Land capability assessment of Lot 12667 (No. 7691) Muir Highway, Frankland River

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Contents

1 Summary

A site specific land capability assessment was made of Lot 12667 (No. 7691) Muir Highway, Frankland River (the Property) on 1-2 October 2025. This involved an assessment of published data-sets and an on-site inspection with 67 observation points and 31 soil samples (0-10 cm depth) analysed for soil salinity.

Approximately 57% of the Property was classified as Priority Agricultural Land in the *Lower Great Southern Strategy 2016* (WAPC, 2016a). **There are clear issues with this WAPC Priority Agricultural Land classification.**.

- It was ultimately based on DPIRD regional 1:100,000 scale soil-landscape mapping and downscaling this mapping to the farm level (e.g. 1:10,000 scale). The soil-landscape mapping units contain a diversity of soils with different land capability. **Simply put, using regional mapping for decision making on specific farms is inappropriate. The limitations of using the underlying soil landscape mapping data are clearly recognised in a disclaimer in the original DPIRD mapping.**
- The areas on the Property classified as Priority Agricultural Land in the *Lower Great Southern Strategy 2016* (WAPC, 2016a), are based on two DPIRD soil-landscape mapping units (BE and Fh4). Unit Fh4 comprises approximately 64% of the total area defined as Priority Agricultural Land. The DPIRD soil-landscape mapping describes a large proportion (43%) of Fh4 as having wet and waterlogged soils. Widespread waterlogging was observed in this unit during the on-site inspection, and this will impede some forms of agricultural production such as intensive agriculture that

require irrigation. **There is no apparent justification for classifying Mapping Unit Fh4 as Priority Agricultural Land, or indeed the classification of any Mapping Unit.**

- Priority agricultural land is defined in this region as having an annual rainfall of >700 mm, whereas Bangalup (8 km east of the farm) has an interpolated rainfall of 650 mm, and Rocky Gully (17 km south-east of the farm) has a mean annual rainfall of 711 mm. Similarly, there is an ongoing decline in rainfall in the south-west of WA. **It is unclear whether the WAPC (2016a) delineation of the 700 mm rainfall isohyet is valid for the Property**.

From the on-site inspection **the Property is considered suitable for dryland farming enterprises (crops and pasture) as with other farms in the surrounding district**. **The major limitation for land-use is seasonal waterlogging in low-lying areas.** In terms of other limitations for agricultural production there were no recorded occurrences of soil salinity (e.g. in surface soils), with two small outcrops of basement (granite and dolerite) bedrock.

Intensive agriculture (fruit and vegetable production) is emphasised as a feature of Priority Agricultural Land in the State Planning Policy 2.5 Rural Planning Guidelines (WAPC, 2016c). **Intensive Agricultural production is not feasible on the Property as it will require irrigation to overcome a summer water deficit**. There are no suitable water supplies for irrigation. Groundwaters are highly saline and surface water impoundment for extensive irrigation is infeasible, based on topography. Any intensive agriculture, if possible, would also have to consider impacts on water flows and nutrient contributions to the immediately adjacent Cobertup and Pinticup Nature Reserves.

2 Introduction

This report provides an independent site specific land capability assessment of Lot 12667 (No. 7691) Muir Highway, Frankland River (the Property) for food production/agricultural purposes having regards to soils, climate, water (rain and irrigation) and access to services.

It has three components:

1. An evaluation of the accuracy of the Priority Agricultural Land classification used in the Western Australian Planning Commission's Lower Great Southern Strategy (WAPC, 2016a) that has been applied to the Property.
2. An on-site assessment of the soils of the Property in terms of their properties and agricultural capability.
3. An overall assessment of the land capability of the Property for food production/agricultural purposes with regards to soils, climate, water (rain and irrigation) and access to services.

3 Evaluation of Priority Agricultural Land classification

3.1 Defining Priority Agricultural Land

The Western Australian Planning Commission's State Planning Policy 2.5 Rural Planning (WAPC, 2016b) defines Priority Agricultural Land:

"Land of State, regional or local significance for food production purposes due to its comparative advantage in terms of soils, climate, water (rain or irrigation) and access to services. Priority agricultural land is derived from High Quality Agricultural Land data that has been subject to consultation and refinement…"

The State Planning Policy 2.5 Rural Planning Guidelines (WAPC, 2016c), further elaborate:

"Primarily, Priority Agricultural Land is where the State's food supply comes from, particularly fruit and vegetables."

High-quality agricultural land (HQAL) is land identified by DPIRD based on soils, landform, capability, water and climate (WAPC, 2016c). The best description of this approach is van Gool et al. (2016) with a case study defining land quality based on soil capability and water resources.

The Priority Agricultural Land classification for the Property is presented in the Lower Great Southern Region Strategy (WAPC, 2016a, Figure 1) and with better resolution in a Tree Farms Fact Sheet (WAPC, 2023, Figure 2).

An explicit document describing how this Priority Agricultural Land classification was developed has not been located. This classification appears to be based on (1) land with > 700 mm annual rainfall, and (b) selection of two specific Mapping Units (BE and Fh4) from DPIRD's regional soil-landscape mapping (Figure 3). The source of the 700 mm rainfall isohyet is unclear.

3.2 Existing soil landscape mapping

The Priority Agricultural Land classification is ultimately based on regional soil-landscape mapping which has been undertaken across the agricultural regions of Western Australia. This is invariably at the scale of 1:100,000, but at larger scales in more intensively farmed areas (Schoknecht et al., 2004). Mapping at this scale doesn't portray individual soils, but soil associations (Dent and Young, 1981; Gunn et al., 1988). These are combinations of soils which can have quite dissimilar properties, but which occur in a repeating pattern across the landscape.

The Property was mapped as part of the Tonebridge-Frankland land resources survey by Stuart-Street (2005) at scale of 1:100,000. This mapping involved a mixture of aerial photographic interpretation and ground observations (Stuart-Street, 2005, pp. 26-27), which was common practice for surveys at this scale (Gunn et al., 1988) at that time.

The Tonebridge-Frankland land resources survey has been digitised and the data are available on the Natural Resource Information (WA) Website[1]. For each of the mapping units shown in Figure 3, there is additional information on this site. This includes a more detailed description of the mapping unit, including the native vegetation and the identity and proportion of different WA Soil Groups within each mapping unit. These are summarized in Table 1.

As with other surveys, individual soils were classified into one of 60 individual WA Soil Groups on the basis of soil profile features such as colour, structure, texture and segregations

[1] https://dpird.maps.arcgis.com/apps/webappviewer/index.html?id=662e8cbf2def492381fc915aaf3c6a0f

(Schoknecht and Pathan, 2013). In the soil-landscape mapping the component WA Soil Groups are identified or inferred and their aerial proportion estimated for each map polygon.

The identity and proportion of the different WA Soil Groups is based on the mapping unit as a whole. Units BE and Fh4 have respective total areas of 1672 ha and 1027 ha whereas their total area on the Property is around 230 ha. This means that the occurrence and proportional area of the WA Soil Groups may differ between what is presented for the whole mapping unit, and what occurs within the Property's boundaries.

Limitations of using the DPIRD soil landscape mapping to make decisions about specific locations are explicitly stated in the disclaimer in the Tonebridge-Frankland land resources survey report (Stuart-Street, 2005, Figure 4a). The report acknowledges (p. 6) that "at the farm scale this information should be considered indicative only…". In addition, the Natural Resource Information (WA) website which contains soil-landscape mapping contains a cautionary note re the use of soil landscape mapping data (Figure 4b). The disclaimer and note clearly indicate the limitations of using 1:100,000 scale survey data to produce recommendations for specific areas of land.

There are thus several key underlying issues regarding the use of this mapping to explicitly define areas of Priority Agricultural Land:

1. The location and composition of the mapping units has been inferred from infrequent ground observations and aerial photograph interpretation. For the Property there were 8 soil observation points on adjacent roads and on the Cobertup Nature Reserve boundary, but no observations within the farmed area itself (Figure 3).
2. Downscaling data: At the 1:100,000 mapping scale 1 cm on a map is equivalent to 1 km on the ground, thus a 400 ha property which is 2 x 2 km, will be represented by 2 x 2 cm on the map.
3. The basis used for interpreting the soil information within each mapping unit in terms of land capability.

3.3 Inferred soil properties for the Property from DPIRD mapping

As part of this site investigation, mapping polygons developed in Stuart-Street (2005) were extracted for the Property from the original soil-landscape mapping (Figure 3). Table 1 contains the estimated proportion of various WA Soil Groups within each of the 7 mapping units developed by Stuart-Street (2005) from the Natural Resource Information (WA) website. These mapping units occur both within and outside the Property, and it is assumed that the proportion of WA Soil Groups within the Property is similar to that in the Mapping Unit as a whole.

In Table 1, the WA Soil Groups have been combined into a series of Supergroups (Schoknecht and Pathan, 2013) which provide a clearer indication of the key features of the soils and their capability. For example, "Wet or waterlogged soils" is the sum of the proportions of the "Saline Wet Soils", "Semi-Wet Soils", and "Wet Soils". Sandy soils are generally less fertile, whereas loamy soils are more fertile.

Priority Agricultural Land has been mapped for the region (WAPC, 2016a; WAPC, 2023), with the distribution of this on the Property shown in Figures 1 and 2. Approximately 57% of the Property has been classified as Priority Agricultural Land.

Table 1: Distribution of WA Soil Groups within each of the mapping units which occur on the Property from data on the Natural Resource Information (WA) website. Several of the WA Soil Groups have been combined into Supergroups. The mapping units occur both within and outside the farm and are shown in Figure 3. Units BE and Fh4 were classified as Priority Agricultural Land in the *Lower Great Southern Strategy 2016* (WAPC, 2016a).

	Mapping Unit						
WA Soil Group	**BE**	**Fh4**	**Fh1**	**Fh2**	**Fh3**	**Uc1**	**Uc3**
Acid deep sand				3	2	3	5
Brown deep loamy duplex				4	4		
Brown deep sand		1		2		1	
Brown loamy earth	5	7	3	4	2		3
Deep sandy duplex gravel	**25**	13	**23**	20	18	7	19
Deep sandy gravel	9	2	15	6	11	4	10
Friable loamy earth	2				2		
Grey deep sandy duplex	5	7	5	7	8	5	17
Grey shallow sandy duplex		6		3	5		8
Ironstone gravelly pale deep sand	2	2	2	2	3	5	
Loamy gravel	19	8	**25**	19	15	5	12
Pale deep sand	3	1	2	2	2	12	10
Pale shallow sand		1		2			5
Red deep sandy duplex	2						
Red shallow loamy duplex				1			
Saline wet soil		5			2		
Semi-wet soil	5	24			11	**27**	
Shallow sandy gravel	8	2	9	9	5	2	
Very shallow soil		1					
Very shallow soil over ferricrete			9	4			
Wet soil	2	14				23	
Yellow deep sand	3			2	2	1	3
Yellow deep sandy duplex	4	2	5	6	4	5	8
Yellow sandy earth	2						
Yellow shallow loamy duplex	2	4		4			
Yellow shallow sandy duplex	2		2		4		
Supergroups							
Ironstone gravelly soils	**61**	**25**	**72**	**54**	**49**	18	**41**
Sandy duplexes	13	15	12	16	21	10	**33**
Wet or waterlogged soils	7	**43**	0	0	13	**50**	0
Deep sands	6	2	2	9	6	17	18

It is clear that mapping units BE and Fh4 (Figure 3) were used as a basis for classifying Priority Agricultural Land, however it is unclear what differentiating soil properties were used to produce this classification. BE and Fh4 comprise 36% and 64% of the priority land area. These areas were estimated by placing a grid over Figures 1 and 3.

In the underlying mapping data (Table 1) Unit Fh4 has a large proportion (43%) of wet soils, which will be unsuitable for intensive agriculture. This was confirmed during the on-site inspection with a large proportion of this Mapping unit waterlogged (Figure 5).

There is also little difference in soil properties between BE and Fh1 and it is unclear why BE was considered as Priority Agricultural Land and Unit Fh1 was not.

Shallow soils over bedrock do not feature in the mapping data, although small exposures of mafic and felsic bedrock did occur on the Property.

4 On-site assessment of the soils of the Property

A field inspection of the Property was made on 1-2 October 2025. This entailed using a colour aerial photograph from the Forest Management Plan (2025, scale 1:8537) as a basemap, which had an overlay of 5 m contour intervals (Figure 5).

67 observation holes (locations in Figure 5) were made using hand-tools and a posthole digger, to depths of 30-100 cm. Soils were described in terms of colour, gravel content and occurrence of waterlogging. Additional observations of surface soil and geological features were made during the survey.

Samples were taken from 0-10 cm for 31 sites and analysed for electrical conductivity and pH in $CaCl_2$ (Rayment and Lyons, 2011). Although an EM38 meter was taken to the Property this could not be used because many low-lying soils were waterlogged.

Two broad soil-landscape units were apparent:

1. *Gently sloping hillslopes and ridge crests*. These contained gravelly soils most likely derived from deeply weathered bedrock, and some deep sands on the slopes (Figure 6d). In the northern part of the property this unit comprised hill-slopes above the 205 m contour, while in the south, this boundary was above 190 m. All soils were well drained and not waterlogged. There were two small bedrock exposures: granitic rocks in the west (Site 4, Figure 6a), and a mafic bedrock was exposed in the north-east (Site 57, Figure 6b). In some areas laterite gravel boulders had been collected from the paddock and piled, however none of the inspection holes had any evidence of laterite hardpans. Surface (0-10 cm depth) soils were non-saline across this area with a mean soil conductivity of 3.4 mS/m (n=16). Mean pH was 4.8. This area corresponds broadly to Units BE, Fh1 and Fh2 in the DPIRD mapping.

2. *Drainage lines.* Broad drainage lines extend across the property from the east to west (Figure 6c), with tributaries from the north. Soils are likely formed on an array of sediments and had surface textures ranging from sand to clay, often with semi-indurated subsoil layers. This area was mostly waterlogged, with waterlogged sites shown on Figure 5. Surface (0-10 cm depth) soils were non-saline across this area with a mean soil conductivity of 7.6 mS/m (n=15). Mean pH was 4.6. This broadly corresponds to Units Fh3, Fh4, Uc1 and Uc3 in the DPIRD mapping.

5 An assessment of the land capability of the Property for food production/agricultural purposes with regards to soils, climate, water (rain and irrigation) and access to services.

5.1 Soils

The major limitation for land-use is seasonal waterlogging in low-lying areas. At one waterlogged site (Site 63), deemed high Priority Agricultural Land, there was an impenetrable humus/iron hardpan.

In terms of other limitations for agricultural production there were no recorded occurrences of surface soil salinity. There were two small outcrops of basement (granite and dolerite) bedrock.

5.2 Climate

The Property is in a region with a hot summer Mediterranean climate (Csb) according to the Köppen climate classification, characterized by warm to hot, dry summers and cool wet winters.

In the Lower Great Southern Strategy this area is assumed to have an annual rainfall of >700 mm (WAPC, 2016a). Rocky Gully, 17 km to the south-east of the Property has a Bureau of Meteorology Station (No. 009964)[2] with data for the period 1996-2025 (Table 2) and a mean annual rainfall of 711 mm.

Records for Bangalup (Station 9506) 8.2 km due east of the Property are on the Silo site[3]. Bangalup has rainfall records from 1920-2024, with a decrease in rainfall over this period of 19.5 mm/decade. Current interpolated rainfall is around 650 mm/year (Figure 7).

Table 2:. Mean rainfall data (1996-2025) for Rocky Gully, 17 km to the south-east of the Property (Bureau of Meteorology Station No. 009964)[4].

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm/yr)	18.5	18.4	36	54	75.8	93.8	111.5	97.8	90.5	55	40.3	26.1	710.8

5.3 Water for irrigation

Groundwater salinity data were collated by Dr John Ruprecht from DWER bore database. Values ranged from 1480 - 21,600 µS/cm or approximately 814-11,880 mg/L (Figure 8). These values are too saline for irrigation. Surface water impoundment for extensive irrigation is considered infeasible, based on topography.

[2] https://www.bom.gov.au/climate/averages/tables/cw_009964.shtml

[3] https://www.longpaddock.qld.gov.au/silo/view-point-data/

[4] https://www.bom.gov.au/climate/averages/tables/cw_009964.shtml

Note that groundwaters in an area can be saline when they are in confined aquifers, whilst the surface soils are non-saline. This appears to be the case with the Property, with no groundwater discharge to the surface.

5.4 Access to services

For dryland agriculture, there are no access limitations to services.

5.5 Overall

From the on-site inspection the farm is considered suitable for dryland farming enterprises (crops and pasture) as with other farms in the surrounding district. The major limitation for land-use is seasonal waterlogging in low-lying areas.

Intensive agriculture (fruit and vegetable production) is indicated as a feature of Priority Agricultural Land in the State Planning Policy 2.5 Rural Planning Guidelines (WAPC, 2016c). This is not feasible on this site as it will require irrigation to overcome a summer water deficit. There are no suitable water supplies for irrigation. Groundwaters are highly saline and surface water impoundment for extensive irrigation is infeasible, based on topography. Any intensive agriculture, if possible, would also have to consider impact on water flows and nutrient contributions to the immediately adjacent Cobertup and Pinticup Nature Reserves.

6 **References**

Dent, D., Young, A., 1981. Soil Survey and Land Evaluation. Allen and Unwin, London.

Gunn, R.H., Beattie, J.A., Riddler, A.M.H., Lawrie, R.A., 1988. Mapping. in: Gunn, R.H., Beattie, J.A., Reid, R.E., van de Graaff, R.H.M. (Eds.), Australian Soil and Land Survey Handbook. Guidelines for Conducting Surveys. Inkata Press, Melbourne, pp. 90-112.

Rayment, G.E., Lyons, D., 2011. Soil Chemical Methods - Australasia. CSIRO Press, Melbourne.

Schoknecht, N., Pathan, S., 2013. Soil groups of Western Australia. A simple guide to the main soils of Western Australia, Department of Agriculture and Food, Perth, Western Australia.

Schoknecht, N., Tille, P., Purdie, B.R., 2004. Soil-landscape mapping in south-Western Australia : an overview of methodology and outputs, Department of Agriculture, Perth, Western Australia.

Stuart-Street, A., 2005. Tonebridge-Frankland area land resources survey. 19, Western Australian Department of Agriculture.

van Gool , D., Stuart-Street, A., Tille, P., 2016. High quality agricultural land in Western Australia: a new decision tool for planning. in: Maheshwari, B., Singh, V.P., Thoradeniya, B. (Eds.), Balanced urban development: Options and strategies for liveable cities. Springer Open, Switzerland, pp. 355-366.

WAPC, 2016a. Lower Great Southern Strategy 2016, Western Australian Planning Commission, Perth.

WAPC, 2016b. State Planning Policy 2.5. Rural Planning, Western Australian Planning Commission, Perth.

WAPC, 2016c. State Planning Policy 2.5. Rural Planning Guidelines. Version 3, Western Australian Planning Commission, Perth.

WAPC, 2023. Tree farms Fact Sheet, Western Australian Planning Commission, Perth.

7. Figures

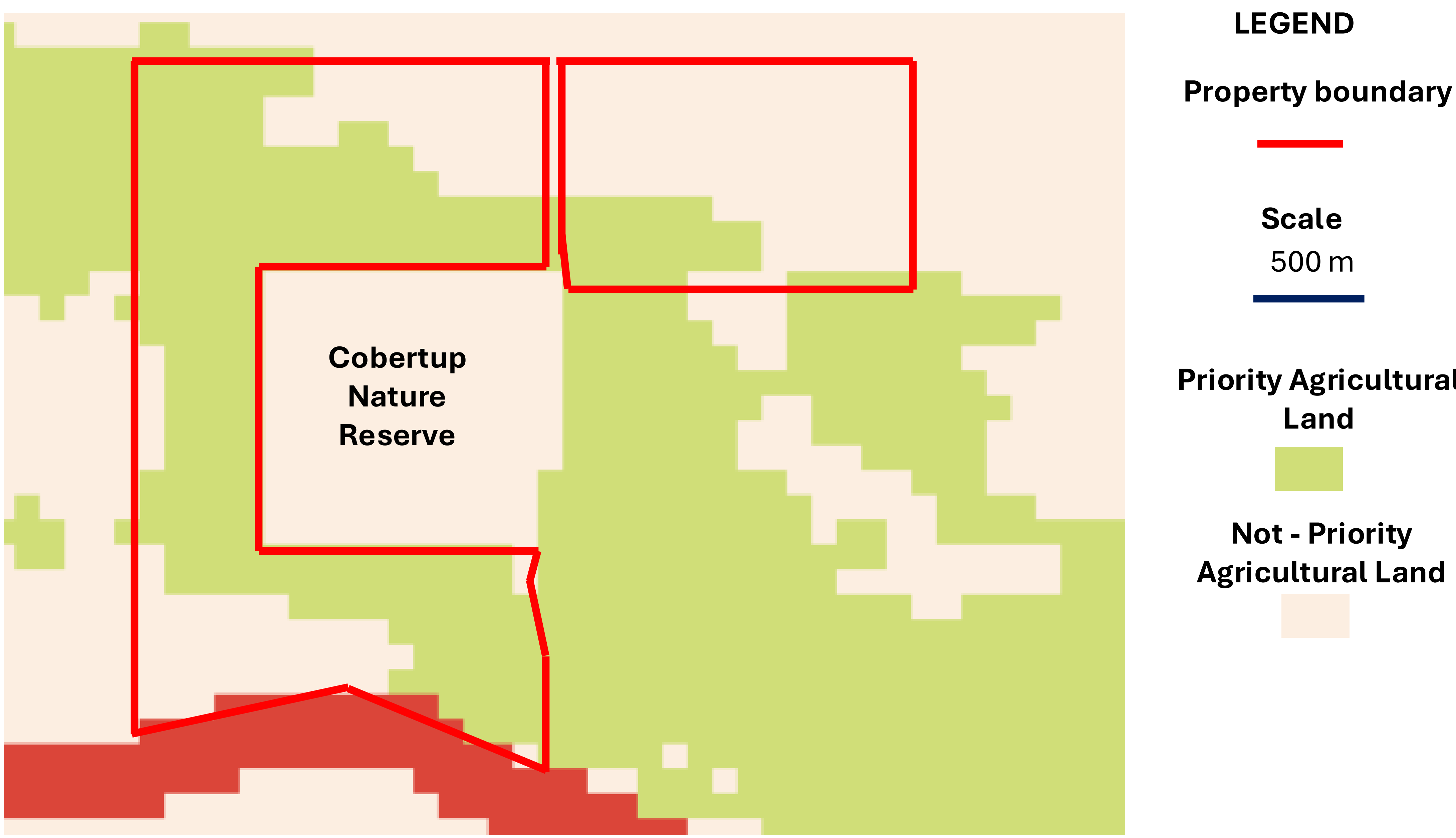


Figure 1: Priority Agricultural Land for the Property taken from Figure 3 the Western Australian Planning Commission's Lower Great Southern Strategy (WAPC 2016a). The Cobertup Nature Reserve has been excluded from the Priority Agricultural Land classification.

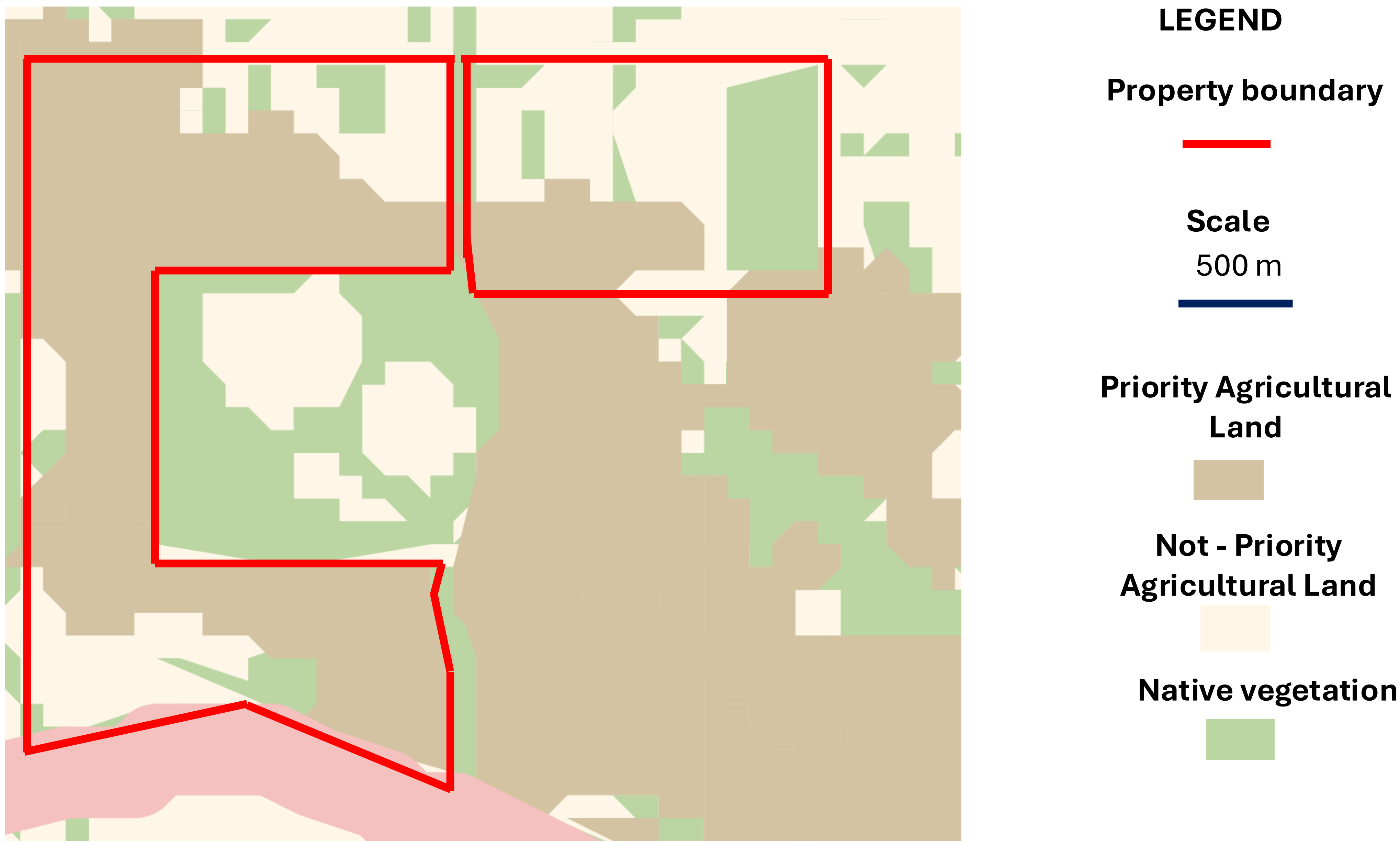
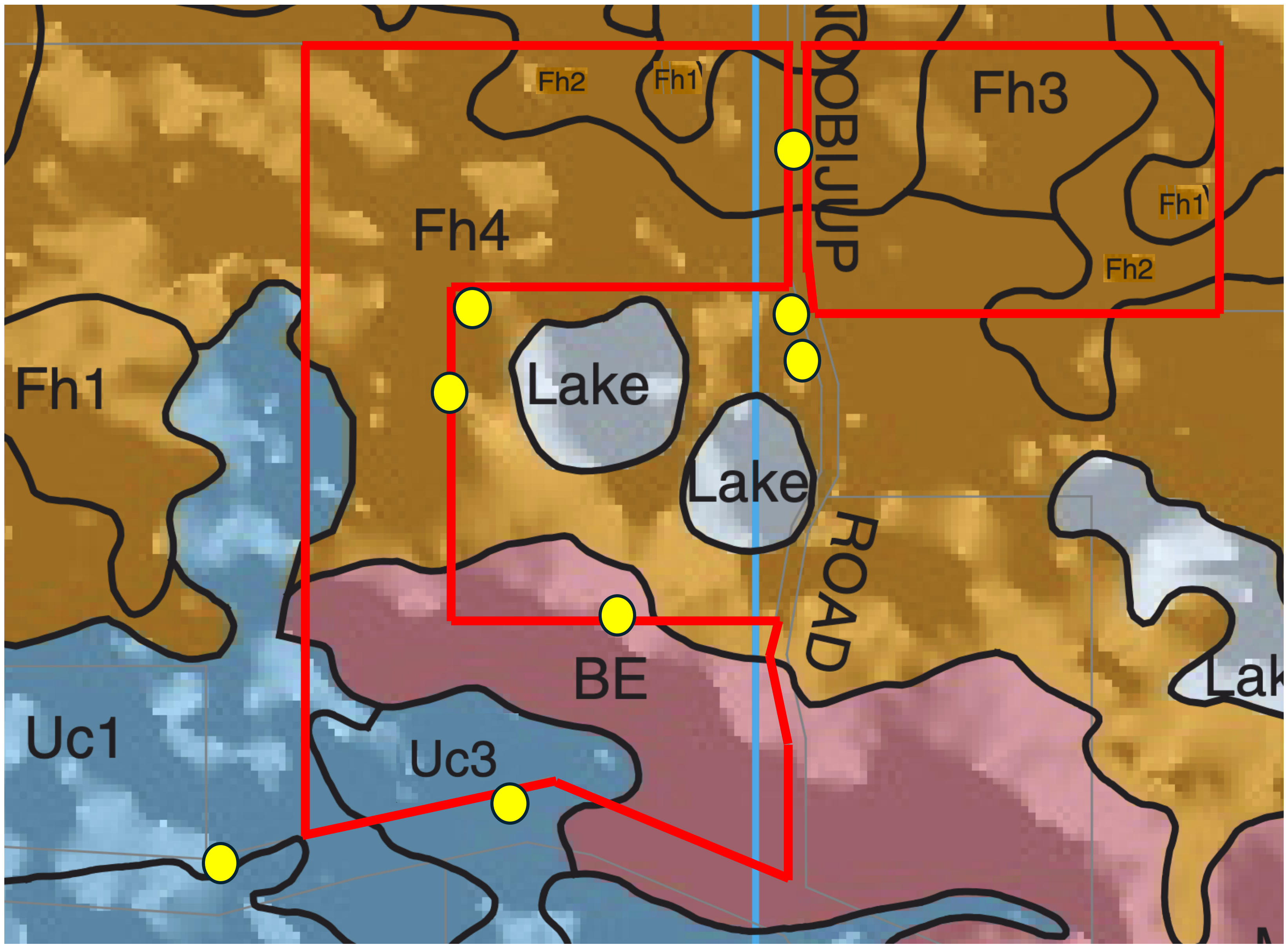


Figure 2: Priority Agricultural Land for the Property enlarged from Figure 3 in the Western Australian Planning Commission's Tree Farms Fact Sheet (WAPC 2023). This mapping is consistent with the WAPC (2016a) mapping but has finer resolution.



Property boundary

Scale
500 m

Field observations in original mapping

Extract from map legend

Unicup System: Poorly drained flats with lakes and low dunes. Pale deep sands, grey deep sandy duplexes, semi-wet soils, pale shallow sands, duplex sandy gravels.

Uc1	Flat to gently undulating plains with occasional minor swamps and low rises. Pale deep sand is dominant with Semi-wet soil, Wet soil and Duplex sandy gravel
Uc3	Low gravelly rises. Duplex sandy gravel, Grey deep sandy duplex and Pale deep sand with Loamy gravel and Deep sandy gravel

Frankland Hills System: Undulating low hills and rises. Loamy gravels, duplex sandy gravels, deep sandy gravel, shallow gravel and grey and yellow/brown deep sandy duplexes.

Fh1	Hill crests and upper slopes. Loamy gravels, duplex sandy gravels, shallow gravels and deep sandy gravels.
Fh2	Lower to upper smooth slopes below hill crests. Loamy gravels, duplex sandy gravels, shallow gravels and deep sandy gravels.
Fh3	Minor valleys with concave slopes and drainage depressions. Duplex sandy gravels, loamy gravels and deep sandy gravels with semi-wet soils and grey deep sandy duplexes.
Fh4	Poorly drained flats, lower slopes and footslopes. Loamy gravels and duplex sandy gravels with semi-wet soils and brown loamy earths.

Manjimup Plateau System: Lateritic plateau with broad swampy depressions. Duplex sandy gravels, loamy gravels and wet and semi-wet soils.

BE	Bevan subsystem: Broad, gently sloping lateritic divides. Loamy gravels, duplex sandy gravels, shallow gravels and deep sandy gravels.

Tonebridge-Frankland Soil Map
https://library.dpird.wa.gov.au/cgi/viewcontent.cgi?filename=0&article=1018&context=land_res&type=additional

Figure 3: Extract from Tonebridge-Frankland Soil Map (Stuart-Street 2005) showing the Property and location of original field observations. Mapping units BE and Fh4 were defined as Priority Agricultural Land in the Western Australian Planning Commission's Lower Great Southern Strategy (WAPC, 2016a).

(a)

Disclaimer

This Survey report is designed for use at the publication scale (1:100,000).
The scale influences:

- how homogeneous the map unit is,
- how accurate the lines are, and
- how accurate the descriptions and attributions are.

Descriptions of map units apply to the whole survey and to any occurrences in adjacent surveys. Individual map units may differ considerably from this description in terms of the proportion of different soils and landforms that occur within them. Thus, the map provides a guide to what soils may occur at a particular point or in selected area, not a definitive statement.

(b)

- The soil-landscape maps and other features reliant on it are designed for use at publication scales, typically between 1:50,000 and 1:250,000. The scale and method of linework capture will influence how uniform a map unit is and how accurate the lines are.
- The underlying data is also of varying quality and will influence how accurate the descriptions and attributions are.
- This information is appropriate for regional and strategic planning, and for identifying areas for more intensive assessment.

Figure 4: (a) Disclaimer in the Tonebridge-Frankland land resources survey report which provides the base data for the priority agricultural land mapping (Stuart-Street, 2005, p. 2) and (b) a note re use of soil landscape mapping data on the Natural Resource Information (WA) website. These clearly indicate the limitations of using 1:100,000 scale survey data to produce recommendations for specific areas of land. Mapping at a scale of around 1:10,000 is required to delineate soils at a farm scale.

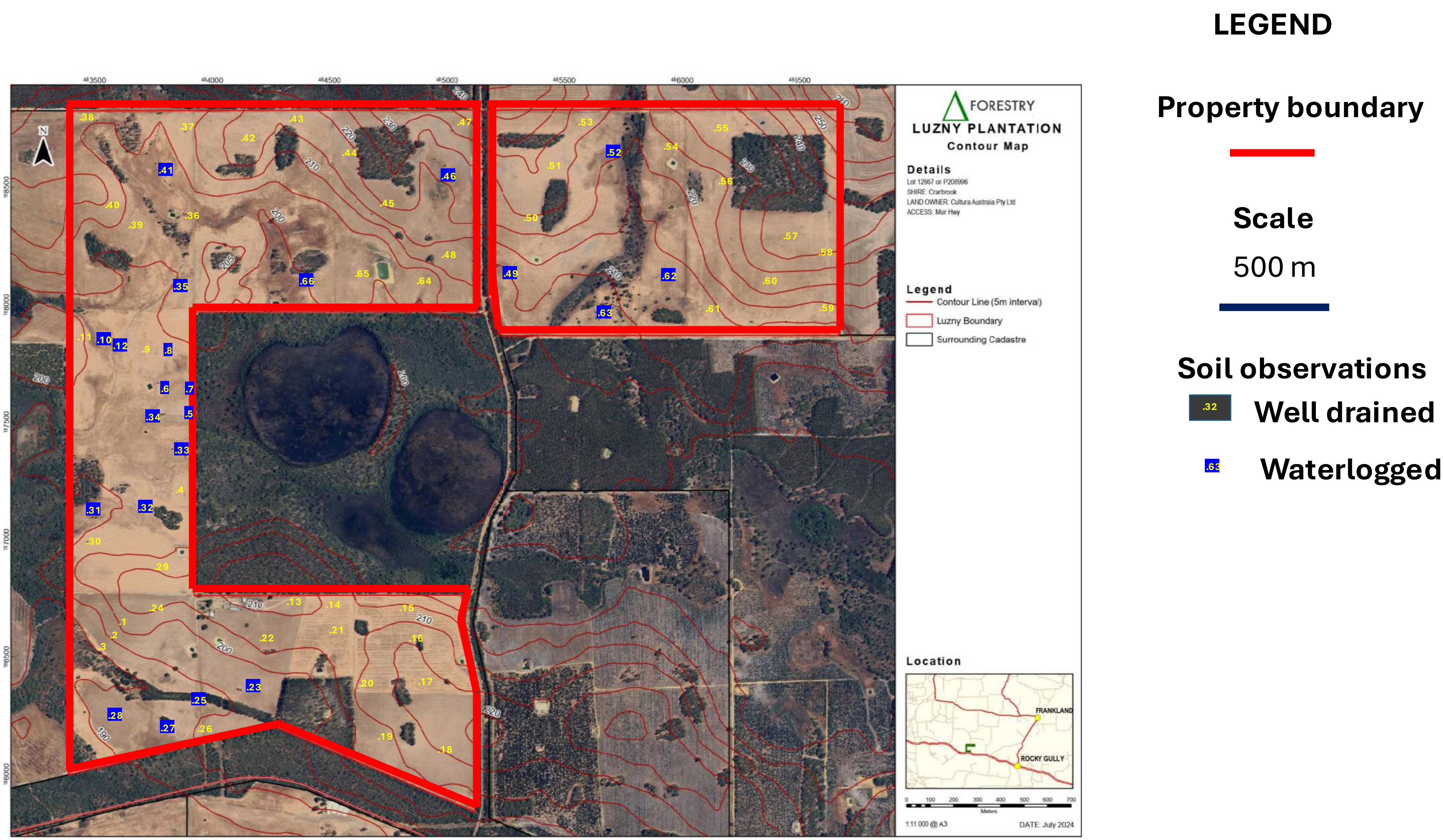


Figure 5: Location of soil observations on the Property. Basemap from amended Forest Management Plan (Delta Forestry 2025, p. 30).

(a)

(b)

(c)

(d)

Figure 6: (a) Granite/gneiss bedrock exposure near Site 4. This was of limited extent and the only noted occurrence on the Property. (b) Collected and stacked doleritic rocks in upper slope position (Site 57). There were small (< 50 cm diameter), isolated rock outcrops in this area. (c) Drainage line (Site 12) in low-lying waterlogged areas. (d) View to east from Site 38, showing a gravelly rise and white sand on lower slopes typical of upland areas.

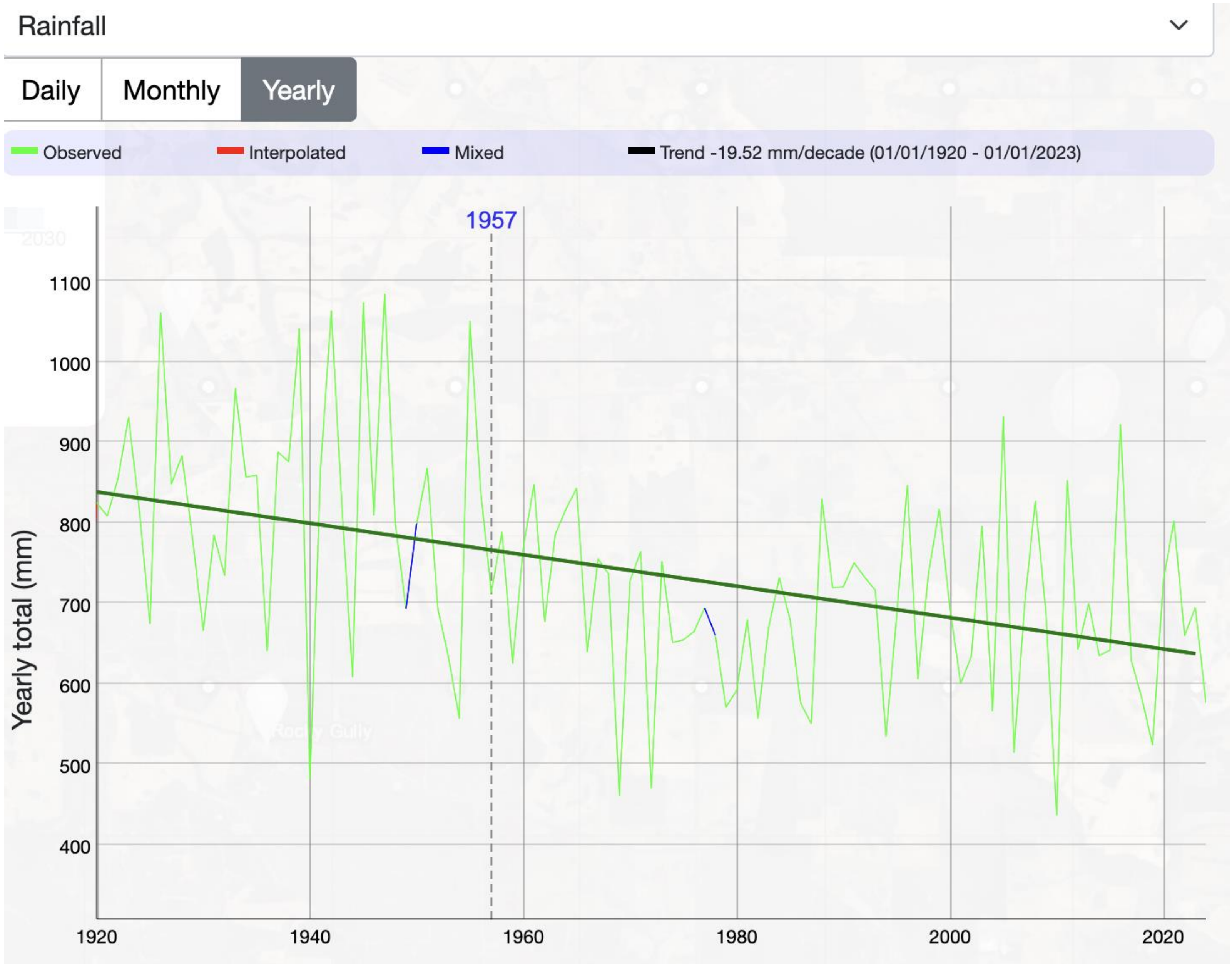


Figure 7: Annual rainfall data (1920-2025) for Bangalup 8.2 km due east of the Property (Silo Station 9506). This shows a decreasing trend of 19.5 mm/decade, with a current interpolated rainfall of around 650 mm/yr. Source: www.longpaddock.qld.gov.au/silo/view-point-data/

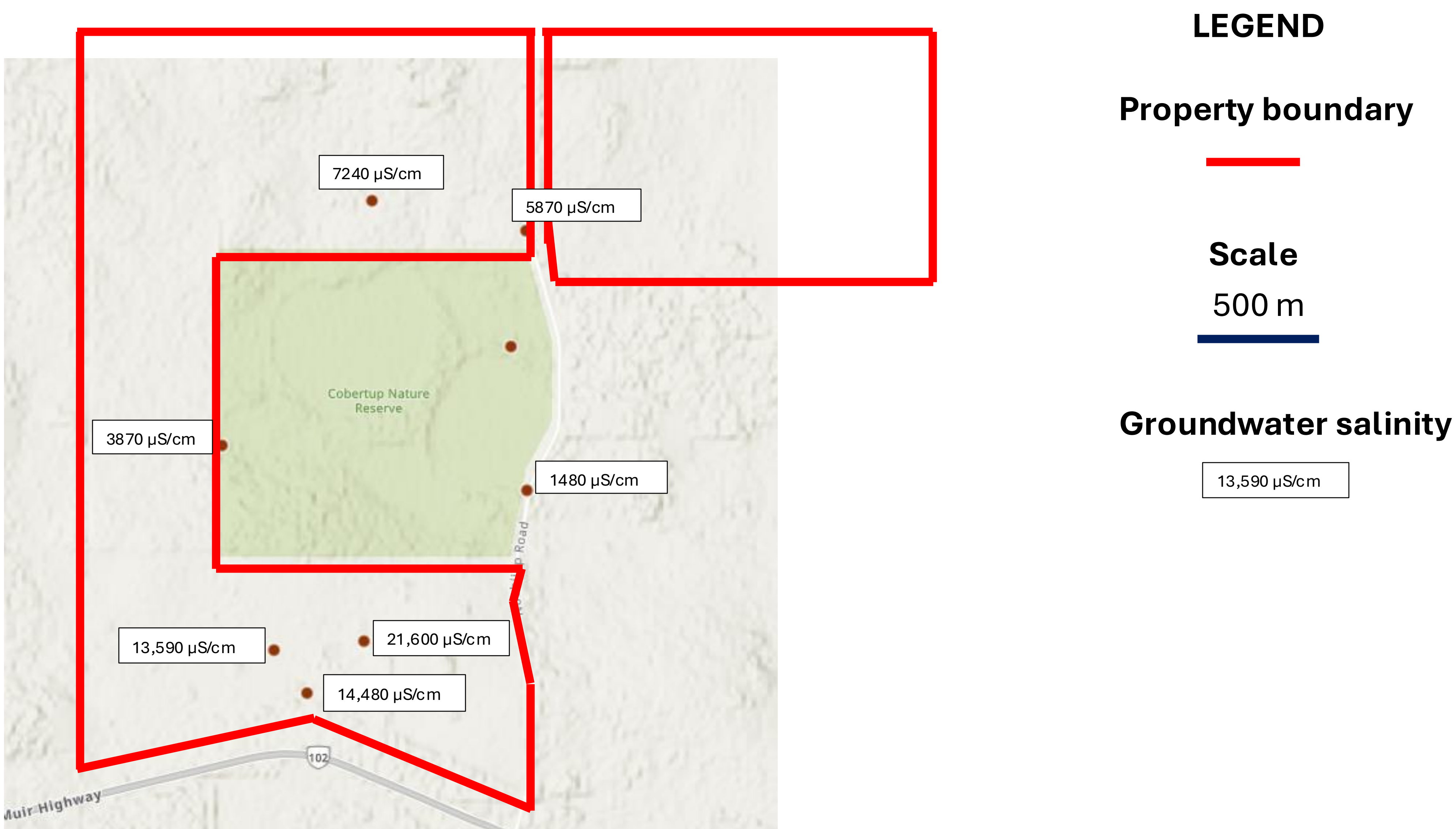


Figure 8: Groundwater salinity measurements from bores on the Property taken from DWER data base. To convert conductivity measurements (µS/cm) to estimated salt content (mg/L) multiply values by 0.55.

8 Curriculum vitae

Richard James HARPER

Note: activities related to soil survey and land evaluation are highlighted in yellow.

Education

B. Sc. (Agric) Hons, University of Western Australia, 1981

PhD University of Western Australia (Agriculture), 1995 Thesis: "Relationships between soil properties, geomorphic history and land degradation in the Western Australian wheatbelt" This involved detailed farm scale mapping of land subject to wind erosion and water repellency.

https://researchportal.murdoch.edu.au/esploro/profile/richard_harper

Publications Summary

https://www.scopus.com/authid/detail.uri?authorId=7401530212

https://scholar.google.com.au/citations?user=_QNddPMAAAAJ&hl=en

Positions Held

Present

Professor, Murdoch University, (2009-)

Associate Dean Research (Agriculture) (2022-)

- In 2021 awarded Vice Chancellor's Excellence in Research Award – Distinguished and Sustained Achievement.
- Leading a research program investigating the use of market-based investments (carbon, water, biodiversity) to drive landscape scale change in soil, water and biodiversity management in agricultural areas. A parallel program has investigated soil water repellency, which is a major issue in agricultural production, this including using digital soil mapping methods.
- Publications have explored both the science and policy aspects of climate mitigation, using bioenergy, reforestation or soil amendments. This includes new approaches that enhance environmental co-benefits particularly in relation to soil and water management where there are many long-standing, intractable problems. The impacts of carbon mitigation on food security and the extension of market-based approaches to other environmental problems (e.g. forest water yield, biodiversity protection) have also been investigated.
- This has included participation in high level international and national panels and recent invited reviews for the WA Government on the carbon and water implications of native forest management.
- Research program currently comprises 3 PhD students; 18 PhD and 12 MSc completions. It has attracted \$4.01m in external funding (career total \$6.76 m) and resulted in 91 journal publications, with a (2014-23) SciVal Field Weighted Citation Index of 1.77. In addition, 14 refereed book chapters and 15 refereed reports have been completed.
- Results have been presented at major national and international meetings, many as an invited speaker. Development and chairing of sessions at several international meetings and convening of several large (>100 attendee) meetings in Perth. Many invited presentations to WA agricultural industry and government groups.

- Lead authorship on the 2014 Intergovernmental Panel on Climate Change 5th Assessment Report (WGIII) chapter on mitigation using Agriculture, Forestry and other Land-Uses (AFOLU).
- Science understanding translated into policy implementation through invited membership of high-level Australian Government statutory committees: (a) Emissions Reduction Assurance Committee (2015-16), under the *Carbon Credits (Carbon Farming Initiative) Act* 2011, and the Threatened Species Scientific Committee (2019-23) under the *Environmental Protection and Biodiversity Conservation Act* 1999.
- Instigation and Chairing of the International Union of Forest Research Organization's (IUFRO) Taskforce on Forests, Water and Soils (2015-17), co-chair (2017-2024). Representation at several high-level FAO meetings and as a contributor to the Global Forest Expert Panel report on forest and water interactions.
- Undergraduate teaching delivered through two units (ENV243 Water and Earth; ANS105 Introduction to Agriculture); Honours thesis supervision (9 completions), and a range of lectures into other units covering topics such as food security, water security, and climate change mitigation. ENV243 lectures focus on soils and hydrology, with case studies from south-western WA.

Previous Positions

Director, Centre for Sustainable Farming Systems, (2020-2021)

Director, Centre for Crop and Food Innovation (2021)

Acting Dean (2017-2019), School of Veterinary and Life Sciences, Murdoch University.

Successfully ran the School of Veterinary and Life Sciences in the period leading up to a major restructure. This School comprised four functional groups: the College of Veterinary Medicine, Agriculture, Environmental and Conservation Sciences and Biomedical Sciences. It was Murdoch's largest School at the time, with 138 academic and 150 professional staff, 2300 undergraduate and 300 PhD students, an annual budget of $85 m, and made the major contribution to Murdoch's research income and publications.

Leader, Agricultural Sciences (2014-2019).

As leader of Agricultural Sciences at Murdoch:

- Elected President of the Australian Council of Deans of Agriculture (2018-19); represented this group on Board of global counterpart (GCHERA).
- Developed a new Crop and Pasture Science Major to complement the existing Animal Science & Animal Health Majors. Murdoch has the largest undergraduate agriculture program in Western Australia with 360 students, 90 agricultural-related PhDs and $12m/yr of external grant income. This included development of several forward focused units related to food security, trade and digital agriculture.
- Consistent growth in agricultural student load and research income during tenure.
- Initiatives included an annual research seminar with 200 attendees, MoU with Muresk College, initiation of international undergraduate student tours (China, Europe), involvement with CRC for High Performance Soils, development of strategic research partnerships across the agricultural and forestry sectors in China and Vietnam.

Research Scientist –Principal Research Scientist, Research & Development Manager, Western Australian Government (Dept of Conservation & Land Management, Forest Products Commission). (1989—2009)

- As part of a major pine and eucalypt reforestation program in the south-west of WA (300,000 ha), developed standards for soil survey and site selection for plantations on farmland (Harper et al. 2008), and investigated and reported the causes of poor yields and plantation collapse (Ryan et al, 2002; Harper et al. 2009). This involved undertaking many property evaluations with operational staff, particularly in the >600 mm rainfall zone.

- Regional land evaluations of plantation suitability using DAFWA/DPIRD datasets (e.g. Harper et al. 2005)
- Led programs addressing salinity, plantation and farm forestry and climate change mitigation on farmland at the science-policy-industry interface.
- Policy leadership through chairing the national Forests and Climate Change Committee, membership of various State and Australian climate change committees, and major contribution to major national initiatives such as the Garnaut Review and state-based emissions trading. Provision of advice to several WA Ministers.
- Developed concept of carbon mitigation for large-scale farmland and watershed restoration following interactions with Tokyo University researchers from 1995 onwards.
- Developed concept of 3-5 yr rotations of trees for biomass production to dewater cropland and restore catchment water balances.
- Program Leader in the Cooperative Research Centre for Greenhouse Accounting based at ANU.
- Developed strong networks across Australian and WA government and the forest and agricultural industries.

Research Officer (Hop Production), Elders IXL, Tasmania, Australia (1984)

Agronomist, CSBP and Farmers (WA fertilizer company), Perth, Australia (1981-83)

- Strong understanding of the soils, soil fertility and farming systems across the WA agricultural region.

Appointments and Committees

- Murdoch University, Professorial Promotions Committee (2021-2024).
- Member, Australian Government Threatened Species Scientific Committee (2019-2023).
- Member, Australian Council of Agricultural Deans (2014-19; 2022-2024), Vice President (2016-2018), President (2018-19).
- Intergovernmental Panel on Climate Change, Lead Author (Agriculture, Forestry and Other Land Uses), 5th Assessment Report, WGIII, Mitigation (2011-2014).
- Chair of the International Forest Research Organization's (IUFRO) Task Force on Forests, Water and Soils (2015-2017); Deputy Chair (2017-2023).
- Member, Global Forest Expert Panel on Forests and Water (GFEP) (2017-2018).
- Member, Australian Emissions Reduction Assurance Committee (2015-6); Department of Environment.
- Visiting Professor, Chinese Academy of Forestry (2013-).
- Primary Industries Adaptation Research Network (PIARN), National Climate Change Adaptation Research Facility, Forestry Node Coordinator (2010-2013).
- Murdoch University; Member of Academic Council (2013-14).
- 18th Congress for the International Soil Conservation Organization, El Paso, Texas, 2015. Member of International Advisory Committee.
- International Conference on Arid Land (DTXI), San Antonio, Texas, 2013. Member of International Advisory Committee.
- *Soil Research*, Associate Editor (2010-present).
- Alcoa Chair in Sustainable Water Management, Murdoch (2009-2012).
- International Conference on Arid Land (ICAL1/DTX), Narita, Japan, 2011. Member of International Advisory Committee.
- WA Chamber of Commerce and Industry, Environment Committee (2011-14)
- National Climate Change Adaptation Research Facility (NCCARF). Griffith University. Member of Management Committee (Murdoch Representative) (2010-12).
- The University of Western Australia, Convocation. Chair of Awards sub-committee (2008-11), Deputy Warden (2011-12); Council Member (2008-2015).
- Chair, Forests and Climate Change Committee, Forestry and Forest Products Committee, Australia (2005-2009) (National). This role included membership of the NRMMC group Climate in Agriculture and NRM (CLAN), Climate Change Strategies for the Primary Industries (CCRSPI), the Steering Committee of the National Climate Change Action Plan for

Commercial Forestry and the Steering Committee of the Forests Climate Change Vulnerability Study (NCCARF).

- Forest and Wood Products Council, Climate Change and Emissions Trading Sub-Committee (2008) (National).
- Co-operative Research Centre (CRC) for Greenhouse Accounting (Canberra) proto-Board and Board – negotiated CALM's contribution (1998-2000), Management team (2000-6); Program Manager (2004-6) (National).
- WA Government Greenhouse Interdepartmental Committee, Perth (2004-2009).
- Western Australian Monitoring and Evaluation Advisory Committee (2005-7) (State).
- Australian Society of Soil Science Inc Federal Secretary (2001-3) (National), WA State President (1994-1996); WA Vice President (1992-1994).
- Forestry and Forest Products Committee, Research Working Group 3, Forest soils and hydrology (1991-2009). (National).
- Scientific and Technical Advisory Panel Roster of Experts, Global Environment Facility, UN Environmental Program (2003-9).
- Member of planning committee for CRC for Plant Based Management of Salinity (1999-2000) (National).
- Australian Greenhouse Office National Carbon Accounting System Soil Carbon Committee (1998-99) (National).
- WA Salinity Council R&D Committee (1997-9) (State).
- National Farm Forestry Silviculture Project Steering Committee (1999-2001) (National).
- Australian Association of Natural Resource Management (WA Committee 1995-7),
- UWA Postgraduate Students Association (President, 1988-1989)

Publications

Book Chapters

1. **Harper**, R. J., and Gilkes, R. J. (2001). Some factors affecting the distribution of carbon in soils of a dryland agricultural system in southwestern Australia. In 'Assessment Methods for Soil Carbon Pools.' (R. Lal, J. M. Kimble, R. F. Follett, and B. A. Stewart Eds), pp. 577-91. (Lewis Publishers: Boca Raton, Florida.)
2. Hatton, T. J., Dawes, W., and **Harper**, R. J. (2002). Woodlots in rotation with agriculture. In 'Trees, Water and Salt – an Australian guide to using trees for healthy catchments and productive farms' (Stirzaker, R., Vertessy, R., and Sarre, A. Eds) (Rural Industries Research and Development Corporation: Canberra). pp 43-55.
3. Smettem, K.R.J., Pracilio, G., Oliver, Y.M. and **Harper** R.J. (2005). Data availability and scale in hydrologic applications. Y. Pachepsky and W.J. Rawls (Eds), Development of Pedotransfer Functions in Soil Hydrology, *Developments in Soil Science*, **30**, 253-271.
4. **Harper**, R.J., Smettem, K.R.J., Reid, R.F., Callister, A., McGrath, J.F. and Brennan, P.B. (2009). Pulpwood crops, pp. 199-218, In "Agroforestry for Natural Resource Management", I.K. Nuberg, B.H. George and R.F. Reid (Eds). (CSIRO Publishing: Melbourne).
5. Smettem, K.R.J. and **Harper**, R.J. (2009). Using trees to manage local and regional water balances, pp. 37-52, In "Agroforestry for Natural Resource Management", I.K. Nuberg, B.H. George and R.F. Reid (Eds). (CSIRO Publishing: Melbourne).
6. Glindemann, R., **Harper**, R.J. and Dawkins, S. (2009). Land use, forestry and native title. In Hodgkinson, D. (Ed), Australian Climate Change Law and Policy. (LexisNexis, Sydney).
7. **Harper**, R.J., Smettem, K.R.J, Townsend, P.V., Bartle, J.R and McGrath, J.F. (2012). Broad-scale restoration of landscape function with timber, carbon and water investment. In "Forest Landscape Restoration: Integrating Social and Natural Sciences", Stanturf, J. A.; Lamb, D.; Madsen, P. (Eds) *World Forests* **15**: 275-292. (Springer: New York).
8. Churchman, G.J., Noble, A., Bailey, G., Chittleborough, D.J and **Harper**, R.J. (2014). Clay addition and redistribution to enhance carbon sequestration in soils. In Soil Carbon, Hartemink, A.E. and McSweeney, K. (Eds). *Progress in Soil Science* **26**: 327-335. (Springer International Publishing: New York).
9. Smith P, Bustamante M, Ahammad H, Clark H, Dong H, Elsiddig EA, Haberl H, **Harper** R, House J, Jafari M, Masera O, Mbow C, Ravindranath NH, Rice CE, Robledo Abad C, Romanovskaya A, Sperling F, Tubiello FN (2014) Agriculture, Forestry and Other Land Use (AFOLU). In 'Climate Change 2014: Mitigation of Climate Change. Contribution of Working

Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change'. (Eds O Edenhofer, R Pichs-Madruga, Y Sokona, E Farahani, S Kadner, K Seyboth, A Adler, I Baum, S Brunner, P Eickemeier, B Kriemann, J Savolainen, S Schlömer, C von Stechow, T Zwickel, JC Minx) pp. 811-922. (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA).
10. Allwood, J.M., Bosetti, V., Dubash, N.K., Gomez-Echeverri, L., von Stechow, C., et al. (2014) Glossary, Acronyms and Chemical Symbols. In 'Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change'. (Eds O Edenhofer, R Pichs-Madruga, Y Sokona, E Farahani, S Kadner, K Seyboth, A Adler, I Baum, S Brunner, P Eickemeier, B Kriemann, J Savolainen, S Schlömer, C von Stechow, T Zwickel, JC Minx) pp. 1249-1279. (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
11. Keith, David A., et al. (2020) IUCN Global Ecosystem Typology 2.0. Gland: IUCN.
12. Sangmanee, P., Dell, B., Henry, D.J. and **Harper, R.J.** (2022). Deep soil carbon – characteristics and measurement with particular bearing on kaolinitic profiles. pp.347-372 In “Subsoil Constraints”, (Eds R.W. Bell, T.S. de Oliveira), (Springer International Publishing: New York). https://doi.org/10.1007/978-3-031-00317-2_14
13. Then, M., Lobsey, C., Henry, D.J., Sochacki, S.J., and **Harper, R.J**. (2024). Proximal sensing in soil water repellency management: A review. pp. 75 - 88 In Sandy Soils, A Hartemink and J. Juang (eds). *Progress in Soil Science,* Springer, Berlin. https://doi.org/10.1007/978-3-031-50285-9_7
14. Dao, M.T.T., Dell, B., Henry, D.J. and **Harper, R.J.** (2024). Explaining the incidence of soil water repellency in sandy soils. pp. 265-274 In Sandy Soils, A Hartemink and J. Juang (eds). *Progress in Soil Science,* Springer, Berlin. https://doi.org/10.1007/978-3-031-50285-9_24

Journal papers

1. **Harper**, R. J., Gilkes, R. J., and Robson, A. D. (1982). Biocrystallization of quartz and calcium phosphates in plants: a re-evaluation of the evidence. *Australian Journal of Agricultural Research* **33**, 563-71.
2. **Harper**, R. J. and Gilkes, R. J. (1994). Hardsetting in the surface horizons of sandy soils and its implications for soil classification and management. *Australian Journal of Soil Research* **32**, 603-19.
3. **Harper**, R. J. and Gilkes, R. J. (1994). Soil attributes affecting water repellency and the utility of soil survey in predicting its occurrence. *Australian Journal of Soil Research* **32**, 1109-24.
4. **Harper**, R. J. and Gilkes, R. J. (1994). Evaluation of the ^{137}Cs technique for estimating wind erosion losses for some sandy Western Australian soils. *Australian Journal of Soil Research* **32**, 1369-87.
5. McKissock, I., Gilkes, R. J., **Harper**, R. J. and Carter, D. J. (1998). Relationships of water repellency to soil properties for different spatial scales of study. *Australian Journal of Soil Research* **36**, 495-507.
6. Wong, M. T. F., and **Harper**, R. J. (1999). Use of on-ground gamma-ray spectrometry to measure plant-available potassium and other topsoil attributes. *Australian Journal of Soil Research* **37**, 267-77.
7. **Harper**, R. J., McKissock, I., Gilkes, R. J., Carter, D. J., and Blackwell, P. S. (2000). A multivariate framework for interpreting the effects of soil properties, soil management and landuse on water repellency. *Journal of Hydrology,* **231-232**, 371-83.
8. Ryan, P. J., **Harper**, R. J., Laffan, M. D., Booth, T. H., and McKenzie, N. J. (2002). Site assessment for farm forestry in Australia and its relationship to scale, productivity and sustainability. *Forest Ecology and Management*, **171**, 133-152.
9. **Harper**, R. J., and Gilkes, R. J. (2004). Aeolian influences on the soils and landforms of the southern Yilgarn Craton of semi-arid, south-western Australia. *Geomorphology*, **59,** 215-235.
10. **Harper**, R. J., and Gilkes, R. J. (2004). The effects of clay and sand additions on the strength of sandy topsoils. *Australian Journal of Soil Research,* **42**, 39-44.
11. **Harper**, R.J., Smettem, K.R.J. and Tomlinson, R.J. (2005). Using soil and climatic data to estimate the performance of trees, carbon sequestration and recharge potential at the catchment scale. *Australian Journal of Experimental Agriculture*, **45**, 1389-1401.
12. **Harper**, R.J., Robinson, N., Smettem, K.R.J., Sochacki, S.J. (2005). Phase farming with trees: the acceleration of farm forestry to combat dryland salinity. *International Forestry Review*, **7**, 276-7.

13. Archibald, R. D., **Harper**, R. J., Fox, J. E. D., and Silberstein, R. P. (2006). Tree performance and root-zone salt accumulation in three dryland Australian plantations. *Agroforestry System*s **66**, 191-204.
14. Pracilio G, Adams ML, Smettem KRJ and **Harper** RJ (2006). Determination of spatial distribution patterns of clay and plant available potassium contents in surface soils at the farm scale using high resolution gamma ray spectrometry. *Plant and Soil* **282**, 67-82.
15. Smettem, K.R.J., **Harper**, R.J. and Watanabe, F. (2006). Can concepts of ecological optimality provide guidance for predicting the performance of replanted perennial vegetation in dryland areas? *Journal of Arid Land Studies* **15**, 367-370.
16. **Harper**, R.J. and Smettem, K.R.J. (2006). Using soil and climatic data to estimate carbon sequestration and recharge reduction at farm, watershed and regional scales *Journal of Arid Land Studies* **15**, 255-258.
17. Robinson, N., **Harper**, R. J. and Smettem, K. R. J. (2006). Soil water depletion by *Eucalyptus* spp. tree belts integrated into dryland agricultural systems. *Plant and Soil* **286**, 141-151.
18. Pracilio G, Smettem KRJ, Bennett, D., **Harper** RJ and Adams ML (2006) Site assessment of a woody crop where a shallow hardpan soil layer constrained plant growth. *Plant and Soil* **288**, 113-125.
19. **Harper** RJ, Beck AC, Ritson P, Hill MJ, Mitchell CD, Barrett DJ, Smettem KRJ, Mann SS (2007) The potential of greenhouse sinks to underwrite improved land management. *Ecological Engineering* **29**, 329-341. https://doi.org/10.1016/j.ecoleng.2006.09.025
20. Sochacki S.J., **Harper** RJ and Smettem, K.R.J. (2007). Estimation of woody biomass for short rotation bio-energy species in south-western Australia. *Biomass & Bioenergy* **31**, 608-616.
21. **Harper** RJ, Smettem KRJ, Carter JO and McGrath JF (2009). Drought deaths in *Eucalyptus globulus* (Labill.) plantations in relation to soils, geomorphology and climate. *Plant and Soil* **324**, 199-207.
22. Kojima, T., Inaba, K., Koyanagi, S., Suganuma, H., Kurosawa, K., Kawarasaki, S., Tanouchi, H. **Harper**, R.J, Yamada, K., Hamano, H. (2009). Improvement effect of semi-arid land afforestation on soil environment. *Journal of Arid Land Studies* **19**, 141-144.
23. **Harper**, R. J., Gilkes, R. J., Hill, M.J and Carter, D.J. (2010). Wind erosion and soil carbon dynamics in south-western Australia. *Aeolian Research* 1, 129-141. https://doi.org/10.1016/j.aeolia.2009.10.003
24. **Harper**, R.J., Sochacki, S.J., Smettem, K.R.J. and Robinson, N. (2010). Bioenergy feedstock potential from short rotation woody crops in a dryland environment. *Energy & Fuels* **24**, 225-231.
25. Kurosawa, K., Suganuma, H., Aikawa, S., Kawarasaki, S., Hamano, H., Utsugi, H, Abe. Y., Kojima, T., **Harper**, R., Luff, J., Stock, W., Lund, M. and Bannister, M. (2010): Long-term changes in precipitation characteristics at Sturt Meadows, Western Australia. *Journal of Ecotechnology Research*, **16**, 27-31.
26. Bi, H., Long, Y., Turner, J., Lei, Y., Snowdon, P., Li, Y., **Harper**, R., Zerihun, A. and Ximenes, F. (2010). Additive prediction of aboveground biomass for *Pinus radiata* (D. Don) plantations. *Forest Ecology and Management* **259**, 2301-2314.
27. **Harper**, R.J., Smettem, K.R.J., Sochacki, S.J., Nakagami, Y., Honda, S., Takahashi, F., Kawamoto, K, and Bulinski, J. (2011). Using carbon reforestation for water and environmental restoration. *Journal of Arid Land Studies* **21**, 57-61.
28. Kurosawa, K., Aikawa, S., Oda, Y., Kojima, T, Kawarasaki, S., Saito, M, Sugunuma, H., **Harper**, R.J. and Tanouchi, H. (2012). An analysis of root biomass in a sapling cultivation experiment for afforestation on salt affected land. *Journal of Arid Land Studies* **22**, 131-134.
29. Dean, C., Wardell-Johnson, G. W. and **Harper**, R.J. (2012). Carbon management of commercial rangelands in Australia: major pools and fluxes. *Agriculture, Ecosystems & Environment* **148**, 44-64.
30. Townsend, P.V., **Harper**, R.J., Brennan, P.D, Wu, S., Smettem, K.R.J. and Cook, S.E. (2012). Multiple environmental services as an opportunity for watershed restoration. *Forest Policy and* Economics 17, 45-58. https://doi.org/10.1016/j.forpol.2011.06.00
31. Sochacki S.J., **Harper R.J.** and Smettem, K.R.J. (2012) Bio-mitigation of carbon from reforestation of abandoned farmland. *GCB Bioenergy* 4, 193-201. https://doi.org/10.1111/j.1757-1707.2011.01139.x
32. Dean, C., Roxburgh, S.H., **Harper**, R.J., Eldridge, D.J., Watson, I.W., Wardell-Johnson, G.W. (2012) Accounting for space and time in soil carbon dynamics in timbered rangelands. *Ecological Engineering* **38**, 51-64.

33. Mitchell, C.D., **Harper**, R.J., Keenan, R.J. (2012). Current status and future prospects for carbon forestry in Australia. *Australian Forestry* **75**, 200-212.
34. **Harper**, R.J., Okom, A.E.A., Stilwell, A.T., Tibbett, M., Dean, C., George, S.J., Sochacki, S.J., Mitchell, C.D., Mann, S.S., Dods, K. (2012). Reforesting degraded agricultural landscapes with *Eucalypts*: effects on soil carbon storage and soil fertility after 26 years. *Agriculture, Ecosystems and Environment* **163**: 3-13.
35. George, S.J., **Harper**, R.J., Hobbs, R.J., Tibbett, M. (2012). A sustainable agricultural landscape for Australia: interlacing carbon sequestration, biodiversity and salinity management in agroforestry systems. *Agriculture, Ecosystems and Environment* **163**: 28-36.
36. Sochacki S.J., **Harper** R.J., Smettem, K.R.J., Dell, B. and Wu, H. (2013). Evaluating a sustainability index for nutrients in a short rotation energy cropping system. *GCB Bioenergy* **5**: 315-326.
37. **Harper**, R.J. and Tibbett, M. (2013). The hidden carbon in deep mineral soils *Plant and Soil* **368**: 641-648.
38. Smith, P., Haberl, H., Popp, A., Erb, K.H., Lauk, C., **Harper**, R.J., Tubiello, F., de Siqueira Pinto, A., Jafari, M., Sohi, S., Masera, O., Böttcher, H., Berndes, G., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Abdalla Elsiddig, E., Mbow, C., Ravindranath, N.H., Rice, C.W., Sperling, F., Herrero, M., House, J.I., and Rose, S. (2013). How much land based greenhouse gas mitigation can be achieved without compromising food security and environmental goals? *Global Change Biology* **19**: 2285-2302.
39. **Harper**, R.J., Sochacki, S.J., Smettem, K.R.J. and Robinson, N. (2014). Managing water in agricultural landscapes with short rotation biomass plantations. *GCB Bioenergy* **6** 544-555.
40. Bustamante, M, Robledo-Abad, C., **Harper**, R., Mbow, C, Ravindranath, N.H., Sperling, F, Haberl, H., de Siqueira Pinto, A. Smith, P. (2014). Co-benefits, trade-offs, barriers and policies for greenhouse gas mitigation in the agriculture, forestry and other land use (AFOLU) sector. *Global Change Biology* **20***:* 3270–3290.
41. Dean, C., Kirkpatrick, J., **Harper, R.J**. and Eldridge, D.J. (2015). Optimising carbon sequestration in arid and semiarid rangelands. *Ecological Engineering* **74**, 148-163.
42. Walden, L.L., **Harper**, R.J., Mendham, D.S., Henry, D.J. and Fontaine, J.B. (2015). Eucalyptus reforestation induces soil water repellency. *Soil Research* **53**, 168–177.
43. Smith, P., Cotrufo, M.F., Rumpel, C., Paustian, K, Kuikman, P.J, Elliot, J.A., McDowell, R., Griffiths, R.I., Asakawa, S., Bustamante, M., House, J.I., Sobocká, J., **Harper**, R., Pan, G., West, P.C., Gerber, J.S., Clark, J.M, Adhya, T., Scholes, J and Scholes, M.C. (2015) Biogeochemical cycles and biodiversity as key drivers of ecosystem services provided by soils. *Soil* **1**: 665-685. doi:10.5194/soil-1-665-2015
44. Smith, P., Bustamante, M., House, J.I., Sobocká, J., **Harper**, R.J., Pan, G., West, P., Clark, J., Adhya, T., Rumpel, C., Paustian, K., Kuikman, P., Cotrufo, M.F., Elliot, J.A., McDowell, R., Griffiths, R.I. Asakawa, S. (2016). Global change pressures on soils from land use and management. *Global Change Biology* DOI: 10.1111/gcb.13068
45. Stewart, J., Anda, M. and **Harper**, R.J. (2016). Carbon profiles of remote Australian Indigenous communities: a base for opportunities. *Energy Policy* **94**: 77-88. dx.doi.org/10.1016/j.enpol.2016.03.036 0301-4215
46. Wocheslander, R., **Harper**, R.J., Sochacki, S. J., Ward, P.R. and Revell, C. (2016). Tagasaste (*Cytisus proliferus* Link.) reforestation as an option for carbon mitigation in dryland farming systems. *Ecological Engineering* **97**: 610-618.
47. Robledo-Abad, C., Althaus, H.J. Berndes, G., Bolwig, S., Corbera, E., Creutzig, F., Garcia-Ulloa, J., Geddes, A., Gregg, J. S., Haberl, H., Hanger, S., **Harper**, R.J., Hunsberger, C., Larsen, R.K., Lauk, Ch., Leitner, S., Lilliestam, J., Lotze-Campen, H., Muys, B., Nordborg, M., Ölund, M., Orlowsky, B., Popp, A., Portugal-Pereira, J., Reinhard, J., Scheiffle, L., Smith, P. (2017). Bioenergy production and sustainable development: the science base for policy making remains limited. *GCB Bioenergy* **9**: 541-556. 10.1111/gcbb.12338
48. Sochacki, S.J., Brand, B, Ritson, P., **Harper**, R.J. and Dell, B. (2017). Accuracy of tree root root sampling methodologies for carbon mitigation projects. *Ecological Engineering* **98**: 264-274**.**
49. Sangmanee, P., Dell, B., **Harper**, R.J. and Henry, D.J. (2017). Quantification of deep soil carbon by a wet digestion technique. *Soil Research* **55**: 78-85. https://doi.org/10.1071/SR15297
50. Zhang, M., Liu, S., **Harper**, R.J., Li, Q, Liu, K., Wei, X., Ning, D., Hou, Y., Liu, S. (2017). A global review on hydrological responses to forest change across multiple spatial scales:

Importance of scale, climate, forest type and hydrological regime. *Journal of Hydrology* **546**: 44-59.
51. **Harper**, R.J., Sochacki, S.J. and McGrath, J.F. (2017). The development of reforestation options for dryland farmland in south-western Australia: a review. *Southern Forests* **79**: 185-196 http://dx.doi.org/10.2989/20702620.2016.1255417
52. Liu, N., **Harper**, R.J., Dell, B., Liu, S and Yu, Z. (2017). Vegetation dynamics and rainfall sensitivity for different vegetation types of the Australian continent in the 2002 – 2010 dry period *Ecohydrology* **10**, e1811. https://doi.org/10.1002/eco.1811
53. Jeong, J., Bolan, N.S., **Harper**, R.J. and Kim, C. (2017). Distribution of carbon and nitrogen in forest floor components in *Pinus radiata* plantations of different ages in South Australia. *Australian Forestry* **80**: 99-104. http://dx.doi.org/10.1080/00049158.2017.1321465.
54. Walden, L.L., **Harper**, R.J., Sochacki, S.J., Montagu, K.D., Wocheslander, R., Clarke, M., Ritson, P., Emms, J., Davoren, C.W., Mowat, D., Smith, A.P., and Gupta, V.V.S.R. (2017). Mitigation of carbon from *Atriplex nummularia* revegetation. *Ecological Engineering* **106**: 253-262. http://dx.doi.org/10.1016/j.ecoleng.2017.05.027
55. Liu, N., **Harper**, R.J., Handcock, R., Evans, B.J., Sochacki, S.J., Liu, S. Dell, B and Walden, L.L. (2017). Seasonal timing for estimating carbon mitigation in revegetation of abandoned agricultural land with high spatial resolution remote sensing. *Remote Sensing* **9**, 545; doi:10.3390/rs9060545. http://www.mdpi.com/2072-4292/9/6/545.
56. Uddin, S.M.M., Daniel, N., **Harper**, R.J. and Henry, D.J. (2017). Why do biogenic volatile organic compounds (BVOC's) derived from vegetation fire not induce soil water repellency? *Biogeochemistry* **134**:147-161. doi: 10.1007/s10533-017-0352-7
57. Liu, N., Shaikh, M.A., **Harper**, R.J., Dell, B. and Liu, S. (2018) Parallelization of a distributed ecohydrology model. *Environmental Modelling and Software* **101**, 51-63. https://doi.org/10.1016/j.envsoft.2017.11.033
58. Daniel, N., **Harper**, R.J., Uddin, S.M.M. and Henry, D.J. (2019). Soil water repellency: A molecular-level perspective of a global environmental phenomenon. *Geoderma* **338**: 56-66. doi.org/10.1016/j.geoderma.2018.11.039
59. Liu, N., **Harper**, R.J., Smettem, K.R.J., Dell, B. and Liu, S. (2019). Responses of streamflow to vegetation and climate change in southwestern Australia. *Journal of Hydrology* **572**: 761-770. doi.org/10.1016/j.jhydrol.2019.03.005
60. Ruthrof, K.X., Hopkins, A.J.M., Danks, M., O'Hara, G., Bell, R., Henry, D., Standish, R., Tibbett, M., Howieson, J., Burgess, T. and **Harper**, R.J. (2019). Rethinking soil water repellency and its management. *Plant Ecology* **220**: 977-984 doi.org/10.1007/s11258-019-00967-4
61. Stewart, J., Anda, M. and **Harper**, R.J. (2019) Low-carbon development in remote Indigenous communities: applying a community-directed model to support endogenous assets and aspirations. *Environmental Science and Policy* **95**: 11-19. doi.org/10.1016/j.envsci.2019.01.003
62. Suganuma, H., Aikawa, S., Sakai, Y., Hamano, H., Takahashi, N., Tahara, K., Kawarasaki, S., Utsugi, H., Egashira, Y., Kawanishi, T, **Harper**, R.J., Tanouchi, H., Kojima, T., Abe, Y., Saito, M., Kato, S., Law, J. and Yamada, K. (2019). Estimation of CO_2 sequestration potential by afforestation in the arid rangelands of Western Australia based on long-term empirical data *Ecological Engineering* **133**: 109-120. doi.org/10.1016/j.ecoleng.2019.04.015
63. Uddin, S.M.M., **Harper**, R.J. and Henry, D.J. (2019). Contribution of binary organic layers to soil water repellency: a molecular level perspective. *The Journal of Physical Chemistry A* **123**: 7518-7527. https://doi.org/10.1021/acs.jpca.9b04033
64. Walden, L.L., Fontaine, J.B., Ruthrof, K.X., Matusick, G, **Harper**, R.J. and Hardy, G.E. (2019). Carbon consequences of drought differ in forests that resprout, *Global Change Biology* **25**: 1653-1664. doi.org/10.1111/gcb.14589
65. Yu, Z., Liu, S., Wang, J., Wei, A., Schuler, J., Sun, P. **Harper**, R.J., Zegre, N. (2019). Natural forests exhibit higher carbon sequestration and lower water consumption than planted forests in China. *Global Change Biology*. **25**: 68-77. doi.org/10.1111/gcb.14484
66. Ruprecht, J.K., Sparks, T., Liu, N., Dell, B. and **Harper**, R.J. (2019) Using reforestation to reverse salinisation in a large watershed. *Journal of Hydrology* **577**: 123976. doi.org/10.1016/j.jhydrol.2019.123976
67. **Harper**, R.J., Smettem, K.R.J., Ruprecht, J.K., Dell, B and Liu, N. (2019). Forest-water interactions in the changing environment of south-western Australia. *Annals of Forest Science* **76**: 95. https://doi.org/10.1007/s13595-019-0880-5

68. **Harper**, R.J. and Sochacki, S.J. (2019). Forestry and carbon mitigation in Australia *Journal of Arid Land Studies* **29**: 93-102. https://doi.org/10.14976/jals.29.3_93
69. Liu, N., **Harper**, R.J., Haverd, V., Kala, J., Liu, S. and Dell, B. (2020). Water use efficiency responses of Australia's forest ecosystems to drought. *Journal of Environmental Sciences* **90**: 262-274. https://doi.org/10.1016/j.jes.2019.11.020
70. Nguyen, T.T., Barber, P., **Harper**, R.J., Khanh, T.V., Dell, B. (2020) Trends in vegetation dynamics associated with urban development: the role of golf courses. *PLOS One* **15**(2): e0228090 https://doi.org/10.1371/journal.pone.0228090
71. Hai, N.T., **Harper, R.J.,** Dell, B. and Phuong, V.T. (2020). Towards a more robust approach for the restoration of mangroves in Vietnam. *Annals of Forest Science* **77** https://doi.org/10.1007/s13595-020-0921-0
72. Thu Thi Nguyen, Truong Tat Do, Richard **Harper**, Trang Thanh Pham, Tran Vu Khanh Linh, Thai Son Le, Le Bao Thanh and Nguyen Xuan Giap (2020) Soil health impacts of rubber farming: the implication of conversion of degraded natural forests into monoculture plantations. *Agriculture **10***(8), 357; https://doi.org/10.3390/agriculture10080357
73. Liu, N., Sun, P., Caldwell, P.V., **Harper**, R.J., Liu, S. and Sun, G. (2020) Trade-off between watershed water yield and ecosystem productivity along elevation gradients on a complex terrain in southwestern China. *Journal of Hydrology* **590**, 125449 https://doi.org/10.1016/j.jhydrol.2020.125449
74. Smettem, K.R.J., Rye, C.J., Sochacki, S.J and Henry, D.J. and **Harper, R.J.** (2021) Soil water repellency and the five spheres of influence: A review of mechanisms, measurement and ecological implications. *Science of the Total Environment* **787**: 147429 https://doi.org/10.1016/j.scitotenv.2021.147429
75. Nguyen, T.H., Chu, L., **Harper, R.J**., Dell, B and Hoang, H. (2022). Mangrove-shrimp farming: A triple-win approach for poor communities in the Mekong River Delta. *Ocean & Coastal Management* **221**: 106082. https://doi.org/10.1016/j.ocecoaman.2022.106082
76. Yeap, S.G.H, Bell, R.W., Scanlan, C., Stefanova, K, **Harper, R.J**. and Davies, S. (2022) Soil water repellence increased early wheat growth and nutrient uptake. *Plant and Soil* **473**: 273-289https://doi.org/10.1007/s11104-021-05282-4
77. Dao, M.T.T., Henry, D.J., Dell, B., Daniel, N.R.R and **Harper**, R.J. (2022). Induction of water repellency by leaves of contrasting Australian native species: effects of composition and heat *Plant and Soil* **478**: 505-517. https://doi.org/10.1007/s11104-022-05492-4
78. Andres, S.E., Standish, R., Lieurance, P.E., Mills, C.H., **Harper, R.J.,** Butler, D. Adams, V., Lehmann, C., Tetu, S., Cuneo, P, Offord, C. and Gallagher, R.V. (2022). Defining biodiverse reforestation: Why it matters for climate change mitigation and biodiversity. *Plants People Planet* **5**: 27-38 https://doi.org/10.1002/ppp3.10329
79. Nguyen, T.T., Eslick, H., Barber, P., **Harper, R.J**. and Dell, B. (2022) Cooling effects of urban vegetation: the role of golf courses. *Remote Sensing* **14**: 4351. https://doi.org/10.3390/rs14174351
80. Nguyen, T.H., Dell, B. and **Harper, R.J**. (2022). Assessment of the feasibility of applying payment for forest ecosystem services in Vietnamese mangrove forests. *APN Science Bulletin*, **12**: 184-189 doi: 10.30852/sb.2022.2016
81. Walden, L.L., Fontaine, J.B., Ruthrof, K.X., Matusick, G. and **Harper, R.J**. (2023). Drought then wildfire reveals a compound disturbance in a resprouting forest. *Ecological Applications* **33** c2775 https://doi.org/10.1002/eap.2775
82. Sangmanee, P., Dell, B., **Harper, R.J**., George, S. and Henry, D.J. (2023) Organic carbon compounds associated with deep soil carbon stores. *Plant and Soil* **488**: 83–99 https://doi.org/10.1007/s11104-022-05627-7
83. Nguyen, T.H., Dell, B. and **Harper, R.J**. (2023) Examining local community understanding of mangrove carbon mitigation: A case study from Ca Mau province, Mekong River Delta, Vietnam. *Marine Policy* **148**: 105398 https://doi.org/10.1016/j.marpol.2022.105398
84. Majid, N, Bahar, M.M, **Harper, R.J.,** Megharaj, M., and Naidu, R. (2023) Influence of biotic and abiotic factors on the development of non-wetting soils and management approaches: a review. *Soil Security* **11**: 100091 https://doi.org/10.1016/j.soisec.2023.100091
85. Le, T.S., **Harper, R.J**. and Dell. B. (2023). Application of remote sensing in detecting and monitoring water stress in forests: A synthesis. *Remote Sensing **15***(13), 3360; https://doi.org/10.3390/rs15133360
86. Le, T.S., Dell. B, and **Harper, R.J**. (2024). A new remote sensing index for forest dryness monitoring using multi-spectral satellite imagery. *Forests* 15 (6), 915; https://doi.org/10.3390/f15060915

87. Suganuma, H., Sakai, Y. Takahashi, N., Egashira, Y., Utsugi, H., Sochacki, S.J., **Harper R.J.,** Hamano, H., Kawarasaki, S., Aikawa, S., Kojima, T., Yamada, K. (2025) *Eucalyptus sargentii:* a prospective candidate tree species for climate and salinity mitigation in Western Australia. *Mitigation and Adaptation Strategies for Climate Change*, 30 (10) https://doi.org/10.1007/s11027-024-10196-4
88. Then, M., Shemehsavar, S., Henry , D.J., **Harper, R. J.** (2025). The effects of climatic and soil properties on soil water repellency, *CATENA*. **258**: 109218. https://doi.org/10.1016/j.catena.2025.109218
89. Le, T.S., Dell. B, and **Harper, R.J**. (2025). Remote-sensed evidence of fire alleviating forest canopy water stress under a drying climate. *Remote Sensing 17: 1979* https://doi.org/10.3390/rs17121979
90. Majid, N., Bahar, M., **Harper, R.J**., Hughes, B., Naidu, R. (2026). Identifying critical determinants of soil water repellency in an Australian dryland farming system. *Soil and Tillage Research* **255**. https://doi.org/10.1016/j.still.2025.106794
91. Shokri et al. (in press) Rethinking soil degradation: drivers, impacts, and solutions. *Review of Geophysics*

Other publications

1. Gilkes, R. J., Patterson, A., Gregory, P. J. and **Harper**, R. J. (1995). Microscopic investigation of some chemical mechanisms of soil hardening. In ‘Sealing, Crusting and Hardsetting Soils: Productivity and Conservation.’ (H. B. So, G. D. Smith, S. R. Raine, B. M. Schafer, and R. J. Loch Eds) pp. 445-50.
2. **Harper**, R. J. and Gilkes, R. J. (1995). Hardsetting of sandy soils and its effect on wind erodibility. In ‘Sealing, Crusting and Hardsetting Soils: Productivity and Conservation.’ (H. B. So, G. D. Smith, S. R. Raine, B. M. Schafer, and R. J. Loch Eds) pp. 171-6.
3. **Harper**, R. J., Hatton, T. J., Crombie, D. S., Dawes, W. R., Abbott, L. K., Challen, R. P., and House, C. (2000). Phase farming with trees: a scoping study of its potential for salinity control, soil quality enhancement and farm income improvement in dryland areas of southern Australia. Rural Industries Research and Development Corporation, RIRDC Publication Nº 00/48. 53 pp. www.rirdc.gov.au/reports/AFT/00-48.pdf
4. **Harper**, R. J., Mauger, G., Robinson, N., McGrath, J. F., Smettem, K. R. J., Bartle, J. R., and George, R. J. (2001). Manipulating catchment water balance using plantation and farm forestry: case studies from south-western Australia. In ‘Plantations, Farm Forestry and Water.’ (E. K. S. Nambier and A.G. Brown Eds.) Proceedings of a national workshop, 20-21 July 2000, Melbourne. Water and Salinity Issues in Agroforestry Nº 7. RIRDC Publication Nº 1/20. pp 44-50. www.rirdc.gov.au/reports/AFT/01-20.pdf
5. **Harper**, R. J., and Gilkes, R. J. (2004). Cairlocup. In ‘Case studies in regolith-landscape evolution.’ (R. R. Anand, and M. Killick Eds), (Cooperative Research Centre for Landscape Evolution and Mineral Exploration: Perth.) leme.anu.edu.au/RegLandEvol/Cairlocup.pdf
6. **Harper**, R. J., Robinson, N., Sochacki, S.J., Smettem, K.R.J. and Pitman, L. (2008). Phase farming with trees: field validation of the tree phase. Final Report Project CAL-6A. Rural Industries Research and Development Corporation, RIRDC Publication Nº 08-002. https://rirdc.infoservices.com.au/downloads/08-002.pdf
7. **Harper**, R. J., Ryan, P. J., Booth, T. H., McKenzie, N. J., and Gilkes, R. J. (2008). Site selection for farm forestry in Australia. Rural Industries Research and Development Corporation, RIRDC Publication Nº 08/152. 101 pp. https://rirdc.infoservices.com.au/downloads/08-152.pdf
8. **Harper**, R. J., Sochacki, S.J., Smettem, K.R.J., Robinson, N., Silberstein, R.P, Clarke, C.J, McGrath, J.F, Crombie, D.S. and Hampton, C.E. (2009). Catchment scale evaluation of “Trees, Water and Salt”. Final Report Project FPC-2A. Rural Industries Research and Development Corporation, RIRDC Publication No. 09/059. 60 pp. https://rirdc.infoservices.com.au/downloads/09-059.pdf
9. **Harper**, R.J., Sochacki, S.J, Mitchell, C.D., Wocheslānder, R. and Cowell, O. (2012). Using climate mitigation investment for broadscale water quality improvement. Water and Climate: Policy Implementation Challenges. Engineers Australia. Canberra, 1-3 May 2012.
10. Food and Agriculture Organization of the United Nations (2016). Forestry for a low-carbon future. Integrating forests and wood products in climate change strategies. FAO Forestry Paper 177 (contributor).

11. Second Murdoch Commission (2015). Food Security, Trade and Partnerships: Towards resilient regional food systems in Asia Murdoch Second Commission Report. Murdoch University, Perth. (contributor).
12. Marsh, H.. Dixon, K., Gore-Birch, C., **Harper**, R., Keith, D., Legge, S., Mitchell, N. and Simpfendorfer, C. (2020). Independent review of the Environmental Protection and Biodiversity Conservation Act 1999 – Submission from the Threatened Species Scientific Committee, a Statutory Committee established by the EPBC Act, 29 pp. https://epbcactreview.awe.gov.au/sites/default/files/2020–05/ANON-K57V-XF2U-J%20-%20Threatened%20Species%20Scientific%20Committee%20%281%29.pdf
13. **Harper, R.J.** (2021). Independent review to assess the impact of climate change in the area covered by the Forest Management Plan. Report to the WA Minister of Environment. 20 pp.
14. Burrows, N., Baker, P., **Harper**, R.J. and Silberstein, R. (2022). A report on silvicultural guidelines for the 2024-2033 Forest Management Plan. Independent Expert Review to the Western Australian Department of Biodiversity, Conservation and Attractions. 44 pp. https://researchportal.murdoch.edu.au/esploro/outputs/report/A-report-on-silvicultural-guidelines-for/991005680769807891
15. Sochacki, S.J. and **Harper, R.J**. (2025) Assessing the potential of saltbush to sequester carbon in the Wheatbelt Region of Western Australia. A report to Wheatbelt Natural Resource Management and the Western Australian Department of Primary Industries and Regional Development, Western Australian Carbon Farming and Land Restoration Program – Future Carbon Scheme. Project P7B204. 22 pp. Murdoch University, Perth. January 30, 2025.

Units Convened (2025)

ENV243: Water and Earth Science. (with Dr W. Vance).

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