GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Nomination *(to be completed by nominator)*

Current conservation status				
Name of ecological community:	Ferricrete floristic community (Rocky Springs type)			
Other names:				
Description:	The community comprises tall shrubland and has been recorded between Arrino and Eneabba, on irregularly inundated red brown sandy loams over ferricrete. It is generally dominated by *Acacia blakelyi*, *Allocasuarina campestris* and *Labichea lanceolata* subsp. *lanceolata*. Associated species include *Alyogyne hakeifolia*, *Borya sphaerocephala*, *Isotoma hypocrateriformis*, *Petrophile seminuda*, *Stylidium dichotomum*, *Thysanotus patersonii* and *Pterochaeta paniculata*.			
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			
Western Australia	Threatened list; under WA Minister ESA list in policy	6/11/2001	Vulnerable	B)
	Priority list		1 ☐ 2 ☐ 3 ☐ 4 ☐	
Other State/Territory				

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 4 table 'IUCN Red List Criteria for ecosystems version 2.2'.*		B1b
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** VU
	Justification of assessment under Criterion A.	For criteria A and B, the ecosystem was assumed to collapse when the mapped distribution declines to zero. • A total of 33 ferricrete soil landscape units have been identified through anecdotal evidence, but many have not been mapped. The vegetation on 20 of these has been cleared. There are 13 occurrences mapped on the TEC database, indicating 60% of areas likely to contain the community have probably been destroyed since ~1750. • A: Based on available evidence, the community meets VU under A3 as an estimated 60% of known occurrences have been cleared. The time period of the clearing is not known but may have occurred in the last 50 years. There is no mapping available therefore there is insufficient evidence to support an inference that a minimum 30% reduction in geographic distribution has or will occur over any particular 50-year period (ie. the minimum thresholds to meet the category VU under criterion A1, A2). • **Plausible rank Vulnerable under A3.**
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.	• B1: EOO is 360.7km^2 (<2,000km^2). The community's EEO is less that the 2,000km^2 threshold for rank CR. Community meets threshold for rank CR under criterion part B1. • B1 b): Continuing decline observed from the impacts of; are hydrological change (water abstraction), clearing, grazing from introduced herbivores, weed invasion, too frequent fire, disease and drying climate. (see Appendix 1 for details of threats).

		• B1 c) Community is considered to occur at 5 threat defined locations, based on the identification of 5 clusters of the community that may be subject to similar threats such as those that affect a particular aquifer, or bushland location. The community meets EN under B1c) as the maximum threshold for threat defined locations to meet EN is 5 (1 threat defined location is indicative of CR). • B2: AOO- the community covers 7 grid cells – greater than the maximum 2 grid cell threshold for CR. The community meets EN under criterion part B2 for which the AOO threshold is 20 grid cells (subcriteria b, and c are the same as for B2) • B3: community is considered to consist of 5 threat defined locations, based on the identification of 5 clusters of the community that may be subject to similar threats such as those that affect a particular aquifer or bushland location. Meets VU under criterion B3, as community occurs at less than 5 threat defined locations and is prone to effects of stochastic events within a very short time period – hydrological change, and too frequent fire, and thus capable of collapse or becoming CR within a short time period. • **Meets criteria for Critically Endangered B1b. Meets Endangered under B1c, B2b, B2c. Meets VU under B3.**
C.	Environmental degradation of abiotic variable *(Evidence of decline over 50-year period)*	☐ **C1** ☐ **C2** ☐ **C3**
	Justification of assessment under Criterion C.	• Hydrological change in the form of groundwater decline is an abiotic variable that is a significant threat to the community. • For criterion C, the assessment of decline in abiotic processes focussed on hydrological change using data on the depth of the watertables. It was assumed conservatively that the community would collapse if the watertable depth fell to about 10.5m below ground surface based on the maximum water depth accessed by deep rooted phreatophytic taxa in nearby areas (Froend & Loomes 2006), and observations that the vigour of canopies declined in groundwater dependent trees in association with declining watertable levels (Froend *et al*. 2004). • There is some available long-term hydrological monitoring data from bores located nearby and across the community. The bore data shows that groundwater levels within the Parmelia aquifer has steadily increased since the 1960s (DoW 2019). The water table rising during this period is indicative of vegetation clearance for agriculture and mining activities that has subsequently increased surface runoff and recharge of groundwater in the local area. However, water levels are expected to fall in the future as a result of usage and drying climate. There is inadequate evidence to indicate the community meets the thresholds for minimum proportion of the extent (30%) or proportional severity of degradation (30%) over any 50-year period to meet VU under these criteria.

		• **Insufficient evidence to indicate the community meets 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.	• Weed invasion is a significant biotic threat to the community. At present there is little weed invasion in occurrences Rocky 1 and Rocky2, but its proximity to a mine site and major highway increase the risk. Due to proximity to a gravel road, agricultural land and a saline creek; and the regular occurrence of fires and road grading activities, weeds are reasonably common in occurrences BUNNEY1, Bunney1a, Bunney1b, Bunney1c and Bunney1d. • The severity of weed invasion associated with collapse is uncertain, but it is assumed conservatively that the community reaches a collapsed state when only 10% (plausible range 0–20%) of its plant species are native. • Currently, there are inadequate systematic collected quantitative data about weed levels to support assessment of the community against criterion D. • **Insufficient evidence to indicate the community meets criterion D.**
E.	Quantitative analysis *(statistical probability of ecosystem collapse)*	• No quantitative estimates of the risk of ecosystem collapse have been completed • **Does not meet criterion**

Reasons for change of status

Genuine change ☐ New knowledge ☐ Previous mistake ☐ Review/Other ☒

Provide details: The community was initially ranked as CR using ranking criteria developed in WA that differ from those in the IUCN Red List Criteria for Ecosystems (version 2.2).

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

EOO	360.7km^2	AOO	Seven 10x10km grid cells.
No. occurrences	13	Severely fragmented (justification below)	Yes ☒ No ☐ Unknown ☐
Justification of whether fragmented	Ferricrete substrate is extremely restricted in distribution in the Eneabba region. The community is naturally restricted to the ferricrete substrate and it is likely that only a limited number of occurrences ever existed.		
Current known area			431ha
Pre-industrialisation extent or its former known extent (if known)			Ferricrete substrate is extremely restricted in distribution in the Eneabba region. To date, only 20 other ferricrete soil landscape units have been identified within an area of approximately 750,000

	ha (N. Schoknecht, personal communication[1]). The vegetation on a number of these has been completely destroyed and the original assemblages that occurred on them are unknown. The assemblage is naturally restricted to the ferricrete substrate and possibly only a small number of occurrences ever existed.
Estimated percentage decline	A total of 33 ferricrete soil landscape units have been identified through anecdotal evidence, but many have not been mapped. The vegetation on 20 of these has been cleared. There are 13 occurrences mapped on the TEC database, indicating 60% of areas likely to contain the community have probably been destroyed since ~1750.

[1] Noel Schoknecht – Research Scientist, Department of Primary Industries and Regional Development, South Perth

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	VU	• Plausible rank VU under A3
B1a	-	• EOO is <2,000km^2 • No available data indicate decline in spatial extent, environmental quality and disruption to biotic interactions that would meet lowest thresholds for the criterion (VU) • Does not meet criterion
B1b	CR	• EOO is <2,000km^2 • Observed and inferred continuing decline from are hydrological change (water abstraction), clearing, grazing by introduced herbivores, weed invasion, disease and drying climate. • Meets criterion for CR
B1c	EN	• EOO is <2,000km^2 • Ecosystem exists at five threat defined locations • Meets criterion for EN
B2a	-	• AOO is seven grid cells • Inadequate data available that indicate decline in spatial extent, environmental quality and disruption to biotic interactions that would meet lowest thresholds for the criterion (VU) • Does not meet criterion
B2b	EN	• AOO is seven grid cells • Observed continuing decline from hydrological change (water abstraction), clearing, grazing by introduced herbivores, weed invasion, too frequent fire, disease and drying climate. • Meets criterion for EN
B2c	EN	• AOO is seven grid cells • Ecosystem exists at 2 threat defined locations • Meets criterion for EN
B3	VU	• Known from five threat-defined locations • Prone to the effects of grazing, weeds and too frequent fire; and inferred changes to hydrological regime • Meets criterion for VU
C1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of degradation (30%) over the past 50 years to meet VU.
C2	-	• Inadequate evidence to indicate 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.
C3	-	• Does not meet the minimum thresholds for proportion of the extent (50%) or proportional severity of disruption of abiotic processes (50%) since 1750 to meet VU.
D1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of disruption of biotic processes (30%) over past 50 years to meet VU.
D2	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of disruption of biotic processes (30%) over any 50-year period to meet VU.
D3	-	• Does not meet the minimum thresholds for proportion of the extent (50%) or proportional severity of disruption of biotic processes (50%) since 1750 to meet VU.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.

		Meets criteria for Critically Endangered B1b. Meets Endangered under B1c, B2b, B2c. Plausible rank Vulnerable under A3. Meets VU under B3. Plausible range of ranks: VU to CR. *'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 Critically Endangered B1b.**

Department of **Biodiversity, Conservation and Attractions**

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
Rocky1 (1)	DBCA South Eneabba Nature Reserve 27886 Water Corporation Reserve 20491 Mains Roads WA (public road)	2000 and 2010	100% excellent (2000 survey)	10.3	Resource extraction (encroaching into nature reserve), weed invasion, too frequent fire, and disease (past, present, future)	Weed control, implement appropriate fire regime, monitoring and hygiene procedures for dieback, rehabilitation, control of introduced animals
BUNNEY1 (2)	DBCA Reserve 12705 Main Roads WA (road reserve) Small portion on private	2000 and 2006	100% excellent (2000 survey)	66.9	Weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	As above
Rocky2 (3)	DBCA South Eneabba Nature Reserve 27886 Main Roads (road verge)	2000	100% excellent	1.9	Resource extraction (encroaching into nature reserve), weed invasion, too frequent fire, and disease (past, present, future)	As above
ES1A (4)	Private	2006	Unknown	17.8	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	Liaise with landholder, weed control, implement appropriate fire regime, monitoring and hygiene procedures for dieback, rehabilitation, control of introduced animals
WINR (5)	DBCA Wilson Nature Reserve 37083)	2006	Unknown	0.8	Inferred weed invasion, too frequent fire, hydrological	Weed control, implement appropriate

					changes and disease (past, present, future)	fire regime, monitoring and hygiene procedures for dieback, rehabilitation, control of introduced animals
YAN075 (6)	Private	Unknown	Unknown	13.6	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	Liaise with landholder, weed control, implement appropriate fire regime, monitoring and hygiene procedures for dieback, re-planting and rehabilitation, control of introduced animals
Wotto1 (7)	DBCA Reserve 29806 Main Roads (public road)	2006 and 2011	100% good	186.2	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	Weed control, implement appropriate fire regime, monitoring and hygiene procedures for dieback, re-planting and rehabilitation, control of introduced animals
Bunney1a (8)	DBCA Reserve 12705 Private	2018	95% excellent 5% good	31.1	Weed invasion, hydrological change and road maintenance (clearing/slashing/herbicide use) (past, present, future)	As above
Bunney1b (9)	DBCA Private	Unknown	Unknown	17.1	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	As above
Bunney1c (10)	Private	Unknown	Unknown	10.6	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	Liaise with landholder, weed control, implement appropriate fire regime, monitoring and hygiene procedures

						for dieback, re-planting and rehabilitation, control of introduced animals
Bunney1d (11)	Private	Unknown	Unknown	6.5	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	As above
Yan05 (12)	Private	Unknown	Unknown	40.9	Inferred weed invasion, too frequent fire, hydrological changes, and disease (past, present, future)	As above
ES4 (13)	Private	Unknown	Unknown	27.4	Inferred weed invasion, too frequent fire, hydrological changes and disease (past, present, future)	As above

*For the purposes of relating condition to IUCN Criteria, condition categories from (Keighery (1994) Vegetation Condition Scale (Government of WA 2000)) are defined below:

Good ('Pristine', 'Excellent', 'Very Good' using Bush Forever (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 (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 (2000) scale): Basic vegetation structure severely impacted by disturbance such as partial clearing, dieback, logging and grazing. Scope for regeneration but not to a state approaching good condition without intensive management.

Beyond recovery ('Completely degraded' using Bush Forever (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.

Table 1. Known vegetation condition occurrences that have been surveyed (5) of '*Ferricrete floristic community (Rocky Springs type)*'

Condition Ranking (Keighery 1994) from Government of Western Australia 2000)	**Hectares**	**IUCN Criteria condition ranking**	**Hectares**
Pristine	0		
Excellent	187.7		
Very Good	0		
Good	187.8	**Good**	187.7
Degraded	0	**Medium**	187.8
Completely degraded	0	**Poor**	0
Total	375.5	**Total**	375.5

APPENDIX 1 THREATS

Hydrological change

Ferricrete is a mineral formed in the soil profile at the water-table when iron-oxides accumulate and cement together to form a gravely or nodule-rich band. Transport and deposition of iron is controlled by fluctuations in the groundwater level. Iron is soluble in, and therefore transported by, reducing acid waters and is precipitated at higher Eh (above 0.4) and/or pH (above 6) (Nielsen 2002). Recent research also indicates that the characteristics of ferricrete are likely to have been influenced by the plant community that historically occurred on these wetlands. Further, certain lateritic soils may have been partly derived from iron-rich complexes generated by roots of proteaceous plants (Pate *et al*. 2001).

Occurrences of this 'Ferricrete floristic community' occur in the Eneabba area which lies in the Northern Perth Basin. The underground water potential of the Perth Basin has long been recognized and water supply in the Eneabba area depends on groundwater because the surface drainage is ephemeral, flowing only in exceptionally wet periods, and is often brackish or saline (Lowry 1974). The Yarragadee Formation is the confined aquifer that underlies two occurrences (Rocky1 and Rocky2). The Parmelia Formation is the unconfined aquifer underlying the remaining occurrences with the base of the aquifer, the Otorowiri siltstones, cropping out along the Dandaragan Scarp.

Land clearing in the northern Perth Basin catchment in the 1950s and 1960s led to a significant rise in rainfall infiltrating the aquifer and hence groundwater levels (see figures 1,2 and 3). Bekele *et al*. (2003) calculated an average recharge for a cleared area of 33 to 50mm per year for the area, which is equivalent to about 8 to 12.5% of the average annual rainfall. However, if regional rainfall continues to decline (see figure 4), this may impact on the amount of recharge to the aquifer, eventually resulting in a decline in groundwater levels. Groundwater monitoring by Department of Water and Environmental Regulation (DWER) indicates that when yearly average rainfall falls below 300mm, very little to no recharge will occur (DWER 2019). Groundwater levels are expected to fall in the future as a result of natural discharge and usage.

Groundwater is used for town water, farm supplies, agriculture (such as flower farming and olives), and for mineral sands processing (Mory 1994; Hydroconcept 2015). Increasing future abstraction of groundwater from the superficial Parmelia for domestic and industrial use has the potential to impact on the community due to drawdown. The Yandanooka borefield, located within 17km to the northeast of the northern most occurrence of the community, was constructed in 2010 and supplies water for an iron ore mine. The borefield uses 65% of the available allocation of the Leederville-Parmelia aquifer for the Mingenew subarea (5.3GL of 8.2GL per year) (DoW 2010). The borefield consists of a minimum of three production bores and extracts 5.3GL of groundwater per year from the Parmelia aquifer in the Mingenew groundwater subarea (Rockwater 2010). Vegetation clearing for mineral extraction also poses a threat to the community and in 2018, an application was submitted to the DMIR to clear 50.37 hectares of native vegetation located within the South Eneabba Nature Reserve.

The community also falls within the Water for Food Midlands project area (Hydroconcept 2018). Six occurrences of the community are located in areas partly or completely classified as "better groundwater resource potential and prospectivity" (Hydroconcept 2018; Groundwater Prospectivity from Water for Food Midlands data from DWER) (see Appendix 3). More recently, orange and almond orchards have been established near the southern portion of the community, close to occurrences ES1A and ES4. A proposed 120GL of groundwater will be abstracted from the Tathra subarea of the Arrowsmith Groundwater area from the Perth-Yarragadee aquifer for the purpose of these orchards (data from DWER Water Register website). The component species affected are unlikely to be able to survive significant increases in saline or water-logged conditions, particularly if flooding events occur more regularly as a result of rising regional water tables due to increased recharge of ground water from cleared farmland. Conversely, if water levels decline in the future this will affect the flow of groundwater responsible for the formation and maintenance of the ferricrete substratum and assemblage that is adapted to it. Figures 1, 2 and 3 reflect the rise in the water table in the area in which the community occurs. It is expected that groundwater levels will begin to stabilise and then decline,

as groundwater abstraction offsets rising groundwater associated with decreased evapotranspiration following vegetation clearing.

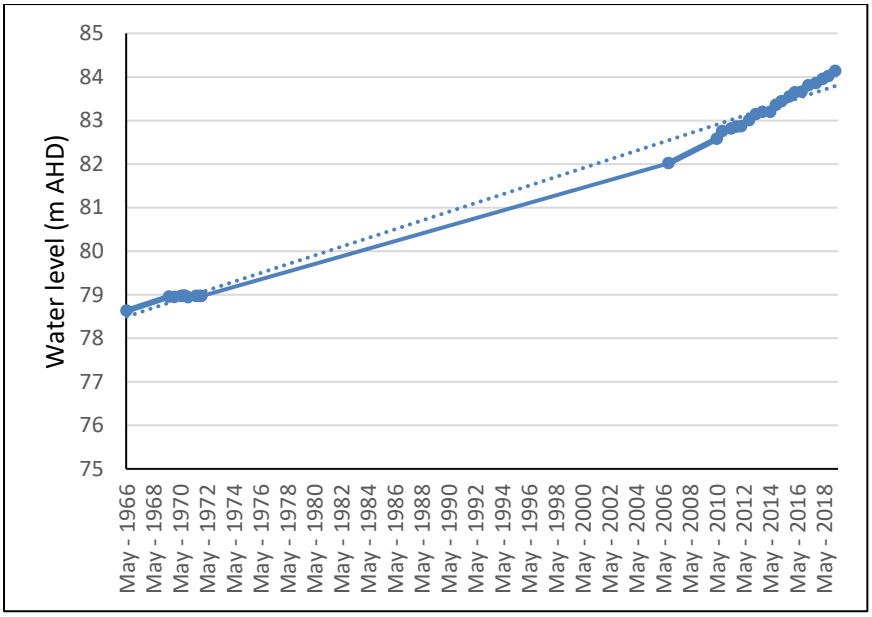

Figure 1. Hydrograph of monitoring bore located 1.5km north Yan075 (6) (site ref: 70118013), sampling the Parmelia aquifer (DoW 2019).

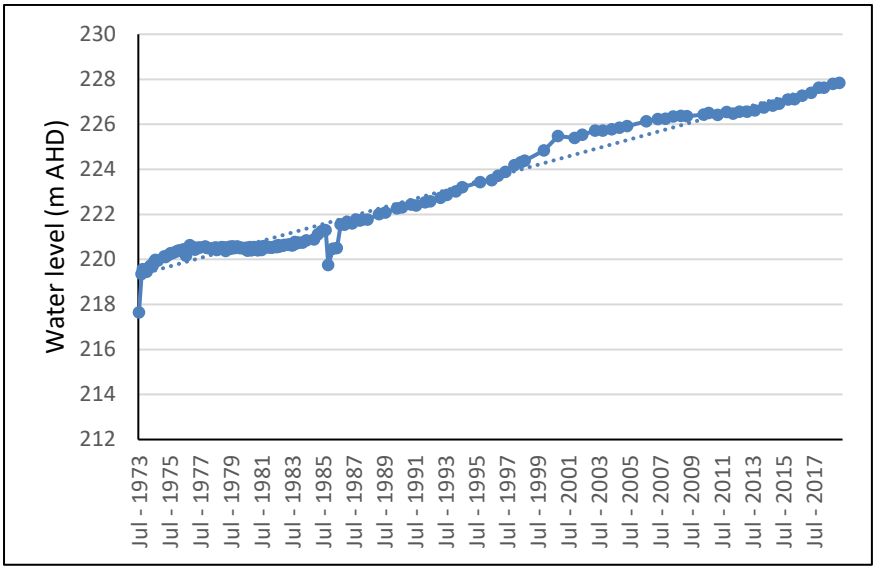

Figure 2. Hydrograph of monitoring bore located 2.8km northeast of ES1A (4) (site ref: 61718126), sampling the Parmelia aquifer (DoW 2019).

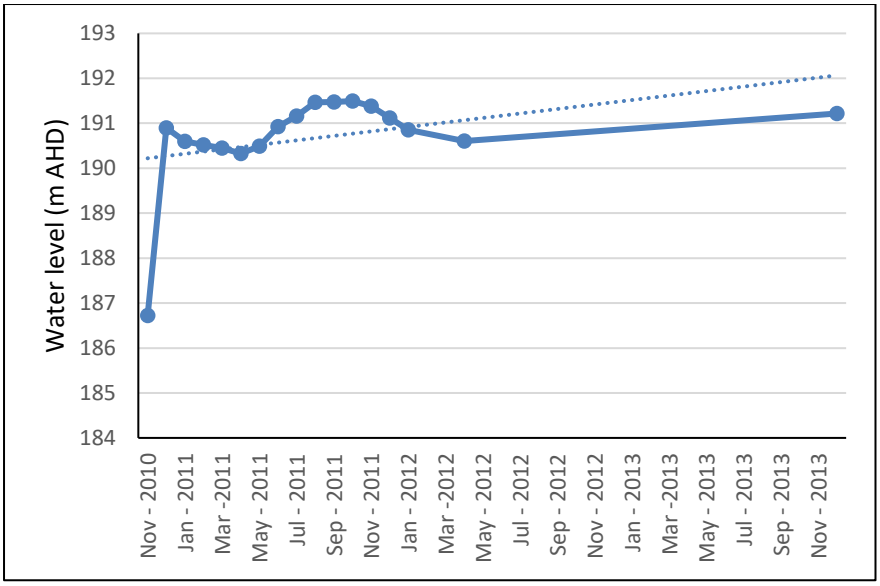

Figure 3. Hydrograph of monitoring bore located 34m south east of occurrence WINR and 2.2km north of occurrence BUNNEY1 (site ref: 70100002), sampling the Parmelia aquifer (DoW 2019).

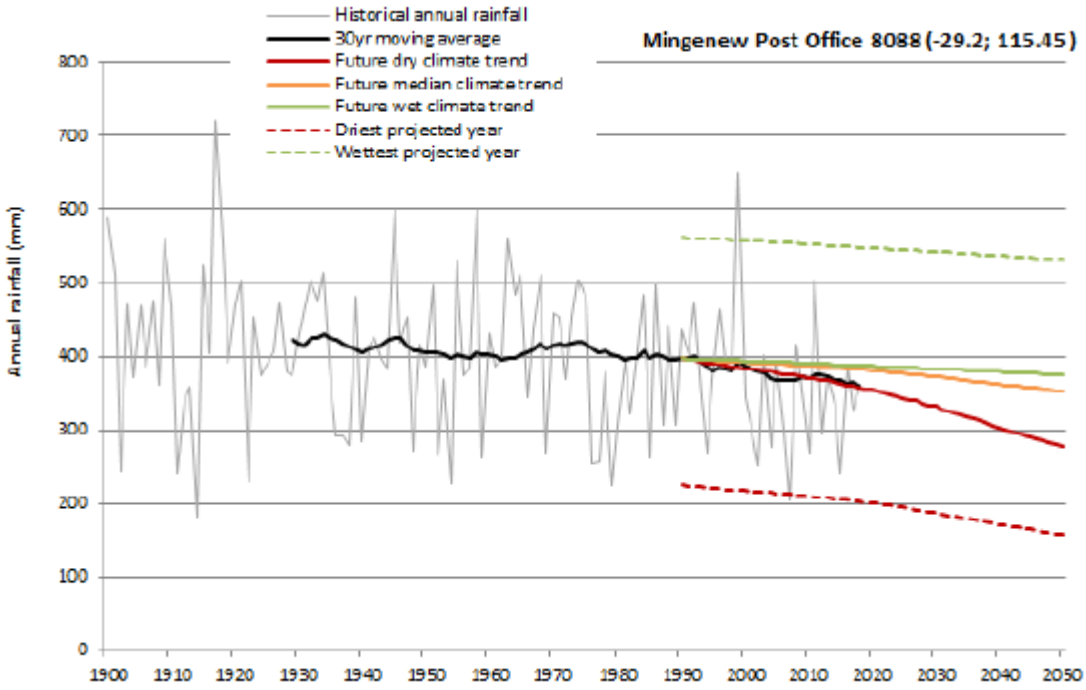

Figure 4. Predicted future trends in annual rainfall at Mingenew Post Office (located approximately 35.2km north of occurrence Yan075 (from DWER 2019).

Drying climate

The 'Ferricrete floristic community' is at risk from a drying climate resulting from a decline in rainfall in the south west of the state. The tolerance of particular species to changes that may occur in association with a drying climate is generally unknown. Commander (2000) indicates that land use changes overshadow the effects of climate variability on deeper groundwater systems. Therefore, altered hydrology due to farming practices or drawdown is likely to have a greater effect on major groundwater aquifers such as the Yarragadee and Parmelia formation than drying climate.

Weed invasion

Weeds can have significant impacts on a community through competition with the native species, prevention of regeneration and increased fire risk (Hobbs and Mooney 1993). Disturbances such as fires, nutrient enrichment, grazing, and death of plants from disease can predispose areas to weed invasion if weed propagules are present. At present there is little weed invasion in occurrences Rocky 1 and Rocky2, but its proximity to a mine site and major highway increase the risk. Due to its proximity to a gravel road, agricultural land and a saline creek; and the regular occurrence of fires and road grading activities, weeds are reasonably common in particular occurrences (BUNNEY1, Bunney1a, Bunney1b, Bunney1c and Bunney1d).

Introduced herbivores

Rabbits (*Oryctolagus cuniculus*) occur in occurrences and may have an impact through grazing of edible components of the community, increased nutrient levels from their droppings and the introduction of weeds**.**

Altered fire regimes

An increase in the frequency of fire can prevent species from completing growth and reproductive cycles and result in altered community structure or local extinction of species. Occasional fire may, however, be required for regeneration of the community. Fire can also influence species composition by increasing weed invasion. Too-frequent fires are a major risk for all occurrences that are surrounded by freehold agricultural properties, and until recently few were managed for conservation. A fire event has not been recorded within or surrounding this community for 6+ years.

Road grading activity

The local government authority regularly grades the road that passes through several occurrences (BUNNEY1, Bunney1a, Bunney1b, Bunney1c and Bunney1d). In the past, vegetation (including from other areas) has been pushed into the reserve and gravel dumped into the creek. This introduced material may be a source of weeds and disease and the grading of drainage areas could also lead to soil erosion problems in the occurrences.

Disease

Dieback disease caused by the plant pathogens *Phytophthora* spp. is a serious threat as there are high numbers of species likely to be susceptible to the disease in and surrounding the assemblage (G. Keighery, personal communication[2]). The *Phytophthora* spp. pathogens, which cause the roots to rot and result in death from drought stress, are commonly introduced and spread in infected soil, mud and gravel.

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[3]Greg Keighery -Previous Principal Research Scientist, DBCA's Science Division

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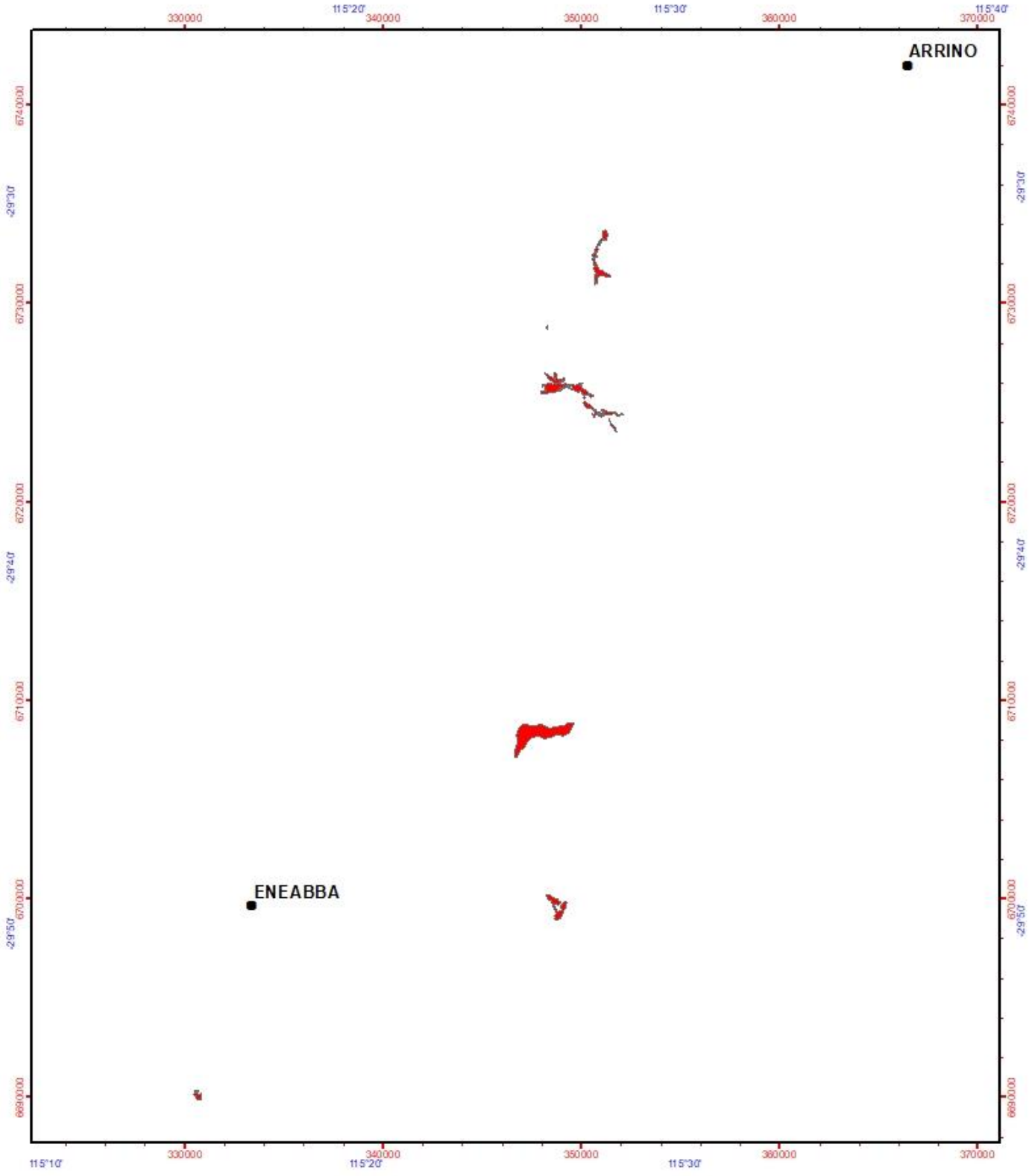
Rockwater (2010) Karara Iron Ore Project Yandanooka Borefield Completion Report and Hydrogeological Assessment. Report for Karara Mining Ltd.

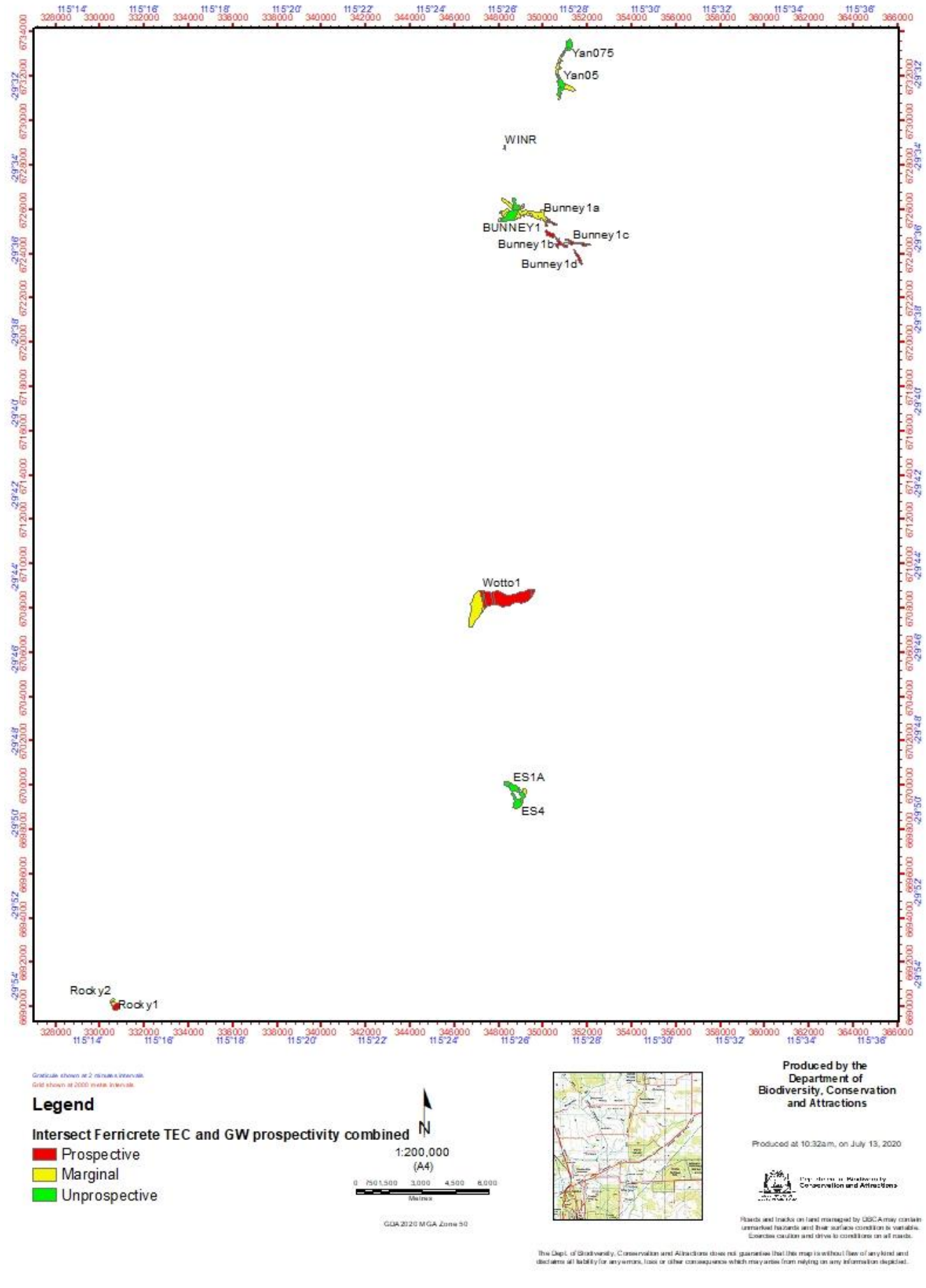
APPENDIX 2 Ferricrete floristic community (Rocky Springs type) (red)



The ferricrete community occurs over range of 45km, with the northernmost occurrence at Arrino and the southernmost occurrence at Eneabba. Occurrences were likely to have been naturally highly fragmented, and have also been subject to clearing, that has increased their isolation and fragmentation.

The map was created from known mapped occurrences of the community contained on the Western Australian Threatened Ecological Community database (TECDB), as administered by the Department of Biodiversity and Conservation (DBCA).

APPENDIX 3 Occurrences of Ferricrete community and groundwater prospectivity (Groundwater Prospectivity from Water for food Midlands data supplied by DWER; from Hydroconcept 2018).



APPENDIX 4 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 km^2	≤ 20,000 km^2	≤ 50,000 km^2
	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:

Extent (%)	≥ 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:

Extent (%)	≥ 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	(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	≥ 50	≥ 30
		≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		
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	≥ 70	≥ 50
		≥ 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