Australian Government
Department of Agriculture, Water and the Environment

Conservation Advice for the subspecies of *Banksia ionthocarpa* (Kambullup Dryandra)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 29 September 2021.

This document provides a foundation for conservation action and further planning.

Banksia ionthocarpa subsp. *ionthocarpa* © Copyright, S Barrett

Conservation status

*Banksia ionthocarpa (*Kamballup Dryandra) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act). The species is eligible for listing because prior to the EPBC Act, it was listed as Endangered under the *Endangered Species Protection Act 1992* (Cwlth).

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the Species Profile and Threat Database.

Species information

Taxonomy

Banksia ionthocarpa (AS George) AR Mast & KR Thiele (2007) was discovered near Kamballup in south-west Western Australia (WA) in 1987 and was originally described as *Dryandra ionthocarpa* in 1996 (George 1996). The species was thought to be represented only by this subpopulation, but in 1998 a new subpopulation was discovered east of Pingelly, over 200 km north of the original site (Obbens et al. 2001). In 2004, the species was divided into two subspecies, *D. ionthocarpa* subsp. *ionthocarpa* (Kamballup subpopulation) and *D. ionthocarpa* subsp. *chrysophoenix* (East Pingelly/Aldersyde subpopulations) (Barrett & Cochrane 2004), with the former being a seeder species (fire-susceptible/killed) and the latter being a resprouting clonal species.

In 2007, all dryandras were transferred to the genus *Banksia*, and thus the species became *Banksia ionthocarpa* (Mast & Thiele 2007). The subspecies became *Banksia ionthocarpa* subsp. *ionthocarpa* and *Banksia ionthocarpa* subsp. c*hrysophoenix*

Due to the differences in distribution, ecology, threats and management practices between each subspecies, detailed reports are provided for each whilst the full species account is relatively brief. However, both subspecies are only listed at the species level under the EPBC Act. For the purposes of this document, the species is referred to as *Banksia ionthocarpa*, and the subspecies are referred to as *Banksia ionthocarpa* subsp. *ionthocarpa* and *Banksia ionthocarpa* subsp. c*hrysophoenix.*

Description

Banksia ionthocarpa* subsp. *ionthocarpa

Banksia ionthocarpa subsp. *ionthocarpa* is a tufted shrub with a very short stem and leaves up to 30 cm long. The leaf lobes are broadly triangular, up to 8 mm and cut within 1.5 mm of the midrib. The subspecies is an obligate seeder (fire killed, with seedlings growing from a seed bank after fire). With pale-yellow flowers borne close to the ground within the leaves, *B. ionthocarpa* subsp. *ionthocarpa* has characteristic follicles (dry fruit containing seeds) that are not woody, differing from those found in most *Banksia* species. Each follicle contains one seed, is about 5 mm in size and covered in 7-8 mm long erect hairs. The subspecies is also unusual in that the floral bracts (leaves around the flower) do not elongate as the fruits develop. This description was adapted from DEC 2008.

Banksia ionthocarpa* subsp. c*hrysophoenix

Banksia ionthocarpa subsp. c*hrysophoenix* is a shrub to 40 cm high with underground stems. The leaves are rigid, with straight margins. The follicles (not seen when mature) are long and ovate, narrowing at the base, and covered in a felt-like covering of cottony hairs on one edge. They also have the characteristic apical tuft found in the other subspecies (Pieroni 2000; George 2005; Cavanagh & Pieroni 2006). Flowering occurs from July to September. *Banksia ionthocarpa* subsp. c*hrysophoenix* differs from *B. ionthocarpa* subsp. *ionthocarpa* through its fire-tolerant

underground stems capable of post-fire resprouting, as well as straighter leaf lobes (George 2005; Cavanagh & Pieroni 2006). *Banksia ionthocarpa* subsp. c*hrysophoenix* also predominately reproduces clonally, whilst *B. ionthocarpa* subsp. *ionthocarpa* reproduces sexually (Millar et al. 2010). This description was adapted from DEC 2007.

Distribution

Kamballup Dryandra is known from a subpopulation near Kamballup and from multiple subpopulations found across approximately 57 km^2 of land in the shires of Brookton and Pingelly (DEC 2007; DEC 2008; DBCA 2021).

Banksia ionthocarpa subsp. *ionthocarpa*

Banksia ionthocarpa subsp. *ionthocarpa* is known from a single natural locality in the Kamballup area, comprising two subpopulations. It is distributed across less than 1 km^2 of land and occupies less than five hectares. One subpopulation (1A) is on a Class C recreation reserve vested in the Shire of Plantagenet, and the other (1B) is in an adjacent unvested Class C reserve for the purpose of public utility (DEC 2008) (Table 1). The unvested reserve has been subject to mining for spongolite stone, and this mine is located near the extant plants. However, mining is historical and there are no current mining tenements approved or pending approval on this land (DEC 2008). As of 2021, the size of this natural subpopulation is estimated at 635 individuals, with 150 individuals in subpopulation 1A and 185 individuals in subpopulation 1B. Both subpopulations appear to be in ongoing decline due to reductions in rainfall, with minimal inter-fire recruitment (Pieroni 2014; DBCA 2020).

During 1999 and 2000, 283 seedlings of the subspecies were translocated to Kalgan Plains Nature Reserve, near Kamballup. The subspecies is not known to have occurred naturally at this site, though it is within the known range of the subspecies and has similar habitat (DEC 2008). Six of these individuals flowered for the first time in the 2003 flowering season. However, survival was poor and, by 2004, the subpopulation consisted of just 46 individuals. In 2005, an additional 566 plants were translocated into this area (DEC 2008). A subsequent translocation to the same reserve in 2010 has had moderate success, with a total of 129 translocated plants alive as of 2019, though not all are reproductive and plant health is variable (DBCA 2020).

Table 1 Summary of *Banksia ionthocarpa* subsp. *ionthocarpa* subpopulation information and threats in Western Australia based on DEC (2008) and DBCA (2021).

Subpopulation No. & Location	Year	No. of plants adults (juveniles)	Condition	Threats
1A. North of Kamballup	1987	400+/-	Healthy	Weeds
	1988	200+/-	Healthy	Fire
	1990	200+/-	Healthy	Drought
	1991	Approx. 15% death	Diseased	Disease
	1992	476 (few)	Unknown	
	1993	200+/-	Diseased	
	1994	475*	Moderate	
	1995	682*	Moderate	
	2000	700	Moderate	

	2001	600+	Moderate	
	2002	612*	Moderate	
	2003	612 (73) *	Moderate	
	2004	589 (46) *	Healthy	
	2005	566 (122 dead)	Excellent	
	2007	460	Unknown	
	2008	529	Unknown	
	2009	686	Unknown	
	2012	450	Unknown	
	2017	460	Unknown	
	2019	450	moderate	
1B. North of Kamballup	1988	200+/-	Healthy	Fire
	1990	200+/-	Healthy	Drought
	1991	Approx. 15% death	Unknown	Disease
	1992	250	Diseased	Possible future mining
	1993	200+/-	Diseased	
	1994	682*	Moderate	
	1995	500+	Moderate	
	1996	475*	Moderate	
	1999	400+	Unknown	
	2000	400-	Moderate	
	2002	340*	Moderate	
	2004	328*	Healthy	
	2005	379 (67 dead)	Unknown	
	2007	20	Unknown	
	2008	325	Unknown	
	2009	393	Unknown	
	2012	203	Unknown	
	2017	190	Unknown	
	2019	185	moderate	
7T. Kalgan Plains	1999	138 seedlings	Unknown	Fire
	2000	145 seedlings	Unknown	Drought
	2002	58*	Moderate	Disease
	2004	46*	Moderate	
	2005	612	Unknown	
	2019	129	moderate	

NB: Early estimates were very approximate and as such are not counted. *Precise count of individuals. T = Translocated.

Banksia ionthocarpa subsp. *chrysophoenix*

Banksia ionthocarpa subsp. *chrysophoenix* has a restricted geographic range over approximately 57 km^2 in the shires of Brookton and Pingelly, south-west WA. Subsequent to the discovery of the first subpopulation in 1998, surveys of the surrounding area resulted in the discovery of another subpopulation in the same subpopulation, and further surveys in 1999 and 2000 resulted in the discovery of three additional subpopulations (DEC 2007) (Table 2).

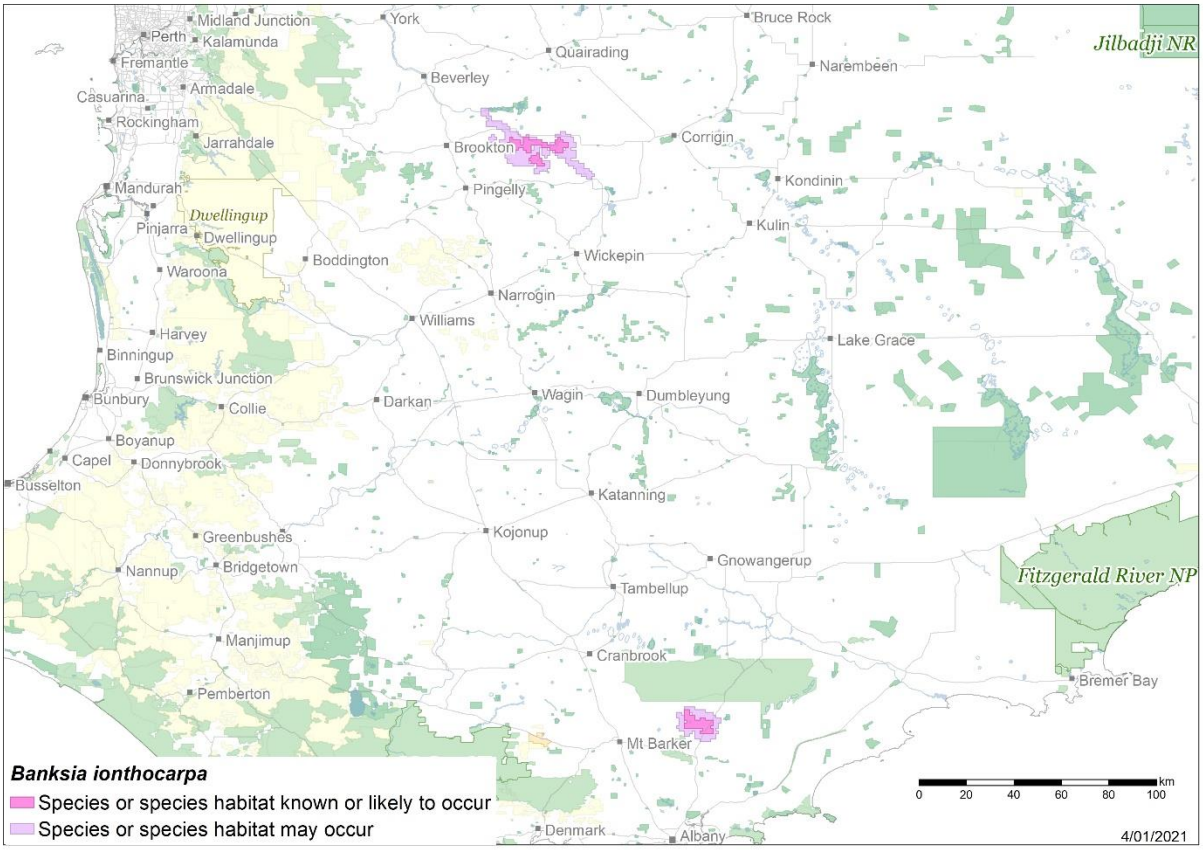
Subpopulation 2 was impacted by fire in 1996, but other subpopulations have not been burnt for a long period of time. In the 2007 recovery plan, the subspecies was known from four subpopulations (one comprising two disjunct patches), totalling 862 mature plants (DEC 2007). However, genetic sampling carried out on the new subpopulations revealed that there are, across all subpopulations, just 16 plants (Millar et al. 2010). The subspecies is clonal (see *Reproductive ecology)* and one individual plant can consist of multiple ramets spread across hundreds of metres of land, accounting for the extreme overestimation of population size (Millar et al. 2010). For example, each new subpopulation discovered in 1999 and 2000 accounted for only one plant, despite being counted as many (Pieroni 2013). Following the genetic study, plants are now monitored by measuring area covered by live plants within quadrats (DBCA 2021).

Table 2 Summary of *Banksia ionthocarpa* subsp. c*hrysophoenix* population information and threats based on DEC (2007) and DBCA (2021).

Pop. No. & Location	Year	No. of plants (juveniles) and measuring area covered by live plants in quadrats	Condition	Threats
1. SE of Brookton^	2001 2009 2013 2015	299* 7 clones 9.2 m^2 7.3 m^2	Healthy Moderate Moderate Moderate	Weeds, rabbits, salinity, competition from native plants, rubbish dumping, fence/firebreak maintenance and construction, drying climate
2. E of Brookton	1999 2001 2005 2013 2015	215 370 425 8.8 m^2 9.2 m^2	Moderate Moderate Moderate	Weeds, rabbits, road maintenance, drying climate
3. E of Brookton	2000 2001 2005 2010 2013 2015	17 (3) 22 (2) 41 41 6.5 m^2 6.5 m^2	Moderate Poor Poor	Weeds, rabbits, road, and firebreak maintenance, fenceline clearing, rubbish dumping, drying climate, invasion by *Allocasuarina huegeliana* (Rock Sheoak),
4. E of Brookton	2000 2001 2005 2013 2015	282 250 97 4.7 m^2 4.7 m^2	Poor Senescent Senescent	Weeds (annual veldt grass), rabbit activity, road maintenance, fenceline clearing, rubbish dumping, invasion by *Allocasuarina huegeliana* (Rock Sheoak), drying climate

* = subpopulations combined. Subspecies is now considered clonal, with an actual population size of 16.

Map 1 Modelled distribution of Kamballup Dryandra



Source: Species distribution data Species of National Environmental Significance database, Base map Geoscience Australia.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.
Species distribution mapping: The species distribution mapping categories are indicati1ve only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

Banksia ionthocarpa subsp. *ionthocarpa*

The cultural significance of *Banksia ionthocarpa* subsp. *ionthocarpa* is unknown. However, the subspecies occurs in the Wagyl Kaip region of Noongar country, in land traditionally belonging to the Minang dialectical group (South West Aboriginal Land & Sea Council 2020a). According to the Department of Indigenous Affairs Aboriginal Heritage Sites Register, *Banksia ionthocarpa subsp. ionthocarpa* occurs on the registered site 'Kamballup Pool', and within two kilometres of at least one of the registered sites 'Kamballup Pool', 'Kamballup Bridge', 'Kalgan Downs' and 'Arizona Pool' (DEC 2008). Aboriginal Heritage Places (4589, 4662, 5112, 5160, 5521) have been registered with the WA Department of Planning, Lands and Heritage in or adjacent to lands where the subspecies occurs (DPLH 2020).

Banksia ionthocarpa* subsp. *chrysophoenix

The cultural significance of *B. ionthocarpa* subsp*. chrysophoenix* is unknown. However, the subspecies occurs in the Ballardong region of Noongar country, in the Njaki Njaki dialectal group (South West Aboriginal Land & Sea Council 2020b). A search of the Department of Indigenous Affairs Aboriginal Heritage Sites Register has identified that there are no sites of Aboriginal significance at or near subpopulations of the subspecies (DEC 2007).

Relevant biology and ecology

Habitat

Banksia ionthocarpa subsp. ionthocarpa

Banksia ionthocarpa subsp. ionthocarpa occurs on clay-loam soils over spongolite, underlaid by the Late Eocene Plantagenet group geological formation (spongolite with minor siltstone and sandstone) (DEC 2008). It is found in open shrub mallee habitat dominated by *Eucalyptus falcata* (Silver mallet) and *Eucalyptus pleurocarpa* (Tallerack), with a range of scrub species including *Melaleuca* spp., *Allocasuarina thuyoides* (Horned Sheoak)*, Beaufortia micrantha* (Small-leaved Beaufortia)*, Isopogon buxifolius, Verticordia* spp. and *Xanthorrhoea platyphylla*. Vegetation surrounding *B. ionthocarpa* subsp. *ionthocarpa*is predominantly less than one metre high and consists entirely of small shrubs and herbaceous species (Monks 1999). It experiences a mean annual rainfall of 930 mm and mean maximum and minimum temperatures of 19.5°C and 11.6°C respectively (Millar et al. 2010).

Reproductive ecology

There are no reliable data on the longevity of the subspecies, however as the habitat is long unburnt, mature plants may be up to 70 years old, The juvenile period for naturally occurring plants is six years (DBCA 2021). However, six plants translocated in 1999 were recorded to have flowered for the first time four years after seedlings were planted.

The seeds of *B. ionthocarpa* subsp*. ionthocarpa* are quite different to those of most other *Banksia* species. They lack a wing, and instead the follicles have a small tuft of hairs that appear to be designed to stick to fur (Kershaw et al. 1997). It is thought that plants are mammal pollinated due to the dull appearance, low positioning, and strong smell of the inflorescences, as well as the large number of viable seeds produced (Monks 1999; DEC 2008).

The subspecies appears not to regenerate from rootstock following a bushfire, though seedlings are recruited post-fire. The magnitude of post-fire recruitment is related to the canopy seed bank. A large quantity of viable seed is produced annually, which is mostly dispersed as the seed ripens. Seed that does not disperse may remain viable within the cones, naturally deteriorate, or be predated upon (DEC 2008). The species has the attributes of an obligate seeder (woody plants that do not re-sprout post fire and instead recruit seedlings from fire-activated seeds), with seedling recruitment mostly confined to the post-fire period. Favourable post-fire conditions, particularly adequate rainfall, are imperative, as most fire-recruited seedlings die from drought over summer (Monks 1999; Barrett and Cochrane 2004). Substantial germination has also been observed after an extreme rainfall event in 2005) indicating that the species has the capacity for non-fire related germination from the soil seed bank. However, after two years very few seedlings had survived (DBCA 2021.

Banksia ionthocarpa subsp. *ionthocarpa* is thought to be weakly serotinous (seeds stored in cones until a fire event) (Monks 1999). Consequently, poorly timed fires (could have a very detrimental effect on the population. An estimate for the minimum desirable fire interval may be determined by multiplying the primary juvenile period by two (Gill & Nichols 1989). The juvenile period for *B. ionthocarpa* subsp. *ionthocarpa* is 6 years to first flowering but longer (8 years) for fruit set. Therefore, a fire regime of around 12 years is desirable. In a study by Barrett and Cochrane (2004), 76 percent of the subspecies' seed was found to remain intact in the soil for at least nine months, and the ability for viable seed to persist in the soil has since been confirmed (DEC 2008) however *Banksia* species generally do not accumulate a soil seed bank hence caution should be exercised in planning management actions that presume a long-lived soil seed bank. Ex situ seed longevity studies indicated the potential longevity of the subspecies' seed under a range of ex situ storage conditions, with greatest viability obtained from fresh seed (Barrett & Cochrane 2004). In the same study, fire was the most significant stimulus for seedling emergence. Smoke treatment resulted in minimal germination of the soil-stored seed and the few recruits observed around unburnt plants failed to survive through summer (Barrett & Cochrane 2004). Recent natural recruitment has been very limited due to a lack of fire. No recent bushfires have occurred in the species' range, and no prescribed burns have been undertaken due to very low seedling survival following a small-scale experimental burn in 2003, where only of 65 seedlings survived to reproduce (DBCA 2020).

Monks (1999) found the number of seedlings recruited per parent plant after the first summer was considerably lower than would be expected for a non-sprouter in south-western Australia. Barrett and Cochrane (2004) concluded that initial recruitment may vary considerably within and between subpopulations and from year to year. This variation may be due to variation in the canopy-stored seed bank of individual plants, as well as seed predation pre- and post-dispersal or the potential lack of an accumulating soil seed bank. It is possible that recruitment under a more extensive burn is higher (Barrett and Cochrane 2004). However, poor seedling survival after the first summer was the critical factor limiting successful recruitment.

Banksia ionthocarpa subsp. Chrysophoenix

Habitat

Banksia ionthocarpa subsp. c*hrysophoenix* is found in sandy loam or sandy clay soils over laterite or granite in Kwongan vegetation, sometimes with an overstorey of Rock Sheoak (DEC 2008). Species associated with the subspecies include *Hakea incrassata* (Marble Hakea), *Hakea trifurcata* (Two-leaf), *Hakea lissocarpha* (Honey Bush), *Lepidobolus preissianus*, *Caustis dioica*, *Mesomelaena pseudostygia*, *Acacia stenoptera* (Narrow-winged wattle), *Allocasuarina microstachya* (Rock Sheoak), *Calothamnus brevifolius*, *Verticordia fimbrilepis* subsp. *fimbrilepis*, *V. densiflora* (Compacted Featherflower), *Loxocarya collina*, *Jacksonia racemosa*, *Synaphea petiolaris* and *Leptospermum erubescens* (Roadside Tea Tree) (DEC 2007). *Banksia ionthocarpa* subsp. c*hrysophoenix* subpopulations experience less than half the mean annual rainfall of *B. ionthocarpa subsp. ionthocarpa* (453 mm), and a higher maximum (24.2°C) and lower minimum temperature (9.7°C) (Millar et al. 2010).

Reproductive ecology

Little is known about the biology and ecology of *B. ionthocarpa* subsp. c*hrysophoenix*. The follicles have the same prominent, fur-sticking tuft characteristic of *B. ionthocarpa subsp. ionthocarpa* (Pieroni 2000; George 2005; Cavanagh & Pieroni 2006). However, the two subspecies appear to have contrasting modes of reproduction. Unlike *B. ionthocarpa subsp. ionthocarpa*, which is a fire-killed (seeder) and reproduces sexually, *B. ionthocarpa* subsp. c*hrysophoenix* has a lignotuber from which it regenerates following fire (Millar et al. 2010). No fruit production or seed set has been observed with plants reproducing vegetatively from the lignotuber after fire, and in 2005 *B. ionthocarpa* subsp. c*hrysophoenix* was described as 'apparently clonal' (George 2005). This was confirmed by Millar et al. (2010), who identified that the subspecies has very low levels of genetic diversity and reproduces clonally. Plants are comprised of large clonal patches that can cover hundreds of square metres. Indeed, some patches are so large that 16 individuals across the four subpopulations were mistaken as 852 mature individuals during population estimates (Pieroni 2013).

It is suggested that the development of clonality in *B. ionthocarpa* subsp. c*hrysophoenix* may be due to the marginal environment in which is it found (Millar et al. 2010). *Banksia ionthocarpa* subsp. c*hrysophoenix* is associated with lower rainfall and more extreme temperatures than its sister subspecies, accounting for the difference in reproductive strategy, as clonal subpopulations are more often associated with marginal environments (Silvertown 2008; Millar et al. 2010). The level of clonality may also have been enhanced by recurrent fires (Millar et al. 2010).

Habitat critical to the survival

Due to the species eligibility for listing (highly restricted range and/or severe fragmentation and/or/small population size), all habitat is considered critical to the survival of the species.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

There is sufficient evidence through the species eligibility for listing, to declare all populations/the national population of this species under particular pressure of survival and which therefore require protection to support the recovery of the species.

Threats

The known subpopulations of both subspecies of *B. ionthocarpa* are threatened by inappropriate fire regimes and drought associated with climate change, habitat disturbance and grazing. The species is threatened by several fire-related threats, including high frequency fire, fire-disease interactions and fire promoted weed invasion. Dieback caused by *Phytophthora cinnamomi* is also a potential threat to *B. ionthocarpa subsp. ionthocarpa*

Table 3 Threats impacting *Banksia ionthocarpa (*Kamballup Dryandra)

Threat	Status and severity [a]	Evidence
Climate change		
Increased temperatures and decreased rainfall	• Timing: current • Confidence: known • Consequence: catastrophic • Trend: increasing • Extent: across the entire range	South-western WA has experienced a significant decrease in autumn and early winter rainfall and an increase in mean ambient temperatures since the turn of the century (CSIRO & Bureau of Meteorology 2015). This is likely to continue in the future, with south-western WA projected to experience decreased rainfall, increased average temperatures and increased frequency of droughts as a result of climate change (CSIRO & Bureau of Meteorology 2015). Drought may directly impact *B. ionthocarpa* subsp. *ionthocarpa* by reducing flowering, seed set and subpopulation recruitment, and by increasing plant mortality (Barrett & Cochrane 2004). Indeed, decline in the number and health of *B. ionthocarpa* subsp. *ionthocarpa* has already been observed due to drought (Pieroni 2014). There has been 62% survival of 50 tagged plants from 2005–2019 due to mortality presumably associated with drought stress, the subspecies has also experienced very low inter-fire recruitment presumably due to dry conditions (DBCA 2020). Monks (1999) monitored the recruitment and survival of seedlings and found that a significant loss of seedlings occurred following summer drought. Current seedling survival is poor, primarily as a result of drought stress, and any further adverse change in conditions due to climate change will be severely detrimental to recruitment. The threat of drought to *B. ionthocarpa* subsp. c*hrysophoenix* is unknown, though reduced rainfall is likely to have some impact on the subspecies. The subspecies' habitat is found in a lower rainfall area than *B. ionthocarpa* subsp. *ionthocarpa* (Millar et al. 2010), so may be more

Threat	**Status and severity** [a]	**Evidence**
		drought tolerant than its sister subspecies. Though both subspecies are currently threatened by lack of fire, elevated temperatures and reduced rainfall will lead an increase in the frequency and severity of fires in WA (CSIRO & Bureau of Meteorology 2015). While occasional fire is required for *B. ionthocarpa* subsp. *ionthocarpa* seedling recruitment, inappropriate timing, intensity, and frequency of fire may be detrimental to the subspecies, as plants need to reach reproductive maturity to build up a seed bank A too-frequent fire regime (<15 years) is likely to kill adult *B. ionthocarpa* subsp. *ionthocarpa* plants before soil-stored seed banks or sufficient seeding can be occur to replace the parent plants (Brown et al. 1998), and a drying climate may also lengthen the minimum fire interval required for self-replacement of obligate seed regenerators such as *B. ionthocarpa* subsp. *ionthocarpa* (Enright et al. 2014). The small population size and restricted distribution of both subspecies may also increase population extinction risk following stochastic events like bushfires.
Habitat loss, disturbance, and modification		
Inappropriate fire regimes	• Timing: current • Confidence: known • Consequence: catastrophic • Trend: static • Extent: across the entire range	Fire stimulates *B. ionthocarpa* subsp. *ionthocarpa* seed germination and recent natural recruitment has been very limited as no bushfires have occurred in the species' range. Furthermore, no prescribed burns have been undertaken, due to very low seedling survival following a small-scale experimental burn in 2003. Due to this lack of recruitment, the population is declining and will likely continue to decline without natural or prescribed fire or physical disturbance of the site (which has been shown to elicit a fire-like germination response). Successful recruitment of the long unburnt population is also highly dependent on adequate rainfall for several

Threat	Status and severity [a]	Evidence
		seasons post-fire (DBCA 2021). If conditions are not favourable for seedling recruitment and survival in the year mature plants are burnt, recruitment will be minimal. In the 2008-2013 recovery plan for *B. ionthocarpa* subsp. c*hrysophoenix*, fire was not classified as a threat, though it is indirectly impacted by a lack of fire in the region. The very low incidence of fire in native vegetation remnants in this landscape has led to significant competition from encroachment of native shrubs (e.g., Rock Sheoak) (DBCA 2021). As with *B. ionthocarpa* subsp. *ionthocarpa*, in the long-term absence of fire or management actions to reduce the encroachment of native shrubs by physical removal, the population of *B. ionthocarpa* subsp. c*hrysophoenix* is likely to continue to decline.
Altered hydrology	• Timing: future • Confidence: inferred • Consequence: major • Trend: increasing • Extent: across the entire range	It is predicted that altered hydrology and increased salinity throughout south-west WA will cause the loss of habitat in many reserves (DEC 2008). Dryland salinity is one of the greatest environmental threats facing WA's biodiversity, and severely affects more than 1 million hectares of land. This is primarily due to changed land use and management, predominantly because of clearing for agriculture replacing deep-rooted vegetation with shallow-rooted crops (DPIRD 2020). Though the reserve in which *B. ionthocarpa* subsp. *ionthocarpa* occurs is low in the catchment and adjacent to the salt-affected Kalgan River, the subpopulation occurs at a higher point in the local topography, and may be less vulnerable to the impacts of altered hydrology (DEC 2008). The reserve may also be affected by chemicals and nutrients from adjacent farmland (Panetta & Hopkins 1991). *Banksia ionthocarpa* subsp.

Threat	Status and severity [a]	Evidence
		c*hrysophoenix* may also be threatened by changes to hydrology, though the level to which this may occur is unclear. No developments or clearing should be approved unless it can be demonstrated that there will be no significant impact on the subspecies, its habitat or potential habitat or on the local surface hydrology (DEC 2007).
Mining and development	• Timing: historical • Confidence: known • Consequence: major • Trend: static • Extent: across parts of the range	One *B. ionthocarpa* subsp. *ionthocarpa* subpopulation reserve has been subject to mining for spongolite stone, and this mine is located near the extant plants. However, mining is historical and there are no current mining tenements approved or pending approval on or adjacent to the habitat of either subspecies. Likely effects of mining include soil compaction, clearing and damage to vegetation (DEC 2007; DEC 2008). Mining would also likely add significant amounts of water and nutrients to the soil, and an increase in the likelihood of *P. cinnamomi* spread due to vehicle and foot traffic (DEC 2007; DEC 2008). Road construction and maintenance may encourage weed spread and threaten both subspecies by herbicide spraying and verge grading. Some *B. ionthocarpa* subsp. c*hrysophoenix* subpopulations are already threatened by these processes, and this is likely to increase if development occurs (DEC 2007).
Fire hazard due to rubbish dump	• Timing: future • Confidence: inferred • Consequence: minor • Trend: increasing • Extent: across the entire range	The rubbish dump to the south of one *B. ionthocarpa* subsp. *ionthocarpa* subpopulation is a potential fire hazard. A firebreak is maintained between the two subpopulations to ensure that the two do not burn at the same time (DEC 2008).
Invasive species		
Weed invasion	• Timing: current • Confidence: known • Consequence: moderate • Trend: unknown • Extent: across the entire range	Weeds can invade, establish in, and outcompete native vegetation, particularly following disturbance events such as prescribed burning and bushfires (Brown et al. 2016). Grassy weeds also increase fuel load,

Threat	Status and severity [a]	Evidence
		ignition capacity, rate of spread and therefore alter fire regimes (Milberg & Lamont 1995) to higher frequency that is favoured by weed species. These altered fire regimes can create conditions that are favourable to the establishment and spread of weeds (D'Antonio & Vitousek 1992; Grigulis et al. 2005) that can outcompete *B. ionthocarpa* subsp. *ionthocarpa*. Weeds that suppress early plant growth by competing for soil moisture, nutrients and light are often blown into *B. ionthocarpa* subsp. *ionthocarpa* subpopulations from adjoining pasture (Panetta & Hopkins 1991). Weed invasion is a particular threat to subpopulation 1A due to the disturbance and environmental changes caused by adjacent farmland. Despite some management, weeds have persisted in subpopulation 1A, primarily at the edge of the site. Weeds of concern include Paddy melon (*Cucumis myriocarpus*), Capeweed (*Arctotheca calendula*) and annual Veld grass (*Ehrharta longiflora*). Rust was introduced to the Bridal Creeper (*Asparagus asparagoides*) in 2002 as the weed has the potential to spread rapidly (DEC 2008). Weeds also threaten *B. ionthocarpa* subsp. c*hrysophoenix*, with Annual Veldtgrass (*Ehrharta longiflora*) posing the greatest threat (DBCA 2021). Weeds compete for space, nutrients, water and light, reducing seedling recruitment (DEC 2007).
Grazing and habitat damage by Rabbits (*Oryctolagus cuniculus*)	• Timing: current • Confidence: known • Consequence: moderate • Trend: static • Extent: across parts of the range	Rabbits are found in all states and territories of Australia and have been listed as a Key Threatening Process under the EPBC Act (DOEE 2016). Grazing by Rabbits can prevent plant regeneration, reverse the normal processes of plant succession, alter ecological communities, and promote weed invasion (DOEE 2016). Rabbit activity threatens all subpopulations of *B. ionthocarpa* subsp. c*hrysophoenix* through soil

Threat	**Status and severity** [a]	**Evidence**
		disturbance, grazing and increased nutrient levels. *Banksia ionthocarpa* subsp. *ionthocarpa* does not appear to be threatened by rabbit activity, though some seedling herbivory by native vertebrates may occur (DEC 2007; DEC 2008).
Disease		
Dieback caused by *Phytophthora cinnamomi*	• Timing: future • Confidence: suspected • Consequence: major • Trend: static • Extent: across the entire range	*Phytophthora cinnamomi* is an introduced soil-borne pathogen which infects a large range of plant species and may contribute to plant death. Mortality is especially likely when other stressors are present, such as waterlogging, drought and bushfire (DOEE 2018). *Phytophthora cinnamomi* can disperse in water flowing from roots of infected plants, and in soil clinging to vehicles, animals, and people (DOEE 2018). Infection results in plant death in susceptible species through the destruction of root systems. Dieback caused by *P. cinnamomi* is listed as a Key Threatening Process under the EPBC Act (DOEE 2018). The impact of the disease on plant communities is variable, as it is dependent on temperature, soil type, nutrient status, soil moisture, and species susceptibility. The greatest impact usually occurs where soils are infertile, and drainage is poor. *Banksia ionthocarpa* subsp. *ionthocarpa* occurs in a winter-wet, poorly drained site, which is likely to favour infestation (DEC 2008). Due to the access tracks passing through the habitat of *B. ionthocarpa* subsp. *ionthocarpa*, the threat of introduction of the pathogen is high. The threat of dieback caused by *P. cinnamomi* may be exacerbated post-fire, due to altered hydrology and increased surface run-off (Barrett 1996), though more research is required to understand this interaction. In general, *Banksia* species are highly susceptible to the disease. Shadehouse experiments indicate

Threat	Status and severity [a]	Evidence
		that *B. ionthocarpa* subsp. *ionthocarpa* is moderately susceptible (Shearer et al. 2013). It is therefore very likely that *B. ionthocarpa* subsp. c*hrysophoenix* is not considered susceptible as rainfall in the species' habitat is too low. The disease has not been associated with any deaths of either subspecies (DEC 2008). As of 2008, all subpopulations of *B. ionthocarpa* subsp. *ionthocarpa* appeared to be *P. cinnamomi*-free (DEC 2007; DEC 2008).
Aerial canker caused by canker-causing fungi.	• Timing: historical • Confidence: known • Consequence: not significant • Trend: unknown • Extent: across parts of the range	Aerial canker caused has in the past been observed on *B. ionthocarpa* subsp. *ionthocarpa* (Kershaw et al. 1997), though no further research was completed on the presence of the fungus. The effect of aerial canker requires further investigation (DEC 2008).
Impacts of native species		
Invasion by Rock Sheoak	• Timing: current • Confidence: known • Consequence: minor • Trend: static • Extent: across parts of the range	Rock Sheoak is dominating vegetation at subpopulations 3 and 4 of *B. ionthocarpa* subsp. c*hrysophoenix* and is competing for space and shading out the subspecies (DEC 2007). It is also a threat to subpopulations 1 and 2 if surrounding habitat species continue to senesce in the absence of fire.

Status—identify the temporal nature of the threat;
Confidence—identify the extent to which we have confidence about the impact of the threat on the species;
Consequence—identify the severity of the threat;
Trend—identify the extent to which it will continue to operate on the species;
Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 3 in terms of the extent that it is operating on the species. The risk matrix (Table 4) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 4 *Banksia ionthocarpa* (Kamballup Dryandra) risk matrix

Likelihood	Consequences				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low risk	Moderate risk **Invasion by Rock Sheoak**	Very high risk **Weed invasion** **Grazing and habitat damage by Rabbits**	Very high risk	Very high risk **Increased temperatures and decreased rainfall** **Inappropriate fire regime**
Likely	Low risk	Moderate risk **Fire hazard due to rubbish dump**	High risk	Very high risk **Altered hydrology**	Very high risk
Possible	Low risk **Aerial canker**	Moderate risk	High risk	Very high risk **Dieback caused by *Phytophthora cinnamomi***	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk **Mining development**	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' or 'high'. For those threats with an unknown or low risk outcome it may be more appropriate to identify further research or maintain a watching brief.

Conservation and recovery actions

Primary conservation objective

- By 2030, the *B. ionthocarpa* subsp. *ionthocarpa* population of approximately 750 will have increased in abundance and viable populations are sustained in habitats which are managed for ongoing threats.
- By 2030, the *B. ionthocarpa* subsp. *chrysophoenix* population of approximately 16 and measuring area of approximately 28m^2 will have increased and viable populations are sustained in habitats which are managed for ongoing threats.

Conservation and management priorities

Fire and Climate change

- Survey fire-affected areas after a fire occurs for sprouts or seedlings growing from seed banks.
- In the aftermath of bushfires, ensure unburnt areas within or adjacent to recently burnt areas do not burn.

- Provide maps of known occurrences to local and state fire services.
- Develop and implement a fire management strategy to protect translocated and natural subpopulations from inappropriate fire regimes. If a natural fire occurs in the species' range, have contingency plans in place to undertake supplemental watering in the event of unseasonal drought that could endanger seedlings.
- Increase fire protection (e.g., firebreaks) in adjacent cleared land directly after fire to ensure that seedlings are given adequate time to mature despite increasing fire frequency.
- Consider the implementation of irrigation systems at extant/translocated subpopulations to mitigate the impact of drought.

Habitat loss, disturbance and modifications

- Conduct targeted removal of bushland biomass (e.g., Rock Sheoak) to assist in regeneration of *B. ionthocarpa* subsp. c*hrysophoenix* habitat.
- Ensure land managers are aware of the species' occurrence and provide protection measures against known and potential threats.
- Ensure that the known distribution of both subspecies continues to be protected from clearing, development for mining and road construction particularly through training, installation of appropriate rare flora markers and literature.
- Ensure that road maintenance work avoids impacting known subpopulations.
- Protect potential suitable habitat from clearing and increase habitat connectivity between subpopulations.

Breeding, seed collection, propagation and other ex situ recovery action

- Continue to collect seeds from *B. ionthocarpa* subsp. *ionthocarpa* to reduce the risk of extinction and preserve the maximum amount of genetic material and genotypes as possible.
- Continue initiation and culture of *B. ionthocarpa* subsp. c*hrysophoenix* under in vitro conditions, with successful tissue cultures to be used for future translocations and for preservation of genetics through cryostorage. Aim to preserve all known clones.
- Conduct further translocations of *B. ionthocarpa* subsp. *ionthocarpa* and initiate translocations of *B. ionthocarpa* subsp. c*hrysophoenix* and *B. ionthocarpa* subsp. *ionthocarpa* to increase extant population sizes (DEC 2007; DEC 2008). Future translocations should make use of updated approaches that include automated, tank-delivered watering during the first two summers after translocation.
- Any translocation should be conducted in accordance with the *Guidelines for the Translocation of Threatened Plants in Australia* (Commander et al. 2018).

Impacts of invasive species (including threats from grazing, trampling, predation)

- Ensure that seedlings and mature individuals are protected against grazing by fencing, maintaining fences and protecting subpopulations from damage.
- Undertake control of rabbits in the distribution of both subspecies.

- Implement weed management actions in consultation with land managers and community groups, using hand weeding or localised application of herbicide during the appropriate season to minimise the effect of herbicide on native vegetation while seeking expert opinion on the deployment methods and chemicals for targeted weed control.
- Implement suitable weed hygiene protocols when undertaking survey, monitoring and management activities. Refer to the *Arrive Clean, Leave Clean Guidelines to help prevent the spread of invasive plant diseases and weeds threatening our native plants, animals and ecosystems* (DoE 2015).
- Prevent introduction or re-introduction of weeds and pest animals, including Rabbits. All weeds and undesirable competing species should be controlled following fire.
- If prescribed burning is applied, ensure that the fire is controllable.

Disease

- Implement a *P. cinnamomi* management plan to ensure it is not introduced into known subpopulations of either subspecies (DOEE 2018). Ensure appropriate hygiene protocols are adhered to when entering or exiting known subpopulations, such as those outlined in DEWHA (2009).
- Control access to the reserve during disease risk times (moist to wet soils) through the maintenance of barriers and signs.

Impacts of native species

- Ensure that seedlings are protected against any vertebrate grazing by fencing, maintaining fences and protecting seedlings from damage. This may include the use of individual enclosures around the plants.
- If necessary, conduct physical removal of Rock Sheoak to prevent it from competing with *Banksia ionthocarpa* subsp. c*hrysophoenix*.

Stakeholder engagement/community engagement

- Conduct a publicity campaign using physical and electronic media to increase local community awareness of the species' conservation.
- Liaise with relevant land managers and landowners to ensure that subpopulations are not accidentally damaged or destroyed. The approval and assistance of land managers should also be sought to implement recovery actions.
- Seek input and involvement from any Aboriginal groups that have an active interest in the areas where the species occurs.
- Continue to work with the Shire of Plantagenet to minimise impacts on the single known natural subpopulation of *B. ionthocarpa* subsp. *ionthocarpa* and investigate the possibility of combining the two Class C reserves into one Nature Reserve (DEC 2008).

Survey and monitoring priorities

- Continue annual monitoring of all subpopulations (natural and translocated), with numbers and condition recorded. Continue regular monitoring of seedlings to determine the percentage survival to maturity and time to first flowering and seed set.
- Undertake annual monitoring of factors such as habitat degradation (including any possible impacts from roadside grading and spraying, weed invasion, invasion by Rock Sheoak and rabbit activity, population stability (expansion or decline), pollination activity, seed production, recruitment, longevity and predation (DEC 2007).
- Map the total habitat that is suitable for each subspecies. If any additional subpopulations are located, map the habitat for these locations.
- Conduct surveys for both subspecies to detect new subpopulations or individuals, especially after a bushfire has impacted the species habitat.
- Management actions to be adapted, added, or removed over time in response to monitoring results.

Information and research priorities

- Improved knowledge of the biology and ecology of both subspecies will provide a scientific basis for the management of the species in the wild. Research priorities include:
  - Pollination biology.
  - Factors limiting the soil seed bank, including post-dispersal predation on soil-stored seed.
  - An analysis of population viability.
  - Extent and effect of aerial cankers.
  - The level of clonal reproduction and genetic diversity of *B. ionthocarpa* subsp. *chrysophoenix*.
  - Investigate seed longevity and viability in situ and ex situ.
- Investigate the use of supplemental, automated watering for establishment of seedlings.
- Increase understanding of both subspecies' fire ecology, and response to low and high frequency and low and high intensity fires.
- Investigate options to increase the resilience of the reserves in which each subspecies is found to changing hydrological regimes and salinisation.
- Encourage restoration of habitat suitable for the species using the principles of the *National Standards of the practice for ecological restoration in Australia* (SERA 2017).
- Improve knowledge of the relative impact of different threats to the species and interactions/synergies between threats.

Links to relevant implementation documents

Aldersyde Banksia (*Banksia ionthocarpa* subsp. *chrysophoenix*) Recovery Plan

Kamballup Banksia (*Banksia ionthocarpa* subsp. *ionthocarpa*) Recovery Plan

Threat Abatement Plan for Competition and Land Degradation by Rabbits (2016)

Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi* (2018)

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