Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status	
Name of ecological community:	Camerons Cave Troglobitic Community
Other names:	
Description:	The community is known from Camerons Cave on the Cape Range peninsula. It comprises a unique assemblage of fauna, at least 8 of which are known only from this location. The listed threatened species *Stygiochiropus peculiaris* (Camerons Cave millipede) and *Indohya damacles* (Camerons Cave pseudoscorpion) (previously *Hyella* sp. BES 1154.2525, 1546, 2554) are endemic to Camerons Cave. *Milyeringa veritas* (blind gudgeon) and *Draculoides bramstokeri* (Barrow Island drakuloides) also occur in the cave.
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	Critically Endangered	B) i) + 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 ☐

<table>
<tr><td colspan="2">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'.</td><td>Critically Endangered B1b,c; B2b,c</td></tr>
<tr><td colspan="3">Eligibility against the criteria</td></tr>
<tr><td colspan="3">Provide justification for the nominated conservation status; is the ecological community eligible or ineligible for listing against the five criteria. For <u>delisting</u>, provide details for why the ecological community no longer meets the requirements of the current conservation status.</td></tr>
<tr><td>A.</td><td>Reduction in geographic distribution
(evidence of decline)</td><td>☐ A1
☐ A2a
☐ A2b
☐ A3</td></tr>
<tr><td></td><td>Justification of assessment under Criterion A.</td><td>For criteria A, the ecosystem is assumed collapsed when the mapped distribution declines to zero.
• No data suggest the community has declined in distribution.
• There is no evidence to support an inference that a minimum 30% reduction in geographic distribution has or will occur over any 50-year period, or a 50% reduction since European settlement (ie. the minimum thresholds to meet the category VU under criterion A).
• Does not meet criterion A</td></tr>
<tr><td>B.</td><td>Restricted geographic distribution
(EOO and AOO, number of locations and evidence of decline)</td><td>☒ 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)</td></tr>
<tr><td></td><td>Justification of assessment under Criterion B.</td><td>• B1: EOO is 0.12 km^2 (≤2,000km^2-threshold for CR).
• Community meets threshold for rank CR under criterion part B1.
• B1 b): The increase in water extraction and the construction of infrastructure to accommodate the growing population of Exmouth are the main threats to this community. These issues are inferred to be likely cause a decline in the environmental quality and biotic interactions of this community within the next 20 years. Other threatening processes include pollution, rubbish dumping, and uncontrolled access.
• B1c): Community is considered to occur at 1 threat defined locations, as it occurs at only at one cave. The community meets CR under B1c as the threshold for CR is 1 threat-defined location.
• B2: AOO is one grid cell (occupies one 10x10 km^2 grid cell - the threshold for CR). The community meets CR under criterion B2</td></tr>
</table>

		for which the AOO threshold is ≤2 grid cells (b and c of B1 are the same for B2). • B3: The community only exists at one location in a residential area close to Exmouth township and is extremely vulnerable to stochastic events that may impact the water quality or the fragile cave habitat within a very short time period in an uncertain future and thus community is capable of collapse or becoming CR within a very short time period (meets VU as <5 threat defined locations). • **Meets criteria for Critically Endangered B1b, B1c, B2b and 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.	• The introduction of energy through nutrients entering subterranean systems changes the energy balance and enhances the competitive abilities of epigean organisms, allowing them to displace hypogean organisms that are adapted to a low energy environment (Humphreys *et al*. 1999). Hence, these ecosystems are sensitive to pollution. • Little pollution of the groundwater of the Cape Range peninsula, either from point sources (e.g. petrol tanks) or diffuse sources (e.g. fertilisers) was observed in 1994 (Humphreys 1994) but the current status is unknown. Further monitoring is required to assess the current level of nutrient enrichment within Camerons cave, and whether this poses a significant threat to the community. • The collapse state is considered to be a level of eutrophication that causes total loss of cave faunae that are crucial to the food web of the community • There are insufficient monitoring data to indicate the level of eutrophication likely to cause total loss of cave faunae that are crucial to the food web of the community. • There are inadequate monitoring data to link eutrophication levels to status of key components of the assemblage • Insufficient data to determine the thresholds of collapse, and to assess the community against criterion • **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.	• Uncontrolled human access to Camerons cave and its surrounds is a biotic threat to the Camerons Cave assemblage (see Appendix 1 for details of threats)

<table>
<tr><td></td><td></td><td>The collapse state is considered to be total loss of cave faunae that are crucial to the food web as a consequence of physical damage to the cave fauna and their habitat by humans
There are insufficient monitoring data to indicate the level of impact of damage caused by human access on the cave, and to link these impacts to the current status of the assemblage
Insufficient data to assess the community against the criterion
Community is data deficient under criterion D</td></tr>
<tr><td>E.</td><td>Quantitative analysis
(statistical probability of ecosystem collapse)</td><td>No quantitative estimates of the risk of ecosystem collapse.
Not assessed</td></tr>
<tr><td colspan="3">Reasons for change of status</td></tr>
<tr><td colspan="3">Genuine change ☐ New knowledge ☐ Previous mistake ☐ Review/Other ☒</td></tr>
<tr><td colspan="3">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).</td></tr>
<tr><td colspan="3">Summary of assessment information (provide detailed information in the relevant sections of the nomination form)</td></tr>
</table>

<table>
<tr><td>EOO</td><td>0.12 km^2</td><td>AOO</td><td>1 (10x10km grid cell).</td></tr>
<tr><td>No. occurrences</td><td>1</td><td>Severely fragmented (justification below)</td><td>Yes ☐ No ☒ Unknown</td></tr>
<tr><td>Justification of whether fragmented</td><td colspan="3">Camerons cave is the only cave that contains this particular assemblage.</td></tr>
<tr><td colspan="3">Current known area</td><td>11.2 ha</td></tr>
<tr><td colspan="3">Pre-industrialisation extent or its former known extent (if known)</td><td>11.2 ha.</td></tr>
<tr><td colspan="3">Estimated percentage decline</td><td>0%</td></tr>
</table>

Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Does not meet criterion
A2a	-	• Does not meet criterion
A2b	-	• Does not meet criterion
A3	-	• Does not meet criterion
B1a	-	• EOO is ≤2,000km^2 • No available data indicate decline in a measure of spatial extent, environmental quality and disruption to biotic interactions that would meet minimum thresholds for the criterion (VU) • Does not meet criterion
B1b	CR	• EOO is ≤2,000km^2 • Inferred continuing decline from altered water levels and quality from over abstraction and developments, uncontrolled access, loss of vegetation buffer and pollution and dumping within the cave • Meets criterion for CR
B1c	CR	• EOO is ≤2,000km^2 • Ecosystem exists at one threat-defined location • Meets criterion for CR
B2a	CR	• AOO is one grid cell • No available data indicate decline in a measure of spatial extent, environmental quality and disruption to biotic interactions that would meet minimum thresholds for the criterion (VU) • Does not meet criterion
B2b	CR	• AOO is one grid cell • Inferred continuing decline from altered water levels and quality from over abstraction and development, uncontrolled access, loss of vegetation buffer and pollution and dumping within the cave • Meets criterion for CR
B2c	CR	• AOO is one grid cell • Ecosystem exists at one threat-defined location • Meets criterion for CR
B3	VU	• Known from one threat-defined location • Meets criterion for VU
C1	-	• No available data indicate if community meets minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over the past 50 years to meet VU.
C2	-	• No available data indicate if community meets minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over the past 50 years to meet VU.
C3	-	• No available data indicate if community meets minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over the past 50 years to meet VU.
D1	-	• No available data indicate if community meets minimum proportion of the extent (≥30%) or proportional severity of disruption of biotic processes (≥30%) over the past 50 years to meet VU.
D2	-	• No available data indicate if 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	-	• No available data indicate if community meets the minimum 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 CR under B1b,c; B2b,c. Meets VU for B3.

		Plausible range of rank: 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 CR for B1b,c; B2b,c**

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

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
CAMERON01	Shire of Exmouth	1998, 2010, 2012 and 2013	100% excellent (Current status not known)	11.2	Mechanical and physical disturbance, pollution and dumping of rubbish or toxic waste and hydrological change	Maintenance of gates, locks and signs, community monitoring, hydrological monitoring.

*Condition categories from (Keighery (1994) Vegetation Condition Scale (in Government of WA 2000)) are defined below:

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.

Table 1. Known condition of occurrences of the Camerons Cave Troglobitic Community.

Condition Ranking (Keighery 1994) from Government of Western Australia 2000	**Hectares**	**IUCN Criteria condition ranking**	**Hectares**
Pristine	0	**Good**	11.2
Excellent	11.2		
Very Good	0		
Good	0	**Medium**	0
Degraded	0	**Poor**	0
Completely degraded	0	**Beyond recovery**	0
Total	11.2	**Total**	11.2

APPENDIX 1 THREATS

Modification to hydrology

Modifications to local catchment

The faunae of Camerons Cave are considered vulnerable to changes in groundwater level and quality and therefore to changes in quantity and quality of surface waters that recharge the aquifers and provide nutrients to cave fauna (Brown and Root 2000).

Urban, rural, industrial, recreational or other forms of development on-site, and in the area around Camerons Cave, are likely to modify the catchment area and, hence, surface water input to the cave, through altering drainage patterns, flow rates and volumes, and water-soil infiltration rates. Changed hydrological conditions are likely to affect the input of allochthonous food resources, and to impact on the humidity in the cave.

Modifications to regional groundwater

Changes to groundwater levels and quality in the Exmouth Groundwater Subarea have the potential to affect the stygofauna of the Cape Range peninsula, including that of Camerons Cave. Altered groundwater hydrology within Camerons Cave could result in loss or modification of habitat for aquatic taxa, and could impact on humidity levels important to troglobitic fauna.

Groundwater is naturally discharged from the aquifer by flow to the ocean, by several springs along the coast (including submarine springs), and by evapotranspiration from vegetation on the coastal plain. It is also discharged by abstraction from the well or borefield. Groundwater is the major water resource for Cape Range peninsula and is currently utilised to meet the public water requirements of the town of Exmouth plus private, tourist and industrial uses. This water resource is limited and is already heavily utilised in the Exmouth area.

Significant population growth is expected in Exmouth, with an associated increase in groundwater use. In addition to Water Corporation, other users who draw smaller amounts of water in the area include private bores, and the naval base. Water Corporation has an extensive borefield that supplies drinking water to the Exmouth Township, derived from bores in the Upper Tulki Karst Aquifer. About 75% of the water abstracted from the aquifer is taken by Water Corporation (about 1029 ML). Another 258 ML is used by the Harold E Holt borefield (naval base), and about 133 ML is used in private bores. Water Corporation has made a commitment to monitor water quality in the bores, with main commitments as follows (Brown and Root 2000):

- monthly rest water levels in all appropriate production and Salt-Water Interface Monitoring (SWIM) Bores
- SWIM bores to be installed adjacent to selected production bores
- stygofauna observation bores (SOB) to be established downstream and sampled for water and fauna monitoring
- salinity of production bores and analysis of all major ions, pH, salinity and Total Dissolved Solids.

These monitoring data were not available however**.**

Bennelongia (2008) note that the following environmental conditions were imposed on Water Corporation when the license to extend the Exmouth borefield was granted in 1997. The commitments in relation to stygofauna are:

- finalize a detailed stygofauna and aquifer monitoring program
- submit data on stygofauna species composition and numbers
- implement actions to protect stygofauna populations and habitat to the requirements of the EPA on the advice of DBCA (the trigger for management response was amended in 2000 from loss of a species in one-third of monitoring

bores to apparent reduction in stygofauna densities and/or stygofaunal diversity within production field when compared with DSO bores) (Brown and Root 2001).

In relation to detection of hydrological change, commitments included that if monitoring reveals that salinity of production or monitoring wells is increasing, the proponent will:

- immediately reduce the rate of pumping from the bore(s)
- reduce the total production from the group of bores in the area
- if the above measures do not improve salinity levels, cease groundwater production from the bores involved.

There has been a proposal to site a horse-racing track on or adjacent to the area above the cave, and the general area is subject to a boat harbour, marina and canal residential developments. Development WA commenced development and construction of the Exmouth Marina Village canal system in 2002. Further development of the harbour is expected in relation to new infrastructure for the offshore industry. At the time of writing, residential development occurred about 300 m to the south of the cave, and a canal occurred within about 1300 m to the north east of the cave. Clearing for the marina development was about 1000 m to the north east.

The canal development had been an issue of concern, however salinity impact from the marina has apparently not extended very far inland, which indicates the karst system is not a very open system in the coastal area. It is not known what has occurred since the canal development. Department of Water and Environmental Regulation (DWER) suggest that it is likely to have had some significant alterations to the system. Lee (2008) notes that there is increasing saline composition in many bores in the borefield and that this is likely to be associated with a drift towards changing water chemistry due to drawdown associated with the Exmouth borefield. SWIM bore data is being collected by Water Corporation.

The Exmouth borefield and submarine coastal areas are primary areas of groundwater discharge (Lee 2008). Low abstraction rates of 7% of the annual recharge (i.e. 700,000 cubic metres of the total annual recharge of 4 million cubic metres) are set in the high-yielding production bores due to the proximity to the saltwater interface (Lee 2008). The borefield covers about 50 km^2 and contains 24 production and 34 monitoring bores. The closest production bore in the Water Corporation borefield is about 1.5 km west of Camerons Cave. The borefield was established in the 1960s, and poor management resulted in saltwater intrusion in the northern parts of the borefield (Lee 2008). Table 1 shows that significant increases in groundwater Total Dissolved Solids (TDS) occurred in some bores since the Exmouth Borefield began its operation in the 1960s. An increase of up to 500mg/L TDS was observed in Bore 24, which is more than double the groundwater salinity of 1968 (Lee 2008).

Table 1. Change in TDS values between the time of drilling in the 1960s and recent data (March 2005; sourced from Lee 2008).

Bore	TDS (Time of drilling)	TDS (March, 2005)	Increase in TDS
#	mg/L (Year)	mg/L	mg/L
1	870 (1963)	1100	+230
10	680 (1965)	897	+217
17	480 (1966)	720	+240
24	440 (1968)	940	+500
26	720 (1967)	1075	+355
38	330 (1969)	710	+380
39	440 (1969)	660	+220

Water levels in the Exmouth borefield bores fell between 1981 and 1991, apparently due to low rainfall (Lee 2008) and, concurrently, salinity has increased across many bores in the borefield. The freshwater lens has thinned and there has been more mixing with seawater in the northern half of the borefield presumably because of a longer history of excessive abstraction relative to recharge, and due to higher conductivities in the Upper Tulki Karst Aquifer (Lee 2008). Increasing groundwater salinity was also noted in periods of lower rainfall (Lee 2008). The lens has thinned considerably with seawater intrusion mainly due to historical groundwater abstraction, long term below average rainfall and tidal influences (Lee 2008). The sustainability of the aquifer will be dependent on ensuring that drawdown does not cause seawater to encroach into the aquifer, as this kind of damage to aquifers is not reversible (Lee 2008). Groundwater salinity levels recorded at Camerons Cave at four sites (figure 1), from 2003 and 2007; and 2014 and 2015 are shown in figures 2 and 3 (DWER 2019; Humphreys and Brooks 2015).

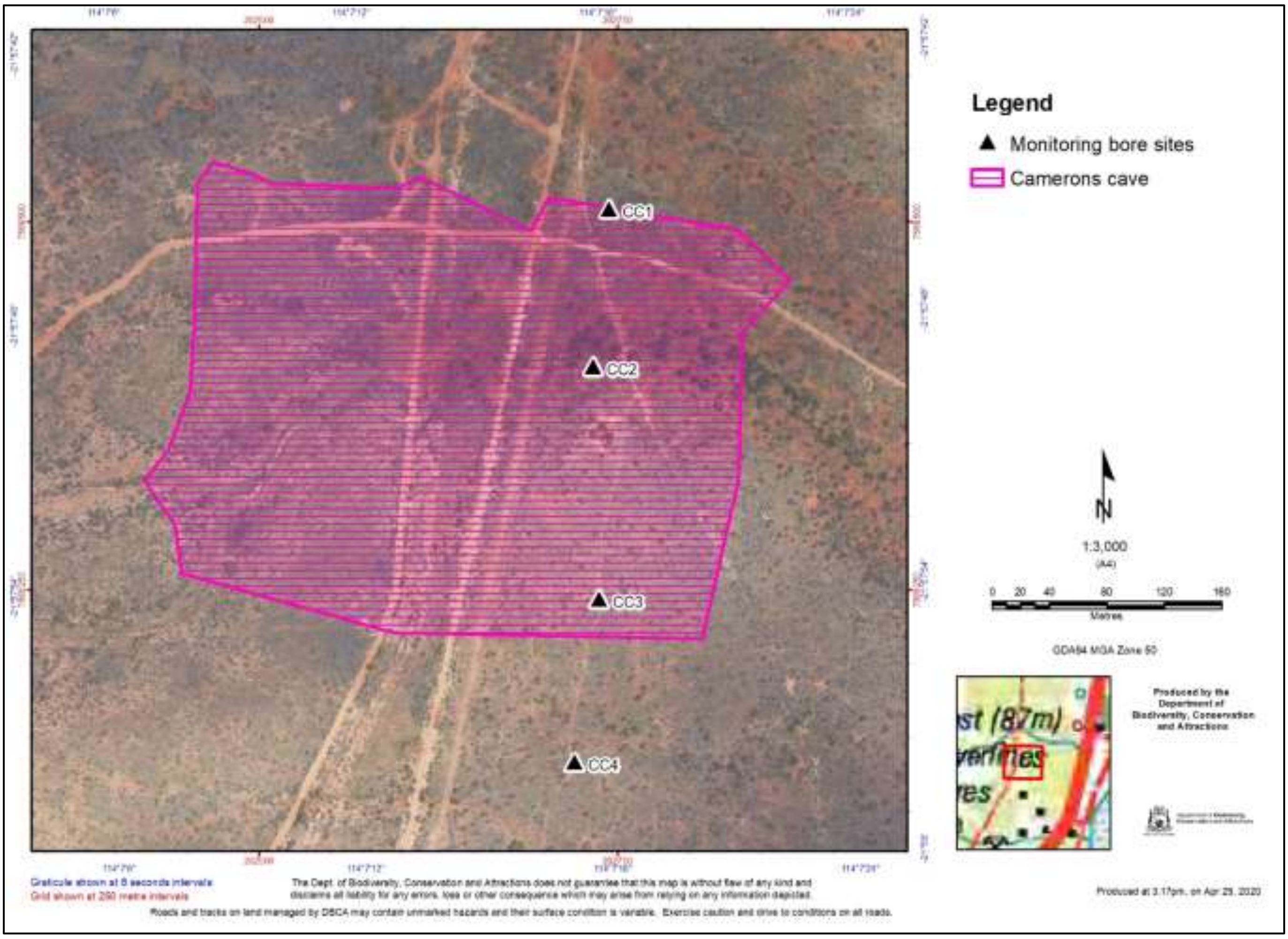


Figure 1. Locations of four bores monitoring groundwater salinity levels at Camerons cave.

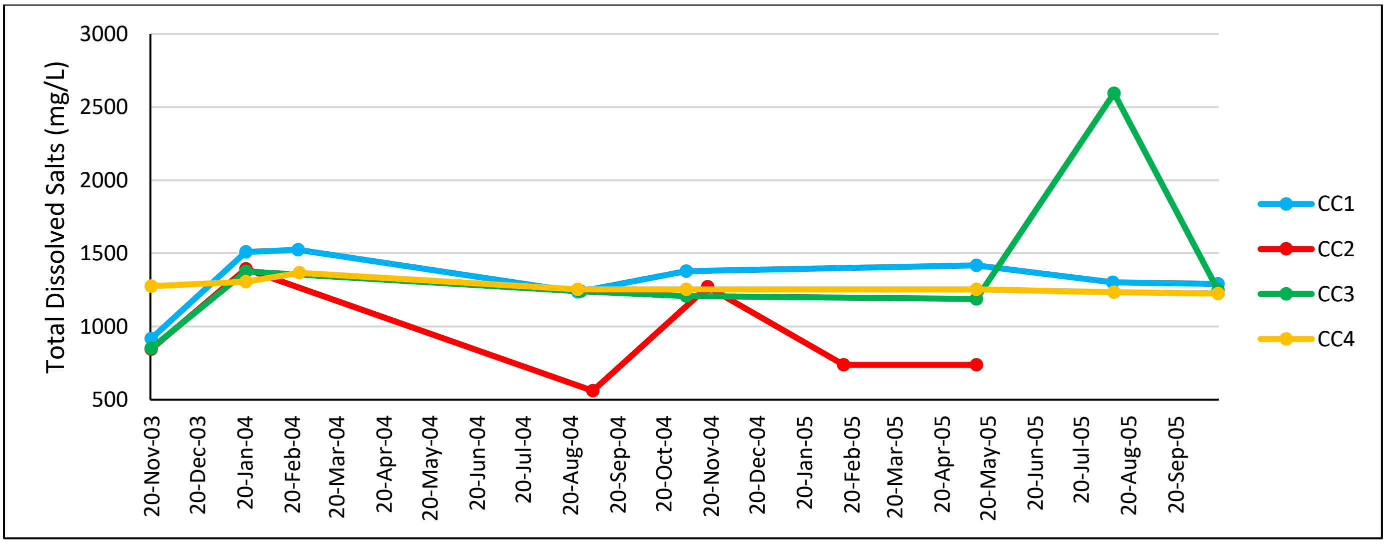


Figure 2. Salinity (Electrical Conductivity) of Camerons Cave at 4 sites between 2003 and 2005 (DWER 2019).

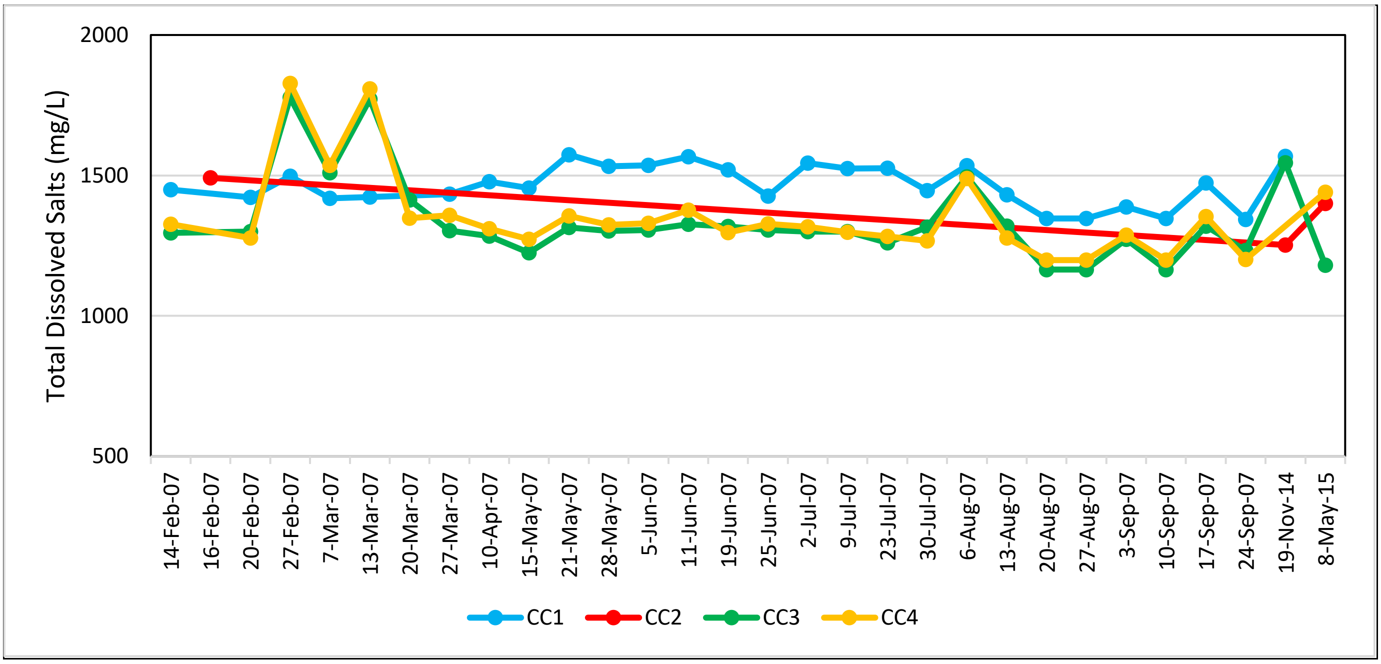


Figure 3. Salinity (Electrical Conductivity) of Camerons Cave at 4 sites in 2007, 2014 and 2015 (2007 data from DWER 2019; 2014/15 data from Humphreys and Brooks 2015).

Groundwater monitoring by B. Humphreys and D. Brooks in 2014 and 2015 indicate that the deepest bore associated with Camerons Cave (series CC1 to CC4) is about 7.5 m. Salinity was not high at depth (maximum PSS 1.77 recorded from CC1 in November 2014; 1.5 from CC3 and CC4 in May 2015) (Figure 3). All the bores, including the shallower holes, had low dissolved oxygen states in November 2014 with strongly negative redox values (to -211 mV). Following two cyclones in May 2015 (Olwyn and Quang), only CC4 had negative oxygen reduction potential (ORP) values and these were only slightly negative indicating an apparent recharge of oxygenated water. This is evident in the mean state of oxygenation where major changes to groundwater quality are apparent. This could result from direct local recharge, or increased groundwater flow. The latter is likely associated with the lack of local karst features and the widespread change in oxygenation (Humphreys and Brooks 2015).

The Department of Water and Environmental Regulation allocates and manages groundwater in Western Australia. On the Cape Range Peninsula the licensing of all groundwater abstraction has been compulsory since the 1999 groundwater allocation plan was released, however this may change in the future. Groundwater licensing is the responsibility of the DWER's Mid-West Gascoyne district office in Carnarvon. DWER proposed to discontinue licensing of domestic bores in Exmouth. The North West Cape Karst Management Advisory Committee (NWCKMAC) have expressed support for continued licensing and monitoring. Current arrangements will continue until a new management plan is released and changes made.

Monitoring undertaken for Camerons Cave by DWER and DBCA through the original borehole sampling had two purposes. These were to determine the extent of fauna at the cave, and to clarify the significance of the cave system to the continued survival of the Camerons Cave community. Monitoring originally included examining water profiles and water depth but the program was only planned to be short-term and was ceased in 2006. Ad hoc sampling still occurs and DWER and Water Corporation have discussed reinitiating periodic sampling. Sampling in 2014 and 2015 by Humphreys and Brooks recovered terrestrial cave fauna (troglobionts), including *Stygiochiropus peculiaris* (troglobiont millipede), and oniscidean isopods, from Camerons Cave (C-452). *Milyeringa veritas*, a stygobiont, was recorded in Camerons Cave for only the third time. The species was also recorded in 1992 and 2008 (Humphreys and Brook 2015).

The Groundwater allocation plan – Exmouth groundwater subarea (WRC 1999) was developed to establish the limits for allocating groundwater and the policies for licensing abstraction. It provides the framework for the department to sustainably allocate and licence groundwater in the Exmouth subareas. In the area around Cameron's Cave (Exmouth Central subarea) water allocation is restricted to within the allocation limits (currently 86% allocated 2010) and restrictions to the location of draw points, and the volume pumped are applied to minimise the impacts on the groundwater-dependent ecosystems and inland movement, or upconing, of saline water.

Bennelongia (2008) state that groundwater management will have little effect on troglofaunal communities in the Exmouth area, but a series of data that conflict with this conclusion were apparently not considered in that report. For example, Bennelongia (2008) does not discuss epikarst, which is now considered a major source of biodiversity. Various references indicate that small perched aquifers may be very important for stygofauna (eg Pipan *et al.* 2006; Pipan 2007a and b).

Physical disturbance

There is proposed clearing of 42 hectares for the construction of a distribution line servicing for Exmouth. This community is within the application area. Possible issues that could arise are; the use of heavy vehicles and the subsequent installation of the powerline will require rock-breaking activities. Coastal Karst area – cave roof is not very thick also. Vegetation clearing will act as a vector for weeds – common weeds such as buffel grass (*Cenchrus ciliaris*). An access track will be created which will likely encourage weed invasion, and will require rehabilitation.

Chemicals such as insecticide used around the poles in the vicinity of the cave may enter the cave. Re-levelling will be needed during construction to ensure surface waterflow is maintained.

Horizon Power have agreed to implement DBCA recommendations where possible. These include;

1. Proposed projected is located further from Camerons cave community than the existing transmission line and will position new poles as far away from the cave entrance as possible.

2. Horizon power will implement standard chemical storage, handling and spill management practises during construction through a project specific EMP to mitigate direct and indirect impacts to Camerons cave community from potential contamination.

3. The access track along the proposed project will be required, however, the track will be for maintenance only with restricted use. Horizon Power will minimise the use of heavy vehicles within the Camerons cave community buffer zone.

Uncontrolled access to Camerons Cave

As the cave is located in a residential area of Exmouth Township, it is readily accessible to people and vehicles. Uncontrolled vehicle or heavy machinery activity or building on-site, particularly directly above the cavity, or explosives used too close to the cave, could cause surface subsidence or partial cave collapse.

People entering the subterranean cavity of the cave could also disturb the habitat and fauna, however, a lockable gate is installed at the entrance of the cave.

A drilling rig has driven along the rim of the cave to establish the bores, and this track needs to be rehabilitated as Camerons Cave should be a walk-in site.

DBCA has developed a draft cave and karst policy, that recommends the development of a cave classification system on DBCA land. Camerons Cave should be designated for scientific purposes and have highly restricted access.

Pollution and/or dumping of rubbish or toxic waste in Camerons Cave

Camerons Cave and the troglobitic community could be threatened by contamination from nutrients, toxic substances or other waste originating from point or diffuse sources. The thin soil cover, typical of karst areas, provides little filtration of percolating fluids making such areas prone to contamination. In addition, the open conduit hydrological systems permit the rapid and distant spread of any contaminants such as nutrients or toxins introduced to the system. As the flushing of groundwater in the arid Cape Range area is exceptionally low, the residence time of contaminants would be long (Humphreys *et al*. 1999). The introduction of energy, via nutrients entering subterranean systems, changes the energy balance and enhances the competitive abilities of epigean organisms, allowing them to displace hypogean organisms that are adapted to a low energy environment (Humphreys *et al*. 1999). Hence, these ecosystems are sensitive to pollution.

The risk of waste dumping and pollution will increase if access to the site and urban, rural, industrial or recreational development in the immediate area is not controlled.

There are three potential aquatic sources of nutrients ([redacted][1] pers. comm.). These are:

1. Freshwater lens – karst movement, determined by cracks in the ground

2. Marine intrusion – marine influence and downstream effects of land use

3. Freshwater influx from seasonal rainfall.

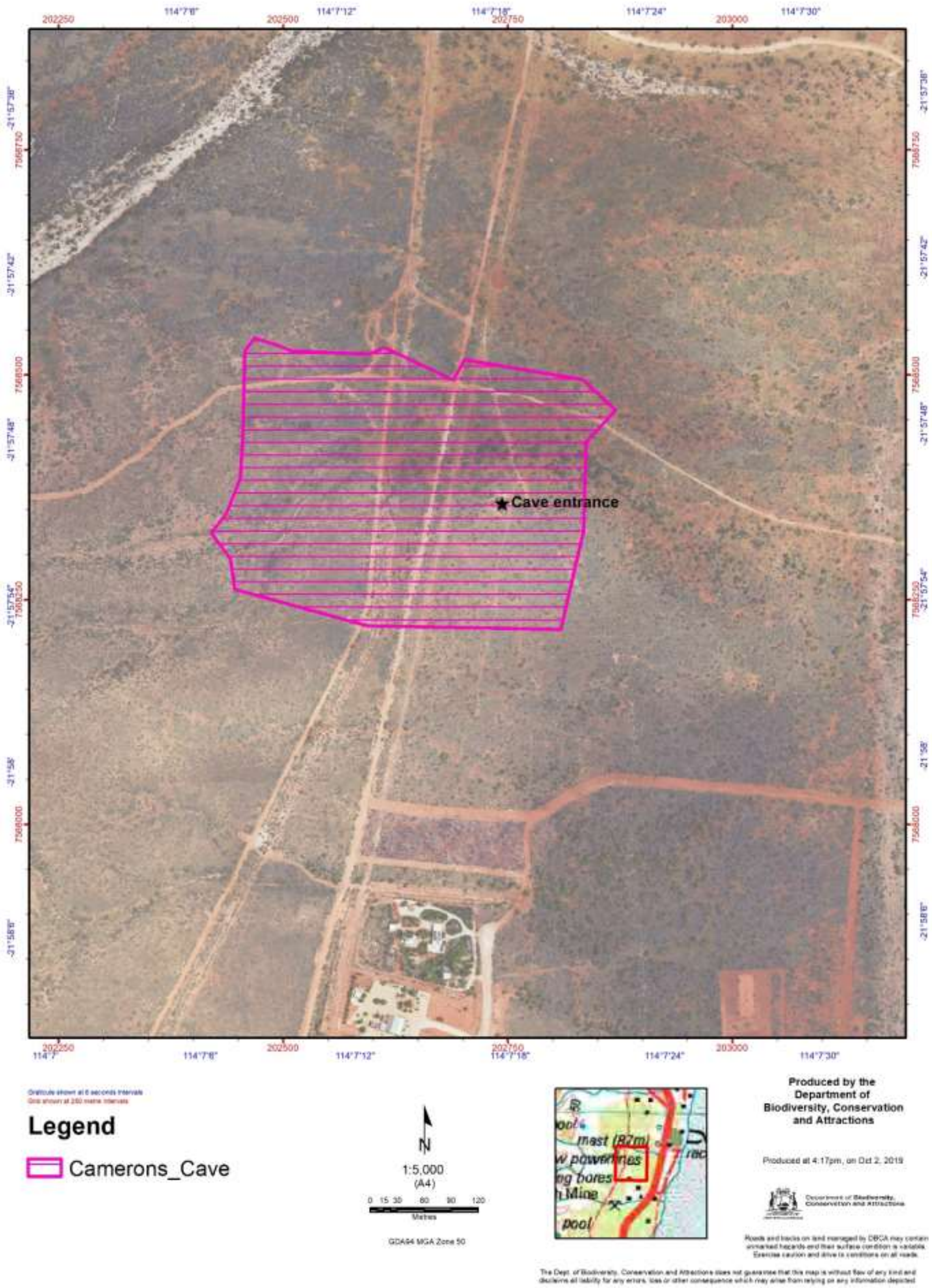
Little pollution of the groundwater of the Cape Range peninsula, either from point sources (e.g. petrol tanks) or diffuse sources (e.g. fertilisers) was observed in 1994 (Humphreys 1994) but the current status is unknown.

Introduction of feral fish

Introduced omnivorous invasive fish, such as guppies (*Poecilia reticulata)*, inhabit an exposed part of the anchialine system. The fish have the potential to introduce a lethal parasite (Asian fish tapeworm) to the cave fish population Guppies could also become permanent inhabitants of the subterranean parts of the ecosystem and threaten the gobioid fish and potentially other fish populations (Humphreys 2010).

[1] [redacted]: previously, Water Corporation

APPENDIX 2: Distribution Map



References

Bennelongia Pty Ltd (2008) Stygofauna Survey - Exmouth Cape Aquifer: Scoping Document Describing Work Required to Determine Ecological Water Requirements for the Exmouth Cape Aquifer (prepared for Department of Water). Bennelongia Pty Ltd, Jolimont.

Brown & Root Services Asia Pacific Pty Ltd (2000). Exmouth Wellfield: Stygofauna Monitoring and Water Column Profiling. Year 2 June 1999 – March 2000. Prepared for Water Corporation, Geraldton Regional Office.

Brown & Root (2001). Exmouth wellfield: Stygofauna monitoring and water column profiling. Year 3, July 2000 - April 2001. Report PN9008-GC-003. Brown & Root Services Asia Pacific Pty Ltd, Victoria Park.

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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:					
			Relative severity (%)		
		Extent (%)	≥ 80	≥ 50	≥ 30
C1	The past 50 years based on change in an <u>abiotic</u> variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:	≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		
			≥ 80	≥ 50	≥ 30
C2	The next 50 years, or any 50-year period including the present and future, based on change in an <u>abiotic</u> variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:	≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		
			≥ 90	≥ 70	≥ 50
C3	Since 1750 based on change in an <u>abiotic</u> 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		

D. Disruption of biotic processes or interactions over ANY of the following time periods:					
			Relative severity (%)		
		Extent (%)	≥ 80	≥ 50	≥ 30
D1	The past 50 years based on change in a <u>biotic</u> variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:	≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		

			≥ 80	≥ 50	≥ 30
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	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