Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status				
Name of ecological community:	Aquatic Root Mat Community Number 4 of Caves of the Leeuwin Naturaliste Ridge (Calgardup Cave) (hereafter termed 'cave community No.4')			
Other names:	Leeuwin Cave community number 4			
Description:	The community occurs in the cave system of the Leeuwin-Naturaliste Ridge incorporating Calgardup Cave. It comprises a complete food web. Rootlets and their associated microflora provide the primary food source, and root mat grazers, predators, parasites, detritivores and scavengers complete the interactions. The root mats are produced by *Corymbia calophylla* (marri). Aquatic cavernicoles (cave animals) in the community include *Cherax preissii* (koonacs), other crustaceans (*Perthia acutitelson*, *Microcyclops*, *Paracyclops*, *Parastenocaris*, *Harpacticoida*, *Oniscoida*, *Bathynellacea*), meiobenthic mites (*Soldanellonyx monardi* and *Oribatida*), non-biting midges (*Chironomus* aff. *alternans* Walker, *Polypedilum* sp.), rotifers (*Rotifera*), microscopic worms (*Enchytraeidae*, *Phraeodrilidae*, *Insulodrilus* sp., *Stenostomum* sp.) and predatory coleoptera (*Helodidae*). The community was originally described in Jasinska (1997) and more recently by Storey and Knott (2002).			
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	16/07/2000	Endangered	
Western Australia	Current ranking under WA Minister ESA list in policy	6/11/2001	Critically endangered	B) (under previous WA criteria)
	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 3 table 'IUCN Red List Criteria for ecosystems version 2.2'.*		B1b,c; B2b,c
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 and B, the ecosystem was assumed to collapse when the mapped distribution declines to zero. • Insufficient data to support a reduction in distribution of the aquatic root mat community within Calgardup Cave, over any time period. • **Insufficient data to assess the community against the criterion**
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 0.009km2 (≤2,000km2-threshold for CR). The community's EEO is less that the 2,000km2 threshold for rank CR. Community meets threshold for rank CR under criterion part B1. • B1 b): Continuing decline observed from the impacts of; hydrological change, pollution, invasion of exotic species, loss of tree roots, and trampling (see Appendix 1 for details of threats). • B1 c): Community is considered to occur at 1 threat-defined location, as there is only 1 occurrence. The community meets CR under B1c) as the threshold for VU is 1 threat-defined location. • B2: AOO. Community covers 1 grid cell. The community meets CR under criterion B2 for which the AOO threshold is ≤2 grid cells (threshold for CR ≤2 grid cells) (b and c of B1 are the same for B2). • B3: community is considered to consist of 1 threat-defined location as there is only 1 occurrence.

		• The community meets VU under criterion B3, as community occurs at 1 threat-defined location. • **Meets criteria for critically endangered B1b,c; B2b,c. 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 the abiotic variable that is the most 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 cave pools supporting aquatic root mat communities. It is assumed that the community will collapse if the cave pools supporting this community completely dried up and did not refill. • Calgardup Cave stream is more dependent on surface waters than other root mat caves. Water levels in Calgardup Cave show seasonal fluctuations from 2002 to 2019. The tannin colour of waters in Calgardup Cave indicates that it is fed by a temporary surface stream and carries more dissolved organic material, reflected in the lower pH. In keeping with surface water sources, the water levels, temperature and pH also undergo seasonal fluctuations in this cave. Figure 1 indicates water levels in Calgardup cave fluctuate seasonally but are relatively stable. • Based on current water levels of Calgardup Cave, this community does not meet the minimum thresholds for proportion of decline in the extent (≥30%) or proportional severity of degradation (≥30%) over any 50 year period to meet VU under C1, C2, or the threshold of decline of ≥50% severity and extent since 1750 to meet C3. • **Does not meet criterion**
D.	Disruption of biotic processes or interactions *(Evidence of decline over 50-year period)*	☐ **D1** ☐ **D2** ☐ **D3**
	Justification of assessment under Criterion D.	• Decline in the root mats that support the community including cave faunae that are important in the food web is a significant biotic variable affecting the community. • The collapse point is assumed to be total loss of the root mats that support the community, that results in loss of very significant parts of the food web.

		• There are insufficient monitoring data to track decline in extent and health of the root mats in relation to cave faunae that are important in the food web. • **Insufficient data to assess the community against the criterion**
E.	Quantitative analysis *(statistical probability of ecosystem collapse)*	• No quantitative estimates of the risk of ecosystem collapse have been completed. • **Not evaluated under criterion E**

Reasons for change of status

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

Provide details: The community was initially ranked critically endangered 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	0.009 km^2	AOO	1 grid cell. 100 km^2 (10x10km grid method).
No. locations	1	Severely fragmented	Yes ☒ No ☐ Unknown ☐ Community is confined to specific habitats in cave pools that are naturally highly fragmented
Current known area			0.87 ha
Pre-industrialisation extent or its former known extent (if known)			Occupies most or all of former area
Estimated percentage decline			No evidence available to indicate area occupied has declined.

Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Inadequate data available to indicate if community meets criterion
A2a	-	• Inadequate data available to indicate if community meets criterion
A2b	-	• Inadequate data available to indicate if community meets criterion
A3	-	• Inadequate data available to indicate if community meets criterion
B1a	-	• EOO is ≤2,000km^2 • Inadequate data available that indicate decline in a measure of spatial extent, environmental quality or disruption to biotic interactions that would meet minimum thresholds for the criterion (VU). • Does not meet criterion
B1b	CR	• EOO is ≤2,000km^2 • Observed and inferred continuing decline from; hydrological change, pollution, invasion of exotic species, loss of tree roots, human trampling and cave collapse. • Meets criterion for CR
B1c	CR	• EOO is ≤2,000km^2 • Ecosystem exists at 1 threat defined location. • Meets criterion for CR
B2a	-	• AOO is 1 grid cell • Inadequate data available that indicate decline in a measure of spatial extent, environmental quality or disruption to biotic interactions that would meet lowest thresholds for the criterion (VU). • Does not meet criterion
B2b	CR	• AOO is 1 grid cell • Observed and inferred continuing decline from hydrological change, and a drying climate and inferred future decline in environmental quality from groundwater decline. • Meets criterion for CR
B2c	CR	• AOO is 1 grid cell • Ecosystem exists at 1 threat defined location. • Meets criterion for CR
B3	VU	• Known from 1 threat-defined location • Meets criterion for VU
C1	-	• Available data indicate community does not meet minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over the past 50 years to meet VU.
C2	-	• Available data indicate community does not meet minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50 year period to meet VU.
C3	-	• Available data indicate community does not meet minimum thresholds for proportion of the extent (≥50%) or proportional severity of degradation (≥50%) since 1750 to meet VU.
D1	-	• Inadequate quantitative data to indicate if the community meets the minimum proportion of the extent (≥30%) or proportional severity of disruption of biotic processes (≥30%) over the past 50 years to meet VU.
D2	-	• Inadequate quantitative data to indicate if the community meets the minimum proportion of the extent (≥30%) or proportional severity of disruption of biotic processes (≥30%) over any 50-year period to meet VU.
D3	-	• Inadequate quantitative data to indicate if the community meets the minimum proportion of the extent (≥50%) or proportional severity of disruption of biotic processes (≥50%) since 1750 period to meet VU.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Meets CR under B1b,c and B2b,c. 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 criterion under B1b,c; B2b,c

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Summary of location (occurrence) information *(provide detailed information in the relevant sections of the nomination form)*						
Occurrence site ID (Occurrence No.)	Land tenure	Survey information: date of survey	Condition	Area of occurrence (ha)	Threats *(note if past, present or future)*	Specific management actions
CALG01 (1)	DBCA (Reserve 8428). Leeuwin Naturaliste National Park	1995, 1998-2019	100% excellent in 1995 Post 1995 - Only groundwater levels have been monitored so condition of root mats and stygofauna is uncertain.	0.87	Groundwater decline, altered surface drainage, high intensity fire that kills trees that provide tree root habitat, water contamination, exotic species, trampling of roots due to human activity	Monitoring of water levels and chemistry, control of human access, management of fire regimes in trees that supply tree roots

*For the purposes of relating condition to the criteria, condition categories from Keighery (1994 Vegetation Condition Scales in 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.

APPENDIX 1 THREATS

Major Threats

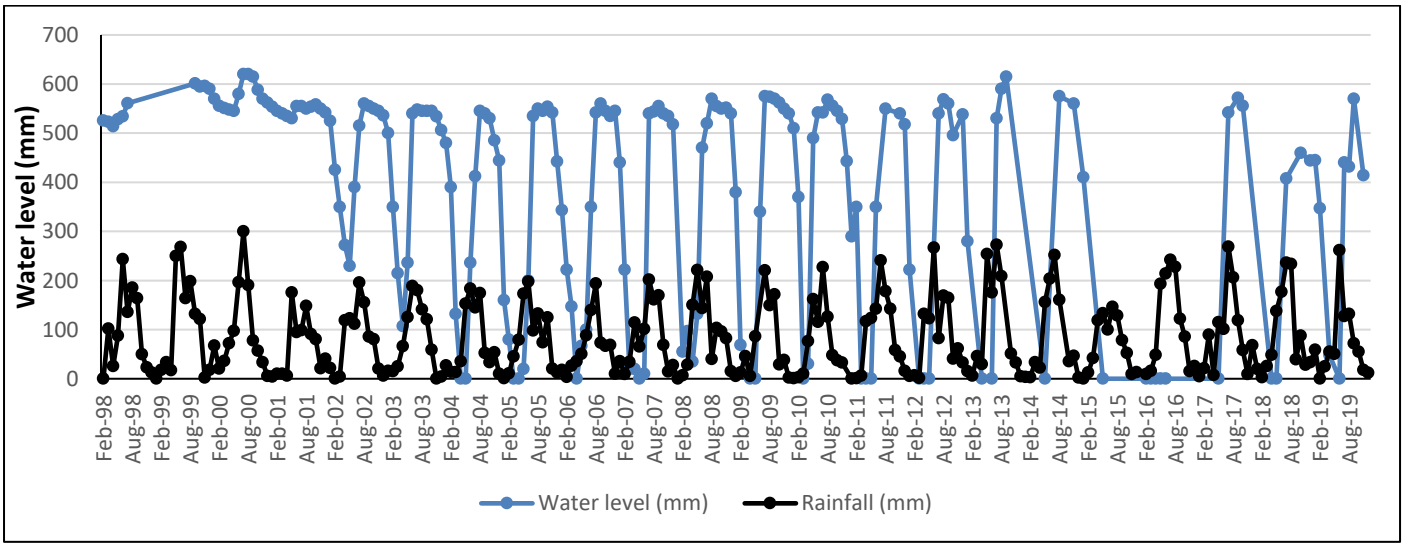
Groundwater Decline

Groundwater decline is overwhelmingly the most important and imminent threat to the survival of root mat assemblages in caves on the Leeuwin Naturaliste Ridge. The caves have experienced reduced groundwater levels and stream flow in recent years. Decline in water level in the four original root mat caves over recent decades has been recorded by both Jasinska (1997) and Eberhard (2004; 2006).

In 2012, the water table in the Jewel Cave Karst System was the lowest level ever recorded, 22.460 m AHD, being more than 2.5 m below the maximum level recorded over the last 52 years since historical measurement commenced (Subterranean Ecology Pty Ltd 2012). The main cause of the water decline is reduced rainfall experienced in southwest Western Australia since the mid 1970s but may be exacerbated due to other land use practises such as tree plantations or altered drainage. Abstraction of water from areas up-gradient of cave streams has the potential to impact on those caves. As suggested by Eberhard (2004) reduced fire frequency in the National Park in which the caves are situated may have contributed to the decline in water levels in these caves as well.

Calgardup Cave stream is more dependent on surface waters than other root mat caves. There were seasonal fluctuations in water levels in Calgardup Cave from 2002 to 2019, with the pool containing the root mat community being without standing water during, on average, March to May, in each consecutive year (figure 1). The tannin colour of waters in Calgardup Cave indicates that it is fed by a temporary surface stream and carries more dissolved organic material, reflected in the lower pH. In keeping with surface water sources, the water levels, temperature and pH also undergo seasonal fluctuations in this cave. Figure 1 indicates that water levels in Calgardup cave are relatively stable.

In the last approximately 10-15 years, the cave has only been seasonally wet with periods of drying ([redacted][1] pers comm.). Although water returns to the cave seasonally, as at 2018, the status of the aquatic invertebrate fauna previously recorded by Jasinska (1997) and more recently by Storey and Knott (2002), with the tree roots in Calgardup Cave was unknown (Anderson 2018). There have been sightings of amphipods and the occasional koonacs (as originally cited in Jasinska (1997) and Storey and Knott (2002)) in the root mats stream beds ([redacted] pers comm.). This suggests further monitoring is required at Calgardup cave. The general condition of tree roots within Calgardup cave is thought to be declining ([redacted] pers. comm.)



[1] [redacted] Caves Manager, DBCA Blackwood district

Figure 1. Calgardup hydrograph 1998 to 2019 showing water levels (mm) at two different sites that host the community within the cave ([redacted] pers comm.).

Minor Threats

Pollution of Groundwater

Karst aquifers are very vulnerable to contamination from pollutants carried in surface waters because of rapid ingress of such waters via sinking streams and free flowing conduits, including sink-holes and solution pipes, and an associated low filtration capacity. Thus, longer-term threats to these assemblages include pollution of the groundwater. Water quality can have significant influence on the taxa present and their growth and survival (Trayler and Davis 1996; Cairns *et al.* 1993).

Long term planning is required to ensure waters entering caves are not polluted with fertilisers, fungicides or pesticides used in agricultural production, by runoff from urban uses, or by waters carrying pollutants from land-uses such as rubbish tips or industrial areas.

At least one ex-tourist cave that may have contained a root mat community was vandalised through pollution of the cave stream with wiring, batteries, and drink containers and it possibly receives subterranean drainage from a waste disposal site nearby and upstream of the cave (Jasinska 1997).

Activities such as agriculture, large tourist developments including caravan parks and hotels that produce substantial amounts of effluent and require large quantities of water already occur near caves that contain stygofauna on the Leeuwin-Naturaliste Ridge, and these types of development can be expected to expand in future.

Invasion of Exotic Species

Introduced fauna such as yabbies (*Cherax destructor*) may compete with or prey upon other fauna in the community, alter habitat and represent a threat to the root mat assemblages, and/or particular species of stygofauna. Yabbies have been recorded from caves at Stockyard Gully, Eneabba, and are thought to have had a significant impact on the cave fauna in that area (Jasinska *et al.* 1993). Crayfish were identified from Lake Cave in August 1995 (Jasinska 1997). All the specimens were the endemic *Cherax preissii* (koonacs). If feasible methods exist, any accidentally or deliberately introduced species should be removed unless side effects of removal are likely to do more harm than the introduced species.

Loss of tree roots by death of trees

Trees whose roots reach the water table may be killed by hot fire, too frequent fire, clearing or disease. However, the much greater distribution of tree roots throughout karst systems of the Leeuwin-Naturaliste Ridge now known, and the hundreds, probably thousands of trees involved, suggest that normal good management of forests should prevent major effects from fires or disease. Clearing may be a localised threat in land adjacent to conservation lands and planning processes should include careful consideration of this factor.

Alternatively, Eberhard (2004) concluded that vigorous growth of native vegetation and heavy accumulations of litter, resulting from lower frequency of fires over the last few decades (with the last significant fire in the catchment in 1977), may have contributed to reduced amounts of rainfall penetrating the soil and reaching the cave system.

A very hot bushfire burned much of the catchment of Calgardup Cave and some of that for Lake Cave, in April 2006. This provides an opportunity to monitor the effect of severe fire on water levels in those caves to help to clarify major hydrological drivers for them.

Damage to root mats from human trampling within the caves

Access to all of the caves that contain root mats on the Leeuwin-Naturaliste Ridge are already controlled to some extent and this helps to prevent physical damage to the communities.

Cave collapse

While cave collapse is a natural process in karst systems, the exacerbation of this by such things as heavy human or vehicular traffic over the caves and the use of explosives nearby should be avoided. Good management practices should include ensuring any tracks or commonly used walk trails do not occur above the caves, and by ensuring heavy machinery and explosives are not used near them.

APPENDIX 2 Aquatic Root Mat Community Number 4 of Caves of the Leeuwin Naturaliste Ridge (Calgardup Cave)

The map above was created using ArcGIS version 10.6.1 and shows the extent of distribution of the cave that supports the 'Aquatic Root Mat Community Number 4 of Caves of the Leeuwin Naturaliste Ridge (Calgardup Cave)'. This community is found along Caves Road within Boranup.

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

References

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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