Department of Biodiversity, Conservation and Attractions

GOVERNMENT OF WESTERN AUSTRALIA

Nomination *(to be completed by nominator)*

Current conservation status	
Name of ecological community:	Shrublands on dry clay flats (floristic community type 10a as originally described in Gibson *et al*. (1994)
Other names:	SCP10a
Description:	The community occurs on clay flats with thin skeletal soils and has been recorded largely between Wattle Grove and Sabina River. It comprises rapidly drying clay flats. Typical and common shrubs include *Hakea sulcata* (furrowed hakea), *Verticordia densiflora* (compacted featherflower), *Hakea varia* (variable-leaved hakea), *Pericallyma ellipticum* (swamp teatree) and *Viminaria juncea* (swishbush). *Aphelia cyperoides*, (hairy aphelia), *Centrolepis aristata* (pointed centrolepis), *Drosera gigantea* (giant sundew) and *Drosera menziesii* (pink rainbow) also commonly occur. The community is also known as "floristic community type 10a" as originally described in Gibson N., Keighery B.J., Keighery G.J., Burbidge A.H. and Lyons M.N. (1994) "A floristic survey of the southern Swan Coastal Plain" (unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.)).
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	27/03/2012	Critically Endangered	
Western Australia	WA Minister ESA list in policy	6/11/2001	Endangered	EN 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 ☐

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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'.*	EN A3; B1a(iii),b; B2a(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. • Gibson *et. al* (1994) lists communities that are thought to have declined by >90% based on their analysis of the level of clearing of vegetation on the geomorphologies and landforms that support the community. This clay pan type was included in that group. • The proportion that remains of the pre-1750 extent of the vegetation complexes in which the community occurs is provided in statistical data in Government of Western Australia (2019). • The reduction in extent of native vegetation in the vegetation complexes on the Swan Coastal Plain that support the community is assumed to be indicative of the level of clearing of the community. • The following vegetation complexes support the community, with the proportion cleared in brackets: Guilford (95%), Southern River (82%), Cannington (88%), Karrakatta Complex-Central and South (77%), Serpentine River (90%) and Abba (93%). • The range of values for the level of clearing of vegetation complexes that support the community is 77-95% (Government of Western Australia 2019). • The timing of the vegetation clearing is not known so is conservatively inferred to be since 1750. • Based on available evidence, the community plausibly meets criterion A3 as the distribution decline ranges from 77%-95%, which is within the ≥70% threshold of decline since 1750 required to meet EN under A3. • **Plausibly meets Endangered A3**
B.	Restricted geographic distribution	☒ **B1** (specify at least one of the following): ☐ **a)(i)** ☐ **a)(ii)** ☒ **a)(iii)** ☒ **b)** ☐ **c);**

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	(EOO and AOO, number of locations and evidence of decline)	☒ **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 5470km^2. Community meets the threshold for Endangered as it occupies ≤20,000km^2 (threshold for EN is ≤20,000km^2 and for CR is ≤2,000km^2). • B1a(iii) Community is subject to measurable decline from observed and inferred ongoing weed invasion (ie. biotic interactions, see criterion D, and Appendix 1 below). • B1 b): Continuing decline observed from the impacts of; vegetation clearing, hydrological change, weed invasion, trampling, altered fire regimes, disease, grazing by introduced fauna, and declining rainfall (see Appendix 1 for details of threats). • B2: AOO is 1300km^2 (occupies 13 10x10 km^2 grid cells). Community meets threshold for endangered with ≤20 cells occupied (threshold for CR is ≤2 grid cells. • B1c: Community is considered to occur at 18 threat-defined locations based on clusters of bushland areas subject to similar management, and threats such as bushfires and local hydrological changes. • Community exists at more than 10 threat-defined locations. Does not meet B1c, B2c or B3. • **Meets criteria for Endangered B1a(iii),b; B2a(iii),b**
C.	Environmental degradation of abiotic variable *(Evidence of decline over 50-year period)*	☐ **C1** ☐ **C2** ☐ **C3**

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	Justification of assessment under Criterion C.	• Altered hydrology is a significant abiotic variable affecting the community. Alterations to depths or seasonality of surface water will result in subsequent changes to composition, in particular to the defining herbaceous layer in the community. • For criterion C, it is assumed the community will collapse when seasonal inundation with surface water no longer occurs. It is assumed that such severe changes to surface water will results in loss of the defining herbaceous wetland adapted flora in the community. Reductions and other changes to seasonal inundation patterns are directly related to rainfall (See Appendix 1 for further details). • There are inadequate quantitative data to link changes to surface water regimes (depths and seasonality) to compositional changes in the community. Bore data of groundwater levels are available for occurrence TUT01, located along Ruabon Rd opposite the Ruabon reserve, however, as mentioned there is a lack of connection of groundwater to surface. • It is therefore not possible to determine the severity of current or projected declines in rainfall and surface water in relation to the collapse state (also see Appendix 1 for details of threats)**.** • There are inadequate data to determine if community meets minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50 year period, or (≥50%) or proportional severity of disruption of abiotic processes (≥50%) since 1750 to meet the criteria for VU. • **Insufficient evidence to determine if 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.	• Weed invasion is a significant biotic threat to the community. • The severity of weed invasion associated with collapse is uncertain, but it is assumed conservatively that the community reaches a collapsed state when only 10% (plausible range 0–20%) of its plant species are native. • Weed data taken from 2 quadrats across 1 occurrence (FISH03) (representative of 17% of the extent of the community) indicate an increase in the average proportion of exotic species between 1994 and 2017-2018 with a 32% reduction of native taxa. • It is assumed that the increase in introduced taxa as indicated by 2 quadrats is linear and is representative of weed invasion across the occurrences in which the specific quadrats occur. Based on these assumptions, 17% of the extent of the community has a projected 56% decline in native taxa in the next 40 years. This represents a projected reduction in the proportion of native

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		species to 1% over the next 40 years, and a proportion of 0% (ie 100% are weed taxa) over the next 50 years across 17% of the extent of the community. This corresponds to a projected 100% severity in relation to the collapse point of ≥90% weeds, as the proportion of native taxa fall below the collapse threshold within the next 50 years, in the absence of effective weed management. • 17% of the extent of the community is predicted to fall below the collapse threshold of ≤10% native taxa (ie ≥90% weeds) within the next 50 years. • It is likely that other occurrences are subject to decline from weed invasion, but monitoring data are only available for a single occurrence. • As the weed data are only available for 17% of the extent of the community, based on available weed monitoring data, the community does not meet the threshold of ≥30% of the extent of the community subject to relative severity of weed invasion of ≥80% to meet VU under criterion D2a. • **Available weed data are inadequate to indicate if 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 ☒ Listing under BC Act

Provide details: The community was initially ranked as Vulnerable 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	5470 km^2	AOO	1300 km^2 (13 10x10km grid method).
No. locations	18	Severely fragmented	Yes ☒ No ☐ Unknown ☐
Current known area			Known from 22 occurrences totalling 87ha
Pre-industrialisation extent or its former known extent (if known)			Based on current area of 87ha and decline of between 77-95%, original area is estimated as between 643ha and 5920ha.
Estimated percentage decline			Estimate from range of level of clearing of vegetation complexes that support the community is 77-95%.

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Table 1: Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Available data do not indicate if community meets criterion
A2a	-	• Available data do not indicate if community meets criterion
A2b	-	• Available data do not indicate if community meets criterion
A3	EN	• Estimated loss of 77-95% since ~1750. • Plausibly meets criterion for EN
B1a	EN	• Measurable decline due to observed and inferred ongoing weed invasion. • Meets criterion for B1a(iii)
B1b	EN	• EOO is ≤20,000km^2 • Known and inferred threats are likely to cause continuing declines in geographic distribution, environmental quality and biotic interactions within the next 20 years. • Meets criterion for EN B1b
B1c	-	• EOO is ≤20,000km^2 • Community exists at more than 10 threat-defined locations. • Does not meet criteria for B1c
B2a	EN	• Measurable decline due to observed and inferred ongoing weed invasion. • Meets criterion for B2a(iii)
B2b	EN	• AOO is 13 grid cells • Known and inferred threats are likely to cause continuing declines in geographic distribution, environmental quality and biotic interactions within the next 20 years. • Meets criterion for EN B2b
B2c	-	• Ecosystem exists at more than 10 threat-defined locations. • Does not meet B2c
B3	-	• Known from more than 5 threat-defined locations. • Does not meet criterion
C1	-	• Inadequate data to determine if community meets minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over past 50 years to meet VU.
C2	-	• Inadequate data to determine if community meets the threshold for proportion of the extent (≥30%) for proportional severity (≥30%) over any 50-year period to meet VU under C2b.
C3	-	• Inadequate data to determine if 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 data about weed invasion do not meet 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	-	• Meets the thresholds for proportion of the extent (≥50%) and proportional severity of disruption of biotic processes (≥50%) for weed invasion over a 50-year period. • Meets criterion for VU under D2A
D3	-	• Inadequate data to determine if community meets 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 EN under A3; B1a(iii),b; B2a(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. Note: Survey by DBCA unless otherwise stated.	Condition	Area of occurrence (ha)	Threats *(note if past, present or future)*	Specific management actions
Occurrence 1 FISH03	Fish Rd Nature Reserve, Shire of Busselton	25/01/1995 08/03/2007 17/02/2010	100% Good/degraded	15.2	Weed invasion Grazing (high numbers of kangaroos, and rabbits) Salinisation Recreational activities Vegetation clearing *(past)* Rubbish dumping Too frequent fire *(all past, present, future unless stated)*	
Occurrence 2 WARO05	Reserve 31437 South Western Hwy Waroona Shire of Waroona Waroona Rail	03/05/1995 Survey of extent, condition, threats 17/02/2010, 21/09/2012	20% Very Good 80% Excellent	6.6	Vegetation clearing Weed invasion Too frequent fire *(all past, present, future)*	
Occurrence 3 KOOLJ06	A23756 Kooljerrenup Nature Reserve Shire of Murray	14/11/1995 18/02/2010 14/10/2010	100% Excellent	6.8	Weed invasion Too frequent Grazing (rabbits) *(all past, present, future)*	
Occurrence 4 YULE04	CNGLC382 University of WA (Botanical Research)	06/01/1995	100% Pristine	4.1	Vegetation clearing Too frequent fire Altered surface drainage *(all past, present, future)*	
Occurrence 5 FL02	C27165 Recreation reserve C27165 City of Armadale	21/04/1995 08/02/2010	80% Very Good, 20% Excellent	2.4	Recreational activities Weed invasion Salinisation Rubbish dumping *(all past, present, future)*	

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Occurrence 6 C5804	A23172 Reserve 23172, Coronation Rd, Shire of Waroona - Camping	14/11/1995 17/02/2010	10% Good, 90% Excellent	17.6	Weed invasion Grazing by native or introduced herbivores Too frequent fire *(all past, present, future)*	
Occurrence 7 NICHOLSON01	WA Planning Commission, City of Gosnells Freehold	30/10/2001 08/02/2010	Excellent 80% Very Good 20%	2.6	Vegetation clearing Too frequent fire Weed invasion Trampling Rubbish dumping *(all past, present, future)*	
Occurrence 8 HALL02	R46587 Hall Rd Res, Shire of Serpentine Jarrahdale	25/01/2002 08/02/2010 17/10/2013	Good 15%, Very Good 85%	1.4	Weed invasion Altered surface drainage *(all past, present, future)*	
Occurrence 9 HALL04	R46587 Gull, Hall, Karnup Roads, Serpentine Conservation Commission	25/01/2002 08/02/2010	Excellent 80% Degraded 20%	1.0776	Weed invasion Grazing (rabbits) Too frequent fire	
Occurrence 10 PUNR03	Shire of Serpentine-Jarrahdale Road Verge, WA Planning Commission	01/02/2002 08/02/2010 21/10/2010	100% Good	1.8188	Weed invasion Altered surface drainage Rubbish dumping Grazing (rabbits) Recreational activities Too frequent fire *(all past, present, future)*	
Occurrence 11 myFL07	Recreation reserve C27165 City of Armadale	11/09/2002 08/02/2010	Good 10% and Excellent 90% in 2002	0.67	Recreational activities Weed invasion Grazing by native or introduced herbivores Too frequent fire *(all past, present, future)*	
Occurrence 12 plant01	Plantation, City of Capel	17/09/2002 17/02/2010	90% Excellent	0.4	Vegetation clearing Weed invasion	

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					Grazing (cattle, rabbits and kangaroos) *(all past, present, future)*	
Occurrence 13 Anstey Plot02	Regional Park	26/11/2002 30/08/2007 08/11/2007 29/09/2011	80% Excellent 20% Degraded	3.2	Vegetation clearing Weed invasion Grazing (rabbits) Hydrological changes Too frequent fire*(all past, present, future)* *(all past, present, future)*	
Occurrence 14 Anstey Plot01	DPLH land Regional Park managed by DBCA.	26/11/2002 17/01/2005 30/08/2007 08/11/2007 29/09/2011 28/10/2015	95% Excellent 5% Very good	17.4	Weed invasion Vegetation clearing Grazing (rabbits) Hydrological changes Too frequent fire Rubbish dumping Recreational activities *(all past, present, future)*	
Occurrence 16 WANAPING02	City of Gosnells	15/07/2010	Excellent 100%	0.1	Weed invasion Too frequent fire Rubbish dumping *(all past, present, future)*	
Occurrence 17 BROOK01	City of Gosnells	09/09/2008 20/08/2010	100% Very good	0.4	Weed invasion Grazing (rabbits) Hydrological changes Too frequent fire *(all past, present, future)*	
Occurrence 19 LOWRIE01	Shire of Capel, 'unmade' road reserve	October 2007	30% Good, 70% Very Good	1.9	Hydrological changes Grazing (livestock grazing on adjacent property) *(all past, present, future)*	

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Occurrence 23 KENWICK04	City of Gosnells	27/10/2007 24/06/2018 28/05/2019	50% Very good 50% Excellent	0.1	Vegetation clearing Weed invasion Grazing (horse droppings) *(all past, present, future)*	
Occurrence 25 ALCOA01	Shire of Murray, Alcoa of Australia	06/10/2011 08/11/2011 01/12/2011	Excellent 100%	1.8	Vegetation clearing Weed invasion Hydrological change *(all past, present, future)*	
Occurrence 26 TUT01	Shire of Busselton, Railway reserve	06/06/1995 20/10/2011	100% Excellent	2.2944	Weed invasion Too frequent fire *(all past, present, future)*	
Occurrence 28 SCP10aInferred	Shire of Busselton, Railway Reserve	09/06/2015	100% Good	2.3	Recreational activities Hydrological change *(all past, present, future)*	

Condition categories from Keighery 1994 Vegetation Condition Scale in Bush Forever (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', '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, to 'Completely Degraded' where vegetation structure is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native shrubs and trees.

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APPENDIX 1 THREATS

Largely taken from Department of Parks and Wildlife (DPAW 2015)

Major threats

Vegetation clearing

The seasonal clay-based wetland communities of the south west are amongst the most threatened assemblages in Western Australia. It is estimated that >90% of the original extent of these wetlands has been cleared for agricultural use (Gibson *et al*. 2005). Clay pans in the Perth area have also historically been cleared and quarried for clay for use in manufacturing bricks and tiles.

Weed invasion

Weeds displace native plants, particularly following disturbances such as too frequent fire, grazing or partial clearing, and compete with them for light, nutrients and water. They can prevent recruitment, cause changes to soil nutrients, affect abundance of native fauna and impact on other conservation values by harbouring pests and diseases, and increasing fire risk.

Introduced South African bulbous plants are a particularly serious group of weeds in clay pans. As the taxa occur in similar habitat in South Africa, many have the ability to invade relatively undisturbed clay pan habitat and displace the rich herbaceous flora. *Watsonia meriana*, *Sparaxis bulbifera* (harlequin flower), *Moraea flaccida* (one leafed cape tulip), *Hesperantha falcata* and *Freesia alba* x *lechtlinii* (freesia) are of particular concern. Seed and cormels are spread into undisturbed areas in sheet waterflow across wetlands (Brown and Brooks 2003b, Brown et. al., 2008). South African perennial grasses are another serious group of weeds that also occur in similar habitat in South Africa and have the ability to invade clay pans in good condition following disturbance events such as fire. *Tribolium uniolae* (haas grass), *Eragrostis curvula* (lovegrass) and *Hyparrhenia hirta* (tambookie grass) are of particular concern and are a priority for control. The impacts of annual weeds are less well known but many move into intact vegetation following a disturbance event and appear to displace the native annual flora. These include *Cyperus hystrix*, *Parentucellia viscosa* (bartsia) and *Hypochaeris glabra* (flat weed).

Sources of weed invasion include adjoining areas of urban and agricultural use, drains, and tracks within and near the clay pans. All these sources increase vulnerability to weed invasion following any type of disturbance. The clay pans may appear reasonably resistant to weed invasions due to seasonal inundation and hardness of soils in the summer and changes to these elements may alter their ability to resist weed invasion (Keighery 1996).

Quadrats established in 1992 in ephemeral claypans during a regional survey of the Swan Coastal Plain (Gibson *et al*. 1994), were resurveyed in 2012 (Gibson *et al*. 2018). A decrease in native species richness, from an average of 38.7 in 1992 to 32.9 per quadrat was indicated after 20 years (Gibson *et al*. 2018). Invasive taxa had increased in richness by 33% from an average of 10.8 taxa to 14.2 taxa per quadrat over the same 20-year period. Six particularly aggressive South African exotic flora had spread into an additional 37% of the previously non-invaded quadrats, with 60% of quadrats containing these taxa at the latter timepoint, an increase of 23%. The increase in exotic taxa could be expected due to the highly fragmented nature of the remnants (Gibson *et al*. 2018). The authors surmised that variability in inundation period in the last decade may be increasingly facilitating a longer period of weed establishment in some years. This indicates that declining rainfall may also be implicated in increased weed invasion in claypans.

Gibson *et al*. (2005) noted that about 16% of the flora for the clay pans were weeds and some were particularly aggressive. Webb (2019) compared data for proportion of native and weed species in occurrences of the community

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in 1994, and at a timepoint between 2010 and 2018. Linear projections of a 50-year forecast based on these trends are shown in Figure 1 below. Linear projections have been calculation based on these two timepoints. The projection indicates that if weeds are unmanaged in these occurrences, the proportion of native species will decline to ~ 0% of the total number of species in the community within the next 50 years (ie. 100% weeds).

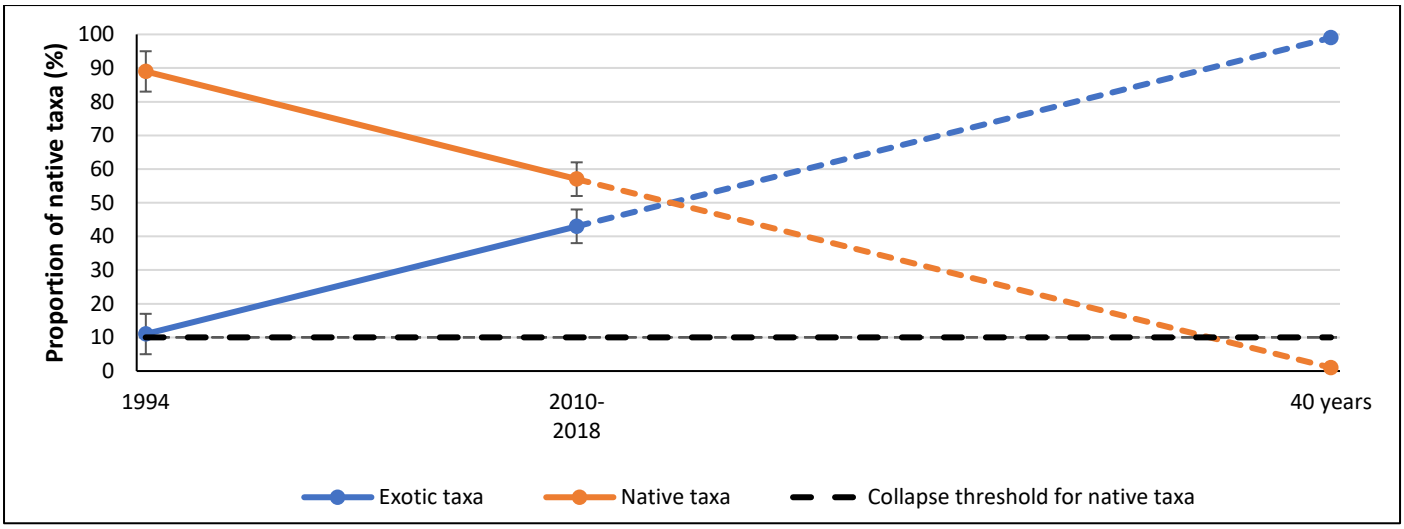

Figure 1. Trend in the proportion of native and exotic plant species based on the mean of 2 sampled sites located in the South-west region (n = 2). A 50-year forecast was calculated using a linear trendline of the proportion of exotic taxa (y=1.333x+9.667) and the proportion of native taxa (y=-1.333x+90.333) (Webb 2019).

Hydrological changes

DPaW (2015) states "The hydrology is the main driver of the ecological functions of the assemblages that occur in clay pans. Variations in depth and timing of inundation have a major influence over the suites of flora that occur in a particular location and this explains some of the variation in the community's composition across its extent. Changes in hydrological status will significantly alter the assemblages in the communities."

Altered hydrology due to anthropogenic causes, in urbanised areas in particular, is likely to be an increasing threat to the clay pans. Drainage to lower watertables, clearing resulting in a decline in evapotranspiration and increased surface runoff, and water quality declines are likely to increasingly impact the hydrologic regimes of the clay pan communities. 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. Any changes to the natural hydrology of the clay pans can affect composition as they are dependent on the timing of filling and drying at appropriate times of the year.

Increased nutrient levels in surface water in occurrences adjacent to areas such as farm lands and residential areas is likely to favour weeds as they are adapted to higher nutrient levels than native flora.

In addition, there are data for a few bores that occur close to or within the clay pan communities, and the bore data for these have been extracted from Department of Water and Environmental Regulation (2020) Water Information (WIN) database. The figures below provide data about changes in groundwater depth over time beneath examples of the clay pan communities

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Figure 2 indicate the seasonal nature of the superficial watertable, and the lack of connection of groundwater to surface. Groundwater levels are relatively stable over the ten year period (2008-2018) at occurrence TUT01.

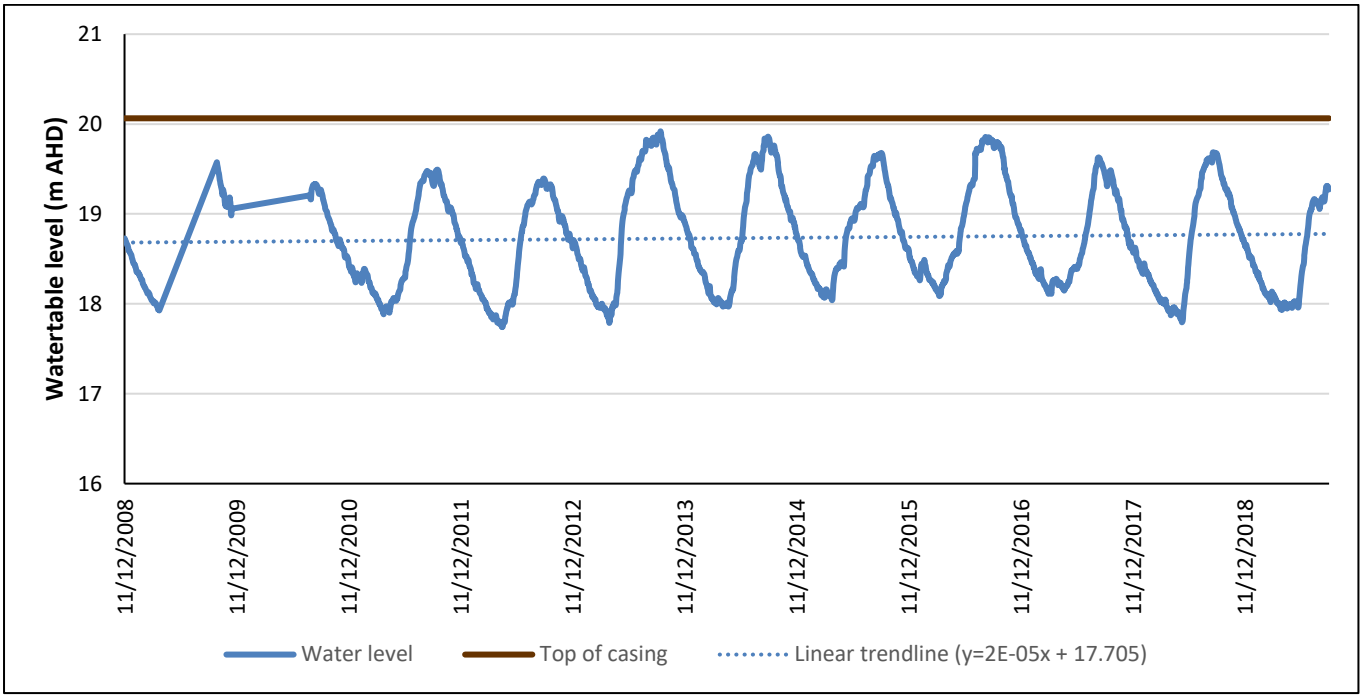

Figure 2. Hydrograph of bore located within Ruabon Reserve, 250m north of occurrence TUT01 (site ref: 61000113) (DWER 2020).

Fire regimes

Inappropriate fire regimes are a significant threat to the clay pan communities. Historically, fire within the clay pans was probably only very occasional. It is likely that some of the clay pan sub-types such as the Shrublands on dry clay flats may be adapted to occasional fire as they contain species that will easily carry fire when vegetation is dry, and some component shrubs would reproduce from seed following fire. The fire response of the major types of clay pan vegetation needs to be determined, however.

The risk of fire is generally increased by the presence of urban areas nearby. In addition, grassy weeds in the understorey are often more flammable than many of the original native species in the herb layer.

Anecdotal evidence indicates that fire may exacerbate the impact of drying climate in clay pan communities. For example, following fire in Ambergate reserve (myAMBR05) community structure changed, and reduced rainfall is believed to be a contributing factor. Shrub species such as *Pericalymma ellipticum* and *Verticordia plumosa* var. *ananeotes* have not recovered well post-fire and there has been a notable increase in sedge cover ([1] [redacted] personal communication).

Declining rainfall

According to the study by Sudmeyer *et al.* (2016), predictions for the south west of WA are as follows:

- By 2030, mean annual temperature is projected to increase by 0.5–1.2°C
- Reduction in rainfall by 2030 by 2-14%. The southwest is predicted to experience some of the largest reductions in rainfall in all of Australia.
- Reduction in runoff by 10-42% (median 24%) by 2030.

[1] [redacted], Department of Parks and Wildlife, Busselton

- Decline in groundwater levels by 2030 (extractive yields may decrease by a third to a half in some areas).

These scenarios are indicative of trends in climatic drying that are likely to affect the depth and seasonality of inundation of the clay pan communities. This has major implications for the future of the clay pan floral assemblages.

Minor threats

Grazing

Grazing of native vegetation causes alterations to species composition through selective removal of edible species, the introduction and enhancement of weeds by the addition of dung, and through trampling and general disturbance. The presence of feral animals such as rabbits (*Oryctolagus cuniculus)* and pigs (*Sus scrofa*) is a concern as they disturb the vegetation by grazing and burrowing.

Occurrences at Plantation Road (plant01), Keane Road (Anstey Plot01 and 02) have been threatened by grazing to some degree, namely by rabbits, horses and high numbers of kangaroos. The significance of the impact, however, has not been quantified through monitoring.

Disease

Soil types have a clear correlation with the occurrence of dieback disease caused by the water moulds *Phytophthora* species around the Perth metropolitan area. Davison and Tay (1986) state 'Increased sporulation and growth of *P. cinnamomi* will not occur in waterlogged soil because aeration is inadequate'. The clay pan communities occur on heavier soils that are thus probably a less susceptible habitat, resulting in a reduced susceptibility of the communities to the disease. The disease has been recorded at Bullsbrook Nature Reserve, where a related claypan type community occurs. *Phytophthora* dieback disease particularly affects Proteaceae and Myrtaceae families that are floristically and structurally dominant in some areas of the clay pan communities.

The disease Myrtle Rust (*Puccinia psidii sens. lat*) also has potential to impact the clay pans if it becomes established in Western Australia, as it may affect some of the dominant myrtaceous shrubs in the community (Australian Network for Plant Conservation 2012). Loss of overstorey including taller shrubs caused by either *Phytophthora* species or Myrtle Rust may lead to a change in the herb layers as a result of increased sun penetration and decreased shading.

Disturbance from recreational activities

Inappropriate recreational uses such as four-wheel drive vehicles and dirt bikes pose a risk to the clay pan communities. Vehicle tracks can be seen on satellite imagery right near occurrence Kenwick04. Rubbish dumping also occurs in clay pans that are close to urban areas such as Brixton St Wetlands. These activities cause direct damage to vegetation, and can lead to weed, or disease introductions such as *Phytophthora* species.

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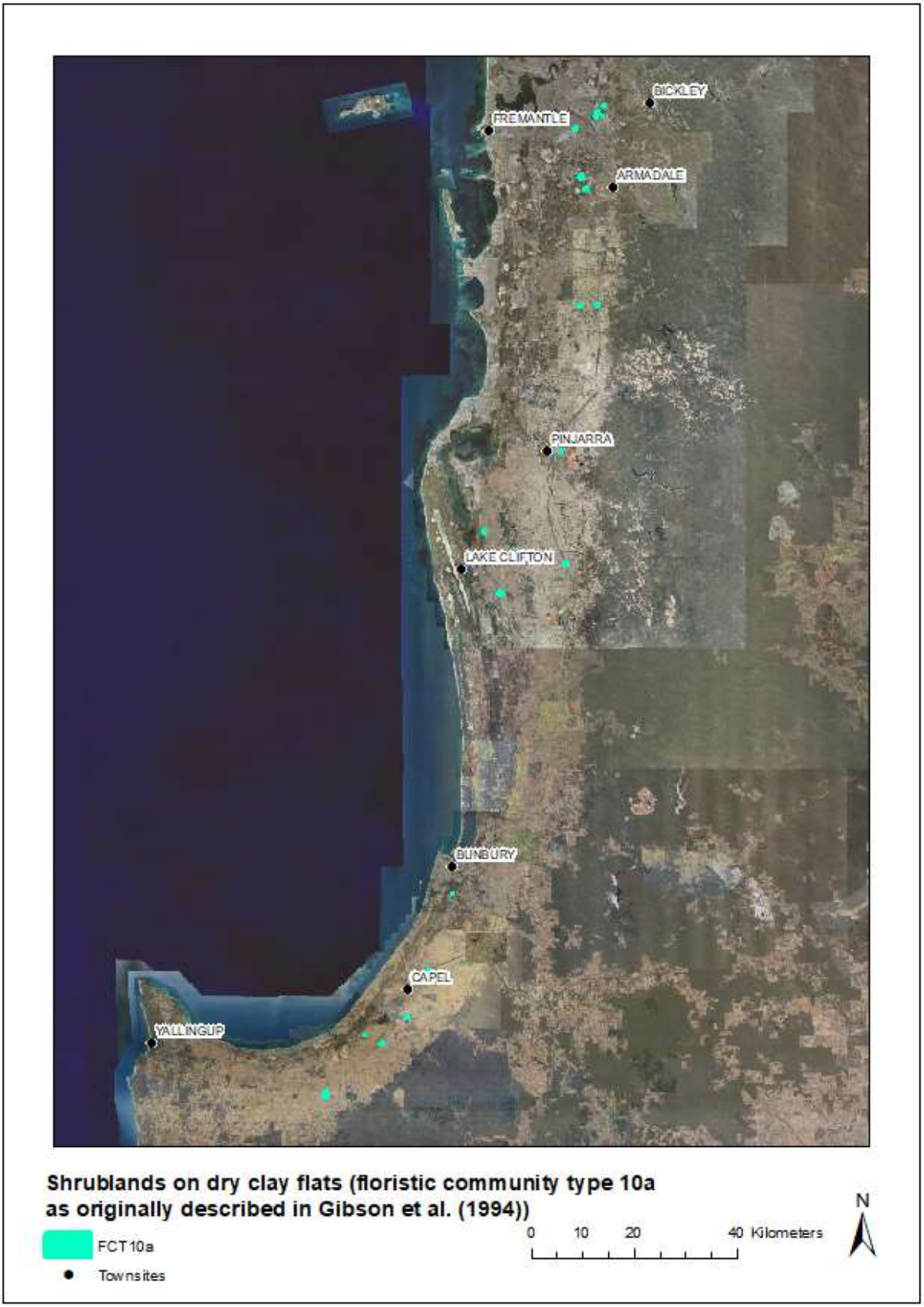
APPENDIX 2: Map of Shrublands on Dry Clay Flats (floristic community type 10a) TEC



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APPENDIX 3 IUCN Red List Criteria for ecosystems (version 2.2) (IUCN 2017)

A. Reduction in geographic distribution over ANY of the following time periods:				
		CR	EN	VU
A1	Present (over the past 50 years).	≥ 80%	≥ 50%	≥ 30%
A2a	Future (over the next 50 years).	≥ 80%	≥ 50%	≥ 30%
A2b	Future (over any 50 year period including the present and future).	≥ 80%	≥ 50%	≥ 30%
A3	Historic (since 1750).	≥ 90%	≥ 70%	≥ 50%
B. Restricted geographic distribution indicated by EITHER B1, B2 or B3:				
		CR	EN	VU
B1	Extent of a minimum convex polygon enclosing all occurrences (Extent of Occurrence)	≤ 2,000 km²	≤ 20,000 km²	≤ 50,000 km²
	AND at least one of the following (a-c):			
	(a) An observed or inferred continuing decline in **EITHER**:			
	i. a measure of spatial extent appropriate to the ecosystem; **OR**			
	ii. a measure of environmental quality appropriate to characteristic biota of the ecosystem; **OR**			
	iii. a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem.			
	(b) Observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years.			
	(c) Ecosystem exists at …	1 location	≤ 5 locations	≤ 10 locations
B2	The number of 10 × 10 km grid cells occupied (Area of Occupancy)	≤ 2	≤ 20	≤ 50
	AND at least one of a-c above (same sub-criteria as for B1).			
B3	A very small number of locations (generally fewer than 5) **AND** prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus capable of collapse or becoming Critically Endangered within a very short time period (B3 can only lead to a listing as VU).			VU

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

		Extent (%)	Relative severity (%) ≥ 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		

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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