Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status				
Name of ecological community:	Scott River Ironstone Association			
Other names:				
Description:	The community occurs in a winter-wet habitat on red clay to clay loam often over massive ironstone on the Scott Coastal Plain. It mainly comprises heaths, shrublands and thickets and is variously dominated by *Melaleuca preissiana* (moonah), *Hakea tuberculata*, *Kunzea micrantha* or *Melaleuca incana* subsp. Gingilup, depending on the degree of waterlogging. The understorey is generally dominated by *Loxocarya magna* (priority 3). Most occurrences have very diverse annual flora of *Stylidium* spp. (triggerplants), *Centrolepis* spp., *Schoenus* spp., *Aphelia* spp. and other herbs. The community also contains a number of endemic and restricted taxa such as *Darwinia ferricola* (endangered), *Grevillea manglesioides* subsp. *ferricola* (priority 3), *Lambertia orbifolia* subsp. Scott River Plains (endangered) and *Melaleuca incana* subsp. Gingilup (priority 2).			
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	23/05/2013	Endangered	
Western Australia	TEC list: WA Minister ESA list in policy	29/11/2004	Endangered	B) iii)
	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'.*		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. • Gibson *et al*. (2000) determined from Tille and Lantzke (1990a,b) mapping of the ironstone substrate in the Scott River area that the original extent was 1,780 ha. It is assumed that the soil and landform mapping is indicative of the original extent of the community. • Community is currently known from 405 ha. As the timing of clearing is unknown, it is assumed that the clearing of 77% of the area of the community occurred since ~1750 (≥70% loss is threshold for EN under A3). Vegetation cover analysis also indicates that four occurrences (8.3ha, 2% of the total area) located on private property showing >50% loss of cover see appendix 3). This equates to a potential loss of 79%. • **Meets criterion EN under A3**
B.	Restricted geographic distribution *(EOO and AOO, number of locations and evidence of decline)*	☒ **B1** (specify at least one of the following): CR ☐ **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 189km^2 (≤2,000km^2). The community's EEO is less than the 2,000km^2 threshold for rank CR. Community meets threshold for rank CR under criterion part B1. • B2: AOO is four 10x10 km grid cells (threshold for EN is 20, and for CR is two grid cells). Community meets threshold for rank EN under criterion part B2. • a iii). Evidence indicates a decline in a measure of disruption to biotic interactions (loss of vegetation cover) to support ranking under B1a(iii) (see criteria D below) **Meets CR under B1a(iii). Meets EN under B2a(iii).** • B1b, B2b): There is observed or inferred continuing decline from vegetation clearing, grazing, weed invasion, too

		frequent fire, dieback disease, and future decline in environmental quality from hydrological changes, that are likely to cause continuing decline in the next 20 years (see Appendix 1 for further information on threats). **Meets CR under B1b. Meets EN under B2b.** • c): Community is considered to occur at three threat defined locations, based on the identification of three clusters of occurrences of the community that are likely to be subject to similar threats (including hydrological change associated with particular aquifers that support the community, or exposure to too frequent fires) (threshold for CR is one, for EN is five, and for VU is 10 threat-defined locations). **Meets EN under B1c, B2c.** • B3): Known from three threat-defined locations based on the identification of three clusters of occurrences of the community which are prone to effects of human activities or stochastic events (for example too frequent fires, hydrological change associated with particular aquifers) within a very short time period in an uncertain future and thus capable of collapse or becoming CR within a very short time period (meets VU as ≤5 threat defined locations). **Meets VU under B3.** **Meets criteria for critically endangered under B1a(iii), B1b. Meets EN under B1c, B2a(iii), B2b, B2c. Meets VU under B3.**
C.	Environmental degradation of abiotic variable *(Evidence of decline over 50-year period)*	☐ **C1** ☐ **C2** ☐ **C3**
	Justification of assessment under Criterion C.	• Hydrological change from groundwater abstraction and a drying climate in the form of rainfall and groundwater decline is an abiotic variable that is a significant threat to the community. • For criterion C, the assessment of decline in abiotic processes is based on hydrological change using data on the depth of the watertables. It was assumed conservatively that the community would collapse if the watertable depth fell to about 10.5 m below ground surface based on the maximum water depth accessed by deep rooted phreatophytic taxa in nearby areas (Froend and Loomes 2006), and observations that the vigour of canopies declined in groundwater dependent trees in association with declining watertable levels (Wilson and Froend 2010). • Determining hydrological risk is problematic due to the complexity of the underlying aquifers, and lack of data linking groundwater levels, flora composition and resilience. • The application of thresholds of severity of environmental degradation and severity in relation to collapse are therefore likely to be an over-simplification. • Groundwater levels in the Yarragadee, Lesueur Sandstone and Leederville aquifers are continuing to decline, while groundwater levels in the Superficial aquifer remain mostly stable, but with some localised areas of decline. A 50-year

		forecast of groundwater decline at occurrence MY4264WST (1.4% of the extent of the community) indicates the level at this location will fall below maximum root depth by 2040, potentially resulting in impacts to a number of species in this occurrence. • A 16% decline in the rainfall (long-term average) has been recorded for the South West Region over a hundred-year period. • It is expected that future changes to community from a decline in rainfall resulting from drying climate and higher temperatures will impact on the community. The likely relative severity of the changes and their impacts on the community is uncertain. • There are inadequate data to indicate community meets the minimum threshold for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50-year period to meet VU. • **Available evidence does not 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.	For criterion D, collapse of this community is defined as 100% loss of vegetation cover. • Grazing is a significant biotic variable affecting the community. Grazing of areas on private property has led to the extensive introduction of pasture weeds. Weeds have also invaded along tracks, firebreaks and road reserves. The assumption is made that impacts of grazing and weeds are measured by changes in vegetation condition. 70-80% of the community was considered in 'good' condition when last surveyed in 1999 to 2000, but these values are very approximate and based only on very broad assessments of condition. • Quantitative analysis by Van Dongen (2020; see Appendix 3) shows decline in vegetation canopy cover with 21% experiencing less than 30% loss, 8% of the community experiencing greater than 30% loss; and 10% experiencing greater than 50% loss in vegetation cover between 1988 to 2019. 61% of the community experienced minimal loss in vegetation cover between 1988 to 2019. • A threshold of is ≥50% of the extent of the community is required to be subject to ≥50% severity of disruption of biotic processes in any 50 year period to meet EN under D1 and D2. The analysis indicates that 10% of the community has been subject to ≥50% vegetation decline in 30 years (does not meet EN D1 or D2). • In any 50 year period, a threshold of ≥80% of the extent of the community must be subject to relative severity of ≥30%

		to meet VU under D1 and D2. The data indicate that 18.2% of the extent of the community has been subject to ≥30% severity of vegetation loss (ie 8.06+10.11%). • The threshold of ≥50% of the extent of the community subject to relative severity of ≥50% to meet VU under D3 is not met. • **Available data do not indicate the community meets criterion D.**
E.	Quantitative analysis *(statistical probability of ecosystem collapse)*	• No quantitative estimates of the risk of ecosystem collapse. • **Unable to assess**

Reasons for change of status

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

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

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

EOO	189km^2	AOO	Four 10x10 km grid cells
No. occurrences	25	Severely fragmented	Yes ☒ No ☐ Unknown ☐
Justification	Historical mapping indicates that the substrate that supports the community was historically restricted in extent. Land clearing has increased the fragmentation of this naturally restricted and fragmented community.		
Current known area			405ha
Pre-industrialisation extent or its former known extent (if known)			Tille and Lantzke (1990a,b) mapping of the substrate that supports the community indicates an original estimated area of ~1780ha.
Estimated percentage decline			It is estimated that 77% of the area of ironstone substrate that supports the community has been cleared.

Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Insufficient evidence to indicate if community meets criterion
A2a	-	• Insufficient evidence to indicate if community meets criterion
A2b	-	• Insufficient evidence to indicate if community meets criterion
A3	EN	• An estimated loss of 77% of the area of the plant community has occurred since ~1750. • Meets criterion for EN
B1a	CR	• Evidence indicates a decline in a measure of disruption to biotic interactions (loss of vegetation cover) to support ranking under B1aiii. • Meets CR B1a(iii)
B1b	CR	• EOO is ≤2,000km^2 • Observed or inferred threatening processes that are likely to cause continuing declines in environmental quality or biotic interactions within the next 20 years. Ongoing grazing and weed invasion are likely to continue to cause continuing declines in environmental quality and biotic interactions • Meets criterion for CR
B1c	EN	• EOO is ≤2,000km^2 • Ecosystem exists at three threat-defined locations • Meets criterion for EN
B2a	EN	• Decline in a measure of disruption to biotic interactions (loss of vegetation cover) support ranking under B2aiii. • Meets criterion EN B2aiii
B2b	EN	• AOO is four grid cells • Observed and inferred threats are likely to cause continuing decline within the next 20 years • Meets criterion for EN
B2c	EN	• AOO is four grid cells • Ecosystem exists at three threat-defined locations • Meets criterion for EN
B3	VU	• Known from three threat-defined locations • Prone to the effects of human activities or stochastic events within a short time period in an uncertain future • Meets criterion for VU
C1	-	• Inadequate evidence to indicate if the community meets the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over past 50 years to meet VU.
C2	-	• Inadequate evidence to indicate if 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 if 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	-	• Available evidence indicates the community does not meet the minimum thresholds for proportion of the extent (≥30%) and proportional severity of degradation (≥30%) over any 50-year period to meet VU.
D2	-	• Available evidence indicates the community does not meet the minimum thresholds for proportion of the extent (≥30%) and proportional severity of degradation (≥30%) over any 50-year period to meet VU.
D3	-	• Available evidence exists to indicate the community does not meet the minimum thresholds for proportion of the extent (≥50%)

		and proportional severity of disruption of biotic processes (≥50%) since ~1750 to meet VU.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Meets criteria for critically endangered under B1a(iii) and B1b. Meets Endangered under A3, B1c, B2a(iii) B2b,c. Meets VU under B3. *The highest risk category obtained by any of the assessed criteria will be the overall risk status of the ecosystem'* (IUCN RLE Guidelines V1.1 page 42). **Meets CR under B1a(iii),b**

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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
GSNR8 GSNR9	Nature reserve	2013	100% excellent Burnt 2001/2, 2011/12	59.9	Clearing for access tracks and firebreaks, pigs, frequent fire (*past, present, future*) Hydrological change, reduced rainfall (*future - apply to all occurrences*)	
SCOTT02NTH	Shire road reserve, UCL	2010	60% completely degraded 40% degraded	2.4	Road maintenance activities, weed invasion (*past, present, future*) Grazing and trampling (*past*)	
SR19 SRFE01 SRFE02	National Park, shire reserve (water, camping, recreation)	2019	50% pristine 50% excellent	20.4	Too frequent fire, weeds (*past, present, future*)	
MYDENIS01	Shire road reserve	2010	100% completely degraded	3.5	Road maintenance activities, weeds (*past, present, future*) Grazing and trampling (*past*)	
CHESTER01	Shire road reserve, nature reserve	2019	10% very good 90% excellent Burnt March 2018, still mostly excellent condition with areas of weed intrusion from edge effects	2.6	Grazing and trampling, recreational activities, off-road vehicles (*past, present, future*)	
MY4155STH	UCL	2010	85% completely degraded 15% very good	0.7	Grazing and trampling (kangaroos) (*past, present, future*) Grazing and trampling (cattle) (*past*)	
MY4155WEST	Private property	2019 (see appendix 3)	40% likely degraded (>50% loss of cover)	4.9	Weeds (*past, present, future*) Grazing and trampling (cattle, sheep), erosion (*past*)	
MY4155CNTR	Private property	2019 (see appendix 3)	80% likely highly degraded (>50% loss of cover)	1.7	Grazing and trampling, weeds (*past, present, future*)	
MY4155EAST	Private property	2019 (see appendix 3)	90% likely excellent	8.5	Grazing and trampling, weeds (*past, present, future*)	
MY4156 MYGVBMN4	DBCA freehold	2019	100% excellent (burnt 2015)	66	Grazing and trampling, too frequent fire (*past, present, future*)	Offset for mine

MYGVBMN5						obtained 2017. Fenced from kangaroo grazing
MY12951SE	Private property, shire reserve (water, camping, recreation)	2010	50% good 50% very good	16.1	Grazing and trampling, weeds (*past, present, future*)	
MY4264NTH MY4264STH	DBCA Freehold	2019	100% excellent	116	Grazing and trampling, too frequent fire, weeds, disease (*past, present, future*)	Land obtained ~15 years prior. Fenced for kangaroos
MY4262NTH	Private property	2019 (see appendix 3)	88% likely highly degraded (>50% loss of cover)	3.4	Grazing and trampling, fragmentation, weeds, clearing, too frequent fire (*past, present, future*)	Fenced
MY4262CN2	Private property	2019 (see appendix 3)	96% likely highly degraded (>50% loss of cover)	2.2	Grazing and trampling, fragmentation, weeds, clearing, too frequent fire (*past, present, future*)	
MY4262CN3	Private property	2019 (see appendix 3)	90% likely highly degraded (>50% loss of cover)	1.0	Grazing and trampling, fragmentation, weeds, clearing, too frequent fire (*past, present, future*)	
MYSCTRDW	Shire road reserve	2010	5% very good 95% excellent Burnt 1993/94	0.6	Road maintenance, altered surface drainage (*past, present, future*)	
MY42377	C class nature reserve	2018	100% excellent ~6ha burnt Dennis Rd fire (2/3/2017). Burnt area recovering well	48	Minor grazing (past, present, future)	
MYSCTRDW2	Shire road reserve	2003	95% pristine 5% excellent Burnt 1993/94	0.66	Road maintenance activities, frequent fire, disease (*past, present, future*)	
MYGOVBMN1 SRFE03	Crown reserve (camping, recreation, waterway), shire road reserve	2010 2003 (RR)	90% excellent 10% very good (road reserve)	4.6	Too frequent fire, road maintenance, disease, grazing (*past, present, future*)	
MYGVBMN2 MYGVBMS2	Shire road reserve	2019	100% very good (burnt 2008)	3.3	Stock movement, too frequent fire, road/utility maintenance (*past, present, future*)	
MYGVBMS3 SRFE04	Shire road reserve	2019	100% excellent	8.2	Clearing for farm access, too frequent fire, road/utility maintenance, grazing and trampling, disease, weeds (*past, present, future*)	
Dennis01	Shire road reserve	2012	100% good	0.3	Frequent fire, road maintenance, disease, firebreak/fenceline clearing (*past, present, future*)	

Dennis02	Shire road reserve	2012	100% good	0.3	Frequent fire, road maintenance, disease (*past, present, future*)	
BPointiron DentNP01 DentNP02 DentNP03	National Park, UCL, shire road reserve	2002	Burnt 2001/2 and 2011/12	24.6	Survey required	
MY4264WST	Private property	2013 2019 (see appendix 3)	60% good 40% degraded 30% likely highly degraded (>50% loss of cover)	5.6	Clearing, disease, grazing, frequent fire, weeds, stock access *(past, present, future)*	

*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 and native plant species diversity fully retained or almost so, zero or almost so weed cover/abundance, to 'Excellent' - Vegetation structure intact, with disturbance only affecting individual species, weeds are non-aggressive species, and the area contains high native plant species diversity, with less than 10% weed cover, and 'Very Good' - Vegetation structure altered, obvious signs of disturbance eg: from repeated fires, dieback, logging, grazing, aggressive weeds are present, with moderate native plant species diversity, and typical weed cover is less than 20% (5 – 20%).

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, logging, grazing, and very aggressive weeds are present, with low native plant diversity (5 – 50%).

Poor ('degraded', 'completely degraded' using Bush Forever (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 are present, very aggressive weeds are present at high density, and very low native plant species diversity is observed (20 – 70%) to 'Completely Degraded' where vegetation structure is no longer intact and the area is completely or almost completely without native flora, referred to also as 'Parkland Cleared', with very low to no native species diversity (weed species greater than 70%).

APPENDIX 1 THREATS

Vegetation clearing and physical disturbance

The Scott River Plain has recently been extensively cleared for agriculture and mining. A number of the remaining occurrences of the community are located on private property and not in secure conservation reserves (Gibson *et al*. 2000). Gibson *et al*. (2000) determined from Tille and Lantzke (1990a,b) mapping of the ironstone substrate in the Scott River area the original extent to be 1,780 hectares. Currently there are 405 hectares known, which represents an estimated loss of 77% of the area of the community. Road, track and firebreak maintenance activities such as creation of new firebreaks, grading of road reserves, road widening, spraying of chemicals, constructing drainage channels and mowing the roadside vegetation to improve visibility and reduce the fire risk, can result in vegetation loss or threaten the integrity of the community. In particular, an extension to the Warren Blackwood Stock route including Milyeannup Coast Road is proposed and has the potential to impact on the community. These disturbance events often encourage weed invasion into the adjacent habitat, as well as causing damage to vegetation, and may spread dieback (DPaW 2015).

Grazing and trampling

Grazing of plant communities causes alterations to species composition by the selective removal of edible species and the introduction and encouragement of weeds by the addition of dung, and through trampling and general disturbance. The Scott River Plain has been cleared extensively for stock grazing, despite the ironstone flats having poor drainage, and hence providing poor grazing (Tille and Lantzke 1990a). Most occurrences on private land are currently grazed, or have been grazed historically, and in some instances only larger shrubs and trees remain. Occurrences along Governor Broome Road are also occasionally subject to impacts from cattle being moved along the road. High kangaroo numbers are also a threat to a number of occurrences. Most occurrences are surrounded by cleared paddocks, and kangaroos impact the vegetation through grazing, trampling and breaking foliage when moving through the area. Grazing would also have an impact on the establishment of young plants through limiting natural recruitment (DPaW 2015).

Weed invasion

Disturbances such as fires and grazing can predispose areas to weed invasion if weed propagules are present. All of the occurrences are close to agricultural areas that act as weed sources, and would be vulnerable to weed invasion following any disturbance. Weeds suppress early plant growth by competing for soil moisture, nutrients and light. They also exacerbate grazing pressure and increase the fire hazard due to the easy ignition of high fuel loads, which are produced annually by many weed species. Grazing has led to the extensive introduction of pasture weeds in most private property occurrences. Major weeds include annual pasture grasses and herbaceous weeds, including Lotus species that have invaded to varying extent along tracks and firebreaks. In some roadside occurrences weeds of most concern include kikuyu (*Cenchrus clandestinus*) and wild gladiolous (*Gladiolus undulatus*) (DPaW 2015).

Altered fire regimes

Many of the taxa that occur in this community, in particular threatened and priority flora, are obligate seeders. Burning needs to occur at appropriate intervals and possibly in the appropriate season and intensity to sustain the integrity of assemblages. Too frequent fire can increase the risk of invasive weeds establishing within small bushland remnants (Abbot and Burrows 2003). It is likely that the burn regime in remnants that contain the community has been modified to one of more frequent fires since European settlement. In addition, factors such as post-fire grazing (e.g. by kangaroos and rabbits) and weed invasion, will be detrimental to the community. Landsat satellite imagery was used to assess the change in vegetation cover between 1988 and 2019 (van Dongen 2020). A total of 27 fires have occurred within the Scott River ironstone community in that time (DBCA fire layer and pers comm. [redacted]). The majority of the fires occurred over the two eastern patches which show little to no decline in cover (see appendix 3).

Six occurrences (MY4156, MY42377, GSNR8/9, Chester01, MY442377, BPointiron01/02) have been burnt in the last 10 years (data from ARCGIS) with two of these occurrences (Chester, BPointiron) occurring on road reserves (see summary of location information table for burn dates). Burrows *et al*. (2008) recommend a minimum period between fires that are lethal to fire-sensitive plants (obligate seeders with long juvenile periods) of at least twice the juvenile period of the slowest maturing species. In fire sensitive habitats, this may be increased to 3-4 times the juvenile period for fire sensitive species (Barrett *et al*. 2009). Drying climate needs to be taken into consideration in designing appropriate fire regimes. It is likely that reduced rainfall will cause diminishing growth rates, and plant maturation times will also therefore increase. The interaction of the impacts of Phytophthora disease and more frequent fire also

needs to be considered in determining inter-fire intervals, as this disease will be an additional source of stress in plant assemblages regenerating from fire.

Alterations to water levels

Shallow groundwater levels fluctuate naturally due to seasonal conditions, but have been altered locally due to changes in land use and groundwater abstraction. The clearing of native vegetation has increased surface water runoff and groundwater recharge, and these increases have been countered by groundwater abstraction to irrigate annual crops and pastures that have replaced the native vegetation. Higher volumes of groundwater are abstracted from the Yarragadee aquifer, in areas of high porosities and permeability, such as sands. The heterogeneity of the ferruginised Guildford 16 Formation (Scott River Ironstone substrate) and the underlying Leederville and Yarragadee aquifers complicates reliably quantifying the impacts of abstraction. Groundwater levels in the Yarragadee, Lesueur Sandstone and Leederville aquifers have continued to decline, while groundwater levels in the Superficial aquifer remain mostly stable, but with some localised areas of decline (DOW 2016). This is apparent in bore data from sites 60930030 and 60930020 which are located near eastern occurrences of the community and on the eastern part of the Scott Coastal Plain, which mostly appear stable (figures 1 and 2).

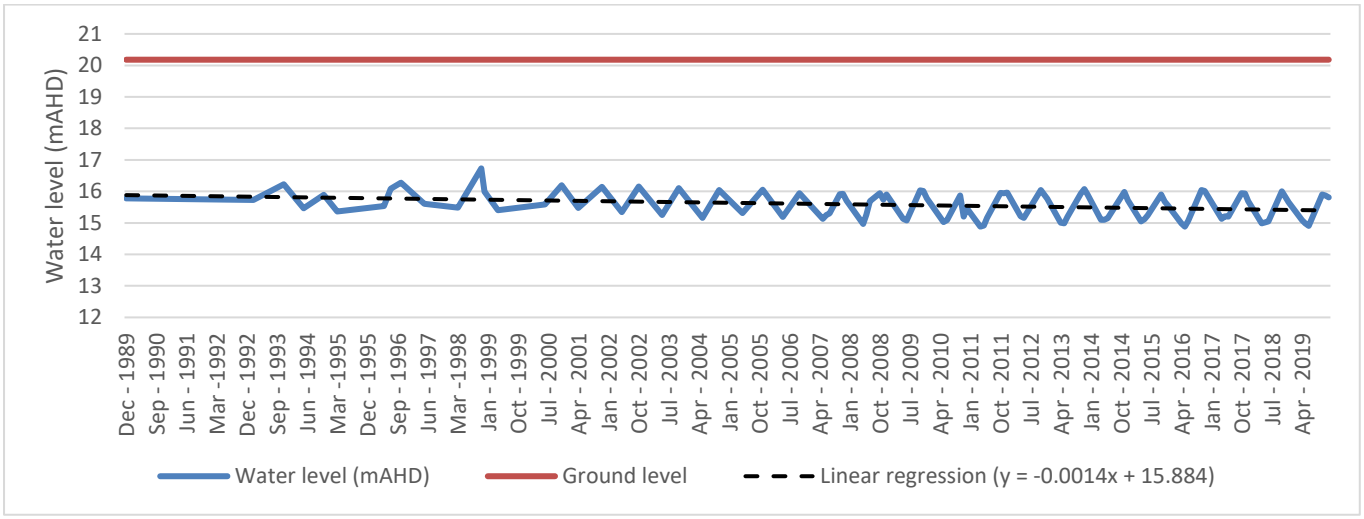

Figure 1a. Hydrograph of bore (site ref: 60930020) located 5.5km west-northwest of occurrences GSNR8 and GSNR9. Bore located on Woodarburrup Rd, Milyeannup. Bore data produced by sampling the Perth Superficial Scott aquifer.

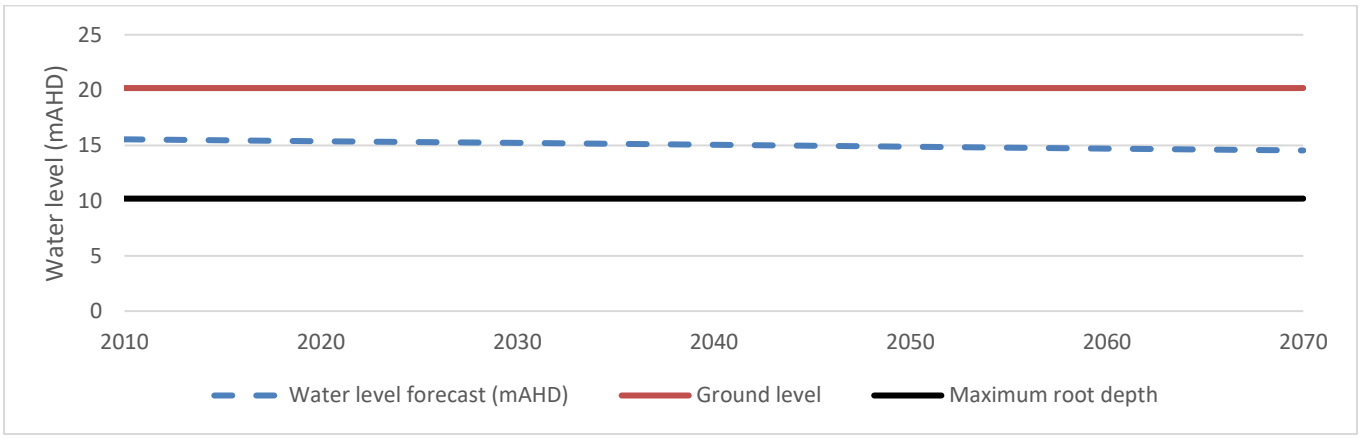

Figure 1b. A 50-year forecast of groundwater level decline at occurrence GSNR8 and GSNR9 (site ref: 60930020), calculated using the trendline (y=--0.0014x + 15.884).

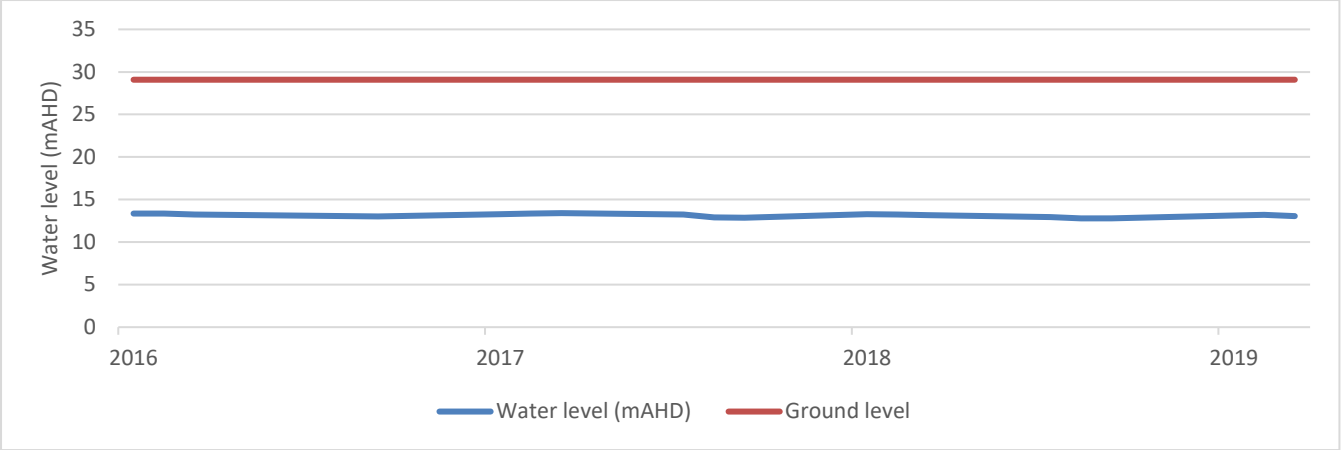

Figure 2. Hydrograph of bore (site ref: 60930038) located 3.6km southeast of occurrences GSNR8 and GSNR9. Bore located at southern end of Gingilup Swamps Nature Reserve, Milyeannup. Bore data produced by sampling the Perth Leederville aquifer.

In the western part of the Scott Coastal Plain, the Leederville aquifer underlies the Scott River Ironstone Association and this may be experiencing reduced, or slower recharge from rainfall compared with the eastern area where the Yarragadee aquifer underlies the communities. The volume and the timing of groundwater abstracted can influence water levels and this must be taken into account when determining impacts to the water table. Water levels near major production bores to supply irrigated agriculture in the western part of the Scott Coastal Plain have decreased by 0.5 to 2m in 10 years. Any groundwater use that has the potential to lower the summer minimum groundwater levels at the water table by more than 0.3m should be considered a potential threat to this community (GCS 2007).

Altered periods of ponding may affect the timing of growth of herbs in the understorey, and may also affect the species composition of the community by favouring different taxa. Ponding occurs in low-lying areas during the winter because vertical drainage of rainfall and run-off is prevented by shallow groundwater (GCS 2007) or by the presence of impeding layers such as rock or clay. It is likely that the vascular systems of some plants will have a limiting depth, below which they cannot draw groundwater (GCS 2007).

Occurrence MY4264WST occurs directly between two irrigated pivot crop circles nearly 1km in diameter. A current licence for abstraction of 1.65GL of water from the Perth-Lesueur Sandstone South exists over the property (data from Department of Water and Environmental Regulation Water Register website). Monitoring bore (site ref: 60930022), located on Scott River Road, within 2km of occurrence MY4264WST, shows a decline in groundwater level (Figure 3a). This monitoring bore recorded an approximate groundwater decline of 13m over 29 years. This bore samples the Perth-Lesueur aquifer.

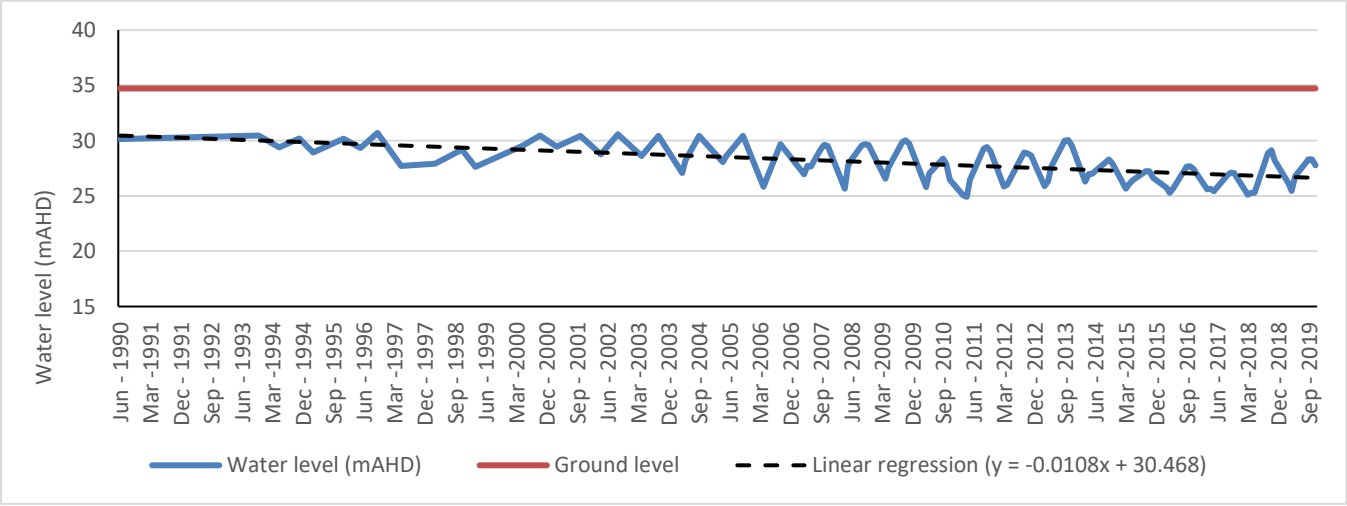

Figure 3a. Hydrograph of bore (site ref: 60930022) located 1.8km northwest of occurrence MY4264WST. Bore located on Scott River Road. Bore data produced by sampling the Perth-Lesueur Sandstone South aquifer.

Figure 4b shows a 50-year forecast of groundwater decline at occurrence MY4264WST. The groundwater level at this location will fall below the level considered to be the maximum root depth by 2040, potentially resulting in impacts to a number of species.

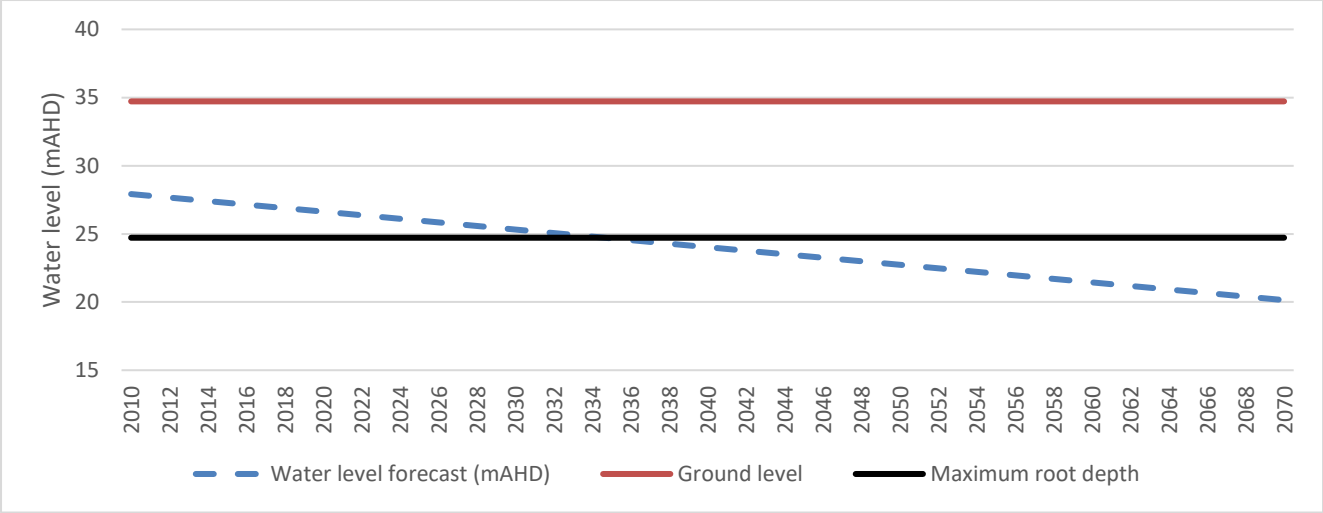

Figure 3b. A 50-year forecast of groundwater level decline at occurrence MY4264WST (site ref: 60930022), calculated using the trendline (y=-0.0108x + 30.468).

Monitoring bore (site ref: 6093009), located on Governor Broome Road within 2km of occurrence MYDENIS01, shows the groundwater level for the Perth-Yarragadee South aquifer has declined (Figure 4a) by approximately 3.5m over 26 years.

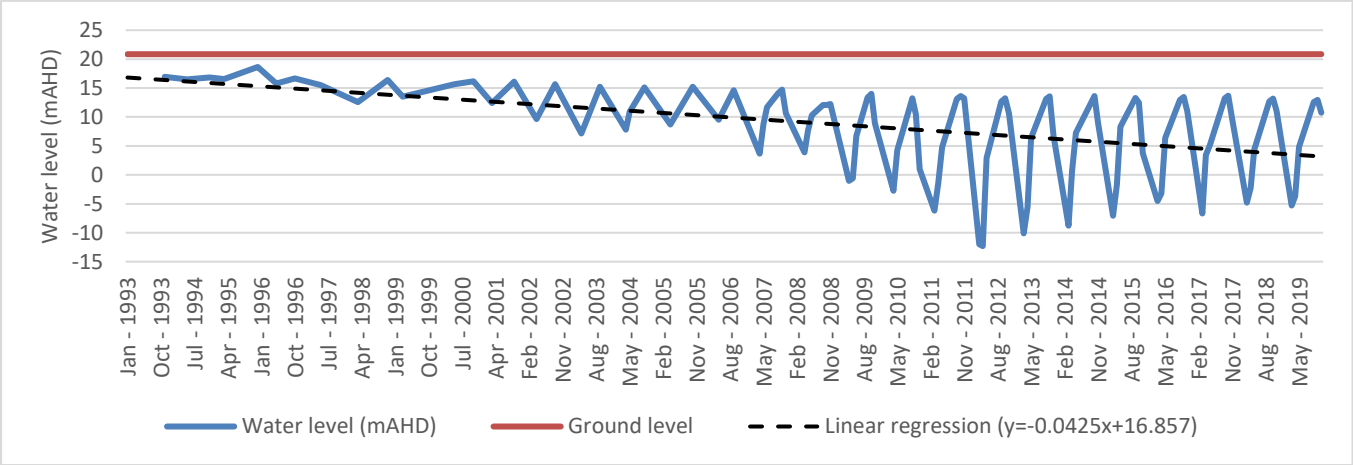

Figure 4a. Hydrograph of bore (site ref: 60930009) located 2km southeast occurrence MYDENIS01. Bore located north of Governor Broome Road. Bore data produced by sampling the Perth-Yarragadee South aquifer.

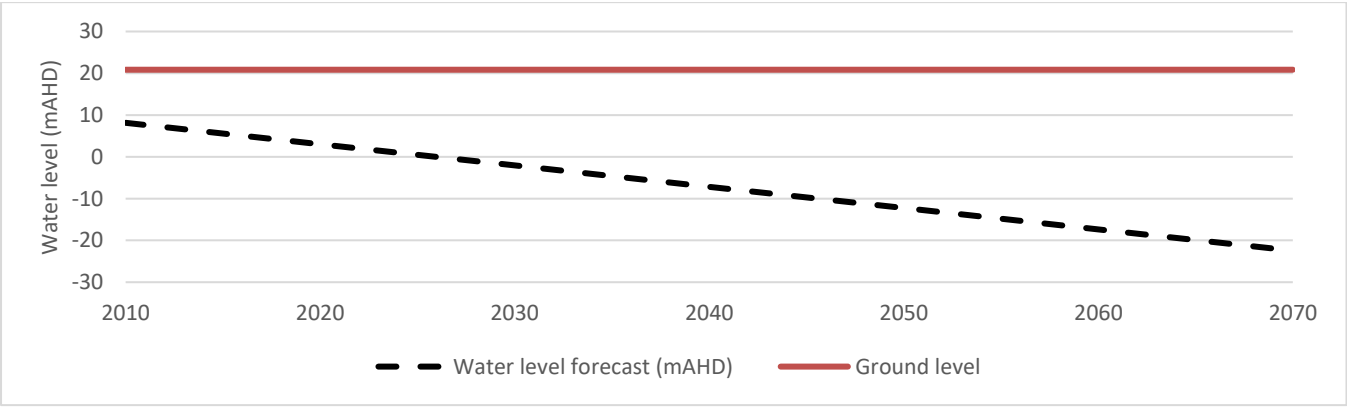

Figure 4b. A 50-year forecast of groundwater level decline at occurrence MYDENIS01 (site ref: 60930009), calculated using the trendline (y=-0.0425x+16.857).

The Scott Ironstone community is at risk from a drying climate with effects such as loss of wetland associated flora taxa from reduced groundwater recharge and surface water availability, thereby contributing to the impacts of abstraction on the community. Climate change predictions for the south-western WA are as follows (from NCCARF website: (https://www.nccarf.edu.au/sites/default/files/attached_files_publications/PDF%20Report%20Card%20Low%20Res.pdf); accessed March 2020):

- Rainfall will reduce by 2-14% (median 8%) by 2030, compared to 1975- 2007 baseline. Southwest is predicted to experience some of the largest reductions in rainfall in all of Australia.

- Runoff will reduce by 10-42% (median 25%) by 2030, compared to 1975- 2007 baseline.
- Temperature will increase by 0.5 -2.0ºC by 2030, compared to 1960-1990 baseline.

Due to the complexity of interactions of aquifers and substrates with this community, predicting the likely impacts of groundwater decline on the community is problematic. Accurate predictions of the impacts of groundwater decline will require systematically collected monitoring data linking groundwater levels in aquifers to composition of the community over time.

Dieback disease

A number of plant taxa that occur in the community are highly susceptible to dieback caused by *Phytophthora* species, particularly members of the families Proteaceae and Ericaceae (Epacridaceae). Most occurrences are thought to be infected with the disease and testing has confirmed the presence in five occurrences (see figure 5 below for positive dieback sample points). Despite this, dieback does not appear to currently pose a significant threat to the community (pers comm. [redacted][1]). As yet no sites have been sprayed with phosphite to control the disease (DPaW 2015).

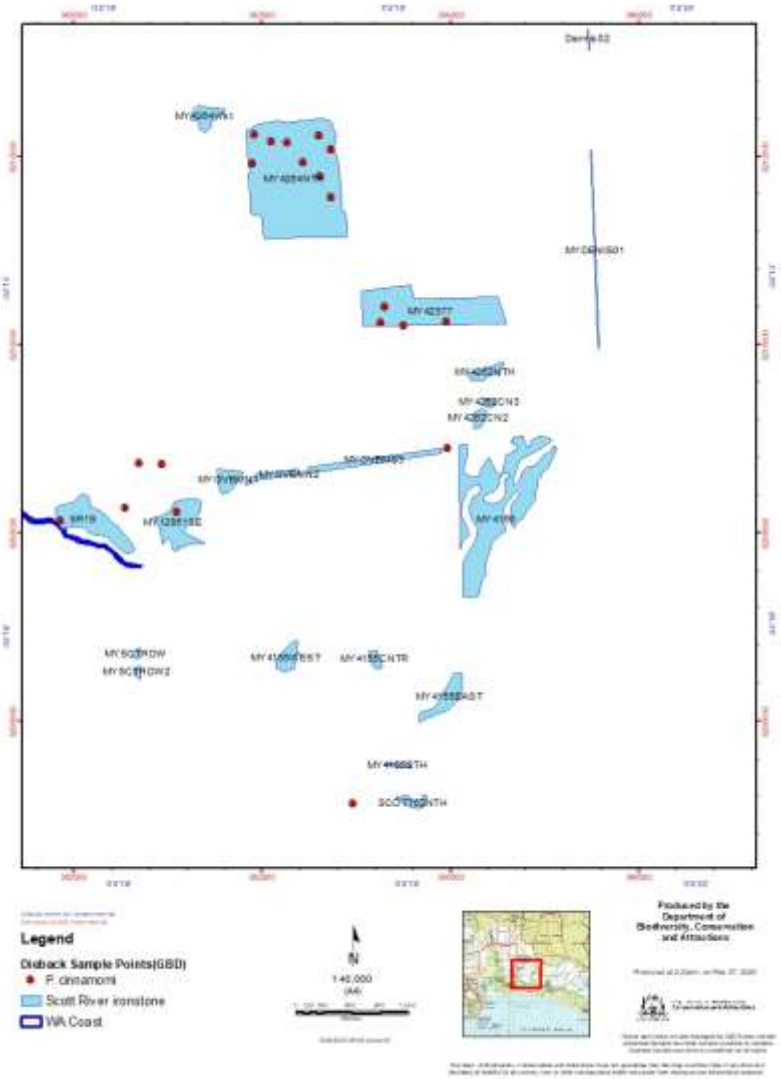

Figure 5. Positive dieback sample points (red dots) in vicinity of Scott River ironstone occurrences (from ARCGIS).

Acid sulphate soils

Extensive areas of the Scott Coastal Plain pose a potential acid sulphate soil hazard (Degens and Wallace-Bell 2009). Mineral exploration and extraction leases exist over the land on which most occurrences of the Scott River Ironstone Association occur. Acid sulphate soil is a naturally occurring soil or sediment that contains iron sulfides that occur over extensive low lying areas under waterlogged or anaerobic conditions. Projects such as mineral sands mining that require dewatering, drainage alterations, excavation in areas where these soils are present, or compacting saturated soils or sediments resulting in groundwater extrusion and aeration of soils, may result in soil, groundwater and/or

[1] [redacted], Flora Conservation Officer, South West Region

surface water acidity and the release of metals and precipitates. When exposed to air, oxidation takes place and when the soil's capacity to neutralise the acidity is exceeded, sulfuric acid is produced (Appleyard *et al*. 2003).

Changes to nutrient status

Surface water in occurrences adjacent to farm lands may be polluted by animal droppings and artificial fertilisers. This is likely to favour weeds as they are adapted to higher levels of nutrients than native species. Nutrient status at surface water sampling sites in the vicinity of the Scott River Ironstone Association occurrences has been measured at some sites for over 30 years. Intensive land use or chemical applications up-gradient of the community are a potential threat because surface water and groundwater can carry excess nutrients and pesticides/herbicides from agricultural lands. Contaminant concentrations in groundwater will reduce as it travels away from the source as a result of dilution, dispersion, adsorption and degradation (GCS 2007).

Salinisation

Hydrological changes such as increased groundwater levels, depth or period of inundation may cause salt accumulation near the ground surface. The Scott River area has been identified in the Australian Dryland Salinity Assessment 2000 as an area being at the highest risk from dryland salinity based on groundwater depth and soil system (National Land and Water Resources Audit 2001). The levels of salinity in the community will need to be monitored to determine the level of threat, and the major sources of the problem determined.

Myrtle rust

Myrtle Rust is a fungal disease that has the potential to infect many species of plants belonging to the family Myrtaceae (DPIRD 2018). Dispersal of rust spores can occur through wind, honey bees, and via contaminated clothing, infected plant material and insect movement. Myrtle rust has the potential to spread into south Western Australia and many plant species occurring in the Scott Ironstone community are potentially vulnerable to infection by this disease if introduced into the State (DPaW 2015).

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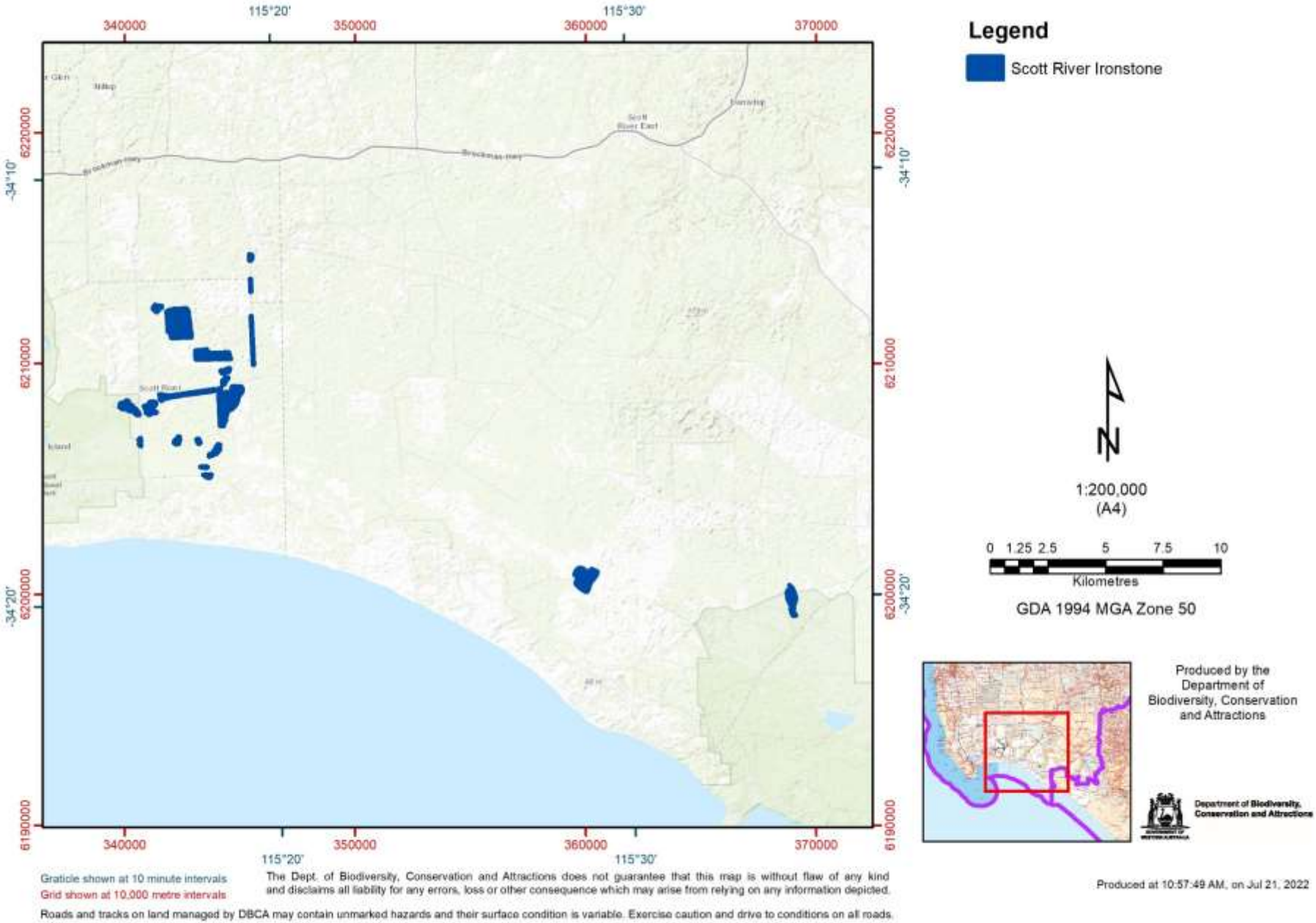
APPENDIX 2 Scott River Ironstone Association



APPENDIX 3 Vegetation cover assessment for "Scott River ironstone" using satellite imagery.

[redacted][2], 7/10/2019

Datasets

Landsat satellite imagery was used to assess the change in vegetation cover between 1988 and 2019. Images used in the analysis to map cover change were captured 11/2/1988 and 16/2/2019.

Canopy cover calibration

To calibrate imagery index values with vegetation cover in the "Scott River ironstone" TEC, 90 by 90 m polygons (n = 15), were digitised in areas of dense and sparse vegetation cover. The percentage cover within these polygons was calculated from aerial photography. Pixel values from the rgb bands in the aerial photography were summed and those with values less than 70 were classified as vegetation. Examples of the classifications are shown in Figure 1. Vegetation cover is delineated in red.

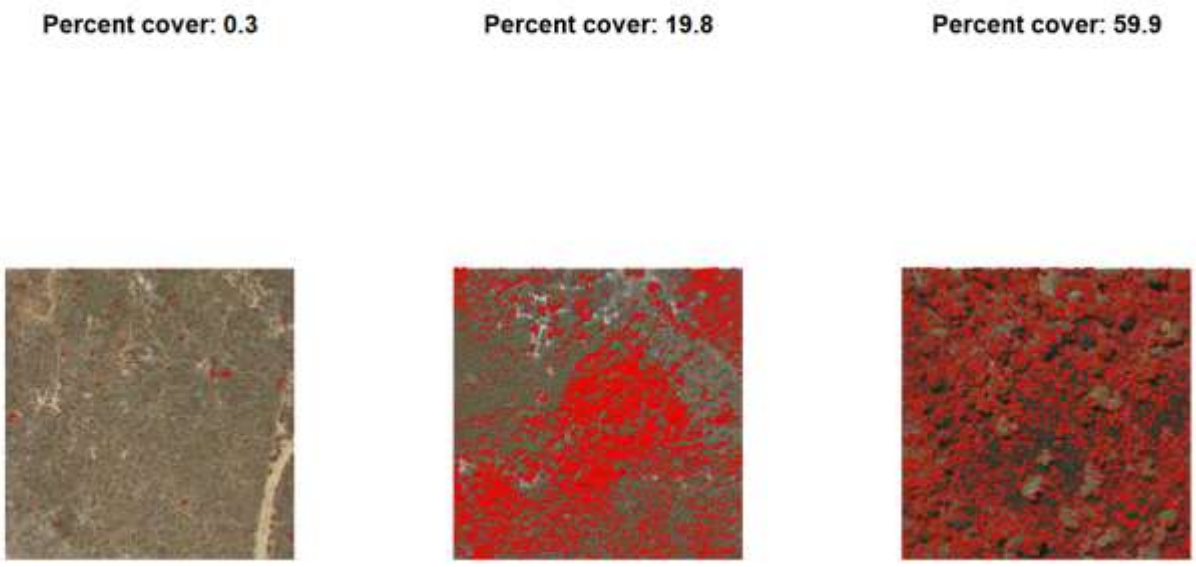


Figure 1: Examples of vegetation classification from aerial photography. Vegetation cover is outlined in red.

[2] Remote sensing officer, DBCA

Table 1. Indices derived from Landsat imagery regressed against canopy cover.

index	mod	r.squared	p.value
i35	quadratic	0.826	0.000
satvi	quadratic	0.789	0.000
srwi	quadratic	0.764	0.000
srwi	linear	0.763	0.000
stvi	quadratic	0.756	0.000
i35	linear	0.756	0.000
satvi	linear	0.754	0.000
stvi	linear	0.733	0.000
ndmi	quadratic	0.708	0.001
nbr	quadratic	0.693	0.001
nbr	linear	0.692	0.000
ndmi	linear	0.688	0.000
ndvi	quadratic	0.570	0.006
ndvi	linear	0.567	0.001

Regression plot of the i35 index is shown below (Figure 2).

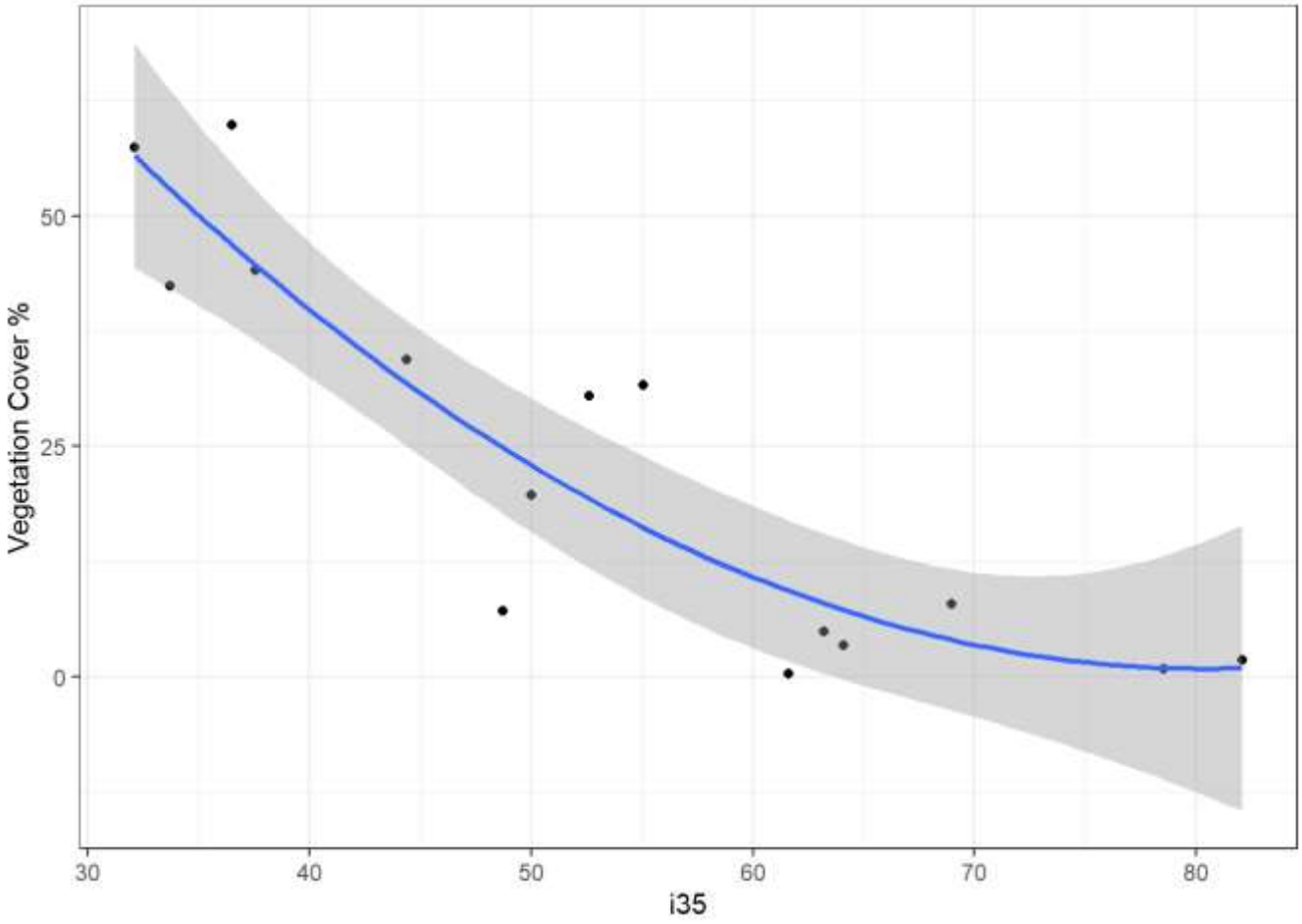


Figure 2. Regression of the i35 index from Landsat imagery and canopy cover from aerial photography (r.squared = 0.826, n = 15).

Change image and statistics

Coefficients from the regression were applied to imagery from 11/02/1988 and 16/02/2019. This produced two vegetation cover images. The percentage difference of cover values between these two images can then be calculated. A vegetation cover change image within the "Scott River ironstone" TEC is shown in Figure 3 and an area summary is provided in Table 2. For further interogation the change image can be acquired viewed in standard GIS software.

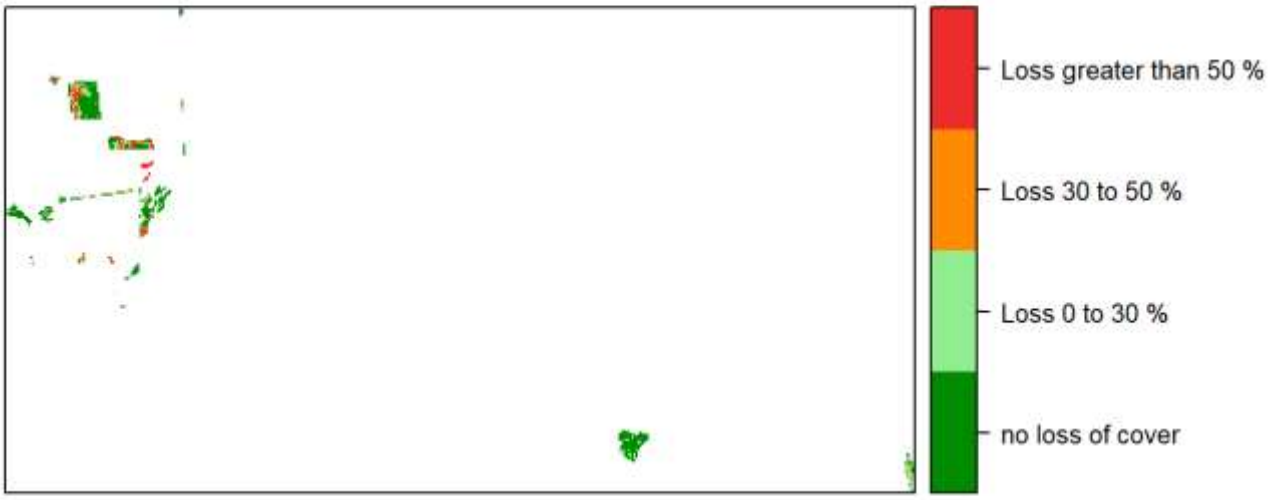


Figure 3. Vegetation cover change within the Scott River ironstone TEC (1988 to 2019).

Table 2: Percent of the TEC within each loss class (1988 to 2019).

Description	Percent of TEC
no loss of cover	61.02
Loss 0 to 30 %	20.81
Loss 30 to 50 %	8.06
Loss greater than 50 %	10.11

Table 3: Percent of vegetation cover loss class (1988 to 2019) within each block within the TEC.

Block ID	no loss of cover	Loss 0 to 30 %	Loss 30 to 50 %	Loss greater than 50 %
MY42377	45.2	19.6	14.4	20.7
SR19	79.8	19.7	0.4	0.0
GSNR8	79.0	20.4	0.6	0.0
MY4155CNTR	10.0	5.0	5.0	80.0
MY4155WEST	16.4	18.2	23.6	41.8
MY4155EAST	91.1	6.7	2.2	0.0
MY4155STH	12.5	75.0	12.5	0.0
SCOTT02NTH	61.5	23.1	11.5	3.8
MY12951SE	59.6	27.0	6.7	6.7
MY4262CN2	0.0	0.0	3.8	96.2
MY4262NTH	0.0	2.5	10.0	87.5
MYSCTRDW	75.0	12.5	0.0	12.5
MYSCTRDW2	57.1	14.3	28.6	0.0
CHESTER01	64.3	32.1	3.6	0.0
MY4262CN3	0.0	9.1	0.0	90.9
MYGVBMN1	68.6	23.5	5.9	2.0
MYGVBMN2	64.9	32.4	0.0	2.7
MYGVBMS3	81.1	5.6	6.7	6.7
Dennis01	60.0	40.0	0.0	0.0
Dennis02	0.0	0.0	0.0	0.0
Bpointiron	32.5	55.7	10.7	1.1
MY4264Wst	50.8	9.5	7.9	31.7
MY4264NTH	61.6	16.4	12.1	9.9
MYDENIS01	61.5	20.5	7.7	10.3
MY4156	65.5	21.0	5.4	8.1

APPENDIX 4 IUCN Red List Criteria for ecosystems (version 2.2) (IUCN 2017)

A. Reduction in geographic distribution over ANY of the following time periods:

		CR	EN	VU
A1	Present (over the past 50 years).	≥ 80%	≥ 50%	≥ 30%
A2a	Future (over the next 50 years).	≥ 80%	≥ 50%	≥ 30%
A2b	Future (over any 50 year period including the present and future).	≥ 80%	≥ 50%	≥ 30%
A3	Historic (since 1750).	≥ 90%	≥ 70%	≥ 50%

B. Restricted geographic distribution indicated by EITHER B1, B2 or B3:

		CR	EN	VU
B1	Extent of a minimum convex polygon enclosing all occurrences (Extent of Occurrence)	≤ 2,000 km^2	≤ 20,000 km^2	≤ 50,000 km^2
	AND at least one of the following (a-c):			
	(a) An observed or inferred continuing decline in **EITHER**:			
	i. a measure of spatial extent appropriate to the ecosystem; **OR**			
	ii. a measure of environmental quality appropriate to characteristic biota of the ecosystem; **OR**			
	iii. a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem.			
	(b) Observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years.			
	(c) Ecosystem exists at …	1 location	≤ 5 locations	≤ 10 locations
B2	The number of 10 × 10 km grid cells occupied (Area of Occupancy)	≤ 2	≤ 20	≤ 50
	AND at least one of a-c above (same sub-criteria as for B1).			
B3	A very small number of locations (generally fewer than 5) **AND** prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus capable of collapse or becoming Critically Endangered within a very short time period (B3 can only lead to a listing as VU).			VU

C. Environmental degradation over ANY of the following time periods:

C1 The past 50 years based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

Extent (%)	Relative severity (%) ≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

C2 The next 50 years, or any 50-year period including the present and future, based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

	≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

C3 Since 1750 based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

	≥ 90	≥ 70	≥ 50
≥ 90	CR	EN	VU
≥ 70	EN	VU	
≥ 50	VU		

D. Disruption of biotic processes or interactions over ANY of the following time periods:

D1 The past 50 years based on change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:

Extent (%)	Relative severity (%) ≥ 80	≥ 50	≥ 30
≥ 80	CR	EN	VU
≥ 50	EN	VU	
≥ 30	VU		

D2

	≥ 80	≥ 50	≥ 30

	(D2a) The next 50 years, or (D2b) any 50-year period including the present and future, based on change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table: OR	≥ 80	CR	EN	VU
		≥ 50	EN	VU	
		≥ 30	VU		
			≥ 90	≥ 70	≥ 50
D3	Since 1750, based on a change in a biotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:	≥ 90	CR	EN	VU
		≥ 70	EN	VU	
		≥ 50	VU		
E. Quantitative analysis					
			CR	EN	VU
	… that estimates the probability of ecosystem collapse to be:		≥ 50% within 50 years	≥ 20% within 50 years	≥ 10% within 100 years