GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Nomination

Current conservation status				
Name of ecological community:	Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale floristic region			
Other names:	Coomberdale Chert			
Description:	The community occurs on ridges and slopes of the chert hills of the Coomberdale floristic region. It was originally described in Griffin E.A. (1992) "Floristic survey of remnant vegetation in the Bindoon to Moora area, Western Australia" (Agriculture Western Australia Resource Management Technical Report 142, Perth). It encompasses 7 vegetation alliances including the core units and 3 vegetation alliances of the buffer units of the Coomberdale Chert community. Vegetation alliances include *Allocasuarina campestris* (sheoak) shrubland, *Allocasuarina microstachya* scrub, *Regelia megacephala* (priority 4) shrubland, *Kunzea praestans* shrubland and scrub, *Melaleuca calyptroides* heath, *Hibbertia subvaginata* shrubland and *Xanthorrhoea drummondii* shrubland on ridges and slopes of the chert hills of the Coomberdale floristic region.			
Nomination for:	Listing under BC Act ☐	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	Current ranking under WA Minister ESA list in policy	6/11/2001	Endangered	B) ii)
	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'.*		CR B1a(iii),b
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 is assumed to collapse when the mapped distribution declines to zero. • Clearing for agriculture in the Shire of Moora has been extensive with less than 12% (88% decline) of the original Coomberdale vegetation remaining (DPAW Comprehensive Adequate Representative (CAR) Reserve Analysis 2007). It is assumed that this is based on decline of vegetation units mapped by J.S. Beard that comprise the community. Trudgen *et al.* (2006) notes that "the Noondine Chert has suffered significant clearing, apparently greater than 60% in the Marchagee to Moora area, with the [vegetation] types on the lower slopes (mostly dominated by *Allocasuarina campestris*) being preferentially cleared". Historical clearing was for activities including gravel extraction, tracks and roads, trees for fence posts, grazing paddocks in the less rocky areas, and small-scale mining. • The distribution of the community is considered to have declined by 60-88% since 1750, which is greater than the ≥50% threshold of distribution decline for VU. • **Vulnerable and Endangered are plausible 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 137km^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 a) iii) A spatial imagery Normalised Difference Vegetation Index (NDVI) analysis between 1989 and 2019 indicates a continuing decline in the canopy cover and quality of the vegetation in this community (Robertson 2019). See Appendix 3 for further detail. • B1b): Threatening processes include vegetation clearing, grazing by introduced herbivores, weed invasion, too frequent fire and herbicide and artificial fertilizers are likely to cause continuing declines in

		environmental quality and biotic interactions within the next 20 years (see Appendix 1 for details of threats). • B1c) Community is considered to consist of 3 threat defined locations, based on the identification of 3 clusters of the community that may be subject to similar threats such as those that affect a particular bushland location such as grazing, or too frequent fire. (threshold for CR is 1 and for EN is 5 threat-defined locations). • B2: AOO- the community covers 4 grid cells – greater than the 2 grid cell threshold for CR. The community meets EN under criterion part B2 for which the AOO threshold is 20 grid cells (b and c of B1 are the same for B2). • B3: community is considered to consist of 3 threat defined locations, based on the identification of 3 clusters of the community that may be subject to similar threats such as those that affect a particular 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 – such as too frequent fire, and thus capable of collapse or becoming CR within a short time period. • **Meets CR B1a(iii),b. Meets EN under B1c, B2a(iii),b,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.	• Substrate loss from mining and gravel extraction is a significant abiotic threat to the community. • For criterion C, collapse is conservatively considered to represent removal of the 80% of the substrate of the community. • The extent of the community that has been subject to mining or other impacts that result in substrate removal has not been determined. • **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.	• The impacts of grazing including removal and damage to vegetation is a significant biotic threat to the community. • Collapse in relation to criterion D is conservatively considered to be loss of 80% of vegetation cover as a consequence of grazing. • The extent and severity of vegetation damage and loss across the community related to grazing is not known. • Currently, there are inadequate quantitative data that indicate vegetation loss and damage as a consequence of grazing 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 Vulnerable using ranking criteria developed in WA that do not match 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	137 km^2	AOO	400 km^2 (4 10x10km grid method).
No. locations	65	Severely fragmented	Yes ☒ No ☐ Unknown ☐ Fragmentation due to clearing for agriculture
Current known area			785.4 ha
Pre-industrialisation extent or its former known extent (if known)			Not known
Estimated percentage decline			Clearing for agriculture in the Shire of Moora has been extensive with 60-88% decline of the original Coomberdale vegetation (Trudgen *et al.* (2006); DPAW Comprehensive Adequate Representative (CAR) Reserve Analysis 2007).

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	EN-VU	• The distribution of the community is considered to have declined by 60-88% since 1750, which meets the 50% threshold of distribution decline for VU-EN • Plausible range VU - EN under A3
B1a	CR	• EOO is <2,000km^2 • NDVI analysis of vegetation decline provides a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem. • Meets CR under B1a(iii)
B1b	CR	• EOO is <2,000km^2 • Ongoing threats contributing to vegetation decline • Meets CR
B1c	EN	• EOO is ≤2,000km^2 • Three threat-defined locations • Meets EN
B2a	EN	• AOO is 4 grid cells • NDVI analysis indicating vegetation decline provides a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem. • Meets criterion for EN under B2a(iii)
B2b	EN	• AOO is 4 grid cells • Ongoing threats contributing to vegetation decline • Meets EN
B2c	EN	• AOO is 4 grid cells • Ecosystem exists at 3 threat-defined locations. • Meets EN
B3	VU	• Known from 3 threat-defined locations • Prone to the effects of grazing, weeds, and inappropriate fire regimes; vegetation clearing and inferred changes to hydrological regime • Meets 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	-	• Inadequate evidence to indicate the community meets 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	-	• Inadequate evidence to indicate the community meets 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.
		Vulnerable and Endangered are plausible under A3. Plausibly meets CR B1a(iii),b. Meets EN under B1c, B2a(iii),b,c. Meets VU under 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 under B1a(iii),b**

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
CH02 (1)	Nature Reserve (DBCA) for conservation of flora and fauna UCL (Department Regional Development and Lands) Private land (farmlands) Mineral tenement (northern section on private property)	Quadrats and relevés (Trudgen *et al*. 2006)	good to very good (northern) Very good to excellent (Cairn Hill)	142ha of [proposed] Nature Reserve 4ha of UCL 95ha of private 65ha of private (mining) Total: 241ha	Grazing, vegetation clearing (for mining), inappropriate fire regimes, weed invasion	Seek to improve tenure security, rehabilitation of gravel pits - Cairn Hill, determine and implement appropriate fire management strategy, manage grazing impacts, control weeds
Chert2b (2)	Private land (farmlands)	Relevé (Trudgen et al. 2006)	Poor to very poor	11.6	Grazing, inappropriate fire regimes, weed invasion	Seek to improve tenure security, determine and implement appropriate fire management strategy, manage grazing impacts, control weeds
CH06 (3)	Private land (farmlands)	Quadrats and relevés (Trudgen *et al.* 2006)	Mostly very good to excellent	56.8	Grazing, inappropriate fire regimes, weed invasion	As above
Chert4 (4)	Private land (mining tenement)	Quadrats and relevés (Trudgen *et al*. 2006)	Good to excellent	92	Vegetation clearing (for mining), grazing, inappropriate fire regimes, and weed invasion	As above
Chert5a (5)	Private land (mining tenements and farmlands)	Quadrats and relevés (Trudgen *et al*. 2006)	Ranges from degraded	45.89	Vegetation clearing (for mining), grazing, inappropriate	As above

			to excellent		fire regimes, weed invasion	
Chert6 (6)	Water Corporation (water supply) Road reserve	Griffin (1992, 1994)	Highly disturbed. Some pockets of good condition	12ha of Water Corporation 1ha of Road reserve Total: 13	Inappropriate fire regimes, weed invasion	As above
Chert7 (7)	Watheroo National Park (DBCA) Small portion on road reserve Small portion on private land	Griffin (1992, 1994)	Mostly good to very good.	46.6ha National Park (DBCA) 3ha on road reserve 1ha on private land Total: 50.6	Grazing, inappropriate fire regimes, weed invasion.	Seek to improve tenure security of remaining portion determine and implement appropriate fire management strategy, control weeds
Chert8 (8)	Private land (farmlands)	Griffin (1992, 1994)	Unknown	9.8	Grazing, inappropriate fire regimes, weed invasion	Seek to improve tenure security, determine and implement appropriate fire management strategy, manage grazing impacts, control weeds
Chert9 (9)	Private land (mining tenement)	Relevés (Trudgen et al. 2006)	Mostly poor to good, some degraded	12.5	Grazing, inappropriate fire regimes, weed invasion	As above
Chert2a (10)	Private land	Relevés (Trudgen et al. 2006)	Degraded	5.3	Grazing, inappropriate fire regimes, weed invasion	As above
Chert11 (11)	Private land	Relevés (Trudgen et al. 2006)	Poor to good	4.8	Grazing, inappropriate fire regimes, weed invasion	As above
Chert12 (12)	Private land	Relevés (Trudgen et al. 2006)	Very poor to good	1.6	Grazing, inappropriate fire regimes, weed invasion	As above
Chart13 (13)	Private land	Relevés (Trudgen et al. 2006)	Good	1.47	Grazing, inappropriate fire regimes, weed invasion	As above

Chert14 (14)	Private land	Relevés (Trudgen et al. 2006)	Good	0.69	Grazing, inappropriate fire regimes, weed invasion	As above
Chert15 (15)	Private land	Relevés (Trudgen et al. 2006)	Good to very good	2.9	Grazing, inappropriate fire regimes, weed invasion	As above
Chert16(16)	Private land	Relevés (Trudgen et al. 2006)	Poor to very good	13.71	Grazing, inappropriate fire regimes, weed invasion	As above
Chert17 (17)	Private land	Relevés (Trudgen et al. 2006)	Good to very good	4.09	Grazing, inappropriate fire regimes, weed invasion	As above
Chert18 (18)	Private land	Relevés (Trudgen et al. 2006)	Poor to good	2.66	Grazing, inappropriate fire regimes, weed invasion	As above
Chert19 (19)	Private land	Relevés (Trudgen et al. 2006)	Very poor to good	11.88	Grazing, inappropriate fire regimes, weed invasion	As above
Chert20 (20)	Private land	Relevés (Trudgen et al. 2006)	Poor to very good	5.43	Grazing, inappropriate fire regimes, weed invasion	As above
Chert 21 (21)	Private land	Relevés (Trudgen et al. 2006)	Very poor to very good	8.89	Grazing, inappropriate fire regimes, weed invasion	As above
Chert 22 (22)	UCL (Department Regional Development and Lands), pastoral/grazing lease	Relevés (Trudgen et al. 2006)	Very poor to poor, some good	1.5	Grazing, inappropriate fire regimes, weed invasion	As above
Chert 23 (23)	Private land	Relevés (Trudgen *et al*. 2006)	Poor to very good	6	Grazing, inappropriate fire regimes, weed invasion	As above
Chert 24 (24)	Private land	Relevés (Trudgen *et al*. 2006)	Poor to very good	4.9	Grazing, inappropriate fire regimes, weed invasion	As above
Chert 25 (25)	Private land	Relevés (Trudgen *et al.* 2006)	Poor to good	3.7	Grazing, inappropriate	As above

					fire regimes, weed invasion	
Chert26 (26)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor to poor	1.77	Grazing, inappropriate fire regimes, weed invasion	As above
Chert27 (27)	Private land	Releves and quadrats (Trudgen et al. 2006)	Good to very good	0.3	Grazing, inappropriate fire regimes, weed invasion	As above
Chert28 (28)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Range from poor to very good	13.35	Grazing, inappropriate fire regimes, weed invasion	As above
Chert29 (29)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Range from poor to very good	1.49	Grazing, inappropriate fire regimes, weed invasion	As above
Chert32 (30)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	0.12	Grazing, inappropriate fire regimes, weed invasion	As above
Chert33 (31)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Range from poor to very good	5.69	Grazing, inappropriate fire regimes, weed invasion	As above
Chert40 (32)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	1.47	Grazing, inappropriate fire regimes, weed invasion	As above
Chert41 (33)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	0.43	Grazing, inappropriate fire regimes, weed invasion	As above
Chert42 (34)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	0.64	Grazing, inappropriate fire regimes, weed invasion	As above
Chert43 (35)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good	1.37	Grazing, inappropriate fire regimes, weed invasion	As above
Chert45 (36)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	1.21	Grazing, inappropriate fire regimes, weed invasion	As above
Chert46 (37)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	0.24	Grazing, inappropriate fire regimes, weed invasion	As above

Chert47 (38)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	0.32	Grazing, inappropriate fire regimes, weed invasion	As above
Chert48 (39)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor to poor	1.98	Grazing, inappropriate fire regimes, weed invasion	As above
Chert49 (40)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor to poor	1.96	Grazing, inappropriate fire regimes, weed invasion	As above
Chert50 (41)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor	1.15	Grazing, inappropriate fire regimes, weed invasion	As above
Chert51 (42)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor	2.47	Grazing, inappropriate fire regimes, weed invasion	As above
Chert52 (43)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Degraded to very poor	0.43	Grazing, inappropriate fire regimes, weed invasion	As above
Chert53 (44)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor to poor	0.28	Grazing, inappropriate fire regimes, weed invasion	As above
Chert54 (45)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good	1.77	Grazing, inappropriate fire regimes, weed invasion	As above
Chert55 (46)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Very poor to poor	0.36	Grazing, inappropriate fire regimes, weed invasion	As above
Chert56 (47)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good	0.09	Grazing, inappropriate fire regimes, weed invasion	As above
Chert57 (48)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good to very good	1.43	Grazing, inappropriate fire regimes, weed invasion	As above
Chert58 (49)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good to very good	0.397	Grazing, inappropriate fire regimes, weed invasion, proposed	As above

					clearing for mining.	
Chert59 (50)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Degraded to very good	3.88	Grazing, inappropriate fire regimes, weed invasion	As above
NorthKiaka01 (51)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Degraded to poor	45.29	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka02 (52)	Private land	Relevés (Trudgen et al. 2006)	Good to poor	3.21	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka03 (53)	Private land	Relevés (Trudgen et al. 2006)	Degraded to very poor	11.35	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka04 (54)	Private land	Relevés (Trudgen et al. 2006)	Degraded to very poor	5.6	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka05 (55)	Private land	Relevés (Trudgen et al. 2006)	Good to degraded	11.69	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka06 (56)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Good to very good with very small area in poor condition	11.39	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka07 (57)	Private land	Relevés (Trudgen et al. 2006)	Poor	1.76	Grazing, inappropriate fire regimes, weed invasion, proposed	As above

					clearing for mining.	
NorthKiaka08 (58)	Private land	Relevés (Trudgen et al. 2006)	Poor	0.55	Grazing, inappropriate fire regimes, weed invasion, proposed clearing for mining.	As above
NorthKiaka09 (59)	Private land	Relevés (Trudgen et al. 2006)	Very poor to very good	6.19	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka10 (60)	Private land	Relevés (Trudgen et al. 2006)	Poor to good	3.47	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka11 (61)	Private land	Relevés and quadrats (Trudgen et al. 2006)	Poor to good	2.64	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka12 (62)	Private land	Relevés (Trudgen et al. 2006)	Very poor to good	0.72	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka13 (63)	Private land	Relevés (Trudgen et al. 2006)	Good to very poor	1.78	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka14 (64)	Private land	Unmapped by Trudgen et al. 2006	Unmapped by Trudgen *et al*. 2006	3.82	Grazing, inappropriate fire regimes, weed invasion and proposed clearing for mining.	As above
NorthKiaka15 (65)	Private land	Relevés and quadrats	Poor to very poor	13.66	Grazing, inappropriate fire regimes,	As above

		(Trudgen et al. 2006)			weed invasion and proposed clearing for mining.	

APPENDIX 1 THREATS

Vegetation clearing

Clearing for agriculture in the Shire of Moora has been extensive with less than 12% of the original Coomberdale vegetation remaining (DPAW Comprehensive Adequate Representative (CAR) Reserve Analysis 2007). Trudgen *et al.* (2006) notes that "the Noondine Chert has suffered significant clearing, apparently greater than 60% in the Marchagee to Moora area, with the [vegetation] types on the lower slopes (mostly dominated by *Allocasuarina campestris*) being preferentially cleared". Historical clearing was for activities including gravel extraction, tracks and roads, trees for fence posts, grazing paddocks in the less rocky areas, and small-scale mining. Current and future clearing is likely to be associated with chert mining, and mining tenements currently exist over occurrences 4, 5 and 9.

Some of the substrate on which the Coomberdale Chert community occurs is currently being mined as it is the best, most suitable quality chert resource in Western Australia (EPA 2001). At present, occurrence 4 is being mined with long-term plans for mining other occurrences in negotiation. Mining proposals are subject to assessment by the Environmental Protection Authority in accordance with the *Environmental Protection Act 1986.*

Mining for chert requires the complete removal of vegetation, which apparently cannot then be regenerated on the sites mined or on waste dumps due to the change to the soil profile and overall loss of substrate (Trudgen *et al.* 2011). The Environmental Protection Authority (2001) noted "Rehabilitation trials thus far have shown that *Regelia* can be successfully regenerated but individual plants are unlikely to survive in the long term in the modified environment after mining, although the seed can be sustained" (EPA, p. 1).

On the occasions where *Regelia megacephala* has been successfully regenerated in waste rock material, after a number of years *R. megacephala* has been outcompeted by *Allocasuarina* species. This is because *Regelia megacephala* is specifically adapted to growing in the very fine joints of the unmined chert rock and can send its roots for a long distance into very fine spaces. When grown on waste rock, other plants that are not able to grow on the undisturbed rock, can grow more rapidly and out compete the *Regelia megacephala.* It is believed however, that the regeneration of *Regelia megacephala* is still valuable as it generates an ongoing source of seed and maximises maintenance of genetic diversity within *Regelia* populations (Robinson 2001).

It is not possible to replace the substrate on which the Coomberdale Chert community relies, post-mining, therefore it is important to seek long term conservation of important occurrences. Conservation initiatives should focus on protecting areas from disturbance and adding areas to the conservation reserve system. The mining company currently mining the chert has continued to rehabilitate waste dumps but has experienced a number of difficulties doing so. Details of the rehabilitation program, including difficulties experienced and recommendations, are elaborated in Trudgen and Adam (2011). Regeneration techniques such as returning the topsoil and controlling weeds may be useful in reducing native species loss and provide linkages and buffers for remaining Coomberdale Chert community occurrences.

The mining company currently operating in the area has carried out additional reconnaissance exploration to identify other parts of the Coomberdale Chert, both within and outside current lease areas, which may contain sufficiently high grade quartz in areas where the Coomberdale Chert community is already absent or is completely degraded. Three of the currently mapped occurrences (6, 7 and 8) were not surveyed by M. Trudgen, and other areas outside of the immediate community area which appear to be a continuation of the Noondine Chert Formation according to geological maps were also not surveyed.

Other impacts associated with mining include the clearing of grid lines for exploration and vehicle movements which can spread weed seeds or crush and compact vegetation and soil (Trudgen *et al*. 2006).

Grazing

The grazing of plant communities such as the Coomberdale Chert community can cause alterations to species composition through the selective removal of the more palatable species, soil compaction and erosion, and the introduction of weed seed and nutrients.

Trudgen *et al.* (2006) notes that the lower shrubs, herbs and sedge layers located on the edges of occurrences that are not rocky and where the vegetation is more open, are heavily impacted by livestock. Observations on-ground also suggest that areas dominated by *Allocasuarina campestris* are more heavily affected by grazing than areas dominated by *Kunzea praestans* (Trudgen *et al*. 2006). The least affected areas were generally those dominated by *Regelia megacephala* as they are mostly dense vegetation and very rocky, making access more difficult for livestock.

Grazing contributes to the introduction and spread of weeds via animal faeces, paws, hooves and coats, and can also lead to the trampling and compaction of soil and smaller plants. Grazing and subsequent weed invasion can have a negative effect on native species regeneration after fire or other disturbances (Trudgen *et al*. 2006).

Most occurrences of the Coomberdale Chert community have been or are still actively grazed and the impact of this grazing has not been quantified through monitoring. Current grazing pressures are from both native animals such as kangaroos and emus, which are often restricted to unnaturally small areas due to roads, paddocks and fences, as well as livestock and rabbits. Occurrences completely fenced off from livestock include occurrences 1, 3 and 7 and most of the southern portion of occurrence 5.

Weed invasion

Weeds can have significant impacts on vegetation through competition with the native species, prevention of regeneration and alteration of fire regimes (Hobbs and Mooney 1993). Disturbances such as fires and grazing can predispose areas to weed invasion if weed propagules are present. All of the occurrences of the Coomberdale Chert community are close to agricultural areas which act as a weed source through carrying agents including wind and animals, and are vulnerable to weed invasion following any disturbance. Occurrence 4 in particular experiences a great deal of soil movement due to the mining and associated tracks and trucks.

Trudgen *et al*. (2006) identified twenty-five weed species in the survey area. Most of the weeds recorded are not highly aggressive species, however, the number of weed species recorded was high. The edges of occurrences and occurrences rated as poor condition appear to be more affected by weed species (Trudgen *et al*. 2006).

A weed control program may be necessary to maintain or improve the current condition of occurrences of the community in the long term.

Altered fire regimes

Bushfires or prescribed burns must occur at appropriate intervals, and if possible at the appropriate season and intensity, to sustain the integrity of plant communities.

The risk of fire is generally increased by the presence of grassy weeds in the understorey which are likely to be more flammable than the naturally occurring herb layer. Many of the weeds recorded in the Coomberdale Chert community are in fact grassy weeds (Trudgen *et al*. 2006). The disturbance caused by fires can also provide optimum opportunities for weed species to outcompete native species, however, the disturbance caused by fire can promote diversity (Knox *et al*. 2001).

It may be possible that the species composition within occurrences of the Coomberdale Chert community has been affected by long periods of fire absence. Research into the ecological attributes and fire responses of this community is therefore important in ensuring the most appropriate burning regime is adopted.

Drying climate needs to be considered when designing appropriate fire regimes. It is likely that reduced rainfall will cause diminishing growth rates, and plant maturation times may also increase. Longer inter-fire intervals may therefore be required under such scenarios.

The Department of Parks and Wildlife fire records based on satellite imagery since 1972 suggest that there have been no fires through the Coomberdale Chert community since 1972. Some private landholders, however, have records of fires occurring since 1972. A fire swept through occurrence 5 in December 1981 damaging the community ([redacted] personal communication[1]). Hamilton-Brown (2000) suggested that some of the species have still not recovered from the 1981 fire, including *Regelia megacephala.* No post fire assessment, however, has been carried out to confirm and determine the factors responsible for the apparent loss of species. A lightning strike started a fire in occurrence 4 in 2009 ([redacted], personal communication, 2011[2]). Many of the other occurrences on private property have had a fire interval of at least 13-20 years ([redacted], personal communication[3], 2011).

Herbicide and artificial fertilizers

Trudgen *et al*. (2006) noted that the cropping of agricultural lands involves the use of herbicides and artificial fertilisers. There is potential for overspray of herbicides into the community to cause death or weakening of susceptible species including soil fungi and associated symbiotic relationships. Fertilisers favour weeds as they are adapted to higher nutrient levels. There are also a small number of disused rubbish dumps within occurrences and these "are often foci for the introduction of weeds into native vegetation and can also be a localised source of pollutants" (Trudgen *et al*. 2006 p. 106).

Hydrological change

There is potential for the dewatering in order to mine below the watertable. The potential for hydrological change due to dewatering to affect the community is not known and requires investigation. There are groundwater level data up only available until the 1990s.

[redacted]

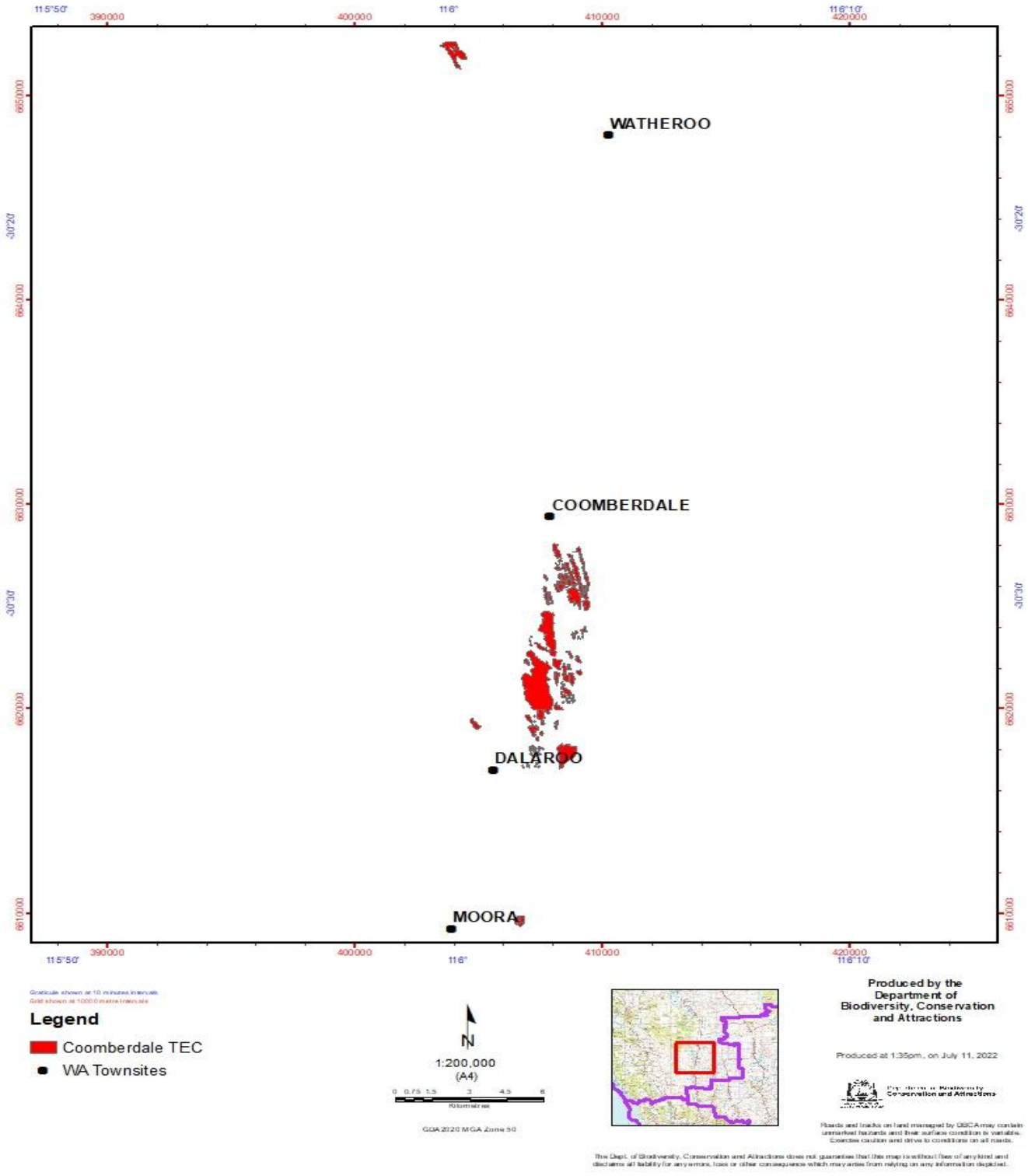
Climate drying

Change in climate may affect various components of the community type. Reduced rainfall and altered hydrology may have a detrimental effect on the community. Dry periods may cause poor germination/recruitment of annuals as well as a poor flowering and seed set.

CSIRO data indicate decreases in winter and spring (and annual) rainfall are projected with high confidence. There is strong model agreement and good understanding of the contributing underlying physical mechanisms driving this change (southward shift of winter and spring storm systems).

According to data provided by the CSIRO, early in the century (2030) and under all emission scenarios, winter rainfall is projected to decrease by up to 15 per cent. Late in the century, intermediate emissions (RCP4.5) lead to a projected decrease in winter rainfall of up to around 30%, and under high emissions (RCP8.5) winter rainfall decline is projected to decrease by up to 45%. Changes in autumn and summer are less clear, although downscaling results suggest a continuation of the observed autumn declines. (https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSWSW&tooltip=true&popup=true)

APPENDIX 2 Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale floristic region (red)



The map above was created using ArcGIS version 10.6.1 and shows the extent of distribution of the 'Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale floristic region' community. This community has a range of 43.5km, with the southernmost occurrence at Moora and the northernmost at Watheroo. The figure indicates occurrences of the community are highly fragmented.

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

Vegetation cover assessment for "Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale floristic region" using satellite imagery (April 2020)

Pierre-Louis Robertson – Department of Biodiversity, Conservation and Attractions

Introduction

The community occurs on ridges and slopes of the chert hills of the Coomberdale floristic region. It was originally described in Griffin E.A. (1992) "Floristic survey of remnant vegetation in the Bindoon to Moora area, Western Australia" (Agriculture Western Australia Resource Management Technical Report 142, Perth). It encompasses 7 vegetation alliances including the core units and 3 vegetation alliances of the buffer units of the Coomberdale Chert community. It was assessed by the TEC Scientific Advisory Committee in 2001 as Endangered due to the ongoing impacts of clearing, grazing, weed invasions, altered fire regimes and introduced fauna. The community occurs over 65 occurrences that cover a total of 785.4 ha.

In the past 50 years there have been significant technological advances in the usage of satellites for gathering remote sensing data. The development of specialised multispectral cameras has been instrumental in gathering critical data regarding our environment on a global scale. One of the most widespread applications of this technology has been the use of remote sensing data for vegetation mapping and monitoring. Healthy plants absorbs a lot of visible light and reflect a large portion of near-infrared light, whereas unhealthy or sparse vegetation absorbs more visible light and reflects less near-infrared light. The most common method for visualising vegetation cover changes is through the use of Normalised Difference Vegetation Index (NDVI).

The objective of this study was to perform a vegetation cover analysis of the Coomberdale floristic community using NDVI datasets from satellite imagery to provide an estimate of vegetation cover density changes from 1989 to 2019.

Methods

Study Area

This study area comprised the 65 occurrences of the Coomberdale floristic community situated in the state of Western Australia. This area represents an area of 785.4 ha.

Datasets

The exact location of the Coomberdale threatened ecological community (TEC) was sourced from the Department of Biodiversity, Conservation and Communities TEC database.

The satellite imagery was sourced from the Landsat 5 and Landsat 8 satellites which are archived and freely available from the U.S Geological Survey website. Imagery from late January was selected as it represents the southern hemisphere summer, which is the harshest season for vegetation in Western Australia and data will therefore show the maximum extent of vegetation degradation. The specific dates used were the 28/01/1989 and the 31/01/2019. The imagery was processed to take into account atmospheric disturbance and cloud cover.

Data analysis

The satellite imagery data was analysed within ArcMap version 10.6.1 and QGIS version 2.18.16. NDVI rasters with 30m x 30m grid cells were created with the ArcMap Image Analysis function and bands 3 and 4 from the Landsat imagery which represent the red band and infra-red bands respectively. The symbology was then classified into 5 distinct classes of increasing vegetation density ranging from 0.0 to 0.5 NDVI.

The NDVI data was then imported in QGIS and the raster statistics from the distinct classes were exported with the Semi-Automatic Classification plugin into a CSV table to be summarised.

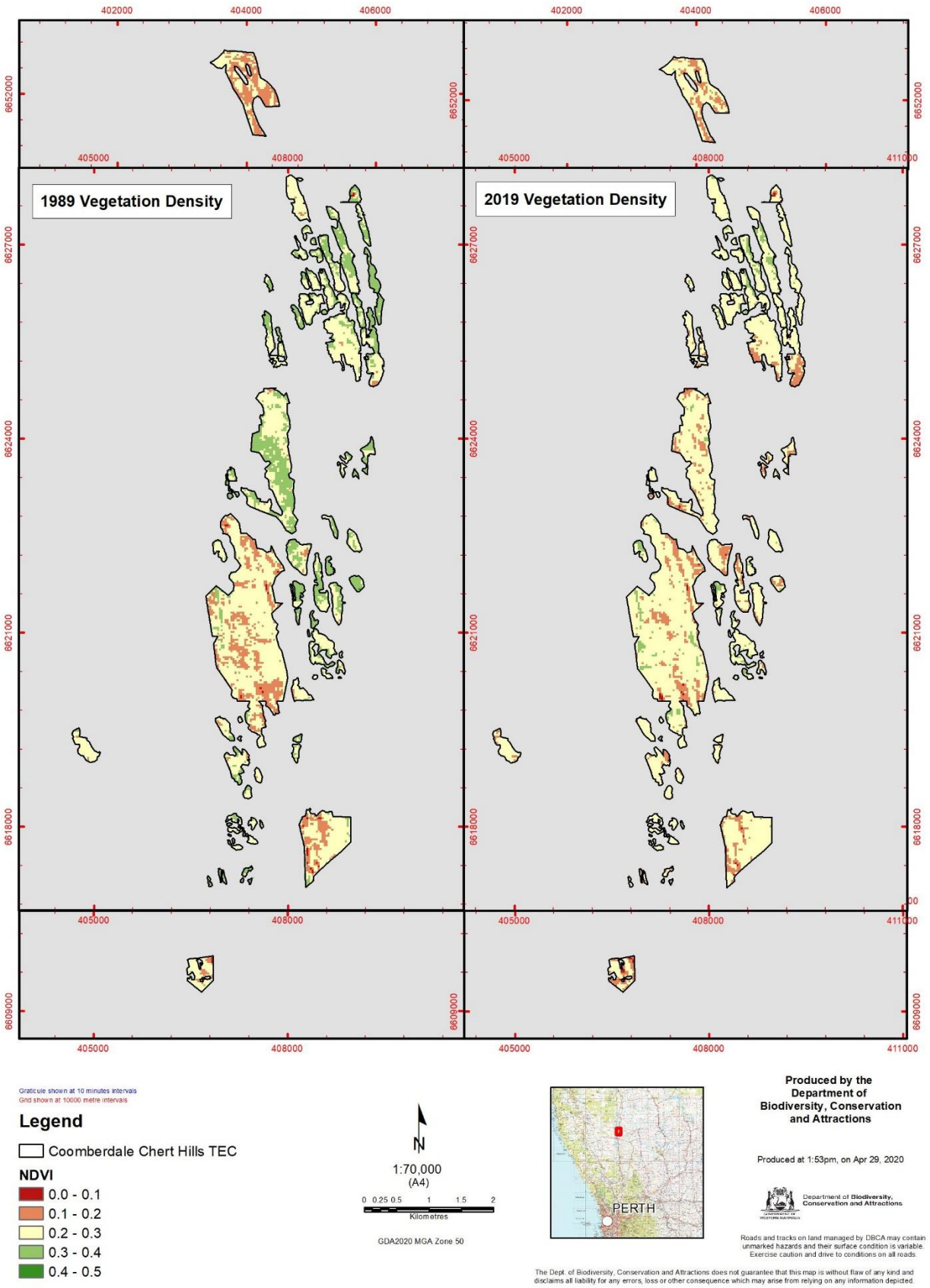
Results

NDVI analysis over 30 years indicates that there was a significant degradation of vegetation density and health between 1989 and 2019.

The most notable changes were for the high vigour 0.3 to 0.4 NDVI class which experienced a 79% decline in area. This decline is mainly concentrated in the central eastern occurrences. Overall, this area has transitioned from large areas of low vegetation density with small remnant pockets of high vigour vegetation to a system completely dominated by low vegetation density.

Table 1. NDVI satellite imagery classification and area

		1989 Landsat imagery		**2019 Landsat Imagery**	
NDVI	Vegetation Density	Area (ha)	Percentage	Area (ha)	Percentage
0.0 – 0.1	Bare soil	2.79	0.35 %	4.05	0.51 %
0.1 – 0.2	Very low	116.46	14.72 %	116.01	14.66 %
0.2 – 0.3	Low	463.41	58.58 %	627.03	79.26 %
0.3 – 0.4	Medium	208.26	26.33 %	44.01	5.56 %
0.4 – 0.5	High	0.18	0.02 %	0.00	0.00 %



NDVI INTERPRETATION

0 – 0-1	Bare soil
0.1 – 0.2	Almost absent canopy cover
0.2 – 0.3	Very low canopy cover
0.3 – 0.4	Low canopy cover, low vigour or very low canopy cover, high vigour
0.4 – 0.5	Mid-low canopy cover, low vigour or low canopy cover, high vigour

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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 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 abiotic 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 abiotic 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 abiotic 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 biotic 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		
D3			≥ 90	≥ 70	≥ 50

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