC	
	Banksia obovata	OSC	medium to slow
	Banksia pulchella	OSC	slow
	Banksia petiolaris	OSC	medium
	Banksia speciosa	OSC	medium to slow
	Beaufortia empetrifolia	OSC	medium
	Beaufortia micrantha	OSC	medium to slow
	Beaufortia schaueri	OSC	
	Bossiaea walkeri		
	Callitris preissii	OSC	slow
	Callitris roei	OSC	slow
	Calothamnus gracilis	RS	
	Conospermum leianthumssp leianthum		
	Conospermum leianthum ssp orientale		
	Conospermum teretifolium	RS	

NUYTSLAND			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Conothamnus aureus	RS	
	Chamelaucium axillare	?OSS	
	Daviesia spp		
	Dodanaea spp		
	Gastrolobium muscaeum		
	Gastrolobium parviflorum	OSS	medium
	Grevillea baxteri		
	Grevillea concinna	?OSS	
	Grevillea oligantha	OSS/RS	
	Grevillea pauciflora	OSS	
	Grevillea plurijuga	OSS	
	Grevillea tripartita ssp. macrostylis	OSS	
	Hakea adnata	OSC?	
	Hakea cinerea	OSC	
	Hakea corymbosa	OSC	slow
	Hakea nitida	RS	
	Hakea obliqua	OSC	medium
	Hakea pandanicarpa ssp. crassifolia	OSC	slow
	Hakea varia	RS	
	Isopogon polycephalus	RS	
	Isopogon trilobus	OSC	medium to slow
	Jacksonia capitata		
	Jacksonia condensata		
	Jacksonia venosa		
	Labichea lanceolata ssp. brevifolia		
	Lasiopetalum parvuliflorum		
	Leucopogon spp		
	Leucopogon breviflorus		
	Leucopogon conostephoides	OSS	medium
	Leucopogon Kau Rock		
	Leucopogon woodsii		
	Lysinema ciliatum	OSS	medium
	Melaleuca apodocephala		
	Melaleuca brevifolia		
	Melaleuca cucullata	OSC?	
	Melaleuca glaberrima	OSC	
	Melaleuca lecanantha		
	Melaleuca pentagona ssp. latifolia		
	Melaleuca pulchella	RS	
	Melaleuca scabra	RS	
	Melaleuca striata	RS	
	Melaleuca strobophylla		

NUYTSLAND			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Melaleuca undulata	OSC	
	Melaleuca viminea	OSC	medium
	Petrophile teretifolia	RS/OSC	
	Phymatocarpus maxwellii	OSC	
	Senna artesmoides		
	Stirlingia anethifolia	OSC	rapid
	Styphelia hainsii		
	Styphelia pulchella		
	Taxandria spathulata	RS/OSC	
	Verticordia spp		

MALLEE LAKES ECODISTRICT

MALLEE LAKES			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Mallet			
Ridley System Mallet	**Trees**		
	E. forrestiana	OSC	
	E. dolichoryncha	OSC	
	E. dundasii	OSC	
	Eucalyptus goniocarpa	OSC	
	E. kumarlensis	OSC	
	E salmonophloia	OSC	
	E. spreta	OSC	
	E. urna	OSC	
	E. valens	OSC	
	Shrubs - data deficient		
Woodland			
Salmon gum in Clay depressions	**Trees**		
	E. salmonophloia	OSC	
	E. occidentalis	RSep/OSC	
	Eucalytpus oleosa	RSep	
	Shrubs - data deficient		
Mallee Shrublands			
Mallee Lake Shrubland	**Trees**		
	Eucalyptus cooperiana	RS	
	Eucalyptus leptocalyx	RS	
	Eucalyptus occidentalis	RS/OSC	
	Eucalyptus uncinata	RS	
	Shrubs		
	Adenanthos ileticos		
	Allocasuarina huegeliana	OSC	
	Allocasuarina scleroclada	RS	
	Allocasuarina spinosissima	?	
	Banksia media	OSC	slow
	Banksia pilostylis	OSC	medium to slow
	Banksia tenuis	OSC	
	Beaufortia schaueri	OSC	
	Callitris canescens	OSC	
	Callitris preissii	OSC	slow
	Callitris roei	OSC	slow
	Calothamnus quadrifidus	RS	
	Choretrum glomeratum		

MALLEE LAKES			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Cratystylis conocephala	OSS?	
	Exocarpus sparteus	OSS	
	Hakea cinerea		
	Hakea laurina	OSC	medium
	Hakea lissocarpha	RS	
	Hakea multilineata	OSC	medium to slow
	Hakea nitida	RS	
	Hakea francisiana	?OSC	slow
	Grevillea acuaria	OSS	
	Grevillea pauciflora	OSS	
	Grevilliea plurijuga	RS/OSS	
	Grevillea huegellii	RS/OSS	
	Leptospermum erubescens	RS	
	Melaleuca acuminata	RS	
	Melaleuca calycina	RS	
	Melaleuca cucullata	OSC	
	Melaleuca hamata	RS	
	Melaleuca eleuterostachya		
	Melaleuca laxiflora		
	Melaleuca pauperiflora ssp. fastigiata	OSC	
	Melleuca pulchella	RS	
	Melaleuca sheathiana	OSC?	
	Melaleuca subalaris		
	Melaleuca undulata	OSC	
	Petrophile squamata	OSC	slow
	Phymatocarpus maxwellii	OSC	
	Santalum acuminatum	OSS	slow
	Santalum murrayanum	OSS?	
	Styphelia hainsii		
	Templetonia retusa	OSS	
	Trymalium myrtillus ssp. myrtillus		
	Thryptomene australis ssp. brachyandra		
	Westringia spp		

ALBANY FRASER ISLANDS ECODISTRICT

ALBANY FRASER ISLAND			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
Woodland/ Mallet /Granite shrubland			
	Tree		
	Eucalyptus conferruminata	OSC	slow
	Eucalyptus utilis	OSC	slow
	Acacia conniana	OSS	
	Allocasuarina trichodon	OSC	
	Callitris preissii	OSC	slow
	Callitris drummondii	OSC	
	Paraserianthes lophantha	OSS	rapid
	Mallee		
	Eucalyptus angulosa	RS	
	Eucalyptus cuspidata	RS	
	Eucalyptus cornuta	RS ep	
	Shrubs		
	Acacia cyclops	OSS	rapid
	Acacia heteroclita spp heteroclita	OSS	
	Acacia myrtifolia	OSS	rapid
	Acacia rostellifera	OSS	rapid to medium
	Alogyne hakeifolia	OSS	rapid
	Alyxia buxifolia		
	Anthocercis genistoides	OSS	rapid
	Anthocercis littorea		
	Anthocercis viscosa ssp. caudata		
	Astartea fascicularis	RS	
	Bossiaea dentata	OSS	
	Calytrix tetragona		
	Calothamnus quadrifidus	RS/OSC	
	Chorilaena quercifolia	OSS	rapid
	Dillwynia pungens	OSS	
	Dodanaea ceratocarpa	RS	
	Dodanaea viscosa	OSS	
	Eucalyptus cornuta	RS ep	
	Eucalyptus aff cornuta	RS	
	Eutaxia myrtifolia	OSS	rapid
	Gastrolobium bilobum	OSS	rapid
	Hakea clavata	OSC	
	Hakea drupacea	OSC	slow
	Hibbertia racemosa	OSS	rapid

ALBANY FRASER ISLAND			
Proposed Priority fire sensitive systems	**Component Species (Key sensitive species in bold)**	**Fire response**	**Post-fire recovery and flowering**
	Kunzea baxteri	OSS	
	Leucopogon apiculatus		
	Leucopogon interruptus	OSS	
	Leucopogon parviflorus	RS	
	Leucopogon obovatus	OSS	
	Leucopogon rotundifolius		
	Melaleuca elliptica	RS/OSC	medium
	Melaleuca globifera	RS/OSC	slow
	Melaleuca lanceolata	OSC	slow
	Melaleuca pentagona	OSC	
	Melaleuca viminea ssp. demissa	?OSC	
	Myoporum insulare		
	Myoporum tetrandum	OSC	
	Phyllanthus calycinus	OSS	
	Phyllantus scaber	OSS	
	Pimelea clavata	OSS	
	Pimelea argentea	OSS	
	Pomaderris myrtilloides		
	Pultenaeae heteroclita	OSS	
	Rhadinothamnus rudis	OSS	
	Rulingia coryfolia		rapid
	Spyridium globulosum	OSS	rapid
	Taxandria marginata	RS/OSC	
	Templetonia retusa	OSS	medium
	Trymalium odaritissimum	OSS	rapid
	Thryptomene saxicola	OSC	

APPENDIX VI. RESPONSE TO FIRE AND PRIMARY JUVENILE PERIOD WHERE KNOWN OF THREATENED AND PRIORITY FLORA SPECIES WITHIN THE SCNRM REGION.

Plants are classified as obligate seeders with a canopy (OSC) or soil-stored seed bank (OSS), basal resprouters (RS), epicormic resprouters (RS ep), facultative resprouter / seeders (RS / OSC or OSS) or geophytes (GEO).
First flowering is defined as time to first flowering of 50% of a population where this data is available**.**
Unpublished data sources were Sarah Barrett, Juliette Wedge, Andrew Brown, Emma Adams, Nathan McQuoid, G. Craig, Roger Hearn, Jannine Liddelow, Ted Middleton (personal observations).
Published sources were Collins *et al* (2008), George and Pieroni (2002), Kavanagh and Pieroni (2006).

Species	**Conservation Code**	**Fire response**	**Primary Juvenile Period[6] (months)**
Acacia aemula ssp. aemula	P4	OSS	
Acacia amyctica	P2		
Acacia ancistrophylla var.. perarcuata	P3		
Acacia arcuatilis	P2		
Acacia argutifolia	P4	OSS	>36
Acacia asepala	P2		
Acacia ataxiphylla ssp. ataxiphylla	P3		
Acacia awestoniana	**R**	OSS	48
Acacia bifaria	P3		
Acacia brachyphylla var.. recurvata	P3		
Acacia declinata	P3		
Acacia depressa	R		
Acacia diaphana	P1		
Acacia dictyoneura	P4	OSS	
Acacia diminuta	P1		
Acacia dissona var.. indoloria	P3		
Acacia disticha	P3	OSS?	
Acacia drummondii ssp. elegans Porongurup variant (R.J. Cumming 938)	P4	OSS	
Acacia durabilis	P3	OSS	≥36
Acacia empelioclada	P4		
Acacia errabunda	P3	?OSS	
Acacia euthyphylla	P3		
Acacia glaucissima	P3		
Acacia grisea	P4		
Acacia heterochroa ssp. robertii	P2		

[6] **based on 50% flowering (months)**

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Acacia heteroclita ssp. valida	P2	OSS	
Acacia hystrix ssp. continua	P1		
Acacia imparilis	P2	OSS	36±
Acacia improcera	P3		
Acacia incanicarpa	P2	RS	
Acacia laricina var.. crassifolia	P3	OSS	
Acacia leioderma Fitzgerald River N.P. variant (A.S. George 9922)	P2	OSS?	
Acacia microneura	P1		
Acacia moirii ssp. dasycarpa	P4	OSS?	
Acacia mutabilis ssp. incurva	P2	OSS	
Acacia mutabilis ssp. rhynchophylla	P3		
Acacia newbeyi	P3		
Acacia nitidula	P2		
Acacia papulosa	P2		
Acacia phlebopetala var.. pubescens	P2		
Acacia pinguiculosa ssp. pinguiculosa	P4	OSS?	
Acacia prismifolia	X		
Acacia rhamphophylla	**R**	OSS	
Acacia simulans	P4	OSS	≤48
Acacia singula	P3		
Acacia sp. Esperance (M.A. Burgman 1833b)	P1		
Acacia sp. Petrudor Rocks (B.R. Maslin 7714)	P1		
Acacia sp. Ravensthorpe Range (B.R. Maslin 5463)	P1		
Acacia subtiliformis	P3		
Acacia truculenta	P3		
Acacia trulliformis	**R**	OSS	
Acacia undosa	P3		
Acacia veronica	P3	OSS	
Acrotriche dura	P2		
Acrotriche parviflora	P4		
Actinotus rhomboideus	P4	OSS	≤24
Actinotus sp Walpole	P3	OSS	
Adenanthos cacomorphus	P2	RS	
Adenanthos dobagii	**R**	OSS	48
Adenanthos ellipticus	**R**	OSS	48
Adenanthos filifolius	P3	OSS	48 to 60
Adenanthos gracilipes	P3		
Adenanthos ileticos	P4		
Adenanthos labillardierei	P4	OSS	
Adenanthos linearis	P2	OSS?	48±
Adenanthos pungens ssp. effusus	**R**		
Adenanthos pungens ssp. pungens	**R**	OSS	
Adenanthos velutinus	**R**		
Adenanthos x cunninghamii	P4	OSS	
Agonis undulata	P3		
Agrostocrinum scabrum ssp. littorale	P2		
Alexgeorgea ganopoda	P3	RS/OSS	24

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Allocasuarina hystricosa	P3	RS	
Amanita carneiphylla	P2		
Amperea protensa	P3	RS	
Andersonia amabile	P3	OSS	24
Andersonia auriculata	P3	OSS	36
Andersonia axilliflora	**R**	OSS	14
Andersonia carinata	P3	OSS	
Andersonia depressa	P3	OSS	
Andersonia echinocephala	P3	OSS	>48
Andersonia grandiflora	P3	OSS	
Andersonia hammersleyana	P2	OSS	36 to 48
Andersonia jamesii	P1	OSS	24 (SB) 36 (JL)
Andersonia pinaster	**R**	OSS	36
Andersonia redolens	P1	OSS	36 to 48
Andersonia setifolia	P3	OSS	
Andersonia lazulina	P3	OSS	24
Andersonia virolens	P2	OSS	24 to 36
Angasomyrtus salina	P2		
Anigozanthos bicolor ssp. minor	**R**	OSS	12 to 24
Anthocercis fasciculata	P4	OSS	≤24
Anthocercis sylvicola	P2	RS	
Aotus franklandii	P2	?	
Aotus lanea	P1		
Aotus prosacris	P1		
Apium prostratum ssp. phillipii	**R**	OSS	12
Apodasmia ceramophila	P2	RS	
Asplenium aethiopicum	P4	FERN	
Asplenium obtusatum ssp. northlandicum	**R**	FERN	
Astartea arbuscula	P4	OSS	36 to 48
Astartea sp. Esperance (A. Fairall 2431)	P1		
Astartea sp. Fitzgerald (K.R. Newbey 10844)	P2		
Astartea sp. Hopetoun area (A.S. George 10594)	P3	OSS	
Astartea sp. Jerdacuttup (A. Strid 21898)	P1		
Astartea sp. Jyndabinbin Rocks (K.R. Newbey 7689)	P2		
Astartea sp. Mt Johnston (A.R. Annels 5645)	P3	OSS	36 to 48
Astartea sp.Fitzgerald(K.R.Newbey 10844)	P2		
Asteridea archeri	P2	OSS	
Asteridea gracilis	P3		
Asterolasia sp. Kalgan River (S. Barrett 1522)	P1	OSS	
Astroloma microphyllum	P3		
Astroloma recurvum	P3		
Astroloma sp. Grass Patch (A.J.G. Wilson 110)	P2		
Astroloma sp.Nannup(R.D.Royce 3978)	P4		
Astus duomilius	P1		
Astus wittweri	P2		
Atriplex muelleri	P1		
Austrofestuca littoralis	P1	RS?	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Baeckea crispiflora ssp. Ongerup (A. Scougall & C. Garawanta E35)	P1		
Baeckea sp. Exclamation Lake (M.E. Trudgen 1524)	P1		
Baeckea sp. Gibson (K.R. Newbey 11084)	P1		
Baeckea sp. Hatter Hill (K.R. Newbey 3284)	P3		
Baeckea sp. Merredin (K.R. Newbey 2506)	P3		
Baeckea sp. Mt Gibbs (G.F. Craig 7031)	P2		
Baeckea sp. Mt Glasse (P.G. Wilson 5717)	P2		
Baeckea sp. Youndegin Hill (A.S. George 15772)	P1		
Banksia aculeata	P2	OSC	96±
Banksia acuminata	P4	RS	
Banksia anatona	**R**	OSC	72
Banksia brownii Stirling Range	**R**	OSC	>120
Banksia brownii Coastal	**R**	OSC	72
Banksia calophylla	P3	RS	
Banksia concinna	P4	OSC	≥84
Banksia corvijuga	P1	OSC	>36
Banksia densa var.. parva	P2	OSC	48 to 60
Banksia foliolata	P4	OSC	60±
Banksia foliosissima	P2	OSC	>36
Banksia goodii	**R**	RS	
Banksia hirta	P3	OSC	
Banksia ionthocarpa ssp. ionthocarpa	**R**	OSC	>60
Banksia laevigata ssp. laevigata	P4	OSC	
Banksia lepidorhiza	P1	RS	
Banksia lullfitzii	P3	RS	
Banksia meganotia	P3	RS	
Banksia montana	**R**	OSC	>120
Banksia mucronulata ssp. retrorsa	**R**	OSC	
Banksia plumosa ssp. denticulata	P2	OSC	≥48
Banksia porrecta	P4	RS/OSC	36
Banksia prolata ssp. archeos	P2	OSC	
Banksia prolata ssp. calcicola	P1	OSC	
Banksia prolata ssp. prolata	P3	OSC	
Banksia pseudoplumosa	**R**	OSC	60 to 72
Banksia rufa ssp. chelomacarpa	P3	RS	
Banksia rufa ssp. flavescens	P3	RS	
Banksia rufa ssp. pumila	P2	OSC	60±
Banksia seneciifolia	P3	OSC	>36
Banksia serra	P4	OSC	36
Banksia sessilis var. cordata	P4	OSC	
Banksia solandri	P4	OSC	>84
Banksia sphaerocarpa var. dolichostyla	**R**	RS	
Banksia sphaerocarpa var.. latifolia	P2	RS	
Banksia subpinnatifida var.. imberbis	P2	OSC	
Banksia verticillata	R	OSC	>120
Banksia viscida	P3	OSC	
Banksia xylothemelia	P3	RS	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Bentleya diminuta	P2	RS?	
Bentleya spinescens	P4		
Beyeria villosa	P4	OSS	
Beyeria cockertonii	**R**	OSS	
Billardiera drummondii	P4	OSS	
Boronia acanthoclada	P2		
Boronia anceps	P3		
Boronia baeckeacea ssp. patula	P1		
Boronia clavata	**R**	OSS	
Boronia coriacea	P2		
Boronia corynophylla	P2		
Boronia crassipes	P3	OSS?	
Boronia crenulata var.. angustifolia	P4		
Boronia oxyantha var.. brevicalyx	P3	OSS	
Boronia penicillata	P3		
Boronia revoluta	**R**	OSS?	
Boronia scabra ssp. attenuata	P3		
Boronia virgata	P3	OSS	24
Borya longiscapa	P2	RS	
Bossiaea atrata	P3		
Bossiaea concinna	P3		
Bossiaea disticha	P3		
Bossiaea divaricata	P4		
Bossiaea flexuosa	P3		
Bossiaea oxyclada	P2		
Bossiaea simulata	P1		
Bossiaea sp. Frankland (E.M. Sandiford EMS 896)	P1		
Bossiaea spinosa	P3		
Brachyloma mogin	P3		
Brachyloma nguba	P1		
Caesia viscida	P2	GEO	
Caladenia abbreviata	P2	GEO	
Caladenia arrecta	P4	GEO	
Caladenia bryceana ssp. bryceana	**R**	GEO	
Caladenia christineae	**R**	GEO	
Caladenia cristata	P4	GEO	
Caladenia dorrienii	**R**	GEO	
Caladenia erythrochila	P2	GEO	
Caladenia evanescens	P1	GEO	
Caladenia exstans	P4	GEO	
Caladenia harringtoniae	**R**	GEO	
Caladenia integra	P4	GEO	
Caladenia interjacens	P4	GEO	
Caladenia longifimbriata	P1	GEO	
Caladenia luteola	P2	GEO	
Caladenia plicata	P4	GEO	
Caladenia startiorum	P2	GEO	
Caladenia voigtii	P4	GEO	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Caladenia x triangularis	P4	GEO	
Calectasia cyanea	**R**	OSS	84
Calectasia keigheryi	P2	RS	
Calectasia obtusa	P3	RS	
Calochilus sp. Hopetoun (H. Taylor s.n.)	P2	GEO	
Calothamnus affinis	P4	OSC	48
Calothamnus crassus	P4	RS/OSC	
Calothamnus macrocarpus	P2	RS	
Calothamnus microcarpus	P2	OSC	36±
Calothamnus robustus	P3	?OSC	
Calothamnus sp. Mt Lindesay (B.G. Hammersley 439)	P2	RS/OSC	60 to 72
Calycopeplus marginatus	P3	?OSS	
Calytrix nematoclada	P3		
Calytrix pulchella	P3		
Carex tereticaulis	P1		
Carpobrotus pulcher	P2		
Caustis sp. Boyanup (G.S. McCutcheon 1706)	P1	RS	
Centrolepis caespitosa	P4	OSS	
Centrolepis cephaloformis ssp. murrayi	P3	OSS	
Chamaescilla gibsonii	P3	GEO	
Chamaexeros longicaulis	P2	RS	24
Chamelaucium aorocladus	P2	OSS?	36±
Chamelaucium floriferum ssp. diffusum	P2	OSS	
Chamaluacium floriferum floriferum	P3	OSS	36 to 48
Chamelaucium forrestii ssp. forrestii	P2	OSS	
Chamelaucium forrestii ssp. orarium	P2		
Chamelaucium juniperinum	P2	OSS	
Chordifex abortivus	**R**	OSS	
Chordifex gracilior	P3	OSS	
Chordifex isomorphus	P4	RS	
Chordifex jacksonii	P2	OSS	24
Chordifex leucoblepharus	P2	RS	
Chordifex ornatus	P2	OSS	
Chorizema carinatum	P3		
Chorizema circinale	P1	OSS	
Chorizema reticulatum	P3	OSS	24
Chorizema ulotropis	P4		
Chthonocephalus multiceps	P2		
Coleanthera coelophylla	P1		
Comesperma calcicola	P3		
Comesperma lanceolatum	P2		
Commersonia sp. Mt Groper (R. Cranfield & D. Kabay 9157)	**R**	OSS	
Conospermum coerulescens ssp. coerulescens	P1		
Conospermum quadripetalum	P2	OSS?	
Conospermum sigmoideum	P2		
Conospermum spectabile	P2	OSS	>36
Conostephium marchantiorum	P3		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Conostephium uncinatum	P1		
Conostylis lepidospermoides	**R**		
Conostylis misera	**R**	RS	
Conostylis seorsiflora ssp. Nyabing(A.Coates s.n.)	P2		
Coopernookia georgei	**R**	OSS	
Corybas limpidus	P4	GEO	
Cryptandra arbutiflora var.. pygmaea	P1		
Cryptandra congesta	**R**	RS/OSS	17
Cryptandra craigiae	P1	?OSS	36±
Cryptandra exserta	P1		
Cryptandra inconspicua	P2		
Cryptandra polyclada ssp. polyclada	P3		
Cyathochaeta stipoides	P3		
Cyathochaeta teretifolia	P3		
Cyathostemon sp. Dowak (J.M. Fox 86/271)	P1		
Cyathostemon sp. Lake King (M.E. & M.E. Trudgen 1462)	P2		
Cyathostemon sp. Salmon Gums (B. Archer 769)	P3		
Cymbonotus preissianus	P3		
Dampiera decurrens	P2		
Dampiera deltoidea	P4	OSS	< 48
Dampiera fitzgeraldensis	P2		
Dampiera orchardii	P2		
Dampiera sericantha	P3	OSS	
Darwinia calothamnoides	R		
Darwinia carnea	**R**		
Darwinia collina	**R**	OSS	72 to 84
Darwinia hypericifolia	P4	OSS	48+
Darwinia leiostyla	P4	OSS	36
Darwinia luehmannii	P2		
Darwinia macrostegia	P4	OSS	≥36
Darwinia meeboldii	**R**	OSS	48 ±
Darwinia oxylepis	**R**	OSS	48 to 60
Darwinia polycephala	P4		
Darwinia sp. Gibson (R.D. Royce 3569)	P1		
Darwinia sp. Mt Baring (K.R. Newbey 9775)	P1		
Darwinia sp. Mt Burdett (N.G. Marchant 80/42)	P4		
Darwinia sp. Mt Ney (M.A. Burgman & S. McNee 1274)	P1		
Darwinia sp. Mt Ragged (S. Barrett 663)	P2	OSS	36 to 48
Darwinia sp. Peak Charles (A.S. George 10627)	P2		
Darwinia sp. Stirling Range (G.J. Keighery 5732)	**R**	OSS	60 to 72
Darwinia sp.Thumb Peak(K.R.Newbey 4847)	P2	OSS?	
Darwinia squarrosa	**R**	OSS	48 to 60
Darwinia wittwerorum	**R**	OSS	60
Daviesia campephylla	P2		
Daviesia glossosema	**R**	OSS	48
Daviesia megacalyx	**R**	OSS	48
Daviesia mesophylla	P2	OSS	≥24
Daviesia newbeyi	P2		

Species	**Conservation Code**	**Fire response**	**Primary Juvenile Period[6] (months)**
Daviesia obovata	**R**	RS/ OSS	
Daviesia ovata	**R**	RS/ OSS	
Daviesia pauciflora	P2		
Daviesia pseudaphylla	**R**	OSS	36
Degelia flabellata	P2	Lichen	
Desmocladus biformis	P3		
Deyeuxia drummondii	**R**	OSS	12 to 24
Deyeuxia inaequalis	P1		
Dicrastylis archeri	P1		
Dicrastylis capitellata	P1		
Dicrastylis corymbosa	P3		
Dicrastylis obovata	P2		
Dillwynia acerosa	P1		
Diuris drummondii	**R**	GEO	
Diuris heberlei	P2	GEO	
Dodonaea hexandra	P1		
Drakaea micrantha	**R**	GEO	
Drepanocladus aduncus	P2	Moss	
Drosera binata	P2	OSS?	12 to 24
Drosera fimbriata	P4	OSS	12
Drosera gibsonii	P2	GEO?	
Drosera salina	P2	GEO?	
Drummondita longifolia	**R**	OSS	36 ±
Eremophila biserrata	P4	OSS	
Eremophila chamaephila	P2	OSS	
Eremophila ciliata	R	OSS	
Eremophila compressa	P3	OSS	
Eremophila denticulata ssp. denticulata	**R**	OSS	
Eremophila denticulata ssp. trisulcata	**R**	OSS	24 to 36
Eremophila glabra ssp. Scaddan (C. Turley s.n. 10/11/2005)	P1	RS/OSS	
Eremophila lactea	**R**	OSS	24 to 36
Eremophila oblonga	P1	RS/OSS	
Eremophila racemosa	P4	OSS	
Eremophila serpens	P4	OSS	
Eremophila subteretifolia	**R**	OSS	
Eremophila succinea	P3	OSS	
Eremophila veneta	P4	RS/OSS	
Eriochilus scaber ssp orbifolia	P1	GEO	12
Eryngium ferox	P3		
Eucalyptus acies	P4	RS	
Eucalyptus aquilina	P4	RS	
Eucalyptus arborella	P3	OSC	
Eucalyptus balanopelex	P1	RS	
Eucalyptus brandiana ms	P?	OSC	
Eucalyptus brevistylis	P4	RS/OSC	
Eucalyptus brockwayi	P3	OSC	
Eucalyptus buprestium x erectifolia	P4	RS	
Eucalyptus buprestium x ligulata	P4	RS	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Eucalyptus buprestium x marginata	P4	RS	
Eucalyptus buprestium x staeri	P4	RS	
Eucalyptus burdettiana	**R**	RS	
Eucalyptus calcicola ssp. calcicola	P4	RS	
Eucalyptus calcicola ssp. unita	P4	RS	
Eucalyptus calyerup	P1	OSC	
Eucalyptus coronata	**R**	RS	
Eucalyptus creta	P3	OSC	
Eucalyptus deflexa	P4	RS	
Eucalyptus desmondensis	P4	RS	
Eucalyptus dielsii x platypus	P1	OSC	
Eucalyptus dolichorhyncha	P4	OSC	
Eucalyptus erectifolia	P4	RS	
Eucalyptus famelica	P3	RS	
Eucalyptus foliosa	P3		
Eucalyptus fraseri ssp. melanobasis	P2	OSC	
Eucalyptus georgei ssp. fulgida	P4	OSC	
Eucalyptus georgei ssp. georgei	P4	OSC	
Eucalyptus goniantha ssp. goniantha	P4	RS	
Eucalyptus histophylla	P3	RS	
Eucalyptus insularis	**R**	RS	
Eucalyptus latens	P4	RS	
Eucalyptus ligulata ssp. ligulata	P4	RS	
Eucalyptus ligulata ssp. stirlingica	P4	RS	
Eucalyptus litorea	P2	RS	
Eucalyptus marginata x pachyloma	P4	RS	
Eucalyptus mcquoidii	P2	OSC	
Eucalyptus melanophitra	P4	OSC	
Eucalyptus merrickiae	**R**	RS	
Eucalyptus microschema	P3	RS	
Eucalyptus misella	P1		
Eucalyptus newbeyi	P3	OSC	
Eucalyptus nutans	**R**	OSC	
Eucalyptus praetermissa	P4	OSC	
Eucalyptus preissiana ssp. lobata	P4	RS	
Eucalyptus preissiana x staeri	P4	RS	
Eucalyptus proxima	P4	RS	
Eucalyptus purpurata	**R**	OSC	
Eucalyptus quaerenda	P3	RS	
Eucalyptus retusa	P?	RS	
Eucalyptus rhomboidea	P4	OSC	
Eucalyptus rugulata	P4	OSC	
Eucalyptus semiglobosa	P3	RS	
Eucalyptus sinuosa	P2	RS	
Eucalyptus sp. Esperance (M.E. French 1579)	P1		
Eucalyptus sp. Fitzgerald River (M.I.H. Brooker 10923)	P2		
Eucalyptus steedmanii	**R**	OSC	
Eucalyptus stoatei	P4	OSC	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Eucalyptus sweedmaniana ms	P1	RS	
Eucalyptus varia ssp. salsuginosa	P4	RS	
Eucalyptus vesiculosa	P2	OSC	
Eucalyptus virginea	P4	RS/OSC	
Eucalyptus x bennettiae	P4	RS	
Eucalyptus x chrysantha	P2	RS	
Eucalyptus x erythrandra	P4	RS	
Eucalyptus x kalganensis	P4	RS	
Eucalyptus x missilis	P4	RS	
Eucalyptus x stoataptera	P2	RS/OSC	
Euphrasia scabra	P2	OSS	?
Euryomyrtus leptospermoides	P3		
Eutaxia acanthoclada	P3		
Eutaxia actinophylla	P1		
Eutaxia andocada	P1		
Eutaxia nanophylla	P3		
Fabronia hampeana	P2		
Frankenia brachyphylla	P2		
Frankenia drummondii	P3		
Gahnia sclerioides	P3	RS	
Galium migrans	P3	OSS	
Gastrolobium acrocaroli	P2	?OSS	
Gastrolobium crenulatum	P2	OSS	
Gastrolobium cruciatum	P3		
Gastrolobium elegans	P2	OSS	
Gastrolobium ferrugineum	P2	OSS	
Gastrolobium formosum	P3		
Gastrolobium humile	P1		
Gastrolobium involutum	P1		
Gastrolobium leakeanum	P2	OSS	48±
Gastrolobium lehmannii	**R**		
Gastrolobium luteifolium	**R**	OSS	72
Gastrolobium mondurup	P2	OSS	48-60
Gastrolobium ovalifolium	P4		
Gastrolobium pycnostachyum	P2		
Gastrolobium sp. crenulatum capitate (E. & S. Pignatti 1588)	P2	OSS	48-60
Gastrolobium sp. East Peak (E.D. Middleton EDM 43)	P2	OSS	36
Gastrolobium stenophyllum	P3	OSS	
Gastrolobium aff bilobum Corackerup		OSS	
Gastrolobium subcordatum	P4		
Gastrolobium tergiversum	P2		
Gastrolobium vestitum	P2	OSS	48-60
Gnephosis intonsa	P1		
Gonocarpus benthamii ssp. Stirling (C.J. Robinson 1080)	P2	OSS	36
Gonocarpus hispidus	P2	OSS	≤36
Gonocarpus pusillus	P3	RS/OSS	12 to 24
Gonocarpus pycnostachyus	P3	OSS	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Gonocarpus rudis	P2	OSS	<u><</u>48
Gonocarpus simplex	P3	RS?	12
Gonocarpus trichostachyus	P3	OSS	12
Goodenia filiformis	P3	OSS?	
Goodenia laevis ssp. laevis	P3		
Goodenia phillipsiae	P4	OSS	
Goodenia quadrilocularis	P2		
Goodenia scapigera ssp. graniticola	P2		
Goodenia sp. South Coast (A.R. Annels ARA1846)	P3	OSS?	24 to 36
Goodenia stenophylla	P4	OSS	≤36
Goodenia trichophylla	P3		
Goodenia turleyae	P1		
Grammosolen sp. Mt Ridley (W.R. Archer 1210911)	P1		
Gratiola pedunculata	P2		
Grevillea acropogon	**R**		
Grevillea aneura	P4		
Grevillea baxteri	P4		
Grevillea coccinea ssp. lanata	P3		
Grevillea fastigiata	P3	OSS	
Grevillea fistulosa	P4	OSS	
Grevillea fulgens	P3	OSS	
Grevillea fuscolutea	**R**	OSS	72 to 84
Grevillea infundibularis	**R**	OSS	48
Grevillea insignis ssp. elliotii	P3		
Grevillea maxwellii	**R**	OSS	60 to 72
Grevillea newbeyi	P3		
Grevillea prostrata	P4		
Grevillea ripicola	P4		
Grevillea sp. Stirling Range (D.J. McGillivray 3488 & A.S. George)	P2	0SS	
Grevillea sulcata	P1		
Guichenotia anota	P1	0SS	36±
Guichenotia apetala	P1	0SS	36±
Guichenotia asteriskos	P2		
Gyrostemon ditrigynus	P4		
Gyrostemon prostratus	P3	OSS	<19
Gyrostemon sessilis	P3	OSS	12
Gyrostemon sp. Ravensthorpe (G. Cockerton & N. Evelegh 9467)	P1	OSS	
Gyrostemon thesioides	P2	OSS	
Haegiela tatei	P2	OSS	
Hakea acuminata	P2	OSC	
Hakea brachyptera	P3		
Hakea hookeriana	P4	OSC	
Hakea lasiocarpha	P3	OSC	
Hakea oldfieldii	P3		
Hakea tuberculata	P3	OSC	
Halgania sp. Peak Eleanora (M.A. Burgman 3547 B)	P2		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Hemiandra australis	P2	OSS	
Hemigenia microphylla	P3		
Hemigenia platyphylla	P4		
Hemigenia rigida	P1		
Hibbertia acrotrichion	P2		
Hibbertia argentea	P3	OSS	
Hibbertia carinata	P1		
Hibbertia charlesii	P2		
Hibbertia fitzgeraldensis	P3	OSS	
Hibbertia hamata	P3		
Hibbertia helianthemoides	P3	OSS	≤36
Hibbertia pachyphylla	P3		
Hibbertia papillata	P2		
Hibbertia porongurupensis	P4	OSS	
Hibbertia priceana	**R**	OSS	24 to 36
Hibbertia sp. Bandalup Hill (G.F. Craig 3479)	P1		
Hibbertia turleyana	P1		
Hopkinsia adscendens	P3	RS	
Hybanthus volubilis	P2		
Hydrocotyle coraginaensis	P2		
Hydrocotyle decipiens	P2	OSS	
Hydrocotyle muriculata	P1	OSS	
Hydrocotyle sp. Truslove (M.A. Burgman 4419)	P1	OSS	
Hydrocotyle vigintimilia	P1	OSS	
Hypocalymma melaleucoides	P2	OSS	
Hypocalymma cordifolium subsp minus	P4		
Hypocalymma phillipsii	P3	RS	
Hypocalymma sp. Cascade (R. Bruhn 20896)	P2		
Isolepis australiensis	P2	OSS	
Isopogon alcicornis	P3	RS	
Isopogon latifolius	P3	OSC	>84
Isopogon uncinatus	**R**	OSS	36 to 48
Jacksonia calycina	P4	OSS	
Jacksonia compressa	P4	OSS	
Jacksonia intricata	P2	OSS	
Juncus meianthus	P2		
Kennedia beckxiana	P4	OSS	
Kennedia glabrata	**R**	OSS	12
Keraudrenia adenogyna	P2		
Kunzea acicularis	P1	OSS	
Kunzea ericifolia ssp. subulata	P2		
Kunzea micrantha ssp. hirtiflora	P2		
Kunzea pauciflora	P4	OSS	
Kunzea similis ssp. mediterranea	**R**	OSS	
Kunzea similis ssp. similis	**R**	OSS	
Lambertia echinata ssp. echinata	**R**	OSC	
Lambertia fairallii	**R**	OSC	84
Lambertia orbifolia ssp. orbifolia	**R**	OSC	48

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Lambertia rariflora ssp. lutea	P3	OSS	
Lasiopetalum dielsii	P2		
Lasiopetalum fitzgibbonii	P3		
Lasiopetalum maxwellii	P2		
Lasiopetalum membraniflorum	P2	OSS	48 to 60
Lasiopetalum monticola	P3		
Lasiopetalum parvuliflorum	P3	OSS	≤48
Lasiopetalum sp. Denmark (B.G. Hammersley 2012)	P3	OSS	24 to 36
Latrobea colophona	R	OSS	48 to 60
Latrobea pinnacula	P2	OSS	
Latrobea recurva	P3		
Laxmannia grandiflora ssp. brendae	**R**	OSS	>48
Laxmannia grandiflora ssp. stirlingensis	P3	0SS?	24±
Laxmannia jamesii	P4	OSS	≤24
Lechenaultia acutiloba	P3		
Lechenaultia superba	P4	OSS	≤24
Lepidium aschersonii	**R**	OSS	
Lepidium desvauxii	P2	OSS	
Lepidium fasciculatum	P1		
Lepidium pseudotasmanicum	P4		
Lepidobolus spiralis	P2	RS	
Lepidosperma gahnioides	P2		
Leptinella drummondii	P2		
Leptospermum confertum	P2	OSC	
Lepyrodia fortunata	P2	OSS	
Leucopogon acicularis	P2	OSS	
Leucopogon alternifolius	P3	OSS	
Leucopogon altissimus	P3	OSS	
Leucopogon apiculatus	P3	OSS	
Leucopogon blepharolepis	P3		
Leucopogon bossiaea	P2		
Leucopogon bracteolaris	P2		
Leucopogon compactus	P4	0SS	≥24
Leucopogon cymbiformis	P2		
Leucopogon denticulatus	P4	OSS	
Leucopogon florulentus	P3		
Leucopogon gnaphalioides	**R**	OSS	60 to 84
Leucopogon interruptus	P2	OSS	
Leucopogon lasiophyllus	P2	OSS	<60
Leucopogon multiflorus	P2	OSS	
Leucopogon pogonocalyx	P4	OSS	
Leucopogon psilopus	P2	OSS	48 ±
Leucopogon rotundifolius	P3		
Leucopogon sp. Barren Range (A.S. George 10092)	P2	OSS?	
Leucopogon sp. Bonnie Hill (K.R. Newbey 9831)	P1		
Leucopogon sp. Ironcaps (N. Gibson & K. Brown 3070)	P3		
Leucopogon sp. Ongerup (A.S. George 16682)	P1		
Leucopogon sp. Roberts Swamp (K.R. Newbey 8173)	P1		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Leucopogon sp. South Coast (K.R. Newbey 8213)	P1		
Leucopogon tamariscinus	P4	OSS	
Levenhookia octomaculata	P3		
Levenhookia pulcherrima	P2	OSS	
Lissanthe pleurandroides	P3		
Lissanthe synandra	P1		
Lomandra ordii	P3	RS/OSS	
Lysinema lasianthum	P4	OSS	
Marianthus granulatus	P4	OSS	
Marianthus mollis	**R**	OSS	36
Marianthus sylvaticus	P3	RS/OSS	12
Meeboldina crassipes	P3	RS	
Meeboldina thysanantha	P3		
Melaleuca agathosmoides	P1		
Melaleuca araucarioides	P4		
Melaleuca basicephala	P4		36?
Melaleuca dempta	P3	OSC	
Melaleuca diosmifolia	P3		
Melaleuca eximia	P2		
Melaleuca fissurata	P4		
Melaleuca incana ssp. tenella	P3	OSC	
Melaleuca macronychia ssp. trygonoides	P3		
Melaleuca micromera	P3		
Melaleuca ordinifolia	P2		
Melaleuca papillosa	P4		
Melaleuca penicula	P2		
Melaleuca polycephala	P3		
Melaleuca pritzelii	P2		
Melaleuca ringens	P3	RS/OSC	36 to 48
Melaleuca sculponeata	P3		
Melaleuca similis	P1	RS	
Melaleuca sp. Kundip (G.F. Craig 6020)	P1	OSC	
Melaleuca stramentosa	P3	OSC	
Melaleuca viminea ssp. appressa	P2		
Meziella trifida	**R**	OSS	
Microcorys lenticularis	P2	OSS	≤48
Microcorys longiflora	P3	OSS	
Microcorys pimeleoides	P3	OSS?	
Microcorys sp. Boxwood (K.R. Newbey 4200)	P1	OSS	
Microcorys sp. Stirling Range (S. Barrett 1392)	P2	OSS?	
Microcybe pauciflora ssp. grandis	P3		
Micromyrtus elobata ssp. scopula	P3		
Micromyrtus navicularis	P3	OSS	
Microseris scapigera	P3		
Microtis globula	**R**	GEO	
Microtis media ssp. quadrata	P4		
Microtis pulchella	P4	GEO	
Mirbelia densiflora	P1		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Mitreola minima	P3	OSS	
Monotoca aristata	P2	OSS	
Monotoca leucantha	P3	OSS	
Muiriantha hassellii	P4	OSS	24
Myoporum cordifolium	**R**	OSS	36
Myoporum turbinatum	**R**	OSS	24 to 36?
Myoporum velutinum	P1	OSS	
Myriocephalus appendiculatus	P3		
Myriocephalus biflorus	P2		
Myriophyllum balladoniense	P4		
Myriophyllum petraeum	P4		
Olax scalariformis	P3		
Olearia laciniifolia	P2		
Opercularia hirsuta	P2		
Opercularia rubioides	P2		
Orthrosanthus muelleri	R	GEO	
Otion rigidum	P2		
Paracaleana parvula	P2		
Parmeliopsis macrospora	P3		
Patersonia inaequalis	P2		
Pentapogon quadrifidus var.. quadrifidus	P2	OSS	12
Persoonia baeckeoides	P1		
Persoonia brevirhachis	P3		
Persoonia cymbifolia	P3		
Persoonia micranthera	**R**	OSS	
Persoonia scabra	P3		
Petrophile biternata	P3		
Petrophile longifolia	P3		
Philotheca apiculata	P2		
Philotheca cymbiformis	P2		
Philotheca gardneri ssp. globosa	P1		
Philotheca gardneri ssp. Ravensthorpe (G.F. Craig 6902)	P1		
Phlegmatospermum eremaeum	P2		
Pilostyles collina	P4		
Pimelea halophila	P2		
Pimelea longiflora ssp. eyrei	P2		
Pimelea neokyrea	P2		
Pimelea pelinos	P1		
Pimelea physodes	P4	OSS	
Pimelea rosea ssp. annelsii	P3		
Pityrodia chrysocalyx	P3		
Platysace sp. Stirling (J.M. Fox 88/262)	P2	OSS	24
Pleurophascum occidentale	P4	MOSS	
Pomaderris grandis	P4	OSS	24
Prasophyllum paulineae	P1	GEO	
Prostanthera carrickiana	P4	OSS	
Prostanthera splendens	P1		
Prostanthera verticillaris	P1	OSS	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Pterostylis sp. Ongerup (K.R. Newbey 4874)	P4	GEO	
Ptilotus halophilus	P4		
Pultenaea adunca	P3		
Pultenaea brachyphylla	P2		
Pultenaea calycina ssp. calycina	P3		
Pultenaea calycina ssp. proxena	P4	OSS	
Pultenaea daena	P3	OSS	≤24
Pultenaea indira ssp. monstrosita	P3		
Pultenaea indira ssp. pudoides	P2		
Pultenaea pinifolia	P3		
Pultenaea sp. Kundip (G.F. Craig 6008)	P1	OSS?	
Pultenaea wudjariensis	P1		
Reedia spathacea	**R**	RS	
Regelia cymbifolia	P4		
Rhacocarpus rehmannianus var.. webbianus	**R**	Cryptogram	
Rhadinothamnus rudis ssp. linearis	P4	?OSS	36 to 48
Rhizanthella gardneri	**R**	GEO	
Rhodanthe pyrethrum	P3	OSS	12
Ricinocarpos pilifer	P2	OSS	
Ricinocarpos trichophorus	**R**	OSS	
Rinzia affinis	P4		
Rinzia longifolia	P1		
Rorippa cygnorum	P2	OSS?	24
Rorripa dictyosperma	P2	OSS	9
Rulingia apella	P1		
Rumex drummondii	P4		
Rumicastrum chamaecladum	P2	OSS	6
Sarcocornia globosa	P3		
Scaevola archeriana	P1		
Scaevola brookeana	P2	OSS/RS	24 to 36
Scaevola macrophylla	**R**	OSS	
Scaevola paludosa	P2		
Scaevola sp. Waychinicup (E.M. Sandiford EMS 1336)	P2	OSS	24
Scaevola tortuosa	P1		
Schizaea rupestris	P2	Comb-fern	
Schoenus benthamii	P3		
Schoenus natans	P4		
Schoenus sp. Grassy (E. Gude & J. Harvey 250)	P2		
Schoenus sp. Grey Rhizome (K.L. Wilson 2922)	P1		
Schoenus sp. Mt Barker (G.J. Keighery 9679)	P1		
Schoenus sp. Stirling (G.J. Keighery 3427)	P2		
Selliera radicans	P2		
Senecio gilbertii	P1		
Siegfriedia darwinioides	P4	OSS	<48
Sowerbaea multicaulis	P4	GEO	
Sphaerolobium benetectum	P1		
Sphaerolobium pubescens	P3	OSS	24 to 36
Sphaerolobium validum	P3		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Sphagnum novozelandicum	P2	Moss	
Sphenotoma drummondii	**R**	OSS	$\geq$60
Sphenotoma parviflora	P3	OSS	24
Sphenotoma sp. Stirling Range (P.G. Wilson 4235)	P3	OSS	$\geq$48
Spyridium glaucum	P4	OSS	
Spyridium montanum	P2	OSS	>36
Spyridium mucronatum ssp. multiflorum	P2		
Spyridium mucronatum ssp. recurvum	P3		
Spyridium oligocephalum	P3	OSS	
Spyridium riparium	P2	OSS	36 to 48
Spyridium spadiceum	P2		
Spyridium villosum	P2	OSS	60
Stachystemon vinosus	P4	OSS	
Stenanthemum bremerense	P3		
Stenanthemum cristatum	P2		
Stenanthemum pumilum ssp. pumilum	P3	OSS?	
Stenanthemum sublineare	P2		
Stirlingia divaricatissima	P3	OSS	24
Stylidium articulatum	P2	OSS	
Stylidium bellum	P2	OSS	
Stylidium clavatum	P3	OSS	
Stylidium corymbosum var.. proliferum	P2	OSS	
Stylidium daphne	P2	OSS	
Stylidium diplectroglossum	P1	OSS	
Stylidium falcatum	P1	OSS	
Stylidium galioides	**R**	OSS	>48
Stylidium glandulosum	P3	OSS	
Stylidium gloeophyllum	P3	OSS	
Stylidium keigheryi	P2	OSS	36 $\pm$
Stylidium leeuwinense	P3	OSS	24
Stylidium lepidum	P3	OSS	
Stylidium plantagineum	P4	RS	
Stylidium pseudohirsutum	P3	OSS	
Stylidium pulviniforme	P3	OSS	
Stylidium rhipidium	P3	OSS	
Stylidium rosulatum	P2	OSS	
Stylidium sejunctum	P2	OSS	
Stylidium sp. Bluff Knoll (S. Barrett s.n. 8/11/1994)	P2	OSS	
Stylidium tylosum	P1	OSS	
Stylidium verticillatum	P3	0SS	<36
Synaphea bifurcata	P3		
Synaphea decumbens	P3		
Synaphea hians	P3		
Synaphea incurva	P1		
Synaphea intricata	P3	OSS	48
Synaphea platyphylla	P3		
Synaphea preissii	P3		
Tecticornia entrichoma	P4		

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Tecticornia indefessa	P2		
Tecticornia uniflora	P4		
Tetratheca applanata	P1		
Tetratheca pilata	P1		
Tetratheca sp. Kent River (B.G. Hammersley 1791)	P1		
Thelymitra jacksonii	P3	GEO	12
Thelymitra psammophila	**R**	GEO	
Thomasia dielsii	P1		
Thomasia discolor	P3	OSS	24
Thomasia multiflora	P1		
Thomasia purpurea x solanacea	P1		
Thomasia pygmaea	P3		
Thomasia quercifolia	P2		
Thomasia solanacea	P3	?RS	
Thomasia sp. Toolbrunup (G.J. Keighery 9895)	P3	RS	
Thysanotus baueri	P1	GEO?	
Thysanotus brachiatus	P2	GEO?	
Thysanotus brachyantherus	P2	GEO?	
Thysanotus brevifolius	P2	GEO?	
Thysanotus gageoides	P3	GEO?	
Thysanotus glaucus	P4	GEO?	
Thysanotus isantherus	P3	GEO?	
Thysanotus parviflorus	P2	GEO?	
Thysanotus tenuis	P3	GEO?	
Torrendia grandis	P2		
Torrendia inculta	P2		
Trachymene anisocarpa var.. trichocarpa	P3	OSS	
Trachymene croniniana	P3	OSS	
Tribonanthes purpurea	**R**	GEO	
Tribonanthes sp. Lake Muir (G.J. Keighery & N. Gibson 2134)	P3		
Triglochin protuberans	P3		
Triglochin stowardii	P3		
Trithuria australis	P2	OSS	
Trymalium litorale	P1	OSS	
Trymalium myrtillus ssp. pungens	P1		
Tyrbastes glaucescens	P4	OSS	
Usnea pulvinata	P1	Lichen	
Velleia exigua	P2		
Velleia foliosa	P4	OSS	24±
Verticordia apecta	**R**	RS	
Verticordia brevifolia ssp. brevifolia	P3	RS	
Verticordia brevifolia ssp. stirlingensis	P2	RS	
Verticordia carinata	R	OSS	add
Verticordia coronata	P3	RS	
Verticordia crebra	**R**	OSS	29
Verticordia endlicheriana var.. angustifolia	P2	RS/OSS	36 to 48
Verticordia fimbrilepis ssp. australis	**R**	RS/OSS	

Species	Conservation Code	Fire response	Primary Juvenile Period[6] (months)
Verticordia harveyi	P4	OSS	>30
Verticordia helichrysantha	**R**	OSS	>48
Verticordia huegelii var.. tridens	P3	RS/OSS	
Verticordia integra	P4	OSS	
Verticordia longistylis	P3	OSS	
Verticordia pityrhops	**R**	OSS	84
Verticordia sieberi var.. pachyphylla	P1	OSS?	
Verticordia verticordina	P3	OSS	
Verticordia vicinella	P4	OSS?	
Villarsia calthifolia	**R**	OSS	24
Villarsia marchantii	P4		
Villarsia submersa	P4		
Warnstorfia fluitans	P1	MOSS	
Wurmbea sp. Cranbrook (A.R. Annels 3819)	P2		
Xanthoparmelia sargentii	P1	Lichen	
Xanthoparmelia subimitatrix	P1	Lichen	
Xanthorrhoea brevistyla	P4		
Xanthosia collina	P3	OSS	
Xanthosia eichleri	P3		
Xanthosia peduncularis	P3		
Xyris exilis	**R**	OSS	48 to 60

APPENDIX VII. RESPONSE TO FIRE OF THREATENED FAUNA WITHIN THE SOUTH COAST REGION.

Summary of responses of South Coast fauna considered ‘fire sensitive’ to some degree and summary information on knowledge of their responses to fire. Indigenous names are included where known.

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
MAMMALS					
Recherche Rock Wallaby	*Petrogale lateralis haketti*	VU	Not sensitive	Increased grazing opportunities in early seral stages. High intensity wildfires on occupied islands may impact population viability.	Pearson & Kinnear (1997)
Woylie	*Bettongia pencillata*	EN	Sensitive	Cover essential to minimise predation.	Christensen (1980); Gill (2002)
Ash-grey Mouse	*Pseudomys albocinereus*	-	Post-fire opportunist Flexible breeding	Generalist. Increase abundance early seral stages. Diet non specialised.	Chapman (1985); Friend (1993); Everhaardt (2003);
Brushtail Possum Koomal	*Trihcousurus vlupecula*	-	Post-fire opportunitst	May be sensitive to loss of hollows in high intensity fires.	Abbot & Whitford (2002)
Chuditch	*Dasyurus geoffroii*	VU	Mobile	May be susceptible to increased predation following fire. Sensitive to loss of hollow logs as den sites following high intensity fire.	Orell & Morris (1994)
Gilbert’s Potoroo	*Potorous gilbertii*	CR	Sensitive	Shelter – habitat in very long unburnt vegetation. Small population size vulnerable to fire.	Courtney & Friend (2004)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
				Currently in long unburnt (50 - 100 years plus). Role of fire and mycophageous fungal response in South Coast heaths not well understood.	
Heath Mouse Dayang	*Pseudomys shortridgei*	VU	Sensitive – prefers long unburnt	Sensitive to successional stage of food resources.	Menkhorst et al. (2008); Cancilla pers comm
Honey Possum Noolbenger	*Tarsipes rostratus*	-	Fire sensitive – especially to large, high intensity fire. Late seral stage. Synchronised breeding	Diet specific – nectar producing plants. Refuge/shelter in flammable vegetation. Smaller patchy burns allow animals to move between burn and unburnt vegetation with the latter providing both refuge and food resources. Long unburnt (50+ years) still provide shelter and food resources. Resprouters and lignotubers can be used as food resource. Increase in abundance up to 20-30 years post fire with capture rates generally low for 4-5 years post fire.	Everaardt (2003, 2008); Quinland et al. (2004); Cancilla pers comm.
Western Pygmy-possum	*Cercartetus concinnus*	-	Late seral stage preference synchronised	Specific diet. Refuge/shelter in flammable vegetation.	Smith (1995)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
			breeding		
Mardo	*Antechinus flavipes*	-	Fire sensitive - prefer	Long unburnt – 10 years plus with well developed leaf litter	Leaf litter invertebrate fauna
Numbat Walpurti	*Myrmecobius fasciatus*	VU	Not affected directly by fire.	Loss of habitat cover post fire may increase mortality through predation. Food resources not directly affected	Friend (1994, 1995); Friend & Wayne (2003)
Dunnarts	*Sminthopsis spp. Sminthopsis grisoventer*	-	Fire sensitive – especially to large, high intensity fire.	Diet largely invertebrates, Refuges/shelter generally flammable, requires dense vegetation. Mid seral stage preference, Grey-bellied Dunnart found to be most abundant in vegetation 5 years post fire. Not observed in vegetation until 22months post fire.	Chapman (1985); Friend (1993), Friend & Wayne (2003); Everhaardt (2003)
Quokka	*Setonix brachyurus*	VU	Mobile, although has been recorded perishing in high intensity fires.	Requirement for dense habitat. Post fire green pick provides increased grazing opportunities	De Tores (2008)
Red-tailed Phascogale Wambenger	*Phasogale calura*	EN	Fire sensitive – scale/intensity. Asynchronous breeding.	Moort & mallet habitat in South Coast slow to recover. Requirement for tree hollows for nesting and refuge.	Friend & Wayne (2003).
Dibbler	*Parantechnus apcialis*	EN	Fire senstivie.	Abundance greatest in long unburnt refuges.	Chapman & Newbey (1987); Friend

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
					(2003)
Tammar Wallaby	*Macropus eugenii derbianus*	P5	Mobile – although site fidelity or lake of appropriaterefuge may result in death in fire.	Preference for long unburnt thickets which, in forest, requires intense fire for regeneration. Early seral stages provide significant increase in grazing habitat. Post fire vulnerability to predation and immediate scarcity (6 weeks) of food resources.	Christensen (1980); Bakker & Weston (1984); Christensen (1987); Maxwell et al. (1996); Chrietensen & Armtrong (2007)
Western Mouse	*Pseudomys occidentalis*	-	Prefers long unburnt vegetation. Late seral stage. Synchronised breeding	Diet specific – nectar producing plants. Refuge/shelter in flammable vegetation.	Friend (1993), Friend & Wayne (2003)
Western Ringtail Possum Nguara	*Psuedocheirus occidentalis*	VU	Sensitive to high intensity fires, low intensity fires not problematic.	Rapid recovery, may be sensitive to predation. Resprouting and epicormic growth beneficial for food	De Tores (2008b)
BIRDS					
Australasian Bittern	*Botaurus piciloptuilus*	VU	Not sensitive	Burning of reed beds may result in disruption of breeding. Intense fire may result in long term loss of peat based reed habitat.	Christensen et al. (2005)
Little Bittern	*Ixobrychus minutus*	P1	Not sensitive	Burning of reed beds may result in disruption of breeding. Intense fire may result in long term loss of peat based reed habitat.	Christensen et al. (2005)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
Baudin's Cockatoo	*Calyptorynchus baudinii*	EN	Not sensitive	Nesting hollows in karri, marri and wandoo. Obligate seeding food plants may be impacted by fire frequency.	Johnstone & Storr (1998)
Bush stone-curlew	*Burhainus grallarius*	P4	Unknown	Nests and lives in open woodland, which may be prone to frequent fires.	Johnstone & Storr (1998)
Carnaby's Cockatoo	*Calyptorynchus latirostris*	EN	Not sensitive	Nesting trees may be sensitive to high intensity wildfires. Hollows up to 120 year old trees may be lost. Some South Coast heaths dominated by obligate seeders which may be impacted by inappropriate fire interval	Johnstone & Storr (1998)
Forest Red-tailed Black Cockatoo	*Calyptorhunchus bansii naso*	EN	Not sensitive	Some nesting trees may be sensitive to high intensity wildfires.	Johnstone & Storr (1998)
Noisy Scrub-bird	*Atrichornis clamosus*	EN	Fire sensitive – poor mobility	Long unburnt thickets and gullies, nesting species resprouters. Leaf litter invertebrates	Smith (1985); Gilfillan et al. (in press)
Regent Parrot	*Polytelis anthopelus*	-	Not sensitive	Requires hollows in old trees for nesting	Forshaw (2002)
Southern Boobook	*Ninox novaeseelandiaei*	-	Not sensitive	Requires hollows in old trees for nesting	Johnstone & Storr (1998)
Western Ground Parrot	*Pezoporus wallicus flaviventris*	CR	Has capacity for flight, but has been	Thought to have requirement for mosaic of long unburnt for	Meredith et al.(1984); McFarland

Common Name	**Species**	**Conservation Status (WA)**	**Organism response**	**Habitat (Shelter & Food)**	**Reference**
			observed to be reticent to move in front of fire.	roosting and younger seral stages for feeding. Diverse range of seeds from a diverse range of plant species. Fire response of this food resource not documented in Western Australia.	(1988); Burbidge, Watkins & McNee (1989); Burbidge et al. (2007); Gilfillan et al (in press)
Western Bristlebird	*Dasyornis longirostris*	VU	Limited capacity for flight, but may be able to move infront of low intensity fires.	The presence of unburnt refuges is believed to be a key factor for recolonisation to occur post-fire.	Smith (1985); Burbidge et al (2009); Lindemayer et al. (2009); Gilfillan et al (in press)
Western Whipbird (heath & malle subspecies)	*Psophodes nigrogularis nigrogularis* & *Psophodes nigrogularis oberon*	EN & P4	Good flight capacity although direct response to fire not known	At Two Peoples Bay occupying heath and thickets not burnt since 1960's – similarly found in long unburnt pockets (>40yo) in FRNP. In areas burnt 1968 and 1972 lake Magenta NR Lower range unclear – not reappearing in areas on Manypeaks burnt in 2004-05 or Angove 2000.	Smith (1985), Gilfillan et al (in press)
Mallefowl	*Leipoa ocellata*	VU	Limited capacity to fly from fire. Increased susceptibility to predation in recently	Long unburnt mallee with well developed leaf litter required for nesting.	Benchemesh (2000); Parsons (2008); Parsons (in press)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
			burnt vegetation.		
Southern scrub-robin	*Drymodes brunneopygia*	-	Unknown	Minimum 20ha of suitable mallee heath, shrubs within 2km to allow recolonisation post fire . Recolonisation of burnt areas likely to be slow.	Chapman & Newbey (1994); Brooker et al. (2001)
Fairy-wrens (Splendid, Red-winged; Blue-breasted		-	Unknown	Survival of adults from fire may enable persistence for some years despite low recruitment. This likely to be related to availability of suitable refuge habitat. Recolonisation of burnt areas likely to be slow.	Rowley & Brooker (1987); Brooker & Brooker (1994); Chapman & Newbey (1994)
REPTILES & AMPHIBIANS					
Frogs (general)	*Eg. Helioporus eyrei Myobatrichus gouldi Limnodynastes dorsalis*	-	Burrowing frogs may be protected by the insulating properties of soil from the effects of fire.	Well developed leaf litter and associated food resources may responsible for increased abundance of frogs with increasing post-fire age of vegetation. Most frogs have generalised invertebrate diets therefore not sensitive.	Main (1981); Bamford (1992)
Sunset Frog	*Spicospina flammocaerulea*	EN	?Fire sensitivie	Unknown relationship between peat burning and onset of high frequency calling.	Tyler (1997); Roberts et al.(1999), Burbidge & Roberts (2001)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
Nornalup Frog	Nornalup *Frog*	P4	?Fire sensitive		Unknown
Reptiles (general)		-			
	Skink *species*	-	Burrowing behaviour generally reduces vulnerability to low – medium intensity fire. Direct impact of intense fire habitat may be detrimental to non-burrowing species. Many may be mid- late successional species	Species which require logs or well developed leaf litter may be impacted by high intensity fire, and fire frequency (short intervals) where habitat does not have time to regenerate.	Bamford (1985); Bamford (1986); Friend (1993); Bamford & Roberts (2003); Christensen et al (2005)
INVERTEBRATES					
General		-		Lack of consistent relationships in invertebrate abundance and stand age – effects of locality override fire effects	Friend (1995, 1996); Friend & Williams (1996)
Relictual invertebrates	*e.g. Neohomogona stirlingii*	-	Not killed by fire.	Some evidence that Neohomogona can survive at least moderate fires. Individuals rebuild pallisades shortly after destruction by fire	Main & Gaull (1992); Department of Environment & Conservation (2008c); Framemau et al. (2008)

Common Name	Species	Conservation Status (WA)	Organism response	Habitat (Shelter & Food)	Reference
Stirling Range Rhytidid	*Undescribed Rhytidid sp. (WAM#2295-69)*	CR	Low dispersal capacity and shallow burrows may indicate organism is fire sensitive.		Department of Environment & Conservation (2008)
Stirling Range Moggridgea	*Moggridgea sp (B.Y.Main 1990/24,25)*	EN	Shallow burrows in gully banks leave individuals susceptible to intense fires.	Structural changes to habitat banks and post-fire impacts of loss of canopy and bank erosion result in impact on Moggridgea. Increase in fire frequency will result in reduced recruitment and long term viability of popuatlions.	Main & Gaull (1992); Main (1993); Department of Environment & Conservation (2008); Framemau et al. (2008)
Tingle Moggridgea		-	Shallow burrows in tree trunks likely to burn with bark. Low dispersal –escape capacity. Low intensity fires may not burn trunks.	Loss of thick spongy moss growing on bark of tingles, with ideal habitat for Moggridgea. Increase in fire frequency will result in reduced recruitment and long term viability of popuatlions.	Main (1987)

APPENDIX VIII. CASE STUDIES AND OBSERVATIONS: MALLET, MOORT AND WOODLAND SYSTEMS.

Woodland systems including moort and mallet communities are particularly sensitive to fire frequency for both the creation and maintenance of the system, and for the development of structures suitable for fauna habitat such as hollows. The moorts and mallets of southwest Australia are obligate seeding usually small to medium trees that often form dense single age, and single or few species stands. Typical moort and mallet stands form following lethal disturbance where replacement plants grow first with mostly leguminous understorey pioneer species, and over time develop again into mostly even age, understorey-poor stands.

These communities are two-stage obligate seeding systems that have a relatively simple composition. Stage one is the flourish response following the disturbance, usually by fire, of the mature stage two systems. This response is dominated by geosporous, obligate-seeding legumes; such as several *Acacia, Gastrolobium* and *Kennedia* species as well as other pioneer plants including *Glisocaryon* spp., *Gyrostemon* spp and *Goodenia scapigera*. Species abundant in this stage are short-lived, up to around 15 years, although some acacias persist longer to perhaps 50 years, particularly at the edges of the community. During the temporal extent of this stage it contributes enormous amounts of durable seed into the likely very long-lived geosporous seed bank.

The second stage is the dominance of the moort or mallet taxa, in some cases both are present. This long-lived bradysporous stage is strongly allelopathic with thick layers of a protective leaf blanket. It begins among the first stage and continues to grow after the loss of the legume dominated understorey and commonly attains a thicket like density. These dense stands often persist very long term, where without partial disturbance to open up the community, slow attrition takes place. The dense attritional stands can be quite old yet the individual plants are relatively small and slender. In these cases the stems may be no greater than around 50mm in diameter on plants greater than 100 years old. Conversely, at community edges or where a storm or frost has killed some plants to open up the stand, trees can relatively quickly attain significant size and habitat forming structures. Very old and open moort and mallet woodlands attain a community of fewer large trees with many hollows, and beneath them open cryptogam-covered and grass-patched soils where the thick leaf blanket has broadly decomposed. These old systems are very rare, are probably several centuries old, and have greatly reduced biomass and fire fuel loads.

Several moort and mallet systems are inherently localised or restricted in occurrence and size, which together with their sensitivity to fire frequencies under 50 or so years makes them vulnerable to severe alteration, diminishment and loss. These include mallet taxa: the newly discovered *Eucalyptus brandiana* from the Fitzgerald River valley of the FRNP, as well as the sympatric *E. arborella;* the similarly restricted *E. melanophitra* from the Chillinup / Corackerup area; *E praeterissima* in small isolated stands on breakaways from Millar's Point on Beaufort inlet at Twertup and on the spongolite escarpments near Moir Track in eastern FRNP; *E. gardneri* ssp.

ravensthorpensis restricted to small scattered stands in Ravensthorpe Range; *E. newbeyi* in isolated stands in a very localised patch distribution from Swan Gully near Cape Riche, through Boat Harbour, Millar's Point, Calyerup Creek Junction with the Gairdner River, to the escarpments along the southern edge of the Yilgarn Block in FRNP near the junction of the Suzetta and Fitzgerald Rivers; *E. megacornuta* in Ravensthorpe Range and Hamersley Inlet, the very localised *E. mcquoidii* from Quoin Head/Marshes Beach in FRNP; the similarly localised *E. purpurata* from Bandalup Hill and the southern outlying small *E. densa* patches in central FRNP on the firelines near Twertup Creek and on the track in the Twertup valley. The moort taxa: *E. vesiculosa* from the Corackerup Valley, *E nutans* in a single stand near Bremer Bay, *E. cernua* in isolated patches in Ravensthorpe Range to near Jerdacuttup, as well common moort *E. platypus* ssp. *platypus* occurs widely across the north western region, albeit in isolated patches which are vulnerable to localised stand change or extinction in some cases if fire frequencies impacting them were less than 30 - 50 year intervals; and lastly the recently evolved *E. calyerup* (of likely hybrid origin) from near Jerramungup is vulnerable to frequent fire as its origins have likely been during times of long fire interval. In addition the tree *E. salmonophloia* at it's southernmost extent in Ravensthorpe Range and nearby is present in small patches and is apparently failing to recruit following fire.

E. salmonophloia is also present in small outlying patches at Gnowangerup, Minderabin, Ongerup, North Needilup and Salmon Gums where its survival depends upon long fire frequencies and what appears to be winter or late autumn disturbances where a winter cool and wet period will allow full seed germination (R. Boase pers. comm.). Observations during the June field trip by the authors revealed Salmon Gum to resprout strongly following fire and damage by chaining. However, it was not apparent that Salmon Gum recruited following fire, despite several burnt and resprouting patches being investigated. It seemed that it recruited where extra moisture and a roughened surface with competition removed was available, such as where adjacent spoon drains had been constructed or where old roads were ripped.

Similarly *E. urna* has been shown to require a cool period for its seeds to fully germinate (K. Vaux pers. comm.); it is at its southwestern most in the region in isolated patches at North Ongerup, North Jerramungup and North Fitzgerald. However, significant regeneration after fire, presumably in summer or autumn, was observed by the authors.

Several mallet and tree taxa that dominate the woodlands in the north of the region are also very sensitive to fire frequency and timing for their survival and stand composition and structure, including: *E. rhomboidea, E. urna, E. salubris, E. ravida, E. prolixa, E. brockwayi, E. diptera, E. crebra, E. terebra, E. optima, E. hypolaena, E. lesouefii,* the extremely restricted *E. pterocarpa, E. valens. E. fraseri, E. georgei, E. tenuis, E. salicola, E. kumarlensis, E. argyphea, E. singularis, E. spathulata, E. salmonophloia, E. extensa, E. protensa, E. alipes, E. platypus* ssp. *congregata, E. dielsii, E. steedmanii, E. goniocarpa and E. sheathiana.*

Several fire sensitive mallet and tree taxa of these inland systems have recently been shown to intergrade in patterns hitherto unrecognised (Nicolle pers. comm; French pers. comm.). It is possible that an explanation for this phenomenon may be a compound separation process, where the spatial separation as a patch distribution has seen their genetic stability and new related taxa result after greatly temporally separated recruitment events.

In the case of the four mallets of the Tetrapterae series *E. brandiana*, *E. dolichorhyncha, E. forrestiana,* and *E. stoatei)*, it appears that they mainly occur as a component of mallee vegetation communities and rarely as pure stands typical of mallets. Pure stands have been seen to occur in two places: *E. brandiana* in the FRNP on the lower central Bell Track area in 1993, and *E. stoatei* in the Kundip East area near the Jerdacuttup River crossing. The stand of *E. brandiana* is a patch of mallets around 6 metres tall alongside an old track. The type-site of *E. brandiana* is also on Bell Track. However, it is south of the original 1993 site and is of a mixed mallee/mallet stand. The stand of *E. stoatei* is a large typical mallet stand. Nearby a few hybrids (mallee) of *E. stoatei* x *E. tetraptera* occur, in 1989 there were eight of these, now there appear to be only two or three remaining. The Tetrapterae mallets predominantly occur as components of mallee systems. This poses questions as to whether pure stand occurrences indicate relictual situations, suggesting the broader loss of the ability to form more pure stands and are the pure stands being lost by increased fire frequencies.

Investigation of disturbances responses of these woodland, mallet and moort systems and the spatial and temporal spacing of gaps between disturbance events, will lead to a fuller understanding of the ecological processes by which these trees, their plant community structure and habitats are maintained.

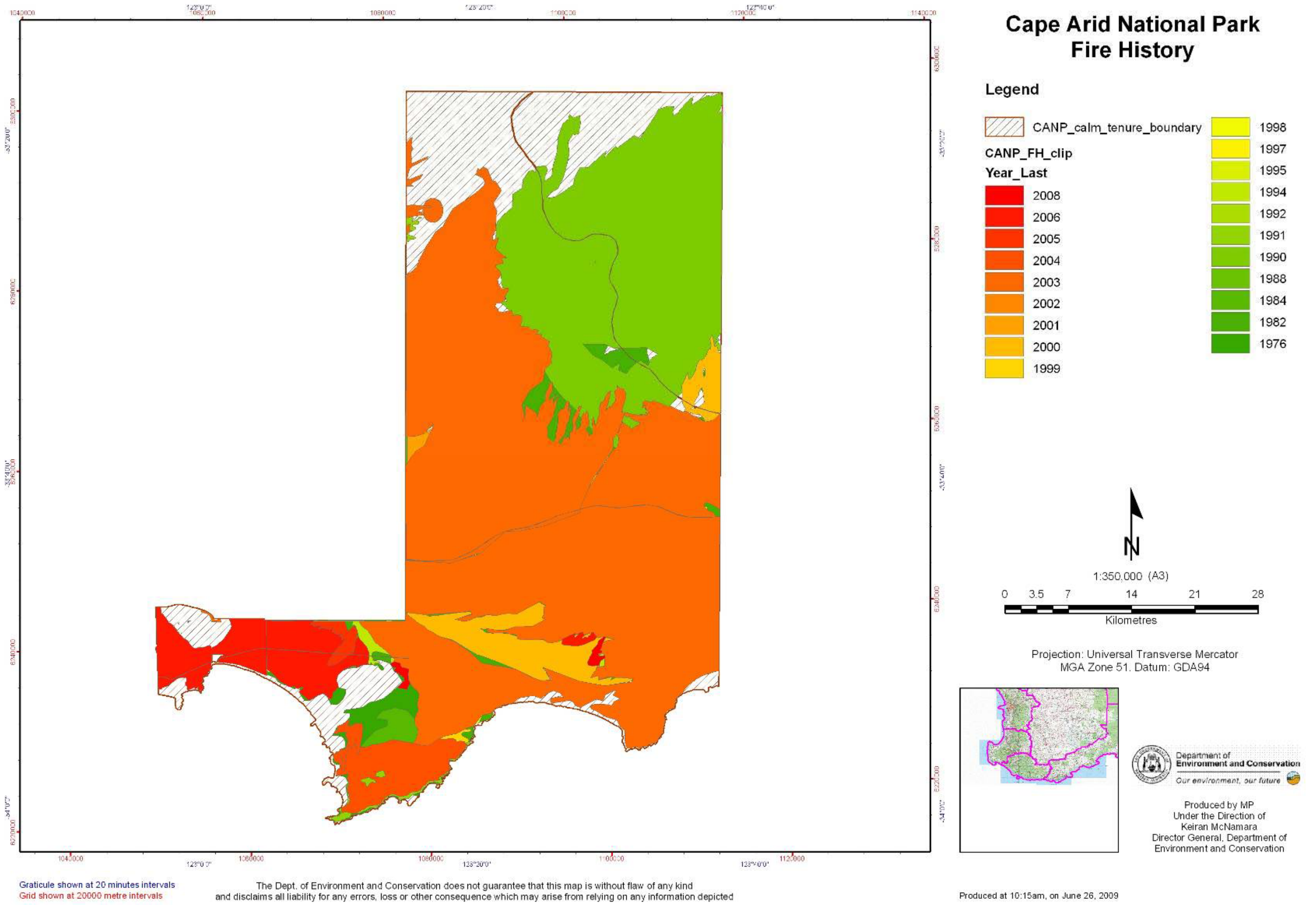
APPENDIX IX. SUMMARY OF FIRE HISTORY FOR ECODISTRICTS AND MAJOR PARKS IN THE PROJECT AREA.

Area Assessed	Total area (ha)	Area rem veg	% No. Burnt Spring	% No. Burnt Autumn	% No. Burnt Summer	% No. Burnt Winter	% No. Unknown	% No. Wildfire	% Prescribed fire	% Unknown	% YSLB[7] 0-5	% YSLB 6-10	% YSLB 11-15	% YSLB 16-20	% YSLB 21+	Unknown
Ecodistricts																
Albany Fraser Coastal	240531.00	181571.94	13.37	19.75	34.95	11.55	20.36	58.66	41.00	0.30	24.32	20.88	9.27	4.84	9.43	31.23
Albany Fraser Inland East	1117273.69	869019.25	5.19	9.09	32.46	1.29	51.94	76.62	22.07	1.29	5.03	26.34	3.18	7.93	11.48	46.01
Albany Fraser Inland West	22910.24	9843.61	51.85	29.62	11.11	0.00	7.40	29.62	70.37	0.00	41.47	1.18	0.05	0.61	0.30	56.36
Albany Fraser Islands	1325880.30	5116.85	18.80	11.96	31.62	2.56	35.04	82.05	14.52	3.41	15.41	18.25	6.04	4.07	5.39	50.82
Esperance Sandplain East	382170.65	74177.20	13.11	26.22	40.16	7.37	13.11	75.40	23.77	0.81	16.91	26.16	5.76	1.95	6.94	42.24
Esperance Sandplain West	496508.17	142153.40	15.73	20.22	42.69	5.61	15.73	78.65	17.97	3.37	15.62	4.39	17.62	7.67	3.30	51.36
Forest Mosaic	579277.01	410835.07	34.65	22.18	8.03	0.89	34.23	40.28	58.15	1.55	19.46	34.36	11.70	1.86	9.83	22.76
Greenstone Range	87782.62	52183.26	13.25	40.96	27.71	7.22	10.84	45.78	54.21	0.00	7.88	21.95	2.53	2.24	13.65	51.73
Mallee Lakes	1094558.14	895252.14	3.84	5.12	33.33	1.28	56.41	78.20	19.23	2.56	12.45	14.97	1.95	22.06	7.74	40.80

[7] Year Since Last Burnt is based on the area of remnant vegetation burnt in the specified period divided by the total area remnant vegetation in the Ecodistrict. Remnant Vegeation is based on the corporate remnant vegetation data set.

Area Assessed	Total area (ha)	Area rem veg	% No. Burnt Spring	% No. Burnt Autumn	% No. Burnt Summer	% No. Burnt Winter	% No. Unknown	% No. Wildfire	% Prescribed fire	% Unknown	% YSLB[7] 0-5	% YSLB 6-10	% YSLB 11-15	% YSLB 16-20	% YSLB 21+	Unknown
Marine Plain	597692.49	279767.01	9.85	22.06	34.74	7.51	25.82	53.05	46.47	0.46	13.31	12.50	5.25	15.69	8.05	45.17
North West Mosaic	656757.67	215789.08	Data Deficient													
Nuytsland	123892.41	123445.70	0.00	0.00	55.55	5.55	38.88	83.33	16.66	0.00	4.41	39.24	1.31	0.43	0.90	53.67
Quartzite Range	266683.14	232081.80	22.47	14.60	28.65	7.30	26.96	44.94	54.49	0.56	18.58	21.46	14.84	29.12	4.25	11.75
Yilgarn Block East	2779316.57	1666097.67	20.88	34.48	18.19	8.62	17.81	41.37	55.74	2.87	8.91	24.23	1.76	15.19	12.74	36.45
Reserve or park																
Fitzgerald River National Park	295817.00	292093.09	23.70	35.80	22.59	16.94	0.84	28.50	71.50	0.00	26.90	19.77	2.76	25.22	7.91	17.43
Stirling Range National Park	113525.88	111911.41	8.60	10.75	8.60	1.07	70.96	21.50	78.49	0.00	5.23	42.45	24.6	2.92	13.81	7.59
Cape Arid National Park	277459.99	275759.31	6.55	11.47	34.42	1.63	45.90	70.49	27.86	1.63	7.80	52.72	0.24	22.80	2.84	13.56
Two Peoples Bay - Manypeaks	28571.51	28531.22	9.67	17.74	25.80	1.61	45.16	38.70	61.29	0.00	19.14	29.60	7.93	9.22	8.05	26.04
Great Western Woodland	6914523.03	6908506.59	7.65	8.67	36.22	1.02	46.42	86.73	11.73	1.53	6.20	14.5	4.78	7.12	4.70	62.66

APPENDIX X. FIRE HISTORY MAPS FOR SELECTED AREAS WITHIN THE SOUTH COAST REGION: CAPE ARID NATIONAL PARK, FITZGERALD RIVER NATIONAL PARK, STIRLING RANGES NATIONAL PARK, TWO PEOPLES BAY – MANYPEAKS, GREAT WESTERN WOODLANDS.


Cape Arid National Park
Fire History
Legend
CANP_calm_tenure_boundary
CANP_FH_clip
Year_Last
2008
2006
2005
2004
2003
2002
2001
2000
1999
1998
1997
1995
1994
1992
1991
1990
1988
1984
1982
1976
N
1:350,000 (A3)
0 3.5 7 14 21 28
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 51. Datum: GDA94
Department of Environment and Conservation
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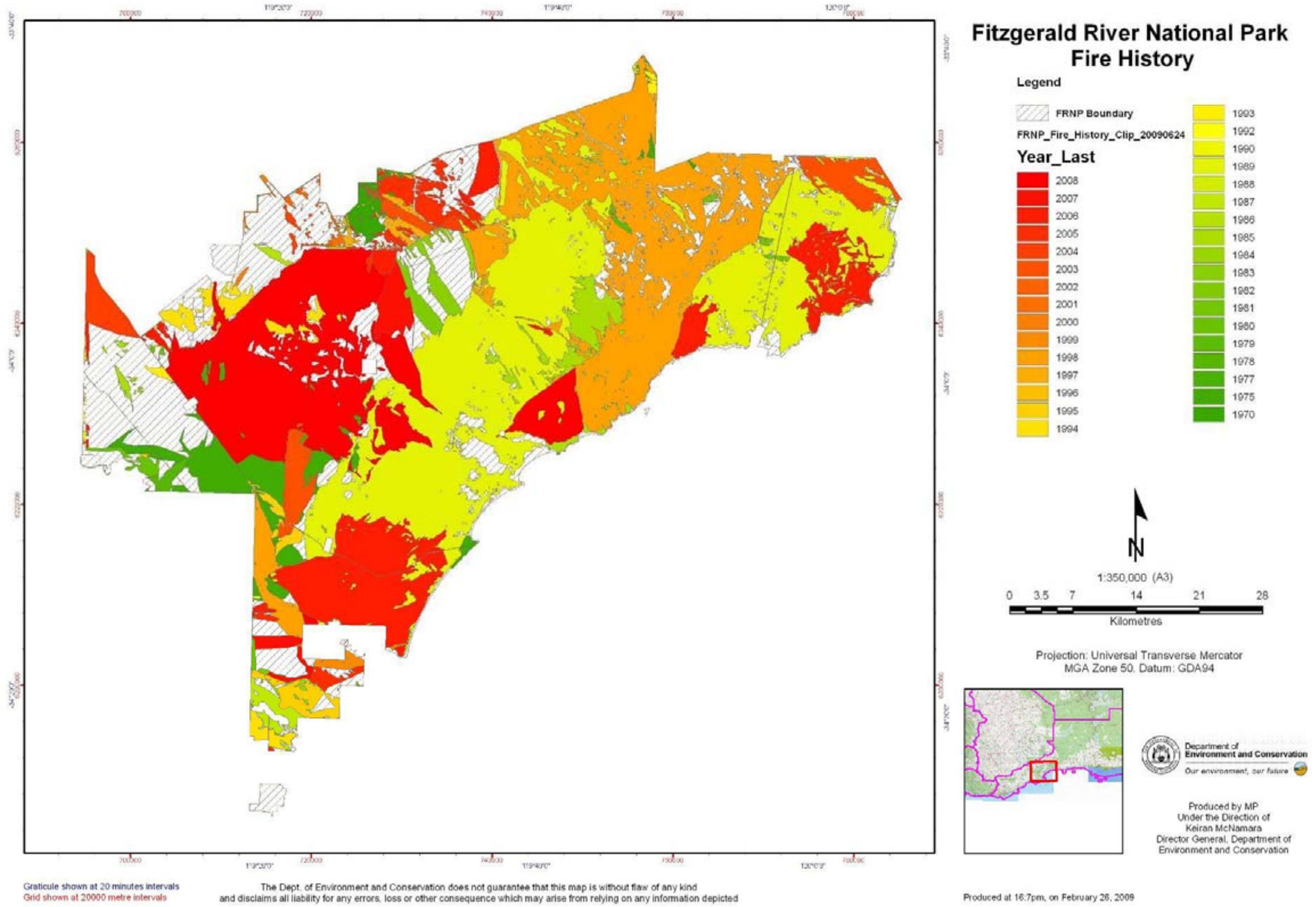

Fitzgerald River National Park
Fire History
Legend
FRNP Boundary
FRNP_Fire_History_Clip_20090624
Year_Last
2008
2007
2006
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N
1:350,000 (A3)
0 3.5 7 14 21 28
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94
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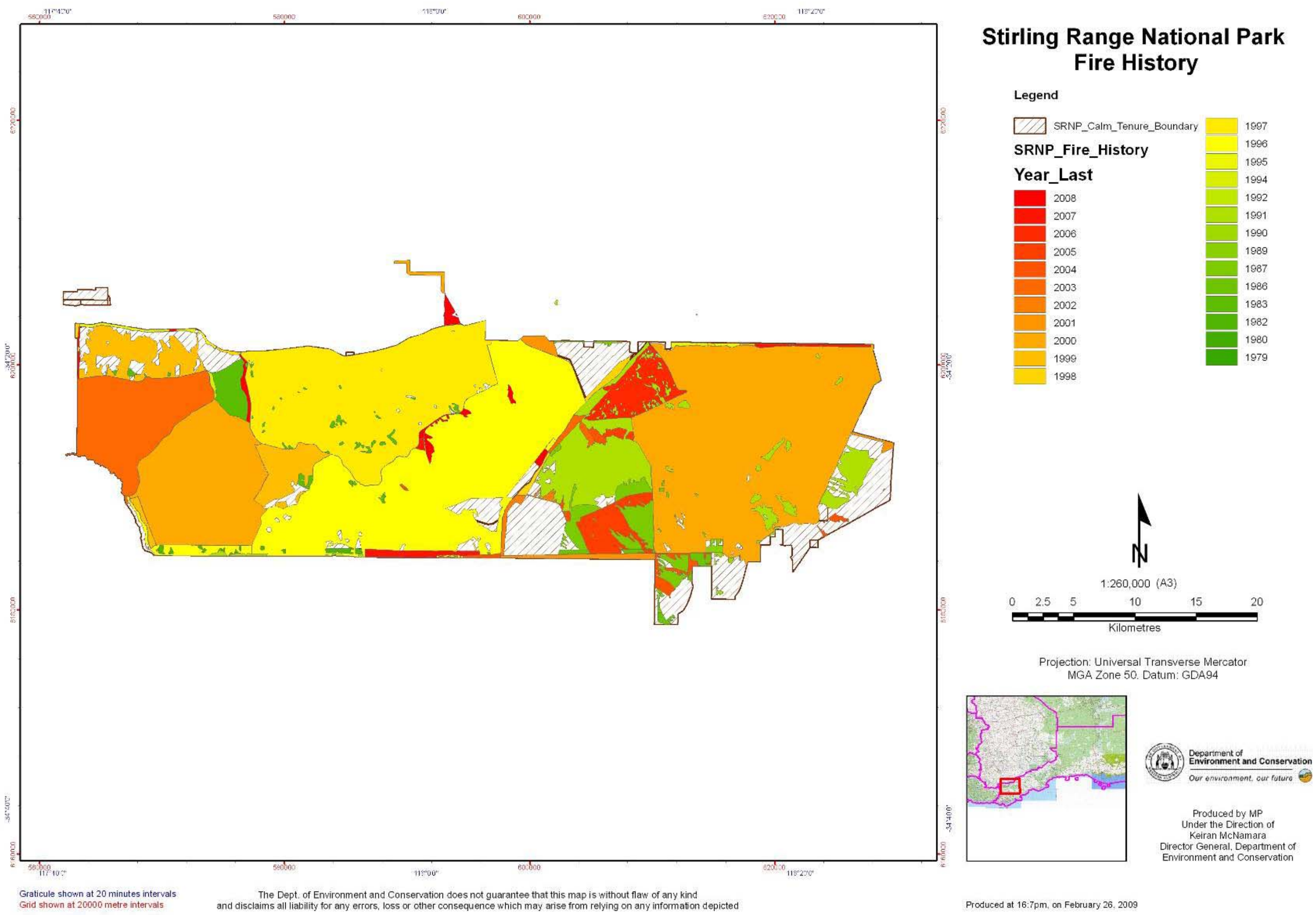
Stirling Range National Park
Fire History
Legend
SRNP_Calm_Tenure_Boundary
SRNP_Fire_History
Year_Last
2008
2007
2006
2005
2004
2003
2002
2001
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1982
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1979
N
1:260,000 (A3)
0 2.5 5 10 15 20
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94
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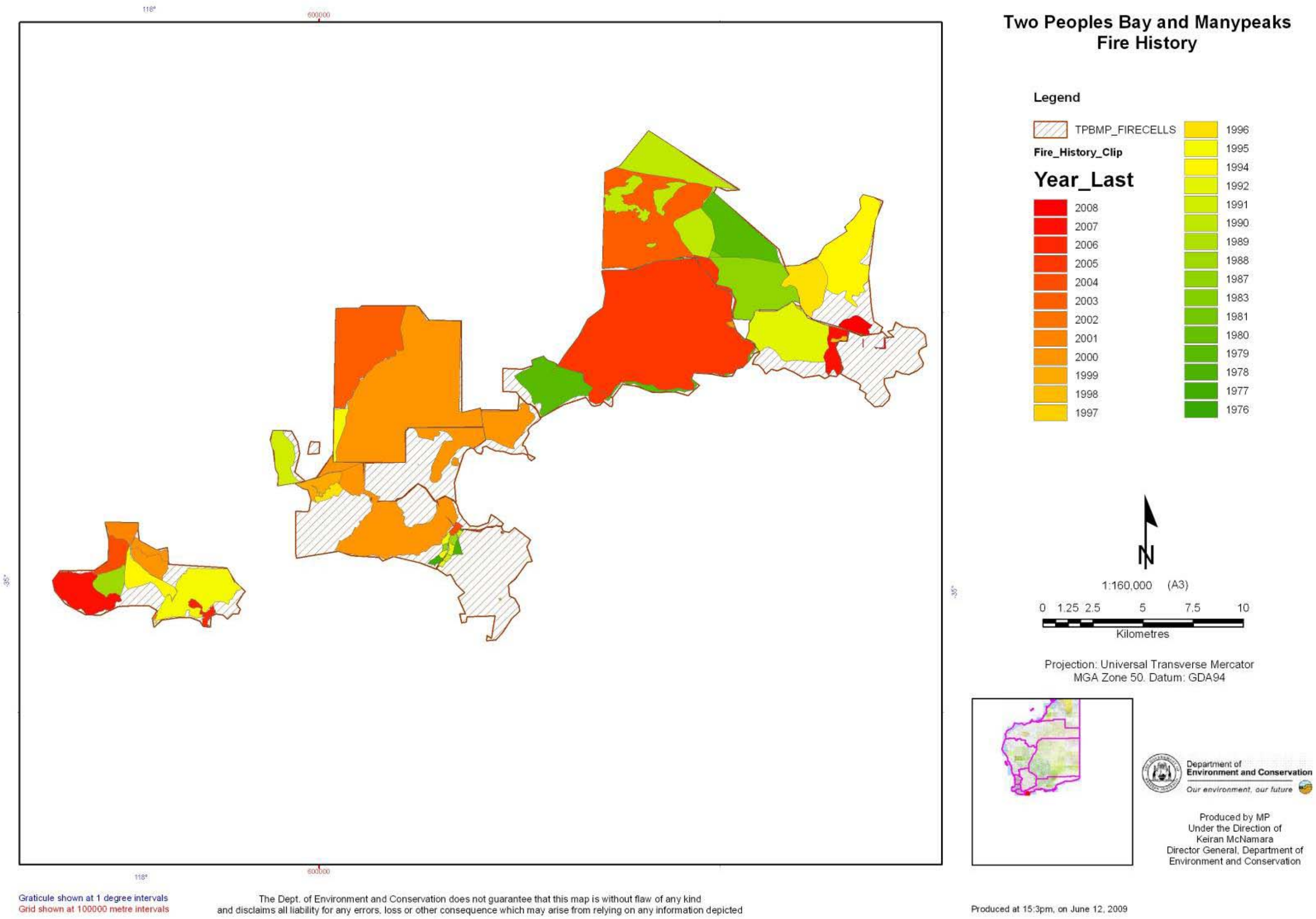
Produced at 16:7pm, on February 26, 2009



Two Peoples Bay and Manypeaks
Fire History
Legend
TPBMP_FIRECELLS
Fire_History_Clip
Year_Last
2008
2007
2006
2005
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2003
2002
2001
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1999
1998
1997
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1976
N
1:160,000 (A3)
0 1.25 2.5 5 7.5 10
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94
Department of Environment and Conservation
Our environment, our future
Produced by MP
Under the Direction of
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Graticule shown at 1 degree intervals
Grid shown at 100000 metre intervals
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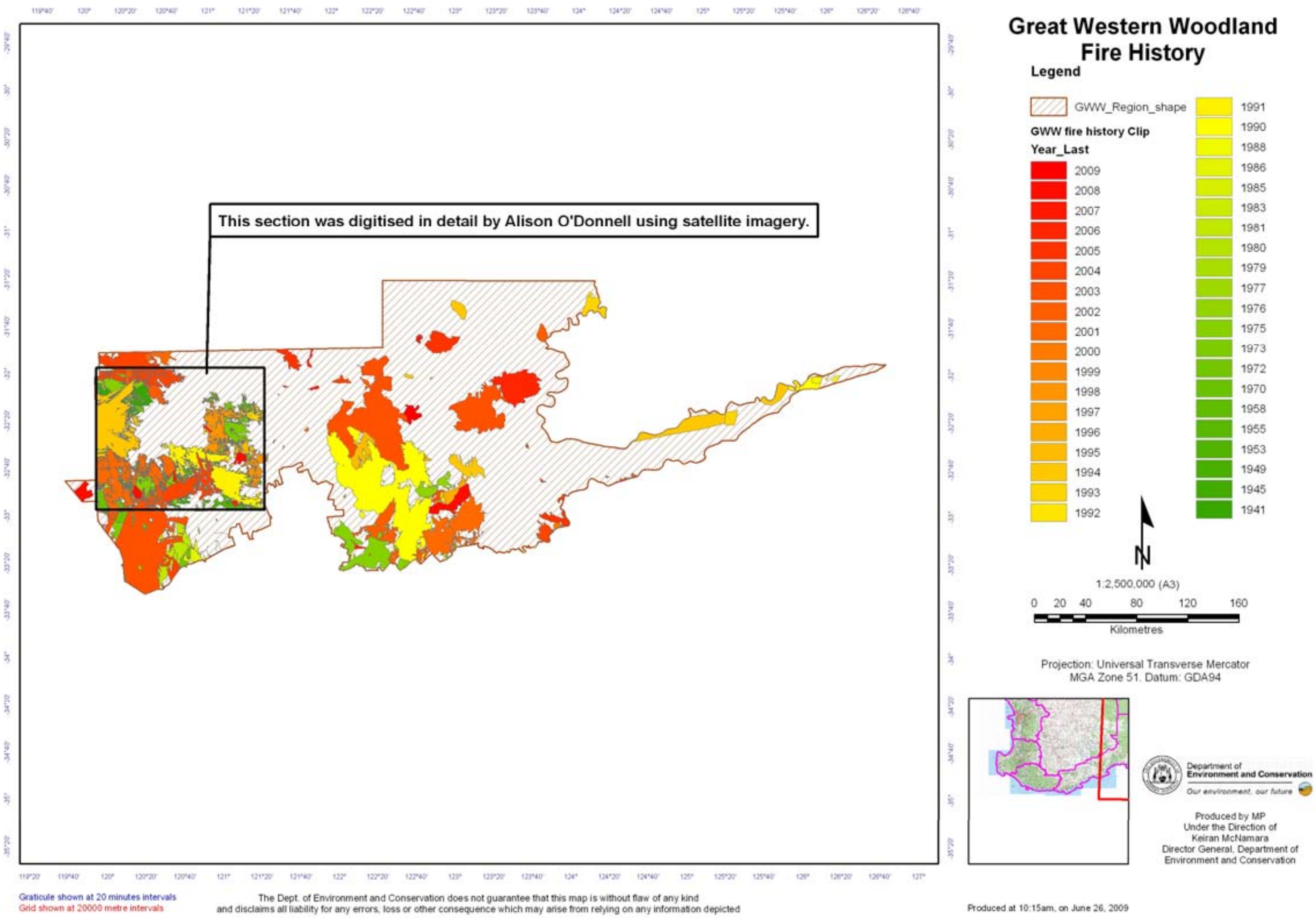
Great Western Woodland
Fire History
Legend
GWW_Region_shape
GWW fire history Clip
Year_Last
2009
2008
2007
2006
2005
2004
2003
2002
2001
2000
1999
1998
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1958
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1953
1949
1945
1941
This section was digitised in detail by Alison O'Donnell using satellite imagery.
N
1:2,500,000 (A3)
0 20 40 80 120 160
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 51. Datum: GDA94
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Environment and Conservation
Graticule shown at 20 minutes intervals
Grid shown at 20000 metre intervals
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APPENDIX XI. EXAMPLE MONITORING PROTOCOLS.

MONITORING PLANT POPULATIONS OF SEROTINOUS SEEDER SPECIES

Introduction

Serotinous species are those that hold fruit and seeds in the plant canopy (canopy-stored seed bank). Banksias, Dryandras, Hakeas, Melaleucas and Eucalyptus are examples of plants exhibiting serotiny. Many serotinous species require fire for seed release from woody fruits. Plants are often killed by fire and rely on seed for regeneration. Seeds of serotinous species generally have no dormancy and seeds germinate readily after dispersal given appropriate temperature regimes and moisture conditions. Serotinous species tend not to accumulate a soil-stored seed reserve. Many serotinous species have a long juvenile period and do not flower or fruit for more than 5 years post germination. In some cases, flowering does not occur until after 10 years e.g. *Andersonia axilliflora, Banksia montana, Banksia verticillata*,(S Barrett per. comm). Short fire intervals (5-10 years) can drive strongly serotinous species to extinction within a vegetation community because they have had insufficient time to build up a canopy-stored seed bank from which they can recruit after fire. Measuring the number of mature fruits held within the canopy of serotinous species and knowing the viability of the seeds can permit informed decisions to be made on whether that vegetation community can tolerate a fire without loss the loss of constituent species, hence to identify a fire interval that is appropriate for that vegetation community.

Method

- Identify vegetation community to monitor. Determine when area was last burnt (fire age)

- Establish replicated quadrats (size dependant on vegetation type) in selected fire age vegetation communities

- Select serotinous species within each plot. Ideally report on several different serotinous species. If time is limited look at only sampling species with the longest juvenile period. Alternatively, pilot sampling of a range of species could be useful if the background knowledge isn't available to robustly identify those with atypically long juvenile periods

  Measure dimensions of each plant and fruit load for each species selected, noting immature, mature, predated and released fruits.

- Assess foliage canopy cover of each species (based on NVIS): 0-2%, 2-10%; 10-30%, 30-70%, 70-100%) and its frequency of occurrence in each quadrant of the quadrat.

Discussion

A number of scenarios can be used to illustrate the effect of fire on different aged vegetation communities. Note these are just examples to demonstrate possible scenarios.

Scenario 1: Burnt 10 years ago. Only 20 plants of a serotinous species (eg Hakea) occur within a quadrat and only 10 of these plants have 5 mature fruits each. Each fruit holds 2 seeds. This amounts to 100 seeds of that species within the quadrat. If only 50% of that seed is viable then there is the potential for only 50 plants to regenerate. Taking into account post-dispersal seed predation and seedling mortality through herbivory and/or desiccation, we will assume that only 25% (quite high) of the available viable seeds will produce mature plants. Therefore after fire has consumed the original 20 adult plants, we can expect only 12 or13 plants to replace them.

Scenario 2: Burnt 10 years ago. Only 20 plants of a serotinous species (eg Melaleuca) occur within a quadrat and all plants have 2 years of mature fruits. Each fruit cluster holds 200 seeds. This amounts to more than 4000 seeds of that species within the quadrat. If only 50% of that seed is viable then there is the potential for 2000 plants to regenerate. Taking into account post-dispersal seed predation and seedling mortality through herbivory and/or desiccation, we will assume that only 25% (quite high) of the available viable seeds will produce mature plants. Therefore after fire has consumed the original 20 adult plants, we can expect 500 plants to replace them.

9 EXAMPLE OF MONITORING PROFORMA FOR FIRE SUCCESSIONAL QUADRATS

Fire Succession Vegetation Quadrats

e.g. 100m^2 quadrats (10 m x 10 m)

Date:……………….. Location/Plot
Description……………..……………………

Plot #…………………
Observers…………………………………………………..

Plot co-ordinates:…………………………………..…………
Datum:…………………….

Species Name	Life form	Fire Response	% flowering	Cover Code	Frequency Code	Distribution Code

FOLIAGE COVER CODE (based on NVIS)

1 = 0-2% cover
2 = < 10% cover
3 = 10-30% cover
4 = 30-70% cover
5 = 70-10025 – 50% cover

Note: when estimating cover, ignore bare ground and only estimate the percentage of live. ie what % of the live is covered by the species being rated.

FREQUENCY CODE

0 = No plant
1 = 1 Plant
2 = < 10 plants
3 = 10 – 50 plants
4 = 50 – 100 plants
5 = > 100 plants

DISTRIBUTION CODE

1	**2**
3	**4**

The plot is divided into 4 quadrants (subplot 1 is always in northwest corner) and if plants occur in equivalent to only 1 quadrant then:

1 = ¼
2 = ½
3 = ¾
4 = 1

Other

Classify plants by life form guilds:

Tree, mallee, woody shrub, perennial herb, geophyte, short-lived herb (regenerates by seed), grass (perennial - hummock, tussock), sedge, fern and whether native or weed.

Fire response categories:

A	Seeder	
		A1: seed stored in soil
		A2: Seed stored on plant (serotinous)
		A3: No seed on site (e.g. blows in)
B	Resprouters	
		B1: from epicormics
		B2: from woody rootstock/lignotuber
		B3: from fleshy below ground organ (corm, bulb, tuber, and rhizome)
		B4 facultative seeder-sprouters

Nested quadrats – pre-fire (1m x 1m)

Quadrat #	Species	No of fruits or fruit clusters/plant	Plant height (score)