INTERIM RECOVERY PLAN NO. 210

FEATHER-LEAVED BANKSIA

(*BANKSIA BROWNII*)

INTERIM RECOVERY PLAN

2005-2010

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Photo: Sarah Barrett

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Natural Heritage Trust
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DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

FOREWORD

Interim Recovery Plans (IRPs) are developed within the framework laid down in Department of Conservation and Land Management (CALM) Policy Statements Nos. 44 and 50.

IRPs 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.

CALM is committed to ensuring that Threatened taxa are conserved through the preparation and implementation of Recovery Plans (RPs) or IRPs and by ensuring that conservation action commences as soon as possible.

This IRP will operate from November 2005 to October 2010 but will remain in force until withdrawn or replaced. It is intended that, if the taxon is still ranked Critically Endangered, this IRP will be reviewed after five years and the need for further recovery actions assessed.

This IRP was given regional approval on 22 October, 2005 and was approved by the Director of Nature Conservation on 14 December 2005. The provision of funds identified in this Interim Recovery Plan is dependent on budgetary and other constraints affecting the Department, as well as the need to address other priorities.

Information in this IRP was accurate at October 2005.

ACKNOWLEDGMENTS

The following people have provided assistance and advice in the preparation of this Interim Recovery Plan:

Anne Cochrane	Manager, CALM Threatened Flora Seed Centre
Malcom Grant	Senior Operations Officer, CALM Albany Work Centre
Greg Freebury	Operations Officer, CALM Albany Work Centre
Renée Hartley	Technical Officer, CALM Albany Work Centre
Dr Bryan Shearer	Principal Research Scientist, CALM Science Division
Andrew Brown	Threatened Flora Coordinator, CALM Species and Communities Branch

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SUMMARY

Scientific Name:	*Banksia brownii*	**Common Name:**	Feather-leaved banksia
Family:	Proteaceae	**Flowering Period:**	March to August
CALM Regions:	South Coast	**CALM District:**	Albany Work Centre
Shires:	Plantagenet, Albany, Gnowangerup, Cranbrook	**Recovery Team:**	Albany District Threatened Flora Recovery Team

Illustrations and/or further information: Brown, A., Thomson-Dans, C. and Marchant, N. (Eds). (1998) *Western Australia's Threatened Flora*. Department of Conservation and Land Management, Western Australia; Western Australian Herbarium (1998) FloraBase - Information on the Western Australian Flora. Department of Conservation and Land Management, Western Australia. http://florabase.calm.wa.gov.au/.

Current status: *Banksia brownii* was declared as Rare Flora under the Western Australian *Wildlife Conservation Act* 1950 in November 1980 and is currently ranked as Critically Endangered (CR) under World Conservation Union Red List criterion A3ce (IUCN, 2001). Although it was previously ranked as Endangered the threat category of *B. brownii* was upgraded because of a projected decline in population size of ≥ 80% within the next three generations due to dieback (*Phytophthora cinnamomi*). *Banksia brownii* is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

Seventeen populations, together containing approximately 10,000 mature plants, are currently known to be extant and ten populations are recorded as presumed extinct due to *Phytophthora cinnamomi* infestation.

Habitat requirements: *Banksia brownii* grows in a range of habitats from mountain tops and slopes, in thicket and mallee-heath on rocky sand clay loam soils in the Stirling Range; and in mallee heath and low woodland, on sandy clay soils on lateritic ridges or granite in southern populations. The associated shrubland is rich in proteaceous and myrtaceous species.

Habitat critical to the survival of the species, and important populations: The critical habitat for *Banksia brownii* comprises the area of occupancy of known populations; similar habitat within 200 metres of known populations; remnant vegetation that links populations; and additional nearby occurrences of similar habitat that do not currently contain the species but may have done so in the past and may be suitable for translocations. Given that this species is ranked as Critically Endangered under Western Australian legislation and Endangered under the Commonwealth EPBC Act it is considered that all known habitat is critical habitat and all populations, including any future translocated ones, are important populations.

Benefits to other species/ecological communities: *Banksia brownii* occurs within the Montane 01 TEC (Montane Thicket and Heath of the South West Botanical Province, above approximately 900m above sea level) which is listed as Endangered under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999 and the Montane Mallee Thicket of the Stirling Range TEC (Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills) which was assessed by the Western Australian Threatened Ecological Communities Scientific Committee on the 15 February 2002 as Endangered. Recovery actions put in place for *B. brownii* will benefit both these threatened communities.

Chordifex abortivus, a species listed as Endangered under the EPBC Act, has a limited distribution and occurs in the same location as a *B. brownii* population in Waychinicup NP (Population 22). This population is also within the known range of three threatened bird species (Western Ground Parrot (*Pezoporus wallicus flaviventris)*, Western Bristlebird (*Dasyornis longirostris*), Western Whipbird (*Psophodes nigrogularis* subsp. *nigrogularis*) and Noisy Scrub-bird (*Atrichornus clamosus*). The area could also contain dibblers (*Parantechinus apicalis*), as records of this species occur within five kilometres and are from vegetation dominated by *Banksia* species with continuous remnant vegetation in between.

Recovery actions put in place for *Banksia brownii* will benefit the above threatened communities and species, and reciprocally, any recovery actions in place for these communities and species will benefit *B. brownii.*

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. *Banksia brownii* is not specifically listed under any international treaty and therefore this plan does not affect Australia's obligations under any other international agreements.

Role and interests of indigenous people: According to the Department of Indigenous Affairs Aboriginal Heritage

Sites Register, the registered site Kojaneerup (S01409) occurs in close proximity to *Banksia brownii* population 16. CALM has welcomed any future consultation that will seek input and involvement from Noongar groups that have an active interest in the areas that are habitat for *B. brownii*, and this is discussed in the recovery actions.

Affected interests: All known populations are on Crown land.

Social and economic impacts: The implementation of this Interim Recovery Plan has minimal social and economic impact as all populations are on CALM-managed land or City of Albany Reserve. However, recovery actions will involve liaison and cooperation with all stakeholders.

Evaluation of the Plans Performance: The Department of Conservation and Land Management (CALM), in conjunction with the Albany District Threatened Flora Recovery Team (ADTFRT) will evaluate the performance of this IRP. In addition to annual reporting on progress and evaluation against the criteria for success and failure, the Plan will be reviewed following five years of implementation.

Existing Recovery Actions: The following recovery actions have been or are currently being implemented:
1. All land managers have been notified of the location and threatened status of the species.
2. Seed collections for long-term conservation have been made by staff of the CALM Threatened Flora Seed Centre (TFSC).
3. Staff from the CALM Albany Work Centre and volunteers regularly monitor populations.
4. Phosphite is applied via aerial spaying annually or biannually to many populations.
5. Monitoring of survival of *Banksia brownii* and the rate of spread of *Phytophthora cinnamomi* in sites sprayed with phosphite has been carried out.
6. A Draft Fire Management Plan has been produced for the Stirling Range NP.

Objectives

1. Abatement of identified threats to improve the conservation status of *Banksia brownii* in the wild.
2. *Ex situ* seed storage from as diverse a range of populations as possible for future translocations and to maintain genetic diversity.

Criteria for success:
1. The number of populations and individuals within populations remains stable over the five years of the plan.
2. An increase in the number and diversity of seed held in long-term storage at the TFSC over the five years of the plan.

Criteria for failure:
1. The number of populations and individuals within populations decreases over the five years of the plan.
2. No change in the number and diversity of seed stored at the TFSC over the five years of the plan.

Recovery actions

1. Coordinate recovery actions
2. Continue, and increase where appropriate phosphite application to extant populations
3. Continue hygiene practices
4. Monitor populations
5. Develop and implement a fire management strategy
6. Continue seed collections for long-term conservation
7. Extract seed from cones already collected and stored in the CALM Threatened Flora Seed Centre
8. Survey for suitable translocation sites for northern and southern forms and write a Translocation Proposal
9. Conduct further surveys
10. Liaise with stakeholders
11. Promote awareness
12. Obtain biological and ecological information
13. Map habitat critical to the survival of the species
14. Review the need for a full Recovery Plan and prepare if necessary

1. BACKGROUND

History

The type collection of *Banksia brownii* (Baxter ex R. Br) was made from King George Sound in 1829 by William Baxter who described it in 1830. The species is named after the botanist Robert Brown. Collections by various botanists since 1829 include those from Vancouver Peninsula in 1902, Millbrook in 1917, and the summits of Bluff Knoll and Coynanarup (Stirling Range National Park) in 1923.

In 1988, Taylor and Hopper located two new populations of *B. brownii* during a survey for the "Banksia Atlas" project, extending the known distribution of the species east to the Cheyne Beach Rd area. At this time there were 18 known populations, with 12 estimated to have less than 100 plants and 10 populations less than 10 plants (Taylor and Hopper 1988).

Surveys since 1988 located several additional populations, including two large populations at Waychinicup NP (Population 22) in 1996 and Cheyne Rd Nature Reserve (Population 26) in 2001.

In June 1995, Greg Keighery from CALM recorded that he had located a population of *Banksia brownii* near Sandalwood Rd, Cape Riche in an area where there were no previous records of the species. Three subsequent surveys by CALM district staff could not locate the population and this record is yet to be confirmed. If confirmed, this location would extend the range approximately 45 km to the east.

In October 2003, a population of one plant was found at Wedge Hill in the Stirling Range NP in healthy vegetation that was last burnt in 1991.

Currently, the species is known from approximately 10,000 mature plants in 17 populations. Ten populations are thought to have become extinct since 1996 due to *Phytophthora cinnamomi* infestation.

Description

Banksia brownii is a smooth barked shrub or small tree, usually growing as an erect bushy shrub to 2-3 m, but growing as a low spreading shrub on some peaks of the Stirling Range and an openly branched small tree to 6 m in sheltered sites. It has smooth, thin, grey-brown bark and pubescent branchlets that become glabrous after several years. The usually whorled leaves are broadly linear, 3-11 cm long and 5-12 mm wide, glabrous bright green above and woolly below. They are divided almost to the midrib into many linear lobes, giving them a somewhat feather-like appearance. The inflorescences are broadly cylindrical, up to 20 cm long and 10 cm wide at flowering, terminal and often partly hidden by the branchlets that radiate from the base. The flowers are arranged in vertical rows, pale brown at the apex and cream below, with a grey-brown limb. The hooked styles are metallic red with a pale yellow apex. The perianth is up to 31 mm long, hairy outside and glabrous inside except along the upper margins. The pubescent, narrowly elliptic follicles have slightly wrinkled valves and are almost hidden among the persistent dead flowers (George 1981, 1987).

Banksia brownii belongs to the family Proteaceae, in the Spicigerae series (species with hooked styles and cylindrical spikes), which also includes *B. occidentalis, B. spinulosa* and the threatened *B. verticillata. B. brownii* is closely related to *Banksia occidentalis* which has smaller, deep red flowers and narrow, sparsely toothed leaves.

Two forms of *Banksia brownii* are recognised (Keighery 1988); a northern form confined to the Stirling Range with short, thin, hard leaves and a southern form with long, wide, soft leaves occurring in the Albany-Cheyne Beach area. Two forms that breed true to form from seed have been identified also by Kevin Collins (Banksia Farm, Mt Barker) who considers there may be three forms in total.

Distribution and habitat

Banksia brownii occurs in a number of small isolated populations over a range of approximately 90 km from the Stirling Range, south to Cheyne Beach. *B. brownii* grows in a range of habitats from mountain tops and slopes, in thicket, and mallee heath on rocky sand clay loam soils in the Stirling Range; and in mallee heath shrubland and woodland communities in sandy clay soils on lateritic ridges or granite in southern populations. The associated vegetation is rich in proteaceous (*Banksia, Dryandra, Lambertia, Isopogon, Hakea, Adenanthos*) and myrtaceous (*Eucalyptus, Agonis, Kunzea, Beaufortia*) species.

There are currently seventeen extant populations of *Banksia brownii*, with ten populations recently presumed locally extinct since 1996. Eight of the currently known extant populations occur in the Stirling Range National Park with other populations occurring at Millbrook, Cheyne Rd, and South Sister Nature Reserves, Waychinicup and Hassell National Parks and the Vancouver Peninsula. Of the current populations, three are close to extinction (Hassel NP, Hassel Beach Rd. and Southeast Ellen Peak) with less than fifteen mature plants remaining in each of these populations.

Only four of the current extant populations have greater than 200 plants (Yungemere, Success, Waychinicup and Cheyne Nature Reserve) and three have an estimated 100 to 200 plants (South Sister, Mt Hassell, Vancouver Peninsula)

Biology and ecology

Much of the information on the biology and ecology of *Banksia brownii* comes from studies on the southern form of the species at Millbrook Nature Reserve conducted over two seasons (1990 and 1993) and South Sister Nature Reserves in one season (1993), in vegetation with a post-fire age of more than twenty years (Collins *et al*. 1994, Galea and Lamont 1993, Sampson *et al.* 1994, Kelly and Coates 1995, Collins *et al*. 1996, Day *et al.* 1997). Limited information is available on the biology and ecology of the northern, Stirling Range form.

Phytophthora cinnamomi is an introduced soil-borne plant pathogen resulting in epidemic destructive root disease of native vegetation. The disease is most virulent in the plant families Proteaceae, Epacridaceae and Papillionaceae, as well as in the grass trees, *Xanthorrhoea* spp. (CALM 2000). The impact of the disease on plant communities is variable between sites, being dependent on species susceptibility, temperature, soil type, nutrient status and water. The greatest impact usually occurs where soils are infertile and drainage is poor. In areas infested by the pathogen the death of susceptible species can cause dramatic changes in vegetation floristic and structure (Weste and Marks 1987, Shearer and Tippett 1989, Wills 1993, Wilson *et al*. 1994).

Banksia brownii is highly susceptible to *Phytophthora cinnamomi* infestation. The species has been given a susceptibility rating of 12, which corresponds to the death of over 80% of plants killed at a site 96 days after inoculation by *P. cinnamomi* (McCredie *et al*. 1985, Wills 1993). In this investigation it was the second highest susceptible species out of 49 *Banksia* species studied, the most susceptible being *B. cuneata.* Susceptibility investigations by CALM also rate *B. brownii* as Highly Susceptible corresponding to the death of over 80% of plants ([1]Bryan Shearer, unpublished data).

Of the current populations of *Banksia brownii*, only one is considered to occur in healthy vegetation adequately removed from *Phytophthora cinnamomi* infestation (Wedge Hill, Population 23), while ten populations have become locally extinct primarily due to *P. cinnamomi*.

Changes in vegetation structure and floristics caused by *Phytophthora cinnamomi* will also affect the abundance of vertebrate pollinators in these communities (Wills 1993). Impacts are not well understood

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but predicted effects include direct (e.g. reduced seeds or pollen) or indirect (e.g. changes in invertebrate fauna) impacts on foods sources, loss of habitat in the form of thick ground cover and increased predation risk (Wilson *et al.* 1994, Nichols 1998).

Wilson *et al*. (1990) found the percentage of vegetation modified by *Phytophthora cinnamomi* in coastal heaths in Victoria to be a significant variable in explaining small mammal diversity and abundance. Further, it was found that changes in vegetation structure rather than invertebrate food supply between diseased and non-diseased areas was the main factor contributing to the abundance of the dasyurid marsupial *Antechinus stuartii* (now *Antechinus agilis*).

A study in coastal heaths in the Waychinicup area (Waychinicup, Cheyne Rd and Mermaid Point) found significantly higher bush rat (*Rattus fuscipes fuscipes)* abundance in healthy sites compared with *Phytophthora cinnamomi* infested sites (Whelan 2003). As bush rats have been shown to be pollinators of *Banksia brownii* (Kelly and Coates 1995, Collins *et al*.1994, Collins *et al*. 1996, Day *et al*. 1997) (see below), an indirect impact of *P. cinnamomi* on *B. brownii* through loss of pollinators is highly likely.

Native animals, feral animals and humans can act as vectors of *Phytophthora cinnamomi* aiding the wide and rapid spread of the disease, thereby enabling it to establish new centres of infestation in previously non-infested areas (CALM 2000). Human activity is thought to have spread the pathogen to many *Banksia brownii* populations in the Stirling Range through the transport of infected soil as a result of recreational and other human activities (Gillen and Watson 1993, Wills 1993). Areas where water pools on tracks or where soils are muddy loams provide ideal conditions for soil and disease transfer (Watson and Passmore 1993).

Evidence for the possible role of native animal vectors in the spread of *Phytophthora cinnamomi* comes from observations of spot infestations of *P. cinnamomi* in the Yungemere population (Population 12). Yungemere occurs within a "Special Conservation" zone, which has limited access by permit only. Recent observations of spot infestations were associated with quokka (*Setonix brachyurus*) and bandicoot (*Isoodon obesulus fusciventer*) diggings (S. Barrett and [2]G. Freebury, personal observation).

Aerial canker (*Zythiostroma* sp.) has been observed to cause mortality of plants in the Vancouver Peninsula (B. Shearer, personal communication), Waychinicup populations as well as limb death in the Millbrook populations. The impact of aerial canker has not been significant in the Stirling Range populations ([3]Malcolm Grant, personal communication) with the exception of Yungemere where sampling in 2003 verified aerial canker (?*Zythiostroma* sp. B. Shearer, personal communication). The root rot fungus *Armillaria luteobubalina* has caused the death of plants in the Vancouver Peninsula population (Populations 8).

Research has shown that application of the fungicide phosphite by stem injection, soil drench or foliar spray is effective in controlling *Phytophthora cinnamomi* in a range of native species (Shearer and Fairman 1991, 1997; Komorek *et al.* 1997; Ali and Guest 1998; Aberton *et al*. 1999; Wilkinson *et al*. 2001). Aerial phosphite application techniques enable the spraying of whole plant communities as well as individual species (Komorek *et al*. 1997, Barrett 2003). Phosphite may be applied to target populations within infested vegetation or along dieback fronts to protect dieback-free vegetation.

Aerial phosphite trials at Millbrook NR and South Sister NR in the early 1990s found phosphite to be effective in controlling *Phytophthora cinnamomi* infestations in *Banksia brownii* populations (Komorek *et al.*1997). After aerial phosphite application at 60 litres per ha (10% phosphite, applied twice) at Millbrook NR, no tree deaths were observed out of twenty plants monitored for three years post-spray. At South Sister NR, two plant deaths were recorded out of twenty plants monitored after application at 26 litres per ha (8.6% phosphite, applied twice).

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However, there were no controls in this study and several dry years followed the year of phosphite application (Malcolm Grant, personal communication).

At Millbrook NR, trial experimental plots were set up on an active *Phytophthora cinnamomi* infection front and phosphite was applied at high volumes using a backpack sprayer. After three years, the infection front had moved more than three metres past the plots in which sprayed plants remained healthy (Bryan Shearer, personal communication).

In a glasshouse study, pre-treatment of *Banksia brownii* plants with phosphite sprayed at low volumes (0.3-1.0 g/m^2) caused a significant reduction in lesion lengths after wound inoculation with *Phytophthora cinnamomi*, compared with controls. Non-treated plants produced a susceptible response to the disease while phosphite treated plants behaved as non-susceptible (Smith 1994).

Gillen and Grant (1997) found mortality of mature plants in coastal populations varied considerably after high volume application of 0.2% phosphite to *Banksia brownii* populations. Percentage mortality was 33% (six months after application) and 2% (two years after application) at Hassell National Park (Population 2), and 9% (18 months post-application) at Vancouver Peninsula (Population 8). Mortality of juveniles at Cheyne Beach Rd was 63% one year after spraying and 0% three years after.

Low volume application of phosphite to *Banksia brownii* plants previously inoculated with *Phytophthora cinnamomi* in a glasshouse situation did not halt the growth of the pathogen, although the extent of the total colonisation of the pathogen was reduced compared with the control. This suggests that low volume phosphite application may control the disease in individuals in the early stage of infection as well as protecting individuals that have avoided infection (Barrett *et al*. 2003a).

Aerial phosphite application is currently conducted at the following *Banksia brownii* populations: Yungemere (Population 12A), Mt Success (Population 14), Mt Hassell (Population 11), Waychinicup NP (Population 22), Millbrook NR (Population 1), Vancouver Peninsula (Population 8), Cheyne Rd NR (Population 26), and Hassell Beach Rd (Population 9). East Bluff (Population 20) and Moongoongoonderup (Population 21) are sprayed as part of the Montane Heath and Thicket community. Phosphite is applied by aerial application at a rate of 24 kg/ha every 2 years. In populations recently burnt in the Stirling Range NP phosphite is applied at 12 kg/ha annually. Spraying at Hassell NP (Population 2) was stopped in 2003 due to insufficient plants surviving in the population.

Monitoring has been established since May 1997 in a number of *Banksia brownii* populations to assess the survival of plants under the current phosphite spraying regime. At Waychinicup (Population 22A, burnt 1996), 68% of plants in quadrats have survived over five years from 1999-2004. In more mature vegetation at Waychinicup (Population 22B), there has been 90% survival in quadrats from 2002 to 2004. At Vancouver Peninsula (Population 8) 80% of quadrat plants survived over 5 years from 1999-2004 in long unburnt vegetation. In contrast, survival was considerably lower at Hassell Beach Rd (Population 9), burnt in 1994, with 41% survival of all individuals monitored over 5 years from 1998-2003. In Hassell National Park, (Population 2) burnt 1990, only 13% of plants in quadrats survived from 1999 to 2002. On a ridge south-east of Ellen Peak (Population 16A), there was 95% survival of *B. brownii* plants within a sprayed quadrat from 1998 to 2000. This compares with 62% survival in sprayed quadrats from 1997 to 2000 on the slopes of Mt Success (Population 14).

The rate of spread of *Phytophthora cinnamomi* along dieback fronts typically ranges from 0.7 to 2.3 m per annum in South Coast plant communities in sites with sandy soils on gentle slopes. Considerably higher rates of up to 250 m per annum down-slope have been observed on sand clay loam soils on hillsides in the Stirling Range (Grant and Barrett 2003). On Mt Hassell (Population

11) the rate of spread of the disease front upslope was a mean of 7.6 cm per annum from 2000 to 2003. At Waychinicup (Population 22B), the rate of spread ranged from 16 to 28 cm per annum in the four years from 1998 to 2002. On Yungemere (Population 12) down-slope rate of spread in a small circular infestation averaged 15-25 cm per annum from 2000 to 2002 but by 2003 the infestation had escaped several metres downhill.

Variation in disease activity from year to year makes it difficult to interpret survival data without controls.
In 2003, at Millbrook NR a controlled experiment was set up, to determine the differences in the number of plants surviving in *control* (non-sprayed) v. *phosphite sprayed* plots to test the effectiveness of phosphite spraying. As these plots were recently burnt in 2004, it will be several years before trends can be determined.

In conclusion, control of *Phytophthora cinnamomi* in populations of *Banksia brownii*, a highly susceptible species, has been variable. This variability may be related to site characteristics including soils, topography, hydrology, fire history and species composition. Phosphite may be relatively effective in reducing root to root spread of the pathogen. However, on slopes with considerable water flow, zoospores would be readily transmitted down slope after rainfall events and infection may spread more rapidly. Altered hydrology after fire may also exacerbate disease spread (M. Grant and G. Freebury, personal communication). Furthermore, it is possible that in this plant community phosphite may be relatively ineffectual in key member species thus providing a weak link in disease control (B. Shearer, personal communication).

Long-term monitoring is required to determine the effectiveness of phosphite application. There is also a need to further refine phosphite application techniques and determine reasons for loss of disease control. Annual application may be required to improve its effectiveness. Alternative application techniques may be more effective in ensuring adequate disease control.

Phytotoxic effects of phosphite have been demonstrated in a number of native species (Barrett 2002). Preliminary trials by Galea and Lamont (1993) showed no phytotoxic effects of phosphite on *Banksia brownii* after high volume application at concentrations of 0.1% and 0.35% applied on a monthly basis over four months. Komorek *et al.* (1997) found no trees with any visible signs of phytotoxicity, up to three years after low volume aerial application of phosphite at 26 litres per ha at South Sister NR and at 60 litres per ha at Millbrook NR. Low volume foliar application of phosphite at 24, 48 and 96 kg/ha to *B. brownii* in the glasshouse caused some growth abnormalities four months after application. These included spindly new shoot growth with rosetted foliage of reduced leaf size and reduced root growth (at 24 and 96 kg/ha) (Barrett *et al*. 2002). While minor impacts on plant health may result from *in situ* phosphite application and should be monitored these impacts are considerably less than those caused by *Phytophthora cinnamomi.*

Banksia brownii is a non-sprouting species that is killed by fire and relies entirely on seed for regeneration (Taylor and Hopper 1988, George 1987). It is a serotinous species with seed reserves accumulated in woody cones and released *en masse* when the parent is burnt. The fire regime is important for the persistence of fire-sensitive serotinous species as a population exists only as seeds after fire and no seeds are stored in the soil until the next fire. Therefore if seedlings fail to establish the population may become locally extinct (Galea and Lamont 1993).

Banksia brownii seedling recruitment does occur spontaneously in the inter-fire period, but this is limited, and fire is necessary to trigger general seed release (Galea and Lamont 1993). Population dynamics in this species is therefore generally controlled by seed dynamics.

A study of the effects of burning on seed release on a population of *Banksia brownii* at Millbrook Rd (Population 3) found that seed release from cones after a fire was gradual, completing at 97 days with 45.8% of seed released. The number of seedlings recorded 200 days post fire represented only 4.4% of the

total number of pre-fire unopened follicles (corresponding to 6.1 seedlings per parent) (Galea and Lamont 1993). This contrasts with the considerably lower post-fire recruitment of 0.04 seedlings per parent in the Mt Success population (Population 14) and 0.08 seedlings per parent in the SE Ellen Peak population (Population 16) after a nine year fire interval (S. Barrett, unpublished data).

Field observations indicate that *Banksia brownii* plants in southern populations reach reproductive maturity after approximately 5-6 years (Lamont and Baker 1988; S. Barrett, personal observation). However, on Mt Hassell only three plants out of twenty were flowering 8 years after a 1996 fire in 2004 (S. Barrett, personal observation).

Kelly and Coates (1995) suggested fire frequencies of at least 10 years or more are required for adequate seed banks to accumulate in *Banksia brownii*. While a minimum desirable fire interval may be estimated by a doubling of the primary juvenile period (time to first flower) (Gill and Nicholls 1989), 2.5 times the juvenile period (based on 50% of population flowering) may be more appropriate for slow maturing serotinous species such as *B. brownii***.** This suggests a fire interval of some 15 years for lowland southern populations.

At 12 years post fire on Yungemere, cone production in *Banksia brownii* was still at very low levels (Table 1). With a time to first flowering of 7 years or longer in the Stirling Range, and longer still for 50% flowering, a fire interval of 17 to 20 years is recommended for upland populations in the Stirling Range.

While there has been no formal study to date of the interactions between fire and *Phytophthora*, field observations suggest that the impact of the pathogen is exacerbated post-fire due to altered hydrology and increased surface run-off (Barrett 1996; Mal Grant, personal communication). The non-suberised root tissue of seedlings may be more vulnerable to the pathogen while phosphite may also be less effective in the seedling stage (Bryan Shearer, personal communication).

There has been poor post-fire regeneration recorded for *Banksia brownii* in the Stirling Range NP following fires in 1991 and 2000. Quadrats were established on Mt Success (Population 14) and SE Ellen Peak (Population 16) in May 1997 in vegetation burnt in 1991. Both were burnt again in spring 2000. Mean numbers of *B. brownii* individuals on Mt Success fell from 2.3/m^2 pre-2000 fire to 0.05/m^2 post-2000 fire. On SE Ellen Peak, *B. brownii* densities fell from 2.4/m^2 to 0.2/m^2 (S. Barrett, unpublished data). Lack of seedling recruitment post-fire is thought to be primarily related to a short fire interval; however both the fire intensity and/or season may also have contributed to poor recruitment.

The mean number of cones per plant was also recorded in two populations burnt in 1996 and one population burnt in 1991 (Table 1). The southern coastal population (Population 22a) had a much greater number of cones per plant than the two northern (Stirling Range) populations (Populations 11 and 12). The Mt Hassell population (11) had no cones eight years after being burnt. Within Stirling Range populations differences in cone production may also occur and may be related to differences in aspect or topography, which can affect fruiting success.

Table 1: Mean number of cones per plant recorded from 20 plants at 3 sites post fire.

Population	Date burnt	Date recorded	Mean no. cones per plant
Waychinicup (Pop. 22a)	1996	April 2004	7.65
Mt Hassell (Pop. 11)	1996	July 2004	0.0
Yungemere (Pop. 12)	1991	October 2003	0.6

The major pollinators of *Banksia brownii* are honeyeaters and small mammals. New Holland Honeyeaters (*Phylidronyris novaehollandiae*), Red Wattlebirds (*Anthochaera caranculata*) and the nocturnal mammals the bush rat (*Rattus fuscipes*) and honey possum (*Tarsipes rostratus*) have all been found to carry

significant loads of *B. brownii* pollen at sites in South Sister and Millbrook Nature Reserves (Kelly and Coates 1995, Collins *et al*.1994, Collins *et al*. 1996, Day *et al*. 1997).

Seasonal abundance of New Holland Honeyeaters, Red Wattlebirds and Western Spinebills has also been positively correlated with the density of *Banksia brownii* inflorescences at South Sister and Millbrook and pollen loads of *B. brownii* on New Holland Honeyeaters have been shown to vary seasonally (Collins *et al*. 1994). At Millbrook nearly 80% of the pollen in pollen smears from New Holland Honeyeaters was from *B. brownii* when it came into flower in May, increasing to 97% in June, coinciding with peak flowering time and decreasing to 69% in July. A similar trend was found at South Sister (Collins *et al.* 1994, Day *et al.* 1997).

Pollinator exclusion experiments at South Sister NR (Collins *et al.* 1994) have shown that fruiting success (proportion of inflorescences that set fruit) and fruit set (proportion of flowers that developed into follicles) was greatest for open inflorescences (51.1%) than for those in total (vertebrate and bird) (9.3%) and vertebrate only exclusion treatments (19.8%). The limited success in the total exclusion treatment shows that *Banksia brownii* is capable of setting fruit by self-fertilisation. Similar results were obtained at Millbrook NR (Collins *et al.* 1996). These results highlight the importance of vertebrates as the pollinators of *B. brownii*, which are likely to be responsible for considerable geitonogamous pollen movement (inter-flower pollination on an individual plant (Day *et al.* 1997)).

The importance of different vertebrate pollinator groups (mammals vs. honeyeaters) may vary between sites. A greater level of pollen removal occurred during the day at Millbrook than at South Sister and the rate of night-time, but not daytime flower opening, which may be triggered by animal visitors, was higher at South Sister than at Millbrook. These site differences are likely to correspond to a greater number of nocturnal mammal pollen vectors being present at South Sister compared with the larger number of daytime bird pollen vectors at Millbrook (Collins *at el*. 1994, Day *et al.* 1997).

Invertebrate pollinators are thought to play a minor role in pollination of *Banksia brownii.* Insect foraging activity at South Sister and Millbrook was low during *B. brownii* flowering times. The Honeybee (*Apis mellifera*) was the only invertebrate observed to come into contact with the stigma and pollen when foraging on flowers, promoting autogamous and geitonagamous pollen transfer (Collins *et al.* 1994, Day *et al.* 1997).

Both the Millbrook and South Sister populations displayed a mixed mating system that involves a significant amount of self-fertilisation with a small degree of outcrossing and biparental breeding (Sampson *et al.* 1994, Collins *et al.* 1994, Day *et al.* 1997). Outcrossing rates were 0.68 and 0.75 respectively (Sampson *et al.* 1994) (an outcrossing rate of 1 = random outcrossing with no self-fertilisation), and is the lowest recorded for an undisturbed *Banksia* population to date (Kelly and Coates 1995). Some species of *Banksia* are almost completely outcrossing (eg. *B. menziesii, B. attenuata, B. paludoasa* and *B. spinulosa*) (Scott 1980, Carthew *et al.* 1988).

It has been suggested that the low level of outcrossing may be related to the fire strategy of *Banksia brownii*. As the species is non-sprouting and is killed by fire, fecundity is likely to be increased with a degree of self-compatibility, thereby reducing the risk of sudden elimination in a fire-prone area (Carpenter and Recher 1979).

The mating system described for *Banksia brownii* is entirely consistent with the fact that *B. brownii* is self-compatible and served by a suite of pollinators whose foraging behaviour is conducive to autogamous (and geitonogamous pollen transfer (Day *et al.* 1997)).

The mating system of a species is a useful indicator for developing strategies for genetic resource conservation (Sampson *et al.* 1994). Sampson *et al.* (1994) suggest that, as a mixed-mating, animal-pollinated species, around 20% of genetic diversity in *Banksia brownii* would be expected to be among populations and that small populations would be more prone to inbreeding than larger ones. The authors therefore recommend that several populations, large enough to maintain the mating system of *B. brownii*, are needed to conserve the genetic diversity of this species.

Banksia brownii is similar to many other Australian Proteaceae in that its flowering extends for many months, with freshly opened inflorescences most abundant during winter. Flowering in *B. brownii* has been recorded from March to August (George 1981, Collins *et al.* 1994, Collins *et al.* 1996, Day *et al.* 1997).

In the 1990 season at Millbrook NR, flowering began in April and peaked in May and June when flowers opened on approximately 93% of the current year's inflorescences. There was also a considerable variation between individual trees in the length of flowering (Collins *et al.* 1996). In the 1993 season at Millbrook and South Sister, flowering occurred from April to August with a peak in both the number of trees in flower and the number of inflorescences open in June. The length of flowering for individual trees ranged from 4 to 15 weeks (mean 8.57 +/- s.e. 0.62) at Millbrook and from 3 to 14 weeks (mean 8.9 +/- s.e. 0.45) at South Sister (Collins *et al.* 1994, Day *et al.* 1997).

At both South Sister and Millbrook, there was a significant positive correlation between the number of inflorescences produced per plant, the duration of flowering, canopy volume and mean canopy width (Collins *et al.* 1994, Collins *et al.* 1996, Day *et al.* 1997). Although trees at the two sites were of similar size the total number of inflorescences produced at South Sister was greater than that at Millbrook in the 1993 season (15.30 +/- 1.85 and 9.56 +/- 1.73 respectively). This may be due to trees at South Sister having greater access to water from run-off from adjacent granite outcrops or that the average age of trees was greater within South Sister (25 yrs) than Millbrook (12 yrs) (Day *et al.* 1997).

Fruiting success (proportion of inflorescences that set fruit) and fruit set (proportion of flowers that develop into follicles) has been shown to be low in *Banksia brownii* and this is characteristic of most hermaphroditic plants (Day *et al.* 1997). At Millbrook and South Sister, in the 1993 season, fruiting success was 45.1% and 51.5% respectively and fruit set was only 2.2% at South Sister (Collins *et al.* 1994). In the 1990 season at Millbrook NR fruiting success was 48% and fruit set was 1.7% (Collins *et al.* 1996).

Collins *et al.* (1994) recorded an average of 36.36 ± 1.254 follicles per fertile infructescence (cone) at both Millbrook and South Sister, and Galea and Lamont (1993) recorded 23.7 ± 6.0 and 27.0 ± 8.3 respectively at these two sites (Table 2). Collins *et al.* (1994, 1996) found a significant difference between tree dimensions (bio-volume, mean width and total tree height) and the number of inflorescences produced by individual trees at both South Sister and Millbrook NRs in 1990 and 1993.

The number of follicles has been significantly correlated with infructescence length. However, although the lengths of inflorescences that successfully set fruit (141.8 ± 1.9 SE mm, n = 194) was significantly greater than those that remained barren (105.8 ± 1.7 SE mm, n = 182), there was no relationship between inflorescence length and percentage fruit set on fertile inflorescences (Collins *et al.* 1994, Day *et al.* 1997). The distribution of follicles was non-random, with most forming in the middle third of the infructescence (Collins *et al.* 1994, 1996, Day *et al.* 1997). Collins *et al.* (1994) concluded that it was unlikely that pollinators limit fruit set or that over-crowding of follicles causes low fruit set. Evidence of insect damage suggests that inflorescence consumers may reduce fruit set.

It has been suggested that fruiting success may be related to nutrient levels in *Banksia brownii*, with possibly a critical level of nutrients and assimilates that must be equalled or exceeded before fruit set occurs (Copland and Whelan 1989, Collins *et al.* 1996). However, fruit set may not be dependant on nutrient levels, as extensive trials involving nutrient addition to plants such as *Banksia laricina* (Stock *et al.* 1989) and *Dryandra sessilis* (B.G, Collins, H. Duff and M. Walsh, unpublished data) failed to significantly alter fruit set.

Galea and Lamont (1993) investigated the seed bank dynamics in three populations of *Banksia brownii*, South Sister, Millbrook and Mt Hassell (Table 2). *B. brownii* is one of only a few banksias to produce only one seed per follicle. Seed set (number of viable seeds per cone) was found to be low in three populations in one season, in particular Mt Hassell at 13 years post-fire (Table 2). Galea and Lamont (1993) suggest their low value for Mt Hassell may be due to site specific factors such as water and nutrient availability, pollinator activity or disease infection. Recent data for Waychinicup and Yungemere populations (Table

2) showed a higher number of follicles per cone in plants than those recorded by Galea and Lamont (1993), the reasons for this are not clear.

Table 2: Contributions of the seed bank of *Banksia brownii* in populations of varying fire ages (from Galea and Lamont 1993 and from Barrett and Cochrane (unpublished data)). Sample = one cone each from 20 plants in each population, unless otherwise indicated.

	Galea and Lamont 1993			**Barrett and Cochrane (unpublished data)**			
	Millbroook	***South Sister***	***Mt Hassell***	***Mt Hassell***	***Waychinicup***		***Yungemere***
Date recorded	1993	1993	1993	2004	2004	2004	2003
Population burnt	1970+/-	Pre 1963	1980	1996	1989	1996	1991
Modal age (years) (% plants with this age)	12 (45%)	25 (20%)	11 (55%)	c. 8 (even age)	c.15 (even age)	c. 8 (even age)	c. 12 (even age)
Fertile cones per plant (mean ± Std. Dev.)	7.4 ± 7.3	46.2 ± 26.8	2.3 ± 1.5	0.0	11.9 ± 2.2	7.65 ± 11.02	0.6 ± 0.7
Follicles per cone (mean ± Std. Dev.)	23.7 ± 6.0	27.0 ± 8.3	20.0 ± 14.2	Not assessed	37.5 ± 23.6 (15 plants, mean of 5 cones per plants)		38.7 ± 13.5 (23 plants, 2 cones per plant)
Non-aborted seeds per cone	10.8 ± 4.2	8.4 ± 5.8	2.0 ± 2.8	Not assessed	25.0		15.0
Viable seeds per cone (mean ± Std. Dev.)	9.7 ± 4.4	3.4 ± 5.2	1.9 ± 2.6	Not assessed	**23.3**	Not assessed	**11.7**
Viable seeds per plant (mean ± Std. Dev.)	66.9 ± 60.2	232.9 ± 558.6	5.8 ± 8.6	Not assessed	**277.27**	Not assessed	**7.02**

Threats

Banksia brownii was declared as Rare Flora under the Western Australian *Wildlife Conservation Act* 1950 in November 1980 and is currently ranked as Critically Endangered (CR) under World Conservation Union Red List criterion A3ce (IUCN, 2001). Although it was previously ranked as Endangered the threat category of *B. brownii* was upgraded because of a projected decline in population size of ≥ 80% within the next three generations due to dieback (*Phytophthora cinnamomi*). *Banksia brownii* is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

All areas occupied by *Banksia brownii* are affected or potentially affected by one or more threats identified in this IRP. Threats include:

- ***Phytophthora cinnamomi* infestation:** Extreme susceptibility to *Phytophthora cinnamomi* is the main single threat to the persistence of *Banksia brownii* populations. Ten populations have become locally extinct since 1996 due to *P. cinnamomi* infestation. Only one population on Wedge Hill is currently disease-free and this consists of a single plant.

  Population 12a, Yungemere, was considered to have only minor spot infestations in 1999 however these have expanded considerably in latter years. A large new population was located on Yungemere in April 2004 (Population 12b), a number of small infestations were observed upslope and adjacent to the *Banksia brownii* population. Population 12 is currently the largest known population of *B. brownii.*

  There are also *Phytophthora cinnamomi* infestations in populations at Cheyne Nature Reserve, Waychinicup, Mt Success and Millbrook NR, which was recently burnt.

  Observed changes in vegetation structure and floristic caused by *Phytophthora cinnamomi* will also have effect the abundance of vertebrate pollinators in communities (Wills 1993), thus *P. cinnamomi* poses an indirect threat to *Banksia brownii* also.

- **Inappropriate fire regime:** A fire interval of 15 years is recommended for southern *Banksia brownii* populations and 17 to 20 years for Stirling Range upland populations. Within the Stirling Range NP, 8 of the 13 populations were burnt in hot fires in both 1991 and in 2000, an interval of only 9 years. Of these, five are considered either almost extinct or presumed extinct. Of the southern populations, the South Sister NR is long unburnt (approximately 35 years or greater) as is the Vancouver Peninsula population (date unknown). A number of populations have been burnt within the last 15 years: Waychinicup 22B (burnt in 1989), Hassell NP (burnt in 1990), Cheyne NR (burnt in 1991), Waychinicup 22A (burnt in 1996), Hassell Beach Rd (burnt in 1994) and Millbrook NR (burnt most recently in 2004).

  Frequent fire has not been a threat to these southern populations to date, however there is a potential threat of an extensive, intense fire that will affect whole populations with the presence of *Phytophthora cinnamomi* limiting post-fire recruitment. The rate and magnitude of decline in cone and seed production in long-unburnt, senescent populations is unknown.

- **Fragmentation and reduction in population size due to impacts of *Phytophthora cinnamomi*:** The fragmentation of populations and reduction of population size due to deaths from *Phytophthora cinnamomi* will likely decrease the amount of genetic diversity through genetic drift. A decrease in fitness in small populations has been demonstrated in *Banksia goodii*, in which a higher proportion of infertile infructescences are produced due to poor pollen quality resulting from matings between related neighbours (Lamont *et al.* 1993).

  Small population size will also increase the vulnerability of these populations to local extinction through stochastic events.

- **Other plant diseases:** Aerial canker and the fungus *Armillaria* has caused mortality and limb death in a limited number of populations and is likely to affect plant vigour and health. Aerial canker has

caused high mortality rate in *Banksia coccinea* on the south coast (Shearer and Fairman 1991b). These diseases may therefore pose a threat to *B. brownii.*

- **Climate change:** Long-term climate change is likely to adversely affect *Banksia brownii* populations given a predicted decrease in rainfall and an increase in temperature and evaporation. It is considered that those groups likely to be most affected by climate change include geographically localised taxa, taxa with peripheral or disjunct populations, such as *B. brownii*, specialised species, poor dispersers, genetically impoverished species, and coastal communities (Peters & Darling 1985).

  In addition, a number of *Banksia brownii* populations occur in the Stirling Range, which lies between the moist, mild areas of the south-west, where rainfall can exceed 1400mm a year, and the drier north, where average annual rainfall is around 400mm. Rainfall on the eastern peaks may be up to double that on the surrounding plains, however rainfall varies significantly on all the peaks (Keighery and Marchant 1993). These unique climatic conditions caused the mid to upper slopes of the Stirling Range to become refugia for several specialised flora and fauna species. It is thought that the onset of drier conditions in the Holocene has caused the contraction of some species to upland slopes and gullies (Hopkins, *et al.* 1983). Therefore, it must be considered that climate change could accelerate this process, significantly reducing the area of habitat suitable for *B. brownii* in the Stirling Range.

  Indirect and cumulative effects of climate change must also be considered. With the onset of warmer, drier conditions, conditions are likely to favour an increase in fire frequency and fire intensity, which as discussed above, is a primary threat to the *Banksia brownii*. An increase in atypical weather events (for example, an increase in summer rainfall) may result in warm, moist conditions to the detriment of the species by favouring *Phytophthora cinnamomi*.

Summary of population land vesting, purpose and tenure

Population	Vesting	Purpose	Tenure
1A	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
1B	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
1C	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
1D	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
1E	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
2	WA Conservation Commission	National Park	National Park
3A	City of Albany		General
3B	City of Albany		General
3C	City of Albany		General
3D	City of Albany		General
3E	City of Albany		General
3F	City of Albany		General
4A	City of Albany	Recreation	General
4B	City of Albany	Recreation	General
5A	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
5B	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
6	City of Albany		General
7	City of Albany		General
8	City of Albany	Recreation	General
9	WA Conservation Commission	National Park	National Park
10	Unvested	Waychinicup River Catchment Area	General
11A	WA Conservation Commission	National Park	National Park
11B	WA Conservation Commission	National Park	National Park
12	WA Conservation Commission	National Park	National Park
13A	WA Conservation Commission	National Park	National Park
13B	WA Conservation Commission	National Park	National Park

13C	WA Conservation Commission	National Park	National Park
13D	WA Conservation Commission	National Park	National Park
14	WA Conservation Commission	National Park	National Park
15	WA Conservation Commission	National Park	National Park
16A	WA Conservation Commission	National Park	National Park
16B	WA Conservation Commission	National Park	National Park
16C	WA Conservation Commission	National Park	National Park
17	WA Conservation Commission	National Park	National Park
18	WA Conservation Commission	National Park	National Park
19	WA Conservation Commission	National Park	National Park
20	WA Conservation Commission	National Park	National Park
21A	WA Conservation Commission	National Park	National Park
21B	WA Conservation Commission	National Park	National Park
21C	WA Conservation Commission	National Park	National Park
22	WA Conservation Commission	National Park	National Park
22	WA Conservation Commission	National Park	National Park
23	WA Conservation Commission	National Park	National Park
24	WA Conservation Commission	National Park	National Park
25	Shire of Plantagenet		General
26	WA Conservation Commission	Conservation of Flora and Fauna	Nature Reserve
27	WA Conservation Commission	National Park	National Park

Summary of population information and threats

Pop. No. & Location	Year/No. plants	Condition	Threats
1A Millbrook Nature Reserve	Same population as 1B	Poor	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
1B Millbrook Nature Reserve	2004 1	Poor, *P. cinnamomi*, burnt in intense fire spring 2004	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
1C Millbrook Nature Reserve	2004 1	Poor, *P. cinnamomi*, burnt in intense fire spring 2004	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
1D Millbrook Nature Reserve	1996 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
1E Millbrook Nature Reserve	1996 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
2 Hassell NP	May 2002 30+/- (0), 9 dead Apr 2003 3 (0)	Almost locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
3A Millbrook Rd	Mar 2002 1 (1), 3 dead Feb 2004 1, 3 dead	Poor, recent deaths due to *P. cinnamomi*	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
3B Millbrook Rd	Mar 2002 6 (0), 7 dead Feb 2004 7 (1 juv), 1 dead	Poor, recent deaths due to *P. cinnamomi*	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
3C Millbrook Rd	Mar 2002 1 (0), 4 dead Feb 2004 0 (0), 5 dead	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
3D Millbrook Rd	Mar 2002 3 (0, 1 dead Feb 2004 4 (0), 2	Poor, deaths due *to P. cinnamomi*, 1 extra mature since 2002	*Phytophthora cinnamomi* Inappropriate fire regime Climate change

		dead		
3E	Millbrook Rd	Sep 1996 0 (0)	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
3F	Millbrook Rd	Sep 1996 0 (0)	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
4A	Shire Rec Res. No. 35381	Jan 1996 2 (0), 3 dead Feb 2004 0 (0)	Presumed locally extinct (Burnt 2002-3, no sign of stags)	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
4B	Shire Rec.Res.No.35381,	Apr 1993 3 (1), many dead Feb 2004 0 (0)	Presumed locally extinct (Burnt 2002-3, no sign of stags)	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
5A	South Sister NR	June 2002 91 (14) 59 dead	Poor	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
5B	South Sister NR	Continuous with 5A	Poor	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
6	Hazard Rd	Jan 1996 3(2), 12 dead Feb 2004 0 (0) , 3 dead	Presumed locally extinct (recent deaths by *P. cinnamomi)*	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
7	Phillips Rd	Dec 1994 (3) Jan 1996 0 (0)	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
8	Vancouver Pen.Rec.Res	May 2003 150+ (0), 10+/- dead Feb 2004 120+ (3), 50+ dead	Poor, deaths due? mostly to canker and some *P. cinnamomi*	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
9	Waychinicup National Park	Apr 2003 16 (0) Apr 2004 11 seen, some missed? (0)	Almost locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
10	Cheyne Beach Rd	Jan 96 15 (0)) Oct 1998 0 (0)	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
11A	Stirling Range National Park	Nov 2003 10 +/- (200+/-) 5+/- dead	Moderate	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
11B	Stirling Range National Park	Nov 2003 (3)	Poor, *P. cinnamomi* present	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
12	Stirling Range National Park	Oct 2003 2000+ (100+/-) 50+/-dead	Moderate, *P.cinnamomi* spreading	*Phytophthora cinnamomi* *Aerial canker* Inappropriate fire regime Climate change
13A	Stirling Range National Park	Apr 2004 5000+	2004 spot infections observed	
13B	Stirling Range National Park	1989 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
13C	Stirling Range National Park	1994 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
13D	Stirling Range National Park	June 2004 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change

14	Stirling Range National Park	1999 0	Presumed locally extinct	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
15	Stirling Range National Park	Feb 2002 100+/- (1000+/-) 20+ dead Mar 2003 100+/- (2000+/-) 20+ dead	Moderate condition, burnt in 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
16A	Stirling Range National Park	Not confirmed		
16B	Stirling Range National Park	Feb 2004 0	Almost locally extinct, burnt 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
16C	Stirling Range National Park	Feb 2004 0 (2)	Almost locally extinct, burnt 1991 and 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
17	Stirling Range National Park	Feb 2004 0	Almost locally extinct, burnt 1991 and 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
18	Stirling Range National Park	Apr 2000 100+/-, 5+ dead Feb 2004 0 (0)	Presumed locally extinct, burnt 1991 and 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
19	Stirling Range National Park	Feb 1996 6 Feb 2004 0 (0)	Presumed locally extinct, burnt 1996	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
20	Stirling Range National Park	Feb 2004 2 (0)	Moderate, one individual with aerial canker	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
21A	Stirling Range National Park	Mar 2000 50+ Apr 2003 0 (0 seen	Presumed locally extinct, burnt 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
21B	Stirling Range National Park	Mar 2000 10+ (75+) Apr 2003 0 (0 seen	Presumed locally extinct, burnt 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
21C	Stirling Range National Park	Nov 1999 20+ (100+) Feb 2002 0 (0 seen)	Presumed locally extinct, burnt 1991 and 2000	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
22	Waychinicup National Park	Apr 2003 100+, 6+ dead Apr 2004 100+ scattered deaths	Moderate	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
22	Waychinicup National Park	Apr 2003 2000+ Apr 2004 2000 + (0)	Moderate, only scattered deaths seen, less aerial canker than 2003	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
23	Stirling Range National Park	Nov 2003 1	Healthy	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
24	Stirling Range National Park	Mar 2004 0 (0), 11 stags seen	Presumed locally extinct (burnt 2000)	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
25	Yellanup Rd	May 1996 3 Feb 2004 2, 2 dead	Poor	*Phytophthora cinnamomi* Inappropriate fire regime Climate change
26	Cheyne Rd	Mar 2003 200+/- (0), 20+/- dead	Poor, deaths due to *P. cinnamomi*	*Phytophthora cinnamomi* Inappropriate fire regime Climate change

27	Stirling Range National Park	Oct 2003 1	Healthy (no *P. cinnamomi*), plant 2m high	*Phytophthora cinnamomi* Inappropriate fire regime Climate change

Numbers in brackets = number of seedlings or juveniles.

Habitat critical to the survival of the species, and important populations

Given that this species is ranked as Critically Endangered under Western Australian legislation and Endangered under the Commonwealth EPBC Act, it is considered that all known habitat is habitat critical to the survival of the species. In addition all populations, including any translocated populations, are considered important to the survival of the species. Habitat is defined as the biophysical medium or media occupied (continuously, periodically or occasionally) by an organism or group of organisms, or once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reintroduced (*Environment Protection and Biodiversity Conservation Act 1999*). The area of occupancy of the currently known *Banksia brownii* populations has been mapped. However, other parts of the habitat critical to the survival of *B. brownii* have not been mapped and an action outlined in this Interim Recovery Plan is to map all habitat as defined above.

Habitat critical to the survival of *Banksia brownii* therefore comprises:

- the area of occupancy of known populations;
- areas of similar habitat within 200 metres of known populations that provide potential habitat for natural recruitment;
- remnant vegetation that surrounds and links populations (this is necessary to allow pollinators to move between populations)
- additional occurrences of similar disease-free habitat that do not currently contain the species but may have done so in the past (these represent possible translocation sites).

Benefits to other species/ecological communities

Banksia brownii occurs within the Montane 01 TEC (Montane Thicket and Heath of the South West Botanical Province, above approximately 900 m above sea level), which is listed as Endangered under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. It also occurs in the Montane Mallee Thicket TEC (Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills) which was assessed by the Western Australian Threatened Ecological Communities Scientific Committee on the 15 February 2002 as Endangered. The Montane Mallee Thicket community occurs on sand clay loam on sandstone and metamorphic rock including quartzite, slate and phyllite (Muhling and Brakel 1985) on the mid to upper slopes of mountains and hills, mainly east of Red Gum Pass and above 400 m above sea level. Both TECs contain an assemblage of plants that are susceptible to *P. cinnamomi,* many of which are threatened or Priority flora species.

Chordifex abortivus, a species listed as Endangered under the EPBC Act, occurs in the same location as a *Banksia brownii* population in Waychinicup NP (Population 22). This population is also within the known range of three threatened bird species (Western Ground Parrot (*Pezoporus wallicus flaviventris)*, Western Bristlebird (*Dasyornis longirostris*), Western Whipbird (*Psophodes nigrogularis* subsp. *nigrogularis*,) and Noisy Scrub-bird (*Atrichornus clamosus*). This area could also potentially contain dibblers (*Parantechinus apicalis*), as records of this species occur within five kms and are from vegetation dominated by *Banksia* spp. with continuous remnant vegetation in between.

Recovery actions put in place for *Banksia brownii* will benefit the above threatened communities and species, and reciprocally, and recovery actions in place for these communities and species will benefit B. *brownii*.

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. *Banksia brownii* is not specifically listed under any international treaty and therefore this plan does not affect Australia's obligations under any other international agreements.

Role and interests of indigenous people

According to the Department of Indigenous Affairs Aboriginal Heritage Sites Register, the registered site Kojaneerup (S01409) occurs in close proximity to *Banksia brownii* population 16. CALM has welcomed any future consultation that will seek input and involvement from Noongar groups that have an active interest in the areas that are habitat for *Banksia brownii*, and this is discussed in the recovery actions.

Affected interests

All known populations are on Crown land.

Social and economic impacts

The implementation of this Interim Recovery Plan is unlikely to cause significant adverse social and economic impact, as all populations are located in reserves (CALM or Shire). Recovery actions will involve liaison and cooperation with all stakeholders.

Guide for decision-makers

Section 1 provides details of current and possible future threats. Developments in the immediate vicinity of the population or within the defined critical habitat of *Banksia brownii* require assessment for the potential for a significant level of impact. No developments should be approved unless the proponents can demonstrate that they will not have a detrimental impact on the species, or its habitat or potential habitat, or the local surface and ground water hydrology.

Evaluation of the Plan's Performance

The Department of CALM, in conjunction with the Albany District Threatened Flora Recovery Team will evaluate the performance of this Interim Recovery Plan. In addition to annual reporting on progress against the criteria for success and failure, the Plan is to be reviewed within five years of its implementation. Any changes to management and/or recovery actions made in response to monitoring results will be documented accordingly.

2. RECOVERY OBJECTIVES AND CRITERIA

Objectives

1. Abatement of identified threats to improve the conservation status of *B. brownii* in the wild.
2. *Ex situ* seed storage from as diverse a range of populations as possible for future translocations and to maintain genetic diversity.

Criteria for success:

1. The number of populations and individuals within populations remains stable over the five years of the plan.
2. An increase in the number and diversity of seed stored in TFSC over the five years of the plan.

Criteria for failure:
1. The number of populations and individuals within populations remains stable over the five years of the plan.
2. No change in the number and diversity of seed stored in TFSC over the five years of the plan.

3. RECOVERY ACTIONS

Existing recovery actions

CALM Albany Work Centre staff and the City of Albany have been notified of the location and threatened status of the species. The notification details the Declared Rare status of *Banksia brownii* and the legal responsibility to protect the species.

1. Phytophthora cinnamomi management

i). Phosphite application Phosphite application remains the only control option available at present to reduce the impact *Phytophthora cinnamomi* on all extant populations. Phosphite control is currently carried out on ten populations by aerial application at a rate of 24 kg/ha every two years. In populations recently burnt in the Stirling Range NP phosphite is applied at 12 kg/ha annually. Aerial application targets all susceptible species in the vicinity of populations which also benefits bird and mammal pollinators of Banksia brownii.

ii) Hygiene All CALM operations within or close to areas of *Banksia brownii* occurrence are carried out according to the CALM Plant Disease management Guidelines and Policy (*Phytophthora cinnamomi* and disease caused by it. Volume 1. Management Guidelines (CALM 2000)) and the Draft Replacement Policy Statement No. 3: *Threat abatement for Phytophthora cinnamomi* 2004.

Within the Stirling Range NP a "Special Conservation Zone" has been gazetted, which encompasses the Yungemere and Wedge Hill *Banksia brownii* populations, and in which there is limited pedestrian access by permit only, and only under dry soil conditions (CALM 1997).

Currently, there is no restricted access to City of Albany Reserves where *Banksia brownii* occurs. There are also no guidelines for *Phytophthora cinnamomi* hygiene for any City of Albany operations, however these are currently being developed ([4]S. Maciejewski, personal communication).

2. Population monitoring

Staff from CALM Albany Work Centre and CALM volunteers monitors populations of this species. All populations are monitored annually and more intensive population monitoring includes monitoring the rate of spread of *Phytophthora cinnamomi*, effectiveness of phosphite application, post-fire seedling recruitment and fruiting success. These aspects of the *Banksia brownii* recovery program have been discussed above.

3. Seed collection, storage and germination rates

Approximately 1485 seeds and 912 cones collected from twelve populations (1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 13 and 18) between 1986 and 1993 are stored in the CALM Threatened Flora Seed Centre

[4] Sandra Maciejewski, Bushcare Officer, City of Albany

(TFSC) at –18°C, 4^0C and room temperature. *Banksia brownii* seed is readily germinable. Fresh seed from nine populations produced between 80-97% germination with subsequent germination after a years storage under low temperature (-20°C) and low moisture (ca. 5% moisture content) conditions being 64-100%. After five years storage under the same conditions, four of these collections were retested and germination was found to be 70-90% (A. Cochrane, unpublished data [5]).

It has been observed that cones of *Banksia brownii* that have been dried and stored for any length of time no longer extract their seed readily like freshly collected cones. Discussions with other professionals working with seed have confirmed the difficulty of extracting seed from cones that have been allowed to dry out and stored for more than a few months. It is clear that to utilise material from *B. brownii* for recovery purposes it is necessary to extract seed from the cones prior to propagation. Currently, eleven collections of *B. brownii* are held in cones in the TFSC. If it is not possible to extract the seed from cones in storage, then an active program to recollect material from *B. brownii* will be required (A. Cochrane and [6]A Crawford, personal communication).

Recollection of cones commenced in April 2004 from the Yungemere and Waychinicup populations and immediate extraction of seeds was undertaken.

4. Development of a Draft Fire Management Strategy for the Stirling Range NP

A Draft Fire Management Strategy has been developed for the Stirling Range NP (Barrett *et al.* 2003b). The strategy recommends that demographic processes and life history attributes (vital attributes) be used to identify fire sensitive species and in particular threatened species and ecological communities within each cell to determine the minimal tolerable fire frequency for these species and communities, and that the core mountain areas (corresponding to all Stirling Range NP *Banksia brownii* populations) are designated as "no planned burn" areas for the duration of the Master Burn Plan. The strategy also recommends the judicious use of prescribed fire within the lowland areas to protect the high conservation values of the montane heath and thicket and montane mallee thicket community.

5. Promote awareness

Presentations have been given to scientific and general audiences on the impact of *Phytophthora cinnamomi* on *Banksia brownii* and on the species management. *B. brownii* is referred to, along with the Montane TECs, in a Bush Book for Stirling Range flora. An article on *B. brownii* was written for the Banksia Study Group Newsletter Spring 2004 (Vol 5 No. 1). An article on *B. brownii* has been written for CALM's Landscope magazine (2005).

Future recovery actions

Where populations occur on lands other than those managed by CALM, permission has been or will be sought from the appropriate land managers prior to recovery actions being undertaken The following recovery actions are roughly in order of descending priority; however this should not constrain addressing any of the priorities if funding is available and other opportunities arise.

1. Coordinate recovery actions

[5] Anne Cochrane, Manager, CALM Threatened Flora Seed Centre
[6] Andrew Crawford, Technical Officer, CALM Threatened Flora Seed Centre

The Albany District Threatened Flora Recovery Team (ADTFRT) is coordinating recovery actions for *Banksia brownii* and will include information on progress in their annual report to CALM Corporate Executive and funding bodies.

Action: Coordinate recovery actions
Responsibility: CALM (Albany Work Centre) through the ADTFRT
Cost: $3,000 per year.

2. Continue, and increase where appropriate, aerial spraying of populations with phosphite

Continue the current regime of aerial phosphite application and increase where appropriate. The new population on Yungemere (12B) with small scattered *Phytophthora cinnamomi* infections should be sprayed. Annual spraying may need to be considered to improve the effectiveness of application for high priority sites. There is also a need to further refine phosphite application techniques, consider alternative application techniques and determine reasons for loss of disease control.

Action: Continue, and increase where appropriate, aerial spraying with phosphite
Responsibility: CALM (Albany Work Centre)
Cost: $24,926 per year.

3. Continue *Phytophthora cinnamomi* hygiene practices

Access by CALM personnel and volunteers to all *Banksia brownii* populations will be restricted to dry soil conditions in accordance with the guidelines outlined in "*Phytophthora cinnamomi* and disease caused by it. Volume 1. Management Guidelines (CALM 2000)". Footwear is to be clean on entry.

The City of Albany will be strongly encouraged to follow hygiene practices in all Shire Reserves where *Banksia brownii* occurs.

Action: Continue *Phytophthora cinnamomi* hygiene practices
Responsibility: CALM (Albany Work Centre)
Cost: $400 per year.

4. Monitor populations

Continue regular monitoring of all populations annually including monitoring the rate of spread of *Phytophthora cinnamomi*, effectiveness of phosphite application, post-fire seedling recruitment and fruiting success. For sites such as Population 12 (Yungemere) with restricted and difficult access, aerial photography should be used to monitor changes in multiple spot infections.

Action: Monitor populations
Responsibility: CALM (Albany Work Centre)
Cost: $7,350 per year.

5. Further develop and implement a fire management strategy

For the life of this Plan (five years) fire will, if possible, be prevented from occurring in all *Banksia brownii* populations within the Stirling Range NP. For populations that are long unburnt some prescribed burning may be considered within 5 years in order to regenerate senescing plants. However there are concerns about an anticipated increase in *P. cinnamomi* activity post fire (Malcolm Grant and Greg Freebury, personal communication).

If fire is to be used, autumn fires are preferable for *Banksia brownii*, which is an obligate seeder with a canopy stored seed bank. An autumn fire will minimise the interval (and therefore predation or deterioration of seed) between seed release and germination in winter.

A fire management strategy specifically for *Banksia brownii* will be expanded to include southern populations.

Action: Further develop and implement a fire management strategy
Responsibility: CALM (Albany Work Centre)
Cost: Further develop: $400 in first tear
Implementation: $5,150 in first year, $5,700 in 2nd year, $3,170 in 3rd year, $5,700 in 4th year.

6. Collect seed and store for long-term conservation and for future translocations

Preservation of germplasm is essential to guard against the possible extinction of wild populations and to propagate plants for future translocations. Seed is required from all populations to maximise the genetic diversity of *ex situ* material.

Action: Collect seed and store for long-term conservation and for future translocations
Responsibility: CALM (Albany Work Centre and Threatened Flora Seed Centre)
Cost: $3,680 per year.

7. Extract seed from cones already collected and stored in the CALM Threatened Flora Seed Centre

Currently there are eleven collections of *Banksia brownii* stored as cones. It is necessary to assess whether these existing collections of *Banksia* cones will release their seed. If so, then all material will be extracted and dried under low moisture and low temperature conditions (15^{o}C and 15%RH) and subsequently frozen for long-term storage. Samples of each collection will be germinated to assess viability of the material prior to storage.

Action: Extract seed from cones already collected and stored in the CALM Threatened Flora Seed Centre
Responsibility: CALM (Threatened Flora Seed Centre)
Cost: $3570 in first year.

8. Survey for suitable translocation sites for northern and southern forms and write a Translocation Proposal

Given the critical status of this species and the susceptibility of all existing populations to *Phytophthora cinnamomi* infestation and the recent loss of a number of populations due to *P. cinnamomi* infestation a translocation to a non-infested site is essential.

A number of potential translocation sites have been preliminarily identified and these will be surveyed for their suitability.

Although translocations are generally undertaken under full Recovery Plans, the immediate threat of *Phytophthora cinnamomi* to wild populations of this species requires the development of a translocation proposal within the five-year time frame of this IRP. Information on the translocation of threatened animals and plants in the wild is provided in the CALM Policy Statement No. 29 *Translocation of*

Threatened Flora and Fauna. All translocation proposals require endorsement by the Director of Nature Conservation.

Action: Survey for suitable translocation sites for northern and southern forms and write a Translocation Proposal
Responsibility: CALM (Albany Work Centre)
Cost: $2260 per year for first two years.

9. Conduct further surveys

The species occurs in a variety of habitats. An attempt will be made to determine other areas where *Banksia brownii* may occur. Volunteers from the local community and Wildflower Societies will be encouraged to be involved in surveys supervised by CALM staff.

Action: Conduct further surveys
Responsibility: CALM (Albany Work Centre)
Cost: $1,550 per year for the first two years.

10. Liaise with stakholders

Staff from CALM Albany Work Centre will continue to liaise with the City of Albany to ensure populations on Shire Reserve are not accidentally damaged or destroyed, and that the impacts of identified threats, are minimised, in particular the impact of *Phytophthora cinnamomi*. Input and involvement will also be sought from any Noongar groups that have an active interest in areas that are habitat for *Banksia brownii*.

Action: Liaise with stakeholders
Responsibility: CALM (Albany Work Centre)
Cost: $1,200 per year.

11. Promote awareness

The importance of biodiversity conservation and the need for the long-term protection of wild populations of this species will be promoted to the community through poster displays and the local print and electronic media. Formal links with local naturalist groups and interested individuals will also be encouraged. An information sheet, which includes a description of the plant, its habitat, threats, recovery actions and photos will be produced and distributed.

Action: Promote awareness
Responsibility: CALM (Albany Work Centre) through the ADTFRT
Cost: $1,400 in first year and $1,100 in remaining years.

12. Obtain biological and ecological information

Improved knowledge of the biology and ecology of *Banksia brownii* will provide a better scientific basis for management of the wild populations. In addition to biological and ecological information already available for *B. brownii*, the following research actions are particularly necessary for effective management of the species:

1. Investigate factors reducing post-fire recruitment other than fire interval and *Phytophthora cinnamomi* (eg. fire intensity or season, lack of pollinators, climate change)
2. Investigate molecular markers to distinguish between southern and northern form of this species

3. Determine the population genetic structure, levels of genetic diversity and minimum viable population size for the species
4. Investigate the role of native animals in the spread of *P. cinnamomi*

Action: Obtain biological and ecological information
Responsibility: CALM (Albany Work Centre and Science Division)
Cost: $5950 in the first year, $23,950 in the second year.

13. Map habitat critical to the survival of the species

It is a requirement of the EPBC Act (Section 207A) that spatial data relating to critical habitat be determined. Although habitat critical to the survival of the species is alluded to in Section 1, all the areas described have not yet been accurately mapped and will be addressed under this action. If additional populations are located, habitat critical to their survival will also be determined and mapped.

Action: Map habitat critical to the survival of the species
Responsibility: CALM (Albany Work Centre)
Cost: $400 in first year

14. Review the need for a full Recovery Plan and prepare if necessary

If *Banksia brownii* is still ranked as Endangered under the Commonwealth EPBC Act at the end of the fourth year of the five-year term of this IRP, the plan will be reviewed and the need for further recovery actions assessed.

Action: Review the IRP and assess the need for further recovery actions
Responsibility: CALM (Species and Communities Branch and Albany Work Centre) through the ADTFRT
Cost: $4,000 in the fifth year (if required).

4. TERM OF PLAN

This Interim Recovery Plan will operate from October 2005 to September 2010 but will remain in force until withdrawn or replaced. If the taxon is still ranked as Critically Endangered after five years, this IRP will be reviewed and if necessary, further recovery actions put in place.

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7. TAXONOMIC DESCRIPTION

From: George, A.S. (1987). The Banksia Book. Kangaroo Press and Society for Growing Australian Plants, NSW.

A shrub to 4 m without a lignotuber, sometimes a small tree. Bark smooth with lenticels. *Branchlets* pubescent, becoming glabrous. *Leaves* whorled, broadly linear, retuse, 3-11 cm long, 5-12 mm wide, divided almost to midrib into many linear obtuse lobes, rather soft, the margins revolute: pubescent becoming glabrous on upper surface, woody below. *Inflorescence* terminal but subtended by branchlets, broadly cylindrical, 6 –9 mm long, 8-10 cm wide at flowering: bracts at base narrow, pubescent, persistent. *Flowers* pale brown with grey-brown limb: styles metallic red with cream apex. *Perianth* 27-31 mm long including limb of 3 mm, slender, hirsuite outside, glabrous inside except hairs on margins in upper half. *Pistil* 31-40 mm long, the apex recurved, glabrous except a few hairs on ovary; pollen presenter narrowly ovoid, 0.3 mm long. Old flowers persistent. *Follicles* up to 60, narrowly elliptic, 17-25 mm long, 5-10 mm high, 4-7 mm wide, the valves slightly rugose, pubescent: usually opening with fire. Seed obovate, 19-20 mm long, 5-6 mm wide, irregularly rugose: wing 9-11 mm wide, not notched.