Interim Recovery Plan No. 359

Banksia attenuata woodlands over species rich dense shrublands

(Swan Coastal Plain Community type 20a – Gibson *et al.* 1994)

Interim Recovery Plan 2016-2021

Department of Parks and Wildlife

August 2016

Foreword

Interim Recovery Plans (IRPs) are developed within the framework laid down in Department of Parks and Wildlife (previously Department of Environment and Conservation) Corporate Policy Statement No. 35 and Corporate Guideline No. 35.

Recovery plans outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

The Department is committed to ensuring that threatened ecological communities are conserved through the preparation and implementation of recovery plans or interim recovery plans and by ensuring that conservation action commences as soon as possible after listing.

This plan will operate from August 2016 but will remain in force until withdrawn or replaced. It is intended that, if the community is still listed after five years, the need for an updated plan will be evaluated.

This plan was approved by the Director of Science and Conservation on 10 August 2016. The provision of funds identified in this plan is dependent on budgetary and other constraints affecting Parks and Wildlife, as well as the need to address other priorities.

Information in this plan was accurate at August 2016

.

Plan preparation: This plan was prepared by Jill Pryde, Valerie English and Adam Turnbull (Department of Parks and Wildlife).

Cover photograph: Koondoola Regional bushland in spring by Jill Pryde

Acknowledgements: The following people provided assistance and advice in the preparation of this plan:

Greg Keighery	Parks and Wildlife, Science and Conservation Division
David Mitchell	Parks and Wildlife, Swan Region
Julia Cullity	Parks and Wildlife, Swan Region
Anne Harris	Parks and Wildlife, Swan Coastal District
Craig Olejnik	Parks and Wildlife, Swan Coastal District
Catherine Bourke	Parks and Wildlife, Perth Hills District
Marnie Mallie	Parks and Wildlife, Perth Hills District

Citation: This plan should be cited as: Department of Parks and Wildlife (2016). *Banksia attenuata* woodlands over species rich dense shrublands (Swan Coastal Plain community type 20a – Gibson *et al.* 1994). Interim Recovery Plan No. 359. Parks and Wildlife, Kensington, Western Australia.

Summary

Name: *Banksia attenuata* woodlands over species rich dense shrublands (also known as Swan Coastal Plain community type 20a, as defined in Gibson *et al.* (1994)).

Description: *Banksia attenuata* woodlands over species rich dense shrublands (hereafter called the *Banksia attenuata* woodlands) was originally described by Gibson *et al.* (1994) and occurs on sands at the base of the Darling Scarp between Chittering and Gosnells. This community is very species rich (average 67 species/100m^2). It is usually dominated by *Banksia attenuata* (occasionally with *Eucalyptus marginata*) with *Bossiaea eriocarpa*, *Conostephium pendulum*, *Hibbertia huegelii*, *H. hypericoides*, *Petrophile linearis*, *Scaevola repens*, *Stirlingia latifolia*, *Mesomelaena pseudostygia* and *Alexgeorgea nitens* being common in the understorey. The introduced bulbous weed *Gladiolus caryophyllaceus* is also common in the community.

Parks and Wildlife Region: Swan

Parks and Wildlife Districts: Swan Coastal and Perth Hills

Local Government Authorities: Canning, Chittering, Gosnells, Kalamunda, Stirling, Swan and Wanneroo

Conservation status: Endorsed as endangered by the WA Minister for Environment in 2001.
[The *Banksia* woodlands of the Swan Coastal Plain were listed as a TEC under the EPBC Act on 16 September 2016. The listing encompassed a suite of WA TECs and PECs including the Banksia woodlands over species rich dense shrublands. The key diagnostic characteristics, condition and size thresholds in the Approved Conservation Advice should be applied to check if particular patches align with the *Banksia* woodlands of the Swan Coastal Plain TEC.]

Habitat requirements: These *Banksia attenuata* woodlands are found on the Bassendean, Forrestfield, Southern River and Karrakatta soil and landform units, and on the Coonambidgee unit of the Dandaragan Plateau. There have been a number of detailed groundwater studies completed for this community that suggest that this community is partially groundwater dependent.

Threats: The main threats to the community are clearing for roads, housing and related infrastructure, too frequent fire, weeds, sand quarrying and hydrological change.

Habitat critical to survival: The habitat critical to the survival of *Banksia attenuata* woodlands is the area of occupancy of known occurrences, the sandy soils on which the community occurs, the fresh superficial groundwater that probably helps to sustain key dominant trees in the community, and the catchment for this groundwater.

Important occurrences: Occurrences that provide for representation of the community across its geographic range and that can be managed for conservation and/or with conservation included in their purpose are considered critical to the survival of this community. Important occurrences include all areas of the community within Bush Forever sites.

Affected interests: Parties affected by the implementation of this plan include Parks and Wildlife's Swan Coastal and Perth Hills Districts, and Swan Region who manage nature reserves and other lands for conservation of flora and fauna that contain occurrences of the TEC, numerous private landholders, the Cities of Canning, Gosnells, Stirling, Swan and Wanneroo and the Shires of Chittering and Kalamunda who manage land that contains occurrences of the TEC. All of these parties have been notified of the locations and importance of the TEC.

Indigenous interests: The South West Aboriginal Land and Sea Council (SWALSC), an umbrella group, covers the areas considered in this plan. Comment was sought from the Council about any aspects of the

plan, but in particular about the proposed on-ground actions. According to the Department of Aboriginal Affairs Aboriginal Heritage Sites Register, there are a number of registered sites known in or near occurrences of *Banksia attenuata* woodlands. Action 1 identifies the intention to continue liaison with relevant groups, including indigenous groups.

Social and economic impacts and benefits: Where specific active recreational pursuits such as four wheel driving and motorbike riding are prevented through access control, this may be perceived as a social impact, however, such access control also helps to prevent the continued degradation of the community and maintain other social benefits.

Occurrences may be threatened by proposals to clear for various developments or from hydrological change following clearing and development of adjacent land. Implementation of actions such as seeking to protect occurrences, or maintain hydrological processes in areas adjacent to the community, may impact on proposed developments.

Related biodiversity impacts and benefits: Three threatened flora and ten priority flora have been recorded in occurrences.

Six TECs and two priority ecological communities (PECs) occur within bushland close to occurrences of *Banksia attenuata* woodlands. Five threatened, six priority, and two specially protected fauna occur within or close to the *Banksia attenuata* woodlands.

Recovery actions implemented to improve the quality or security of *Banksia attenuata* woodlands, are likely to also benefit the threatened and priority flora and fauna populations, and occurrences of other TECs and PECs that occur within or close to the bushland that supports the community.

IRP Objectives: To maintain or improve the overall condition of the community in the known locations and reduce the level of threat.

Criteria for success:

- An increase in the number of occurrences of this community managed for conservation and/or with conservation included in the purpose over the life of the plan.
- Representative areas of the community across its geographical range with condition rank maintained, or with improved condition rank (Bush Forever, Government of Western Australia (2000) scales) over the life of the plan.
- 90% or more of the aerial extent of occurrences maintained at the same condition rank, or improved (Bush Forever 2000 scales) over the life of the plan, excluding effects of drying climate that are outside the scope of this plan.

Criteria for failure:

- Decline in condition rank of 10% or more of the area of the community over the life of the plan, excluding effects of drying climate that are outside the scope of this plan.
- Failure to achieve an increase in the area managed for conservation over the life of the plan.

Summary of recovery actions:

1. Liaise with stakeholders to implement recovery
2. Seek to minimise further clearing of the community
3. Verify occurrences as required
4. Continue to monitor the extent and boundaries of occurrences
5. Install markers
6. Encompass monitoring in an adaptive management framework
7. Implement weed control and rehabilitation as required
8. Develop and implement a fire management strategy
9. Interpret and map disease areas
10. Implement disease hygiene procedures
11. Design and conduct research
12. Seek long term protection of the community for conservation
13. Report on recovery plan implementation

1 Background

1.1 History, defining characteristics, and conservation significance

The significance of this diverse *Banksia* community was recognized in 1992 during a survey of remnant vegetation on the eastern side of the Swan Coastal Plain (Keighery and Trudgen 1992). The floristic community was then defined through statistical analysis of data from 500 quadrats, in Gibson *et al.* (1994). Gibson *et al.* (1994) named the community '*Banksia attenuata* woodlands over species rich dense shrublands'. The community type is often referred to as 'Swan Coastal Plain community type 20a' in reference to the numerical identifier applied in Gibson *et al.* (1994).

Banksia attenuata woodlands are known from small to medium-sized sand ridges between Chittering and Gosnells. Occurrences additional to those identified in Trudgen and Keighery (1992) and Gibson *et al.* (1994) have been recognized through further work undertaken by the Department of Environmental Protection (DEP 1996) for Bush Forever (Government of Western Australia 2000), surveys by local government authorities for the Perth Biodiversity Project, studies undertaken by various consultants and surveys by staff from state agencies.

The *Banksia attenuata* woodlands are very restricted in distribution and are the richest of any *Banksia* community found on the Swan Coastal Plain. The average number of species recorded in 100m^2 quadrats established for Gibson *et al.* (1994) was 67, with some sites having over 80 species per 100m^2. Sites of *Banksia attenuata* woodlands were differentiated from the other two subgroups (20b, 20c) by the occurrence of species such as *Alexgeorgea nitens*, *Daviesia nudiflora*, *Synaphea spinulosa*, *Hibbertia racemosa*, *Stylidium androsaceum* and a variety of other taxa occurring at low frequency (Gibson *et al.* 1994).

Banksia attenuata woodlands are regionally rare. The community is restricted to the sands at the base of the Darling Scarp in the Forrestfield area and north of Perth in the Koondoola area on the Perth Swan Coastal Plain 2 IBRA Region and the Chittering area on the Dandaragan Plateau Swan Coastal Plain 1 IBRA Region. It is likely that there has been a severe decline in the area of the *Banksia attenuata* woodlands due to land clearing on the Swan Coastal Plain.

The community was only known from about 120 ha in 1996. Further survey work has since identified a total of about 585 ha, and includes 290.5 ha in Crown reserves, 270.5 ha freehold, 19.2 ha public roads, and 4.7 unallocated Crown land. The remaining areas of the community comprise highly fragmented occurrences, some of which would historically have been contiguous, but are now separated as a consequence of clearing (e.g. occurrences 20-21, 39-42, 51 and 55). Approximately 366 ha (62%) of the community type is found in conservation reserves (165 ha in nature reserves and 201 ha in reserves managed for conservation by local government authorities). The remaining 219 ha is on private property and on reserves vested in other authorities.

The majority of the community is in 'very good' condition or better, and the remainder is in 'good condition' (as defined in Bush Forever 2000 Vol 2).

In a re-assessment of the status of the *Banksia attenuata* woodlands in 2014 the Threatened Ecological Community Scientific Committee recommended that the community retain its endangered ranking. This was partly because many recommendations held in Bush Forever that would increase the protection of the community had not yet been implemented.

Forty five occurrences covering about 433 ha are within Bush Forever sites and are proposed to be provided increased protection through reservation or through other planning processes. Occurrences 1-4, 6-29, 34-35, 38-41, 44 (part), 45-47, 51, 54-57, 64, 66, and 74 are included in Bush Forever, in areas of 'regionally significant bushland to be retained and protected forever' (Bush Forever 2000). Additional occurrences not included in Bush Forever occur on private property, or on local government reserves, and were identified after the publication of Bush Forever, and/or are outside of the boundary covered by Bush Forever. The Bush Forever document recommends that any proposals likely to affect occurrences of threatened ecological communities will be dealt with through the 'Bush Forever planning process', coordinated by the WA Planning Commission. Bush Forever (page 6 Vol. 1) states a 'Presumption against clearing' for bushland that contains TECs.

The most significant threats to the community are land clearing for roads, housing and related infrastructure, too frequent fire, weeds, sand quarrying and hydrological change. With many of the occurrences occurring within the greater Perth metropolitan area, the frequency of fires, impact of recreational users, weed invasion and incidence of illegal rubbish dumping are generally increased. These factors can all lead to degradation of vegetation and alteration of structure, species composition or loss of component taxa.

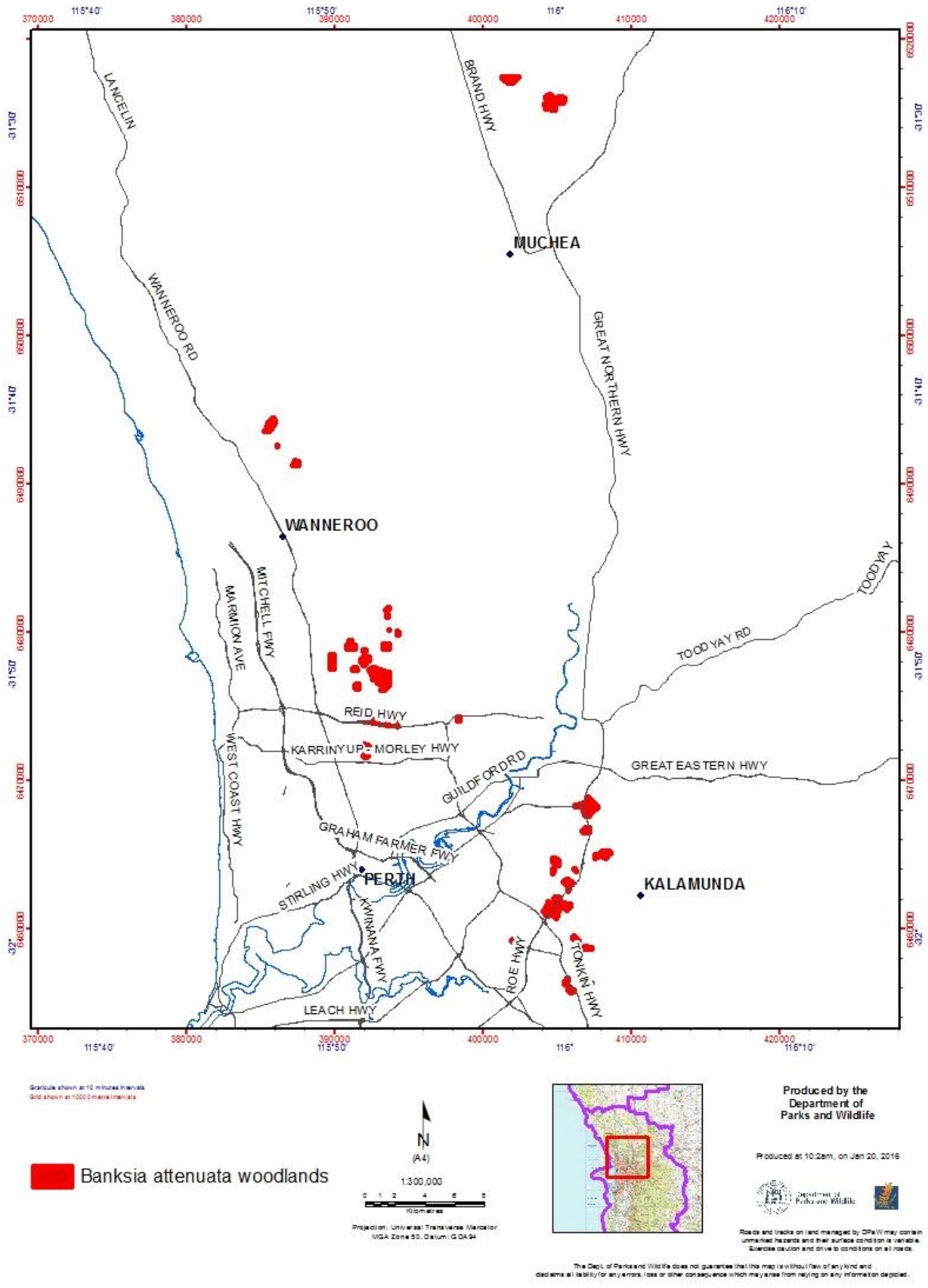

Figure 1: Location map

1.2 Habitat critical to survival, and important occurrences

The habitat critical to the survival of *Banksia attenuata* woodlands is the area of occupancy of known occurrences, the sandy soils on which the community occurs, the fresh superficial groundwater that probably helps to sustain key dominant trees in this community, and the catchment for this groundwater.

Occurrences that provide for representation of the community across its geographic range and that can be managed for conservation and/or with conservation included in their purpose are considered critical to the survival of this community.

All areas of the community within Bush Forever sites, and relatively large intact areas of the community that are in good condition outside of Bush Forever and that can be managed for conservation and/or with conservation included in their purpose are important occurrences (Occurrences 1-35, 40-41, 43-47, 51-52, 54-57, 64-66).

Recovery actions include survey for further occurrences that may lead to the identification of additional important occurrences.

1.3 Related biodiversity impacts and benefits

Recovery actions implemented to improve the quality or security of the community are likely to improve the status of any species within the community. Three declared rare (threatened) flora (DRF) taxa are associated with this community (Table 1). *Conospermum undulatum* is frequently recorded in southern occurrences, *Chamelaucium* sp. Gingin occurs within occurrence 5 and *Macarthuria keigheryi* occurs within occurrences 2 and 14. Ten Priority flora are also found in the community (Table 1).

Table 1: Threatened and priority flora taxa that occur in the TEC

Species name	Conservation status (WA)	Conservation status (EPBC Act)
Banksia pteridifolia subsp. *vernalis*	P3	-
Chamelaucium sp. Gingin	DRF (VU)	EN
Conospermum undulatum	DRF (VU)	VU
Haemodorum loratum	P3	-
Hypolaena robusta	P4	-
Isopogon drummondii	P3	-
Jacksonia sericea	P4	-
Macarthuria keigheryi	DRF (EN)	EN
Persoonia sulcata	P4	-
Persoonia rudis	P3	-
Platysace ramosissima	P3	-
Schoenus griffinianus	P4	-
Schoenus pennisetis	P3	-

CR = critically endangered; EN = endangered; VU = vulnerable

Other TECs and PECs (described in Gibson *et al*. (1994), Griffin (1994) and Keighery and Trudgen (1992)) that are found in bushland adjacent to occurrences of the *Banksia attenuata* woodlands are as follows:

- *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain' (critically endangered in WA, endangered under EPBC Act)
- *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' (critically endangered in WA, endangered under EPBC Act)
- Shrublands and woodlands of the eastern side of the Swan Coastal Plain (critically endangered in WA, endangered under EPBC Act)
- Southern wet shrublands, Swan Coastal Plain (endangered in WA)

- *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain (endangered in WA)
- *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain (vulnerable in WA)
- *Banksia ilicifolia* woodlands (Priority 3)
- *Banksia* woodland of the Gingin area restricted to soils dominated by yellow to orange sands (Priority 2).

Threatened, specially protected and priority fauna that occur within and close to occurrences of the *Banksia attenuata* woodlands include:

- *Bettongia penicillata ogilbyi* (woylie) (critically endangered)
- *Calyptorhynchus latirostris* (Carnaby's cockatoo) (endangered)
- *Calyptorhynchus baudinii* (Baudin's Cockatoo) (endangered)
- *Calyptorhynchus banksia naso* (forest red-tailed black cockatoo) (vulnerable)
- *Dasyurus geoffroii* (chuditch) (vulnerable)
- *Hylaeus globiluferus* (a native bee) (Priority 3)
- *Neelaps calonotos* (black-striped snake) (Priority 3)
- *Tyto novaehollandiae novaehollandiae* (southern masked owl) (Priority 3)
- *Macropus Irma* (western brush wallaby) (Priority 4)
- *Synemon gratiosa* (graceful sun moth) (Priority 4)
- *Isoodon obesulus fusciventer* (quenda) (Priority 4)
- *Falco peregrinus* (peregrine falcon) (other specially protected fauna)
- *Merops ornatus* (rainbow bee-eater) (other specially protected fauna)

Recovery actions implemented to improve the quality or security of *Banksia attenuata* woodlands are likely to also benefit the threatened and priority flora populations, threatened and priority fauna and occurrences of other TECs and PECs that occur within or close to the community.

1.4 Biological and ecological characteristics

Plant taxa that commonly occur in the community are listed at Appendix 1. The mean species richness for seven quadrats in the community surveyed by Gibson *et al.* (1994) was 67.4 species in 100 square metres. This is higher than subgroup 20b (62.7 species) or 20c (64). An average of one weed species was also recorded per quadrat in the Gibson *et al.* (1994) study, which is lower than that found in Swan Coastal Plain community types 20b or 20c, and represents a low level of weed invasion. This summary floristic information does not include data for many additional occurrences on the threatened ecological communities database. Although the floristic community type of some of the occurrences listed in Appendix 2 has not been fully verified through analyses of quadrat data, the sites are considered to be the *Banksia attenuata* woodlands over species rich dense shrublands as they were once part of contiguous bushland areas identified as the community but are now separate occurrences as a consequence of land clearing, or based on analyses of key taxa and habitat features by experienced staff from Department of Parks and Wildlife or by environmental consultants.

The following is mainly an extract from Gibson *et al.* (1994), with additional information from data collected after 1994. "Community type 20 occurs from Koondoola south to Yarloop. Sites in this community type were generally *Banksia attenuata* woodland, *Eucalyptus marginata – Banksia attenuata* woodlands or shrublands. The three subgroups of this community type share high frequencies of species in species group O with community type 28 which encompasses much of the *Banksia* woodland sites on Spearwood Dunes. However this community lacks most species of group A which are common on the Spearwood System."

Sites in *Banksia attenuata* woodlands were found on sandy soils near Koondoola and also the base of the Scarp at Forrestfield covering two distinct land form units, Southern River Unit (part of the Bassendean system), and Karrakatta unit (part of the Spearwood system). The Environmental Geology series (Gozzard

1986) also places the sites north of Perth on the Spearwood Dunes. Structurally this community was recorded as either *Banksia attenuata* woodlands or *Eucalyptus marginata – Banksia attenuata* woodlands by Gibson *et al.* (1994), but additional structural units have since been identified that do not necessarily include *Banksia attenuata,* and can include *Corymbia calophylla* as a dominant in the overstorey. This group is the richest of any of the *Banksia* communities recorded, with an average species richness of 67.4 species/site. Weed frequency was low and the community was distinctive in having a diverse shrub layer and *Mesomelaena pseudostygia* occurs in all plots established in the type for Gibson *et al.* (1994) and surveys completed for Bush Forever (Keighery *et al.* 2012; Government of Western Australia 2000). Sites of *Banksia attenuata* woodlands are differentiated from the other two subgroups by occurrence of species such as *Alexgeorgea nitens, Daviesia nudiflora, Synaphea spinulosa, Hibbertia racemosa, Stylidium androsaceum* and a variety of other taxa at low frequency. These unusual *Banksia* woodlands were previously identified by Keighery and Trudgen (1992) and Keighery and Keighery (1992).

1.5 Soils

Banksia attenuata woodlands have been recorded from six different landform and soil types as defined by Churchward and McArthur (1978).

Twenty six occurrences are located on the Southern River aeolian deposit. This is described as 'Sandplain with low dunes and many intervening swamps; iron and humus podzols, peats and clays' (Churchward and McArthur 1978).

Twenty occurrences are on the Karrakatta Aeolian deposits. These are described as 'undulating landscape with deep yellow sands over limestone' (Churchward and McArthur 1978). Karrakatta sands are further described in Department of Conservation and Environment (DCE, 1980), as one of the ridges formed parallel to the coast that overlies Tamala limestone that is overlain by leached sand. This sand is said to be likely to be the decalcified remnants of the Pleistocene lime sand dunes. This aeolianite (wind deposited) limestone is mainly composed of shell fossils and quartz sands that formed ancient dune systems. These dunes were then believed to have been leached by percolating ground water and lithified by precipitation as lime cement (DCE 1980). The sands are composed of fine to coarse quartz grains, with some patches of calcareous sand remaining. The sands are typically off-white to grey, grading through buff to deep yellow where they occur close to limestone.

Fifteen occurrences are on the Forrestfield unit of the Ridge Hill Shelf. This is described as 'laterised foothills of the Darling Scarp dominated by gravely and sandy soils' (Churchward and McArthur 1978). This area consists of coalescing alluvial fans at the bottom of the scarp and remnants of marine terraces (Ecologia Environmental Consultants 1991). The Forrestfield Unit consists of a belt one to three kilometres wide between the Darling and Gingin Scarps and the Darling Fault, from Walyunga National Park to Harvey. This system has been extensively cleared for agriculture, mining, forestry, and urban development. Only nine percent of the original area of the unit remained uncleared in the Perth Metropolitan Region in 2000 (Bush Forever 2000).

Two occurrences are located on the Guildford Unit of the Fluviatile Deposit group as mapped by Churchward and McArthur (1978). The soils are otherwise known as the Guildford clays. The Guildford Unit is also part of the Pinjarra Plain System and constitutes most of the Pinjarra Plain. The Guildford Unit is found in flat terrain with medium textured deposits and yellow duplex soils of sandy loams over clay (Churchward and McArthur 1978). Only six percent of the original area of the unit remained uncleared in the Perth Metropolitan Region in 2000 (Bush Forever 2000).

Two occurrences are located on the Coonambidgee fluviatile deposit which is described as 'gently sloping fringe to the Dandaragan Plateau; deep grey sands' (Churchward and McArthur 1978).

The remaining occurrences are located on the Bassendean Complex (central and south). The Bassendean sands are defined as 'sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes' (Churchward and McArthur 1978). Bassendean sands are further described in DCE (1980) as a series of dunes that are parallel to the coast and inland of the Tamala Limestone. The sands are generally fine to medium grained, but coarse in places. The soils form a 15km wide zone between the Pinjarra Plain and the coastal belt and consist of low hills of quartz sand with seasonal swamps.

1.6 International obligations

This plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993, and will assist in implementing Australia's responsibilities under that convention. The *Banksia attenuata* over species rich dense shrublands community is not listed under any specific international treaty, however, so this plan does not affect Australia's obligations under any other international agreements.

1.7 Affected interests

Parties affected by the implementation of this plan include Parks and Wildlife's Swan Coastal and Perth Hills districts and Swan Region who manage nature reserves and other conservation lands that contain occurrences of the TEC; numerous private landholders; the cities of Canning, Gosnells, Stirling, Swan and Wanneroo and shires of Chittering and Kalamunda who own land that contains occurrences of the TEC. All of these parties have been informed of the importance of the TEC and will be involved in implementation of this IRP.

1.8 Indigenous interests

The South West Aboriginal Land and Sea Council (SWALSC), an umbrella group, covers the areas considered in this plan. According to the Department of Aboriginal Affairs, Aboriginal Heritage Sites Register there are a number of registered sites known to occur in or near occurrences of these *Banksia attenuata* woodlands. There are art sites in the vicinity of occurrences 6, 9, 16, 19, 20, 21, 30, 38, 40 and 41. There is a scarred tree site in the vicinity of occurrence 26, and an unspecified site near occurrence 8. A site called 'Emu Swamp' occurs near occurrence 3 and two occurrences are within Bennett Brook Registered site. Occurrences 7, 29, 60-63, 66, and 70-74 are within the site registered as Poison Gully Creek. Comment was sought from the Council about any aspects of the plan, but particularly about the proposed on-ground actions. Action 1 identifies the intention to continue liaison with relevant groups, including indigenous groups.

1.9 Social and economic impacts and benefits

The implementation of this recovery plan has the potential to have some social and economic impact as some occurrences are located on private property, or in areas not specifically managed for conservation, such as open space, local government reserves and reserves for other purposes. Areas on private land and other areas not specifically managed for conservation including those outside of Bush Forever sites may be regarded as having potential for uses other than conservation by landholders. Approaches that may minimise this potential impact could include covenants, management agreements or land acquisition. There is a mineral tenement in the vicinity of occurrence 5 in the Shire of Chittering, and existing open cut sand quarries in the immediate vicinity of occurrence 9. Recovery actions refer to continued liaison between stakeholders with regard to these areas. Development proposals are imminent over occurrences 37, 38, 53, 68, 69 and 75 and occurrences (or part occurrence) 12, 34, 39-42, 48, 51 and 58, may be targeted for development in the mid-term future.

1.10 Guide for decision-makers

Proposed developments in the immediate vicinity of *Banksia attenuata* woodlands require assessment. Activities that may have a significant impact on the community include land clearing, too frequent burning, or significantly altering drainage in the immediate vicinity of the community may require assessment. Proponents should demonstrate that on-ground works will not have a significant impact on the community, or on the habitat that is defined as being critical for its survival.

1.11 Conservation status

The *Banksia attenuata* woodlands community was endorsed by the WA Minister for Environment in 2001 as meeting the following criterion for endangered (EN) ecological communities:
B) Current distribution is limited, and:

iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.

[*The* Banksia *woodlands of the Swan Coastal Plain were listed as a TEC under the EPBC Act on 16 September 2016. The listing encompassed a suite of WA TECs and PECs including the* Banksia *woodlands over species rich dense shrublands. The key diagnostic characteristics, condition and size thresholds in the Approved Conservation Advice should be applied to check if particular patches align with the Banksia woodlands of the Swan Coastal Plain TEC.*]

2 Threatening processes

Clearing

Although many occurrences are included in Bush Forever, actions recommended under Bush Forever have not yet been implemented for many areas, and security is not yet assured. Most of the Bush Forever sites are surrounded by urban development. Some parts of Bush Forever sites are likely to be targeted for clearing for road widening, or infrastructure such as installation of transmission line easements and access.

The presence of TECs is considered by the Department of Environment Regulation when evaluating the impact of proposed developments. As a result of amendments to the *Environmental Protection Act 1986*, any clearing of native vegetation requires a permit, unless done for an exempt purpose. Threatened ecological communities have been defined under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, as environmentally sensitive areas and any clearing proposals in a TEC are to be undertaken under a specific permit unless exempted under the Act itself.

There is generally no real security of tenure for sites outside of Bush Forever, and a series of areas are proposed for development. Occurrences 37, 38 and 48 are to be cleared for development. Part of Occurrence 34 is planned for infrastructure including a power substation. Occurrence 12 is likely to be in the path of planned power grid infrastructure. Occurrence 58 is proposed to be partly cleared for the construction of a water storage tank. Occurrences 39-42 and 53 are within Main Roads WA road reserves, and are within the area that may be considered for future redevelopment of the junction of Roe and Great Eastern Highway bypass road. Some newly identified occurrences of this community are also subject to clearing, including occurrence 69 that has already been cleared, occurrence 68 that is within the proposed Perth-Darwin National Highway Swan Valley bypass corridor and occurrence 75.

Occurrences that have already been cleared include an occurrence that formerly covered 9.4ha in Wangara which was quarried and then developed into a light industrial area; 2.6ha in Landsdale which was cleared for the extension of Hepburn Avenue; and 0.4ha along Roe Highway Hazelmere which was cleared for development. Two other areas located in Dianella and High Wycombe were considered to be the community, but were cleared before they were included in the TEC database.

Disease

Dieback disease caused by *Phytophthora* species has the potential to impact the community, although it is not known if these particular *Banksia attenuata* woodlands are very susceptible to the disease. Elevated dry sands, are not particularly conducive to dieback, and the disease may not spread rapidly despite the number of highly susceptible species in the overstorey (Appendix 1). Dieback usually spreads much more slowly on the yellow and orange sands on which these *Banksia attenuata* woodlands generally occur than it does on grey nutrient poor soils of the Bassendean system. Regardless, even small, slow-moving infestations of dieback can be exacerbated by soil disturbance and movement, and may be significant in small areas of remnant vegetation. Dieback assessment and mapping has been conducted at ten occurrences (2, 3, 5, 6, 9, 18, 22, 23, 37, 39, 40-42). Infestations of *Phytophthora* were found at occurrences 2 (6.5ha), 37 (0.6ha), 39 (1.25) and 42 (0.43ha).

Dieback disease results in the loss of susceptible species and may result in altered composition and structure of vegetation. Infected areas will need to be mapped to help guide future management such as rehabilitation, treatment of priority areas with phosphite to control dieback, and closure of specific tracks where vehicle or foot access may spread or amplify disease impact. The risk of introduction and spread can be further minimised by ensuring good hygiene practices that involve the adequate washing down of any equipment used on or adjacent to the community and restricting access by vehicles, people and machinery

to dry soil conditions. Areas adjacent to infected areas, those downslope from infected areas and areas where access is not controlled are highly susceptible to dieback infestation.

Other disease causing pathogens can be mistaken for dieback when appropriate interpretation has not been undertaken. These include aerial cankers and the Australian honey fungus, *Armillaria* (white rot). These pathogens can be highly destructive and particularly *Armillaria* could be carried into bushland areas with mulch as it survives on dead plant material. A small patch of *Armillaria lubteobubalina* was detected in occurrence 3.

Myrtle Rust (*Puccinia psidii* s.l. syn. *Uredo rangelii*) is an airborne fungal disease that has the potential to infect many species of plants belonging to the family Myrtaceae (Department of Agriculture and Food 2015). It was first detected in a commercial nursery in eastern Australia in 2010. Dispersal of rust spores can occur through wind, honey bees, and via contaminated clothing, infected plant material and insect movement. A suite of Myrtaceae species occur in this community (Appendix 1) and are potentially vulnerable to infection by this disease if it is introduced into the State.

Altered fire regimes

There are few data available through which fire regimes that enhance/protect the composition of *Banksia attenuata* woodlands can be elucidated, so that what actually constitutes an appropriate fire regime will require investigation. It seems likely that fire regimes such as long periods of fire exclusion, sustained frequent burns, and post-fire grazing (eg by rabbits) will be detrimental to the community. Many of the occurrences of this community are within the Perth urban area, and have been burnt relatively frequently in recent years. Brundrett and Longman (2015) are currently studying the effects of hot summer wildfire on plant diversity and have documented the timing and method of recovery of some species in *Banksia* woodland. Early results on comparisons of diversity, density and cover of native and weed species pre and post fire show that nine months following a hot wildfire, the total number of native plant species pre and post fire was similar, however composition had altered with the biggest change being in weed diversity post fire.

Burrows (2008) notes that there is no single optimum fire regime that will meet all management objectives, but that there are fire regimes that can be applied based on available evidence. Burrows (2008) recommends fire regimes based on vital attributes, regimes that provide for diversity of frequency, season and intensity, and provide habitat diversity, and a fine-grain mosaic of habitats. Burrows (2008) suggests that if these fire regimes are implemented in an adaptive management framework, they provide good data and can lead to better fire management.

Burrows *et al.* (2008) recommended a minimum period between fires that are lethal to fire-sensitive plants (obligate seeders with long juvenile periods) of at least twice the juvenile period of the slowest maturing species. That is, the juvenile period of plant taxa that are killed by fire and only reproduce from seed can be used as a guide to determine minimum inter-fire intervals. In fire sensitive habitats, this may be increased to 3-4 times the juvenile period for fire sensitive species (Barrett *et al.* 2009).

The juvenile period of many species that occur in the community is listed in Appendix 1. Although the juvenile periods of many taxa are not known, the data included in Appendix 1 can be used as a guide. In the case of this community, *Petrophile macrostachya* is a serotinous species that is killed by fire and only reproduces from seed. The juvenile period is 60 months, therefore a minimum inter-fire interval of ten years, and up to 20 years would be recommended for occurrences that contain this species. The juvenile period for other taxa that are unlikely to survive fire in the *Banksia attenuata* woodlands is also quite long. For example, *Eremaea pauciflora, Patersonia occidentalis* and *Gompholobium tomentosum* have juvenile periods of 48, 36 and 31 months respectively. Other species that are likely to survive fire also have long juvenile periods. These include *Banksia attenuata* and *Eucalyptus marginata* (both 48 months). These long juvenile periods should also be taken into account when designing appropriate fire regimes for this community.

A recent study by Wilson *et al.* (2014) produced a model to assist development of suitable ecological burning regimes for *Banksia* woodlands and similar ecosystems. The study incorporated both flora and fauna responses to fire in *Banksia* woodlands on the Gnangara Groundwater System in Perth's north metropolitan area. These guidelines estimated the ideal age class distribution at a landscape level to aid the determination of the maximum and minimum fire intervals of crucial fire response species.

Drying climate also needs to be considered when designing appropriate fire regimes. It is likely that reduced rainfall will cause diminishing growth rates, and plant maturation times may also therefore increase. Longer inter-fire intervals are therefore likely to be desirable.

Disturbances within remnants often lead to an increase in weed invasion, particularly where remnants are small. Therefore, fire frequency should be minimised unless studies indicate that fire is not occurring frequently enough. In addition, the risk of fire is increased by the presence of grassy weeds in the understorey, as they are likely to be more flammable than the original native species in the herb layer. The increased number of fires may well be impacting the community in terms of structure, composition and level of weed invasion. Areas that have been recently burnt should be monitored to determine if weed control is required. Monitoring the general floristics of as many sites in comparatively good condition as possible is also required to elucidate the community's response to fire.

Disturbance due to recreational use and maintenance activities

Many occurrences are in areas utilized heavily for public recreation where visitation is high and the impact from recreational users from trampling, rubbish and track creation is increased. Parts of occurrences 10-11 and 33-34 have also been used as unofficial rubbish tips. Apart from being visually unappealing, rubbish, in particular garden waste, introduces weeds and seeds into the bushland and increases the fire hazard.

Almost all occurrences would be expected to be affected by firebreak construction and maintenance as they occur in small vegetation remnants. It is important to construct and maintain firebreaks, however this should be strategic and will need to be undertaken with minimal disturbance to the vegetation.

Weed invasion

In a recent study of *Banksia* resilience to climate change, weed invasion was shown to be a major factor influencing local extinctions of *Banksia* spp. (Randell 2016). Current weed levels in most occurrences are still quite low, with the exception of some localized areas within occurrences that have been subject to heavy disturbance historically. Many sites are burnt relatively frequently in fires that are deliberately lit by arsonists, and have suffered increased weed invasion as a consequence (eg occurrences 3, 10, 11, 13 and 46). Most of the occurrences of this community are close to or surrounded by urban areas that act as weed sources, and would be vulnerable to weed invasion following any disturbance. Common weeds in occurrences include *Aira caryophyllea, Ehrharta calycina, Vulpia* sp. and *Gladiolus caryophyllaceus*.

Hydrological change

The *Banksia attenuata* woodlands are deep-rooted perennial vegetation and include eucalypts and banksia species that are considered facultative phreatophytes; species that utilise groundwater when rainfall and surface water are unavailable. The component understorey of the *Banksia attenuata* woodlands comprise shrubs, herbs, sedges and grasses that utilise moisture at varying depths and are not dependent on specific hydrological conditions (Sommer and Froend 2011).

Banksia attenuata woodlands are one of a number of groundwater dependent ecosystems in southwestern Western Australia that are threatened by groundwater abstraction (Sommer and Froend 2011), and in addition to this threat, is an ongoing decline in regional water tables due to a drying climate. These groundwater dependent communities are generally adapted to natural fluctuating groundwater levels,

however, a sudden drawdown may exceed their adaptive capacity. Coupled with long-term climatic drying, groundwater drawdown may cause the rate of groundwater decline to exceed potential root reach or growth rate, or physiological tolerance (Sommer and Froend 2011).

These *Banksia attenuata* woodlands are likely to rely on groundwater for survival. If abstraction of groundwater or developments that may otherwise impact groundwater quality or levels are planned in areas near the community, the following issues should be considered:

- natural patterns of recharge should be maintained;
- seek to minimise disruption to groundwater levels; and
- seek to maintain groundwater quality.

There are a series of bores listed in the Department of Water's Groundwater Information System (DoW 2015) located close to or within occurrences of the community, for which data can be extracted to determine groundwater levels over a long period of time. Some data indicate that static water levels are well below the natural ground surface when bores were drilled. There are additional data for some of the areas where the community occurs and these data would be a useful indicator for further field analyses to determine water levels and quality in this community. Groves (2014) used available data from the Water INformation (WIN) database to assess risk to three *Banksia* woodland types located on the Swan Coastal Plain between Pinjar and Serpentine, and determined trends in the water table levels in the superficial aquifer for the years 1990-2011. Figure 2 taken from Groves (2014) indicates groundwater levels for Koondoola Regional bushland, the largest occurrence of these *Banksia attenuata* woodlands. The data shows an increasing depth to groundwater level over the past 20 years. Groves (2014) noted that increasing groundwater abstraction and reductions in rainfall in the region will likely continue to cause groundwater levels to continue to decline into the future. Continued groundwater decline also has the potential to change the composition and structure of the *Banksia attenuata* woodlands from deep rooted to shallow rooted plant species.

Quarrying

The yellow sands commonly associated with this community are a focus for quarrying. Existing open cut sand mines occur in the immediate vicinity of occurrences 9, 24, 25-28, 44, 55 and 57.

Grazing

Rabbits have invaded a number of occurrences, causing damage to vegetation root structure through warren construction. Rabbits are likely to cause alteration to species composition by selective grazing of edible species and introducing nutrients that promote weed growth. Grazing is likely to impact the establishment of young plants and limit natural recruitment. Rabbits also spread weeds, and seedlings are frequently seen germinating next to rabbit droppings, indicating they are a major vector for weeds (Brundrett and Longman 2015).

3 Recovery objectives and criteria

IRP Objective(s): To maintain or improve the overall condition of the *Banksia attenuata* woodlands over species rich dense shrublands in the known locations and reduce the level of threat with the aim of ensuring it does not meet criteria for a higher threat rank.

Criteria for success:

- an increase in the number of occurrences of this community managed for conservation and/or with conservation included in the purpose over the life of the plan.
- representative areas of the community across its geographical range maintained in the same or improved condition (Bush Forever condition scales) over the life of the plan.
- 90% or more of the aerial extent of occurrences maintained at the same condition rank, or improved over the life of the plan, excluding effects of drying climate that are outside the scope of this plan.

Criterion for failure:

- decline in condition rank of 10% or more of the aerial extent of the community over the life of the plan, excluding effects of drying climate that are outside the scope of this plan or
- failure to achieve an increase in the area managed for conservation over the life of the plan.

4 Recovery Actions

The responsible authority is frequently listed as the relevant Parks and Wildlife District. This refers largely to initiating and guiding actions. In general the relevant Parks and Wildlife District, in liaison with Species and Communities Branch and the relevant recovery team share the primary responsibility for securing funds for recovery and coordinating the implementation of recovery actions.

Completed actions

Relevant managers of lands that contain the *Banksia attenuata* woodlands have been notified of the importance of the community.

The extent and boundaries of all accessible occurrences have been mapped.

A biodiversity strategy that details recovery actions for all reserves managed by the City of Wanneroo is in place (City of Wanneroo 2011). The City of Wanneroo has management plans that specifically detail recovery actions for;

- Koondoola Regional Bushland, that contains occurrence 3 (City of Wanneroo 2008),
- Montrose Conservation Reserve, that contains occurrence 31 (City of Wanneroo 1995a),
- Highview Park, that contains occurrences 35 and 36 (City of Wanneroo 1995b),
- Marangaroo Conservation Reserve, that contains occurrence 1 (City of Wanneroo 1990).

Community groups in the City of Wanneroo assist in managing areas that contain the *Banksia attenuata* woodlands including: Koondoola Regional Bushland, Landsdale Park, and Marangaroo Conservation Reserve.

A biodiversity strategy is in place for areas of this community managed by the Shire of Kalamunda, (Shire of Kalamunda 2008), City of Swan (City of Swan 2015), City of Gosnells (City of Gosnells 2010). The City of Stirling has developed management plans for regionally significant conservation reserves. The City of Canning considers natural bushland as key assets that they actively manage with the support of friends groups. An Environment Management Plan has been prepared for Telstra Corporation to oversee management of the community at Cullacabardee (BSD Consultants Pty Ltd 2002).

Negotiations with land owners have resulted in the transfer of a number of occurrences to more secure tenure purposed for the conservation of flora and fauna. Occurrence 6 that was previously privately owned freehold land is now a Class A nature reserve. Occurrence 5 previously Crown freehold is now a Class C nature reserve managed by Parks and Wildlife. Occurrences 3, 33 and 43 previously freehold land are now Crown reserves vested with the City of Wanneroo. Occurrence 29 previously privately owned freehold land is now a reserve for the conservation of flora and fauna managed by the Shire of Kalamunda. Freehold land that accounts for around half of occurrence 34 is now a reserve for the conservation of flora and fauna managed by the City of Swan. Lots 30-31, 43-44 and 63 within Crown Reserve 37997 (part of Occurrence 2), previously managed by WA Planning Commission was transferred to the Conservation Commission of WA (now the Conservation and Parks Commission) and is now managed by Parks and Wildlife for the protection of fauna and flora.

Actions recently completed for occurrence 2 include completion of fencing of reserves 37997 and 37260. Internal rabbit proof fencing, rabbit baiting, translocation (re-establishment) of *Macarthuria keigheryi* have been completed, and rehabilitation of degraded areas of Reserve 37997 has been initiated.

Edith Cowan University has initiated a PhD research project aimed at defining the habitat preferences for the *Banksia attenuata* woodlands and *Conospermum undulatum*. A survey of vegetation condition and

threatening processes coupled with this study will assist in developing a risk assessment framework to assist future management.

Recommended recovery actions

1. Liaise with stakeholders to implement recovery

Many of the occurrences are managed by authorities other than Parks and Wildlife, or are privately owned. Liaison with all land managers will be required in seeking conservation management and avoiding further loss or damage to the community. Indigenous groups will also be consulted about relevant on-ground actions in this plan.

Information about the community will continue to be provided by local Parks and Wildlife staff to all stakeholders including landholders and managers of land containing the community to help prevent accidental destruction of the community, and gain public support for its conservation. This will include information from the TEC database, maps indicating the location of the community, and this recovery plan.

Responsibility:	Parks and Wildlife (Swan Coastal District (SC) and Perth Hills District (PH)) and Species and Communities Branch (SCB))
Cost:	$2,000 per year
Completion date:	Ongoing

2. Seek to minimise further clearing of the community

Further clearing or destruction by other means, especially of areas of the community in good condition, will be minimised wherever possible by acquisition, negotiation, planning and provision of advice about the community to regulators assessing proposals that impact the community.

There is approximately 433 ha of *Banksia attenuata* woodlands recorded on the TEC database that is within Bush Forever sites however a suite of recommendations held in Bush Forever have not yet been implemented (parts or whole of occurrences 1, 8, 14, 16 and 17).

Responsibility:	Parks and Wildlife (SC, PH and SCB), relevant local authorities, Department of Planning and the Department of Environment Regulation
Cost:	Costs included in action 1, other costs to be determined
Completion date:	Ongoing

3. Verify occurrences as required

There is a suite of occurrences that are considered to be the *Banksia attenuata* woodlands based on key combinations of component taxa and habitat features and the identity of these, and any other potential occurrences, should be confirmed where possible (occurrences 11, 13, 43). Quadrats will need to be installed as per methods in Gibson *et al.* (1994) and appropriate statistical analyses completed to assign the community type. In addition, in some cases the analysis of quadrat data did not return conclusive results, and further investigation may clarify their identity. The TEC database will then be amended as required.

Responsibility:	Parks and Wildlife (SC, PH and SCB)
Cost:	$5,000 per year
Completion date:	Ongoing

4. Continue to monitor the extent and boundaries of occurrences

To date many of the occurrences have been manually mapped or mapped using aerial photographs. Extent and boundary information will continue to be updated on the TEC database.

Responsibility:	Parks and Wildlife (SC, PH and SCB)
Cost:	$3,000
Completion date:	Ongoing

5. Install markers

To reduce the likelihood of accidental destruction, Parks and Wildlife will encourage land managers to mark roadside occurrences of threatened ecological communities, and occurrences located on tracks or firebreaks, with the same pegs as used to mark threatened flora. These will be placed about 50 m either side of the boundaries of the community to provide a protective buffer.

Responsibility:	Parks and Wildlife (SC, PH)
Cost:	To be determined
Completion date:	Ongoing

6. Encompass monitoring in an adaptive management framework

A monitoring program will be established for a representative subset of the *Banksia attenuata* woodlands and management practices. A quantitative method such as the line intercept will be used, which will consist of installing a transect or number of transects, and/or utilising the permanent plots already in place from the Gibson *et al.* (1994) survey wherever possible. Monitoring protocols will be based on those developed through the Resource Condition Monitoring project (Clarke 2009, and Brown and Clarke 2009). The monitoring will be linked to areas where active management or impacts are anticipated, so analysis of results can be incorporated to improve management of fire, hydrology, grazing by native or feral animals, weed invasion, disease and other factors, as is recommended for an adaptive management framework.

The occurrences will be monitored every five years, or following a disturbance event such as fire to provide information on condition and response to environmental variables. Data collected will then be entered on to a database and analysed. The results of data analyses will be added to the TEC database. This information is essential for determining changes in the community over time and the effects of specific events such as fires.

The limits of tolerance to change in water levels and quality are not known and will only be determined through the application of an adaptive management framework. Hydrology will be examined with detailed quantitative monitoring of floristic composition and structure linked to areas where there is likely to be significant change in groundwater levels or quality.

Remote sensing data such as 'Vegetation Trend' from Landsat TM provides a coarse measure of change in vegetation cover. The interpretation of these data requires ground truthing as factors such as recovery from fire may not otherwise be evident. This remote sensing method may be suitable for some aspects of monitoring in future.

Responsibility:	Parks and Wildlife (SC, PH)
Cost:	$6,000 every fifth year
Completion date:	Ongoing

7. Implement weed control and rehabilitation as required

Weed control plans will be developed for areas of bushland that contain the community and will be based on information from weed mapping. Plans will identify the highest priority weeds that pose the greatest threat to the community in the early stages of invasion. Appropriate methods of weed control are found in Brown and Brooks (2002) and Brown and Bettink (2009). Methods may include hand weeding or localised application of herbicide. The herb layer is an integral part of this plant community and care will be taken to minimise disturbance of native herbs in any weed control program.

Rehabilitation through reintroduction of local native species may be necessary if areas are no longer capable of regenerating following weed control. Piles of weed-contaminated soil in any occurrences should be removed and the areas replanted. Tracks excess to requirements should be left to revegetate naturally. Seed from the same occurrence should ideally be used for rehabilitation but this may not be practical, in particular where species richness of sites is depleted. Where seed from the site is not available, seed from nearby occurrences of the local species should be used.

Highest priorities include maintenance and control of perennial/annual grass weeds, including *Ehrharta calycina, Eragrostis curvula* and *Vulpia* sp. (annual), the cormous Iridaceae *Gladiolus caryophyllaceu*s and cormous *Watsonia meriana* that have potential for significant impact. The highest priority occurrences to target for weed control are 2, 5, 6, 7, 51 and 55.

Local government authorities who manage land on which this community occurs, contribute substantially to weed control and rehabilitation.

Responsibility:	Parks and Wildlife (Swan Region(SR), SC, PH) in consultation with landholders, land managers)
Cost:	$10,000* per annum for weed control; rehabilitation costs to be determined
Completion date:	Ongoing

* Parks and Wildlife managed lands

8. Develop and implement a fire management strategy

There is an urgent need for research into the fire-response of the community, and to determine the implications of findings for management. This would also include developing a fire history map of the occurrences, which is updated annually. A fire management strategy will include recommendations on fire frequency, intensity, season, and control measures, including the location of fire-breaks in occurrences. Close liaison with all stakeholders will be required to develop a fire management strategy.

The outcomes of implementation of a particular regime on the composition and structure of the community should be quantitatively monitored and results and data analyses incorporated into an adaptive management framework.

Based on the fire response of one of the most fire sensitive taxa in the community, *Petrophile macrostachya,* a minimum inter-fire interval of ten years and up to 20 years is initially recommended for the community.

Drying climate also needs to be considered when designing appropriate fire regimes. It is likely that reduced rainfall will cause diminishing growth rates, and plant maturation times will also therefore increase. Longer inter-fire intervals will therefore be desirable.

Given the peri-urban location of most of the occurrences long-term fire exclusion is unlikely due to the frequency of wild fires in bushland with easy access close to human population centres.

Maintenance of existing firebreaks is appropriate where firebreaks are already constructed, unless maintenance is likely to cause spread or intensification of disease or otherwise degrade the community. Careful use of herbicides is the preferred method of maintenance of firebreaks to minimise soil movement and risk of disease spread in the community. No new firebreaks should be constructed in intact vegetation in occurrences. Local Parks and Wildlife staff should be involved in planning fire break construction and maintenance for the community.

Fire management or response plans are recommended especially for important occurrences. Fire fighting authorities need to recognise the importance of not constructing new tracks during their operations, including during wild fires. The use of heavy machinery to create new fire breaks within the community should be avoided where safe and practical to do so, to avoid further degrading the community.

A local Parks and Wildlife staff member will ideally be present during wild fires and controlled burns in remnants that contain occurrences of the community, to advise on protecting the conservation values of the community.

Responsibility:	Parks and Wildlife (SR, SC, PH); in consultation with all stakeholders
Cost:	$10,000 in first year and $5,000 each following year
Completion date:	Ongoing

9. Interpret and map disease areas

Data on dieback presence and impact, and future biodiversity implications such as loss or decline of threatened and/or priority taxa, or structurally or functionally important taxa, are likely to be important determinants of the priority of treatment of individual occurrences.

Areas of the *Banksia attenuata* woodland community affected by dieback should be mapped and treatment applied according to the Dieback Protocol (Dieback Working Group (2000)). Guidelines according to the Department of Parks and Wildlife's Policy statement No 3 Management of *Phytophthora* disease (2015c) will be followed.

Responsibility:	Parks and Wildlife
Cost:	$2,500 per year
Completion date:	Ongoing

10. Implement disease hygiene procedures

The disease susceptibility of the *Banksia attenuata* woodlands community is likely to vary greatly depending on local habitat and flora. Risk of introduction of disease will be minimized by ensuring good hygiene procedures. This will involve adequately washing down any equipment and footwear used near or in the *Banksia* woodland, and restricting access by vehicles and machinery to dry soil conditions. No vehicle access should be allowed onto areas of the *Banksia attenuata* woodlands.

Hygiene management plans should be prepared for all occurrences in conjunction with disease mapping (Action 9).

Responsibility:	Parks and Wildlife (SC, PH in consultation with landholders and land managers)
Cost:	$1,500 per year
Completion date:	Ongoing

11. Design and conduct research

Research will be designed to increase understanding of the biological and ecological characteristics of the community to assist future management. Research will ideally include:

1. Improving characterisation of the floristics of the *Banksia attenuata* woodlands;
2. Defining habitat preferences for the *Banksia attenuata* woodlands (and the rare flora taxon *Conospermum undulatum*) that is associated with numerous southern occurrences of the community;
3. Verifying vegetation condition and threatening processes in each occurrence; and
4. Utilising improved data on vegetation condition and threatening processes to develop a risk assessment framework to assist future management.

Responsibility:	Parks and Wildlife (Science and Conservation Division, SCD)
Cost:	TBD
Completion date:	Year 5

12. Seek long term protection of the community for conservation

If suitable areas containing the community and funding avenues become available, Parks and Wildlife will seek to acquire the remnants, including an adequate buffer as relevant, or otherwise ensure their protection. These areas will be protected through perpetual protection agreements (such as conservation covenants) or reserved as conservation reserves vested with the Conservation and Parks Commission.

A series of occurrences or part thereof, are in Bush Forever sites that are proposed for future conservation management (eg 20, 21, 40, 44, 46, 51, 54, 55, 57, 66, 70-74).

Responsibility:	Parks and Wildlife (SC, PH, SCB, Land Unit), in consultation with all stakeholders
Cost:	To be determined
Completion date:	Ongoing

13. Report on recovery plan implementation

Reporting will be part of annual reports prepared by the Recovery Team, and will include results of analysis of monitoring within an adaptive management framework. A final report will be presented as part of review and update of the recovery plan, if deemed necessary.

Responsibility:	Parks and Wildlife (SD, PH)
Cost:	$2,000 per annum
Completion date:	Year 5

Table 2. Summary of costs for each recovery action

Recovery actions	Year 1	Year 2	Year 3	Year 4	Year 5
Liaise with stakeholders to implement recovery	$2,000	$2,000	$2,000	$2,000	$2,000
Seek to minimise further clearing of the community	TBD	TBD	TBD	TBD	TBD
Verify occurrences as required	$5,000	$5,000	$5,000	$5,000	$5,000
Continue to monitor the extent and boundaries of occurrences	$3,000	$3,000	$3,000	$3,000	$3,000
Install markers	TBD	-	-	-	-
Encompass monitoring in an adaptive management framework		-	-	-	$6,000
Implement weed control and rehabilitation as required	$10,000	$10,000	$10,000	$10,000	$10,000
Develop and implement a fire management strategy	$10,000	$5,000	$5,000	$5,000	$5,000
Interpret and map disease areas	$2,500	$2,500	$2,500	$2,500	$2,500
Implement disease hygiene procedures	$1,500	$1,500	$1,500	$1,500	$1,500
Design and conduct research	TBD	-	-	-	-
Seek long term protection of the community for conservation	TBD	-	-	-	-
Report on recovery plan implementation	$2,000	$2,000	$2,000	$2,000	$2,000
Total	$36,000	$31,000	$31,000	$31,000	$37,000

TBD – to be determined

Total of all costs over five years (not including uncosted actions): $166,000

5 Term of plan

The plan will operate from 2016 to 2021 but will remain in force until withdrawn or replaced. It is intended that, if the ecological communities are still ranked endangered in Western Australia after five years, the need for further recovery actions and for an updated recovery plan will be evaluated.

6. References

Abbott, I. and Burrows, N. (eds.) (2003). Fire in ecosystems of south-west Western Australia: impacts and management. Bachhuys Publishers, Leiden, Netherlands.

Barrett, S., Comer, S., McQuoid, N., Porter, M., Tiller, C. and Utber, D. (2009). Identification and Conservation of Fire Sensitive Ecosystems and Species of the South Coast Natural Resource Management Region. Department of Environment and Conservation, South Coast NRM. Albany, Western Australia.

Bennett Environmental Consulting Pty Ltd (2008). Flora and Vegetation Bush Forever Site 401, Bougainvillea Avenue Forrestfield. Prepared for: MBS Environmental 4 Cook Street West Perth 6005.

Brown, K. and Brooks, K. (2002) Bushland weeds; a practical guide to their management. Environmental Weeds Action Network (Inc.), Western Australia.

Brown, K.L. and Bettink, K.A. (2009–) Swan Weeds: Management Notes, *FloraBase* — The Western Australian Flora. Department of Parks and Wildlife. https://florabase.dpaw.wa.gov.au/weeds/swanweeds/

Brown, K. and Clark, V.T. (2009). Monitoring Protocol: Weed control within Brixton Street Wetlands Herb Rich Shrublands in clay pans (FCT 8) Threatened Ecological Community. Department of Environment and Conservation, Western Australia.

Brundrett, M. and Longman, V. (2015). Recovery of *Banksia* woodland after fire *in* Wildflower Society of WA Newsletter May 2015. Wildlife Society of WA (Inc.).

BSD Consultants Pty Ltd (2002). Telstra PITC, Landsdale. Environment Management Plan. Unpublished report prepared for Telstra Corporation Ltd. Subiaco, Western Australia.

Burrows N.D. (2008). Linking fire ecology and fire management in south-west Australian forest landscapes. Forest Ecology and Management. 255: 2394–2406.

Burrows, N.D., Wardell-Johnson, G. and Ward, B. (2008). Post-fire juvenile period of plants in south-west Australia forests and implications for fire management. Journal Royal Society, Western Australia. 91: 163-174.

Churchward H.M and McArthur, W.M. (1978) Darling System Landform and Soils. Department of Conservation and Environment. Perth, Western Australia.

City of Gosnells (accessed 2016). Natural area management plans. http://www.gosnells.wa.gov.au/About_our_City/Environment/Caring_for_our_environment/Bushland/Natural_area_management_plans

City of Swan (accessed 2015). Our Conservation Estate. http://www.swan.wa.gov.au/Residents/Sustainable_Living/Conserve_Nature/Land/Focus_stories/Our_conservation_estate. Accessed June 2015.

City of Wanneroo (1990). Marangaroo Conservation Reserve Draft Management Plan. City of Wanneroo.

City of Wanneroo (1995a). Montrose Conservation Reserve Management Plan. City of Wanneroo.

City of Wanneroo (1995b). Highview Park Management Plan. City of Wanneroo.

City of Wanneroo (2008). Koondoola Regional Bushland Management Plan (July 2008). Prepared by Ecoscape for the City of Wanneroo.

City of Wanneroo (2008). City of Wanneroo Local Environmental Plan 2009-2014. Wanneroo Western Australia.

City of Wanneroo (2011). Local Biodiversity Strategy (2011-2016). City of Wanneroo.

Clarke, V. (2009). Monitoring the impacts of fire and Phytophthora within the shallow soil plant communities of the Mt Lindesay Threatened Ecological Community, Denmark WA. Unpublished report prepared for Significant Native Species and Ecological Communities – Resource Condition Monitoring Project. Department of Environment and Conservation, Perth.

Department of Agriculture and Food. https://www.agric.wa.gov.au/. Accessed June 2015.

Department of Conservation and Environment (1980). Atlas of Natural Resources Darling System Western Australia. Perth.

Department of Conservation and Environment (1983). Conservation Reserves for Western Australia as recommended by the Environmental Protection Authority - 1983. The Darling System, System 6. Part II: Recommendations for Specific Localities. Perth.

Department of Environment and Conservation (2013a). *Phytophthora* Disease Interpretation Report Dundas Nature Reserve. Perth, Western Australia.

Department of Environment and Conservation (2013b). *Phytophthora* Disease Interpretation Report Stirling Crescent TEC Site. Perth, Western Australia.

Department of Environmental Protection (1996). System 6 update program unpublished site and area records and analyses. Environmental Protection Authority, Perth, Western Australia.

Department of Parks and Wildlife (2015a). Corporate Policy Statement No. 35. Conserving Threatened Species and Ecological Communities. Perth, Western Australia.

Department of Parks and Wildlife (2015b). Corporate Guideline No. 35. Listing and Recovery of Threatened Species and Ecological Communities. Perth, Western Australia.

Department of Parks and Wildlife (2015c). Corporate Policy statement No 3. Management of *Phytophthora* disease.

Ecologia Environmental Consultants (1991). Bushmead Rifle Range Development Draft Environmental Impact Statement: Biological Survey. Unpublished report for Australian Property Group.

English, V. and Blyth, J. (1997a) Identifying and Conserving Threatened Ecological Communities in the South West Botanical Province. Project N702, Final Report to Environment Australia. Department of Conservation and Land Management. Perth, Western Australia.

English, V. and Blyth, J. (1997b) Development and application of procedures to identify and conserve threatened ecological communities in the South-west Botanical Province of Western Australia. Pacific Conservation Biology 5, 124-138.

Environmental Resources Management Australia (2004). Draft Report. Flora Survey Lot 15141 Alexander Drive, Malaga. Report prepared for LandCorp. Perth, Western Australia.

Froend, R., Sommer, B. (2010) Phreatophytic vegetation response to climatic and abstraction-induced groundwater drawdown: Examples of long-term spatial and temporal variability in community response. Ecol. Eng. 36: 1191-1200.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A and Lyons, M. (1994) A floristic survey of the Southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.).

Government of Western Australia (2000). Bush Forever. Department of Environmental Protection, Perth.

Gozzard, J.R. (1986). Perth Sheet 2034 II and part Sheets 2034 II and 2134 III, Environmental Geology Series. Geological Survey of Western Australia, Department of Minerals and Energy, Perth.

Groves, H. (2014). Predicted risk to *Banksia* woodlands in the Swan Coastal Plain in response to groundwater decline. Study completed for the WA Department of Parks and Wildlife in accordance with the hydrogeological industry placement for the completion of a Master of Hydrogeology degree at the University of Western Australia.

Heddle, E. M., Loneragan, O. W., and Havel, J. J. (1980). Vegetation Complexes of the Darling System, Western Australia. In Department of Conservation and Environment, Atlas of Natural Resources, Darling System, Western Australia

Griffin E.A. and Trudgen M.E. (2015 revised). Analysis of floristic data from Ioppolo Road and Hepburn Avenue to assign sites to floristic community types. Prepared for Coffey Environments. E.A. Griffin and Associates with M.E. Trudgen and Associates.

Griffin, E.A. (1994). Floristic survey of northern sandplains between Perth and Geraldton. Dept. of Agriculture Resource management technical report 144 South Perth.

Keighery, G.J. and Keighery, B.J. (1992). Plant Communities of the Northern Swan Coastal Plain – with Special Reference to Uncommon and Potentially Rare Plant Communities. In: Bushland in Our Backyard. Editors N. Gibson and B.J. Keighery. Wildflower Society of WA Inc., Nedlands.

Keighery, B.J. and Trudgen, M.E. (1992). The Remnant Vegetation of the Eastern Side of the Swan Coastal Plain. Unpublished report to the Department of Conservation and Land Management for the National Estate Grants Program.

PGV Environmental (2016). Description on the vegetation condition of remnant bushland of Lot 25 Victoria Road Kenwick on behalf of property owners. Statement to Parks and Wildlife. Unpublished document.

Randell, Sarah. (2016). Is Banksia resilient to climate change? Research Thesis dissertation Honours (Botany). The University of Western Australia. School of Plant Biology.

Shire of Kalamunda (2008). Local Biodiversity Strategy: Natural area planning in the Shire of Kalamunda (October 2008). The Shire of Kalamunda.

Sommer, B and Froend R (2011). Resilience of phreatophytic vegetation to groundwater drawdown: is recovery possible under a drying climate? J. Ecohydrol. 4: 67-82.

Tauss, C and Weston, A.S. (2010). The flora, vegetation and wetlands of the Maddington-Kenwick Strategic Employment Area. A survey of the rural lands in the vicinity of the Greater Brixton St Wetlands. Report to the City of Gosnells.

Tauss and Associates Biodiversity Consultants, (2015). Flora and Vegetation Survey of Dianella Bushland. Part 1 Gay St, Lot 13 Dianella Drive & Cottonwood Crescent BFS (City of Stirling) Western Australia.

Perth Airport Corporation (2014). Perth Airport Preliminary Draft Master Plan 2014. Perth.

Western Australian Local Government Association and Perth Biodiversity Project (2004). Local Government Biodiversity Planning guidelines for the Perth Metropolitan Region. West Perth.

Wilde, S.A. and Low, G.H. (1978). 1: 250,000 Geological Series – Map and Explanatory Notes. Perth Sheet SH50-14. Geological Survey of Western Australia. Perth.

Wilson B.A. Kuehs, J., Valentine, E., Sonneman, T. and Wolfe, KM., (2014). Guidelines for ecological burning regimes in Mediterranean ecosystems: a case study in *Banksia* woodlands in Western Australia. Pacific Conservation Biology Vol. 20(1)57-74. Surrey Beatty & Sons, Sydney.

Appendix 1: Vascular plants recorded from at least 40% of plots in occurrences (DEP 1996), including ecological characteristics of native flora commonly recorded in occurrences

Taxon	Fire response	Months to first flowering	Longevity	Dieback response
Alexgeorgea nitens			Perennial	
Allocasuarina humilis	Survives 100% scorch, basal sprouts	36	Perennial	Inferred high susceptibility
Amphipogon turbinatus	Survives 100% scorch, soil suckers	12	Perennial	Inferred evidence of resistance
Banksia attenuata	Survives 100% scorch, epicormics	48	Perennial	Inferred high susceptibility
Banksia menziesii	Survives 100% scorch, epicormics	24	Perennial	Some evidence of high susceptibility
Banksia dallanneyi			Perennial	
Bossiaea eriocarpa	Survives 100% scorch, basal sprouts	12	Perennial	Unknown
Burchardia congesta			Perennial	
Calectasia narragara			Perennial	
Caustis dioica	Survives 100% scorch, soil suckers	-	Perennial	Unknown
Conospermum undulatum (V)			Perennial	
Conostephium pendulum			Perennial	
Conostylis aurea	Survives 100% scorch, basal sprouts	24	Perennial	Unknown
Conostylis setigera	100% scorch kills, in soil seed storage	24	Perennial	Good evidence of resistance
Cyathochaeta equitans			Perennial	
Dampiera linearis	Survives 100% scorch, soil suckers	24	Perennial	Good evidence of resistance
Dasypogon obliquifolius			Perennial	
Dasypogon bromeliifolius	Survives 100% scorch, large apical bud	6	Perennial	Some evidence of variable susceptibility
Daviesia triflora			Perennial	
Daviesia divaricata			Perennial	
Daviesia nudiflora			Perennial	
Desmocladus fasciculatus			Perennial	
Drosera erythrorhiza	Geophyte (Survives 100% scorch)	11	Perennial	Good evidence of resistance
Drosera menziesii	Geophyte (Survives 100% scorch)	8	Perennial	Unknown
Eremaea pauciflora	100% scorch kills, in soil seed storage	48	Perennial	Unknown
Eucalyptus marginata	Survives 100% scorch, epicormics	48	Perennial	Good evidence of moderate susceptibility
**Gladiolus caryophyllaceus*			Perennial	
Gompholobium tomentosum	100% scorch kills, in soil seed storage	31	Perennial	Inferred evidence of resistance
Haemodorum laxum	Geophyte (survives 100% scorch)	6	Perennial	Inferred evidence of resistance
Hemiandra pungens	100% scorch kills, in soil seed storage	24	Perennial	Unknown
Hibbertia hypericoides	Survives 100% scorch, basal sprouts	22	Perennial	Unknown
Hibbertia huegelii			Perennial	
Hypolaena exsulca			Perennial	
Isopogon drummondii (3)			Perennial	
Lambertia multiflora	Survives 100% scorch, basal sprouts	24	Perennial	Unknown
Lomandra hermaphrodita			Perennial	
Lomandra sericea			Perennial	
Lyginia barbata	Survives 100% scorch, basal sprouts	21	Perennial	Inferred evidence of resistance
Mesomelaena pseudostygia	Survives 100% scorch, soil suckers	-	Perennial	Unknown
Monotaxis grandiflora			Perennial	
Patersonia occidentalis	100% scorch kills, in soil seed storage	36	Perennial	Inferred moderate susceptibility
Petrophile linearis	Survives 100% scorch, basal sprouts	25	Perennial	Unknown
Petrophile macrostachya	100% scorch kills, in soil seed storage	60	Perennial	Unknown
Philotheca spicata			Perennial	
Phlebocarya filifolia			Perennial	

Taxon	Fire response	Months to first flowering	Longevity	Dieback response
Scaevola repens			Perennial	
Stirlingia latifolia	100% scorch kills, in soil seed storage	24	Perennial	Unknown
Stylidium piliferum	100% scorch kills, in soil seed storage	12	Perennial	Unknown
Synaphea spinulosa			Perennial	
Tetraria octandra	Survives 100% scorch, soil suckers	12	Perennial	Unknown
Thysanotus sparteus	Survives 100% scorch, soil suckers	12	Perennial	Unknown
Trachymene pilosa	100% scorch kills, in soil seed storage	12	Annual	Unknown
**Ursinia anthemoides*	100% scorch kills, in soil seed storage	12	Annual	Unknown
Xanthorrhoea drummondii	Survives 100% scorch, large apical bud	6	Perennial	Unknown
Xanthosia huegelii	Survives 100% scorch, basal sprouts	32	Perennial	Unknown

All other data sourced from NatureMap (accessed, 2014)

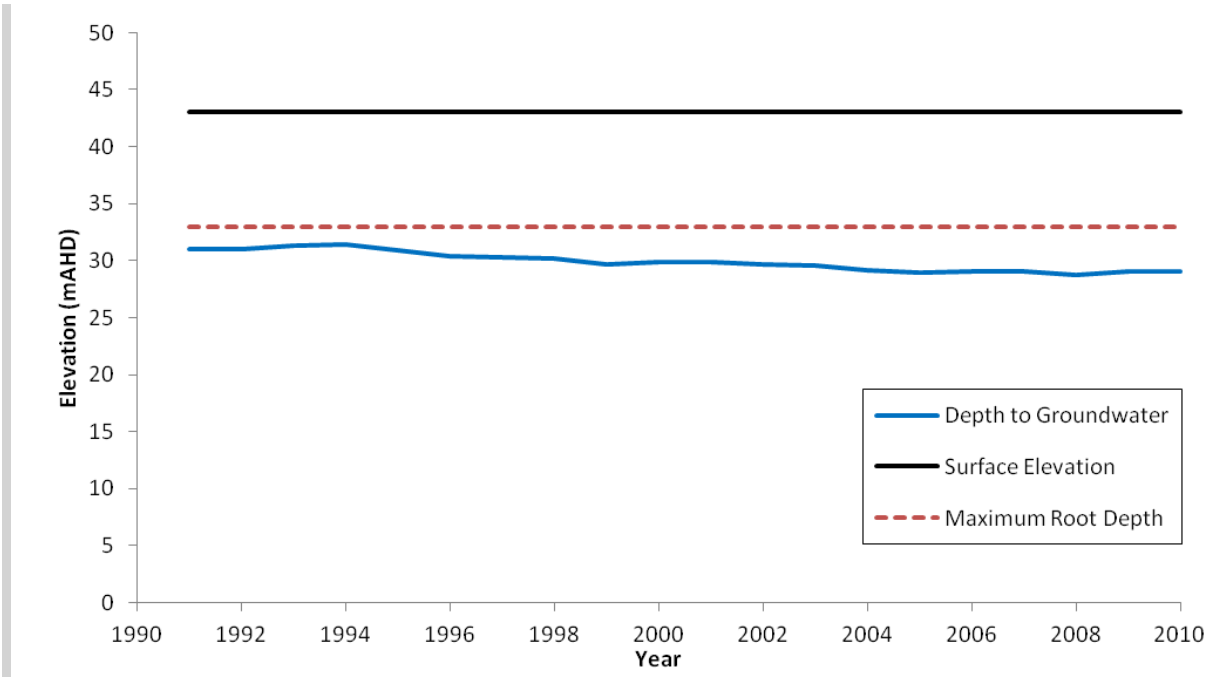

Figure 2: Taken from Groves (2014); Koondoola Regional Bushland average depth to groundwater for the period 1990-2010