Department of Biodiversity, Conservation and Attractions
GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status				
Name of ecological community:	Rimstone pools and cave structures formed by microbial activity on marine shorelines (Augusta microbialites).			
Other names:	Augusta microbial; Augusta microbialites; tufa			
Description:	The community occurs along the south-west coast near Augusta and comprises microbialites, which are structures produced through the growth and metabolic activity of benthic microbial communities. The tufa that comprise the community are microbialite structures that have a less defined internal framework that are precipitated from freshwater springs and seeps, formed through the growth and metabolic activity of a diverse variety of microbial organisms, including cyanobacteria, diatoms and other algal components. They form chemical sedimentary rock composed of calcium carbonate. These tufa have many forms including drapes, curtains, small cylindrical stalactites and larger campanulate (bell-shaped) masses on the sea cliffs, as well as fans or terraces consisting of a series of rimstone pools and nodular masses in small brackish pools.			
Nomination for:	Listing ☒	Change of status ☐	Delisting ☐	

1. *Is the ecological community currently on any conservation list, either in a State or Territory, Australia or Internationally?* 2. *Is it present in an Australian jurisdiction, but not listed?*	*Provide details of the occurrence and listing status for each jurisdiction in the following table*

Jurisdiction	**List or Act name**	**Date listed or assessed (or N/A)**	**Listing category eg. critically endangered (or none)**	**Listing criteria eg. B1ab(iii)+2ab(iii) (or none)**
National	EPBC Act	N/A	none	none
Western Australia	TEC list: WA Minister ESA list in policy	06/11/2001	Endangered	B) ii)
	Priority list	N/A	1 ☐ 2 ☐ 3 ☐ 4 ☐	
Other State/Territory		N/A	none	none

Nominated conservation status: category and criteria (include recommended status for deleted ecological communities)

Critically endangered (CR) ☐ Endangered (EN) ☒ Vulnerable (VU) ☐ Collapsed (CO) ☐

Priority 1 ☐ Priority 2 ☐ Priority 3 ☐ Priority 4 ☐ None ☐

What criteria support the conservation status category for listing as a threatened ecological community or collapsed ecological community? *Refer to Section 32 of the Biodiversity Act 2016 for definition of 'Collapsed', and Appendix 3 table 'IUCN Red List Criteria for ecosystems version 2.2'.*		**EN B1b; B2b**
Eligibility against the criteria		
*Provide justification for the nominated conservation status; is the ecological community eligible or ineligible for listing against the five criteria. For **delisting**, provide details for why the ecological community no longer meets the requirements of the current conservation status.*		
A.	Reduction in geographic distribution *(evidence of decline)*	☐ **A1** ☐ **A2a** ☐ **A2b** ☐ **A3**
	Justification of assessment under Criterion A.	• For criteria A, the ecosystem is assumed collapsed when the mapped distribution declines to zero. • Survey data from 2003 indicate that 24 occurrences were deemed inactive or dead (pers. comm. [redacted]). This represents a 6% to 27 % reduction in geographic distribution. This is thought to be an underestimate as there are a many extinct occurrences that have not yet been mapped (pers. comm. [redacted]). The reasons for loss or decline of some occurrences is not known and may include physical crushing by visitors, and natural diversions of groundwater associated with rainfall decline or other factors. • Insufficient evidence to support an inference that a ≥30% reduction in geographic distribution has or will occur over any 50-year period, or a ≥50% reduction since 1750 (ie. the minimum thresholds to meet the category VU under criterion A). • **Available evidence indicates community does not meet criterion A.**
B.	Restricted geographic distribution *(EOO and AOO, number of locations and evidence of decline)*	☒ **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 of assessment under Criterion B.	• For criteria B, the ecosystem is assumed collapsed when the mapped distribution declines to zero. • Potential additional occurrences of the community at Black Point and Frankland tufa require further survey and comparison with microbial composition of Augusta occurrences to verify. The range of EOO and AOO reflect values with and without potential additional occurrences.

		• B1: The plausible range of the EOO is 683 km^2 to 9643 km^2 (threshold for CR is ≤2 000 km^2 and the threshold for EN is ≤10000 km^2). • B2: The plausible range of AOO ranges from 7 to 11 grid cells (10 km^2). Threshold for CR is ≤2 and the threshold for EN is ≤20. • a) Inadequate data to indicate continuing decline in a measure of spatial extent, environmental quality or disruption of biotic interactions. • b) Physical crushing due to recreational activities, reductions in water flows or quality due to reduced rainfall and land use changes are the main threats to this community (pers. comm. [redacted]; Forbes *et al*. 2010). These threatening processes are likely to cause a continuing decline in the environmental quality and geographic distribution of this community within the next 20 years. • c) The plausible range of number of threat-defined locations is 8-12 based on number of clusters of occurrences that may be subject to similar threats associated with a particular aquifer. Meets VU under sub-criterion c. (threshold of threat-defined locations is ≤5 for EN and ≤10 for VU). • B3: Does not meet as >5 threat-defined locations. • Plausibly meets Critically Endangered B1b, or Endangered B1b and Endangered B2b, and Vulnerable under B1c, B2c. • **Most conservative rank Endangered B1b; B2b due to potential additional occurrences at Black Point and Frankland.**
C.	Environmental degradation of abiotic variable *(Evidence of decline over 50-year period)*	☐ **C1** ☐ **C2** ☐ **C3**
	Justification of assessment under Criterion C.	• The observed reduction in rainfall and runoff in the south west of Australia resulting in declining groundwater flows to occurrences is a significant abiotic variable affecting this community. • The ecosystem is assumed collapsed when all occurrences become inactive due to insufficient groundwater flows to sustain the microbial assemblages that form the community. • C1, C2: Groundwater discharge is likely to continue decreasing with declining rainfall. No data are available to link reduction in groundwater flows in the habitats of the community to compositional and structural changes in the microbial assemblages. • It is not possible to extrapolate a collapse point at which a particular level of rainfall or groundwater discharge will result in loss of all occurrences of the community. • No available evidence indicates if the community meets the minimum proportion of the extent (≥30%) or proportional severity of disruption of abiotic processes (≥30%) over any 50-year period to meet criteria C1 or C2.

		• C3: No available data indicate if the community meets the threshold proportion of extent (≥50%) or severity of disruption of abiotic processes (≥50%) since 1750 to meet VU. • Community is data deficient under criterion C.
D.	Disruption of biotic processes or interactions *(Evidence of decline over 50-year period)*	☐ **D1** ☐ **D2** ☐ **D3**
	Justification of assessment under Criterion D.	• Increasing nutrient levels in source spring waters from agricultural land use within the catchments have potential to impact on tufa development through encouraging excessive levels of growth of undesirable algae (Forbes *et al.* 2010). • The collapse state under this criterion is considered to be increased nutrient levels that result in high levels of undesirable algae that completely smother and inhibit accretion of tufa. • There are insufficient systematically collected monitoring data about the level of undesirable algae and their impacts on the growth of tufa to assess their level of impact on the community. • D1, D2: There are inadequate data to indicate if the community meets the minimum proportion of the extent (≥30%) or proportional severity (≥30%) over any 50-year period to meet criteria D1 or D2. • D3: Inadequate data available to indicate if the community meets the minimum proportion of the extent (≥50%) or proportional severity of disruption of biotic processes (≥50%) since 1750. • **Community is data deficient under criterion D**
E.	Quantitative analysis *(statistical probability of ecosystem collapse)*	• No quantitative estimates of the risk of ecosystem collapse. • **Not assessed**

Reasons for change of status

Genuine change ☐ New knowledge ☐ Previous mistake ☐ Review/Other ☒
Assessment of rank under the BC Act

Provide details: The community was initially ranked as Endangered using ranking criteria developed in WA that differ from those in the IUCN Red List Criteria for Ecosystems (version 2.2) that are applied under the BC Act

Summary of assessment information *(provide detailed information in the relevant sections of the nomination form)*

EOO	683.29 - 9643.82 km^2	AOO	7 - 11 (10x10km grid cell).
No. occurrences	34 - 43	Severely fragmented (justification below)	Yes ☒ No ☐ Unknown ☐

Justification of whether fragmented	This community is naturally fragmented as it occurs in isolated patches where groundwater discharge and substrate are appropriate habitat and to support the growth of the tufa assemblages	
Current known area		Plausible range 0.44 – 1.95 ha
Pre-industrialisation extent or its former known extent (if known)		Plausible range 0.56 – 2.07 ha
Estimated percentage decline		Plausible range 6 – 27%

Personal Communications:

[redacted] A/Nature Conservation Coordinator, Blackwood District, DBCA - [redacted]
[redacted] Operations Officer Nature Conservation, Blackwood District, DBCA - [redacted]

Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Available evidence indicates community does not meet criterion.
A2a	-	• Available evidence indicates community does not meet criterion.
A2b	-	• Available evidence indicates community does not meet criterion.
A3	-	• Available evidence indicates community does not meet criterion.
B1a	-	• Available evidence indicates community does not meet criterion.
B1b	CR or EN	• Plausible range of EOO is 683 km^2 to 9643 km^2. • Trampling and reduced water flows likely to cause continuing declines in environmental quality and geographic distribution within the next 20 years. • Plausible range CR to EN.
B1c	-	• Plausible range of number of threat-defined locations is 8-12. • Plausibly meets VU.
B2a	-	• Does not meet criterion.
B2b	EN	• Plausible range of AOO is 7 to 11 grid cells (10 km^2). • Trampling and reduced water flows are likely to cause continuing declines in environmental quality and geographic distribution within the next 20 years. • Meets criterion for EN.
B2c	-	• The plausible range of number of threat-defined locations is 7-11. • Plausibly meets VU.
B3	-	• Does not meet criterion.
C1	-	• Inadequate evidence to indicate if community meets criterion.
C2	-	• Inadequate evidence to indicate if community meets criterion.
C3	-	• Inadequate evidence to indicate if community meets criterion.
D1	-	• Inadequate evidence to indicate if community meets criterion.
D2	-	• Inadequate evidence to indicate if community meets criterion.
D3	-	• Inadequate evidence to indicate if community meets criterion.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Plausibly meets Critically Endangered B1b or Endangered B1b, and Endangered B2b. Plausibly meets Vu B1c; B2c. Additional potential occurrences at Black Point and Frankland. Most conservative and defensible rank is EN under B1b; B2b that take into account potential additional range and number of occurrences. **Conservatively meets EN under B1b; B2b.**

Summary of location (occurrence) information *(provide detailed information in the relevant sections of the nomination form)*

Occurrence	Land tenure	Survey information: date of survey	Condition	Area of occurrence (ha)	Threats *(note if past, present or future)*	Specific management actions
AUG01	Unallocated Crown Land (UCL)	2017	Unknown	0.06	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUG02	Reserve 25141 (Recreation – Shire of Augusta-Margaret River) and 50466 (Harbour purposes – Minister for Transport)	2019	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUG03	UCL, and Reserve 25141 (Recreation – Shire of Augusta-Margaret River)	2019	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUG032	UCL	2017	Unknown	0.04	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUG04	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	Track diversions implemented to reduce trampling – requires ongoing monitoring
AUG05	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	Track diversions implemented to reduce trampling – requires ongoing monitoring
AUG06	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	Track diversions implemented to reduce trampling – requires ongoing monitoring
AUG07	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Limestone instability (past, present and future)	N/A
AUG08	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Limestone instability (past, present and future)	N/A
AUG09	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	Track diversions implemented to reduce trampling – requires ongoing monitoring
AUG10	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Medium	0.01	Excessive algae growth, trampling from recreation (past, present and future)	Potential diversion to avoid trampling
AUG11	UCL	2017	Medium	< 0.01	Weed invasion and altered hydrological	N/A

					flow (past, present and future)	
AUG12	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.01	Excessive algae growth, weed invasion, and physical disturbance along shoreline (past, present and future)	Potential diversion to avoid trampling
AUG13	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Good	< 0.01	Physical disturbance and tufa crumbling (past, present and future)	Site visit is planned by district conservation officer
AUG14	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and tufa crumbling (past, present and future)	Site visit is planned by district conservation officer
AUG15	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and tufa crumbling (past, present and future)	Site visit is planned by district conservation officer
AUG16	UCL	2017	Unknown	< 0.01	Excessive algae growth (past, present and future)	Site visit is planned by district conservation officer
AUG17	UCL	2017	Unknown	< 0.01	Excessive algae growth and physical disturbance (past, present and future)	Site visit is planned by district conservation officer
AUG18	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Smothered (past, present and future)	Site visit is planned by district conservation officer
AUG19	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.01	Physical disturbance, sand and tidal movement and altered hydrological flow (past, present and future)	N/A
AUG20	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and erosion (past, present and future)	N/A
AUG21	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.03	Physical disturbance (past, present and future)	N/A
AUG22	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and erosion (past, present and future)	N/A
AUG23	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUG24	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance (past, present and future)	N/A
AUG25	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Physical disturbance, bird excretion and rocks crumbling (past, present and future)	N/A
AUG26	Reserve 8428 (Leeuwin-	2017	Unknown	< 0.01	Weed invasion (past, present and future)	N/A

	Naturaliste National Park)					
AUG27	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Good	< 0.01	Physical disturbance, weed invasion (arum lily) and erosion (past, present and future)	N/A
AUG28	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.01	Physical disturbance and limestone collapse (past, present and future)	N/A
AUG29	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Altered hydrological flow, lack of water, dead sections, erosion (past, present and future)	N/A
AUG30	Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	< 0.01	Altered hydrological flow, lack of water (past, present and future)	N/A
AUG31	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Good	0.06	Physical disturbance, limestone collapse, tidal movement (past, present and future)	Potential diversion to avoid trampling
AUGNE	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.08	Physical disturbance and altered hydrological flow (past, present and future)	N/A
AUGSE	UCL and Reserve 8428 (Leeuwin-Naturaliste National Park)	2017	Unknown	0.10	Physical disturbance and altered hydrological flow (past, present and future)	N/A
BPE01	Reserve 36996 (D' Entrecasteaux National Park)	2017	Unknown	0.97	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
BPW01	Reserve 36996 (D'Entrecasteaux National Park)	2017	Unknown	0.14	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
BPW02	Reserve 36996 (D'Entrecasteaux National Park)	2017	Unknown	0.07	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
SteppingStones	Reserve 36996 (D'Entrecasteaux National Park)	2017	Unknown	0.29	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
Fra_Aug01	Reserve 36996 (D'Entrecasteaux National Park)	2017	Unknown	0.01	Physical disturbance and altered	Requires further surveys and comparison with the

					hydrological flow (past, present and future)	Augusta Microbial TEC to confirm as additional occurrence
Fra_Aug02	Reserve 36996 (D'Entrecasteaux National Park)	2017	Unknown	0.01	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
Fra_Aug03	Reserve 31362 (Walpole-Nornalup National Park)	2017	Unknown	0.01	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
Fra_Aug04	Reserve 31362 (Walpole-Nornalup National Park)	2017	Unknown	0.01	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence
Fra_Aug05	Reserve 33842 (Quarram Nature Reserve)	2017	Unknown	0.01	Physical disturbance and altered hydrological flow (past, present and future)	Requires further surveys and comparison with the Augusta Microbial TEC to confirm as additional occurrence

Vegetation condition categories from (Keighery 1994 Vegetation Condition Scale in Government of WA 2000) are defined below. These are not directly applicable to condition of microbialites, but have been broadly applied in the location summary table above.

Good ('Pristine', 'Excellent', 'Very Good' using Bush Forever (Government of WA 2000) scale): This includes vegetation ranging from 'Pristine' - with no obvious signs of disturbance, to 'Excellent' - Vegetation structure intact, with disturbance only affecting individual species, weeds are non-aggressive species and 'Very Good' - Vegetation structure altered, obvious signs of disturbance eg: from repeated fires, dieback, logging, grazing.

Medium ('Good' using Bush Forever (Government of WA 2000) scale): This includes vegetation categorised as 'Good' - Vegetation structure altered but retains basic vegetation structure or ability to regenerate it, obvious signs of disturbance are present, from activities including partial clearing, dieback and grazing.

Poor ('Degraded' using Bush Forever (Government of WA 2000) scale): This includes vegetation ranging from 'Degraded' Basic vegetation structure severely impacted by disturbance, the vegetation requires intensive management, and disturbance such as partial clearing, dieback, logging and grazing, to 'Completely Degraded' where vegetation structure is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native shrubs and trees.

Beyond recovery ('Completely degraded' using Bush Forever (Government of WA 2000) scale): Vegetation structure is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native shrubs and trees.

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Personal Communications

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[redacted] Operations Officer Nature Conservation, Blackwood District [redacted]

APPENDIX 1 - Major threats

Physical disturbance

Tufa is chemical sedimentary rock composed of calcium carbonate precipitated from freshwater streams and springs. The Augusta microbialites (tufa) occur in near-shore shallow bedrock habitats and are associated with local groundwater discharge (Forbes *et al.* 2010). Tufa is formed through the growth and metabolic activity of a diverse variety of microbial organisms, including cyanobacteria and diatoms. Tufa structures seemingly grow and recede depending on the activity of these organisms and their production of calcium carbonate (Onton *et al.* 2009).

The habitat of the community includes areas that are popular for recreational fishing, surfing, hiking and sightseeing. Uncontrolled vehicle access has resulted in the creation of a number of tracks in sensitive areas, that has led to the degradation of coastal vegetation and wetlands (Newland 2009). The popularity of these areas has resulted in significant trampling of certain occurrences and modifications of the local hydrology (*pers. comm.* [redacted]). Tufa are slower growing in sluggish flow settings (Gradziński 2010), as is the case in the habitat of this community, and recovery is likely to be slow.

Altered hydrological flows

The flows of water that are essential to growth and survival of this community are associated with local discharge of groundwater. Disturbance around springs and stream flows including trampling of vegetation and soil disturbance may alter water flows away from the tufa and may be a serious threat (Newland 2009). Furthermore, the reduced rainfall from a drying climate are predicted to significantly reduce the water input into the local catchments (Sudmeyer *et al.* 2016).

Groundwater sources for some occurrences may include aquifers that are utilised for human water supply. Drawdown of such aquifers has potential to impact the Augusta microbial community.

Changes to water quality

Tufa morphology, texture, mineral composition and elemental chemistry vary within and between sites that have been confirmed as the Augusta microbial community (Forbes *et al*. 2010). Variations in water chemistry correlate with the elemental and mineralogical composition of the tufa identified in the lithological analysis. Specifically, CO^{3-} /HCO^{3-} concentrations need to remain at a level that is suitable to facilitate tufa accretion through calcite precipitation. A decrease in alkalinity or an increase in acidity could cause rapid undesirable consequences. Nitrogen and phosphorous concentrations need to remain at low levels to discourage excessive levels of undesirable algal growth. Increasing nutrient levels in spring waters from agricultural land use within the catchments poses a very significant threat and could in future impact on tufa development (Forbes *et al.* 2010).

Competition from macroalgae that smother the assemblages that contribute to accretion of microbialites has been reported for the thrombolites of Lake Clifton and Lake Richmond (Luu *et al.* 2004; English *et al*. 2003). Nutrient enrichment and associated impacts of undesirable algae on tufa growth and survival is a potential threat to the Augusta microbial community.

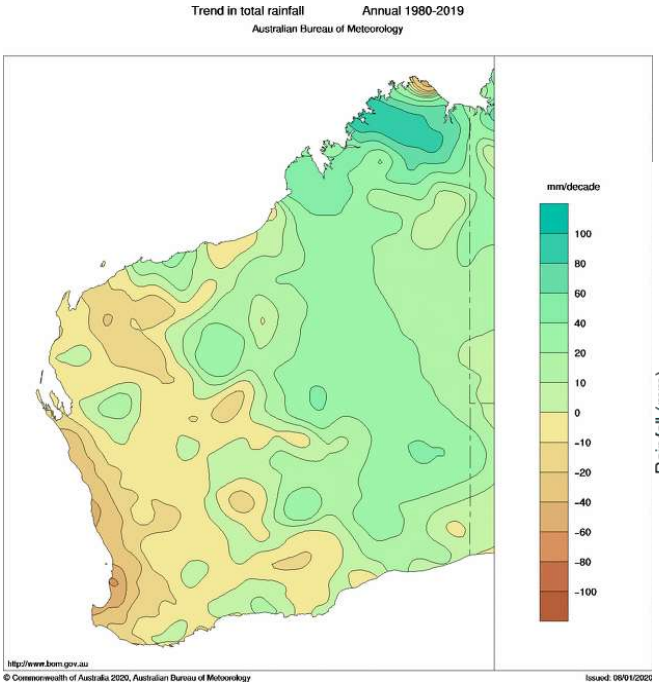
Fire in the surrounding vegetation would also result in a short-term flush of contaminants being washed into the pools and smothering the tufa. Such an event occurred following a hot fire December 2019.

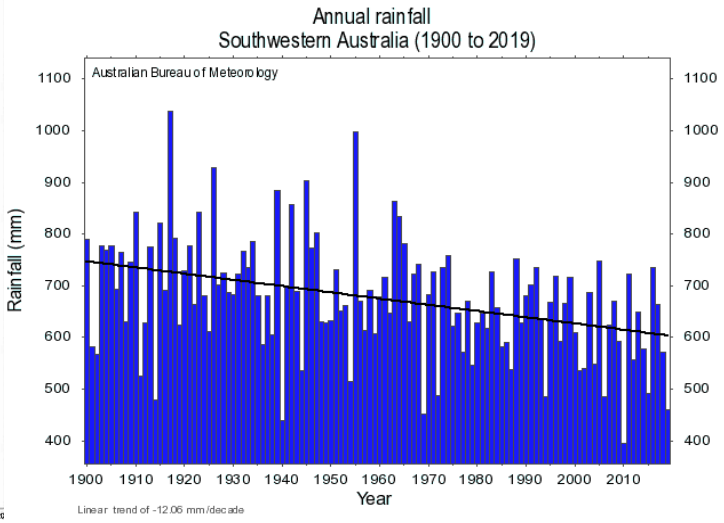
Declining rainfall

The community is at risk from declining rainfall in the south west of Western Australia. The tolerance of tufa communities to changes that may occur in association with changes in rainfall and temperatures is unknown. According to the 2016 study by Sudmeyer and colleagues, predictions for the south west of WA are as follows:

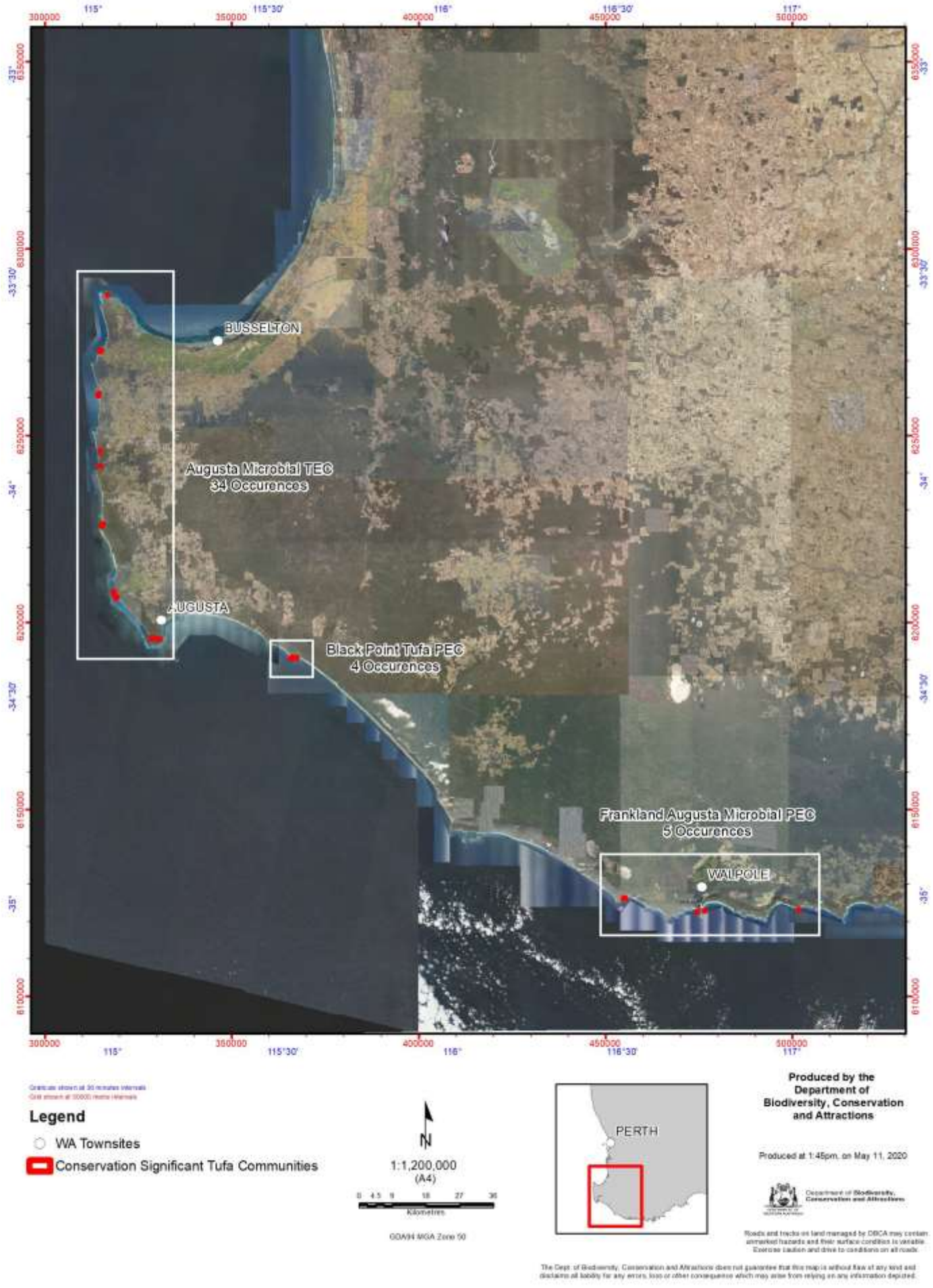
- By 2030, mean annual temperature is projected to increase by 0.5–1.2°C (increased temperatures may be advantageous to growth and accretion of some microbial assemblages)
- Reduction in rainfall by 2030 by 2-14%. The southwest is predicted to experience some of the largest reductions in rainfall in all of Australia.
- Reduction in runoff by 10-42% (median 24%) by 2030.

- Decline in groundwater levels by 2030 (extractive yields may decrease by a third to a half in some areas).





APPENDIX 2 - Distribution map



APPENDIX 3 - IUCN Red List Criteria for ecosystems (version 2.2) (IUCN 2017)

A. Reduction in geographic distribution over ANY of the following time periods:

		CR	EN	VU
A1	Present (over the past 50 years).	≥ 80%	≥ 50%	≥ 30%
A2a	Future (over the next 50 years).	≥ 80%	≥ 50%	≥ 30%
A2b	Future (over any 50 year period including the present and future).	≥ 80%	≥ 50%	≥ 30%
A3	Historic (since 1750).	≥ 90%	≥ 70%	≥ 50%

B. Restricted geographic distribution indicated by EITHER B1, B2 or B3:

		CR	EN	VU
B1	Extent of a minimum convex polygon enclosing all occurrences (Extent of Occurrence)	≤ 2,000 km²	≤ 20,000 km²	≤ 50,000 km²
	AND at least one of the following (a-c):			
	(a) An observed or inferred continuing decline in **EITHER**:			
	i. a measure of spatial extent appropriate to the ecosystem; **OR**			
	ii. a measure of environmental quality appropriate to characteristic biota of the ecosystem; **OR**			
	iii. a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem.			
	(b) Observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years.			
	(c) Ecosystem exists at …	1 location	≤ 5 locations	≤ 10 locations
B2	The number of 10 × 10 km grid cells occupied (Area of Occupancy)	≤ 2	≤ 20	≤ 50
	AND at least one of a-c above (same sub-criteria as for B1).			
B3	A very small number of locations (generally fewer than 5) **AND** prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus capable of collapse or becoming Critically Endangered within a very short time period (B3 can only lead to a listing as VU).			VU

C. Environmental degradation over ANY of the following time periods:

C1 The past 50 years based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

Extent (%)	Relative severity (%) ≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

C2 The next 50 years, or any 50-year period including the present and future, based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

	≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

C3 Since 1750 based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

	≥ 90	≥ 70	≥ 50
≥ 90	CR	EN	VU
≥ 70	EN	VU	
≥ 50	VU		

D. Disruption of biotic processes or interactions over ANY of the following time periods:

D1 The past 50 years based on change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

Extent (%)	Relative severity (%) ≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

D2

	≥ 80	≥ 50	≥ 30

	(D2a) The next 50 years, or (D2b) any 50-year period including the present and future, based on change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table: OR	≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		
			≥ 90	≥ 70	≥ 50
D3	Since 1750, based on a change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:	≥ 90	CR	EN	VU
		≥ 70	EN	VU	
		≥ 50	VU		
E. Quantitative analysis					
			CR	EN	VU
	… that estimates the probability of ecosystem collapse to be:		≥ 50% within 50 years	≥ 20% within 50 years	≥ 10% within 100 years