

Abridged Threatened Species Nomination Form

For nominations under the Common Assessment Method (CAM) where supporting information is available, but not in a format suitable for demonstrating compliance with the CAM, and assessment against the IUCN Red List threat status.

Cover Page (Office use only)

Species name (scientific and common name):	<i>Pseudococcus markharveyi</i> (<i>Banksia montana</i> mealybug)
Nomination for (addition, deletion, change):	Addition
Nominated conservation category and criteria:	Critically Endangered: B1+2ab(iii)

Scientific committee assessment of eligibility against the criteria:		
This assessment is consistent with the standards set out in Schedule 1, item 2.7 (h) and 2.8 of the Common Assessment Method Memorandum of Understanding.		Yes <input type="checkbox"/> No <input type="checkbox"/>
A.	Population size reduction	•
B.	Geographic range	•
C.	Small population size and decline	•
D.	Very small or restricted population	•
E.	Quantitative analysis	•

Outcome:			
Scientific committee meeting date:			
Scientific committee comments:			
Recommendation:			
Ministerial approval:		Date of Gazettal/ Legislative effect:	

Nomination summary *(to be completed by nominator)*

Current conservation status				
Scientific name:	<i>Pseudococcus markharveyi</i>			
Common name:	<i>Banksia montana</i> mealybug			
Family name:	Pseudococcidae	Fauna <input checked="" type="checkbox"/>	Flora <input type="checkbox"/>	
Nomination for:	Listing <input checked="" type="checkbox"/>	Change of status <input type="checkbox"/>	Delisting <input type="checkbox"/>	
1. Is the species currently on any conservation list, either in a State or Territory, Australia or Internationally? 2. Is it present in an Australian jurisdiction, but not listed?		Provide details of the occurrence and listing status for each jurisdiction in the following table		
Jurisdiction	State / Territory in which the species occurs	Date listed or assessed (or N/A)	Listing category i.e. critically endangered or 'none'	Listing criteria i.e. B1ab(iii)+2ab(iii)
International (IUCN Red List)		12/03/2014	Critically Endangered	B2ab(i,ii,iii,iv,v)
National (EPBC Act)				
State / Territory	1. WA (WC Act 1950)	17/09/2013	Critically Endangered	A4ce, B1+2ab(iii)
	2.			
	3.			
Consistent with Schedule 1, item 2.7 (h) and 2.8 of the Common Assessment Method Memorandum of Understanding, it is confirmed that:				
<ul style="list-style-type: none"> this assessment meets the standard of evidence required by the Common Assessment Method to document the eligibility of the species under the IUCN criteria; 			Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Comments:				
<ul style="list-style-type: none"> surveys of the species were adequate to inform the assessment; 			Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Comments:	Invertebrate surveys in late spring and summer were conducted in and around the Stirling Range National Park in 2000, 2001, 2007, 2008, 2011 and 2012. A total of 21 species of <i>Banksia</i> , 16 other species of Proteaceae and 69 other plant species have been sampled. The mealybug was discovered in 2007, following its collection from <i>Banksia montana</i> plants. <i>B. montana</i> sister taxa, <i>B. plumosa</i> and <i>B. pseudoplumosa</i> , as well other <i>Banksia</i> species occurring naturally within 100m of the <i>B. montana</i> individuals were also sampled.			
<ul style="list-style-type: none"> the conclusion of the assessment remains current and that any further information that may have become available since the assessment was completed supports or is consistent with the conclusion of the assessment. 			Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Comments:	Further monitoring of <i>Banksia montana</i> subpopulations have been conducted since the conclusion of the assessment. This new monitoring data does not change the conclusion made by the WA TSSC in 2013.			

Nominated national conservation status: category and criteria		
Presumed extinct (EX) <input type="checkbox"/> Critically endangered (CR) <input checked="" type="checkbox"/> Endangered (EN) <input type="checkbox"/> Vulnerable (VU) <input type="checkbox"/>		
None (least concern) <input type="checkbox"/> Data Deficient <input type="checkbox"/> Conservation Dependent <input type="checkbox"/>		
What are the IUCN Red List criteria that support the recommended conservation status category?	B1+2ab(iii)	
Eligibility against the IUCN Red List criteria (A, B, C, D and E)		
Provide justification for the nominated conservation status; is the species eligible or ineligible for listing against the five criteria. For delisting , provide details for why the species no longer meets the requirements of the current conservation status.		
A.	Population size reduction (evidence of decline)	<ul style="list-style-type: none"> No population counts of the mealybug have been conducted. However, due to their direct dependence on the host species, <i>Banksia montana</i>, the population size reduction can be inferred based on <i>Banksia montana</i> population monitoring results. In 2000, the total <i>Banksia montana</i> population was known to have 137 adult plants and 39 juvenile plants. In that same year, a fire burnt all four remaining subpopulations, killing 63% of adult plants and 77% of juveniles. A total of 116 plants were lost and only 13 seedlings germinated after the fire. The most recent population counts, in 2015, found only 40 adult plants and 2 juvenile plants in total. <i>Banksia montana</i> plants are highly susceptible to <i>Phytophthora cinnamomi</i> dieback, which is now found throughout the Stirling Ranges. Individuals are known to have died due to <i>P. cinnamomi</i> infection and overgrazing by vertebrate herbivores. Two other subpopulations of the host species, considered to have been abundant at their discovery, are now presumed extinct. The mealybug was only discovered in 2007, and so it is unknown if it was found in all subpopulations of the host plant. However, based on observations of their abundance at Pyungorup Peak, it is likely that the mealybug used to be established on more host plants at Bluff Knoll. Additionally, molecular work has shown that the individuals from both subpopulations are identical, likely indicating that there previously was a relatively continuous population of <i>B. montana</i>, and consequently the mealybug, across the Stirling Ranges. Therefore, a ≥80% population reduction from the past and into the future is inferred based on (c) a decline in area of occupancy, extent of occurrence and habitat quality of the host plant species due to fire, climate change and (e) the effects of <i>Phytophthora cinnamomi</i> dieback. However, based on the available data, the known time period for this is greater than 10 years, and the generation length of the mealybug is not expected to extend this time frame for this assessment period. Insufficient information to assess.
B.	Geographic range (EOO and AOO, number of locations and evidence of	<ul style="list-style-type: none"> The (B1) EOO and (B2) AOO are estimated to be <1km² (or <8km² using IUCN standard 2kmx2km grid). (a) The species is considered to be severely fragmented as it is only

	decline)	<p>found at two isolated subpopulations, and is considered to be at a single location because the major threats of a fire event, <i>Phytophthora cinnamomi</i> dieback and climate change are already and will likely continue to rapidly affect all <i>B. montana</i> in the eastern Stirling Ranges.</p> <ul style="list-style-type: none"> (b) The number of <i>B. montana</i> plants in the remaining subpopulations are continuing to decline (see above). It is suspected that this decline will continue to occur due to the ongoing impacts of fire, <i>Phytophthora cinnamomi</i> dieback infection and a drying climate due to climate change. Therefore there is an observed and projected decline in the mealybug's (iii) area, extent and quality of habitat. Meets criteria for Critically Endangered B1+2ab(iii)
C.	Small population size and decline (population size, distribution and evidence of decline)	<ul style="list-style-type: none"> No population counts of the mealybug have been conducted. Insufficient information to assess.
D.	Very small or restricted population (population size)	<ul style="list-style-type: none"> No population counts of the mealybug have been conducted. The AOO is estimated to be <1 km² or 8 km² using standard IUCN 2kmx2km grid. The plausible threats are considered to have already driven the species to be critically endangered. Meets criteria for Vulnerable D2.
E.	Quantitative analysis (statistical probability of extinction)	<ul style="list-style-type: none"> Insufficient information to assess

Summary of assessment information

EOO	< 1 km ² (Moir & Leng, 2012) Calculated to 8 km ² based on AOO estimation.		AOO	Estimated AOO 8 km ² (2kmx2km grid) Area mapped subpopulations < 1 km ² (Moir & Leng, 2012)		Generation length	Unknown. Males of the Pseudococcidae family live 3-4 days.
No. locations			1		Severely fragmented	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/> Unknown <input type="checkbox"/>
No. subpopulations			2		No. mature individuals	Unknown	
Percentage global population within Australia						100%	
Percentage population decline over 10 years or 3 generations						≥80% (past, present and future)	

Threats (detail how the species is being impacted)

Threat (describe the threat and how it impacts on the species. Specify if the threat is past, current or potential)	Extent (give details of impact on whole species or specific subpopulations)	Impact (what is the level of threat to the conservation of the species)
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Note: The following are threats to *Banksia montana*, the host plant, and therefore are considered to be threats to the insect, due to their dependency on the host species.

<p><i>Phytophthora cinnamomi</i> dieback & other plant diseases</p> <p>Infection leading to the death of the host species will reduce the number of host plants available to the mealybug.</p> <p>If the single plant that hosts the mealybug on Bluff Knoll were to be infected, the entire mealybug subpopulation could be lost from that location.</p> <p><i>Past, present and future</i></p>	Entire	Severe
<p>Recreational activities</p> <p>Human visitation, particularly to Bluff Knoll, has helped to spread <i>P. cinnamomi</i> dieback and lead to the direct trampling and damage of host plants.</p> <p>If the single plant that hosts the mealybug on Bluff Knoll were to be destroyed, the entire mealybug subpopulation could be lost from that location.</p> <p><i>Past, present and future</i></p>	Entire, particularly Bluff Knoll	Moderate to severe
<p>Wildfire and inappropriate fire regimes</p> <p>Fire will extinguish available host plant structures and therefore cause the local extinction of the mealybug if no host can be located.</p> <p>If the single plant that hosts the mealybug on Bluff Knoll were to be destroyed, the entire mealybug subpopulation could be lost from that location.</p> <p><i>Past, present and future</i></p>	Entire	Severe
<p>Vertebrate grazing of juvenile host plants</p> <p>Following fire events, vertebrate grazing (quokka and/or rabbit) has affected a significant proportion of juvenile host plant. Considering the low number of individual host plants, the predation pressure may reduce recruitment and the vigour of the plants in the future.</p> <p><i>Past, present and future</i></p>	Entire, particularly Bluff Knoll	Low to moderate
<p>Host population size decrease and isolation increase</p> <p>It is possible that if the host population becomes too small, it may not be able to sustain a viable population of the mealybug, thereby leading to its extinction.</p> <p>The mealybug is a short range endemic, and the host plant subpopulations are too far apart to allow for exchange and recolonization.</p> <p><i>Future</i></p>	Entire	Severe
<p>Climate change</p> <p>A drying climate could lead to the loss of the montane habitats in Stirling Range NP. This may lead to the loss of the host plant and therefore the mealybug.</p> <p>Climate change may also increase the frequency and</p>	Entire	Severe

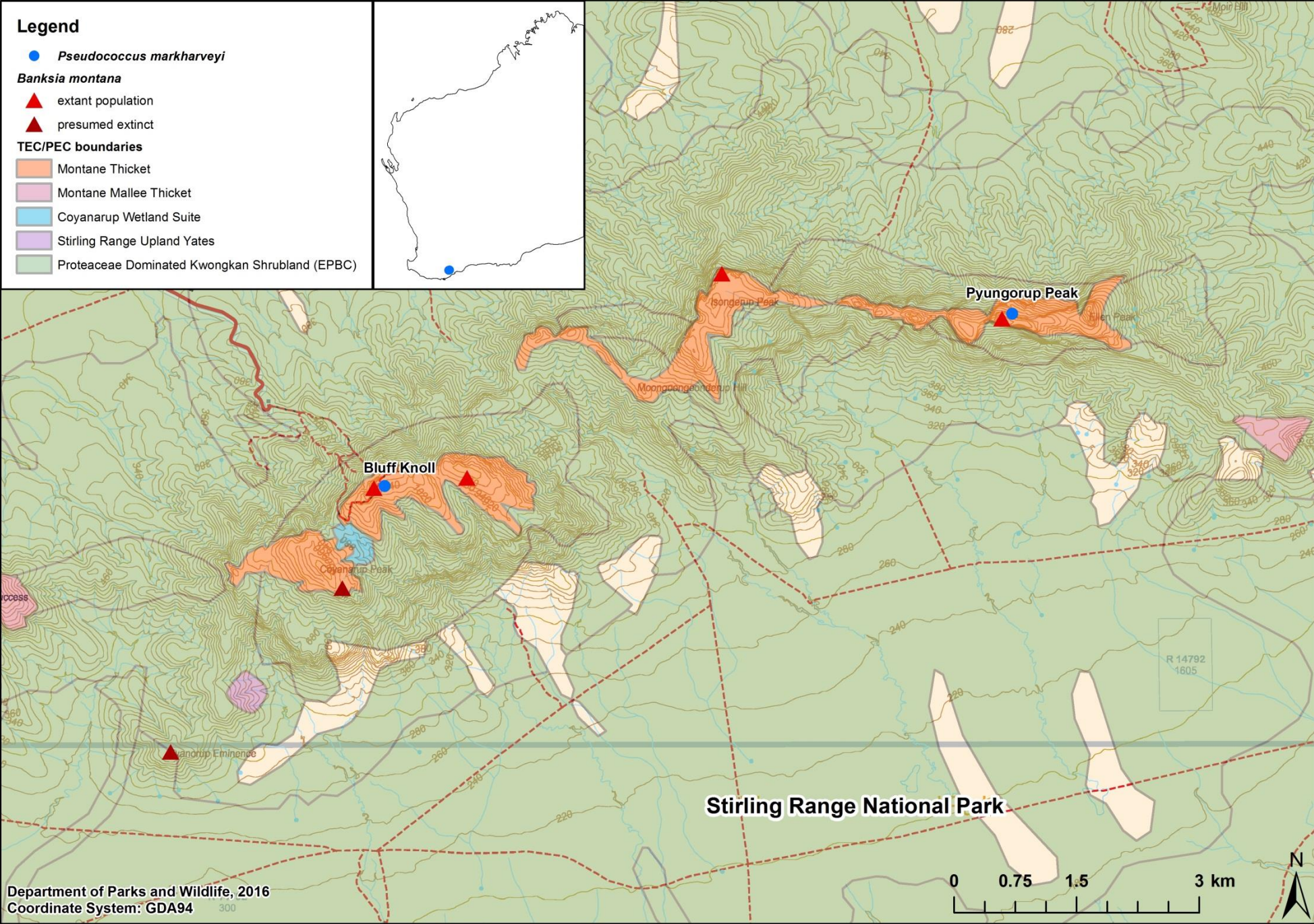
intensity of wildfire. <i>Future</i>		
Management and Recovery		
Is there a Recovery Plan (RP) or Conservation Management Plan operational for the species?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
<p>List all relevant recovery or management plans (including draft, in-preparation, out-of-date, national and State/Territory recovery plans, recovery plans for other species or ecological communities, or other management plans that may benefit or be relevant to the nominated species).</p> <ul style="list-style-type: none"> • Department of Conservation and Land Management (2005). <i>Stirling Range Dryandra (Dryandra montana) Interim Recovery Plan 2005-2010 (Interim Recovery Plan No. 207)</i>. Perth, WA: Department of Parks and Wildlife. Retrieved from: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/198-approved-interim-recovery-plans • Department of Conservation and Land Management (2000). <i>Montane Heath and Thicket of the South West Botanical Province, above approximately 900 m above sea level (Eastern Stirling Range Montane Heath and Thicket Community) Interim Recovery Plan 1999-2002 (Interim Recovery Plan No. 52)</i>. Perth, WA: Department of Parks and Wildlife. Retrieved from: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/198-approved-interim-recovery-plans • Department of Conservation and Land Management (1999). <i>Stirling Range and Porongurup National Parks Management Plan 1999-2009 (Management Plan No. 42)</i>. Perth, WA: Department of Parks and Wildlife. Retrieved from: https://www.dpaw.wa.gov.au/parks/management-plans/approved-management-plans • Commonwealth Threatened Species Scientific Committee (2014). <i>Approved Conservation Advice for Proteaceae Dominated Kwongan Shrublands of the southeast coastal floristic province of Western Australia</i>. Canberra, ACT: Department of the Environment and Energy. Retrieved from: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/126-conservation-advice.pdf 		
<p>List current management or research actions, if any, that are being undertaken that benefit the conservation of the species.</p> <ul style="list-style-type: none"> • Phosphite spraying of all <i>Banksia montana</i> plants to control the spread of <i>Phytophthora cinnamomi</i> dieback since 1997. • Signage has been erected along the Bluff Knoll track to highlight the values of the TEC, reduce trampling and explain the threats to the TEC and the reason for fencing. Information is also available for visitors on dieback hygiene practices. • A <i>B. montana</i> translocation to a private property 40km S of the Stirling Ranges was undertaken, and a subsequent mealybug translocation was undertaken in 2012. Seeds of the host plant have been collected and a seed orchard has been established, providing opportunities for further translocations of both the host plant and the mealybug. • Annual monitoring of <i>B. montana</i> to determine plant numbers, recent deaths, impact of threats and general plant and habitat health. • Sites where the <i>B. montana</i> are located have been identified as a fire exclusion zone until the TEC that they reside within have sufficiently recovered from the 2000 fire. • A rabbit control strategy has been implemented since 2008 with annual and triannual baiting occurring on Bluff Knoll and Pyungorup. <i>B. montana</i> plants on Bluff Knoll have been fenced to prevent further damage from vertebrate grazing. 		
<p>List further recommended management or research actions, if any, that would benefit the conservation of the species.</p> <ul style="list-style-type: none"> • Conduct research into the effect of phosphite spraying on the mealybug and whether it is negatively affecting the remaining individuals. 		

- Continue *Phytophthora cinnamomi* hygiene practices and increase visitor awareness on how to limit the spread of the disease.
- Continue to implement fire exclusion practices for all *B. montana* subpopulations.
- Continue to cage *B. montana* plants threatened by vertebrate grazing.
- Obtain further biological and ecological information: Conduct research to determine the relationship between the mealybug and the host plant species, with a focus on what is required for the mealybug to establish on new plants. Determine whether it is possible to help the Bluff Knoll subpopulation establish on more plants.
- Determine a method for estimating the size of the mealybug population.
- Continue to monitor the translocated subpopulation to determine if it was successful, and investigate the possibility of future translocations to ensure the survival of the mealybug.
- Conduct regular monitoring of the Bluff Knoll and Pyungorup Peak subpopulations.

Nomination prepared by:	
Contact details:	
Date submitted:	8 September 2016
<i>If the nomination has been refereed or reviewed by experts, please provide their names and contact details:</i>	

Summary of subpopulation information (detailed information to be provided in the relevant sections of the form)						
Location (include coordinates)	Land tenure	Survey information: Date of survey and No. mature individuals	AOO	Site / habitat Condition	Threats (note if past, present or future)*	Specific management actions
Bluff Knoll, Stirling Range National Park 118.2548, -34.3763	National Park	2007, 2011 & 2012: no population counts, only found on one host plant Last count of <i>Banksia montana</i> in 2015: 11 mature plants, 2 juvenile plants	<10 m ²	Habitat modified by <i>P. cinnamomi</i> and grazing, <i>Banksia montana</i> population in moderate condition with 1 death due to grazing in 2014 (total 61 dead from grazing before fencing could be constructed)	<i>P. cinnamomi</i> dieback & other plant diseases: <i>past, present and future</i> Recreational activities (spread of <i>P. cinnamomi</i> dieback, direct trampling and damage to host plants): <i>past, present and future</i> Wildfire and inappropriate fire regimes: <i>past, present and future</i> Vertebrate grazing of juvenile host plants: <i>past, present and future</i> Host population size decrease and isolation increase: <i>future</i> Climate change: <i>future</i>	Continue aerial phosphite spraying of host plant plants to control <i>P. cinnamomi</i> . Continue <i>P. cinnamomi</i> hygiene practices. Implement actions to reduce recreational impacts to host plants (install signs, track maintenance) Continue implementing the fire management strategy for Stirling Range NP. Place cages over host plants where they are being impacted by grazing, and consider rabbit control methods. Collect and store seeds of host plants for future translocations. Translocate the mealybug to other populations of the host species. Survey for the mealybug on all known occurrences of the host species and identify possible translocation sites.
Pyungorup Peak, Stirling Range National Park	National Park	2007, 2011 & 2012: no population counts Last count of	<100 m ²	Habitat is long-unburnt thicket. <i>Banksia montana</i> population in moderate condition – most plants	<i>P. cinnamomi</i> dieback & other plant diseases: <i>past, present and future</i> Wildfire and inappropriate fire	Continue aerial phosphite spraying of host plant plants to control <i>P. cinnamomi</i> . Continue <i>P. cinnamomi</i> hygiene

118.3229, -34.3585		<i>Banksia montana</i> in 2015: 9 plants		healthy but 2 plants have died since the previous monitoring. Some deaths previously due to <i>P. cinnamomi</i> .	regimes: <i>past, present and future</i> Host population size decrease and isolation increase: <i>future</i> Climate change: <i>future</i>	practices. Continue implementing the fire management strategy for Stirling Range NP. Collect and store seeds of host plants for future translocations. Translocate the mealybug to other populations of the host species. Survey for the mealybug on all known occurrences of the host species and identify possible translocation sites.
Lot 6541, Washpool Rd, Woogenellup 117.8653, -34.5825 <i>Note: this is a translocation site but the required 5 years of monitoring has not yet been concluded to determine if it is a successful, self-sustaining population.</i>	Private Property	2012: translocation 2013: on 40% of host plants Last count of <i>Banksia montana</i> in 2012: 67 mature plants, 43 juvenile plants	0.01 km ²	Habitat in excellent condition but showing some signs of summer drought stress. <i>Banksia montana</i> plants in moderate to healthy condition –a total of 27 plants have died since translocation.	Introduction of <i>P. cinnamomi</i> dieback & other plant diseases: <i>future</i> Wildfire and inappropriate fire regimes: <i>future</i> Host population size decrease and isolation increase: <i>future</i> Climate change: <i>future</i>	Continue <i>P. cinnamomi</i> hygiene practices. Implement a fire management strategy Continue to monitor the translocated host population. Continue to monitor the mealybug's establishment on the host plants to determine if the translocation was successful.





Department of Environment and Conservation

Our environment, our future



Form to nominate a Western Australian species for listing as threatened, change of category or delisting.

NOTICE: Incomplete forms may result in delays in assessment, or rejection of the nomination. To fill out this form you must refer to the Guidelines and contact the relevant Officer in the DEC Species and Communities Branch. DEC staff can advise you on how to fill out the form and may be able to supply additional, unpublished information.

Answer all relevant sections, filling in the white boxes and indicating when there is no information available. **Note**, this application form applies to both flora and fauna species, and hence some questions or options may not be applicable to the nominated species – for these questions, type “N/A”.

To mark boxes with a **cross**, double click the box and select not checked or checked.

SECTION 1. NOMINATION

1.1. Nomination for:

Flora ☐ Fauna ☒ Threatened / DRF ☒ Change of category ☐ Delisting ☐

1.2. Scientific Name

This name will be used to identify the species on all official documentation. Use the approved name used by the Western Australian Museum or Herbarium. If this is not possible, use unpublished names or numbers of voucher specimens.

Pseudococcus markharveyi (Insecta: Hemiptera: Coccoidea: Pseudococcidae)

[Gullen et al., 2013]

1.3. Common Name

If the species has a generally accepted common name, please show it here. This name will be used on all official documentation.

Banksia montana mealybug

1.4. Current Conservation Status. If none, type 'None'.

	IUCN Red List Category e.g. Vulnerable	IUCN Red List Criteria e.g. B1ab(iv);D(1)
International IUCN Red List	Critically Endangered	B2ab(i,ii,iii,iv,v)
National EPBC Act 1999	None	None
State of Western Australia	Critically Endangered	A4ce, B1+2ab(iii)
State of WA Priority	1 <input type="checkbox"/>	2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>

Is the species listed as 'Threatened' in any other Australian State or Territory? If Yes, list these States and/or Territories and the status for each.

No ☒ Yes ☐

Does the species have specific protection (e.g. listed on an annex or appendix) under any other legislation, inter-governmental or international arrangements e.g. CITES? If Yes, please provide details.

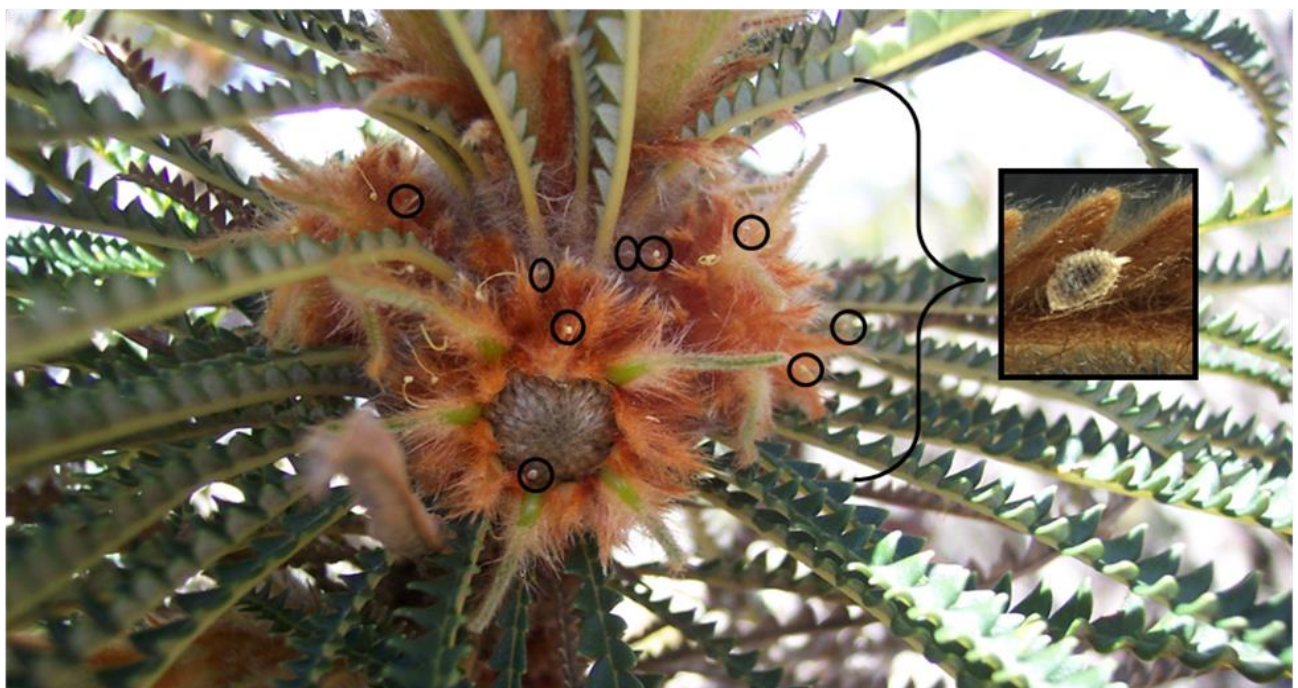
No <input checked="" type="checkbox"/> Yes <input type="checkbox"/>					
1.5. Nominated Conservation Status.					
	IUCN Red List Category e.g. Vulnerable			IUCN Red List Criteria e.g. B1ab(iv);D(1)	
State of Western Australia	Critically endangered			B1+2ab(iii);	
State of WA Priority	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>
1.6. Reasons for the Nomination.					
Briefly summarise the reasons for the nomination in dot points. Please include details relevant to the IUCN Categories and Criteria where appropriate.					
<p>The reason to nominate <i>Pseudococcus markharveyi</i> is based on the following:</p> <ul style="list-style-type: none"> • dependent on Critically Endangered host species (<i>Banksia montana</i>) for its survival, • low dispersal ability, • host plants have a small restricted population, • the immediate threat to the host plants survival from processes such as dieback, fire and climate change. 					
SECTION 2. SPECIES					
2.1. Taxonomy.					
Describe the taxonomic history, using references, and describe the key distinguishing features that can be used to separate this taxon from closely related taxa. Include details of the type specimen, changes in taxonomy, scientific names and common names used for the species.					
<p><i>Pseudococcus markharveyi</i> is a recently described species (Gullan <i>et al.</i>, 2013). It is currently called <i>Banksia montana</i> mealybug. Specimens were held by Melinda Moir and Penny Gullan whilst being described, but types have been lodged in the Western Australian Museum and the Australian National Insect Collection (ANIC), CSIRO Ecosystem Sciences, Canberra.</p> <p>We have adhered to the precautionary principle for this nomination. The mealybug has been described based on specimens taken from the Stirling Range National Park (SRNP). However, it is possible that specimens collected from Fitzgerald River National Park (FRNP) are the same species. We have been attempting to collect specimens (approximately 150 plants sampled) from FRNP without success to date, for molecular comparison. But given the differences, as noted by Gullan <i>et al.</i> (see excerpt below from Gullan <i>et al.</i> 2013), we believe that these will prove to be separate species.</p> <p>“The two adult females on <i>B. heliantha</i> from Fitzgerald River National Park differ from the adult females collected on the mountains in the Stirling Range in having a larger body (up to twice the size of the Stirling Range females), 25–66% longer antennae and legs, better developed ostioles (each lip of anterior ostioles with 5–8 setae and 14–22 pores; each lip of posterior ostioles with 7–12 setae and 22–30 pores), more pores (52–60) on each anal lobe cerarius, and usually two (rather than one) ventral oral-collar tubular ducts on each side of the anterior abdominal segments with one duct of each pair smaller than the other.”</p>					
Is this species conventionally accepted? If no, explain why. For example, is there any controversy about the taxonomy? For undescribed species, detail the location of voucher specimens (these should be numbered and held in a recognised institution and be available for reference purposes).					
No <input type="checkbox"/> Yes <input checked="" type="checkbox"/>					
Voucher specimens have been lodged with the Western Australian Museum and the Australian National Insect Collection (ANIC), CSIRO Ecosystem Sciences, Canberra.					
Describe any known hybridisation with other species in the wild, indicating where this occurs and how frequently.					
None known.					

2.2. Description

Describe the physical appearance, habit, behaviour/dispersion and life history. Include anatomy or habit (e.g. size and/or weight, sex and age variation, social structure) and dispersion (e.g. solitary, clumped or flocks etc), and life history (eg short lived, long lived, geophytic, etc).

Very little is known of the biology of *Pseudococcus markharveyi*, which has only been recently discovered. It is extremely small (1-3mm, see photograph below) and has the typical shape of the family; oval, and covered in a film of white 'wax'. It is presumed to have poor powers of dispersal like most other members of Pseudococcidae. It is also presumed to be short-lived (see sections 2.6 and 2.8 below for an account of life history).

Excerpt describing the morphology taken from Gullan *et al.* 2013 "...adult female is characterised by having drum-like dorsal tubular ducts that often have one or two minute discoidal pores associated with the duct rim, slightly smaller and marginal drum-like ventral tubular ducts, 17 pairs of cerarii with each with two conical setae except first two pairs on head often with three conical setae, translucent pores confined to the femur and tibia, small ventral oral-collar tubular ducts confined to near the vulva, and by absence of a circulus and multilocular pores."

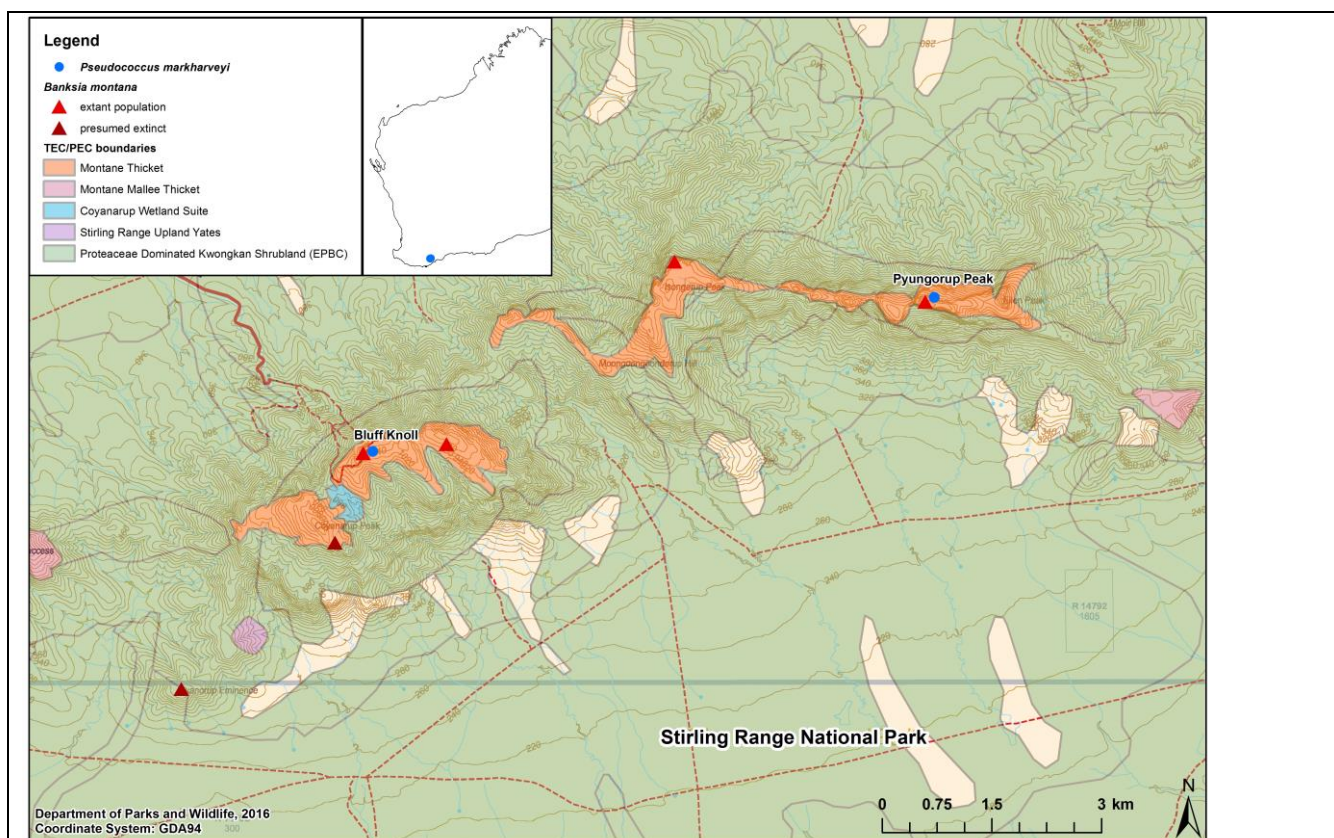


2.3. Distribution

Describe the distribution of the species in Australia and, if possible, provide a map.

To date, *Pseudococcus markharveyi* has only been recorded from Western Australia. It is restricted to old *Banksia montana* plants (Moir *et al.* 2011). *Pseudococcus markharveyi* is found on a sole *B. montana* plant at Bluff Knoll, but on most plant individuals at the Pyungorup Peak population (Gullan *et al.* 2013). As such, *Pseudococcus markharveyi* has a total geographic range of <1km².

There is potential for *Pseudococcus markharveyi* to be the same species as a mealybug found on *Banksia heliantha* (previously known as *Dryandra quercifolia*) at Fitzgerald River National Park (Gullan *et al.* 2013). This will be investigated further by molecular analysis when specimens at FRNP can be located. We have been attempting to collect specimens (approximately 150 plants sampled) from FRNP without success to date, for molecular comparison. But given the differences, as noted by Gullan *et al.* (2013), we believe that these will prove to be separate species. No other record of *Pseudococcus markharveyi* has been found (Gullan *unpubl. data*; Moir *unpubl. data*).



2.4. Habitat

Describe the non-biological habitat (e.g. aspect, topography, substrate, climate) and biological habitat (e.g. forest type, associated species, sympatric species). If the species occurs in various habitats (e.g. for different activities such as breeding, feeding, roosting, dispersing, basking etc) then describe each habitat.

Non-biological habitat

Pseudococcus markharveyi is closely associated with its host plant *B. montana*, which is confined to the higher altitudes of Bluff Knoll and Pyungorup Peak (>900m above sea level), growing on rocky shallow brown loam soil on schist/quartz. No weather data has been collected from these areas in the Stirling Ranges; however the closest town, Mt Barker, is situated further to the east and has an annual average rainfall of 500-600mm with mean maximum temperature 20°C and mean minimum temperature 9°C, with up to 30 days above 30°C (BOM http://www.bom.gov.au/climate/averages/tables/cw_009581.shtml accessed online 18th September 2012).

Biological habitat

Pseudococcus markharveyi is associated with its host plant *B. montana*, hence occurs at the higher altitudes of Bluff Knoll and Pyungorup Peak where there is rocky soil. It can be found amongst dense montane heath/kwongan vegetation.

Twenty-one species of *Banksia*, 16 species of other Proteaceae and a further 69 other plant species have been surveyed in and around the SRNP, and *Pseudococcus markharveyi* was not found on any other plant (Moir *et al.* 2011). Furthermore, this sampling included the only two sister taxa to *B. montana* (*B. plumosa* and *B. pseudoplumosa*), as well as other *Banksia* species occurring naturally within 100m of *B. montana* individuals.

Does the (fauna) species use refuge habitat e.g. in times of fire, drought or flood? Describe this habitat.

Pseudococcus markharveyi is not known to move to refuge habitat

Is the species part of, or does it rely on, a listed threatened ecological community? Is it associated with any other listed threatened species?

Pseudococcus markharveyi is closely associated with its host plant *B. montana* which is listed nationally as Endangered under the Environment Protection and Biodiversity Conservation Act 1999,

and under the Western Australian Wildlife Conservation Act 1950 as Critically Endangered B1+2ab(iii,v), C2a(i), D
It occurs within Montane Thicket of the Eastern Stirling Range Threatened Ecological Community (Critically Endangered), which falls within the EPBC listed Proteaceae Dominated Kwongan Shrubland TEC (Endangered).
2.5. Reproduction Provide an overview of the breeding system. For <u>fauna</u>: Provide an overview of the breeding system and breeding success, including: when does it breed; what conditions are needed for breeding; are there any breeding behaviours that may make it vulnerable to a threatening process? For <u>flora</u>: When does the species flower and set fruit? Is the seed produced viable? What conditions are needed for this? What is the pollinating mechanism? If the species is capable of vegetative reproduction, a description of how this occurs, the conditions needed and when. Does the species require a disturbance regime (e.g. fire, ground disturbance) in order to reproduce?
Very little is known on the ecology and biology of <i>Pseudococcus markharveyi</i> as it has only recently been discovered (2007 – Moir)). It is part of the second largest family of mealybugs; Pseudococcidae. An account of general biology is given below.
2.6. Population dynamics Provide details on ages of sexual maturity, extent of breeding success, life expectancy and natural mortality. Describe population structure (presence of juveniles/seedlings, mature and senescing individuals).
Reproduction is oviparous, ovoviviparous or viviparous with some species being parthenogenic (Williams 1985). Within this family there are generally four instars in the females where they are neotenic (retain nymphal characteristics) and in males there are five instars, including two pupal stages where the males become stationary and alabiate (Williams 1985, Mendel <i>et al.</i> 2012). Males tend to fully develop into winged adults due to the need to disperse during their mating season, and during this time have a life expectancy of three to four days i.e. they are shorter lived than females (Mendel <i>et al.</i> 2012).
Questions 2.7 and 2.8 apply to <u>fauna</u> nominations only
2.7. Feeding Summarise food items or sources and timing/availability.
Both larval and adult mealybugs feed intracellularly via stylet penetration on soluble plant material found in plant phloem and xylem of their host plant during the season's spring and summer. The sole food source for <i>Pseudococcus markharveyi</i> is the host plant <i>Banksia montana</i> .
Briefly describe feeding behaviours, including those that may make the species vulnerable to threatening processes.
All mealybugs are sap-suckers that are often closely linked with their host plants therefore they are vulnerable to the threatening process affecting the host plants that they are dependent on. As they are also relatively sedentary they make easy prey for a range of predators. The most frequent being anthocorid, lygaeid and nabid bugs, earwigs, brown and green lacewing larvae, coccinellid beetle larvae and adults, ants, syrphid fly larvae, mites, spiders, and harvestmen. Birds are the main vertebrate predator.
2.8. Movements Describe any relevant daily or seasonal pattern of movement for the species, including relevant arrival/departure dates if migratory. Provide details of home range/territories.
Mealybugs are relatively sedentary with often colonial lifestyles. Females tend to be sedentary whereas males are more mobile when they have reached winged adult form. Males will tend to disperse for up to four hours during ambient conditions (i.e. early mornings and early afternoons) at their sexual maturity phase to mate. They are low active dispersers and usually rely on prevailing wind systems for long distant dispersal (<10m). Although relatively selective in their host plants, possibly due to their lack of dispersal ability (therefore taking time to colonise the host plant) <i>Pseudococcus markharveyi</i> appears abundant on <i>B. montana</i> at Pyungorup Peak (Moir <i>pers. obs.</i>).
SECTION 3. INTERNATIONAL CONTEXT
For species that are distributed both in <u>Australia</u> and in <u>other countries</u>.

3.1. Distribution					
Describe the global distribution.					
Only found in south-west Australia.					
Provide an overview of the global population size, trends, threats and security of the species outside of Australia.					
n/a					
Explain the relationship between the Australian population and the global population. What percentage of the global population occurs in Australia? Is the Australian population distinct, geographically separate or does part, or all, of the population move in/out of Australia's jurisdiction? Do global threats affect the Australian population?					
n/a					
SECTION 4. CONSERVATION STATUS AND MANAGEMENT					
4.1. Population					
What is the total population size in terms of number of mature individuals? Has there been any known reduction in the size of the population, or is this likely in the future? – provide details. Are there other useful measures of population size and what are they? Or if these are unavailable, provide an estimate of abundance (e.g. scarce, locally abundant etc).					
The total population size is unknown and hence it is not known if there has been a reduction of <i>Pseudococcus markharveyi</i> to date. However, the host plant, <i>Banksia montana</i> has almost been extinguished at Bluff Knoll due to a combination of severe fires and the plant pathogen <i>Phytophthora cinnamomi</i> dieback. The mealybug is only found on the oldest plant at this site, suggesting that it hasn't had time to colonize younger plants and has been extinguished on other plants during fires.					
Provide locations of: captive/propagated occurrences or <i>ex situ</i> collections; recent re-introductions to the wild; and sites for proposed re-introductions. Have these sites been identified in recovery plans?					
Leng & Moir submitted a proposal to translocate <i>Pseudococcus markharveyi</i> to translocated hosts at Kamballup (~40 km south of SRNP). The proposal was approved by WA Parks & Wildlife and trials began in October 2012. The translocation trials, using nymphs, were performed in Oct 2012 and were reassessed in Dec 2012 but had failed. Therefore in Dec 2012 another trial, using adults, was undertaken. In April 2013, the translocated population was monitored and the mealybugs were found on 40% of the plants.					
How many locations do you consider the species occurs in and why? Where a species is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.					
<p><i>Pseudococcus markharveyi</i> has been recorded from subpopulations of <i>B. montana</i> in Western Australia at Bluff Knoll and Pyungorup Peak in the SRNP (Gullan <i>et al.</i> 2013).. Molecular work has shown that the individuals from both peaks are identical, likely indicating that there previously was a relatively continuous population of <i>B. montana</i> across the eastern Stirling Ranges, <i>B. montana</i> is no longer a continuous population and is only found at isolated sites, and therefore the mealybug cannot naturally disperse. Therefore, these sites are considered two separate subpopulations.</p> <p>The mealybug is considered to be a single location, because the major threats of a fire event, <i>Phytophthora cinnamomi</i> dieback and climate change are already and will likely continue to rapidly affect all subpopulations of <i>B. montana</i> in the eastern Stirling Ranges, and therefore affect both subpopulations of the mealybug.</p>					
For <u>flora</u>, and where applicable, for <u>fauna</u>, detail the location, land tenure, estimated number of individuals, area of occupancy, and condition of site for each known date, location or occurrence.					
<i>Pseudococcus markharveyi</i> known occurrence in south-west Western Australia.					
Date of survey	Location	Land status	Number of individuals at location	Area of occupancy at location	Condition of site
27 th December	Bluff Knoll,	National Park	Unknown -	<10 m ²	<i>Banksia</i>

2007	Stirling Ranges, south-west WA.		located on a single <i>B. montana</i> plant		<i>montana</i> populations healthy, no signs of disease.
30 th November 2007	Pyungorup Peak, Stirling Ranges, south-west WA.	National Park	Unknown	<100 m ²	<i>Banksia montana</i> populations healthy, no signs of disease.
13 th & 17 th October 2011	Bluff Knoll & Pyungorup Peak, Stirling Ranges, south-west WA.	National Park	Unknown	<100 m ²	<i>Banksia montana</i> populations healthy, no signs of disease.
14 th & 16 th February 2012	Pyungorup Peak & Bluff Knoll, Stirling Ranges, south-west WA.	National Park	Unknown	<100 m ²	<i>Banksia montana</i> populations healthy, no signs of disease.

Has the number of individuals been counted, or is this an estimate? Provide details of the method of determining the number of individuals.

No, the numbers of individuals have not been counted as this is hard to achieve due their size and the rarity of *Pseudococcus markharveyi*.

Has there been any known reduction in the number of locations, or is this likely in the future? – provide details.

As there is no known records of population estimates of the mealybug, it is not known if there has been any reduction in numbers. As *Pseudococcus markharveyi* is reliant on its host plant *B. montana* for survival, any threat to its host plant population can be seen as a direct threat to *Pseudococcus markharveyi*. *Banksia montana* has almost been extinguished at Bluff Knoll due to a combination of severe fires and the plant pathogen *Phytophthora cinnamomi* dieback. By 2005 only 45 adult and 16 juvenile plants remained in total in all subpopulations (Gilfillan *et al.* 2005). Two subpopulations of *B. montana* are presumed to be extinct, and the most recent surveys of the remaining subpopulations in 2015 found only a total of 40 adults and 2 juveniles (excluding the translocated subpopulation), compared to a total of 137 adults and 39 juveniles in the same subpopulations in 2000 (prior to a major fire event). The mealybug is only found on the oldest plant at Bluff Knoll, suggesting that it hasn't had time to colonize younger plants and has been extinguished on other plants during fires. Subpopulations of *B. montana* may come under threat in the future as they become further exposed to *Phytophthora cinnamomim* dieback, inappropriate fire regimes, wildfires and a drying climate due to climate change.

What is the extent of occurrence (in km²) for the species; explain how it was calculated and datasets used. If an accurate estimate is unavailable, provide a range of values or a minimum or maximum area estimate. Include estimates of past, current and possible future extent of occurrence. If available, include data that indicates the percentage decline over 10 years or 3 generations (whichever is longer) that has occurred or is predicted to occur.

Pseudococcus markharveyi extent of occurrence is associated with the extent of its host plant *B. montana*. *Banksia montana* is found in various locations in the SRNP. Of these *B. montana* subpopulations, *Pseudococcus markharveyi* were found at two locations (Bluff Knoll and Pyungorup Peak), these *B. montana* subpopulations covered an area <1 km².

Is the distribution of the species severely fragmented? Why?

The distribution of *Pseudococcus markharveyi* is severely fragmented due to its very narrow host-breath association with its host plant *B. montana*. *Banksia montana* was originally distributed over a

<p>large area in the SRNP in the late 1980s' but later declined, due to <i>Phytophthora</i> dieback disease and fire. To date, these <i>B. montana</i> subpopulations are only found on two peaks in the SRNP (Bluff Knoll and Pyungorup Peak) and are under threat from <i>Phytophthora</i> dieback disease, inappropriate fire regimes (Barrett <i>et al.</i> 2008) and, due to their montane habitat, potentially climate change. Given the distance between the two peaks which house host subpopulations (~7km), <i>Pseudococcus markharveyi</i> recolonisation of either of the sites would be highly unlikely.</p>
<p>Identify important occurrences necessary for the long-term survival and recovery of the species? This may include: key breeding populations, those near the edge of the range of the species or those needed to maintain genetic diversity.</p>
<p>To ensure <i>Pseudococcus markharveyi</i> survival and recovery there is a need to protect and manage natural subpopulations of the host plant <i>B. montana</i> from threats such as <i>Phytophthora</i> dieback disease, inappropriate fire regimes (Barrett <i>et al.</i> 2008) and potentially climate change. Ex-situ conservation techniques for the mealybug (such as translocation with host plants) may ensure survival of the species in the event that natural subpopulations are extinguished.</p>
<p>4.2. Survey effort Describe the methods to conduct surveys. For example, (e.g. season, time of day, weather conditions); length, intensity and pattern of search effort (including where species not encountered); any limitations and expert requirements.</p>
<p>Survey was conducted in daylight hours during the periods from Sept – Dec 2007, April 2000 - Nov 2001, October 2008, October 2011 and February 2012. The majority of survey effort occurred in late spring and summer as it coincided with the adult life stage of <i>Pseudococcus markharveyi</i>.</p> <p>Collecting methods were beating, vacuum sampling and hand foraging (see Moir <i>et al.</i> 2005 for a description of these methods).</p> <p>Severe wet weather conditions limited sampling due to the difficulty in sampling in these conditions (water clogs the vacuum sampler and makes beating very unproductive).</p> <p>For localities of sampling please refer to section below.</p>
<p>Provide details on the distinctiveness and detectability of the species, or the distinctiveness of its habitat, that would assist survey success.</p>
<p><i>Pseudococcus markharveyi</i> has the typical Pseudococcidae family shape, oval, and covered in a film of white 'fluff'. It also has a very narrow host-breadth and is only found on its host plant <i>B. montana</i>. Specifically targeting <i>B. montana</i> subpopulations will further assist survey success in detecting <i>Pseudococcus markharveyi</i>.</p>
<p>Has the species been reasonably well surveyed? Provide an overview of surveys to date (include surveys of known occurrences and surveys for additional occurrences) and the likelihood of its current known distribution and/or population size being its actual distribution and/or population size. Include comments on potential habitat and surveys that were conducted, but where the species was not present/found.</p>
<p>Twenty-one species of <i>Banksia</i>, 16 species of other Proteaceae and a further 69 species of other plant have been surveyed in and around the Stirling Range National Park, and <i>Pseudococcus markharveyi</i> was not found on any plants except <i>B. montana</i> (Moir <i>et al.</i> 2011). Furthermore, this sampling included sister taxa of <i>B. montana</i>, as well as other <i>Banksia</i> species occurring naturally within 100m of <i>B. montana</i> individuals. Below is an account of the sampling effort to date:</p> <p>Sept – Dec 2007</p> <p>Mt Hassel, Stirling Range National Park, species absent.</p> <p>Stirling Range Drive, Stirling Range National Park, species absent.</p> <p>West Kamballup, Albany region, species absent.</p> <p>The Lookout, Stirling Range National Park, species absent.</p> <p>Mt Toolbrunup, Stirling Range National Park, species absent.</p> <p>Mt Talyuberlup, Stirling Range National Park, species absent.</p> <p>SE gully, Stirling Range National Park, species absent.</p> <p>SE sand plains, Stirling Range National Park, species absent.</p>

Mt Trio, Stirling Range National Park, species absent.

Bluff Knoll, Stirling Range National Park, species present.

Moingup Springs, Stirling Range National Park, species absent.

Pyungorup Peak, species present.

Northern sandplains, Stirling Range National Park, species absent.

October 2008

Vancouver Peninsula National Park, Albany region, species absent.

Northern sandplains, Stirling Range National Park, species absent.

Formby Nature Reserve, Stirling Range National Park, species absent.

Southern Stirling Range National Park, species absent.

Mt Hassel, Stirling Range National Park, species absent.

Paper collar, Stirling Range National Park, species absent.

Moir Hill, Stirling Range National Park, species absent.

North Ongerup, species absent.

South Lake Grace, species absent.

Bullaring, species absent.

Totagin Rock, species absent.

Bluff Knoll, Stirling Range National Park, species present.

April 2000 – Dec 2001

Jarradale district, species absent.

October 2011 – only sampling host plant *B. montana*

Pyungorup Peak, species absent, most likely too early in their life stage to collect.

February 2012 – only sampling host plant *B. montana*

Bluff Knoll, Stirling Range National Park, species present.

Pyungorup Peak, species present.

4.3. Threats

Identify past, current and future threats indicating whether they are actual or potential. For each threat describe:

- a). how and where they impact this species**
- b). what the effect of the threat(s) has been so far (indicate whether it is known or suspected)**
- c). present supporting information/research**
- d). does it only affect certain populations?**
- e). what is its expected effect in the future (is there supporting research/information; is the threat only suspected; does it only affect certain populations?).**

Climate change

- a) Montane habitats at both Pyungorup Peak and Bluff Knoll, due to drying of the habitat.
- b) Unknown. Suspected to impact on the species in the future.
- c) No research of climate change on the host population (or the mealybug) has been conducted to date, although we are monitoring the climate at some localities.
- d) Mountain subpopulations of host plant through drying of the habitat (all subpopulations of host plant could be experiencing similar conditions).
- e) Drying of the habitat (through less rainfall) may extinguish subpopulations of the host plant, and therefore the mealybug. This drying could act synergistically on other threatening processes such as

wildfire and indirectly cause the extinction of the mealybug.

Phytophthora dieback disease and other plant diseases

a) Bluff Knoll and Pyungorup Peak (SRNP) by reducing the number of host plants available to the mealybug.

b) *Phytophthora cinnamomi* dieback has caused the deaths of *Banksia montana* individuals, and has widely affected the surrounding habitat throughout the Stirling Ranges. Any mealybugs located on these plants likely would have perished and would not have been able to re-establish unless a suitable and unaffected host plant was nearby (<10m). *P. cinnamomi* will continue to cause plant deaths and plant health degradation into the future.

c) No research of the effect of plant diseases on the populations of the mealybug has been conducted to date.

d) All subpopulations at risk.

e) The local extinction of the mealybug subpopulation, with no recolonisation, even if the host subpopulation restores itself because the mealybug subpopulations are too far apart for natural recolonisation to occur.

Wildfires and inappropriate fire regimes

a) All subpopulations are at risk of wildfires. Fire will extinguish available host plant structures and therefore cause the local extinction of the insect herbivores if no nearby host can be located.

b) Large scale fires have previously affected subpopulations of *Banksia montana*, including a fire in 2000 that burnt all four *Banksia montana* subpopulations. This fire caused the deaths of 63% of adults and 77% of juveniles, with a total of 116 plants lost. Following the fire, only 13 seedlings emerged. Any mealybugs located on these plants would have perished and would not have been able to re-establish unless some older plants survived. It is assumed that fires, exacerbated by the effects of a drying climate, will likely further impact on the species in the future.

c) Not conducted to date.

d) All subpopulations are at risk.

e) The local extinction of the mealybug subpopulation, with no recolonisation, even if the host subpopulation restores itself because the mealybug subpopulations are too far apart for natural recolonisation to occur. This appears to be the case on Bluff Knoll where the mealybug is only found on 1 host plant, despite other mature plants being available.

If possible, provide information threats for each current occurrence/location:

Location	Past threats	Current threats	Potential threats	Management requirements (see section 4.4)
Bluff Knoll, Stirling Range National Park, WA.	Fire, plant disease.	Fire, plant disease.	Climate change.	Conserve host population in adequate numbers.
Pyungorup Peak, Stirling Range National Park, WA.	Fire, plant disease.	Fire, plant disease.	Climate change.	Conserve host population in adequate numbers.

Identify and explain why additional biological characteristics particular to the species are threatening to its survival (e.g. low genetic diversity). Identify and explain any models addressing the survival of the species.

This species of mealybug is particularly at risk of extinction as its likely host breadth is very low (1 host plant species). We have used the host-breadth models of Vesik *et al.* (2010), which assess host-breadth in light of uncertainty (such as the potential of the insect to be a tourist and not actually feeding on any given plant species that it is found on), to examine this. Coupled with the low

dispersal ability, and other such factors the probability of extinction is high (refer to framework to assess coextinction risk in Moir <i>et al.</i> 2011).	
4.4. Management	
Identify key management documentation for the species e.g. recovery plans, conservation plans, threat abatement plans etc.	
At this stage there are no management plans developed for <i>Pseudococcus markharveyi</i> , although a translocation proposal was submitted to WA Parks & Wildlife and translocation trials commenced in October 2012.	
Does this species benefit from the management of another species or community? Explain.	
<i>Pseudococcus markharveyi</i> should benefit from the management of its host plant <i>B. montana</i> as to date it has only been recorded from this plant host. Any threat to <i>B. montana</i> can be considered an indirect threat to <i>Pseudococcus markharveyi</i> .	
How well is the species represented in conservation reserves or covenanted land? Which of these are actively managed for this species? Provide details.	
No areas are actively managed for the <i>Pseudococcus markharveyi</i> . It is found in the Stirling Range National Park.	
Are there any management or research recommendations that will assist in the conservation of the species? Provide details.	
There was a translocation trial in Oct 2012 to introduce <i>Pseudococcus markharveyi</i> to translocated host individuals. The translocation site is located at Kamballup which is approximately 40km south from the nearest natural subpopulation. The translocation trials, using nymphs, were performed in Oct 2012 and were reassessed in Dec 2012 but had failed. Therefore in Dec 2012 another trial, using adults, was undertaken. In April 2013, the translocation was monitored and the mealybugs were found on 40% of the plants.	
4.5. Other	
Is there any additional information that is relevant to consideration of the conservation status of this species?	
It should be noted that populations of <i>Banksia montana</i> may survive but still result in the extinction of the mealybug. This early extinction of the mealybug could occur when the host population becomes too small to sustain a viable population of bug (see Moir <i>et al.</i> 2010). The level at which an organism will go extinct due to a change in some required variable (e.g., number of habitat patches) has been termed the extinction threshold in studies of metapopulations (e.g., Benton 2003).	
SECTION 5. NOMINATOR	
Nominator(s) name(s)	
Organisation(s)	
Address(s)	
Telephone number(s)	
Email(s)	
Date	18 September 2012
If the nomination has been refereed or reviewed by experts, provide their names and contact details.	
SECTION 6. REFERENCES	
What references or sources did you use to prepare your nomination? Include written material, electronic sources and verbal information. Include full references, address of web pages and the names and contact details of authorities with whom you had verbal communications.	
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