Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status				
Name of ecological community:	Plant assemblages of the Moonagin System as originally described in Beard (1976)			
Other names:				
Description:	The community occurs on the fine-grained Archaean rocks of the Moonagin and Milhun Ranges. It comprises *Acacia* spp. scrub on red soil on the summits and slopes of the hills; *Acacia* spp. scrub with scattered *Eucalyptus loxophleba* (York gum) and *Eucalyptus oleosa* (giant mallee) on red loam flats on the foothills; and *Eucalyptus loxophleba* woodland on red loam flats of the pediments. The community was originally described in Beard J.S. (1976) "The vegetation of the Perenjori area, Western Australia: Map and explanatory memoir" (1:250,000 series, Vegmap Publications, Perth, Western Australia).			
Nomination for:	Listing ☐	Change of status ☒	Delisting ☐	
1. *Is the ecological community currently on any conservation list, either in a State or Territory, Australia or Internationally?* 2. *Is it present in an Australian jurisdiction, but not listed?*	*Provide details of the occurrence and listing status for each jurisdiction in the following table*			

Jurisdiction	**List or Act name**	**Date listed or assessed (or N/A)**	**Listing category eg. critically endangered (or none)**	**Listing criteria eg. B1ab(iii)+2ab(iii) (or none)**
National	EPBC Act			
Western Australia	Threatened list; under WA Minister ESA list in policy	6/11/2001	Vulnerable	B)
	Priority list		1 ☐ 2 ☐ 3 ☐ 4 ☐	
Other State/Territory				

Nominated conservation status: category and criteria (include recommended status for deleted ecological communities)				
Critically endangered (CR) ☒	Endangered (EN) ☐	Vulnerable (VU) ☐	Collapsed (CO) ☐	
Priority 1 ☐	Priority 2 ☐	Priority 3 ☐	Priority 4 ☐	None ☐

What criteria support the conservation status category for listing as a threatened ecological community or collapsed ecological community? *Refer to Section 32 of the Biodiversity Act 2016 for definition of 'Collapsed', and Appendix 3 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 was assumed to collapse when the mapped distribution declines to zero. • It is estimated that sixty per cent of the Moonagin System remains (ie 40% decline), and much of the remaining area of the community has been modified. • The timing of the clearing is not known but may have occurred in the last 50 years. The clearing is, however, conservatively assumed to have occurred since 1750. According to the interim recovery plan, (Department of Conservation and Land Management (CALM) 2002)) the extent of the community has declined by 40%. This is less than the ≥50% threshold of decline in distribution to meet VU. There is insufficient evidence to support an inference that the threshold ≥ 30% reduction in geographic distribution has or will occur over any particular 50-year, or the ≥50% since 1750 to meet the category VU under criterion A1, A2. • **Does not meet criterion A**
B.	Restricted geographic distribution *(EOO and AOO, number of locations and evidence of decline)*	☒ **B1** (specify at least one of the following): ☐ **a)(i)** ☐ **a)(ii)** ☒ **a)(iii)** ☒ **b)** ☐ **c);** ☒ **B2** (specify at least one of the following): ☐ **a)(i)** ☐ **a)(ii)** ☐ **a)(iii)** ☒ **b)** ☐ **c);** ☐ **B3 (only for Vulnerable Listing)**
	Justification of assessment under Criterion B.	• B1: EOO is 80.8km^2 (≤2,000km^2). The community's EEO is less that the ≤2,000km2 threshold to meet rank CR. • B1 a) iii) A spatial imagery NDVI analysis between 1989 and 2019 revealed that there has been a continuing decline in the canopy cover and quality of the vegetation for this community (Robertson, 2019). See Appendix 4 for further detail. • B1 b): Continuing decline is inferred from the impacts from impacts of grazing, weed invasion, land clearing, altered fire

		regimes and drying climate that are likely to cause declines in geographic distribution, environmental quality or biotic interactions within the next 20 years (see Appendix 1 for details of threats). • B1 c) Community is considered to occur at 3 threat-defined locations, based on the identification of 3 clusters of the community that are likely to be subject to similar threats that affect a particular bushland location such as weed invasion, inappropriate fire regimes, and vegetation and soil damage and loss from grazing. The community meets EN under B1c) as the threshold for CR is ≤1 and for EN is ≤5 threat-defined locations. • B2: AOO. Community covers 5 grid cells. The community meets EN under criterion B2 for which the AOO threshold is ≤20 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 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 vegetation and soil damage and loss from grazing, weed invasion, and inappropriate fire regimes. 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 and thus capable of collapse or becoming CR within a short time period. • **Meets criteria for Critically Endangered for B1a(iii),b**
C.	Environmental degradation of abiotic variable *(Evidence of decline over 50-year period)*	☐ **C1** ☐ **C2** ☐ **C3**
	Justification of assessment under Criterion C.	• Damage to the substrate and soil loss, particularly as a consequence of grazing, represent a change to an abiotic variable that is a significant threat to the community. Removal of substrate for mining is also a potential threat as there is a mineral tenement over the northern portion of the community. • Collapse in this context is considered to be complete loss of surface soil across the extent of the community. The assumption is that complete loss of soil will result in loss of all characteristic vegetation of the assemblage and replacement with weeds or native species that can tolerate rock substrate. • The extent and severity of soil loss has not been measured. Quantitative data that would link loss of substrate with decline of the community are also not available. The extent and effects of substrate loss require further investigation. • **Insufficient evidence to indicate the community meets criterion C**
D.	Disruption of biotic processes or interactions	☐ **D1** ☐ **D2**

	(Evidence of decline over 50-year period)	☐ **D3**
	Justification of assessment under Criterion D.	• Vegetation loss through grazing is a significant biotic variable that threatens the community. • The severity of vegetation grazing associated with collapse is uncertain, but it is assumed conservatively that the community reaches a collapsed state when there is 80% loss of vegetation cover. • All occurrences are either currently, or were historically, grazed by sheep. This has caused alterations to the species composition by the selective grazing of edible species, the introduction of weeds and nutrients, trampling and general disturbance (Figure 1). No quantitative analysis has been completed for vegetation loss in the community but substantial loss is evident in aerial photographs and photographs taken within the community. • Currently, there are inadequate quantitative data 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 completed • **Not assessed**

Reasons for change of status

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

Provide details: The community was initially ranked as CR using ranking criteria developed in WA that differ to 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	80.8km^2	AOO	5 grid cells
No. occurrences	11	Severely fragmented (justification below)	Yes ☒ No ☐ Unknown ☐
Justification of whether fragmented	Has a naturally narrow endemic range and is considered highly fragmented. Natural fragmentation has been exacerbated by clearing of vegetation within and around occurrences.		
Current known area			2099ha
Pre-industrialisation extent or its former known extent (if known)			Original extent estimated at ~3,500ha.
Estimated percentage decline			40% (CALM 2002)

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	-	• The distribution of the community is considered to have declined by 40% since 1750, which is lower than the >50% threshold of distribution decline for VU. • Does not meet criterion
B1a	CR	• EOO is <2,000km^2 • Spatial imagery NDVI analysis showing vegetation decline provides a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem. • Meets criterion under B1a(iii)
B1b	CR	• EOO is <2,000km^2 • Observed and inferred continuing decline from vegetation and soil loss from grazing, weed invasion, land clearing, altered fire regimes and drying climate • Meets criterion for CR
B1c	EN	• EOO is <2,000km^2 • Ecosystem exists at 3 threat defined locations • Meets criterion for EN
B2a	EN	• AOO is 5 grid cells • Spatial imagery NDVI analysis showing vegetation decline provides a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem. Meets criterion under B2a(iii)
B2b	EN	• AOO is 5 grid cells • Observed and inferred continuing decline from a drying climate, de-watering, weed invasion, land clearing, altered fire regimes and introduced animal activity • Meets criterion for EN
B2c	EN	• AOO is 5 grid cells • Ecosystem exists at 3 threat defined locations • Meets criterion for EN
B3	VU	• Known from 3 threat-defined locations • Prone to the effects of soil and vegetation damage and loss from grazing, weed invasion, and altered fire regimes • Meets criterion for VU
C1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of degradation (30%) over the past 50 years to meet VU.
C2	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of degradation (30%) over any 50-year period to meet VU.
C3	-	• Does not meet the minimum thresholds for proportion of the extent (50%) or proportional severity of disruption of abiotic processes (50%) since 1750 to meet VU.
D1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of disruption of biotic processes (30%) over past 50 years to meet VU.
D2	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (30%) or proportional severity of disruption of biotic processes (30%) over any 50-year period to meet VU.
D3	-	• Does not meet the minimum thresholds for proportion of the extent (50%) or proportional severity of disruption of biotic processes (50%) since 1750 to meet VU.

E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Meets CR under B1a(iii),b. Meets EN under B1c, B2a(iii),b, B2c. 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 B1a(iii),b.**

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
GL36 (1)	Private Small portion managed by Shire of Morawa and Landgate	1999, 2007 and 2014	50% good and 50% degraded (2007) with northern tip of occurrence (On AC MIDWEST PTY LTD property) in excellent condition (2014)	739.2	Weed invasion, grazing, drying climate and road/rail maintenance	Maintain existing fencing, continue rabbit baiting program, eradicate goats, weed control, determine and apply appropriate fire regime
MILHUN1 (2)	Private Small portion managed by Department of Planning, Lands and Heritage (DPLH)	1999 and 2007	50% good and 50% degraded	1065.8	Weed invasion, grazing by native or introduced species, drying climate and clearing	Fencing, weed control, determine and apply appropriate fire regime
MILHUN2 (3)	Private	2007	50% good and 50% degraded	116	Weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN2 (4)	Private	2002, 2007 and 2014	100% Very good - excellent	45.6	Resource extraction, weed invasion, grazing, drying climate and clearing	As above
MOONAGIN3 (5)	Private	2007 and 2014	50% Very good - excellent	68.2	Weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN4 (6)	Private	2002 and 2007	100% good	4.1	Weed invasion, grazing by native or introduced species, drying climate and clearing	As above

MOONAGIN5 (7)	Private	2002 and 2007	100% good	5.8	Weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN6 (8)	Private	2002, 2007 and 2014	100% Very good-excellent	16.7	Resource extraction, weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN7 (9)	Private	2002 and 2007	100% good	4.6	Resource extraction, weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN8 (10)	Private	2002 and 2007	100% good	3.9	Resource extraction, weed invasion, grazing by native or introduced species, drying climate and clearing	As above
MOONAGIN9 (11)	Private	2014	100% Excellent	28.9	Resource extraction, weed invasion, grazing by native or introduced species, drying climate and clearing	As above

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

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

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

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

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

APPENDIX 1 THREATS

It is estimated that forty per cent of the Moonagin System has been cleared, and that much of the remaining area of the community has been modified. Threatening processes include:

Clearing

The Moonagin Range has been fragmented into eight smaller and one large occurrences as a result of clearing (for agricultural purposes) of the lower-lying areas. Occurrences; MOONAGIN2 (4), MOONAGIN3 (5), MOONAGIN4 (6), MOONAGIN5 (7), MOONAGIN6 (8), MOONAGIN7 (9), MOONAGIN8 (10) and MOONAGIN9 (11) were originally part of occurrence GL36 (1). The Milhun Range – located two km south east of the Moonagin Range – comprises two occurrences, originally one, but fragmented at the lower-lying area of the southern portion for road access. Occurrence MILHUN2 (3) was originally part of MILHUN1 (2).

Clearing for agriculture in the Shire of Morawa has been extensive but approximately 20% of the original vegetation remains ([redacted], pers. comm.[1]). Hillside vegetation has been moderately to severely impacted through passive clearing caused by grazing (feral and domestic), timber removal, weed invasion and edge effects.

No areas of the community occur within the conservation estate (nature reserves or national parks), and all occurrences are on private land. The northern half of occurrence GL36 (1), as well as MOONAGIN2 (4), MOONAGIN3 (5), MOONAGIN4 (6), MOONAGIN5 (7), MOONAGIN6 (8), MOONAGIN7 (9), MOONAGIN8 (10) and MOONAGIN9 (11), all are within a live mineral tenement.

Revegetating between remnants, initiated in 2014/15, is creating corridors and linkages to improve movement of fauna and flora between occurrences.

Grazing

All sites are either currently, or historically, grazed by sheep. This has caused alterations to the species composition by the selective grazing of edible species, the introduction of weeds and nutrients, soil damage, trampling and general disturbance (Figure 1).

Some fencing exists in the Moonagin Ranges and helps protect some occurrences from grazing impacts. The remnants are still subject to grazing by goats and rabbits, although a baiting program in 2014/15 resulted in a significant decrease in the rabbit population. Sensor camera monitoring over the period of February to June 2015 did not record any rabbits. Grazing pressure from kangaroos and euros can also impact on vegetation condition, with numbers increasing. Edible species include many of the *Acacia, Senna* and *Mirbelia* species; grasses, *Ptilotus* and many forbs.

Grazing has also removed ground cover and disturbed the land surface resulting in loss of soil through sheet erosion, rills and gully erosion.

[1] [redacted] Research Officer, Department of Agriculture.

Figure 1. Observable vegetation loss caused by overgrazing by introduced herbivores throughout the northern portion of the Moonagin community, captured in 2008 by [redacted].

In a 2018 visit to the community, parts of community were observed to be in very poor condition and close to collapse ([redacted] personal observation[2]). There was significant impact from grazing by goats.

Weed invasion

Weeds can have significant impacts on a community through competition with the native species, prevention of regeneration and alteration to fire regimes (Hobbs and Mooney 1993). Combined disturbances such as fires and grazing can predispose areas to weed invasion if weed propagules are present. All occurrences of this community are adjacent to agricultural areas that act as weed sources and are vulnerable to weed invasion following any disturbance.

Weed invasion has been observed around the margins of remnants of the community, as well as along drainage lines of these remnants. This is particularly noticeable at occurrence GL36 (1), where *Arctotheca calendula* (capeweed) is dense on the southwestern side.

Altered fire regimes

Fire can cause alterations to the species composition by increasing the number or density of weeds. In addition, an increase or decrease in the fire frequency can prevent species from completing growth and reproductive cycles.

Fertilisers from adjacent farmlands

Fertiliser overspray from adjacent farmlands can result in nutrient enrichment leading to increased weed invasion within the community.

[2] [redacted] Previously Senior Principal Research Scientist, DBCA Kensington

Climate variation

Climatic changes may affect various components of the community. Reduced rainfall 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 and Department of Meteorology 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 CSIRO and Department of Meteorology data, 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.

(URL https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSWSW&tooltip=true&popup=true: accessed October 2019)

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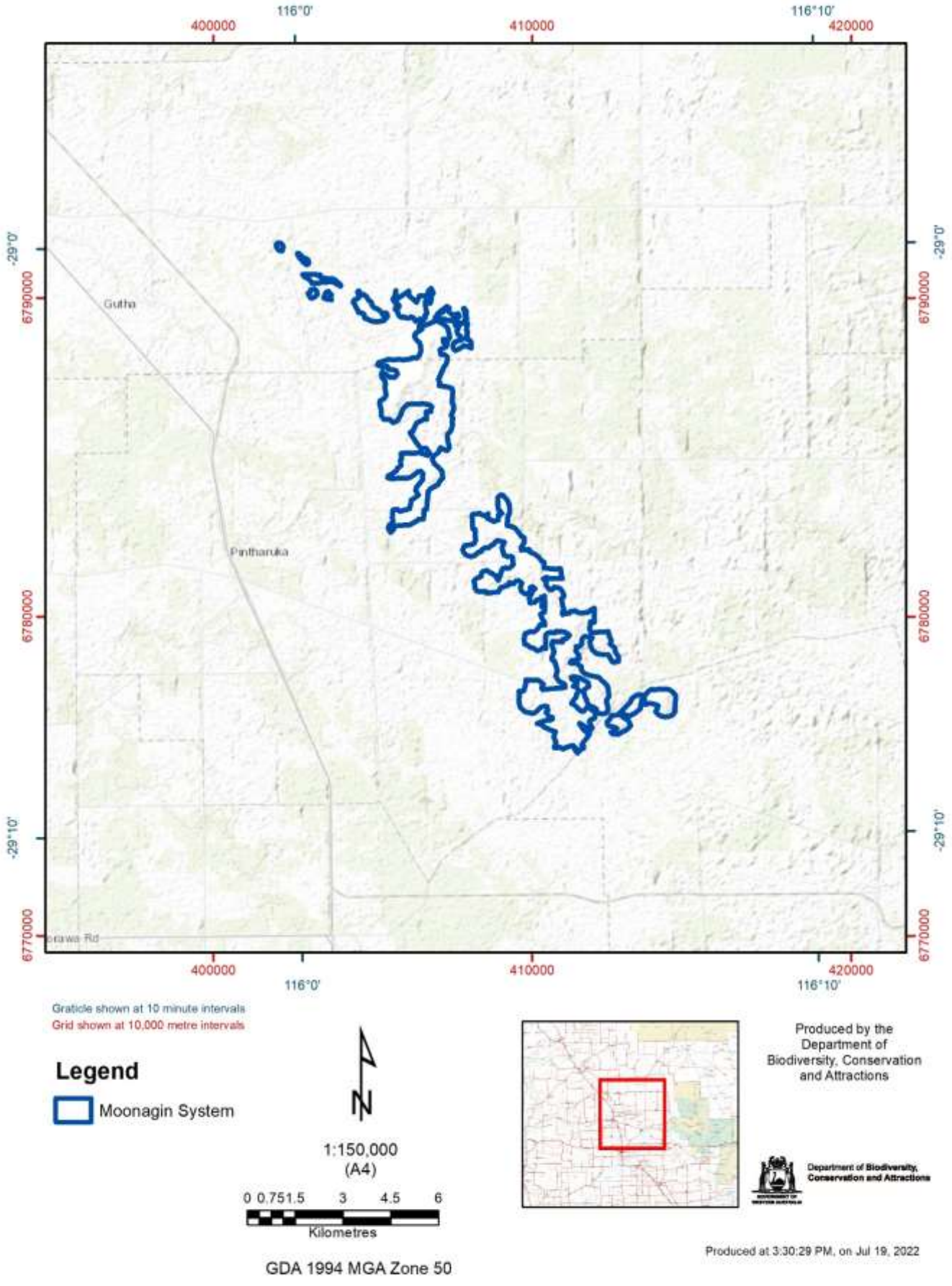
APPENDIX 2 Distribution of the Plant assemblages of the Moonagin System (brown)



The map above was created using ArcGIS version 10.6.1. The community has a range of 17km, located within Pintharuka, 18 km north west of Morawa. Occurrences of the community are fragmented and surrounded by agricultural lands.

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 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		≥ 90	CR	EN	VU

	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:	≥ 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		
			≥ 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

Appendix 4

Vegetation cover assessment for "Plant assemblages of the Moonagin System as described by Beard (1976)" using satellite imagery.

[redacted] – Department of Biodiversity, Conservation and Attractions
[redacted]

Introduction

The plant assemblages of the Moonagin System (Beard 1976) cover the fine-grained Archaean rocks of the Moonagin and Milhun Ranges. It was assessed by the TEC Scientific Advisory Committee in 1999 as Vulnerable due to the ongoing impacts of clearing, grazing, weed invasions and altered fire regimes. The community is present in 11 occurrences that cover a total of 2098 ha.

In the past 50 years there has 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 plant absorbs a lot of visible light and reflects 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 is through the use of Normalised Difference Vegetation Index (NDVI).

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

Methods

Study Area

Our study area comprised the eleven occurrences of the Moonagin community located on the Moonagin and Milhun Ranges situated in the state of Western Australia. This area represents an area of 2098 ha.

Datasets

The exact location of the Moonagin 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. We only selected imagery from March and April as they represent the southern hemisphere autumn, which is the harshest season for vegetation in Western Australia and will therefore show the maximum extent of vegetation degradation. The specific dates we used were the 17/03/1989 and the 05/04/2019. 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 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 6 distinct classes of increasing vegetation density ranging from -0.1 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

Our NDVI analysis over 30 years indicated that there has been some degradation of vegetation density and health between 1989 and 2019. The most notable change was for the sparsely vegetated 0.2 to 0.3 NDVI class which experienced a 59% decline in area. This decline is mainly concentrated in the northern occurrences. Overall the vegetation of this area has transitioned from a degraded area in roughly half of its range to an area which is significantly degraded over most of its range.

Table 1. NDVI satellite imagery classification and area.

		1989 Landsat imagery		**2019 Landsat Imagery**	
NDVI	Vegetation Density	Area (ha)	Percentage	Area (ha)	Percentage
-0.1 – 0.0	Bare soil	0.45	0.02 %	0.18	0.01 %
0.0 – 0.1	Bare soil	22.68	1.08 %	126.18	6.01 %
0.1 – 0.2	Very low	1591.02	75.74 %	1773.63	84.43 %
0.2 – 0.3	Low	484.65	23.07 %	199.26	9.49 %
0.3 – 0.4	Medium	1.80	0.09 %	1.35	0.06 %
0.4 – 0.5	High	0	0 %	0	0 %

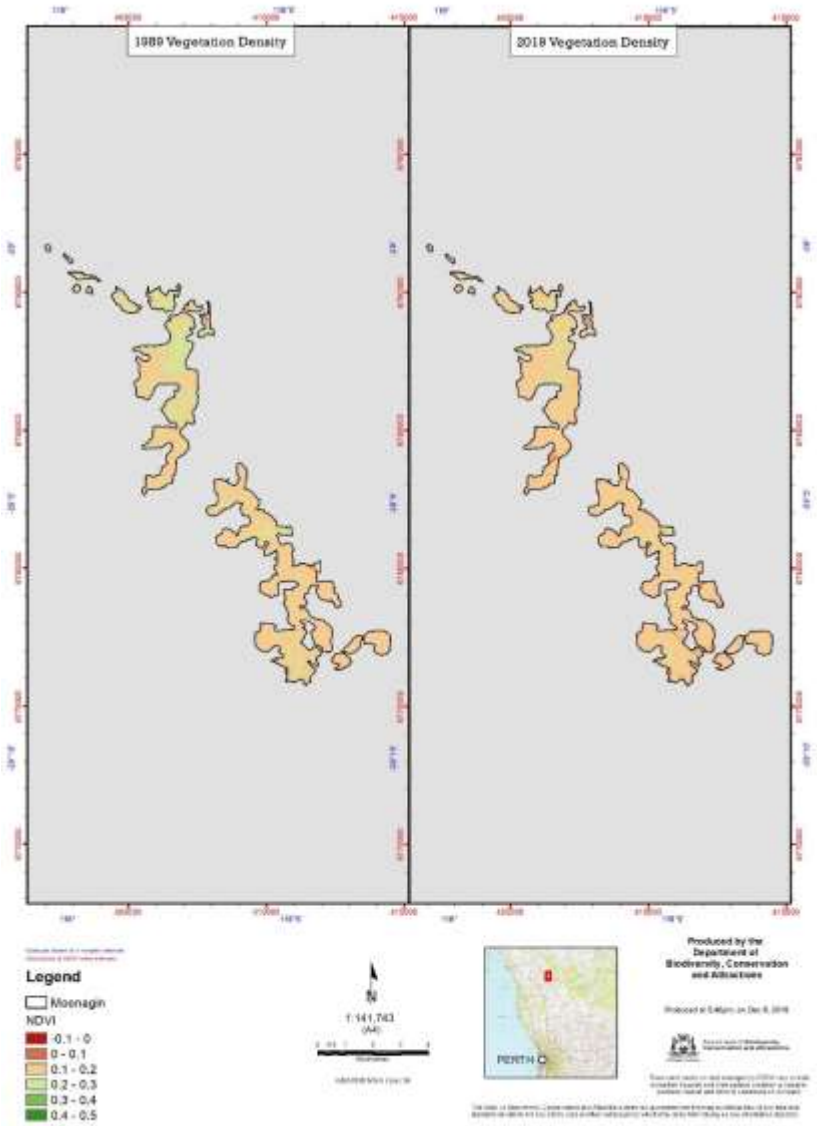


Fig. 1 – NDVI map of the Moonagin System TEC in 1989 and 2019. High NDVI values indicate denser and healthier vegetation (illustrated here in increasing shades of green).

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
0.5 – 0.6	Average canopy cover, low vigour or mid-low canopy cover, high vigour
0.6 – 0.7	Mid-high canopy cover, low vigour or average canopy cover, high vigour
0.7 – 0.8	High canopy cover, high vigour
0.8 – 0.9	Very high canopy cover, very high vigour
0.9 – 1	Total canopy cover, very high vigour