Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Section 1 – Eligibility for Listing		
1. Name of the ecological community		
Montane Heath and Thicket of the Eastern Stirling Range		
2. Listing Category for which the ecological community is nominated		
	WA Minister ESA list in policy	EPBC Act (wholly or as a component)
Current listing category (Please check box)	☒ Critically endangered ☐ Endangered ☐ Vulnerable ☐ Priority 1-4 ☐ Data Deficient ☐ None – not listed	Name: Eastern Stirling Range Montane Heath and Thicket ecological community ☐ Critically endangered ☒ Endangered ☐ Vulnerable ☐ None – not listed
Proposed listing category (Please check box)	☐ Collapsed ☒ CR: Critically endangered ☐ EN: Endangered ☐ VU: Vulnerable ☐ Priority 1-4	
Select one or more of the following criteria under which the community is to be nominated for BC Act listing. (Please check box). For further details on these criteria please refer to the Attachment to this form. The information you provide in Section 3 should support the criteria you select here.	☐ Criterion A – Reduction in geographic distribution ☒ Criterion B – Restricted geographic distribution ☐ Criterion C – Environmental degradation based on change in an abiotic variable ☒ Criterion D – Disruption of biotic processes or interactions based on change in a biotic variable ☐ Criterion E – Quantitative analysis that estimates the probability of ecosystem collapse	

Section 2 – Description, Condition, Threats & Recovery
Please answer all the questions, providing references where applicable. If no or insufficient information exists to answer a question, you must indicate this instead of leaving the question blank. The answers may be provided within this form or as attachments, ensuring that responses clearly indicate which question number they refer to.
Classification
3. What is the name of the ecological community?
Note any other names that have been used recently, including where different names apply within different jurisdictions. For example, is it known by separate names in different States or regions?
The community is also known as:

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)

Under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act):

Eastern Stirling Range Montane Heath and Thicket ecological community, listed Endangered (EN).

N.B. Most of the text in this nomination form is taken directly from Barrett S., Yates C.J. (2015). Risks to a mountain summit ecosystem with endemic biota in southwestern Australia. Austral Ecology 40, 423-432.

4. What authorities/surveys/studies support or use the name?

The community was first described by Ludwig Diels in 1906 (Diels 2007), then subsequently in more detail by Pignatti *et al*. (1993), and more recently by Barrett (1996; 2000). The community was endorsed as a critically endangered threatened ecological community (TEC) by the WA Minister for Environment in 2001. The ranking criteria developed in WA do not match those used in the International Union for the Conservation of Nature's Red List of Ecosystems Criteria (IUCN RLE) that is now the internationally recognised standard. The community was also listed endangered under the name 'Eastern Stirling Range Montane Heath and Thicket ecological community' when the *EPBC* Act was enacted but has not been re-ranked using the new criteria recognised under that Act that also differ from the ranking criteria used for the IUCN RLE. Barrett *et al*. (2000) named the community the 'Eastern Stirling Range Montane Heath and Thicket'.

5. How does the nominated ecological community relate to other ecological communities that occur nearby or that may be similar to it?

Does it intergrade with any other ecological communities and, if so, what are they and how wide are the intergradation zones?
Describe how you might distinguish the ecological community in areas where there is overlap (also see Description section below).

The community overlaps with the umbrella EPBC listed TEC, Proteaceae dominated kwongkan shrublands of the southeast coastal floristic province of Western Australia (EN), that is also listed as a Priority 3 ecological community (PEC) in WA. An additional two PECs adjoin or occur nearby and include the Montane Mallee Thicket of the Stirling Range (Priority 1), and Coyanarup wetland suite (Priority 1).

1. Proteaceae dominated kwongkan shrublands of the southeast coastal floristic province of Western Australia, Priority 3 in WA, EN under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).
   Description: Dense, obligate seeding Proteaceae dominated shrublands and kwongan of the Esperance Sandplains. Areas of the Montane Heath and Thicket community are a component of or overlap/intergrade with the Proteaceae dominated shrubland community on the lower slopes.
2. Coyanarup wetland Suite Priority 1 in WA
   Description: This wetland is composed of microscale paluslopes associated with seepage and creeks in the zone between Coyanarup Peak and Bluff Knoll (Semeniuk Research Group, 1998) at approximately 900m above sea level. Wetland deposits contain peat and the water is fresh. Soils are organic peaty sandy clay loam on shale and quartzite with quartz gravel. Vegetation consists of mallee-heath thicket and low woodland over sedge. Dominant species include *Eucalyptus megacarpa, Allocasuarina decussata, Homalospermum firmum, Astartea montana, Taxandria linearifolia, Xanthorrhoea preissii, Lepidosperma longitudinale* and *Gahnia decomposita*. Threatened flora species *Xyris exilis* (EN) is restricted to the community and grows adjacent to creeklines and seepages. Priority flora that occur within the community including, *Gonocarpus benthamii* subsp. Stirling sp. (P4), *Stylidium keigheryi* (P2), *Calothamnus montanus.* Frog species recorded from this wetland, include *Geocrinia laeai, Ranidella pseudinsignifera, R. subinsignifera, Limnodynastes dorsalis* and *Crinia georgiana*. The threatened marsupial species *Setonix brachyurus* occurs across the community. An undescribed spider of the genus Toxops (family Toxopidae) which has Gondwanan affinities has been collected from this community as well as the Mygalomorph species *Chenistonia tepperi* and *Stanwellia* sp. The seasonally waterlogged wetlands inhabit a range <50 km^2 or <20 km linear, totalling ~14 ha and occur within the saddle of Coyanarup Peak and Bluff Knoll. Coyanarup Wetland suite provides a link with two occurrences of the Montane heath and thicket TEC.
3. Montane mallee thicket community of the Stirling Range (Priority 1)

Description: Thicket, mallee-thicket and heath community occurs on mid-upper slopes in the central and western Stirling Range and hills east of Red Gum Pass. This community is distinct from the Montane heath and thicket TEC that occurs at higher altitude.
Listed Priority 1 in WA and is a component of the Proteaceae Dominated Kwongan Shrublands of the Southeast Coastal Floristic Province of Western Australia EPBC Listed TEC.
The Montane mallee thicket community surrounds the Montane heath and thicket TEC on the lower slopes and intergrades with a component of the Proteaceae Dominated Kwongkan Shrublands of the Southeast Coastal Floristic Province of Western Australia.

Description

6. List the main features that distinguish this ecological community from all other ecological communities.

Characteristic (or diagnostic) features can be biological (e.g. taxa or taxonomic groups of plants and animals characteristic to the community; a type of vegetation or other biotic structure), or associated non-biological landscape characteristics (e.g. soil type or substrate, habitat feature, hydrological feature). Please limit your answer to those features that are specific to the ecological community and can be used to distinguish it from other ecological communities.

The Montane Heath and Thicket of the Eastern Stirling Range of the South West Botanical Province, above approximately 900 m above sea level (Eastern Stirling Range Montane Heath and Thicket Community) [herein referred to as Montane Heath and Thicket] comprises a heathland and dense shrub thicket with a suite of endemic species. It occupies the high peaks of the eastern Stirling Range mountains. The community is commonly found at altitudes of approximately 900 to 1090 m above sea level but extends to lower altitudes in two occurrences. Several endemic and characteristic species within the community and the near absence of *Eucalyptus* species differentiate it from other plant communities in the range. Thirteen threatened flora are known from the community including *Andersonia axilliflora, Banksia brownii, Banksia montana, Darwinia collina, Darwinia nubigena, Darwinia squarrosa, Daviesia obovata, Deyeuxia drummondii, Lambertia fairallii, Latrobea colophona, Leucopogon gnaphalioides, Persoonia micranthera* and *Sphenotoma drummondii,* and 23 priority flora taxa are also associated with the community. *Andersonia axilliflora* is a characteristic endemic species and is or was an abundant and dominant member of the community. Using *A. axilliflora* as an indicator, the community extends from the eastern limit of the Stirling Range, Ellen Peak (1012 m), in four more or less continuous occurrences connected by downslope plant communities, to Coyanarup Peak (1045 m) with a separate occurrence on the summit area of Mt Success (750 m).

Five threatened fauna occur within the community including the quokka (*Setonix brachyurus*), *Banksia montana* mealybug (*Pseudococcus markharveyi*), *Banksia brownii* plant-louse (*Trioza barrettae*), eastern massif assassin spider (*Zephyrarchaea robinsi*), Bluff Knoll *Atelomastix* millipede (*Atelomastix tumula*); as well as the priority fauna *Bothriembryon glauerti* (a P2 snail).

The community occurs over a 12.5 km range (Appendix 4) and occupies approximately 334 ha over 10 mountain summits (Ellen Peak, Pyungoorup, Bakers Knob, the Arrows, Isongerup, Moongoongoonderup, East Bluff, Bluff Knoll, Coyanerup and Mt Success).

The geology of the Stirling Range is comprised of sandstone and meta-sandstone (quartzite, shale and phyllite) (Semeniuk 1993). The Montane heath and thicket grow on sandy clay loam to peaty clay loam soils with quartz and quartzite fragments. These soils are generally acidic (pH < 5) and have macro-nutrient and organic carbon concentrations that are high relative to the typically nutrient poor soils of the surrounding lowland plains (Barrett 2001). Plant growth is limited by low temperatures and high wind speeds that prevail for much of the year (Barrett 1996). The Stirling Range runs in an east-west direction and intercepts prevailing southerly winds from the Southern Ocean resulting in low-level stratified clouds draping over peaks on many days of the year. Long term climate data are not available for the ecosystem, but mean annual precipitation is estimated to be greater than 1000 mm (Courtney 1993). Although humidity is high for much of the year, the ecosystem is prone to fires spreading from the plains below during warmer, drier summer months (Barrett and Yates 2015).

7. Give a description of the biological components of the ecological community.

For instance, what species of plants and animals commonly occur in the community; what is the typical vegetation structure (if relevant).

Biological environment

The ecosystem was described by Barrett (2000) as 'Montane heath and thicket' following Muir's Structural Classification (1977). The Montane heaths and thickets vary in height (from 0.5-2 m) with projected foliage cover (cover) up to 80% depending on abiotic factors including soil depth, aspect and fire as well as biotic factors such as disease and grazing. Taller thicket vegetation occurs on more sheltered sites on deeper soils.

Flora

Characteristic plant taxa belong to the families Proteaceae, Myrtaceae, Fabaceae, Ericaceae, Apiaceae and Cyperaceae (Barrett and Yates 2015) (Appendix 1). Descriptions of the vegetation are found in Barrett (1996; 2000). The upper shrub stratum is characterised by *Andersonia axilliflora* (a key endemic species), *Kunzea montana, Beaufortia anisandra, Calothamnus montanus, Hakea florida, Banksia oreophila, B. solandri, B concinna, and Sphenotoma* sp. Stirling Range over sedges including *Lepidosperma* sp. Bluff Knoll robust, *Desmocladus flexuosa* and *Tetraria* sp. Jarrah Forest. Annual and perennial graminoids and herbs are most abundant in the first five years after fire and then decline as the dominant shrub overstorey develops (Keith *et al*. 2014).

A range of proteaceous species were, or are, structurally significant and include *Banksia brownii, B. montana, B. concinna, B. oreophila, B. solandri* and *Hakea florida. Eucalyptus* species are notable for their absence from the community but occur at immediately lower altitudes. Species endemic to the community are *A. axilliflora, Banksia montana, Persoonia micranthera, Darwinia collina, Microcorys* sp*. Stirling Range, Stylidium* sp. Bluff Knoll and *Stylidium keigheryi*.

Thirteen threatened and 23 priority flora, are known to occur in the community (Appendix 2).

Threatened flora include, giant Andersonia - *Andersonia axilliflora,* Feather-leaved Banksia - *Banksia brownii, Banksia montana,* yellow mountain bell - *Darwinia collina, Darwinia nubigena,* pink mountain bell -*Darwinia squarrosa, Daviesia obovata,* Drummond grass *Deyeuxia drummondii,* Fairall's honeysuckle - *Lambertia fairallii, Latrobea colophona, Leucopogon gnaphalioides, Persoonia micranthera and* mountain paper-heath - *Sphenotoma drummondii.*

Fauna

One threatened vertebrate occurs in the community - quokka (*Setonix brachyurus*). Other mammals include the mardo (*Antechinus flavipes*), bush rat (*Rattus fuscipes*), quenda (*Isoodon obesulus*) and honey possum (*Tarsipes rostratus*). The two feral animals recorded are the rabbit (*Oryctolagus cuniculus*) and feral cat (*Felis catus*).

Invertebrate fauna

The Stirling Range is notable for the prevalence of short-range endemic and relictual invertebrate species (Harvey 2002; Moir *et a*l. 2009; 2010, 2011, Rix and Harvey 2012) including a suite of endemic species of spiders, snails and millipedes. Threatened invertebrate fauna include *Banksia montana* mealybug*, Pseudococcus markharveyi, Banksia brownii* plant-louse - *Trioza barrettae,* Robin's assassin spider - *Zephyrarchaea robinsi,* Bluff Knoll Atelomastix millipede - *Atelomastix tumula* and the Priority 2 snail, *Bothriembryon glauerti.*

8. Give a description of the associated non-biological landscape characteristics or components of the ecological community.

For instance, what is the typical landscape in which the community occurs? Note if it is associated with a particular soil type or substrate; what major climatic variables drive the distribution of the ecological community (e.g. rainfall). Note particular altitudes, latitudes or geographic coordinates

The high peaks of the eastern Stirling Range are mountains that are effectively biological islands in a landscape of otherwise low relief. The Montane Heath and Thicket is found at altitudes of approximately 900 to 1090 m above sea level but extend to lower altitudes in two occurrences. Conditions are distinctively montane with skeletal soils on quartzite, extremes of temperatures, high humidity and exposure with occasional snowfalls. The community is geographically restricted (Figure 1).

The geology of the Stirling Range is comprised of sandstone and meta-sandstone (quartzite, shale and phyllite) (Semeniuk 1993). The Montane heath and thicket occurs over sandy clay loam to peaty clay loam soils with quartz and quartzite fragments. These soils are generally acidic (pH < 5) and have macro-nutrient and organic carbon concentrations that are high relative to the typically nutrient poor soils of the surrounding lowland plains (Barrett 2001). Plant growth is limited by low temperatures and high wind speeds that prevail for much of the

year (Barrett 1996). The Stirling Range runs in an east-west direction and intercepts prevailing southerly winds from the Southern Ocean resulting in low-level stratified clouds draping over peaks on many days of the year. Long term climate data are not available for the ecosystem, but mean annual precipitation is estimated to be greater than 1000 mm (Courtney 1993). Although humidity is high for much of the year, the ecosystem is prone to fires spreading from the plains below during warmer, drier summer months (Barrett and Yates 2015).

9. Provide information on the ecological processes by which the biological and non-biological components interact (where known).

The peaks are effectively biological islands in a landscape of otherwise low relief, and were part of an archipelago during the Eocene when sea levels were higher. On the highest peaks of the Stirling Range, the characteristic heathland (Kwongan) of the region becomes a dense shrub thicket with many endemic species. Conditions are distinctively montane, with skeletal organic soils, low temperatures, high humidity and exposure, and occasional snowfalls (Moir and Leng 2013). Fire regimes play a key role in maintaining the diversity of the system, particularly as many of the rare and restricted flora that ascribe the ecosystem's uniqueness are killed by fire and rely on seedling establishment to maintain their populations. Most of the component species are killed by fire and rely on seeds to regenerate. As a consequence fire intervals are particularly important for the dynamics and persistence of the ecosystem.

Anthropogenic climate change is also a major threat to the Montane Heath and Thicket. Mean ambient temperatures in southwestern Western Australia have increased during the 20th century and since the 1970s there has been a significant decline in autumn and early winter rainfall (Bates *et al.* 2008). The consensus among global climate models is for a continuation of the present trends with projected increases in temperature of 1–5.5°C and decreases in annual rainfall of 5–60% by 2070 (CSIRO 2007; Bates *et al.* 2008). Because the Montane Heath and Thicket is confined to mountain summits, there is no bioclimatic zone for component species to move to with projected warming and drying.

10. Does the ecological community show any consistent regional or other variation across its extent, such as characteristic differences in species composition or structure?

If so, please describe these.

On the highest peaks of the Stirling Range the characteristic heathland (Kwongan) of the region becomes a dense shrub thicket where the montane heath and thicket varies in height (>2m) and cover to 80% depending on abiotic factors including soil depth, aspect and fire regime as well biotic factors such as disease and grazing (Barrett and Yates 2015).

11. Does the ecological community provide habitat for any listed threatened species and/or endemic species?

If so, please note the species and whether the species is listed on State and/or national lists and the nature of their dependence on the ecological community.

Flora

Appendix 1 lists flora taxa that commonly occur in the Montane heath and thicket community.

Thirteen threatened flora are known to occur in the community, with twelve listed under the *EPBC* Act. Giant Andersonia, *Andersonia axilliflora,* feather-leaved Banksia *Banksia brownii, Banksia montana,* yellow mountain bell, *Darwinia collina, Darwinia nubigena,* pink mountain bell *Darwinia squarrosa, Daviesia obovata,* Drummond grass, *Deyeuxia drummondii,* Fairall's honeysuckle, *Lambertia fairallii, Latrobea colophona, Leucopogon gnaphalioides, Persoonia micranthera* and mountain paper-heath *Sphenotoma drummondii.* An additional 23 taxa are listed as Priority flora.

Fauna

Mammals: quokka *Setonix brachyurus*, listed Vulnerable (VU) in WA and under the *EPBC* Act. Other mammals, brushtail possum, *Trichosurus vulpecula,* quenda*, Isoodon obesulus fusciventer* and honey possum *Tarsipes rostratus*

Reptiles: Napolean's skink, *Egernia napoleonis*, marbled gecko, *Christinus marmoratus* and crowned snake, *Notechis coronatus* and frogs, quacking frog, *Crinia georgiana, Geocrinia leai* and *Metacrinia nichollsii*.

Short-range endemic and relictual invertebrate species: *Banksia montana* mealybug - *Pseudococcus markharveyi*, *Banksia brownii* plant-louse - *Trioza barrettae*, Robin's assassin spider- *Zephyrarchaea robinsi*, Bluff Knoll Atelomastix millipede - *Atelomastix tumula* and a Priority 2 snail, *Bothriembryon glauerti.*

12. Identify major studies on the ecological community (authors, dates, title and publishing details where relevant).

Barrett S. (1996). Biological Survey of Mountains of southern Western Australia. Department of Conservation and Land Management, Albany.

Barrett S., Comer S., McQuoid N., Porter M., Tiller C., Utber D. (2009). Identification and conservation of fire sensitive ecosystems and species of the South Coast Natural Resource Management Region. Department of Environment and Conservation, Albany.

Barrett S., Yates C.J. (2015). Risks to a mountain summit ecosystem with endemic biota in southwestern Australia. Austral Ecology 40, 423-432.

Keith D., Lindenmayer D., Lowe A., Russell-Smith J., Barrett S., Enright N. *et al*. (2014). Heathlands. In: Biodiversity and Environmental Change: Monitoring, Challenges and Direction (eds D. Lindemayer, E. Burns, N. Thurgate and A. Lowe) pp. 213−281. CSIRO Publishing, Australia.

Pignatti E., Pignatti S., Lucchese F. (1993). Plant Communities of the Stirling Range, Western Australia. J. Veg. Sci. 4: 477-488

Harvey M.S. (2002). Short-range endemism in the Australian fauna: some examples from non-marine environments. Invert. Syst. 16, 555-70.

Moir M.L., Coates D.J., Kensington W.J., Barrett S., Taylor G.S. (2016). Concordance in evolutionary history of threatened plant and insect populations warrant unified conservation management approaches. Biological Conservation 198: 135–144.

Rix M.G., Harvey M.S. (2012) Phylogeny and historical biogeography of ancient assassin spiders (Aranae: Archaeidae) in the Australian mesic zone: Evidence for Miocene speciation with Tertiary refugia. Mol. Phylogenet. Evol. 62, 375-96.

Distribution

13. Describe the distribution across WA and nationally.

State the appropriate bioregions where the ecological community occurs. Attach or provide any maps showing its distribution with details of the source of the maps, or explain how they were created and the datasets used.

The Montane heath and thicket occurs within Interim Biogeographic Regionalisation for Australia (IBRA) (WA): Esperance Plains; IBRA Sub name: Fitzgerald
Beard's phytogeographic regions, Botanical Province: South-West Botanical Province

Mapping of distribution generated from comprehensive, detailed spatial mapping to include historical scale maps and on ground survey and orthography (Appendix 4).

The community is limited to the highest peaks of the Stirling Range wholly within Stirling Range National Park, ~65 km north of the Town of Albany on the south coast of Western Australia, within the Shire of Gnowangerup.

14. What is the area of distribution of the ecological community?

For answers to parts a, b, c & d: please identify whether any values represent extent of occurrence or area of occupancy (as described in the Attachment); provide details of the source(s) for the estimates and explain how they were calculated and the datasets used.

144 a. What is the current known area (in ha)?

Total area of ~323 ha over 10 mountain summits Ellen Peak, Pyungoorup, Bakers Knob, the Arrows, Isongerup, Moongoongoonderup, East Bluff, Bluff Knoll, Coyanerup and Mt Success. Lineal extent 12.5 km (Figure 1).

144 b. What is the pre-industrialisation extent or its former known extent (in ha)? An ecological community is considered to be naturally restricted if it has a pre-industrialisation area of occupancy that is less than 10 000 ha or a pre-industrialisation extent of occurrence that is less than 100 000 ha (refer to the Attachment A)

Unlikely to have declined in extent since ~1750 however, much of the area is now highly modified.

144 c. What is the estimated percentage decline of the ecological community?

Approximately 280ha (~85%) of the Montane heath and thicket community has declined in terms of species composition and vegetation condition.

144 d. What data are there to indicate that future changes in distribution may occur?

Keith *et al.* (2014). Long term monitoring and historical records indicate that the Montane Heath and Thicket has undergone substantial decline in recent decades attributed to "impacts of the plant pathogen *Phytophthora cinnamomi*, invasive species and climate" (Watson & Barrett 2004).

Barrett *et al.* 2008; Wills 1993; Barrett 1996; Barrett and Yates (2015) state "*In the Stirling Range National Park (SRNP), 14 endemic taxa have a 'high' risk of extinction and impact on plant communities has been devastating"*.

Patch size

15. What is the typical size (in ha) for a patch of the ecological community (if known)?

Explain how it was calculated and the datasets that are used. Relevant data includes the average patch size, the proportion of patches that are certain sizes, particularly proportions below 10 ha and below 100 ha, (but also below 1 ha and above 100 ha, for example). This could be presented as the range of patch sizes that comprise 90% of the occurrences.

The Montane Heath and Thicket was mapped using ArcGIS© and a range of data sources including historic photography, quadrat and survey data (Barrett 1996), topography and altitude and on ground survey. The extent of occurrence of the community was estimated using a minimum convex polygon and the area of occupancy was estimated by determining the number of 10 × 10 km grids covered by the ecosystem.

The Montane heath and thicket community occupies ~323 ha, with a total of four occurrences recorded, with three occupying <100 ha and one occurrence > 100 ha.

16. Quantify, if possible, the smallest percentage or area required for a patch of the ecological community to be considered viable.

This refers to the minimum size of a remnant that can remain viable without active management. It may be determined through the requirements for dominant native species, level of species diversity, or the nature of invasive weeds.

Mean patch size: 65.4 ha Minimum patch size: 17 ha (Mount Success): Maximum patch size: 152 ha (Bluff Knoll).

Areas of vegetation that remain in relatively good of better condition have been mapped. The community generally occurs within patches of other vegetation, and not in isolation, therefore there is no minimum area specified for a remnant that could remain viable without active management. Patches are all small and most require management such as dieback control.

Functionality

17. Is the present distribution of the ecological community severely fragmented?

If so, what are likely causes of fragmentation?
If fragmentation is a natural or positive characteristic of this ecological community, please explain this and state the reason.
Severely fragmented refers to the situation in which increased extinction risk to the ecological community results from most remnants being found in small and relatively isolated patches.

English and Keith (2015): "The southwest of Western Australia was identified as a global biodiversity hotspot due to its high numbers of endemic species, many of which face high risks of extinction (Mittermeier *et al*. 2004). Within the region, diversity is expressed primarily at and below the species level (Byrne 2007), indicating relatively recent diversification within genera such as Acacia, Banksia, Eucalyptus, Grevillea, Hakea, Melaleuca and Stylidium (Paczkowska & Chapman 2000). The mechanisms responsible for this diversity are complex and thought to be related to post-Miocene climatic instability resulting in cycles of expansion and contraction of mesic and arid conditions across an edaphically and hydrologically varied landscape. The resulting fragmentation and isolation of plant populations promoted genetic divergence, local adaptation and speciation in localised refugia (Hopper 1979, Byrne 2007). As a consequence, high levels of diversity are expressed within local sites, across environmental gradients and at landscape scales (Hopper & Gioia 2004). The extremely high beta-diversity within the region is related in part to the turnover of species along climatic and edaphic gradients, with contrasting substrates supporting distinctive assemblages of flora (Hopper 1979*)."*

The Montane heath and thicket lies within an ecosystem that is geographically restricted largely to the summit areas of the ridge to nine mountain peaks running in an east-west direction. Each occurrence is interconnected by downslope plant communities including the Proteaceae dominated kwongan shrubland, the Coyanarup wetland suite and the Montane mallee thicket communities. Each occurrence is effectively a biological island in a landscape of otherwise low relief at ~ 200-230 m above sea level.

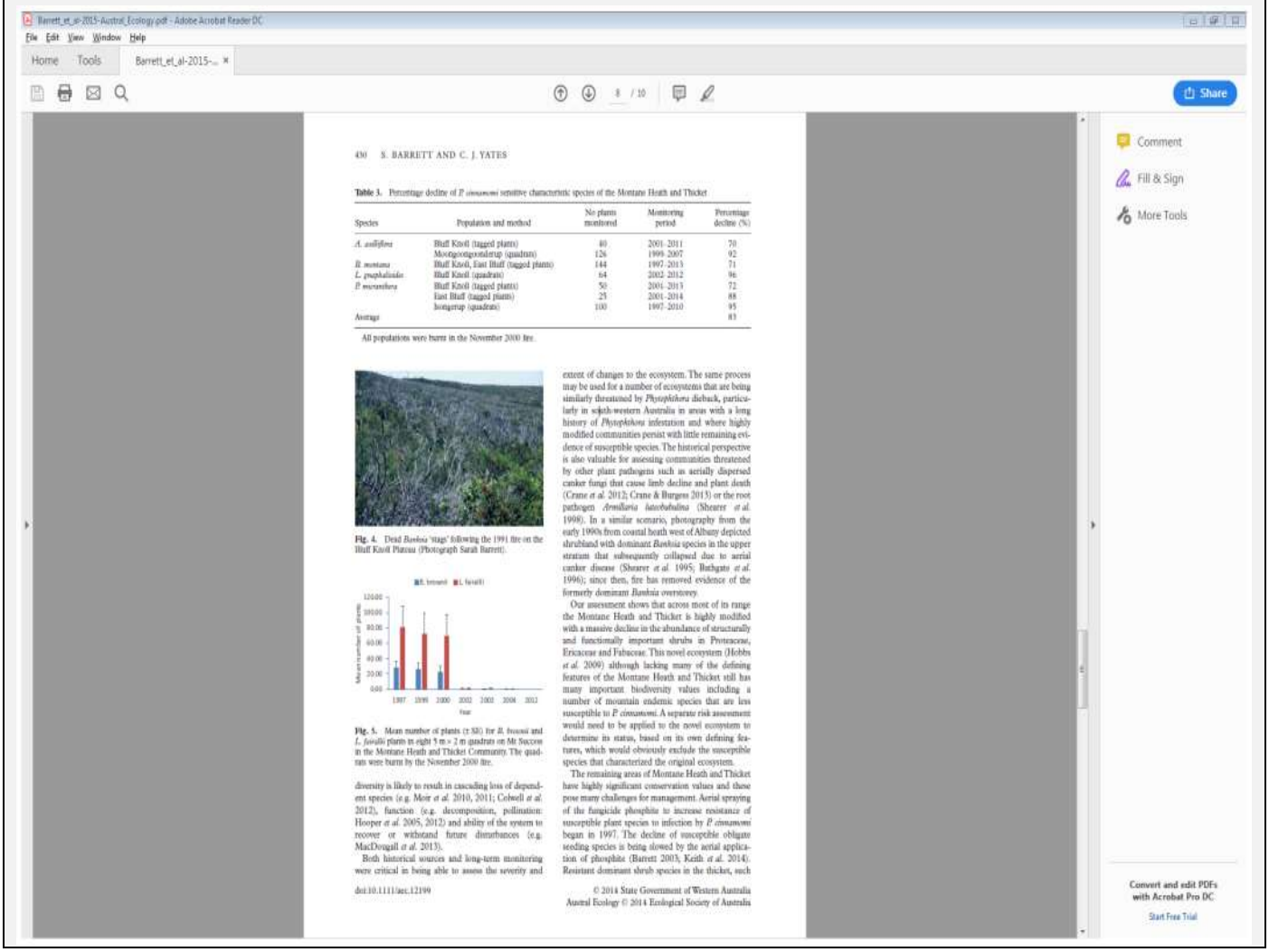
18. Has there been a loss or decline of functionally important species?

This refers to native species that are critically important in the processes that sustain or play a major role in the ecological community and whose removal has the potential to precipitate change in community structure or function sufficient to undermine the overall viability of the community.

Plant taxa belonging to the families Proteaceae, Myrtaceae, Fabaceae, Ericaceae, Apiaceae and Cyperaceae (Barrett and Yates 2015) define the community with the upper shrub stratum containing *Andersonia axilliflora* (a key endemic species), *Kunzea montana, Beaufortia anisandra, Calothamnus montanus, Hakea florida, Banksia oreophila, B. solandri, B concinna, and Sphenotoma* sp. Stirling Range over a sedge layer comprising *Lepidosperma* sp. Bluff Knoll robust, *Desmocladus flexuosa* and *Tetraria* sp. Jarrah Forest. A range of proteaceous species that are susceptible to dieback disease caused by *Phytophthora* species were, or are, structurally significant and include *B. brownii, B. montana, B. concinna, B. oreophila, B. solandri* and *Hakea florida*.

18 a. If yes, which species are affected?

Changes are most evident in the decline of species of Proteaceae that were dominant in the thicket (Keith *et al.* 2014). Photography from the 1960s to the 1980s records healthy stands of *B. montana, B. brownii* and *Isopogon latifolius* on the summit of Bluff Knoll. Monitoring since 1994 has shown these species to be locally extinct, or as in the case of *B. montana*, extremely rare.



Extract derived from Keith *et al.* (2014).

18 b. How are the species functionally important and to what extent have they declined?

Long term monitoring of *P. cinnamomi* susceptible defining species of the Montane heath and thicket in the last two decades has shown a 35% decline in the number of populations of *B. montana, B. brownii and Isopogon latifolius* (Barrett and Yates 2015). The severity of this decline is further emphasized where long term monitoring of plants in individual populations has been undertaken showing a mean decline of 83% in the number of plants within populations. Population extinctions have been recorded for eight species from the community (Barrett and Yates 2015).

Reduction in community integrity

19. Please describe any processes that have resulted in a reduction in integrity and the consequences of these processes, e.g. loss of understorey in a woodland. Include any available information on the rate of these changes.

This recognises that an ecological community can be threatened with extinction through on-going modifications that do not necessarily lead to total destruction of all elements of the community. Changes in integrity can be measured by comparison with a benchmark state that reflects as closely as possible the natural condition of the community with respect to the composition and arrangement of its abiotic and biotic elements and the processes that sustain them. Please provide a description of the benchmark state where available. For further information please refer to the Guidelines.

Extensive changes in the composition of the ecosystem through local extinction or severe reduction in populations of defining plant species particularly in the Proteaceae, Eriacaeae and Fabaceae families are indicated in the community.

Local extirpation of species has occurred in some areas, including *B. brownii, B. montana* although they still exist elsewhere.

Survey and Monitoring

20. Has the ecological community been reasonably well surveyed?

Provide an overview of surveys to date, including coverage of different land tenure, and the likelihood of the ecological community's current known distribution and/or patch size being a true reflection of its actual distribution (consider area of occupancy and area of extent, including any data on number and size of patches).

The entire extent of the eastern Stirling Range on Pyungoorup, Bakers Knob, Isongerup, west Moongoongoonderup, East Bluff, Bluff Knoll, Coyanerup and Mt Success, was mapped following on-ground survey from the early 2000s. Boundaries have been amended to reflect changes.

The combination of researchers, naturalists and the department's Albany based personnel and volunteers have undergone intensive survey of all likely habitat of the community in prospective areas.

21. Where possible, please indicate areas that haven't been surveyed but may add to the information required in determining the community's overall viability and quality.

Include commentary on issues to do with accessing different land tenures within the area of distribution, including private property, and the likelihood that these areas may include occurrences.

Historically and over the past ~30 years, all peaks across Stirling Range have been surveyed and or subjected to ongoing survey to assess condition, monitor threats and extent of the Montane heath and thicket.

22. Is there an ongoing monitoring program? If so, please describe the extent and length of the program.

A combination of monitoring programs developed for the community, include (but not limited to):

- Aerial phosphite applications of susceptible defining species for the control of *Phytophthora cinnamomi* has continued over 20 years, monitoring the survival of susceptible (mainly threatened) flora species and to evaluate the effectiveness of phosphite application. Application includes plant communities adjacent including the Montane mallee thicket PEC and the Kwongan Proteaceous Heath TEC across the Stirling Range
- Regular monitoring of critically endangered flora populations
- Monitoring the effects of browsing exclusion plots with the aim of recording growth, recruitment, vegetation cover and abundance of all vascular plant species were assessed at establishment and one year

later at four of the ten exclosures. Includes *B. montana, P. micranthera, L. gnaphalioides, L. colophona, D. collina, A. axilliflora* plants within the community that were fenced from 2001

- Monitoring vegetation condition post establishment of larger fenced enclosures to protect the community on Bluff Knoll, Coyanerup and East Bluff in 2014-2015
- Monitoring survival of (mostly) threatened flora susceptible to *Phytophthora cinnamomi* to evaluate the effectiveness of phosphite application
- Long-term monitoring (started in 2001) investigating fire ecology of the community
- Monitoring dieback-fire Individual Threatened flora (*B. montana, P. micranthera, L. gnaphalioides, L. colophona, D. collina, A. axilliflora*) within the community were fenced 2001 with the aim of reducing reduce grazing (Rathbone and Spencer 2011). Larger fenced enclosures to protect the community were constructed on Bluff Knoll, Coyanerup and East Bluff in 2014-2015 and detailed monitoring established (Rathbone *et al*. 2016);
- Herbivory: The RHDV1-K5 Calicivirus was released on Bluff Knoll to reduce rabbit grazing impacts. Rabbit activity was monitored using IR cameras and scat plot counts. High quokka activity seen on camera may have decreased carrot available for consumption by rabbits and the efficacy of the release
- Enclosures established on Coyanerup and East Bluff to protect *Darwinia collina, Leucopogon gnaphalioides, Latrobea colophona* and *Andersonia axilliflora* from browsing by quokka. The growth and reproduction of fenced plants, monitored after 1-2 years, exhibited a significant growth than non-fenced plants.

Condition Classes and Thresholds

23. Do you think condition classes/thresholds apply to this ecological community? If not, give reasons.

The Committee recognises that ecological communities can exist in various condition states. In reaching its decision the Committee uses condition classes and/or thresholds to determine the patches that are included or excluded from the listed ecological community (see the Guidelines for details of the process of determining condition classes). Relevant here is recognition of different states following disturbance and the natural recovery of the occurrence towards a higher condition class.

In the last three decades the entire ecosystem has been infested by *P. cinnamomi* to varying degrees, and only small remnants of the community remain relatively intact in terms of species composition (Barrett 1996). The threshold that is generally applied to 'extant' occurrences of community's is 'Good', with vegetation in poorer condition than 'good' not being considered to be representative of the community.

Occurrence name	**Total area and impacts** **[ ] = ha low plant disease**	**date last surveyed**	**Condition when last surveyed**
Mount Success	17.6 ha [10 ha]	2019	Good-Very Good
Bluff Knoll – East Bluff Coyanarup	152.6 ha [19 ha]	2019	Good-very Good
Moongoongoonderup	30.3 ha [8 ha]	2019	Good-Very Good
Ellen Peak, Pyungoorup, Bakers Arrows	51.6 ha [2 ha]	2019	Good-Very Good
Isongerup Peak	75.0 ha [9 ha]	2019	Good-Very Good

Area figures derived from shape files supplied by [redacted].

24. If so, how much of the community would you describe as in relatively <u>good condition</u>,

i.e. likely to persist into the long-term with minimal management?

Approximately 48 ha of 334 ha (14%) of the total historic distribution of the ecosystem remains relatively intact in terms of species composition. The entire eastern Stirling Range has been infected by *P. cinnamomi* to some degree, but small remnants of the Montane Heath and Thicket may be dieback-free due to location.

25. What features or variables do you consider to be most valuable for identifying a patch of the ecological community in relatively <u>good condition</u>?

Variables for establishing the highest condition class may include: patch size; connectivity; native plant species composition; diversity and cover (for example in overstorey; mid-shrub and/or understorey layers); recognised faunal values; and cover of weeds or other invasive species.

- Intact populations of rare and priority and dieback susceptible flora for locations previously recorded as habitat of such flora
- Few weed taxa, and low weed cover (eg <10%)

26. How much of the community would you describe as in relatively <u>medium condition</u>, i.e. likely to persist into the long-term future with management?

100 % of the mapped area of the community for which condition has been recorded is in Very Good to Good condition on Bush Forever scales. The ecological community that has lost some indicator species with major threatening process caused by *P. cinnamomi* (high plant disease impact) but retains its functionality.

27. Please describe how you would identify areas in <u>medium condition</u> using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

- Moderate diversity of native flora retained.

28. How much of the community would you describe as in relatively <u>poor condition</u>, i.e. unlikely to be recoverable with active management?

None

29. Please describe how you would identify areas in <u>poor condition</u> using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

- Total area intact vegetation reduced -exposed bare ground (eg. >50-70%)
- Very low diversity of native flora in relation to previously recorded diversity.

Threats

Note: If you plan to identify <u>climate change</u> as a threat to the ecological community, please refer to the Guidelines for information on how this should be addressed.

30. Identify <u>PAST</u> threats to the ecological community indicating whether they are *actual* or *potential*.

The major threatening processes currently affecting the community is *Phytophthora* dieback resulting from the plant pathogen *P. cinnamomi* (actual); too frequent fire (actual); browsing by native or introduced animals (actual), disturbance from recreational activities (actual) and anthropogenic climate change (potential).

<u>*Phytophthora cinnamomi* (dieback)</u>

More than 40 per cent of Western Australian native plants are susceptible to the disease, particularly those in state's south-west. The area of land infected in Western Australia by Phytophthora dieback is or over one million hectares. Up to eighty percent of the Stirling Range National Park is infected.
https://www.dpaw.wa.gov.au/management/pests-diseases/129-phytophthora-dieback

The most significant threat to the community is *Phytophthora* dieback resulting from the plant pathogen *P. cinnamomi* (Wills 1993; Barrett 1996, 2000; Barrett *et al*. 2008). The presence of *Phytophthora* dieback was first noted in Stirling Range National Park by CSIRO researchers in 1974 and since then the pathogen has spread to many of the peaks through the transport of infested soil, mainly by foot access (Grant and Barrett 2003). Infestations high in the landscape have led to considerable down-slope spread in broad fronts and extensive infestation of the Montane Heath and Thicket. Many of the ecosystem's characteristic flora species are susceptible to the pathogen (Barrett *et al.* 2008), which thrives in the humid montane conditions and shallow organic soils. Introduction of dieback high in the landscape has led to considerable down-slope spread in broad

fronts leading to extensive infestation. The entire extent of the eastern Stirling Range has been infested by *P. cinnamomi* to at least some degree, but small pockets remain dieback-free or less extensively infested.

Inappropriate fire regimes Inappropriate fire regimes are also a major threat to the ecosystem. Most of the component species are killed by fire and rely on seeds to regenerate. As a consequence fire intervals are particularly important for the dynamics and persistence of the ecosystem. Major fires occurred in the thicket in February 1972, April 1991, and in November 2000, May 2018 and December 2019. Some patches were burnt by more than one of the fires. There has been a trend towards larger fires over time. Fire may also interact with *P. cinnamomi* to increase disease impact and accelerate the collapse of obligate seeding populations of Proteaceae (Moore 2006).

The combination of plant disease and inappropriate fire regimes threaten the persistence of the Montane Heath and Thicket and its endemic species. These processes by themselves and in combination are having a substantial impact on the community.

In the bush fire in May 2018, 86% of community was burnt between Isongerup and Bluff Knoll.

Aerial surveys suggests significant impact to the majority of the remaining unburnt patches of the community, including include Mt Success, East Bluff and Mooongoongoonderup, that were all burnt in December 2019 ([1] [redacted] personal observation).

Browsing by native and introduced animals

Detrimental impacts caused by native browsing fauna are not unprecedented and suggest disequilibrium in normal ecosystem process, potentially due to multiple interacting threats. Montane ecosystems may be particularly vulnerable to browsing due to their naturally slow recovery after disturbance. Since 1999 and specifically after the 2000 fire, the impact of browsing by vertebrate fauna has become increasingly apparent.

Disturbance from recreational activities

The higher peaks of the eastern Stirling Range attract visitors interested in bushwalking, nature observation and rock-climbing. The Ridge Walk has implications for areas of the community that contain a relatively intact ecosystem as it traverses several remnants. Negative impacts that result from recreational activity include braiding of tracks, erosion, bare-ground occurrences, campfire remains, litter and nutrient enrichment of soils, and introduction or spread of different isolates of *P. cinnamomi*.

Potential threats:

Anthropogenic climate change

Mean ambient temperatures in southwestern Western Australia have increased during the 20th century and since the 1970s there has been a significant decline in autumn and early winter rainfall (Bates *et al.* 2008). The consensus among global climate models is for a continuation of the present trends with projected increases in temperature of 1–5.5°C and decreases in annual rainfall of 5–60% by 2070 (CSIRO 2007; Bates *et al.* 2008). As the Montane Heath and Thicket is confined to mountain summits, with projected warming and drying there is no bioclimatic zone for component species to move in to.

31. Identify <u>CURRENT</u> threats to the ecological community indicating whether they are *actual* or *potential*.

As above

Root rot disease caused by *Phytophothora* species is an actual threat with increased fire frequency and intensity an emerging significant threat.

32. Identify FUTURE threats to the ecological community indicating whether they are *actual* or *potential*.

All occurrences have some level of root rot disease caused by *Phytophthora* species and the impacts are enhanced with increased fire frequency and intensity emerging as a serious threat.

[1] [redacted]: DBCA South West Region

Future management could promote persistence of the Montane heath and thicket including a range of disease prevention and mitigation measures, and managing invasion of weeds and their effects on native species. Major bushfires can occur any time and have potential for major impacts to the community.

For <u>each</u> threat describe:

322 a. How the threat has impacted on this ecological community in the past.

***Phytophthora cinnamomi* (dieback)**

This pathogen has spread to many of the peaks. The entire extent of the eastern Stirling Range has been infested by *P. cinnamomi* to at least some degree, but small pockets remain dieback-free or less extensively infested.

Changes are most evident in the decline of species of Proteaceae family that were dominant in the thicket (Keith *et al.* 2014). Photography from the 1960s to the 1980s records healthy stands of *B. montana, B. brownii* and *Isopogon latifolius* on the summit of Bluff Knoll. Monitoring since 1994 has shown these species to be locally extinct, or as in the case of *B. montana*, extremely rare.

Long term monitoring of *P. cinnamomi* susceptible defining species of the Montane heath and thicket in the last two decades has shown a 35% decline in the number of populations of these species (Barrett and Yates 2015). The severity of this decline is further emphasized where long term monitoring of plants in individual populations has been undertaken showing a mean decline of 83% in the number of plants within populations. Population extinctions have been recorded for eight species from the community (Barrett and Yates 2015).

Inappropriate fire regimes

Prior to the May 2018 fire, approximately 5% of the ecosystem remained unburnt since at least 1972, 2% was last burnt in 1991, 74% was burnt in both 2000 and 1991, and 19% was burnt in 2000 but not 1991. Consequently, prior to the May 2018 fire, a large proportion (74%) of the ecosystem had experienced a fire interval of 9 years which is at the lower – mid bounds of thresholds of collapse for characteristic non-sprouting species in the ecosystem. The May 2018 fire burnt ca. 86% of the community, and as a consequence a substantial proportion of the community has experienced two fires at the lower – mid bounds of thresholds for substantial decline of characteristic non-sprouting species in the ecosystem. Approximately 43% of the community was burnt in 2019-20 fires, and 16% of the community was burnt twice in the last 18 months..

Browsing by native and introduced animals

Montane ecosystems are vulnerable to the removal of vegetation cover through grazing or browsing by feral or native vertebrate fauna (Leigh *et al.* 1987; Bridle and Kirkpatrick 1999; Bridle *et al.* 2001). The presence of the European rabbit, *Oryctolagus cuniculus* and native quokka, *Setonix brachyurus* was confirmed during a 1994 survey (Barrett 1996). Since a bush fire in 2000, it has become increasingly apparent that browsing by vertebrate fauna is impacting the Montane heath and thicket. Survey and camera trapping confirmed the herbivorous feral rabbit and Quokka are present. Survey and dietary analysis through faecal examination revealed contrasting diets and implicates native rather than feral species as responsible for impacts on dicotyledonous species and in particular, those of conservation significance (Rathbone and Barrett 2017).

Quokkas are highly abundant throughout the Montane heath and thicket favouring leaves and stems (Hayward 2005). A study on browsing impacts of at least six species of conservation significance, including *B. anatona, B. montana, Leucopogon gnaphalioides, Darwinia collina, Latrobea colophona* and *Persoonia micranthera* found that the rabbits are less abundant than quokkas.

For plant species with critically low population numbers, the impact of browsing poses a threat to population persistence and undermines investment in other conservation recovery actions (Rathbone *et al*. 2016). In addition, browsing by quokkas, as well as grazing by rabbits, reduces cover and increases soil exposure thereby creating environmental conditions more conducive to plant disease.

Disturbance from recreational activities

The Ridge Walk traverses several occurrences of the community. Negative impacts that result from recreational activity include braiding of paths (particularly Bluff Knoll and East Bluff), erosion, bare-ground occurrences, camp-fire remains, litter and nutrient enrichment of soils and introduction or spread of different isolates of *P. cinnamomi*. Side paths have formed on the summit of Bluff Knoll where people have explored or accessed

viewing points. The paths in the Montane heath and thicket community are particularly at risk of track erosion where they run across the contour lines, due to erodible soils and steep inclines. There are scattered bare ground occurrences and fire places along the ridge walk. These impacts tend to be concentrated in saddle areas adjacent to the community but impacts also occur within the community on ridge-lines and summit areas.

322 b. What its expected effects are in the future. Include or reference supporting research or information.

- Barrett *et al.* 2018 state *"*The impact of the plant pathogen *P. cinnamomi* and the fungicide phosphite on species assemblages, richness, abundance and vegetation structure was quantified at three sites in Kwongan communities in the Southwest Australian Floristic Region."… "Healthy and diseased vegetation treated with phosphite over 7–16 years was compared with non-treated healthy and diseased vegetation. After site differences, disease had the greatest effect on species assemblages, species richness and richness within families. Disease significantly reduced cover in the upper and lower shrub layers and increased sedge and bare ground cover. Seventeen of 21 species assessed from the families Ericaceae, Fabaceae, Myrtaceae and Proteaceae were significantly less abundant in non-treated diseased vegetation. In diseased habitats, phosphite treatment significantly reduced the loss of shrub cover and reduced bare ground and sedge cover."
- "Aerial spraying of the fungicide phosphite to increase resistance of susceptible species to infection by *P. cinnamomi* began in 1997. Some 52 ha are sprayed annually to biennially at 12-24 kg/ha in eight targets. The effectiveness of disease control has shown some variability between and within sites and with season. The reasons for this variability are not well understood and there has only been limited sampling of in-planta phosphite levels due to costs and access to analysis. There has been only limited use of controls to compare survival of susceptible species in sprayed and non-sprayed habitat (Barrett 2003). The abundance and diversity of susceptible species remains higher within long-term sprayed targets compared with non-sprayed areas although this has not been well quantified. Overall, the decline of susceptible obligate seeding species has been slowed by phosphite application (Keith *et al*. 2014) and this has 'bought time' for other conservation measures including ex-situ conservation."
- Long term monitoring of *P. cinnamomi* susceptible defining species of the Montane heath and thicket in the last two decades has shown a 35% decline in the number of populations of these species (Barrett and Yates 2015). The severity of this decline is further emphasized where long term monitoring of plants in individual populations has been undertaken showing a mean decline of 83% in the number of plants within populations. Population extinctions have been recorded for eight species from the community (Barrett and Yates 2015).

322 c. Identify whether the threat only affects certain portions or occurrences. Give Details.

Dieback infection is widespread and causing extreme impacts (Fig. 1). Regenerating seedlings of many species are killed by dieback. Many flora species in the community are obligate seeders and require sufficient time between fires to produce seed.

33. Identify any natural catastrophic event/s

Explain its likely impact and indicate the likelihood of it occurring (e.g. a drought/fire in the area every 100 years). Catastrophic events are those with a low predictability that are likely to severely affect the ecological community.

Climate models for southern WA predict warmer temperatures and a significant reduction in rainfall. This may result in loss of vegetation due to changes in the hydrological regime from a decline in rainfall, as well as more extreme fire behaviour, the result of higher temperatures and a greater number of severe fire danger days.

The incidence of more frequent and intense fires is likely. Major fires can occur any time and have potential for major impacts to the structure of the community, increasing weed invasion.

34. Additional biological characteristics

Identify and explain any additional biological characteristics particular to the community or species within it that are threatening to its survival (e.g. low genetic diversity). Identify and explain any models addressing survival or particular features.

Many characteristic species in the community are either susceptible or highly susceptible to *Phytophthora* species (Barrett *et al.* 2008; Shearer *et al.* 2013). These include *Banksia solandri, Banksia montana, Banksia concinna, Banksia oreophila, Lambertia uniflora, Andersonia axilliflora, Andersonia echinocephala, Leucopogon gnaphalioides, Latrobea colophona, Isopogon latifolius; Darwinia collina, Persoonia micranthera* and *Gastrolobium*

leakeanum. For many of these species, samples taken from stressed plants in the community have returned positive results (Barrett 1996).

34 a. How does it respond to disturbance?

The community recovers from occasional fire, but too frequent fire can result in loss of fire-sensitive species. Fire results in an increase in grazing pressure by native and feral animals, and compounds the impacts of *Phytophthora* dieback disease.

344 b. How long does it take to regenerate and/or recover?

Most of the component species are killed by fire and rely on seeds to regenerate. As a consequence, fire intervals are particularly important for the dynamics and persistence of the community. In the Montane heath and thicket community, 71% of species are non-resprouters and of these 22% are serotinous (Barrett *et al*. 2009) rendering the community highly vulnerable to fire interval-dependant effects. For non-resprouting species, minimum fire intervals may be defined by a reproductive threshold at which the 50% of the population has reached reproductive maturity (Burrows *et al.* 2008; Gosper *et al.* 2013). The minimum time to at least 50% reproduction varies between 5 and 13 years for common and threatened non-resprouting species (Barrett and Yates 2015).

Using a more conservative estimate based on 2× minimum time to at least 50% of the population being reproductive, the range in minimum fire interval for the community varies between 10 and 26 years (Barrett and Yates 2015). Additionally, measurements of growth for a dominant overstory species*, K. montana*, indicate that it may take at least 30 years for the community to recover maximum height structure following fire (Keith *et al*. 2014).

Fire may also interact with *P. cinnamomi* to increase disease impact and accelerate the collapse of obligate seeding populations of Proteaceae (Moore *et al.* 2015). The species most susceptible to fire-related decline (serotinous non-sprouting species in Proteaceae) are coincidentally the species most susceptible to the pathogen (Barrett and Yates 2015). Estimates of the density of this group of species in the four fire histories where the pathogen is present show they are most abundant in areas that have not been burnt since at least 1972 and lowest in areas that have experienced the most fire (Barrett and Yates 2015). Minimal recruitment of serotinous Proteaceae occurred in areas burnt in 1991 and 2000.

Threat Abatement and Recovery

35. Identify key management documentation available for the ecological community, e.g. recovery plans, biodiversity management programmes, or site specific management plans (e.g. for a reserve).

- Department of Parks and Wildlife (2016). 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 2016-2021 for Interim Recovery Plan No. 370. Perth.
- Stirling Range and Porongurup National Parks management Plan 199-2009 Management Plan No. 42.
- Corporate Policy Statement No. 3. Management of Phytophthora disease August 2015.
- Information Sheet 8 / 2009 Science Division. Phytophthora Dieback – detecting the pathogen by Mike Stukely, DEC Science Division. http://www.cpsm-phytophthora.org/
- Quokka (*Setonix brachyurus*) Recovery Plan Western Australian Wildlife Management Program No. 56 2015, Department of Environment and Conservation.
- *Draft* Recovery Plan for the Threatened Invertebrates of the Stirling Range National Park (2014). DBCA Albany.
- Department of the Environment (2014). Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/threat-abatement-plans/approved In effect under the EPBC Act from 31 January 2014.
- Department of the Environment (2014). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/threat-abatement-plans/approved In effect under the EPBC Act from 31 January 2014.

36. Give an overview of how threats are being/potentially abated and other recovery actions underway and/or proposed. Identify who is undertaking these activities and how successful the activities have been to date.

Occurrences of the ecosystem have been treated with the chemical phosphite since the early 1990s to mitigate symptoms of the disease, and on ground observations indicate that the rate of plant deaths associated with impacts of the disease have declined since then.

Key measures required to mitigate risks to the community include management of *Phytophthora* dieback disease, minimising the impacts from sources other than climatic drying, and managing fire and grazing. The lands on which the community occurs are all within managed national park, and require continued resourcing.

37. What portion of the current extent of the ecological community is protected in a reserve set aside for conservation purposes, and what proportions are private land, or other tenure? Give details including the name of the reserves, and the extent the ecological community is protected within these reserves.

The entire extent of the Montane heath and thicket community occurs within the Stirling Range National Park, vested in the Conservation Commission of WA (CCWA) managed by the Department of Biodiversity, Conservation and Attractions for the purposes of national park.

378 a. Which of the reserves are actively managed?
Note which, if any, reserves have management plans and if they are being implemented.

All occurrences occur on lands managed by Parks and Wildlife Service, South Coast Region, Department of Biodiversity, Conservation and Attractions.

378 b. Give details of any other forms of protection, such as conservation covenants, and whether the protection mechanisms are permanent.

Tenure: A Class Crown reserve (National Park).

378 c. Indigenous interests
Is the nominated ecological community or parts thereof known to occur on any culturally significant sites? If so comment on any issues with respect to aboriginal interests, in particular with regard to management of the ecological community.

An Aboriginal Sites Register is kept by the Department of Aboriginal Affairs and lists one artifact/scatter site within the vicinity of the occurrences. Actions identify the intention to continue liaison with relevant groups, including Indigenous groups. Traditional Owner Group: Minang.

378 d. Native Title
Do Native Title or Indigenous Protected Areas apply to any parts of the community? If so comment on any issues with respect to exclusive possession and rights to plants and animals, in particular with regard to management of the ecological community.

39. Give details of recovery actions that are or could be carried out at the local and regional level, e.g. develop and implement management plan for the control of specific weed species (regional), undertake weeding of known sites (local).

Assistance with resourcing of major actions including phosphite programs, and monitoring.

40. Is there an existing support network for the ecological community that facilitates recovery? e.g. an active Landcare group, Conservation Management Network.

The department's Albany District is largely responsible for initiating and guiding actions and securing funds, in liaison with the Albany District Threatened Flora and Communities Recovery Team. Team members include community members, representatives from land care groups, scientific experts and researchers in the fields of conservation biology, botany, ecology. Reports are prepared by the department annually and include review of progress of the recovery plan, implementation of recovery actions and results of analysis of monitoring within an

adaptive management framework. Volunteers (including indigenous Green Rangers) and recovery team members assist in a diverse range of on ground activities, including survey, monitoring and fencing.

41. Describe methods for identifying the ecological community including when to conduct surveys.

For example, season, time of day, weather conditions; length, intensity and pattern of search effort; and limitations and expert acceptance; recommended methods; survey-effort guide. Include references.

The threatened ecological community is found at altitudes of approximately 900 to 1090 m above sea level however extending to lower altitudes of ~750m in two occurrences. Conditions are distinctively montane; with skeletal soils on quartzite, extremes of temperatures, high humidity and exposure, and occasional snowfalls. Several endemic and characteristic species within the community and the near absence of Eucalyptus species differentiate it from other plant communities in the Stirling Range.

A characteristic endemic species indicative of its distribution is *Andersonia axilliflora*, which is or was an abundant and dominant member of the community. Using *A. axilliflora* as an indicator, the community extends from the eastern limit of the Stirling Range, Ellen Peak (1012m), in four more or less continuous occurrences connected by downslope plant communities, to Coyanarup Peak (1045m) with a separate occurrence on the summit area of Mt Success (750m).

42. Are there other any aspects relating to the survival of this ecological community that you would like to address?

Significant investment has been made into the conservation actions for the Montane heath and thicket community. Threat mitigation includes the application of the fungicide phosphite to mitigate *Phytophthora* dieback and ex-situ conservation strategies including seed collection, germplasm storage and threatened flora translocations (and restocking) and revegetation/rehabilitation.

Section 3 - Justification for this nomination

In order for the nomination to be considered further, one or preferably more of the following criteria need to be fulfilled and substantiated. A clear case for why the ecological community is eligible for listing under the criteria is required, including evidence as to how it meets the requirements for listing under a particular listing category, e.g. 'David *et al*. (1999) finding of 95% decline in geographic distribution suggests it should be listed as critically endangered'. The type of data available will determine which criteria will be used to justify the application of a listing category.
At least one criterion must trigger the thresholds of a listing category as indicated in the Attachment. Criteria may be of different levels of listing category e.g. Criterion 1 = CR and Criterion 3 = VU.

43. Provide data that demonstrates why the ecological community meets at least one of the following criteria for the nominated listing category.

Please use data provided in previous sections to demonstrate how it specifically meets at least one of the following criteria. Advice on how to interpret the listing criteria is in Attachment A. Provide a response for every sub-criterion.

Criterion A: Reduction in geographic distribution.

Criterion A	
☐ CR ☐ EN ☐ VU ☒ not eligible	☐ **A1** ☐ **A2a** ☐ **A2b** ☐ **A3**

Justification for assessment under Criterion A:

For criteria A and B, the ecosystem was assumed to collapse when the mapped distribution declines to zero.

The steep terrain and skeletal rocky soils of the Stirling Range make it unsuitable for agriculture and have ensured no clearing of the community. As a consequence there has been no reduction in the geographic distribution of the ecosystem over the past 50 years and the status of the community under Criterion A1 is not threatened. There is no threat of land clearing to the community in the next 50 years and although the precise boundaries of the ecosystem in 1750 are unknown they are unlikely to have changed. The status of the community is therefore not threatened under Criterion A2 and A3.

Does not meet Criterion A.

Criterion B: Restricted geographic distribution.

Criterion B	
☒ CR ☐ EN ☐ VU ☐ not eligible	☒ **B1** (specify at least one of the following) ☐ **a)(i)** ☐ **a)(ii)** ☒ **a)(iii)** ☒ **b)** ☒ **c);** ☒ **B2** (specify at least one of the following) ☐ **a)(i)** ☐ **a)(ii)** ☒ **a)(iii)** ☒ **b)** ☒ **c);** ☐ **B3** (only for Vulnerable Listing)

Justification for assessment under Criterion B:

B1: The extent of a minimum convex polygon enclosing the Montane heath and thicket community is 19.2km^2 (≤2,000km^2, which is less than the threshold for CR) (Figure 1).

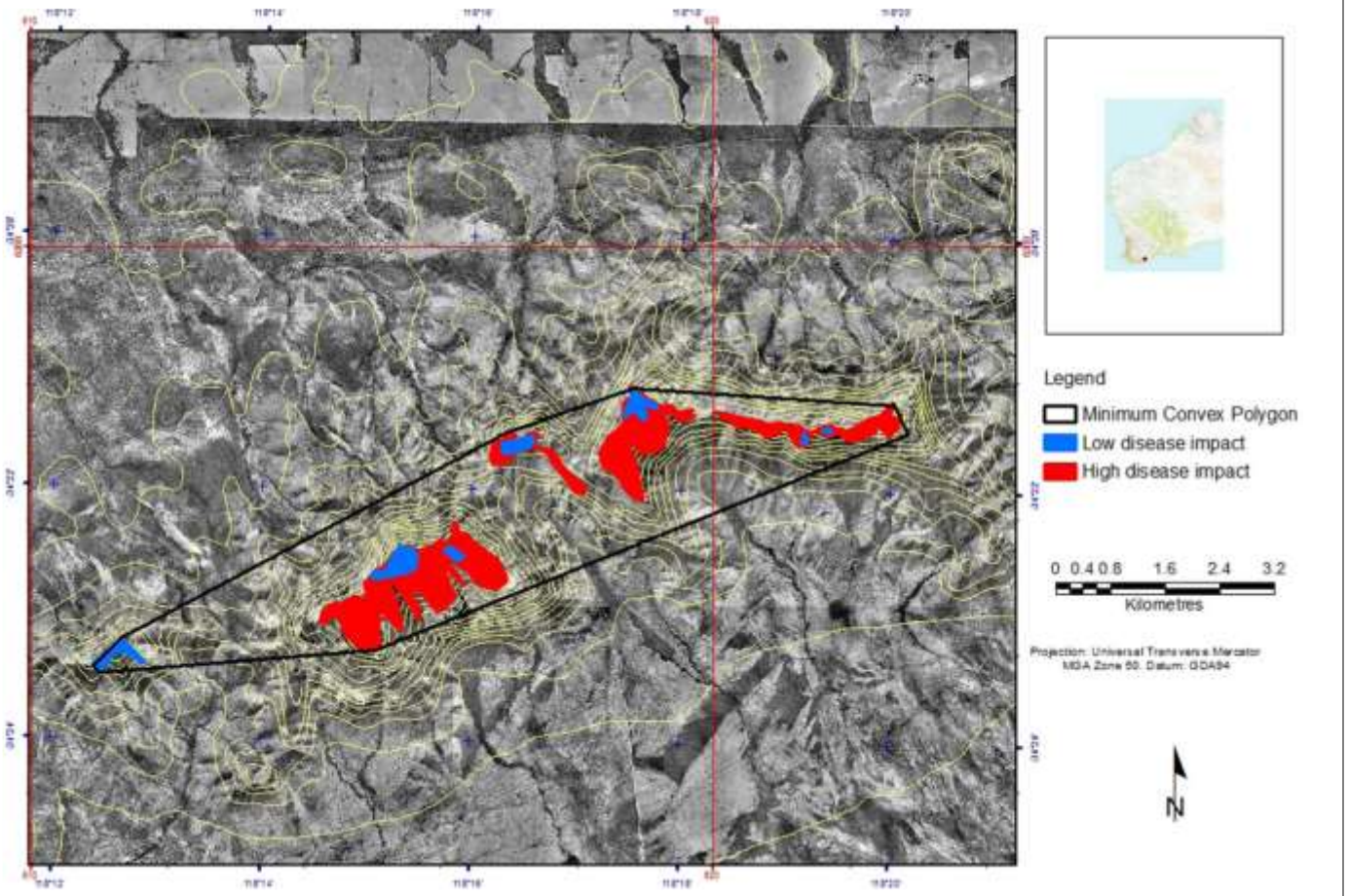


Figure 1. Area of occupancy of Montane Heath and Thicket of the Eastern Stirling Range showing degree of impact of *Phytphthora cinnamomi*.

B2: The Montane heath and thicket community is estimated to occupy two 10 × 10km square grid cells (threshold for EN is 20 and for CR is two grid cells).

a): Long-term monitoring and historical sources demonstrate continuing decline in characteristic and functionally important plant species due to *P. cinnamomi* infestation and provide evidence of disruption to biotic interactions appropriate to the characteristic biota of the community. **Meets CR B1a(iii), B2a(iii)**.

b): Observed threatening processes (*Phytophthora* dieback, particularly in combination with bush fire) will continue to cause declines in the characteristic biota of the community within the next 20 years. The impacts of *P. cinnamomi* are assessed in more detail using criterion D below. **Meets CR B1b, B2b**.

c): Ecosystem exists at one threat-defined locations based on the distance between occurrences, topography and presence of continuous vegetation in-between, and the potential spread of dieback disease and fire (threshold for CR is one and for EN is five threat-defined locations). **Meets CR B1c, B2c**.

B3: The community is geographically restricted to nine mountain peaks in a 12.5 km × 2 km area of the eastern Stirling Range, but these are more or less contiguous and connected by downslope plant communities which are fire prone. The community is therefore estimated to occupy effectively one location that is prone to stochastic disturbances such as fires which can have a substantial impact if intervals are shorter than the time necessary for seed banks to re-establish. All occurrences are likely to burn to varying degrees in one event as happened in fires that occurred in 1972, 1991 and 2000, and in May 2018 where 86% of the community was burnt between Isongerup and Bluff Knoll (over ~4 km). The 2019 fire is likely to have burnt the areas of the community that were not burnt in 2018. Therefore, the community is capable of collapse or becoming CR within a very short time period (meets VU as <5 threat defied locations). **Meets criterion VU B3**

Meets CR under criteria B1a(iii),b,c, B2a(iii),b,c

Criterion C: Environmental degradation based on change in an abiotic variable.

Criterion C	
☐ CR ☐ EN ☐ VU ☒ not eligible	☐ **C1** ☐ **C2** ☐ **C3**

Full explanation for Criterion C:

Fire is a recurrent disturbance process in the Montane Heath and Thicket community. It is well recognized that particular combinations of plant traits render some species vulnerable to certain fire regimes, especially variations in fire interval (Bond & van Wilgen 1996; Keith *et al*. 2007; Gosper *et al*. 2013). Large departures from historical fire intervals can cause substantial changes to community composition (Pausas 1999; Pausas & Lloret 2007). Plants which are typically killed by complete canopy scorch (non-resprouters) and which store their seed in persistent fruits on the canopy (serotinous) are most vulnerable to fire interval related decline (Bond & van Wilgen 1996). In the Montane Heath and Thicket community 71% of species are non-resprouters and of these 22% are serotinous (Barrett *et al*. 2009) rendering the community highly vulnerable to fire interval-dependent effects (Bond & van Wilgen 1996). Minimum fire intervals may be defined through estimates of the reproductive potential of the slowest maturing non-resprouting species in the community (Bradstock & Kenny 2003; Gosper *et al*. 2013). For the Montane Heath and Thicket, the minimum time to at least 50% of the population being reproductive varies between 5 and 13 years for non-resprouting species in the community. Using a more conservative estimate based on 2× minimum time to at least 50% of the population being reproductive, the range in minimum fire interval for the community varies between 10 and 26 years (Barrett &Yates 2015). Additionally, measurements of growth for a dominant overstorey species, *K. montana*, indicate that it may take at least 30 years for the community to recover maximum height structure following fire (Keith *et al.* 2014). Approximately 5% of the community has remained unburnt since at least 1972, 2% was last burnt in 1991, 74% was burnt in both 2000 and 1991, and 19% was burnt in 2000 but not 1991. As a consequence, over the last 50 years, a large proportion of the community has experienced a fire interval of 9 years which is at the lower – mid bounds of thresholds of collapse for characteristic non-sprouting species in the community. The relative severity of a 9 year fire interval using the two different methods of calculating thresholds for collapse was $100 \times (13 - 9)/13 - 5) = 44\%$ and $100 \times (26 - 9)/(26 - 10) \geq 100\%$. In the last 50 years two fires have burnt 74% of the community with a relative severity of 44% (vulnerable) or >100% (endangered). However, fire may also increase the susceptibility of the community to biotic threats including *Phytophthora* dieback (see Criterion D) and the severity of fire impacts needs to be considered in this context. The species most susceptible to fire related decline (serotinous non-resprouting species in Proteaceae) are coincidentally the species most susceptible to the pathogen. Estimates of the density of this group of species in the four fire histories when the pathogen has been present show they are most abundant in areas that have not been burnt since at least 1972 and lowest in areas that have experienced the most fire. The consensus among global climate models is that temperature will increase and rainfall will continue to decline in southwestern Western Australia (CSIRO 2007; Bates *et al*. 2008) with an increased frequency of extreme fire weather days (Williams *et al.* 2009). As a consequence, the risk of fire return intervals below the threshold for the community is likely to increase. Projected increases in temperature may also negatively affect component species. Investigations of temperature and seed germination for selected species from the Montane Heath and Thicket show a negative relationship between increasing mean temperature and germination (Cochrane *et al.* 2009).

In the future, given its mountain-top location, climate change may threaten the future persistence of the Montane Heath and Thicket community through its effects on temperature, moisture and fire regimes. However, there is currently insufficient evidence available to support an inference that the community meets the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50-year

period to meet VU under C1 and C2; or meets the minimum thresholds for proportion of the extent (≥50%) or proportional severity of disruption of abiotic processes (≥50%) since 1750 to meet VU under C3.

Insufficient evidence to indicate community meets criterion C.

Criterion D: Disruption of biotic processes or interactions based on change in a biotic variable.

Criterion D	
☒ CR ☐ EN ☐ VU ☐ not eligible	☒ **D1** ☒ **D2** ☐ **D3**

Justification for assessment under Criterion D:

D1, D2, D3: The most significant biotic variable affecting the community is considered to be the changes in floristic composition as a result of dieback disease. In the last three decades the entire community has been infested by *P. cinnamomi* to varying degrees, and only small remnants of the community remain relatively intact in terms of species composition (Barrett 1996). Current mapping of the Montane Heath and Thicket community shows that 48 of 334 ha (14%) of the total historic distribution of the community remains relatively intact in terms of species composition. The entire eastern Stirling Range has been infected by *P. cinnamomi* to some degree, but small remnants of the Montane Heath and Thicket may be dieback-free due to their location. Investigations of disease progress in juvenile plants of defining Montane and Heath Thicket Shrub species indicate that many species are highly susceptible to the pathogen (Barrett *et al*. 2008; Shearer *et al*. 2013). For example, Kmax (%) the asymptote of a logistic mortality curve for inoculated plants were as follows *B. brownii* (100%); *L. gnaphalioides* (100%); *I. latifolius* (95%); *L. fairallii* (95%); *B. solandri* (85%); *A. echinocephala* (75%); *D. collina* (75%); *B. concinna* (70%); *P. micranthera* (70%); *G. leakeanum* (60%); *B. montana* (55%); *B. oreophila* (50%), *K. montana* (25%) (Barrett *et al*. 2008; Shearer *et al*. 2013). For many of these species, sampling for *Phytophthora* spp. in stressed plants in the community has returned positive results (Barrett 1996).

Systematically collected time series data on the impacts of *P. cinnamomi* on the Montane Heath and Thicket are not available but published surveys of floristic composition and cover, and historical photography indicate the impact on defining species has been severe. The changes are most evident in (but not restricted to) the decline of species of Proteaceae that were dominant in the thicket (Keith *et al*. 2014). In 1965 there were healthy stands of *B. brownii* on the summit of Bluff Knoll. In the period 1985–1989, *B. brownii, B. solandri* and *I. latifolius* were recorded as common and dominant shrubs in the thicket on the Bluff Knoll plateau with species being assigned a qualitative cover score covering a range of 1–20% (Pignatti *et al*. 1993). Monitoring since 1994 has not detected these three species on Bluff Knoll and these populations are presumed to be locally extinct (Barrett 1996; Barrett and Yates 2015 Figure 2b). Similarly, *B. montana* which was locally common on parts of Bluff Knoll in 1980, is now extremely rare (Barrett and Yates 2015; Figures 3a and b). Long-term monitoring of *P. cinnamomi* susceptible defining species of the Montane Heath and Thicket in the last two decades shows a 34% decline in the number of populations (Table 2). The severity of this decline is further emphasized where long-term monitoring of plants in individual populations has been undertaken showing a mean decline of 83% in the number of plants within remaining populations (Table 3). This equates to a (0.34 × 100) + (0.66 × 83) = 88% decline in the abundance of defining shrubs. The minimum estimate for the relative severity of decline in the abundance of defining shrubs in the community through *P. cinnamomi* is 100 × (88 − 0)/(90 − 0) = 98% and the maximum estimate is 100 × (88 − 0)/(100 − 0) = 88%. As discussed for criteria C the *Phytophthora* impacts on the Montane Heath and Thicket need to be considered in the context of fire history. Photographs following the 1991 fire show the dead stems of the banksias in the recovering thicket on Bluff Knoll, indicating their high pre-fire densities. Furthermore, long-term monitoring of *B. brownii* and *L. fairallii* populations in the community on the nearby peak Mount Success, suggests that *P. cinnamomi* and fire act synergistically to accelerate the collapse of obligate seeding populations of Proteaceae with severe impacts and local extirpation of populations. The infestation of *P. cinnamomi* has caused a reorganization of the Montane Heath and Thicket into a compositionally new entity which is unable to sustain key component plant species across 86% of the community's range with between 88 and 98% relative severity. The community therefore meets CR under criterion D1.

There are currently no techniques available for eliminating *P. cinnamomi* from the Montane Heath and Thicket community. The status of the community is therefore unlikely to change in the foreseeable future and based on this it is predicted to remain CR under criterion D2b.

There is inadequate evidence to indicate the community meets the minimum proportion of the extent (≥50%) or proportional severity of disruption of biotic processes (≥50%) since 1750 to meet VU under criterion D3.

Meets CR under criteria D1, D2b

Criterion E: Quantitative analysis that estimates the probability of ecosystem collapse.

Criterion E	
☐ CR ☐ EN ☐ VU ☒ not eligible	

Justification for assessment under Criterion E:

The ecosystem could not be assessed under Criterion E as no quantitative estimates of the risk of ecosystem collapse have been completed. In addition, an assessment of Criterion E would not affect the overall status of the community because recent impacts and ongoing threats have been severe. For each of the selected criteria, the community was assessed in terms of current impact, historic impact since 1750 and future impact over the next 50 years, depending on available information.

Section 4 – References/Standard of Scientific Evidence/Critical habitat

Note: The opinion of appropriate scientific experts may be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and full contact details must also be provided in the reference list below. Harvard style of referencing is preferred.

44. Please provide copies of key documentation/references used in the nomination.

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45. Statement on the Standard of Scientific Evidence

Published data on the Montane thicket and heath community was sufficient to apply the Red List of Ecosystem criteria, although there are likely to be inaccuracies in various aspects of the assessment. However, the outcomes of the assessment are robust.

46. Has this document been reviewed and/or have relevant experts been consulted?
If so, indicate by whom and provide their contact details.

The data used in ranking were taken from the peer reviewed publication Barrett and Yates (2015) Risks to a mountain summit community with endemic biota in southwestern Australia. A draft of this nomination was provided to Regional DBCA staff for comment.

Principal Ecologist, DBCA Species and Communities Program

47. Do you wish to propose any areas of habitat for consideration as Critical Habitat for the nominated community?
If so, refer to Ministerial Guideline No 5 and attached a separate nomination proposal addressing the matters required under that guideline. Indicate location/s including a map, and attached shapefiles.

Section 5 - Nominator Details & Declaration	
48. Contact Details Note: Nominator details are subject to the provision of the *Privacy Act 1988*	
Title/Full Name	[redacted]
Organisation or Company name	Department of Biodiversity, Conservation and Attractions
Postal address	17 Dick Perry Avenue, Kensington Post: Locked Bag 104, Bentley Delivery Centre, WA 6983.
Email	[redacted]@dbca.wa.gov.au
Phone	[redacted]
Fax	
49. Declaration	
Signature (Or insert electronic signature)	***I declare that the information in this nomination form and any attachments is true and correct to the best of my knowledge.***
Date signed	

Table 1: Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Available data do not indicate community meets criterion
A2a	-	• Available data do not indicate community meets criterion
A2b	-	• Available data do not indicate community meets criterion
A3	-	• Available data do not indicate community meets criterion
B1a	CR	• EOO is ≤2,000km^2 • Long-term monitoring demonstrates measures of continuing decline in characteristic biota due to *P. cinnamomi* infestation. • Meets CR under criterion B1a(iii)
B1b	CR	• EOO is ≤2,000km^2 • Observed continuing decline from impacts from *Phytophthora* dieback; fire and drying and warming climate • Meets CR under criterion B1b
B1c	CR	• EOO is ≤2,000km^2 • Ecosystem exists at one threat defined location based on the potential impact of fire • Meets CR under criterion B1c
B2a	CR	• AOO is two grid cells • Long-term monitoring and historical sources demonstrate measures of continuing decline in characteristic and functionally important plant species due to *P. cinnamomi* infestation, and provide evidence of disruption to biotic interactions appropriate to the characteristic biota of the community. • Meets CR under criterion B2a(iii)
B2b	CR	• AOO is two grid cells • Observed continuing decline from impacts of dieback, fire and drying and warming climate.

		• Meets CR under criterion B2b
B2c	CR	• AOO is two grid cells • Ecosystem exists at one threat-defined location based on the potential impact of fire • Meets CR under criterion B2c
B3	VU	• Known from one threat-defined location • Prone to the effects resulting from dieback disease, fire and drying and warming climate • Meets criterion for VU
C1	-	• Does not meet the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over past 50 years to meet VU.
C2	-	• Does not meet the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50-year period to meet VU.
C3	-	• Does not meet the minimum thresholds for proportion of the extent (≥50%) or proportional severity of disruption of abiotic processes (≥50%) since European settlement (1750) to meet VU.
D1	CR	• *P. cinnamomi* has caused compositional change and disruption to key component plant species over more than 80% of the community's range with ~88 and 98% relative severity. • Therefore meets the threshold for proportion of the extent (≥80%) or proportional severity of disruption of biotic processes (≥80%) over past 50 years. • Meets CR under criterion D1.
D2	CR	• The status of the community is unlikely to change in the foreseeable future as there is no known treatment to eliminate *P. cinnamomi.* • Therefore meets the threshold for proportion of the extent (≥80%) or proportional severity of disruption of biotic processes (≥80%) over any 50-year period. • Meets CR under criterion D2b.
D3	-	• Does not meet the minimum thresholds for proportion of the extent (≥50%) or proportional severity of disruption of biotic processes (≥50%) since European settlement (1750) to meet VU.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Plausibly meets CR under B1a(iii),b,c, B2a(iii),b,c; D1, D2b. Meets VU under B3. *'The highest risk category obtained by any of the assessed criteria will be the overall risk status of the ecosystem'* (IUCN RLE Guidelines V1.1 page 42). **Meets CR under B1a(iii),b,c, B2a(iii),b,c; D1, D2b.**

Section 6 – Completed nomination form checklist

Please check all items on this list have been completed or are included with your nomination.

- ☐ I have read and applied the further information and guidelines for completing this nomination form in Attachment A
- ☐ Nominator details including name, address contact phone number included
- ☐ Name of the EC
- ☐ Any other names it is known by
- ☐ Map included or attached
- ☐ References cited
- ☐ If questions are left unanswered, a statement indicating that insufficient information is available

A description of:

- ☐ Biological components of the ecological community
- ☐ Non biological components of the ecological community
- ☐ Key interactions and functional processes
- ☐ Characters distinguishing it from other ecological communities
- ☐ Key species (dominant, characteristic or diagnostic, threatened etc)
- ☐ Known or estimated current extent of the ecological community
- ☐ Past/current/future threats including actual/potential, how/ where, how being/how could be abated
- ☐ Which listing category/categories it should be listed under and why

How to lodge your nomination

Completed nominations may be lodged either:

1. by email to: **communities.data@dbca.wa.gov.au**

If submitting by email, please also mail hard copies of attachments that cannot be emailed.

OR

2. by mail to: Species and Communities Branch
Department of Biodiversity, Conservation and Attractions, WA Government
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

If submitting by mail, please include an electronic copy on memory stick or CD.

Appendix 1: Flora taxa that commonly occur in the Montane heath and thicket community

Anarthriaceae	*Melaleuca thymoides*
Anarthria prolifera	*Hypocalymma myrtifolium*
Cyperaceae	*Kunzea montana*
Tetraria sp. Jarrah Forest (R. Davis 7391)	*Taxandria floribunda*
Lepidosperma sp. Bluff Knoll robust (GJK 12595)	*Taxandria parviceps*
Schoenus efoliatus	**Proteaeceae**
Dasypogonaceae	*Adenanthos filifolius*
Kingia australis	*Banksia solandri*
Hemerocallidaceae	*Banksia brownii*
Stypandra glauca	*Banksia oreophila*
Poaceae	*Banksia montana*
Amphipogon laguroides subsp. *laguroides*	*Banksia concinna*
Deyeuxia drummondii	*Banksia formosa*
Rhytidosperma caespitosa	*Banksia grandis*
Restionaceae	*Hakea florida*
Desmocladus flexuosus	*Persoonia micranthera*
Orchidaceae	*Isopogon latifolius*
Cryptostylis ovata	*Lambertia uniflora*
Thelymitra graminea	**Lamiaceae**
Apiaceae	*Microcorys* sp. Stirling Range (S Barrett 1392)
Actinotus rhomboideus	**Lauraceae**
Xanthosia rotundifolia	*Cassytha glabella*
Platysace sp. Stirling Range	**Pittosporaceae**
Asteraceae	*Billardiera drummondii*
Xerochrysum bracteatum	**Rubiaceae**
Droseraceae	*Opercularia nubicola*
Drosera huegelii var philmanniana	**Rutaceae**
Drosera monticola	*Boronia crenulata* var. *viminea*
Ericaceae	*Boronia spathulata*
Andersonia axilliflora	*Muiriantha hassellii*
Andersonia echinocephala	**Santalaceae**
Lysinema fimbriatum	*Leptomeria squarrulosa*
Dielsiodoxa tamariscina	**Stylidiaceae**
Leucopogon gnaphalioides	*Levenhookia pusilla*
Leucopogon interstans	*Stylidium bellum*
Leucopogon atherolepis	*Stylidium diversifolium*
Sphenotoma drummondii	*Stylidium keigheryi*
Sphenotoma sp. Stirling Range	*Stylidium rosulatum*
Euphorbiaceae	*Stylidium monticola*
Amperea conferta	*Stylidium scandens*
Fabaceae	**Thymeliaceae**
Aotus genistoides	*Pimelea angustifolia*
Gastrolobium leakeanum	
Gompholobium sp. Stirling Range	
Latrobea colophona	
Goodeniaceae	
Dampiera leptoclada	
Velleia foliosa	
Mimosaceae	
Acacia drummondii subsp. *elegans*	
Myrtaceae	
Astartea montana	
Beaufortia decussata	
Beaufortia anisandra	
Calothamnus montanus	
Darwinia collina	
Darwinia squarrosa	
Darwinia nubigena	

Appendix 2: Threatened and priority flora taxa that occur in the Montane heath and thicket community

*endemic to community

Species name	WA Conservation status and rank	Conservation status (EPBC Act 1999)
Andersonia axilliflora	T* (CR)	EN
Banksia brownii	T (CR)	EN
Banksia montana	T* (CR)	EN
Darwinia collina	T* (CR)	EN
Darwinia nubigena	T (EN)	VU
Darwinia squarrosa	T (VU)	VU
Daviesia obovata	T (EN)	EN
Deyeuxia drummondii	T (VU)	EN
Lambertia fairallii	T (CR)	EN
Latrobea colophona	T (CR)	-
Leucopogon gnaphalioides	T (CR)	EN
Persoonia micranthera	T* (CR)	EN
Sphenotoma drummondii	T (EN)	EN
Dielsiodoxa tamariscinus	P2	
Gastrolobium leakeanum	P2	
Microcorys sp. Stirling Range	P2*	
Schoenus sp. Stirling	P2	
Spyridium montanum	P2	
Stylidium bellum	P2	
Stylidium keigheryi	P2*	
Stylidium oreophilum	P2	
Stylidium monticola	P2*	
Hypocalymma myrtifolium	P2	
Opercularia nubicola	P2	
Hibbertia argentea	P3	
Actinotus rhomboideus	P4	
Adenanthos filifolius	P4	
Andersonia echinocephala	P4	
Banksia concinna	P4	
Banksia solandri	P4	
Boronia crenulata var. *angustifolia*	P4	
Isopogon latifolius	P4	
Muiriantha hassellii	P4	
Platysace sp. Stirling Range	P4	
Sphenotoma sp. Stirling Range	P4	
Stylidium rosulatum	P4	

Appendix 3. Location of Montane Heath and Thicket of the Eastern Stirling Range community