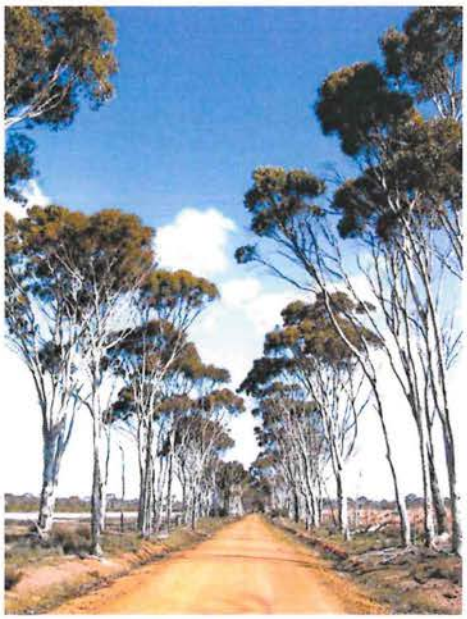
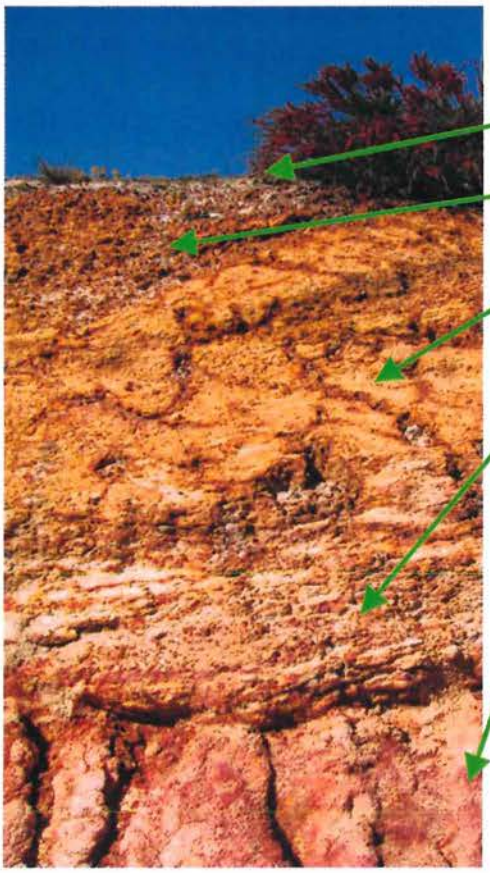
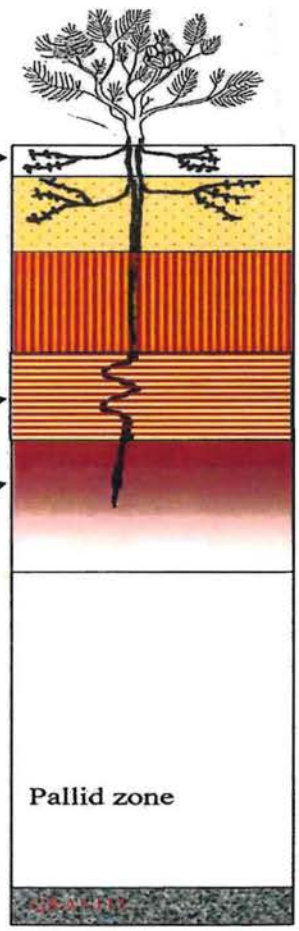


INTRODUCTION TO LANDSCAPES, VEGETATION AND SOILS OF THE NARROGIN AGWEST DISTRICT





INTRODUCTION TO THE LANDSCAPES, SOILS, AND VEGETATION OF THE NARROGIN AGWEST DISTRICT

Thursday 7th December 8.15am - ~4.30pm

Venue Narrogin AGWEST conference hall

Agenda

8.15 am Introduction

8.30 am Laterites and their formation

9 am mystery competition

9.15 am Landscape units and their recognition

9.45 am morning tea

10.15am Development and distribution of land systems in the Narrogin district

10.45 am field tour and exercises

approx 4.30pm return, course assessment, finish

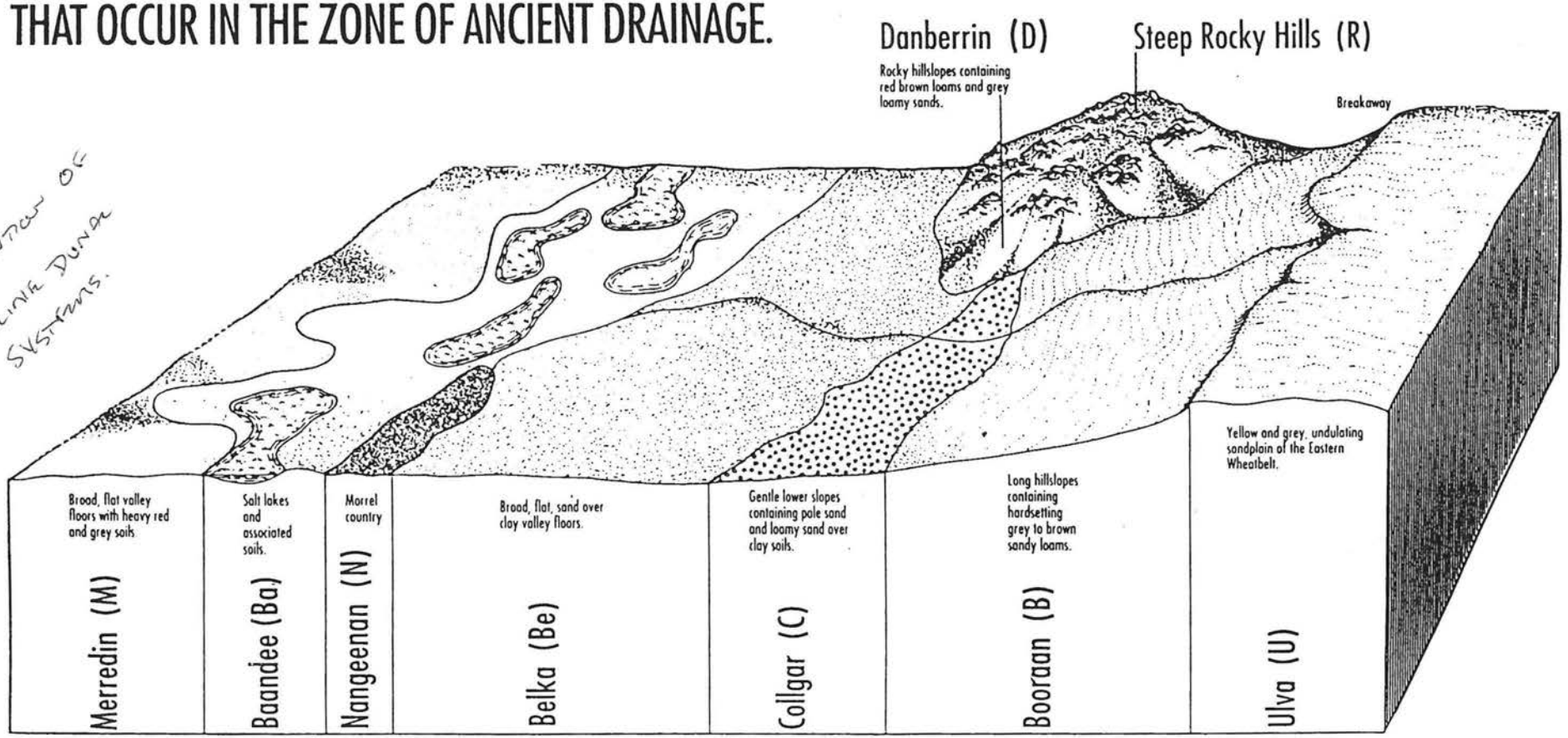
Course cost $30 to cover catering and bus (non AGWEST people will get an invoice)
Participants will receive a manual and a CD.

Bring your hat, sun lotion, fly repellent and sense of humour

See you there!

Land Surfaces

IDEALIZED BLOCK DIAGRAM SHOWING THE SOIL LANDSCAPE UNITS THAT OCCUR IN THE ZONE OF ANCIENT DRAINAGE.



MERREDIN NANGEENAN

SOIL LANDSCAPE UNIT		Baandee		Belka	Collgar	Danberrin	Steep Rocky Hills	Booraan	Ulva
MAJOR SOIL TYPES	Red Brown Sandy Loam Over Clay Valley Soil. 30 Red Clay Valley Soil. 54 Grey Clay Valley Soil. 32 Grey to Brown Cracking Clay. 92	Salt Lake and Channels. Soils Fringing The Salt Lakes.	Powdery Surfaced Calcereous Soil. 96	Deep Sandy Surfaced Valley Soil. 72 Shallow Sandy Surfaced Valley Soil. 76 GREY CLAY	Loamy Sand Over Clay	Rocky Red Brown loamy Sand/Sandy Loam. 58 Brownish Grey Granitic Loamy Sand. 62 Red Brown Doleritic Clay Loam. 66	Steep Rocky Hill Soils.	Sandy Loam Over Clay. 50 Shallow Hardsetting Grey Sandy Loam Over Clay. 46 Loamy Sand Over Clay. 54	Yellow Gradational Loamy Sand. 26 Deep Yellow Sand. 22 Pale Sand Over Gravel/Loamy Sand. 30 Deep Pale Sand. 18 Shallow Mottled Zone. 42 Deep Yellow Acid Sand. 38
VEGETATION	Salmon Gum Gimlet	Barley Grass Bluebush Saltbush Samphire Bare Ground	Morrel	Salmon Gum York Gum White Gum Gimlet	Mallee Species	York Gum Jam Sheoak White Gum Salmon Gum	Jam York Gum Sheoak White Gum	Salom Gum White Gum Mallee Gimlet	Banksia Sandplain Pear Tammar Sandplain Mallee Woodjil Flame Grevillea Christmas Tea

ANCIENT DRAINAGE - MERREDIN

Map unit	Danberrin	Nangeenan	Baandee	Nangeenan	Merredin	Collgar	Booraan	Ulva
Landform	Low rocky hills	Low dunes	Salt lakes & playas	Low dunes	Flat plain	Gently sloping terrain	Pediment	Undulating sandplain
Soils	Red or yellow duplex soils	Calc. earths	Solodic soils	Calcareous earths	Red or yellow duplex soils	Yellow duplex soils	Red duplex soils	Yellow sands; Gravelly duplex soils
Reference sites	KELL 4,6,8			KELL 9	KELL 7,7A	KELL 5	KELL 3	KELL 1, 2

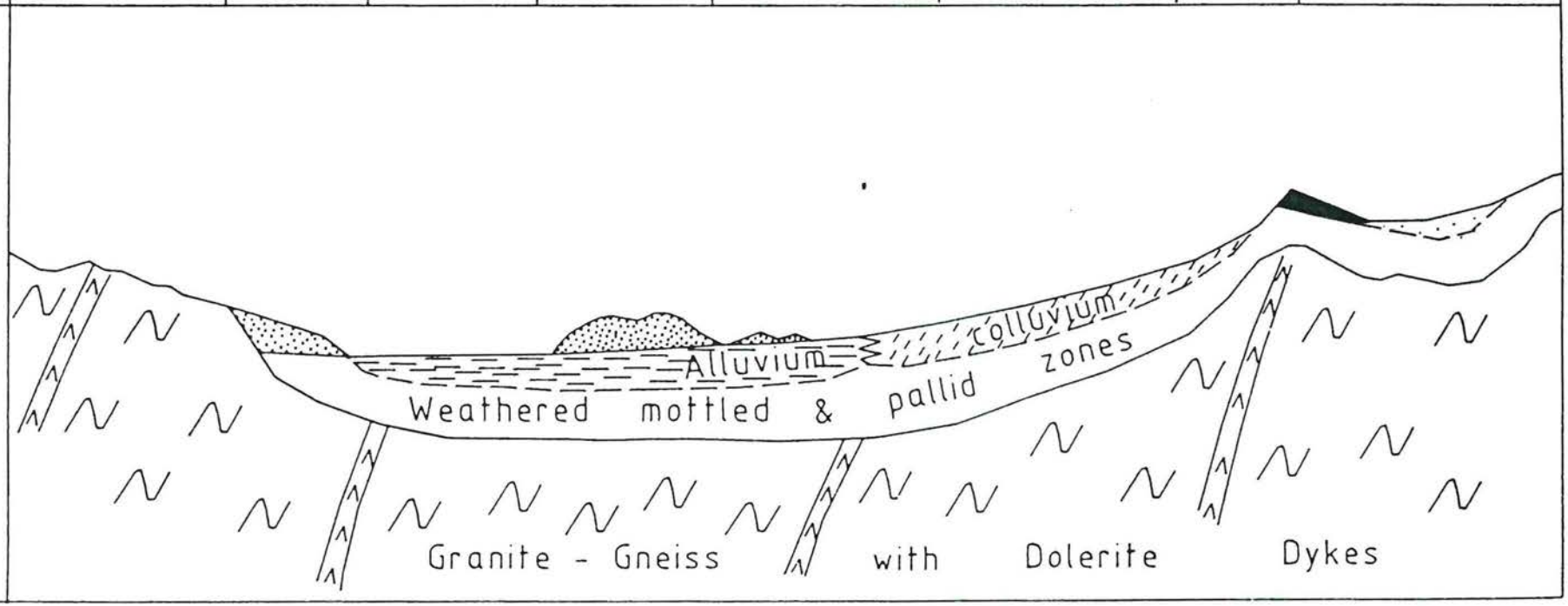


Figure 25. Wheatbelt. Reference Sites in relation to geology, landscape history and topography; map units modified from Bettenay and Hingston (1964).

ANCIENT DRAINAGE

Table 1. Soil types in each soil landscape unit

The following table breaks down each soil landscape unit into its respective soil types. The table can be used as a key to aid in the identification of a particular soil type. An estimate of the percentage area that each soil type occupies within the soil landscape unit is given.

Sandplain soils

Map Unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Ulva	Deeply weathered laterite	Undulating yellow and pale sandplain	Christmas tree, banksia, tea tree and low scrub	Loose, grey sand to a depth of 10-15 cm	Loose, white or pale yellow sand to a depth of 80 cm or greater. Occasionally overlying ironstone gravel.	1.**Deep pale sand** (3%)
			Banksia and sandplain pear. Flame grevillea in some areas	Loose, brown sand to a depth of 10-15 cm	Loose, yellow sand to a depth of 70 cm or greater. Sometimes overlying yellow loamy sand.	2. **Deep yellow sand** (25%)
			Tammar or sandplain mallee	Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Often contains ironstone gravel.	Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone	3. **Yellow gradational loamy sand** (50%)
			Tea tree (*Leptospermum erubescens*) scrub	Loose, pale greyish brown sand to a depth of 10-15 cm.	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer or mottled zone	4. **Pale sand over gravel/loamy sand** (15%)
			Wodjil scrub	Firm, brown loamy sand to a depth of 10-15 cm	Coherent, yellow loamy sand to sandy loam grading to a sandy clay loam. Very acidic at depth.	6. **Deep yellow acid sand** (2%)
			Wodjil and tammar scrub	Hardsetting, brownish to yellowish loamy sand to a depth of 5-15 cm. Often contains ironstone gravel.	Coherent, yellow clayey sand often containing ironstone gravel to 10- 25 cm over mottled zone	7. **Shallow mottled zone** (4%)
		Poorly drained depressions within undulating yellow and pale sandplain	Rushes	Loose, grey sand to a depth of 10-15 cm.	Loose, pale sand to a depth of greater than 70 cm over sandy clay.	5. **Waterlogged sand** (< 1%)

ANCIENT DRAINAGE

Hillside soils

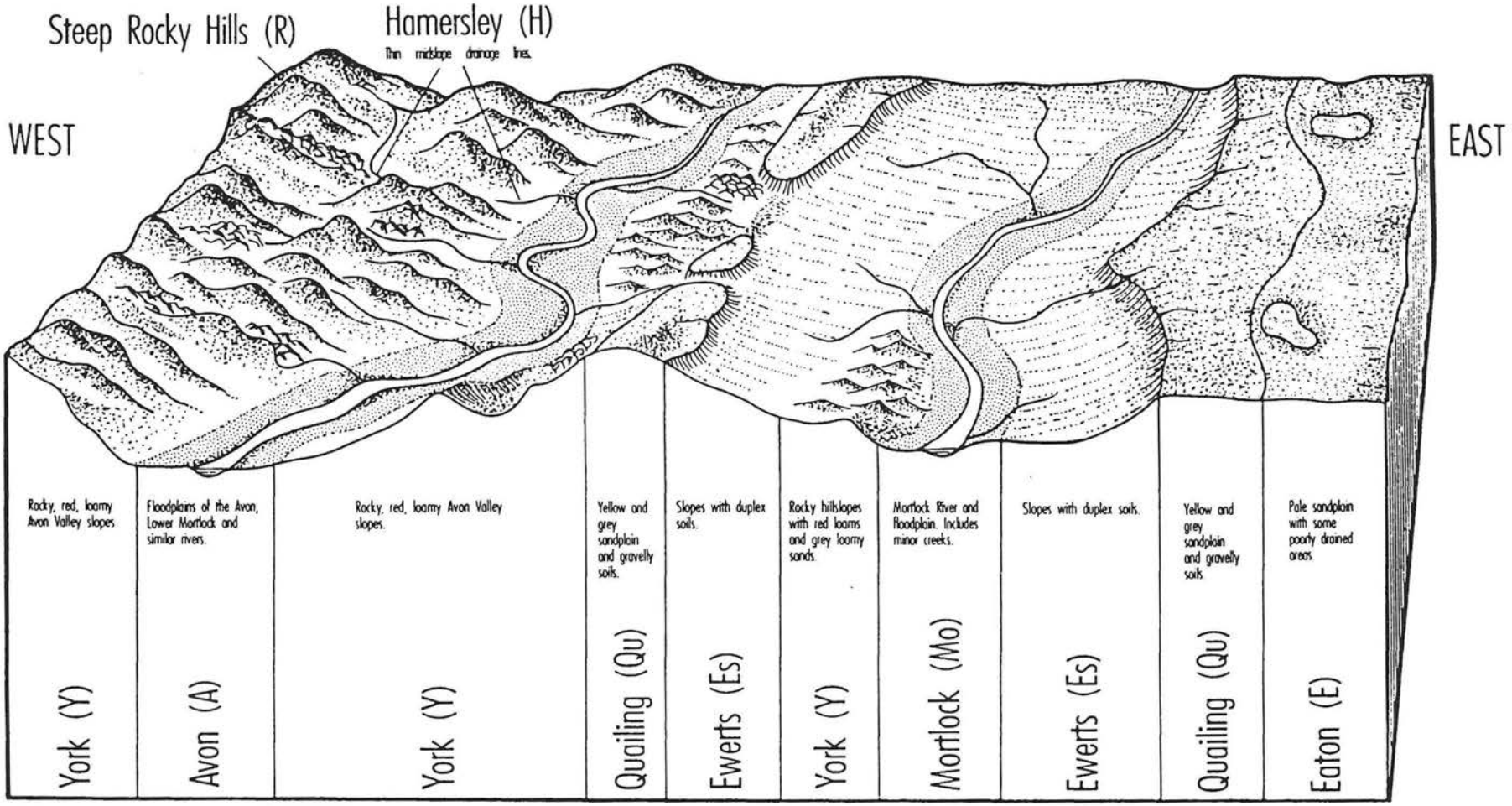
Map Unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Booraan	Colluvium derived from lateritic profile	Upper and mid slopes	White gum, some mallee species and salmon gum	Hardsetting, structureless, dark grey brown sandy loam to a depth of 5-10 cm	Massive, grey brown sandy loam to sandy clay loam to 10-15 cm overlying a structured pale brown clay and/or pallid zone.	8. **Shallow hardsetting grey sandy loam over clay** (15%)
		Upper, mid and lower slopes	Salmon gum, gimlet, white gum and some mallee species	Hardsetting, dark greyish-brown to reddish brown sandy loam to a depth of 5-15 cm	Massive, dark yellowish brown sandy loam to sandy clay loam overlying a structured, light yellowish brown clay at about 20 cm. Lime may be present in the clay.	9. **Sandy loam over clay** (70%)
		Mid and lower slopes	Mallee, some stunted salmon gums on heavier versions	Loose to firm grey brown sand to loamy sand to a depth of 5-15 cm.	Coherent, pale yellowish brown sand to clayey sand overlying a yellowish brown clay at about 40 cm.	10. **Loamy sand over clay** (15%)
Collgar	Colluvium derived from lateritic profile	Footslopes	Mallee sp.	Loose to firm grey brown sand to loamy sand to a depth of 5-15 cm.	Coherent, pale yellowish brown sand to clayey sand overlying a yellowish brown mottled clay at about 40 cm.	10. **Loamy sand over clay** (100%)
Danberrin	Granitic and basic bedrock	Upper, mid and lower slopes often adjacent to rock outcrop	York gum and jam	Loose to hardsetting, brown loamy sand to sandy loam to a depth of 15 cm.	Reddish brown to brown clayey sand to sandy loam to a depth of 20-60 cm over a reddish to yellowish brown structured clay and/or decomposing bedrock.	11. **Rocky red brown loamy sand/sandy loam** (45%)
		Upper, mid and lower slopes often adjacent to rock outcrop	Jam, occasional York gum, sheoak and in some areas white gum	Loose to hardsetting grey brown sand to loamy sand to a depth of 15 cm.	Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic rock.	12. **Brownish grey granitic loamy sand** (50%)
		Upper, mid and lower slopes immediately adjacent to dolerite dykes	York gum, salmon gum and needle bush	Red brown clay loam to a depth of 15 cm, often self-mulching.	Well structured, dark red clay overlying decomposing dolerite rock. May contain lime at depth.	13. **Red brown doleritic clay loam** (5%)

ANCIENT DRAINAGE

Valley floor soils

Map Unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Belka	Alluvium	Sandy surfaced, broad valley floors	Salmon gum, York gum, white gum and some types of mallee	Loose, grey brown sand to a depth of 10-20 cm	Coherent, light yellow brown sand to a depth of 40-80 cm overlying a brownish yellow, calcareous, structured clay.	14. **Deep sandy surfaced valley soil** (40%)
			Salmon gum, gimlet, York gum, white gum and some types of mallee	Loose to firm, grey brown sand to loamy sand to a depth of 10 cm.	Coherent, light yellow brown sand to clayey sand, to a depth of 15-40 cm, overlying a light yellowish brown, calcareous, structured clay.	15. **Shallow sandy surfaced valley soil** (60%)
Merredin	Colluvium and Alluvium	Loamy or clayey surfaced broad valley floors (sometimes contains crabholes)	Salmon gum and gimlet	Hardsetting, dark reddish brown sandy loam to a depth of 10-15 cm.	Structured, reddish brown sandy clay loam to about 30 cm overlying a structured, reddish brown clay with lime nodules at depth.	16. **Red brown sandy loam over clay valley soil** (75%)
			Salmon gum and gimlet	Hardsetting, reddish brown clay loam to light clay to a depth of 10-15 cm.	Structured, reddish brown clay with lime nodules.	17. **Red clay valley soil** (10%)
			Gimlet and salmon gum	Hardsetting, grey clay loam to clay to a depth of 10-15 cm.	Structured, grey brown clay with lime nodules.	18. **Grey clay valley soil** (10%)
			Salmon gum, gimlet and needle bush	Cracking, grey to brown sandy clay loam to clay to a depth of 10-15 cm	Structured grey to brown, clay with lime Inodules.	19. **Grey to brown cracking clay** (3%)
Ian-eenan	Aeolian material derived from salt lakes	Valley floor (occasionally on lower slopes)	Morrel	Powdery, dark reddish brown to grey sandy clay loam to a depth of 20-40 cm.	Structured, reddish to dark yellow brown clay loam to clay. Abundant lime present.	20. **Powdery surfaced calcareous soil** (100%)

IDEALIZED BLOCK DIAGRAM SHOWING THE SOIL LANDSCAPE UNITS THAT OCCUR IN THE ZONE OF REJUVENATED DRAINAGE.



SOIL LANDSCAPE UNIT	York	Hamersley	Steep Rocky Hills	Avon	Mortlock	Ewerts	Quailing	Eaton
MAJOR SOIL TYPES	Rocky Red Brown Loamy Sand/ Sandy Loam 60 64 Brownish Grey Granitic Loamy Sand. Red Brown Dolemitic Clay Loam. 68	Waterlogged Greyish Loamy Sand/Sandy Loam. 72 Rocky Red Brown Loamy Sand/Sand Loam. 60 Brownish Grey Granitic Loamy Sand. 64	Stony Soils 76	Red Brown Alluvial Loam. 40 Grey Alluvial Clay. 20 Orange Alluvial Loamy Sand. 44	Loamy Sand Surfaced Valley Duplex. 82 Pale Valley Floor Sand. 76 Grey Alluvial Clay. 80	Loamy Sand Surfaced Duplex. 48 Deep Sandy Surfaced Duplex. 56 Shallow Sandy Surfaced Duplex. 52 Yellow Gradational Loamy Sand. 30 Sandy Loam Over Clay. 44	Deep Yellow Sand. 22 Deep Pale Sand. 18 Pale Sand Over Gravel/Loamy Sand. 26 Yellow Gradational Loamy Sand. 30	Deep Pale Sand. 18 Deep Yellow Sand. 22 Pale Sand Over Gravel/Loamy Sand. 26 Waterlogged Sand. 34
VEGETATION	York Gum Jam Sheoak Salmon Gum White Gum	York Gum Jam Flooded Gum	Sheoak Jam York Gum	Salmon Gum York Gum Flooded Gum Sheoak	White Gum York Gum Jam Salmon Gum Sheoak	White Gum Jam Tammar Salmon Gum Sheoak	Sandplain Pear Banksia Tammar Tea Tree Christmas Tree White Gum white gum	Banksia Christmas Tree White Gum Tammar Tea tree Rushes

Map unit	Balkuling	Tutanning	Quailing	Kauring	Balkuling	Malebelling - Belmunging		Calje	Malebelling
Landform	Pediment	Undulating	Lateritic	Plateau	Pediment	Gently sloping terrain		Flat valley floor	Gently sloping terrain
Soils	Red or yellow duplex soils	Duricrust	Yellow sands	Grey siliceous sand	Red or yellow duplex soils	Red or yellow duplex soils	Yellow duplex soils	Yellow solonetzic soils	Yellow duplex soils
Reference sites		TUT 5	TUT 6	TUT 3	TUT 4, 8	TUT 1,2,7,9	TUT 10	TUT 12	

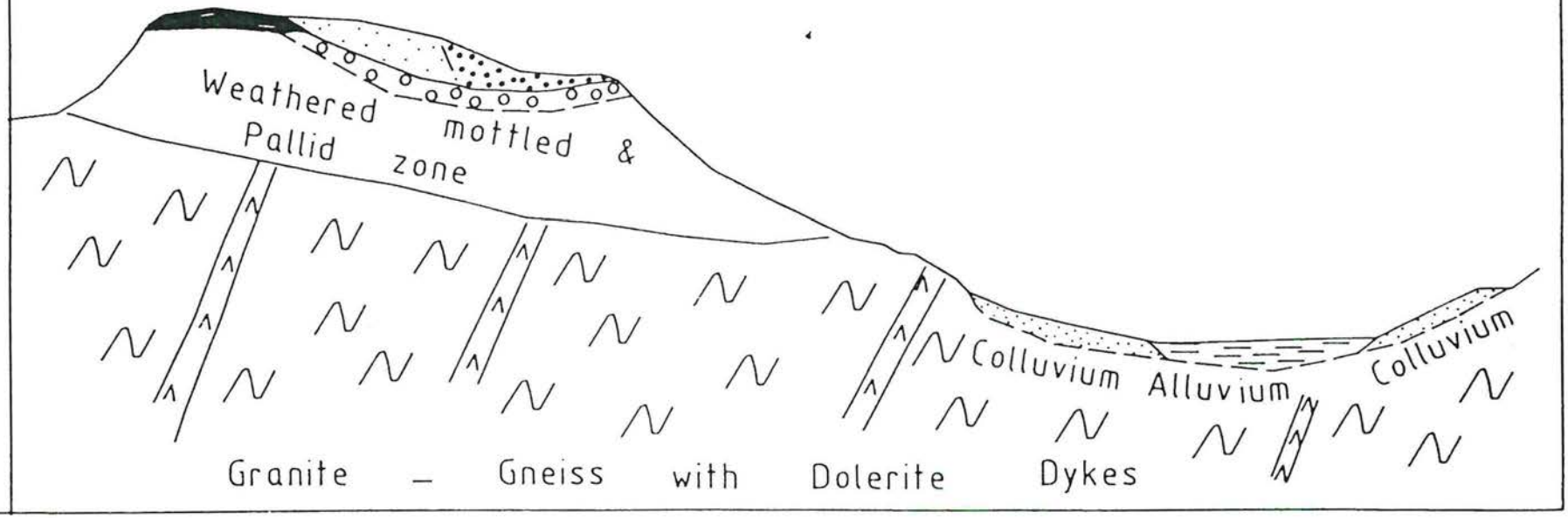


Figure 19. Tutanning: Reference Sites in relation to geology, landscape history and topography—map units from Mulcahy and Hingston (1961).

REJUVENATED

2.5 Table 1. Soil types in each soil landscape unit

The following table divides each soil landscape unit into its respective soil types. The table can be used as a key to aid in the identification of a particular soil type. An estimate of the percentage area that each soil type occupies within the soil landscape unit is given.

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Quailing	Deeply weathered laterite	Undulating yellow and pale sandplain often above a breakaway	Banksia sp., Christmas tree, sheoak and low scrub	Loose, grey sand to depth of 10-15 cm	Loose, white or pale yellow sand to a depth of 80 cm or greater. Occasionally overlying ironstone gravel	1. **Deep pale sand** (15%)
			Banksia sp. and sandplain pear	Loose, brown sand to a depth of 10-15 cm	Loose, yellow sand to a depth of 70 cm or greater. Sometimes overlying yellow loamy sand	2. **Deep yellow sand** (15%)
			Tammar, sandplain mallee, white gum and *Eucalyptus macrocarpa*	Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Often contains ironstone gravel	Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone	4. **Yellow gradational loamy sand** (30%)
			Tea tree scrub and white gum	Loose, pale greyish brown sand to a depth of 10-15 cm	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or mottled zone	3. **Pale sand over gravel/loamy sand** (35%)
			Parrot bush, blackboy, white gum and *Eucalyptus macrocarpa*	Firm, brownish sand to loamy sand to a depth of 10-15 cm. Large amounts of ironstone gravel	Coherent, yellowish brown sand to clayey sand with large amounts of ironstone gravel over laterite cap rock at depth	22. **Buckshot gravel** (3%)
		Poorly drained seepage areas	Rushes	Loose, grey sand to a depth of 10-15 cm	Loose, pale sand to a depth of greater than 70 cm over sandy clay	5. **Waterlogged sand** (2%)

REJUVENATED

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Ewerts	Colluvium derived from lateritic profile	Upper, mid and lower slopes	White gum with some jam. Tammar may occur on gravelly phases	Loose to hardsetting, greyish brown loamy sand to a depth of 10-15 cm	Coherent, pale to yellowish brown clayey sand overlying a yellowish brown, mottled clay about 40 cm. Ironstone gravel commonly occurs above the clay	9. **Loamy sand surfaced duplex** (45%$^{+}$) (20%^{X})
			White gum with some sheoak, jam and tea tree	Loose, greyish brown sand to a depth of 10-15 cm	Loose, pale sand overlying a yellowish brown, mottled clay at depths of less than 45 cm. Ironstone gravel commonly occurs above the clay	10. **Shallow sandy surfaced duplex** (15%$^{+}$) (10%^{X})
			White gum, sheoak and tea tree	Loose, greyish brown sand to a depth of 10-15 cm	Loose, pale sand overlying a yellowish brown, mottled clay at depths greater than 45 cm. Ironstone gravel commonly occurs above the clay	11. **Deep sandy surfaced duplex** (15%$^{+}$) (10%^{X})
			Tammar and white gum	Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Often contains ironstone gravel	Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone	4. **Yellow gradational loamy sand** (15%$^{+}$) (30%^{X})
			Salmon gum, white gum and some mallee species	Hardsetting, dark greyish brown to reddish brown sandy loam to a depth of 5-15 cm	Massive, dark yellowish brown sandy loam to sandy clay loam overlying a structured, light yellowish brown clay at about 20 cm. Lime may be present in the clay	8. **Sandy loam over clay** (5%$^{+}$) (5%^{X})
			White gum and tea tree	Loose, pale greyish brown sand to a depth of 10-15 cm	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or mottled zone	3. **Pale sand over gravel/loamy sand** (1%$^{+}$) (20%^{X})

\+ Percentage occurrence south of the Great Eastern Highway.

x Percentage occurrence north of the Great Eastern Highway.

Other soil types including:

7. **Shallow hardsetting grey sandy loam over clay**
24. **Sandy loam over pinkish clay below breakaways**
1. **Deep pale sand**
6. **Breakaway face and ironstone cap**
18. **Loamy sand surfaced valley duplex**

REJUVENATED

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
York	Predominantly granite, gneiss and migmatite	Upper, mid and lower slopes adjacent to rock outcrop	York gum and jam	Firm to hardsetting, brown loamy sand to sandy loam to a depth of 15 cm	Reddish brown to brown clayey sand to sandy loam to a depth of 20-60 cm over a reddish to yellowish brown, structured clay and/or decomposing bedrock	12. **Rocky red brown loamy sand/sandy loam** (65%+) (40%x)
			Jam, occasional york gum, sheoak and in some areas white gum	Loose to hardsetting, grey brown sand to loamy sand to a depth of 15 cm	Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic bedrock	13. **Brownish grey granitic loamy sand** (15%+) (55%x)
	Dolerite and other fine grained, basic rocks	Upper, mid and lower slopes immediately adjacent to dolerite dykes	York gum, salmon gum and needle bush	Red brown clay loam to a depth of 15 cm, often self-mulching	Well structured, dark red clay overlying decomposing dolerite rock. May contain lime at depth	14. **Red brown doleritic clay loam** (15%+) (1%x)
			-	-	-	Rock outcrop (3%+) (2%x)

\+ Percentage occurrence in the Avon Valley.
x Percentage occurrence east of the Avon Valley.

Other soil types including:

26. **Hardsetting gritty quartzitic soil**
15. **Waterlogged greyish loamy sand/sandy loam**
25. **Coarse granitic sand**

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Hamersley	Predominantly granite, gneiss and migmatite	Narrow, 1st and 2nd order, midslope drainage lines which occur within the York unit	Flooded gum, york gum and jam	Dark greyish brown sand to sandy loam to a depth of 10-15 cm	Light yellowish brown sand to sandy loam overlying a brownish clay at 15 to 50 cm	15. **Waterlogged greyish loamy sand/sandy loam** (60%)
			York gum and jam	Firm to hardsetting, brown loamy sand to sandy loam to a depth of 15 cm	Reddish brown to brown clayey sand to sandy loam to a depth of 20-60 cm over a reddish to yellowish brown, structured clay and/or decomposing bedrock	12. **Rocky red brown loamy sand/sandy loam** (15%)
			Jam, occasional york gum, sheoak and in some areas white gum	Loose to hardsetting grey brown sand to loamy sand to a depth of 15 cm	Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic bedrock	13. **Brownish grey granitic loamy sand** (15%)
			-	-	-	Rock outcrop (10%)

REJUVENATED

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Avon	Alluvium	Floodplains of the major waterways within the Avon Valley	York gum, salmon gum and jam	Hardsetting, dark reddish brown clayey sand to sandy clay loam to a depth of 10-15 cm	Structured, reddish brown sandy loam to clay loam to a depth of 10 to 50 cm overlying a structured, red to brown clay. Lime may occur at depth	20. **Red brown alluvial loam** (40%)
			Salmon gum, york gum, and needle bush	Hardsetting, dark greyish brown sandy loam to clay to a depth of 10-15 cm	Structured, greyish brown clay. Lime may occur at depth	19. **Grey alluvial clay** (30%)
			Flooded gum, sheoak, york gum and jam	Firm, brown, fine grained sand to clayey sand to a depth of 10-15 cm	Coherent, orange, fine grained sand to clayey sand to a depth of at least 40 cm. A reddish to light yellowish clay may occur at depth	21. **Orange alluvial loamy sand** (20%)

Other soil types including:

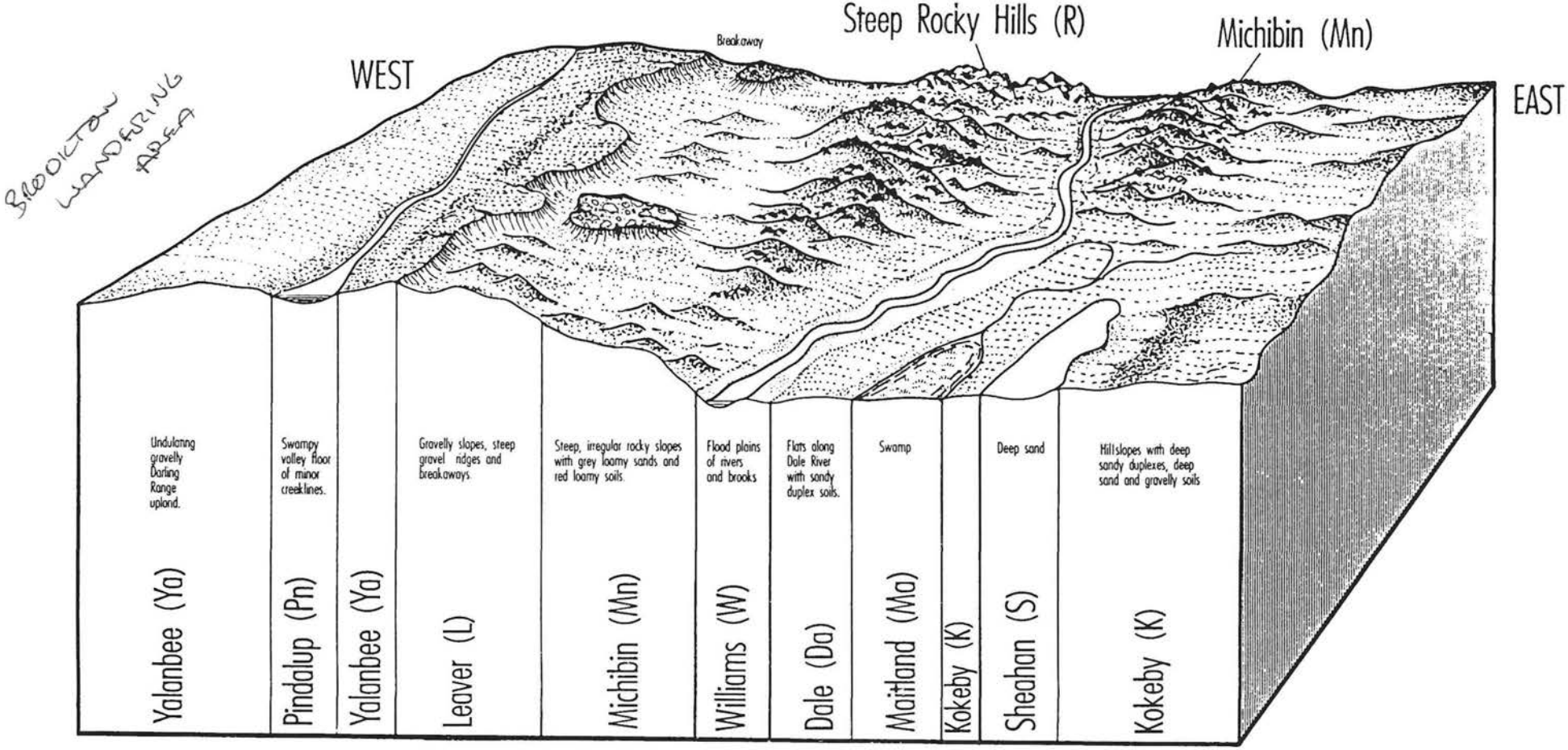
28. **Grey alluvial self-mulching clay**
27. **Yellow alluvial sand**
17. **Pale valley floor sand**
18. **Loamy sand surfaced valley duplex**
12. **Rocky red brown loamy sand/sandy loam**

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Mortlock	Alluvium	Alluvial flats and low lying areas adjacent to the Mortlock River and similar water courses	White gum, jam, york gum, sheoak and the occasional salmon gum in some areas	Loose to hardsetting, greyish brown sand to clayey sand to a depth of 10-15 cm	Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay	**18. Loamy sand surfaced valley duplex** (65%)
			Sheoak, jam and some york gum and white gum. Flooded gum on poorly drained areas	Loose, greyish brown sand to a depth of 10-15 cm	Loose, pale sand overlying a pale yellow, mottled, structured clay at depths of 50 cm to greater than 100 cm	**17. Pale valley floor sand** (25%)
			Salmon gum, york gum and needle bush	Hardsetting, dark greyish brown sandy loam to clay to a depth of 10-15 cm	Structured, greyish brown clay. Lime may occur at depth	**19. Grey alluvial clay** (5%)

Other soil types including: 21. **Orange alluvial loamy sand**
27. **Yellow alluvial sand**

Soil landscape unit	Parent material	Landform	Dominant vegetation	Surface soil material	Subsurface soil material	Soil type
Eaton	Deeply weathered laterite	Undulating pale and yellow sandplain	Tea tree scrub and white gum	Loose, pale greyish brown sand to a depth of 10-15 cm	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or a mottled zone	**3. Pale sand over gravel/loamy sand** (40%)
			Christmas tree, banskia, tea tree and low scrub	Loose, grey sand to depth of 10-15 cm	Loose, white or pale yellow sand to a depth of 80 cm or greater. Occasionally overlying ironstone gravel	**1. Deep pale sand** (30%)
			Tammar and white gum	Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Ironstone gravel present	Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone	**4. Yellow gradational loamy sand** (15%)
			Banksia and sandplain pear	Loose, brown sand to a depth of 10-15 cm	Loose, yellow sand to a depth of 70 cm or greater. Sometimes overlying yellow loamy sand	**2. Deep yellow sand** (10%)
		Poorly drained depressions within pale and yellow sandplain	Rushes	Loose, grey sand to a depth of 10-15 cm	Loose, pale sand to a depth of greater than 70 cm over sandy clay	**5. Water - logged sand** (5%)

IDEALISED BLOCK DIAGRAM SHOWING THE SOIL LANDSCAPE UNITS OF THE DARLING RANGE AND WEST KOKEBY ZONES



SOIL LANDSCAPE UNIT	Yalanbee	Pindalup	Leaver	Michibin	Steep Rocky Hills	Williams	Dale	Maitland	Sheahan	Kokeby
MAJOR SOIL TYPES	Buckshot Gravel. 16 Yellow Gravelly Loamy Sand. 30	Poorly Drained Sandy Loam Duplex. 42 Alluvium Loam. 44	Yellow Gravelly Loamy Sand. 30	Brownish Grey Granitic Loamy Sand. 34 Rocky Red Brown Loamy Sand/Sandy Loam. 32	Stony Soils 38	Poorly Drained Sandy Loam Duplex. 42 Loamy Sand Surfaced Valley Duplex. 50 Alluvial Loam. 44 Grey Alluvial Clay. 48	Sandy Surfaced Valley Duplex. 46 Pale Valley Floor Sand. Loamy Sand Surfaced Valley Duplex. 50	A variety of swampy soils.	Deep Pale Sand. 20 Pale Sand Over Gravel/Loamy Sand. 24 Deep Yellow Sand. 54	Pale Sand Over Gravel/Loamy Sand. 24 Deep Sandy Surfaced Duplex. 40 Yellow Gravelly Loamy Sand. 30 Deep Pale Sand. 20
VEGETATION	Jarrah Marri White Gum Powder Bark Parrot Bush	Flooded Gum Rushes White Gum	White Gum Marri Powder Bark	York Gum Jam White Gum Sheoak Marri	Sheoak White Gum Marri Jam York Gum	Flooded Gum Jam York Gum White Gum	White Gum Flooded Gum Tea Tree Jam	Paper Bark Rushes Low Scrub	Banksia Christmas Tree Tea Tree Marri	Marri White Gum Jarrah Sheoak

DARLING RANGE

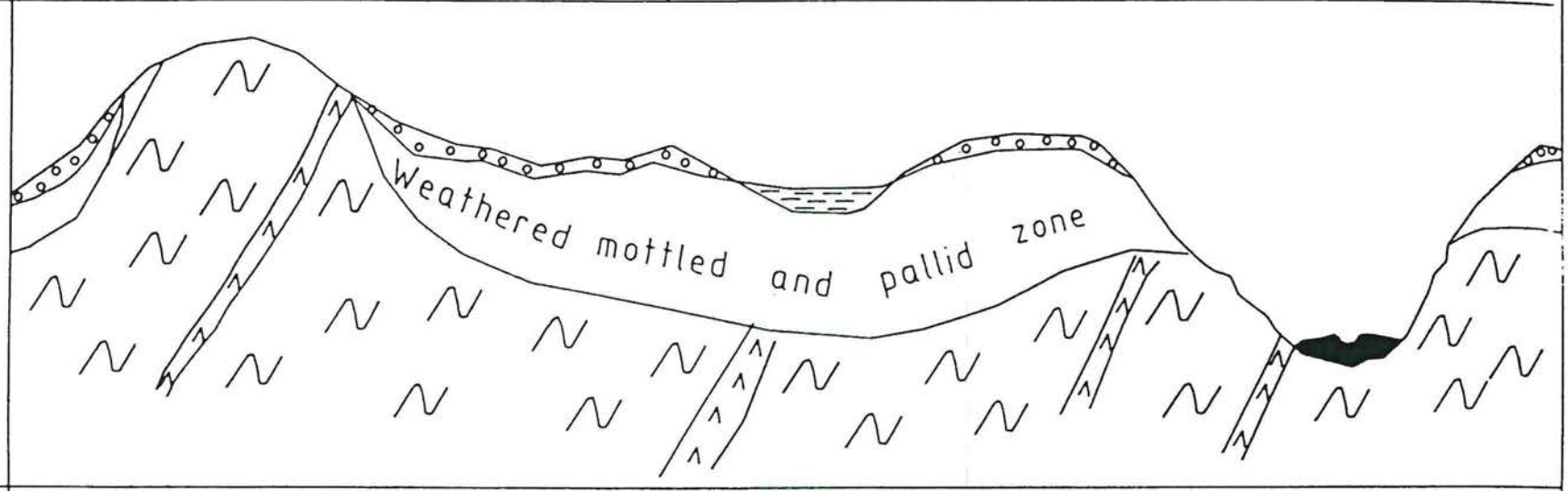
Map unit	Cooke	Dwellingup	Yarragil – Pindalup	Dwellingup	Murray - Helena
Landform	Emergent hill	Undulating plateau surface	Swampy valley	Undulating plateau surface	Major river valley
Soils	Red earths in colluvial deposits	Sandy and gravelly yellow earths	Yellow duplex soils or yellow earths	Gravelly yellow duplex soils	Red or yellow earths in colluvial deposits
Reference sites	DP 4	DP 1,2,3	DP 5,7,8; BTN 3	BTN 2	DP 6; BTN 1
					
Geology	Precambrian Granite – Gneiss with Dolerite Dykes				

Figure 17. Darling Plateau: Reference Sites in relation to geology and topography—map units are those described by Churchward and McArthur (1980).

DARLING RANGE

2.3 Table 1. Soil types of each soil landscape unit

The following table divides each soil landscape unit (map unit) into its respective soil types. The table can be used as a key to aid in the identification of a particular soil type. An estimate of the percentage area that each soil type occupies within the soil landscape unit is given.

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Yalanbee	Deeply weathered laterite	Undulating upland plateau.	Jarrah, marri, parrot bush with white gum in some areas.	Loose to firm, greyish brown sand to loamy sand. Abundant, fine, round ironstone gravel. Non-wetting.	Coherent, brownish yellow sand to loamy sand sometimes overlying lateritic cap rock. Abundant, fine, round ironstone gravel present.	1. **Buckshot gravel** (80%).
			Marri, white gum with jarrah in some areas.	Hardsetting, greyish brown loamy sand. Abundant ironstone gravel	Coherent, yellowish brown sandy loam often increasing to a clay at depth. Abundant ironstone gravel present.	6. **Yellow gravelly loamy sand** (15%).
			Marri, jarrah and white gum with a shrub layer of parrot bush, tea tree and blackboy.	Loose, pale greyish brown sand.	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or a massive, yellow loamy sand.	3. **Pale sand over gravel/ loamy sand** (3%).
			Banksia, Christmas tree and tea tree with scattered marri.	Loose, grey sand.	Loose white or pale yellow sand to a depth of 80 cm or greater.	2. **Deep pale sand** (1%).
			Banksia, jarrah, marri, tea tree and sheoak.	Loose, brown sand.	Loose, yellow sand to a depth of 70 cm or greater.	17. **Deep yellow sand** (1%).
Pindalup	Alluvium and colluvium derived from the lateritic profile.	Shallow, concave, thin valley floor found within the Darling Range Zone.	Flooded gum and rushes. White gum grows on the margins of these valleys.	Dark grey to dark brown loamy sand to sandy loam.	Pale to yellowish sandy loam to sandy clay loam overlying a mottled, light grey to brownish yellow, structured clay. Ironstone gravel may be present.	11. **Poorly drained sandy loam duplex** (75%).
				Hardsetting, brownish, fine loamy sand to loam.	Brown to yellow loam often grading into structured clay at depth.	12. **Alluvial loam** (15%).
				Dark greyish brown sand with a loose surface.	White to light yellowish brown sand which overlies a mottled, light yellowish brown to pale clay at about 40-70 cm. Ironstone gravel may occur.	13. **Sandy surfaced valley duplex** (5%).

Other soils including

14. **Grey alluvial clay**
6. **Yellow gravelly loamy sand**
22. **Waterlogged sand**

DARLING RANGE

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Leaver	Dissected lateritic material and associated colluvium.	Steep, upper slopes and moderately inclined, mid and lower slopes.	White gum, marri and powder bark wandoo.	Hardsetting, greyish brown to brown loamy sand. Abundant, ironstone gravel.	Coherent, yellowish brown sandy loam often increasing to a clay at depth. Abundant ironstone gravel present.	6. **Yellow gravelly loamy sand** (90%).
		Small areas found immediately below the breakaway face. Slopes are often 5-10% but can be 20%.	Powder bark wandoo and white gum.	Shallow, grey to brownish sandy loam. Usually hardsetting and non-wetting. Can have a 'dusty' appearance.	At about 5-15 cm a pinkish to white, dispersive clay occurs (this subsoil is often exposed by erosion of the topsoil).	5. **Sandy loam over pinkish clay below break-aways** (2%)
				Breakaway face		
		Breakaway face, mallet hills and ironstone cap which occurs above the breakaway face.	Powder bark wandoo, white gum, box poison and parrot bush.	5 to 30 cm of dark brownish grey sand to clayey sand. Has a 'dusty' appearance and is very non-wetting.	Pinkish to white dispersive clay.	4. **Break-away face and ironstone cap** (3%).
				Ironstone cap		
				Large ironstone boulders with minimal soil development	Ironstone or lateritic caprock.	
		Moderately inclined mid and lower slopes.	Marri, white gum, jarrah and a shrub layer of parrot bush, tea tree and blackboy.	Loose, pale greyish brown sand.	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or a massive yellow loamy sand.	3. **Pale sand over gravel / loamy sand** (3%).
	Deeply weathered laterite.	Moderately to steeply inclined upper slopes. Often found as a spur to the sides of breakaways.	Jarrah, marri and parrot bush with white gum in some areas.	Loose to firm, greyish brown sand to loamy sand. Abundant, fine, round ironstone gravel present. Often non-wetting.	Coherent, brownish yellow sand to loamy sand, sometimes overlying lateritic caprock. Abundant, fine, round ironstone gravel present.	1. **Buck-shot gravel** (2%).

DARLING RANGE

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Michibin	Predominantly gneiss, granite and migmatite.	Hillslopes containing scattered rock outcrop.	In the eastern Darling Range Zone – York gum, jam and sheoak. Further to the west – marri and white gum.	Firm to hardsetting, brownish grey sand to loamy sand. Granitic rocks often occur on the surface.	Pale to yellowish brown sand to clayey sand over a structured yellowish clay at about 50 cm overlying decomposing granitic rock.	8. **Brownish grey granitic loamy sand** (60%).
				Firm to hardsetting, brown loamy sand to sandy loam to depth of about 15 cm.	Reddish brown to brown clayey sand to sandy loam to a depth of 20-60 cm overlying a reddish to yellowish brown structured clay and/or decomposing bedrock.	7. **Rocky red brown loamy sand/ sandy loam** (30%).
	Dolerite and other similar, fine grained, basic rocks.	Hillslopes immediately adjacent to dolerite dykes.	In the eastern Darling Range Zone – York gum and jam. Further to the west – marri and white gum.	Hardsetting or self-mulching red brown loam to clay.	Well structured, dark red clay overlying decomposing dolerite.	18. **Red brown doleritic clay loam** (4%).

Other soils including:

16. **Coarse granitic sand**
19. **Hardsetting gritty quartzitic soil**
20. **Waterlogged greyish loamy sand/sandy loam**

Rock outcrop (3%)

DARLING RANGE

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Williams	Alluvium and some colluvium.	Thin, alluvial terraces of the major drainage lines within the Darling Range Zone.	Flooded gum, jam, York gum and white gum.	Firm to hardsetting, greyish loamy sand.	Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay.	15. **Loamy sand surfaced valley duplex (30%)**
				Dark grey to dark brown loamy sand to sandy loam.	Pale to yellowish sandy loam to sandy clay loam overlying a mottled, light grey to brownish yellow, structured clay.	11. **Poorly drained sandy loam duplex (25%)**
				Hardsetting, brownish, fine loamy sand to loam.	Brown to yellow loam often grading into structured clay at depth.	12. **Alluvial loam** (25%).
				Hardsetting, grey sandy loam to clay loam to about 10 to 20 cm.	Structured, grey clay.	14. **Grey alluvial clay** (10%).

Other soils including:

21. **Orange alluvial loamy sand**
8. **Brownish grey granitic loamy sand**
7. **Rocky red brown loamy sand/sandy loam**

KOKEBY

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Sheahan	Spillway sand derived from the dissected lateritic profile.	Hollows and depressions on gently undulating hillslopes.	Banksia, Christmas tree and tea tree with scattered marri.	Loose, grey sand.	Loose white or pale yellow sand to a depth of 80 cm or greater.	2. **Deep pale sand** (85%).
			Marri, jarrah and white gum with a shrub layer of parrot bush, tea tree and blackboy.	Loose , pale greyish brown sand.	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or a massive, yellow loamy sand.	3. **Pale sand over gravel / loamy sand** (10%).

Other soils including: 17. **Deep yellow sand**
22. **Waterlogged sand**

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Dale	Colluvium and alluvium	Flats and broad tributary valleys to the Dale and Avon Rivers and Talbot Brook.	White gum, flooded gum, tea tree and sheoak.	Dark greyish brown sand with a loose surface.	White to light yellowish brown sand which overlies a mottled, light yellowish brown to pale clay at about 40-70 cm. Ironstone gravel may occur above the clay layer.	13. **Sandy surfaced valley duplex** (80%).
				Firm to hardsetting, greyish loamy sand.	Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay.	15. **Loamy sand surfaced valley duplex** (20%).
Maitland	Alluvium and colluvium.	Swamps and poorly drained areas that occur within the broad valley floors of the Dale unit.	Paperbark, rushes and low scrub.			A variety of swampy soils.

DARLING RANGE - KOKEBY

Map unit	Parent material	Landform	Dominant vegetation	Surface soil material	Sub surface soil material	Soil type
Kokeby	Dissected lateritic profile.	Gently undulating hillslopes.	Marri, jarrah and white gum with a shrub layer of parrot bush, tea tree and blackboy.	Loose, pale greyish brown sand.	Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or a massive, yellow loamy sand.	3. **Pale sand over gravel / loamy sand** (50%).
			White gum, marri, sheoak and tea tree.	Loose, greyish brown sand.	Loose, pale sand which overlies a mottled, light grey to yellow clay subsoil at greater than 45 cm. Ironstone gravel may occur above the clay.	10. **Deep sandy surfaced duplex** (30%).
		Gravelly ridges on gently undulating hillslopes.	Marri and white gum with jarrah in some areas.	Hardsetting, greyish brown loamy sand. Abundant, ironstone gravel.	Coherent, yellowish brown sandy loam often increasing to a clay at depth. Abundant, ironstone gravel present.	6. **Yellow gravelly loamy sand** (10%).
		Hollows and depressions within gently undulating hillslopes.	Banksia, Christmas tree and tea tree with scattered marri.	Loose, grey sand.	Loose white to pale yellow sand to a depth of 80 cm or greater.	2. **Deep pale sand** (8%).

Other soils including:
17 **Deep yellow sand**
15. **Loamy sand surfaced duplex**
22. **Waterlogged sand**

Vegetation Key

INDICATOR VEGETATION OF THE NARROGIN AGWEST DISTRICT

ANCIENT DRAINAGE ZONE

NOTE this table is only a rough guide which should be used in conjunction with other clues, such as landscape position, rock outcrops, and surface soil texture

VEGETATION	ASSOCIATED WITH	DISTRIBUTION	COMMENTS
Blue mallet, *(Eucalyptus gardneri)* **Silver mallet** *(E. argyphea)*	*Hakea francisiana* complex	More common in the east and south of the district	Often associated above breakaways with soil formed on the top of the laterite profile (sand over duricrust)
Swamp sheoak *Casuarina obesa*	Broombush (several forms) Oblong leaf honey myrtle	More common in the west ADZ	Found around salt lakes and winter wet saline soils
Dryandra heath	Dryandra is an indicator of gravelly surfaced soils, often associated with ridges, particularly in the south and west		
Gimlet *E. salubris*	Salmon gum Merrit	Corrigin east	Heavy clay soils mainly in large valleys
Jam *Acacia acuminata*	Usually an indicator of shallow loams or sandy loams associated with granitic soils.		
	York gum Rock Sheoak	Outcropping igneous rock	Shallow loams, sandy loams Sandy or gritty gradational soils
Kondinin Blackbutt *E. kondininensis*	*Melaleuca pauperiflora*	NE and eastern edge of district	Aeolian saline loams fringing salt lakes * some exceptions noticeable near Corrigin with trees growing in midslope positions
Roadside Teatree *Leptospermum erubescens*	Various species	Uplands, heath	Indicator of poor sand often as pockets in gravels or better sandplain
Mallee complex	Becomes common in the far E /NE of district. Usually on sandy duplex soils, often with poor clay subsoil (eg sodic clays, soil formed off kaolinised granite)		

VEGETATION	ASSOCIATED WITH	DISTRIBUTION	COMMENTS
***Melaleuca* thickets**	Halophytes Broombush (several forms Oblong leaf honey myrtle York gum Snap and rattle	Associated with saline flats and salt lake soils	
Mottlecah *Eucalyptus macrocarpa*	Associated with stony white sandy laterite ridges in the eastern fringe. There is another species that is represented on this soil type, but over a larger area – specifically *Eucalyptus albida* (Blue mallee or White mallee)		
Red Morrel *E. longicornis*	Usually an indicator of well drained soils with higher salt and/or iron content Wandoo, *Eucalyptus phenax,* Salmon gum (occ.), other *Eucalyptus* spp	Usually near salt lakes Mafic laterite ridges Lower slopes (occasionally)	well drained calcareous loams, associated with aeolian soils on NW to SW of salt lakes brownish gravelly loams, loams sandy loams associated with lateritic ridges formed from basic rock. Brown duplex loam
Rock Sheoak *Allocasuarina huegeliana*	Generally an indicator of a well drained soil, sandier and/or deeper duplex phase		
	Wandoo York gum Heath	Granite rocks Slopes mainly in SW slopes	Coarse sandy soils around granite rocks Deep duplex soils Sand over gravel
Round fruited Banksia Banksia *sphaerocarpa*	Mainly in the SW ADZ as a part of Dryandra heath over sandy gravels.		
Salmon gum *E. salmonophloia*	Always an indicator of clay loams or shallow duplex soils, usually in valleys		
	Wandoo York gum	Valleys Slopes Mainly NE ADZ	Shallow duplex or clay loams Deeper clay soils formed from igneous rock
Tamma *Allocasuarina campestris and A. acutivalvis*	Common on ridges and slopes where it often indicates denser gravel phase. Thick Tamma bush is often found on erosional ridges/ upper slopes where soil has formed off rhizolite and reticulite Tends to replace Dryandra on gravelly soils in the far east/ NE		
White gum **Wandoo in west** *(E wandoo)* Wheatbelt wandoo in east (*E. capillosa*)	Widespread, but generally indicates a more duplex (sand over pale clay) phase in the landscape		
	Salmon gum Heath, rock sheoak Tamma, *Callitris* spp.	ADZ except NE ADZ except NE Breakaways Mainly NE	Deeper valley duplex soils (shallow duplex indicated by salmon, deeper by white gum. Indicates a more duplex phase, often a shallower sand or gravel over clay . Pallid zone soil below breakaway (Wheatbelt wandoo)

INDICATOR VEGETATION OF THE NARROGIN AGWEST DISTRICT

REJUVENATED DRAINAGE ZONE

NOTE this table is only a rough guide which should be used in conjunction with other clues, such as landscape position, rock outcrops, and surface soil texture

VEGETATION	ASSOCIATED WITH	DISTRIBUTION	COMMENTS
Brown mallet *E. astringens*	Generally, an indicator of water-repellent pink duplex loams formed from the mottled zone on breakaway faces, mainly west of the Great southern Highway.		
Dryandra heath *Dryandra* spp.	Dryandra is an indicator of gravelly surfaced soils, often associated with ridges.		
Flooded gum *E. rudis*	Often the dominant tree alongside larger waterways, swamps, and rivers, generally west of the 450mm annual rainfall area Flooded gum can also be found in mid and upper slope situations, mainly on shallow soils formed from granite or mafic rock, and indicates susceptibility to winter waterlogging.		
Jam *Acacia acuminata*	Usually an indicator of shallow loams or sandy loams associated with granitic soils.		
	York gum	Outcropping igneous rock	Shallow loams, sandy loams
	Rock Sheoak		Sandy or gritty gradational soils
Roadside Teatree *Leptospermum erubescens*	Heath	Uplands	Indicator of poor sand often as pockets in gravels or better sandplain
Mallee complex	Very variable occurrence, but may indicate a harder setting or shallower clay phase in upland gravel or duplex soils		
Marri *Corymbia calophylla*	Widespread on well drained soils formed on laterite generally west of the Great Southern Highway. Most common on gravelly colluvial soils (gravelly loams, sand over gravel) on the gentle back slopes of breakaways. Also found in deeper sandy soils around Narrogin and as far east as Toolibin. Associated with a wide range of species.		
Red Morrel *E. longicornis*	Usually an indicator of well drained soils with higher salt or iron content		
	Eucalyptus phenax, Eucalyptus salmonophloia (occ.), other Eucalyptus spp.	Ridges depends on level of laterite stripping	brownish gravelly loams, loams sandy loams associated with lateritic ridges formed from basic or iron rich rock.
Powderbark wandoo *E. accedens*	Generally found on water repellent sandy gravel ridges and crests west of the Great southern highway, often above breakaways associated with dryandra and some stunted wandoo. Often grades into Brown mallet at the breakaway face.		
Rock Sheoak *Allocasuarina Huegeliana*	Generally an indicator of a well drained soil, sandier and/or deeper duplex phase		
	Wandoo	Granite rocks	Coarse sandy soils around granite rocks
	York gum	Slopes mainly in SW	Deep duplex soils
	Heath	slopes	Sand over gravel

VEGETATION	ASSOCIATED WITH	DISTRIBUTION	COMMENTS
Round fruited Banksia Banksia *sphaerocarpa*	Associated with Marri and some Dryandras on sandy gravels or gravelly loams (often on the back slopes of breakaways)		
Salmon gum *Eucalyptus salmonophloia*	Always an indicator of clay loams or shallow duplex soils, usually in valleys		
	Wandoo	Major valleys	Shallow duplex or clay loams
	York gum	Slopes Mainly east RDZ	Deeper clay soils formed from igneous rock
Tamma *Allocasuarina campestris and A. acutivalvis*	Common on ridges and slopes generally east of the RDZ where it usually indicates denser gravel phase. Thick Tamma is often found on erosional ridges/ upper slopes where soil has formed off rhizolite and reticulite		
Wandoo / White gum *E. wandoo*	Widespread, but generally indicates a more duplex (sand over pale clay) phase in the landscape		
	Salmon gum	Major valleys	Deeper valley duplex soils (shallow duplex indicated by Salmon gum, deeper by White gum.
	Dryandra, Heath, Sheoak	slopes and some ridges	Indicates a more duplex phase, often a shallower sand or gravel over clay. Wandoo may be a minor component with Marri and Dryandra on gravelly crests.
York gum *(E loxophleba)*	Usually an indicator of deep brown loams or clay loams formed from igneous rock		
	Jam	General	Usually deeper loamy soils formed off igneous rock
		Minor valleys	Occasionally wetter duplex soils or loamy soils

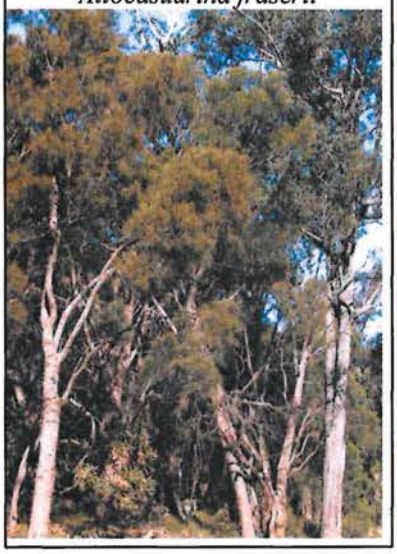
INDICATOR VEGETATION OF THE NARROGIN AGWEST DISTRICT

DARLING RANGE ZONE

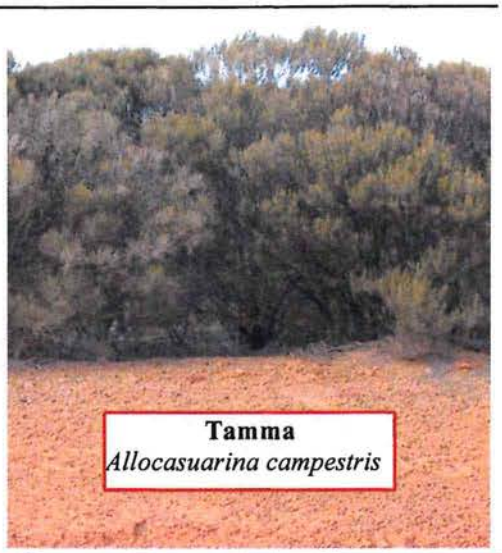
NOTE this table is only a rough guide which should be used in conjunction with other clues, such as landscape position, rock outcrops, and surface soil texture

Brown mallet *Eucalyptus astringens*	Generally an indicator of water repellent pink duplex loams formed from the mottled zone on breakaway faces, mainly on the dissected eastern edge of the Darling range
Flooded gum *E. rudis*	Often the dominant tree alongside larger waterways, swamps, and rivers, particularly on valley flats. Flooded gum can also be found in mid and upper slope situations, mainly on shallow soils formed from granite or mafic rock, and indicates susceptibility to winter waterlogging.
Forest Sheoak *Allocasuarina fraseriana*	Associated with Jarrah on (possibly lower clay content soils) ridges
Jarrah *E. marginata*	Widespread on well-drained soils formed on laterite in association with a wide range of species (particularly Marri.) Tends to be more dominant on indurated laterite ridges, and on the Darling Plateau gravel and sandy gravel plains. Lower clay content than marri dominant soils.
Roadside Teatree *Leptospermum erubescens*	Associated with various species, it is an indicator of poor sand often as pockets on crests and slopes.
Marri *Corymbia calophylla*	Widespread on well-drained soils formed on laterite in association with a wide range of species (particularly Jarrah and Wandoo.) Tends to be more dominant on gravelly colluvial soils (gravelly loams, sand over gravel) on the gentle back slopes of breakaways. Also found in association with rock sheoak on sandy soils formed from granite Also found in deeper sandy soils around Narrogin and as far east as Toolibin
Melaleuca **thickets**	Usually indicate swampy soils. Associated with Flooded gum and WA blackbutt and occasionally Bullich in the Western side of the district.
Powderbark wandoo *E. accedens*	Generally found on water repellent sandy gravel ridges and crests west on the eastern Darling range, often above breakaways associated with Dryandra and stunted wandoo. Often grades into Brown mallet at the breakaway face.
Rock sheoak *Allocasuarina huegeliana*	Widespread, but can be dominant on sandy soils from weathering granite
Wandoo / White gum *E. wandoo*	Widespread, but generally indicates a more duplex (sand over pale clay) phase in the landscape NOTE – the sparser the understorey the shallower and heavier the clay subsoil In flat valleys with little understorey, Wandoo indicates sandy duplex soils. On slopes and some ridges, Wandoo indicates a more duplex phase, often a shallower sand or gravel over clay. Wandoo may be a minor component with Marri, Jarrah, and Dryandra on gravelly uplands
York gum *E. loxophleba*	Usually an indicator of deep brown loams or clay loams formed from igneous rock, particularly dolerites. Associated with Jam (eastern side of Darling Range) and Rock Sheoak.

Forest sheoak
Allocasuarina fraserii



Swamp sheoak
Casuarina obesa

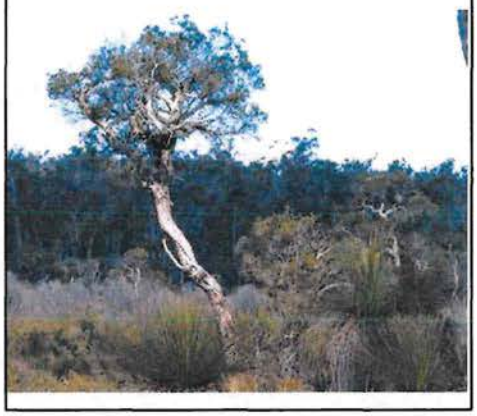


Tamma
Allocasuarina campestris

Darling range winter wet sandy valley

Ti tree
Toolibin saline valley

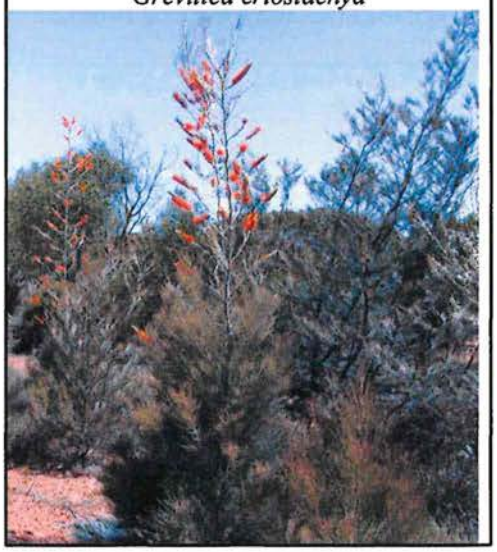
Darling range paperbark swamp



Acorn banksia
Banksia prionotes

Roadside ti tree
Leptospermum erubescens

Flame grevillea
Grevillea eriostachya

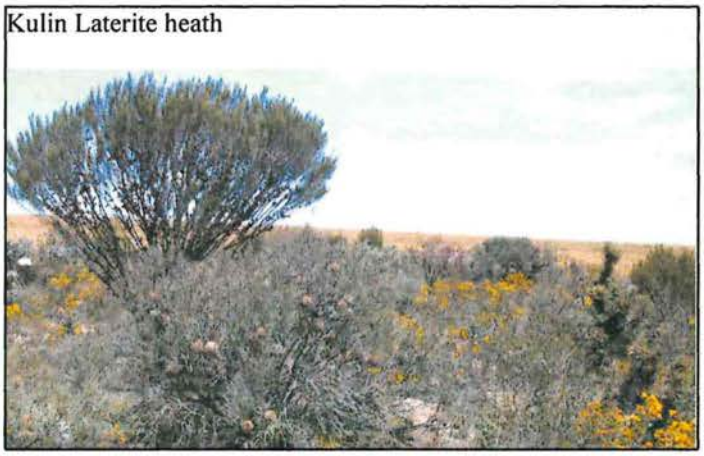


Narrogin

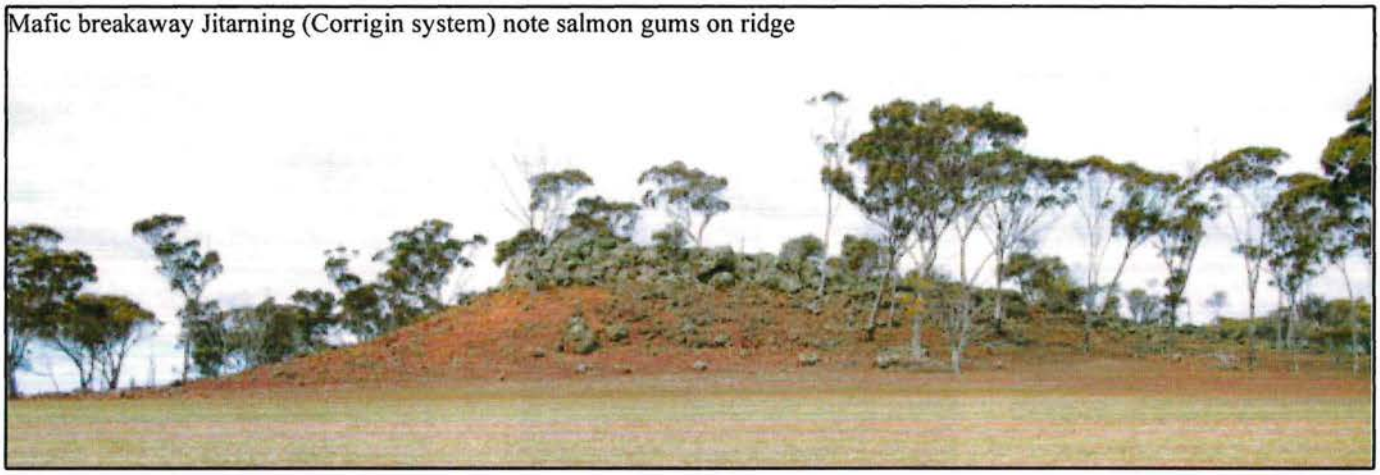
Wandoo on slopes , marri and dryandra on ridge

Sandy gravel formed over sandy deposit east of lake Toolibin

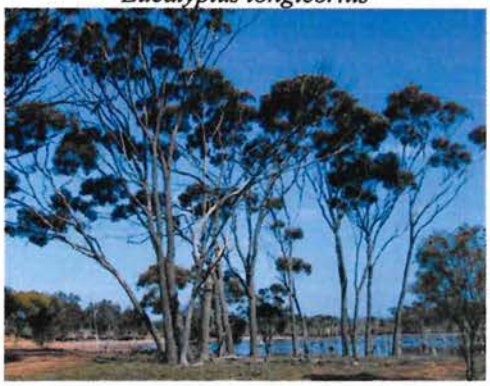
Kulin Laterite heath



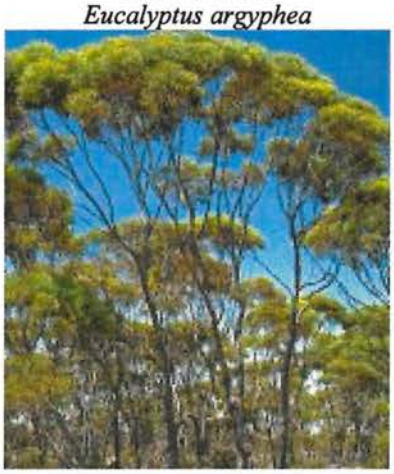
Mafic breakaway Jitarning (Corrigin system) note salmon gums on ridge



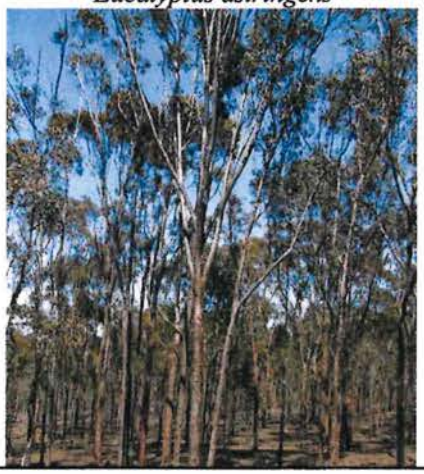
Red morrel
Eucalyptus longicornis



Silver mallet
Eucalyptus argyphea

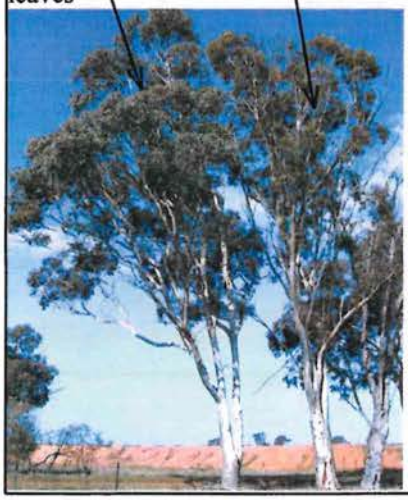


Brown mallet
Eucalyptus astringens



Wandoo Dull blue green leaves

salmon gum shiny green leaves

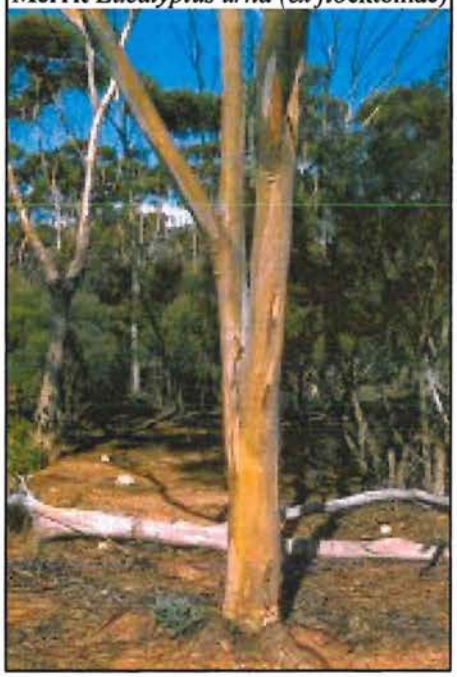


Salmon gum *Eucalyptus salmonophloia*

Gimlet *E. salubris*

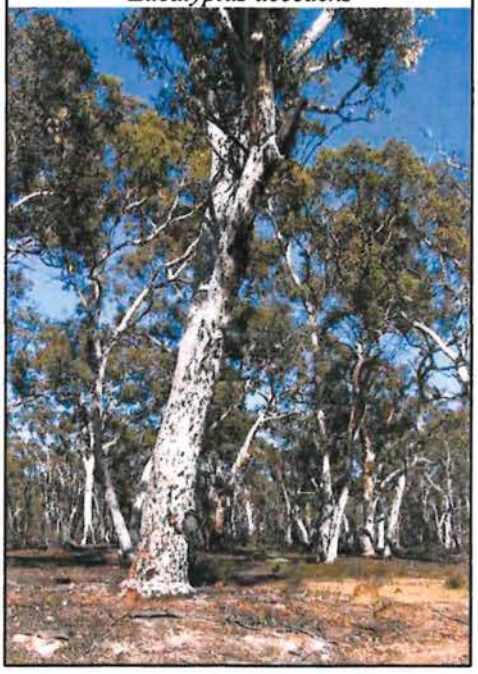
Jarrah
Eucalyptus marginata

Merrit *Eucalyptus urna (ex flo*cktoniae)



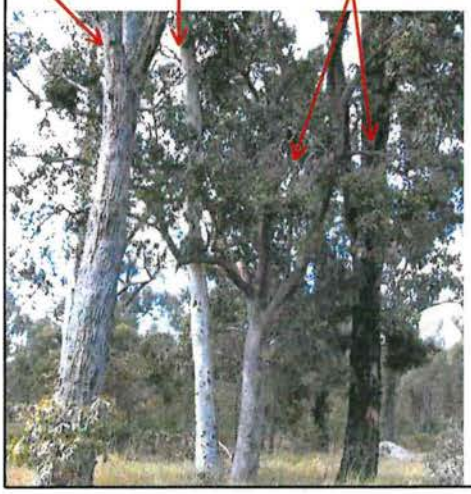
Kondinin Blackbutt
Eucalyptus kondininensis

Powderbark wandoo
Eucalyptus accedens

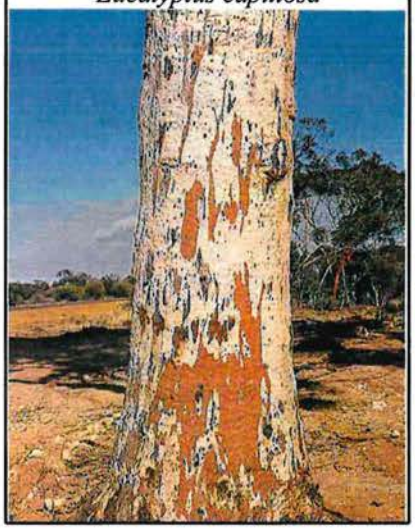


York gum *Eucalyptus loxophleba*

Jarrah **wandoo** **marri**



Wheatbelt Wandoo
Eucalyptus capillosa



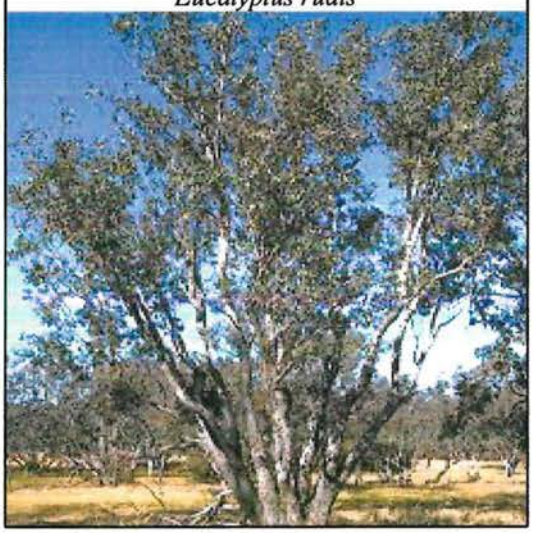
Jam
Acacia acuminata
Light green leaves
Flowers September

Manna wattle
Acacia microbotrya
blue green leaves
flowers April

Australian Golden wattle
Acacia pycnantha
broad light green leaves
flowers September

Marri
Coryumbia calophylla

Flooded gum
Eucalyptus rudis



Mottlecah
Eucalyptus macrocarpa

Rock sheoak
Allocasuarina huegeliana

Land Systems

LAND SYSTEMS OF THE NARROGIN AGWEST DISTRICT

DARLING PLATEAU ZONE

Detrital strongly indurated laterites and sandy upland drainage

Darling Plateau Lateritic plateau, in the Western Darling Range, with sandy gravel, loamy gravel, deep sand and wet soil. Jarrah-marri-wandoo forest and woodland.

Murray valley Deeply incised valleys, in the south of the Western Darling Range. Loamy earth, loamy duplex, gravel and stony soils. Jarrah-marri forest.

EAST DARLING RANGE ZONE

Detrital strongly indurated laterites

Wundowie/Lupton (Avon catchment)
Marradong (Murray and north Blackwood catchments)
Plateau remnants with sandy gravel, loamy gravel, grey deep sandy duplex and loamy duplex.
Jarrah-marri-wandoo forest and woodland.

Clackline/Boyagin (Avon catchment) Moderately dissected areas with gravelly slopes and ridges and minor rock outcrop over weathered granite and granitic gneiss. Loamy gravels, shallow duplexes and pale deep sand common. Wandoo

Quindanning (Murray catchment). Deep granitic valleys, with deep sandy duplex soils, shallow sand loamy duplex and bare rock. Similar to Marradong but more dissected. Marri-wandoo-york gum-jam woodland.

West Kokeby (Avon catchment). Extinct channel of Avon river Gently undulating sandy and swampy terrain, with pale deep sand, grey deep sandy duplex and non-saline wet soils.
Also in Rejuvenated drainage zone.

Blackwood catchment influenced by Eocene sediments

Eulin Plateau remnants, with waterlogging prone upland sandy and gravelly plains formed on Eocene lake sediments.
Gravel sandy duplex soil and wet soil. Jarrah-marri-wandoo forest and woodland.

Darkan Undulating rises and rolling low hills, formed by dissection of the Eulin plateau
Gravels (mostly sandy) and grey sandy duplex (mostly deep). Wandoo-jarrah-marri woodland.

Beaufort. Broad valley floors, in the southern Darling Range and Zone of Rejuvenated Drainage.
Grey sandy duplex soils and saline wet soils. Wandoo-sheoak-jam woodland. Located along the Beaufort, Carlecatup and Hillman rivers.

ZONE OF REJUVENATED DRAINAGE

Strongly indurated laterites which have been variably stripped with soils forming on the parts of the truncated profile, underlying rock, and covering colluvial erosion products

Pingelly. (Avon catchment) Rejuvenated uplands with few lateritic mesas. Mainly soil from fresh granite, granitic colluvium, dolerite and isolated lateritic soils.
Sheoak on sandy granites, York gum gradational granitic soils, wandoo duplexes, and flooded gum wet low lying incised areas. Powderbark wandoo/dryandra on mesas, patchy Kwongan heath on more extensive laterites, mallet downslope of breakaways.

Goomalling (Avon catchment) Poorly drained valley flats, in the Pingelly system, with grey deep sandy duplex (sometimes alkaline) and saline wet soil. York gum-jam-wandoo-salmon gum-sheoak woodland.

Dryandra (Murray catchment) Gently undulating granitic terrain, similar to the Pingelly unit but less dissected and more residual lateritic mesas.
Deep sandy duplex, loamy duplex and brown loamy earth. Wandoo sheoak woodland
Pumphreys Bridge (Murray catchment). Valley floors with deep sandy duplex, pale deep sand and wet soil (often saline). Wandoo-sheoak-jam woodland, ti tree scrub and samphire flats

Whinbin (Blackwood catchment) Undulating rises, similar to the Pingelly system but having gentler slopes and more dissected laterite soils
Grey sandy duplex (mostly deep), sandy gravel and alkaline red shallow loamy duplex. Wandoo-sheoak woodland.

Arthur River (Blackwood catchment) Broad valley floors,in the Whinbin system
Saline wet soil, salt lake soil and grey sandy duplex.

Beaufort. (Blackwood catchment) Broad valley floors downstream of the Arthur river and the Dumbleyung/ Wagin salt lake chain

Dellyanine (Blackwood catchment) Undulating rises and low hills on granite, with rock outcrops and narrow drainage lines. More dissected than the Whinbin system to the east.
Grey sandy duplex (shallow and deep), sandy gravel and red deep sandy duplex.

ZONE OF ANCIENT DRAINAGE

weakly indurated laterites zone yellow sandplain (Avon catchment)

Walyerming Undulating terrain largely composed of colluvium
Shallow gravels, shallow and deep sandy duplexes, becoming alkaline downslope. Minor granitic sands, red loamy earths and loamy duplexes on fresh rock

Bendering Gently undulating rises of old lateritic surface formed on gneissic rocks with occasional breakaways.
Gravelly soils and yellow loamy earths predominate. Tammar scrub, sandplain heath and mallee.

Kellerberrin Broad valley floors characteristic of the Eastern wheatbelt
Alkaline red shallow loamy duplex, alkaline grey sandy duplex (shallow and deep), calcareous loamy earth and hard cracking clay.
Salmon gum-gimlet-wandoo-York gum woodland.

Lagan Salt lake chains downstream of the Kellerberrin system, with salt lake soil and calcareous loamy earth.
Mallee, morrell woodland and saltbush-bluebush-samphire flats.

Moderately indurated laterites with mainly grey sandplain

Kukerin (Avon and Blackwood catchments) Gently undulating rises of the main drainage divide.(eastern edge of district)
Grey deep sandy duplex, sandy gravel, alkaline grey shallow sandy duplex and shallow gravel.
Mallee scrub and heath.

Coblinine Broad valley floors of the ancient river system draining from Kukerin system into the Avon and Blackwood catchments Saline wet soil, alkaline grey shallow sandy duplex and deep sandy duplex.
Salmon gum-wandoo woodland, mallee scrub and samphire flats.

Dongolocking (Blackwood and Avon catchments) Gently undulating to undulating rises and low hills ,with more sandy duplexes and less gravel plateau soils than the Kukerin system. Intermediate in dissection between the Kukerin and Whinbin systems.
Grey deep sandy duplex, sandy gravel and shallow sandy duplex.
Wandoo-sheoak woodland and mallee.

Corrigin (Avon catchment)
Datatine (Blackwood catchment)
Undulating terrain based on mafic and siliceous gneisses. More dissected and with more loams, gravelly loams and clays than adjoining systems formed from granites

Kondinin (Avon catchment) Broad valleys associated with Corrigin system. Less deep duplex and saline soils than Coblinine.
Calcareous loamy earths, saline wet soils, cracking clays, non-cracking clays and alkaline grey shallow sandy duplexes
York gum-salmon gum-morrell woodland and samphire flats

Kweda (Avon catchment).Smoothly undulating terrain with "U" shaped valleys. Old aeolian deposits from Yenyenning lakes, and colluvial soils over granite rocks.
Grey deep sandy duplexes, grey shallow sandy duplexes, alkaline grey deep sandy duplexes pale deep sands and yellow deep sands

Aldersyde (Avon catchment) Major low gradient valleys containing old alluvium and colluvium derived from adjacent sandplain.
Casuarina and Tea tree thicket, with scattered Wandoo on heavy duplex soils

Soil-landscape Information in the South-West Agricultural Zone

Brendan Nicholas[A] *and Noel Schoknecht*[B]

[A]Agriculture Western Australia PMB 50 Esperance W.A. 6450
[B]Agriculture Western Australia Locked Bag No. 4 Bentley Delivery Centre W.A. 6983

Abstract

To meet the demand for soil-landscape information Agriculture Western Australia is near to completing a regional program of soil-landscape mapping covering the south-west agricultural zone. To manage the wealth of soil-landscape information across large areas of the state and to provide information in a structure accessible to land managers, a map unit hierarchy and soil-landscape data management scheme for Western Australia has been developed. Two examples of land resource information products tailored to the land managers requirements at a regional and catchment scales are discussed.

Introduction

Land resource assessment in the south-western agricultural zone of Western Australia was conducted in a piecemeal fashion during the 1930s to 1960s by a number of agencies, including CSIRO, the then Department of Lands and Survey, and the Department of Agriculture. These surveys were largely targetted at evaluating the potential for agriculture in areas of native vegetation.

The advent of the National Soil Conservation Program in the late 1980s saw funding specifically targetted for land resource assessment, and the commencement of a systematic inventory of the land resources of 25 million hectares of Western Australia's south-west agricultural zone. The detail of the assessment, ranging from 1:50,000 to 1:250,000 scale, is related to the intensity of land use.

In parallel, an assessment of the rangeland areas has been conducted since the 1950s, and this program is scheduled to be completed this decade. Western Australia's commitment to a systematic overview of its land resources, and the storage of the data (points and polygons) in digital form, has resulted in the development of extremely valuable and widely sought, datasets.

Soil-landscape Approach

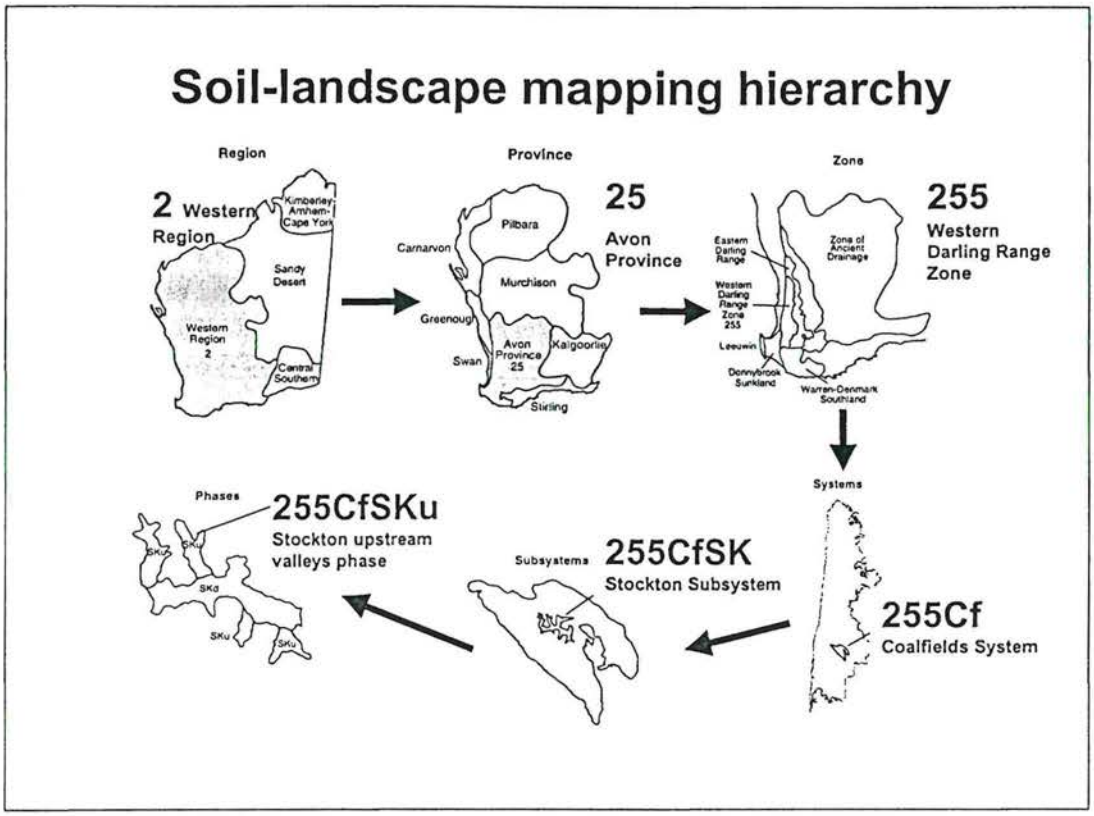
Agriculture Western Australia uses a soil-landscape approach in mapping soil and land resources (Purdie, 1993). Landscape units are identified with the aid of remotely sensed information such as aerial photographs and satellite images. The landscape units are defined in terms of physiography. Within the landscape unit, geology, soils and vegetation patterns are described to identify the characteristics of the map unit. Soil-landscape mapping integrates a defined combination of these characteristics into spatial units.

Mapping hierarchy

The mapping program in Western Australia has had to overcome the problem of varying degrees of complexity in landscapes and different scales of assessment projects. To maintain a consistent approach across the state a hierarchy of map units has been developed.

Each map unit in the hierarchy has a unique symbol describing how it fits within the soil-landscape hierarchy. The example in Figure 1 shows the Coalfields System Stockton Subsystem upstream valleys phase map unit which has a unique code of 255CfSKu.

Figure 1 Mapping hierarchy in Western Australia using Coalfields System Stockton Subsystem upstream valleys phase map example.



Varying scale of assessment projects across the state

Depending on location in the state and the scale of assessment project, soil-landscape information is available for the different levels in the hierarchy. Figure 2 shows assessment projects in the south-west according to mapping scale. There is a relationship between mapping scale and the level of the map unit hierarchy mapped. Table 1 shows that as the mapping scale decreases map units are identified to lower levels in the map unit hierarchy.

Table 1 Scale of assessment project and level of map unit hierarchy used

Scale of mapping	Level used in map unit hierarchy
1:250 000 (large scale)	Subsystem or System
1:100 000 to 1: 150 000	Phase or Subsystem
1:20 000 to 1:50 000 (small scale)	Phase

The areas of more intensive land use pressures have been assessed to subsystem and phase levels while the extensive farming areas of the wheatbelt have been assessed to system or sub-system level in the map unit hierarchy.

South-west Systems Map

The information from the fifty land assessment projects in the south-west agricultural zone has been used to prepare a small scale soil-landscape map of the south-west agricultural zone at the system level. This map and associated attributes is used for projects that require a uniform level of information over the south-west Agricultural Zone such as resource management and agriculture development projects.

Figure 2 Soil-Landscape mapping in South Western Australia according to scale

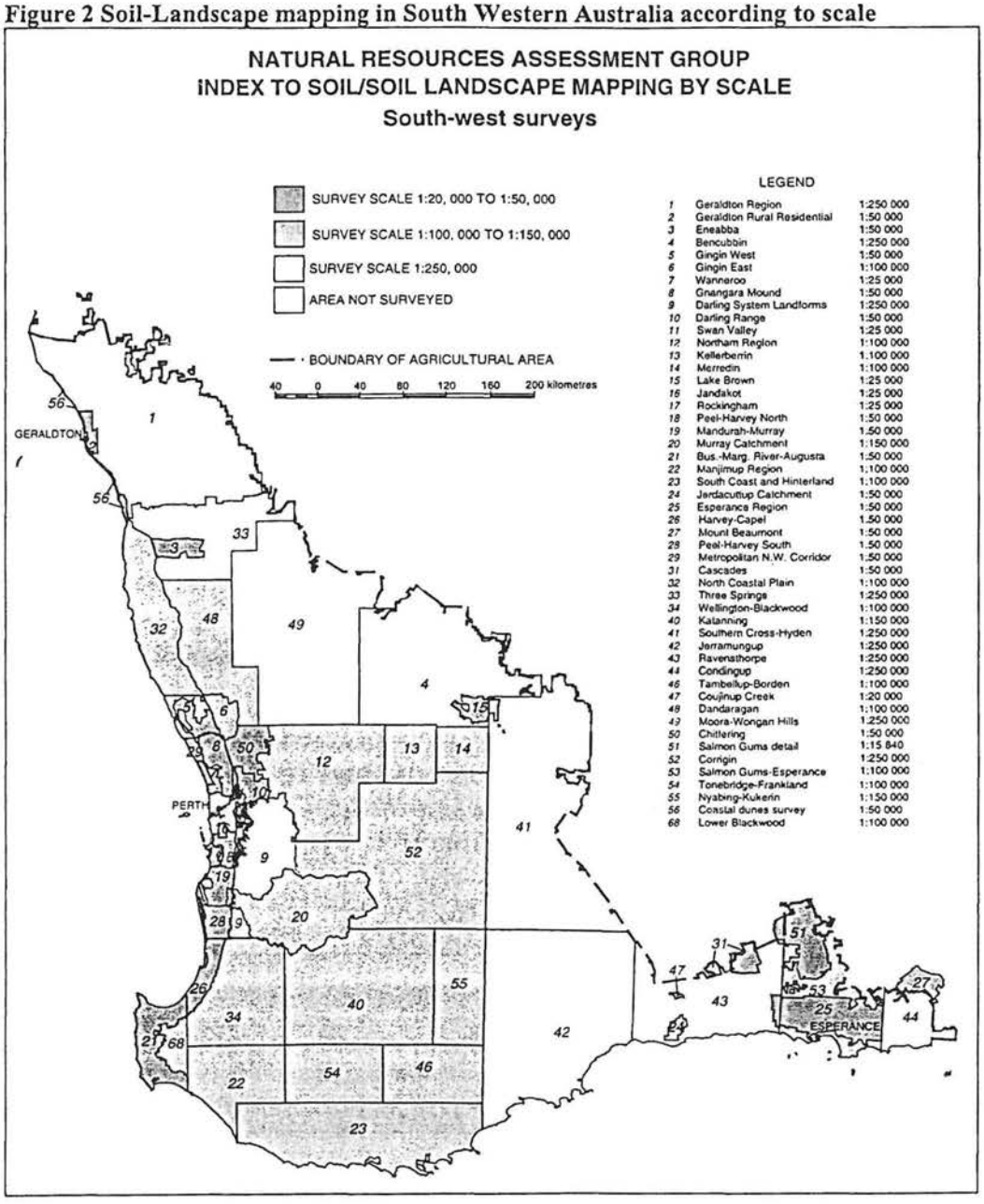
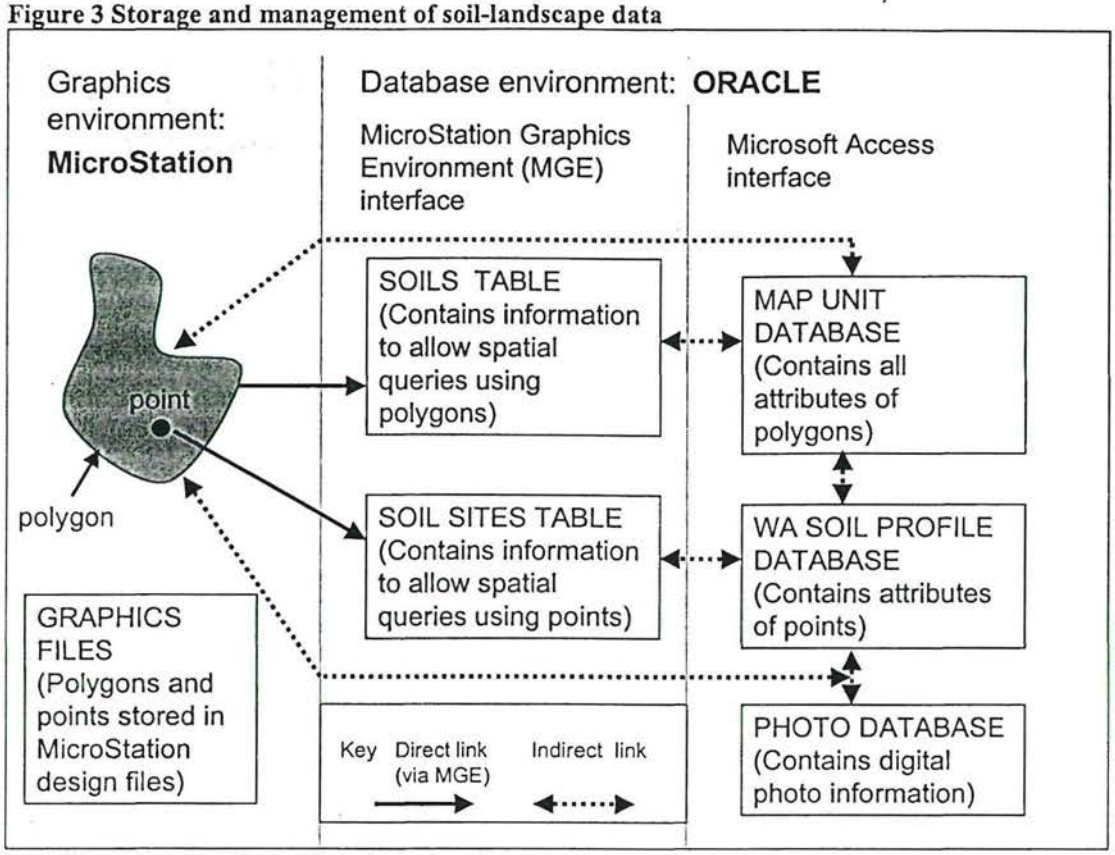


Figure 3 Storage and management of soil-landscape data



Storage of Soil-landscape datasets

Figure 3 shows the scheme for the storage of soil-landscape data held by Agriculture Western Australia. The graphical environment stores map unit (polygon) and site description location (point) information in Microstation® design files. The Oracle® database environment stores attributes of the map unit (polygon) and soil profile (point) data. The Microstation graphical and Oracle database environments are joined by a spatial link. The spatial link is done using Microstation Graphics Environment® (MGE). The linkage between the two data environments allows spatial queries to be done on the map unit and profile databases. For ease of use and to allow offline use, a Microsoft Access® database application is used to view, edit and query the map unit and soil profile information stored in the Oracle database.

Description of soils

Soil are described by proportional allocation within map units. For the systems level the Western Australian Soil Groups (Schoknecht, 1999) are used. The Western Australian Soil Groups and description of the Coalfield System (255Cf) is shown in Table 2 as an example.

Table 2 Coalfields System description and Proportional allocation of WA. Soil Groups.

Lateritic plateau with broad swampy depressions (gently undulating rises, gently undulating plains) on deeply weathered profile over sedimentary rocks in the Western Darling Range around Collie. Duplex sandy gravels, pale deep sands, yellow deep sands and wet soils. Jarrah marri paperbark woodland.		
WA Soil Group Code	WA Soil Group	Proportional Allocation (%)
302	Duplex sandy gravel	35
444	Pale deep sand	10
103	Semi-wet soil	10
446	Yellow deep sand	9
303	Loamy gravel	7
105	Wet soil	7
464	Yellow sandy earth	6
301	Deep sandy gravel	6
403	Grey deep sandy duplex	4
304	Shallow gravel	4
424	Yellow/brown shallow sand	1
422	Pale shallow sand	1

Examples of use of soil-landscape datasets

1 State-wide example: Durum Wheat Capability assessment

One of the uses of the soil-landscape datasets at the system level is to identify soils suitable for new farming enterprises or the possible expansion of existing enterprises. The Agriculture Western Australia cereals program is looking at the potential to expand durum wheat production. The following steps summarise the development of the durum capability map.

Step 1: Factor rating table

The south-west systems map and the Western Australian soil group attributes (Schoknecht 1999) where examined to determine the capability for durum wheat based on topsoil and subsoil pH and texture attributes. Table 4 shows the pH and texture attribute values and capability rankings for durum wheat. The most limiting factor determines the capability of a soil, for example a soil with a high capability for pH and low capability for texture will be assessed as having low capability for durum wheat.

Table 4 Durum wheat pH and texture capability ratings

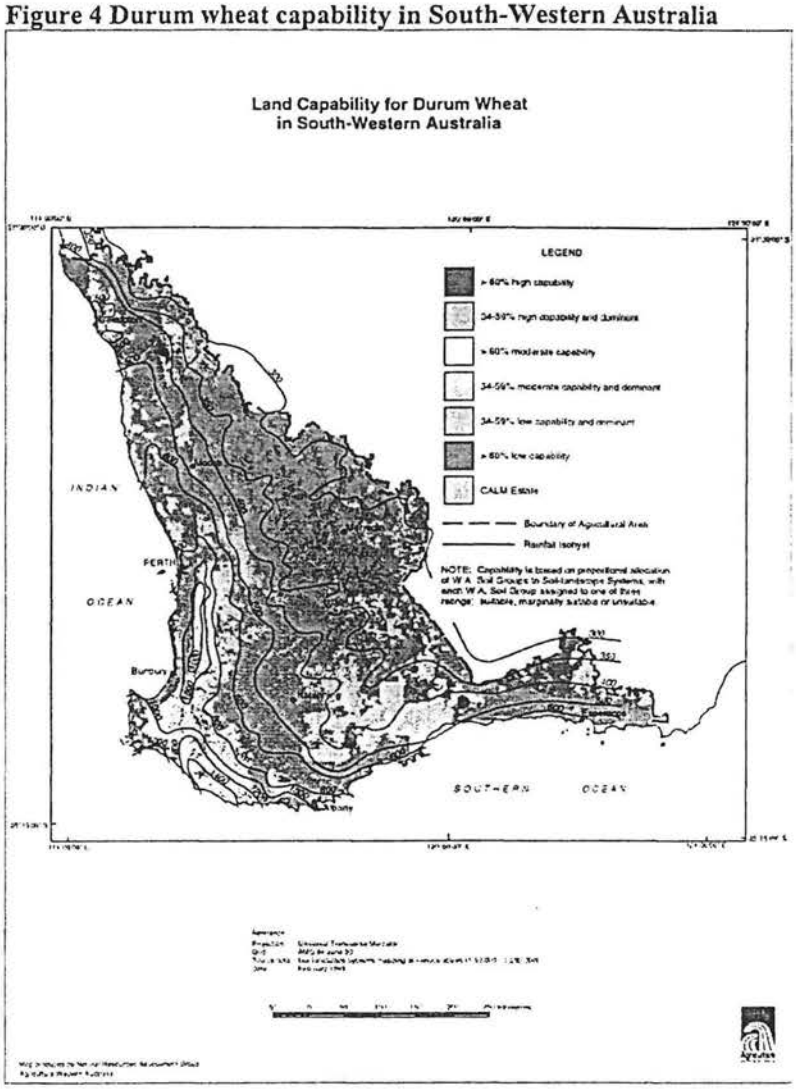
pH Topsoil	pH Subsoil	pH capability rating
acid	acid	low
	neutral to acid	low
acid to strongly acid	acid to strongly acid	low
	strongly acid	low
alkaline	alkaline	high
neutral	alkaline	high
	neutral	moderate
	neutral to alkaline	low
neutral to acid	neutral	moderate
	neutral to acid	moderate
	neutral to alkaline	high
neutral to alkaline	neutral-alkaline	low

Topsoil texture	Subsoil texture	Texture capability rating
clay	clay	high
loam	clay	high
	substrate	low
sand	clay (<30cm)	high
	clay (30-80cm)	moderate
	loam	moderate
	sand	low
	substrate	low

Step 2: Proportional allocation of ratings to spatial units (soil-landscape systems)
Rating data for the soil group attributes is linked to the proportional soil group allocations in the map unit database to determine the proportional allocation of durum wheat capability ratings to the soil-landscape system level map units. This data is used to generate a map representing the proportional capability for durum wheat in each soil-landscape system (Figure 4).

Step 3: Using the data
The durum wheat capability map has been used to define the potential areas of durum production. The estimated area information when combined with yield estimates gives an indication of the tonnes of durum wheat available to market for a developed durum wheat industry. The durum wheat capability map can be improved by being combined with other datasets such as point source information and trial data to look at management issues such as Boron toxicity.

Figure 4 Durum wheat capability in South-Western Australia



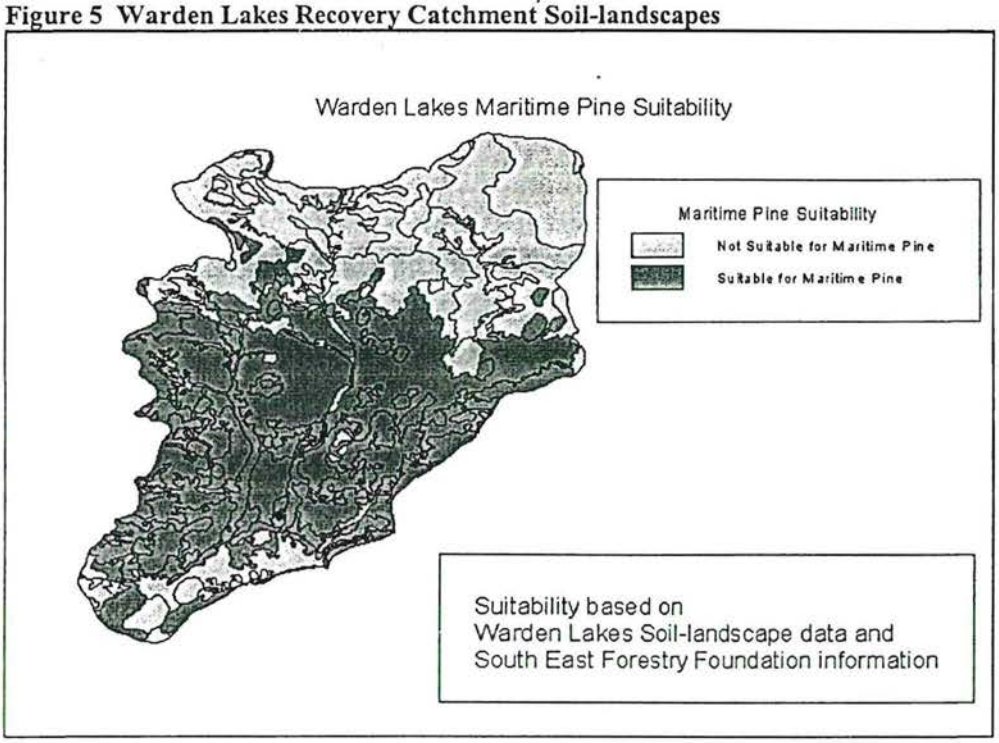
2 Regional Example: Warden Lakes Recovery Catchment

The Warden Lakes catchment and wetland system was designated a biodiversity recovery catchment under the State Salinity Action Plan (SSC, 1998). Since 1999 the Esperance Catchment Support Team has been assisting with the development of a recovery catchment plan to protect the Warden Lakes catchment and wetland system.

The soil-landscape information being provided in the Warden Lakes catchment aims to be in an easy to use extension oriented format while maintaining links to the statewide datasets and standards. The soil-landscape datasets used in the Warden Lakes project consists of:

- digital maps for use in a GIS;
- map unit description database;
- points source information of soil profile morphology, physical and chemical data.

Figure 5 Warden Lakes Recovery Catchment Soil-landscapes



Soil-landscape information has been used for a variety of purposes in the Warden Lakes project such as:

- Recovery Catchment Plan and Atlas (Massenbauer 2000);
- planning revegetation plantings in the catchment;
- high water use options for soil types in the catchment.

The flexibility of the soil-landscape databases allows the information to be customised to each particular end users requirements. Figure 5 shows the soil-landscape map of the Warden Lakes catchment coloured according to Maritime Pine Suitability. Soil-landscape information has also been used in the National Land and Water Resource Audit for following activities:

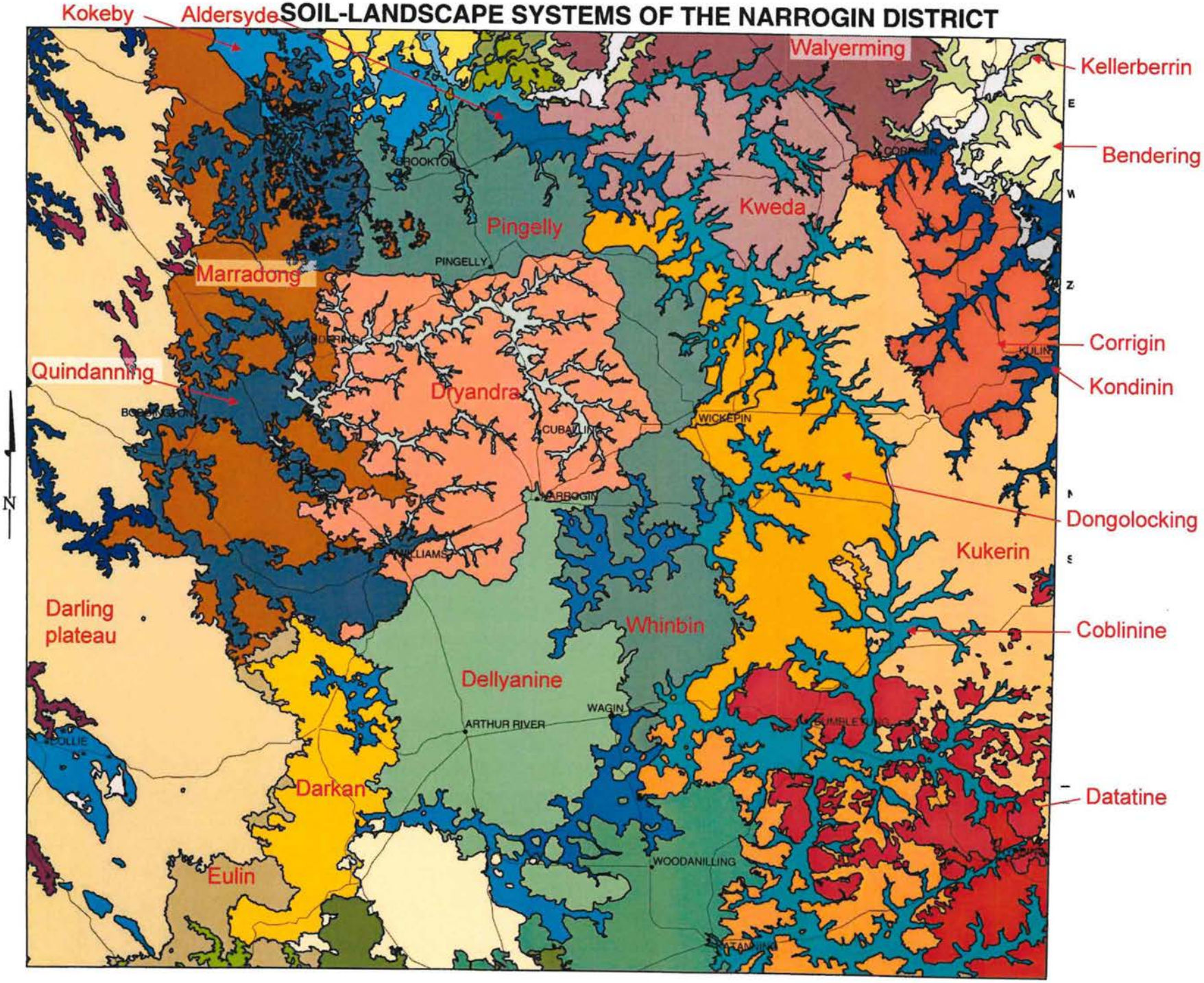
- Catchment Modelling Project
- Extent and Impacts of Salinity Project

Conclusion

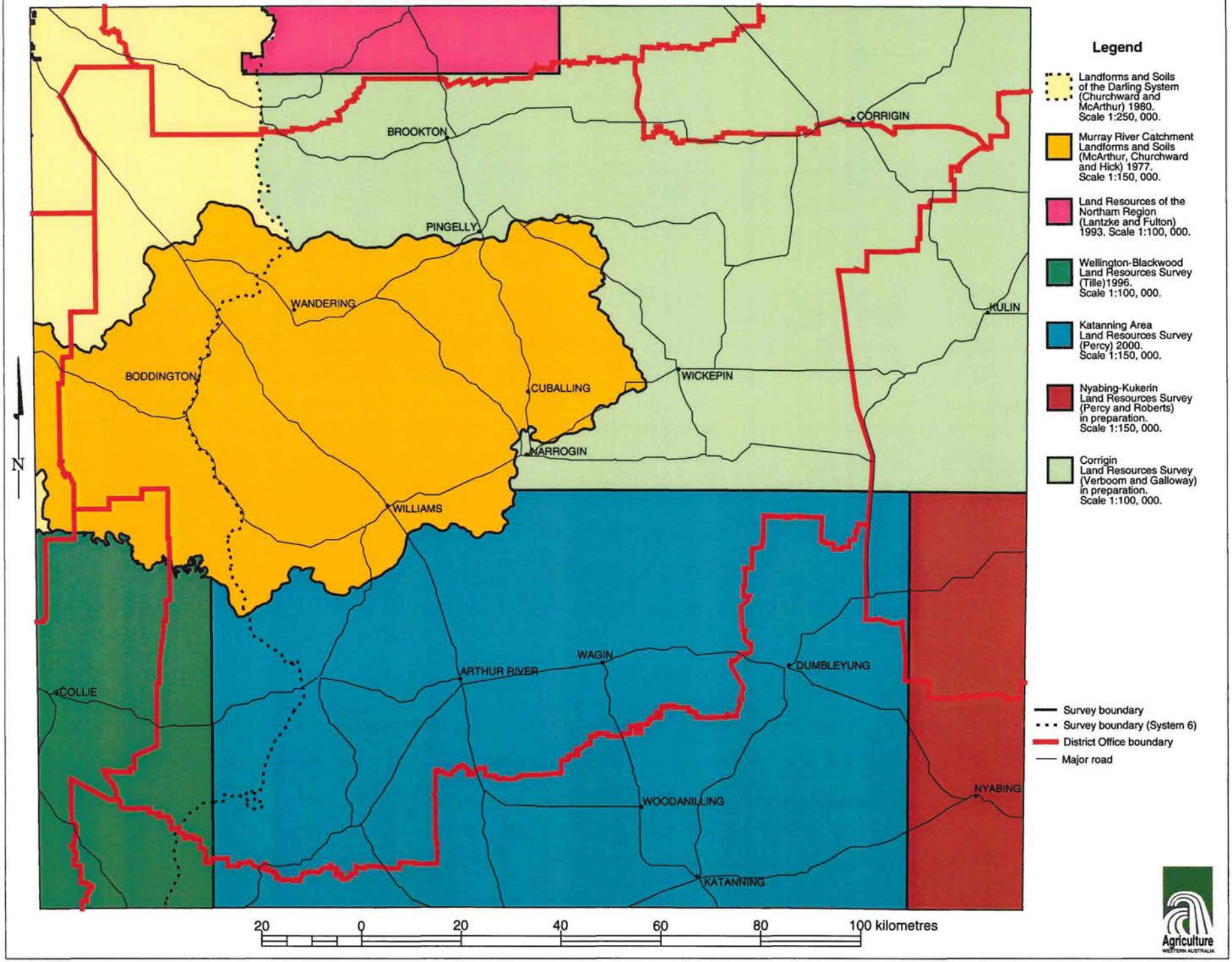
Experience has demonstrated that a uniform approach to mapping and storing state-wide soil-landscape information is an invaluable asset. The state-wide approach and standards for soil-landscape mapping provide a logical framework for further studies at a regional or local level. The standard approach across the south-west agricultural zone also allows for easy comparisons between different areas of the state

The ability to customise the soil-landscape information to the users requirements makes it an excellent decision support tool for agricultural and resource management projects at all scales.

SOIL-LANDSCAPE SYSTEMS OF THE NARROGIN DISTRICT



SOIL-LANDSCAPE MAPPING IN THE NARROGIN DISTRICT



Katanning Survey

Legend to symbols used in system cross-section diagrams

Aoelian deposits, mainly deep sands

Alluvial deposits

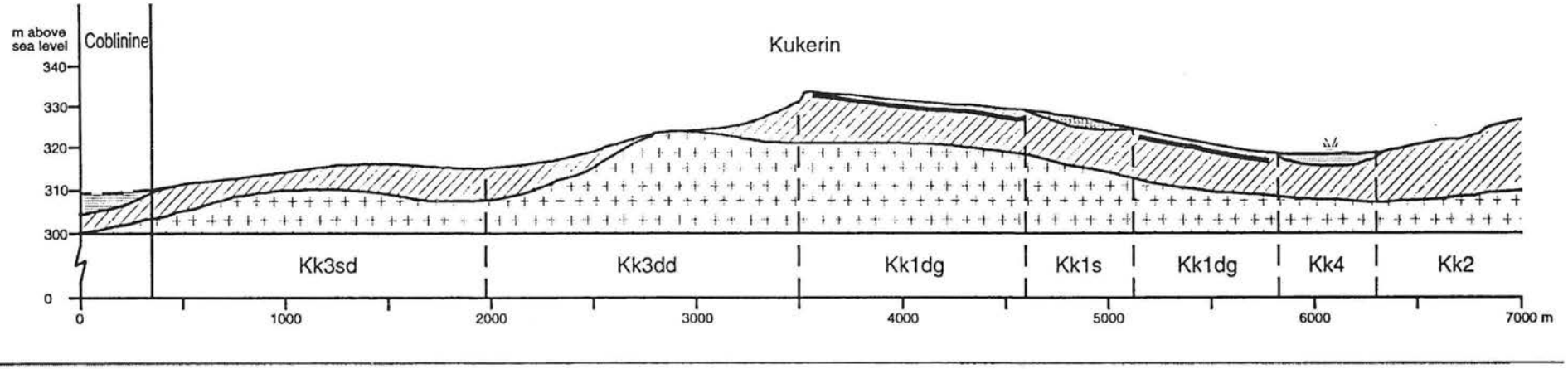
Wet or waterlogged soils, including saline wet soils

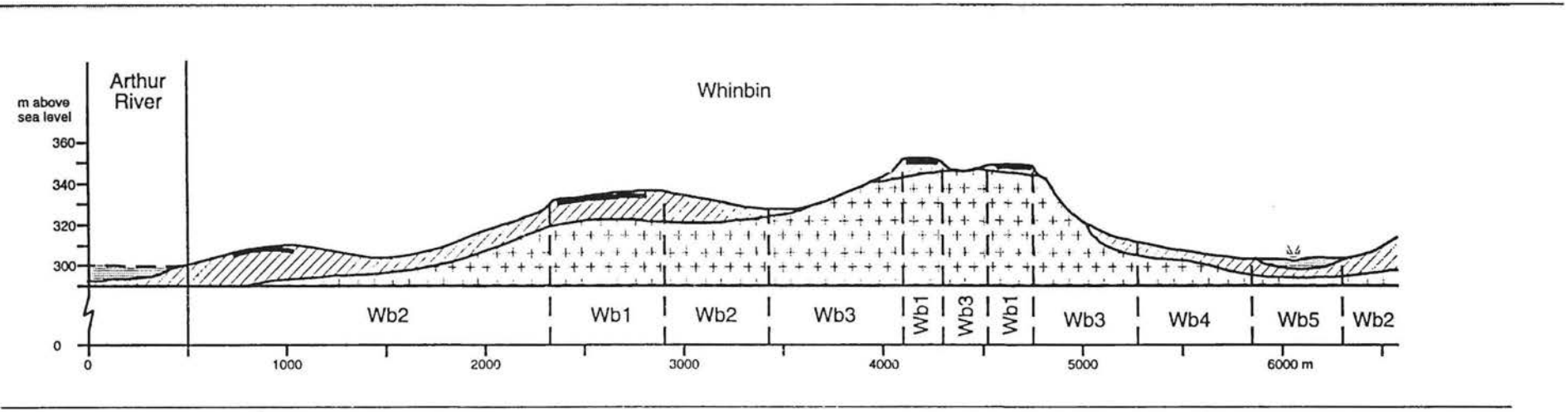
Eocene sediments

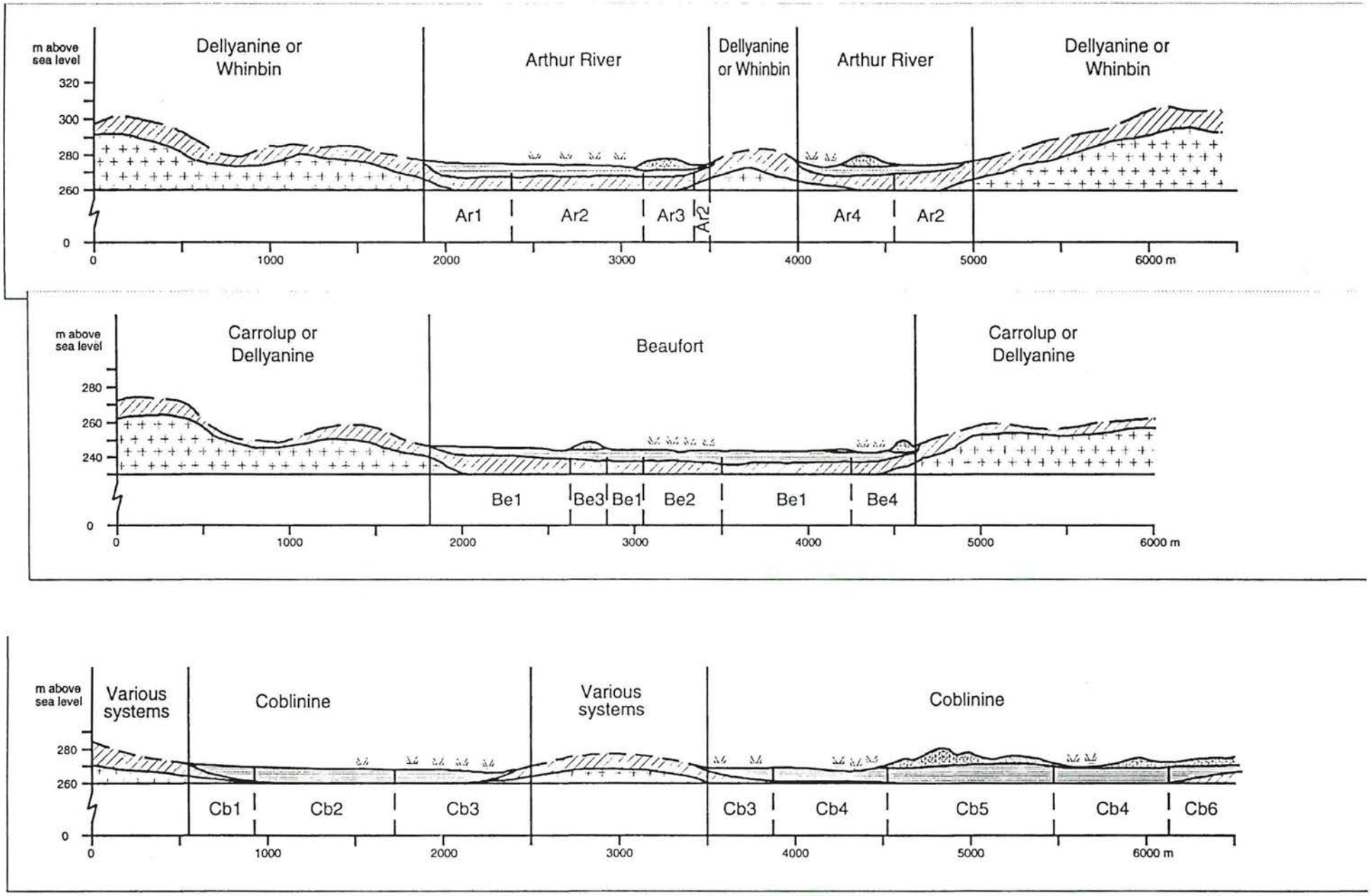
Tertiary laterite profile with duricrust

Colluvium and/or Tertiary laterite profile

Granite, gneiss and/or adamellite with dolerite dykes, colluvial deposits also occur






m above sea level
320
300
280
260
0
Dellyanine or Whinbin
Arthur River
Dellyanine or Whinbin
Arthur River
Dellyanine or Whinbin
Ar1
Ar2
Ar3
Ar2
Ar4
Ar2
0
1000
2000
3000
4000
5000
6000 m
m above sea level
280
260
240
0
Carrolup or Dellyanine
Beaufort
Carrolup or Dellyanine
Be1
Be3
Be1
Be2
Be1
Be4
0
1000
2000
3000
4000
5000
6000 m
m above sea level
280
260
0
Various systems
Coblinine
Various systems
Coblinine
Cb1
Cb2
Cb3
Cb3
Cb4
Cb5
Cb4
Cb6
0
1000
2000
3000
4000
5000
6000 m

Arthur River System Ar

16,759 ha 1.2% of survey area

Broad (1.5 to 4.5 km) level to gently undulating alluvial plains of the Arthur River with small areas of dunes, lunettes, swamps and lakes. The system is named after the Arthur River.

The main soils are saline wet soils, mainly saline grey shallow sandy duplex soils. Other soils include grey shallow and deep sandy duplex soils with grey or brown sodic clay subsoil, which are often alkaline and calcareous at depth.

Geology: Alluvial deposits of sand, silt and clay (*Cza*) with small areas of lacustrine deposits (*Ql*) associated with lakes and swamps (Chin and Brakel 1986).

Native vegetation: Valleys of the Wagin Vegetation System (Beard 1980)

- **Dominant trees:** wandoo (*Eucalyptus wandoo*) woodland
- **Other trees:** rock sheoak (*Allocasuarina huegeliana*), jam (*Acacia acuminata*), York gum (*E. loxophleba*), swamp sheoak (*Casuarina obesa*), and salmon gum (*E. salmonophloia*) in the east
- **Shrubs:** *Melaleuca* spp., and samphire
- Other salt-tolerant species including introduced grasses such as barley grass (*Hordeum* sp.) are also common.

Present land use and land management

- Grazing of salt-tolerant vegetation and improved pastures
- Limited cropping of oats or barley in long pasture dominated rotations
- High soil salinity is the main limitation to production
- Frost, waterlogging and flooding also further limit production mainly to grazing.

Similar systems

- Beaufort and Coblinine are also broad alluvial plains
- Beaufort has a lower proportion of saline wet soils
- Coblinine has a higher proportion of alkaline and calcareous soils and salt lake soils
- Norring is mainly a lacustrine plain with a much higher proportion of salt lake soils.

Arthur River System

Subsystem	Landform description	WA Soil Group	Soil Series	% of unit
Ar1	Plains with	Grey shallow sandy duplex	Indinup 1	20
Arthur River 1	stream channels	Alkaline grey shallow sandy duplex	Fairclough	20
Subsystem	0-2% gradient	Saline wet soil	Brynie 2	15
(5,907 ha)	1-2 m relief	Grey deep sandy duplex	Indinup	10
		Grey deep sandy duplex	Warup	10
			Main others: Brynie 7; Warren; Yowangup; Eastwood	25
Ar2	Plains with	Alkaline grey shallow sandy duplex	Fairclough 2	15
Arthur River 2	stream channels	Grey deep sandy duplex	Indinup	15
Subsystem	0% gradient	Saline wet soil	Brynie	15
(8,649 ha)	0-3 m relief	Saline wet soil	Brynie 2	15
		Saline wet soil	Brynie 5	10
		Saline wet soil	Brynie 7	10
			Main others: Brynie 9; Eulanda; Moodiarup 1; Warren; Yowangup	20
Ar3	Dunes	Brown deep sand	Yowangup	90
Arthur River 3	0-5% gradient		Main others:	10
Subsystem	1-5 m relief		Warren; Brynie 7	
(867 ha)				
Ar4	Swamps, small	Salt lake soil		40
Arthur River 4	lakes with dunes	Saline wet soil	Brynie 7	30
Subsystem	and lunettes	Alkaline grey shallow sandy duplex	Fairclough	10
(1,336 ha)	0-1% gradient	Alkaline grey deep sandy duplex	Ballard	10
	1-5 m relief		Main others: Yowangup; Fairclough 2	10

Beaufort System Be

31,171 ha 2.1% of survey area

Broad (1.5 to 6 km), level to very gently inclined alluvial plains of the Beaufort and Hillman Rivers with small areas of dunes, swamps and lakes. The system is named after the Beaufort River.

The main soils are grey deep sandy duplexes with grey or brown sodic clay subsoils that are neutral to slightly alkaline. Other soils include saline wet soils and grey shallow sandy duplexes, sometimes with alkaline, calcareous subsoils.

Geology: Alluvial deposits of sand, silt and clay (*Cza*) with small areas of lacustrine deposits (*Ql*) associated with lakes and swamps (Wilde and Walker 1982, Chin and Brakel 1986).

Native vegetation: Valleys of the Beaufort Vegetation System (Beard 1980)

- **Dominant trees:** wandoo (*Eucalyptus wandoo*) woodland, usually associated with rock sheoak (*Allocasuarina huegeliana*) and jam (*Acacia acuminata*)
- **Other trees:** flat-topped yate (*E. occidentalis*), swamp sheoak (*Casuarina obesa*), slender banksia (*Banksia attenuata*) with some marri (*E. calophylla*) and jarrah (*E. marginata*) along the Hillman River
- **Shrubs:** stinkwood (*Jacksonia sternbergiana*), paperbark (*Melaleuca* sp.)
- Salt-tolerant species including samphire and introduced grasses such as barley grass (*Hordeum* sp.) are common on saline soils.

Present land use and land management

- Sheep grazing of improved pastures and salt-affected land
- Limited cropping of oats or barley in long pasture-dominated rotations
- Uncleared land reserved for nature conservation
- Some areas used for oil mallee plantations and alley farming
- Soil salinity and waterlogging are the main limitations to production
- Frost and flooding further limit production mainly to grazing.

Similar systems

- Arthur River and Coblinine Systems are also broad alluvial plains
- Arthur River has a higher proportion of saline wet soils
- Coblinine has a higher proportion of alkaline and calcareous soils and salt lake soils
- Norring is mainly a lacustrine plain with a much higher proportion of salt lake soils
- Norring 1 Subsystem is very similar to Beaufort 1.

Beaufort System

Subsystem	Landform description	WA Soil Group	Soil Series	% of unit
Be1	Plains with stream	Grey deep sandy duplex	Indinup	20
Beaufort 1	channels	Grey shallow sandy duplex	Indinup 1	15
Subsystem	0-1% gradient	Grey shallow sandy duplex	Eastwood	15
(25,500 ha)	0-5 m relief	Grey deep sandy duplex	Eulanda	10
		Saline wet soil	Brynie	10
		Alkaline grey shallow sandy duplex	Fairclough 1	10
			Main others: Yowangup; Warup; Tarwonga 1; Brynie 8; Eastwood 1; Eastwood 2; Warup 3; Tarwonga 3; Ballard 3; Warren; Lennard 1	20
Be2	Plains with stream	Grey deep sandy duplex	Indinup	30
Beaufort 2	channels	Saline wet soil	Brynie	20
Subsystem	<1% gradient	Saline wet soil	Brynie 3	20
(3,082 ha)	1-5 m relief	Saline wet soil	Brynie 2	10
		Grey shallow sandy duplex	Indinup 1	10
			Main others: Warup 2; Warren	10
Be3	Dunes	Brown deep sand	Yowangup 1	50
Beaufort 3	0-5% gradient	Brown deep sand	Yowangup	40
Subsystem	2-5 m relief		Main others: Brynie; Indinup; Indinup 1	10
(1,448 ha)				
Be4	Swamps and	Saline wet soil	Brynie	30
Beaufort 4	small lakes with	Salt lake soil		30
Subsystem	lunettes and	Brown deep sand	Yowangup 1	20
(1,141 ha)	dunes		Main others: Yowangup; Moojebin 5	20

Coblinine System Cb

107,481 ha 7.4% of survey area

Broad alluvial plains, lacustrine plains, including lakes, swamps, dunes and lunettes, and small areas of sandplain along the Coblinine River, Lefroy River and Dongolocking Creek. The width of the plains varies from 750 m to 7 km. The system is named after the Coblinine River.

The main soils are saline wet soils. Also common are alkaline grey shallow sandy and loamy duplex soils with sodic grey, brown and less commonly yellow clay subsoils.

Geology: Alluvial deposits of sand, silt and clay (*Cza*), lacustrine deposits (*Ql*), and quartz sand deposits (*Qd*) with small areas of reworked sand plain (*Czs*) from Chin and Brakel (1986).

Native vegetation: Dumbleyung Vegetation System in valleys (Beard 1980)

- **Dominant trees:** salmon gum (*Eucalyptus salmonophloia*) woodland and/or mallee *Eucalyptus* species, wandoo (*E. wandoo*) woodland is also common
- **Other trees**: York gum (*E. loxophleba*), flat-topped yate (*E. occidentalis*), morrel (*E. longicornis*) and jam (*Acacia acuminata*). Less common trees include rock sheoak (*Allocasuarina huegeliana*), swamp sheoak (*Casuarina obesa*), swamp mallet (*E. spathulata*), moort (*E. platypus*) and various *Banksia* spp.
- **Shrubs:** *Melaleuca* spp. shrubs are common as well as centipede bush (*Exocarpis aphylla*) and prickle bush (*Hakea preissii*)
- Salt-tolerant vegetation is common including samphire and introduced such as barley grass (*Hordeum* sp.).

Present land use and land management

- Sheep grazing of salt-tolerant vegetation and improved pastures with very limited cropping of oats, barley or canola in long pasture dominated rotations
- Cropping is common on lunettes and sandplain with rotations including wheat, barley, oats, canola, peas, faba beans and lupins
- Nature conservation, including nature reserves around lakes and along the Coblinine River
- High salinity is the main limitation to production
- Frost, waterlogging and flooding further limit production mainly to grazing, except on lunettes and sandplain.

Similar systems

- Arthur River and Beaufort are also broad alluvial plains, but generally have alkaline, calcareous soils and salt lake soils
- Arthur River has a similar proportion of saline wet soils
- Norring is mainly a lacustrine plain with a much higher proportion of salt lake soils.

Coblinine System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Cb1 Coblinine 1 Subsystem (4,312 ha)	Plains with stream channels and dunes. 0-1% gradient 1-5 m relief	Alkaline grey shallow loamy duplex Alkaline grey shallow loamy duplex Grey shallow sandy duplex Grey shallow sandy duplex Undifferentiated	Peterson 1 Peterson 2 Eastwood Indinip 1	15 10 5 5 65
Cb2 Coblinine 2 Subsystem (40,523 ha)	Plains with stream channels and dunes 0-1% gradient 1-5 m relief	Saline wet soil Saline wet soil Alkaline grey shallow sandy duplex Alkaline grey shallow sandy duplex Alkaline grey shallow loamy duplex Grey deep sandy duplex Alkaline grey deep sandy duplex	Brynie 5 Brynie 7 Fairclough Fairclough 1 Peterson Eulanda Ballard Main others: Brynie; Warup 3; Yowangup; Beynon; Warren 2; Warren 1	20 10 15 15 10 10 10 10
Cb2c Coblinine 2 Subsystem clay phase (2,934 ha)	Plains with stream channels <1% gradient 1-5 m relief	Hard cracking clay Saline wet soil Brown loamy earth	Beynon Brynie 7 Warren 1 Main others: Warren 2; Fairclough; Ballard 1	35 20 20 25
Cb3 Coblinine 3 Subsystem (32,455 ha)	Plains with stream channels and dunes 0-2% gradient 1-2 m relief	Saline wet soil Saline wet soil Saline wet soil Hard cracking clay Alkaline grey shallow sandy duplex Alkaline grey shallow sandy duplex	Brynie 8 Brynie 9 Brynie 7 Beynon Fairclough Fairclough 1 Main others: Brynie; Brynie 3; Brynie 5; Brynie 6; Peterson; Indinup 1; Warren 2; Yowangup	25 25 20 10 5 5 10
Cb3c Coblinine 3 Subsystem clay phase (1,722 ha)	Plains <1% gradient 1-2 m relief	Saline wet soil Saline wet soil Hard cracking clay Calcareous loamy earth	Brynie 7 Brynie 8 Beynon Warren 2 Main others: Brynie 5; Brynie 9; Warren	25 25 20 10 20
Cb4 Coblinine 4 Subsystem (18,344 ha)	Lakes, swamps with lunettes, swales and dunes 0-4% gradient 1-5 m relief	Saline wet soil Saline wet soil Hard cracking clay Alkaline grey shallow loamy duplex Brown deep sand Salt lake soil	Brynie 5 Brynie 7 Beynon Peterson-2 Yowangup Main others: Brynie 2; Warup; Fairclough	15 15 10 10 5 30 15
Cb5 Coblinine 5 Subsystem (4,903 ha)	Lunettes, dunes and swales 0-5% gradient 2-20 m relief	Brown deep sand Alkaline grey shallow loamy duplex Pale deep sand Alkaline grey shallow sandy duplex Saline wet soil Alkaline grey deep sandy duplex Other grey and red loamy soils	Yowangup Peterson Ravenscliffe Fairclough 2 Brynie Unnamed Unnamed	25 15 10 5 5 25 15
Cb6 Coblinine 6 Subsystem	Sandplain and dunes 1-4% gradient	Grey deep sandy duplex Brown deep sand Gravelly pale deep sand	Indinup Yowangup Kauring	40 30 20

Darkan System Dk

92,477 ha 6.4% of survey area

Gently undulating to rolling rises and low hills. Also includes the narrow alluvial plains of the Blackwood, Arthur and Hillman Rivers. The system is named after the town of Darkan

The main soils are sandy gravels, in particular duplex sandy gravels with yellow clay or clay loam subsoils. Shallow gravels, yellowish brown loamy and deep sandy gravels and grey deep sandy duplex soils usually with yellow, slightly acid to neutral, sodic subsoils are also common.

Geology: Significant areas of granite (*Age, Agp*), adamellite (*Agg*) and quartz monzonite (*Agzp, Agze*), particularly south of Darkan. Laterite (*Czl*) and colluvial deposits (*Qc*) are also common. Alluvial deposits (*Cza*) occur along the Hillman and Arthur Rivers. Very small areas of Eocene alluvial deposits (*Tg*) occur south of Capercup (Wilde and Walker 1982).

Native vegetation: Williams Vegetation System (Smith 1974)

- **Dominant trees:** wandoo (*Eucalyptus wandoo*) usually associated with jarrah (*E. marginata*) and/or marri (*E. calophylla*)
- **Other trees:** jam (*Acacia acuminata*), rock sheoak (*Allocasuarina huegeliana*), flooded gum (*E. rudis*), bull banksia (*Banksia grandis*) and less commonly slender banksia (*B. attenuata*), acorn banksia (*B. prionotes*) and Christmas tree (*Nuytsia floribunda*)
- **Shrubs:** most common are *Dryandra* spp. as well as stinkwood (*Jacksonia sternbergiana*), harsh hakea (*Hakea incrassata*), poison bushes (*Gastrolobium* spp.), teatree (*Leptospermum erubescens*) and low sheoak (*A. humilis*).

Present land use and land management

- Sheep and cattle grazing on annual pastures
- Cropping in long rotations, usually cereals or canola or less commonly lupins and field peas
- Forestry and nature conservation on the western edge
- Water erosion, with high run-off from water repellent sandy gravel in autumn
- Waterlogging on sandy duplexes, footslopes and valley flats.

Similar systems

- The Boscabel System also consists of rises with dominantly gravel soils on the crests and slopes. Boscabel has lower relief than Darkan, having mainly gently undulating to undulating rises and very few areas of soil formed on freshly weathered rock. Boscabel soils are dominantly pale sandy gravels with significant areas of pale deep sands. Eocene sediments occur in both systems but are less common in Darkan.
- The soils in Boyup Brook Valleys System are similar to Darkan although somewhat loamier. The landforms differ as Darkan consists of rises and low hills separated by valley flats while the Boyup Brook Valleys are valleys and valley flats separated by remnants of laterite plateau.

Darkan System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Dk4 Darkan 4 Subsystem (7,844 ha)	Footslopes and lower slopes 0-4% gradient 5-20 m relief	Grey deep sandy duplex Duplex sandy gravel Loamy gravel Grey deep sandy duplex Grey shallow sandy duplex Duplex sandy gravel	Moojebin Lennard 6 Cumming 1 Malebelling Tarwonga 3 Wahkinup Main others: Gibbs; Ravenscliffe	25 20 15 10 10 5 15
Dk5 Darkan 5 Subsystem (8,449 ha)	Valley flats, narrow plains (300-1000 m wide) and swamps 0-1% gradient 1-5 m relief	Grey deep sandy duplex Grey deep sandy duplex Grey shallow loamy duplex Saline wet soil	Indinup Eulanda Moodiarup Brynie Main others: Cundinup 3; Yowangup; Indinup 1	50 15 15 10 10
Dk5w Darkan 5 Subsystem wetlands phase (932 ha)	Swamps and lakes	Salt lake soil Saline wet soil Brown deep sand	 Yowangup	60 20 20
Dk6f Darkan 6 Subsystem footslopes phase (3,284 ha)	Footslopes formed on Eocene sediments 0-3% gradient 10-20 m relief	Duplex sandy gravel Loamy gravel Deep sandy gravel Shallow gravel	Lennard 2 Cumming Yalanbee Gorn 1 Main other: Kauring	30 20 20 10 20
Dk6i Darkan 6 Subsystem gravelly rises phase (2,705 ha)	Gravelly rises formed on Eocene sediments 0-2% gradient 10-30 m relief	Deep sandy gravel Gravelly pale deep sand Pale shallow sand Grey deep sandy duplex Undifferentiated	Gorn Kauring Kauring 1 Moojebin	50 10 10 10 20
Dk7 Darkan 7 Subsystem (3,506 ha)	Dunes and lunettes 1-6% gradient	Brown deep sand Brown deep sand	Yowangup Yowangup 1	80 20

Darkan System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Dk1 Darkan 1 Subsystem (22,972 ha)	Hill crests, mid to upper slopes with breakaways 1-15% gradient 10-50 m relief	Deep sandy gravel Loamy gravel Duplex sandy gravel Shallow gravel Loamy gravel	Yalanbee Cumming 1 Lennard 6 Worsley 1 De Campo 2 Main others: Gorn 1; Wahkinup 1; Lennard; Kauring; Ravenscliffe; Balkuling 1; Indinup	20 20 20 15 5 15
Dk1p Darkan 1 Subsystem steep phase (6,547 ha)	Upper slopes, crests and breakaways 4-15% gradient 30-50 m relief	Deep sandy gravel Duplex sandy gravel Shallow gravel Deep sandy gravel Loamy gravel	Yalanbee Lennard Worsley 1 Gibbs De Campo Main others: Cumming 1; Balkuling	30 20 20 10 5 15
Dk2 Darkan 2 Subsystem (15,267 ha)	Lower to upper slopes and crests 0-5% gradient 10-50 m relief	Duplex sandy gravel Grey deep sandy duplex Loamy gravel Shallow gravel Deep sandy gravel Grey shallow sandy duplex	Lennard 1 Moojebin 2 Cumming Gorn 1 Gibbs Warup 3 Main others: Deep and shallow loamy duplex; Worsley 1; Wahkinup 1; Brynie	35 15 10 10 5 5 20
Dk2i Darkan 2 Subsystem gravelly phase (4,115 ha)	Lower to upper slopes and hill crests 1-5% gradient 10-30 m relief	Duplex sandy gravel Deep sandy gravel Deep sandy gravel Shallow gravel Grey deep sandy duplex Gravelly pale deep sand	Lennard 2 Gibbs 1 Yalanbee Gorn 1 Moojebin 2 Kauring Main others: Ravenscliffe; Lennard 6	30 20 10 10 10 5 15
Dk3 Darkan 3 Subsystem (9,085 ha)	Mid to upper slopes and hillcrests 1-8% gradient 10-60 m relief	Friable red/brown loamy earth Grey sandy duplex Brown deep loamy duplex Red shallow loamy duplex Red deep loamy duplex Duplex sandy gravel Bare rock	Ferndale 1 Tarwonga Beelerup 2 Muradup Hensman Lennard 1 Dolerite; granite Main others: Lowdon 2; Lowdon 4; Four Acre; Malebelling; De Campo 2; Cumming 1; Brynie	20 15 15 10 10 10 5 15
Dk3p Darkan 3 Subsystem steep phase (7,771 ha)	Lower to upper slopes and crests 6 30% gradient 10-60 m relief	Brown deep loamy duplex Friable red/brown loamy earth Red shallow loamy duplex Bare rock Loamy gravel Undifferentiated	Beelerup 2 Ferndale 1 Muradup granite, dolerite Cumming 1	25 20 20 15 10 10

Darkan System

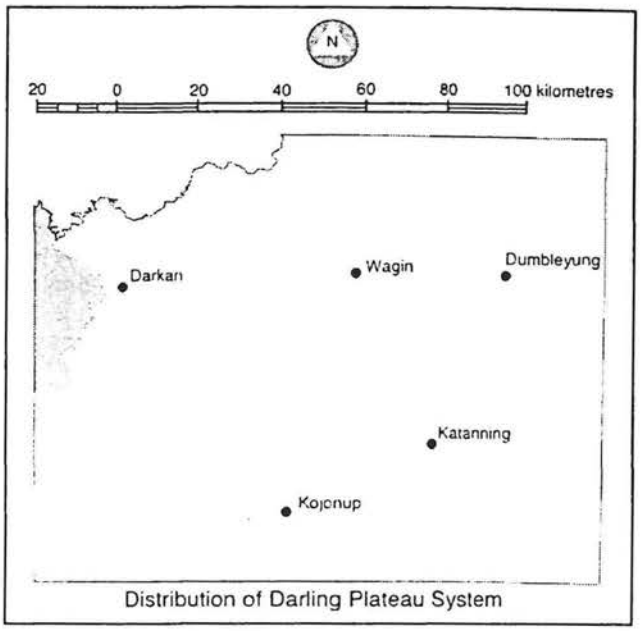
Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Dk4 Darkan 4 Subsystem (7,844 ha)	Footslopes and lower slopes 0-4% gradient 5-20 m relief	Grey deep sandy duplex Duplex sandy gravel Loamy gravel Grey deep sandy duplex Grey shallow sandy duplex Duplex sandy gravel	Moojebin Lennard 6 Cumming 1 Malebelling Tarwonga 3 Wahkinup Main others: Gibbs; Ravenscliffe	25 20 15 10 10 5 15
Dk5 Darkan 5 Subsystem (8,449 ha)	Valley flats, narrow plains (300-1000 m wide) and swamps 0-1% gradient 1-5 m relief	Grey deep sandy duplex Grey deep sandy duplex Grey shallow loamy duplex Saline wet soil	Indinup Eulanda Moodiarup Brynie Main others: Cundinup 3; Yowangup; Indinup 1	50 15 15 10 10
Dk5w Darkan 5 Subsystem wetlands phase (932 ha)	Swamps and lakes	Salt lake soil Saline wet soil Brown deep sand	 Yowangup	60 20 20
Dk6f Darkan 6 Subsystem footslopes phase (3,284 ha)	Footslopes formed on Eocene sediments 0-3% gradient 10-20 m relief	Duplex sandy gravel Loamy gravel Deep sandy gravel Shallow gravel	Lennard 2 Cumming Yalanbee Gorn 1 Main other: Kauring	30 20 20 10 20
Dk6i Darkan 6 Subsystem gravelly rises phase (2,705 ha)	Gravelly rises formed on Eocene sediments 0-2% gradient 10-30 m relief	Deep sandy gravel Gravelly pale deep sand Pale shallow sand Grey deep sandy duplex Undifferentiated	Gorn Kauring Kauring 1 Moojebin	50 10 10 10 20
Dk7 Darkan 7 Subsystem (3,506 ha)	Dunes and lunettes 1-6% gradient	Brown deep sand Brown deep sand	Yowangup Yowangup 1	80 20

Darling Plateau System — Dp

49,525 ha 3.4% of survey area

Undulating lateritic plateau over a crystalline basement forming undulating rises and low hills with some gently undulating rises. The system was first described in the Wellington-Blackwood survey (Tille 1996). Its name has been in common usage for a long time, probably dating back to the 1800s. Jutson (1912) claims to have named the Darling Plateau or Peneplain. The area covered by these terms has varied greatly. Woolnough (1918) used the term Darling Peneplain to refer to the lateritic plateau. Teakle (1938) used the term Darling Region to cover the Darling Plateau and associated valleys. Comprehensive descriptions of each subsystem are available in Tille (1996).

The main soils are duplex sandy gravels and loamy gravels. Others include saline wet soils, deep sandy gravels, pale deep sands and grey deep sandy duplex soils.



Distribution of Darling Plateau System

Geology: Mainly laterite (*Czl*) with areas of lateritic colluvium (*Qrc*), colluvial sand (*Qrcs*), Eocene sediments (*Tg*) and sand over laterite (*Czs*). On some slopes, granite (*Age*), gneiss (*Ana, Ang, Ang*), migmatite (*Am*) and adamellite (*Agg*) rocks are exposed. Small areas of alluvium (*Tn*) and sandy alluvium (*Ta*) are associated with the Harris, Pindalup and Wilga Subsystems (Wilde and Walker 1982).

Native vegetation: Bridgetown Vegetation System (Smith 1974)

- **Dominant trees:** jarrah (*Eucalyptus marginata*) and marri (*E. calophylla*) forest and/or wandoo (*E. wandoo*) woodland
- **Other trees:** flooded gum (*E. rudis*), rock sheoak (*Allocasuarina huegeliana*), bull banksia (*Banksia grandis*), paperbark (*Melaleuca preissiana*) and snotty gobble (*Persoonia longifolia*)
- **Shrubs:** *Dryandra* spp. including parrot bush (*Dryandra sessilis*), *Hakea* spp., blackboy (*Xanthorrhoea* sp.) and various *Melaleuca* spp.

Present land use and land management

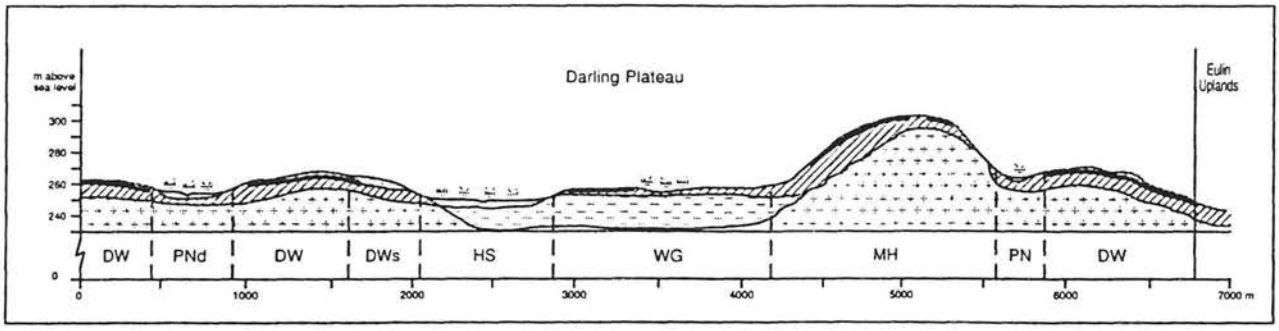
- Mainly State forests and nature reserves
- Grazing of annual pastures by sheep and cattle is the most common use of cleared land
- Tasmanian blue gum (*E. globulus*) is grown for fibre production in plantations and alleys
- Some cropping in rotation with long pasture phases e.g. cereals and canola, less commonly lupins and field peas
- Most soils have moderate to good moisture and nutrient retention, except sandy soils which have poor moisture and nutrient retention and high wind erosion risk
- Risk of water erosion under cropping on the steeper slopes
- Waterlogging and salinity are problems, especially in depressions and valley floors.

Similar systems

- The Darling Plateau grades into the Eulin Uplands System in the Eastern Darling Range Zone. The Wellington-Blackwood catchment divide has been used as a convenient boundary separating the two in this survey. The Darling Plateau System consists mainly of a continuous plateau surface, while the Eulin Uplands System contains many isolated plateau remnants. Soils in both systems are similar although the Eulin Uplands contains extensive areas of poorly drained upland flats developed on Eocene sediments.

Darling Plateau System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
DW Dwellingup Subsystem (14,354 ha)	Divides, hillslopes and crests 2-15% gradient 5-40 m relief	Duplex sandy gravel	Lennard	20
		Loamy gravel	Cumming	15
		Duplex sandy gravel	Wahkinup	10
		Deep sandy gravel	Yalanbee	10
		Loamy gravel	Cunningham	5
		Loamy gravel	Cundinup	5
		Shallow gravel	Worsley 1	5
		Pale gravelly deep sand and pale deep sand	Kauring,; Leecherup; Ravenscliffe	5
		Semi-wet soil	Yourdamung; McAlinden; McAlinden 1; Shotts; Shotts 1	5
			Main others: Gibbs; Jarrahwood; Brockman; Brooklands; Brookhampton; Yourdamung; McAlinden; Malebelling 1; Goldfields; Gorn; Beelerup; Katterup	20
DWs Dwellingup Subsystem sandy phase (717 ha)	Divides, hillslopes and hill crests 2-15% gradient 5-40 m relief	Duplex sandy gravel	Wahkinup	20
		Duplex sandy gravel	Lennard	15
		Duplex sandy gravel	Lennard 1	5
		Pale deep sand	Leecherup	5
		Gravelly pale deep sand	Kauring	5
		Yellow deep sand	Katterup	5
		Yellow deep sand	Jarrahwood	5
		Yellow sandy earth	Goldfields	5
		Loamy gravel	Cumming	5
		Loamy gravel	Cunningham	5
		Deep sandy gravel	Yalanbee	5
		Shallow gravel	Worsley	5
			Main others: Cundinup; Gibbs; Gorn; Ravenscliffe; Shotts; Eulanda 1; Moojebin 1	15
HS Harris Subsystem (2,758 ha)	Poorly drained valley flats (250-1500 m wide) and lower slopes 1-5% gradient 5-10 m relief	Saline wet soil	Deadman	20
		Wet soil	Pindalup 1	20
		Wet soil	Noggerup	10
		Wet soil	Jasper	10
		Saline wet soil	Deadman 1	10
		Saline wet soil	Brynie 1	10
		Grey deep sandy duplex	Indinup	10
			Main others: Dudinyillup; Mervyn 1; McAlinden; Yourdamung	10



Darling Plateau System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
MH Mornington Hills Subsystem (15,978 ha)	Hillslopes, crests and drainage lines 5-20% gradient 40-80 m relief	Duplex sandy gravel Loamy gravel Duplex sandy gravel Loamy gravel Loamy gravel Deep sandy gravel Shallow gravel Gravelly pale deep sand	Lennard Cumming Wahkinup Cunningham Cundinup Yalanbee Worsley 1 Kauring Main others: Cundinup 1; Gibbs; Gorn; Worsley; Katterup; Leecherup; Ferndale; Ferguson; Ferguson 1; Beelerup; Jarrahwood; outcrop	20 15 10 10 10 5 5 5 15
PNd Pindalup Subsystem downstream valleys phase (4,968 ha)	Shallow minor valleys with swampy floors (75-250 m wide) with hillslopes 1-10% gradient 5-20 m relief	Saline wet soil Saline wet soil Saline wet soil Wet soil Duplex sandy gravel Loamy gravel Wet soil Wet soil Brown deep sand	Deadman Deadman 1 Brynie 1 Pindalup 1 Lennard Cumming Jasper Noggerup Dudinyillup Main others: Cunningham; Cundinup; Indinup; Katterup Eulanda 1; Witchcliffe; Jarrahwood; Tutunup;	15 10 10 10 10 10 10 5 5 15
PNu Pindalup Subsystem upstream valleys phase (8,960 ha)	Valley flats (5-20 m wide), footslopes and hillslopes 1-10% gradient 5-20 m relief	Duplex sandy gravel Loamy gravel Loamy gravel Loamy gravel Duplex sandy gravel Saline wet soil Wet soil	Lennard Cumming Cundinup Cunningham Wahkinup Deadman Pindalup 1 Main others: Eulanda 1; Moojebin 1; Indinup; Katterup McAlinden 1; Yourdamung 1; Witchcliffe; Deadman 1; Brynie 1; Noggerup; Jasper; Jarrahwood; Tutunup;	30 15 10 5 5 5 5 25
DpWG Wilga Subsystem (1,790 ha)	Plain 1-5% gradient 2-15 m relief	Duplex sandy gravel Duplex sandy gravel Loamy gravel Loamy gravel Semi-wet soil Semi-wet soil Gravelly pale deep sand Semi-wet soil Grey deep sandy duplex Wet soil Wet soil	Lennard Wahkinup Cumming Cundinup Yourdamung Witchcliffe Kauring Shotts Eulanda 1 Jasper Pindalup 1 Main others: Jarrahwood; Katterup; Cunningham; McAlinden 1; Moojebin 1;	20 10 10 10 5 5 5 5 5 5 5 15

Datatine System Dt

57,991 ha 4.0% of survey area

Gently undulating to undulating rises and low hills associated with gneiss rock outcrops including some valley flats and alluvial plains (0.8 to 1.5 km wide). The system is named after the locality of Datatine, north-east of Katanning.

The main soils are red loamy calcareous earths and alkaline red shallow loamy duplex soils with significant areas of grey deep sandy duplex soils, duplex sandy gravels and alkaline grey shallow and deep loamy duplex soils. Footslopes and valley flats often have gilgai microrelief.

Geology: Mainly gneiss (*Ang*) into which granite, adamellite, granodiorite and gneiss (*Ans, Agp, Agm, and Age*) has been intruded. Dolerite dykes (*d*) are common with only small areas of laterite (*Czl*), colluvium (*Qc*) and alluvium (*Qa*) according to Chin and Brakel (1986).

Native vegetation: Dumbleyung Vegetation System (Beard 1980)

- **Dominant trees:** York gum (*Eucalyptus loxophleba*) associated with jam (*Acacia acuminata*), salmon gum (*E. salmonophloia*) and/or red morrel (*E. longicornis*)
- **Other trees**: various mallee *Eucalyptus* spp., wandoo (*E. wandoo*) and rock sheoak (*Allocasuarina huegeliana*)
- **Shrubs:** *Dryandra* spp., poisons (*Gastrolobium* spp.), *Melaleuca* spp. shrubs and centipede bush (*Exocarpos aphylla*).

Present land use and land management

- Cropping in rotation with annual pastures, including subterranean clover and medic-based pasture
- Crops include wheat, barley, oats, canola, field peas, chickpeas, lentils and faba beans. Lupins are also grown but some of the calcareous soils are not suitable.
- The former Badgebup gold mine in located in the Datatine System
- Highly productive, although calcareous soils have some nutrient deficiencies
- Water erosion risk, particularly on steeper slopes and drainage lines
- Salinity on valley flats
- Wind erosion risk, particularly after pulse crops.

Similar systems

- Many soils in the Upper Pallinup System are similar to those in Datatine. Upper Pallinup also consists of with rises and low hills of gneiss and granite with dolerite and gabbro dykes common. It has a lower proportion of red loamy calcareous earths and alkaline red duplex soils than Pallinup. Datatine includes broad valley flats with dominantly red loamy soils which are quite different from the alluvial soils in the Upper Pallinup System.
- The Dongolocking System has rises and low hills with dominantly grey sandy duplex soils. On Dongolocking 3 Subsystem, soils are formed on weathered granite, gneiss, dolerite and gabbro and are similar to Datatine soils, although with a lower proportion of red earths and duplexes.

Datatine System

Subsystem	Landform description	WA Soil Group	Soil Series	% of unit
Dt1	Upper slopes,	Shallow gravel	Worsley	30
Datatine 1	hill crests and	Deep sandy gravel	Gibbs	20
Subsystem	breakaways	Deep sandy gravel	Yalanbee	10
(6,774 ha)	0-7% gradient	Loamy gravel	Cumming 1	10
	15-50 m relief	Duplex sandy gravel	Lennard 2	10
		Loamy gravel	De Campo-2	5
			Main others: Ferricrete; Lowdon 4; Balkuling	15
Dt2	Drainage lines,	Calcareous loamy earth	Filmer	20
Datatine 2	lower to upper	Alkaline shallow red loamy duple:	Winspear	15
Subsystem	slopes, and	Grey deep sandy duplex	Indinup	15
(39,851 ha)	hill crests	Red deep sandy duplex	Lowdon 3	10
	1-6% gradient	Self-mulching cracking clay	Filmer 1	5
	20-60 m relief	Brown deep sand	Boyaminning 1	5
		Duplex sandy gravel	Lennard 4	5
		Alkaline grey shallow sandy duplex	Wishbone	5
			Main others: Granite and gneiss outcrop; Brynie; Cumming 1; Fairclough 1; Eastwood 1; Worsley; Warren 1; Peterson 1	20
Dt3	Drainage lines,	Calcareous loamy earth	Filmer	35
Datatine 3	footslopes and	Alkaline grey shallow loamy duplex	Peterson	15
Subsystem	lower slopes	Alkaline grey shallow sandy duplex	Fairclough	15
(6,153 ha)	0-2% gradient	Alkaline red shallow loamy duplex	Winspear	10
	20-60 m relief		Main others: De Campo; Cumming 1; Brynie 5; Beynon; granite and dolerite outcrop	25
Dt4	Valley flats and narrow plains	Alkaline grey shallow loamy duplex	Peterson	30
Datatine 4	(800-1500 m	Alkaline red shallow loamy duplex	Winspear	25
Subsystem	wide)	Alkaline grey shallow sandy duplex	Fairclough	20
(5,213 ha)	0-1% gradient	Saline wet soil	Brynie 4	10
	1-5 m relief		Main others: Brynie 5; Warren 1	15

Dellyanine System De

216,098 ha 14.9% of survey area

Gently undulating to undulating rises and low hills drained by the Arthur, Beaufort and Hillman Rivers. The system also includes valley flats and narrow alluvial plains less than 1.5 km wide. It is named after the locality of Dellyanine south-west of Wagin.

The main soils are grey deep sandy duplexes with yellow, grey and less commonly brown clay subsoils. These often have slightly acid to neutral, sodic subsoils. Other common soils are duplex sandy gravels, with yellow or brown clay subsoils, shallow sandy gravels and grey shallow sandy duplex soils. Granite outcrops are prominent particularly on the low hills. Gritty brown deep sands occur near these outcrops.

Geology: Adamellite (*Agv*) and small areas of granite, adamellite and granodiorite (*Age, Agm, Agp*) with dolerite and gabbro dykes trending east to west and south-east to north-west. Slopes are mainly covered with colluvium and minor alluvial deposits (*Qc*) with small areas of laterite (*Czl*) capping the rises. Alluvial deposits (*Cza*) comprise the narrow alluvial plain of the Arthur River (Wilde and Walker 1982, Chin and Brakel 1986).

Native vegetation: Wagin Vegetation System (Beard 1980) with small areas of the Williams Vegetation System (Smith 1974) along the western edge of the Dellyanine System

- **Dominant trees:** wandoo (*Eucalyptus wandoo*) woodland with rock sheoak (*Allocasuarina huegeliana*)
- **Other trees:** York gum (*E. loxophleba*) often associated with jam (*Acacia acuminata*), marri (*E. calophylla*) and jarrah (*E. marginata*) particularly in the west. Less commonly Christmas tree (*Nuytsia floribunda*), bull banksia (*Banksia grandis*), flooded gum (*E. rudis*) and salmon gum (*E. salmonophloia)*
- **Shrubs**: *Dryandra* spp., stinkwood (*Jacksonia sternbergiana*), teatree (*Leptospermum erubescens*), poison (*Gastrolobium* spp.), rough hakea (*Hakea prostrata*) and sheoak (*Allocasuarina humilis).*

Present land use and land management

- Long annual pasture phases (3 to 8 years) in rotation with cereal crops, canola or lupins
- Minor valley floors are not cropped and often remain vegetated while major valley floors are infrequently cropped to oats; saline areas are grazed or fenced and revegetated with trees and/or salt-tolerant perennials
- Waterlogging is the main limitation to production, particularly on valley floors and lower slopes
- Salinity occurs on the valley floors and on a few hillside seeps
- Water erosion is high on cleared mallet hills or below breakaways, and on the steeper slopes.

Similar systems

- Farrar System consists of low hills and rises with mainly grey deep sandy duplex soils formed in weathered granite. Red loamy and sandy duplex soils and gritty brown deep sands are associated with the dolerite and granite outcrops. Although the soils in both systems are similar, relief, slope gradients and proportion of rock outcrop is lower in Farrar.
- Jingalup also consists of low hills and rises with mainly grey deep sandy duplex soils formed in weathered granite. In Jingalup, these laterite plateau remnants capping the rises and low hills are more extensive than in the Dellyanine. Relief in Jingalup is lower than in Dellyanine, and the hill crests are generally closer together forming distinct shallow valleys.
- The Carrolup and Whinbin Systems are also similar although these have lower relief and less rock outcrop than Dellyanine.

Dellyanine System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
De1 Dellyanine 1 Subsystem (22,860 ha)	Hillcrests and upper slopes 0-5% gradient 15-50 m relief	Deep sandy gravel	Gibbs	25
		Shallow gravel	Worsley 1	20
		Duplex sandy gravel	Lennard 1	15
		Duplex sandy gravel	Wahkinup 1	5
		Gravelly pale deep sand	Kauring	5
			Other gravel soils: Gorn; Gorn 1; Yalanbee; Cumming; Worsley	20
			Main others: Moojebin; Moojebin 2; Ravenscliffe	10
De1s Dellyanine 1 Subsystem sandy phase (608 ha)	Mid and upper slopes 1-4% gradient 20-35 m relief	Gravelly pale deep sand	Kauring	30
		Pale shallow sand	Kauring 1	30
		Pale deep sand	Kauring 2	30
			Main others: Ravenscliffe; Wahkinup	10
De2 Dellyanine 2 Subsystem (70,415 ha)	Lower to upper slopes, hillcrests and breakaways 1-10% gradient 10-80 m relief	Grey deep sandy duplex	Warup	20
		Grey deep sandy duplex	Moojebin	15
		Duplex sandy gravel	Lennard 4	10
		Grey deep sandy duplex	Eulanda	5
		Grey deep sandy duplex	Indinup	5
		Grey shallow sandy duplex	Warup 3	5
		Grey shallow sandy duplex	Indinup 1	5
		Brown deep sand	Boyaminning	5
		Red shallow loamy duplex	Muradup	5
		Red deep sandy duplex	Lowdon 1	5
			Other deep duplex soils: Tarwonga 2; Moojebin 3; Moojebin 4; Warup 2	5
			Main others: Kauring; Winspear; Cumming; Gibbs 1; Eastwood 2; Tarwonga 3; Brynie 2; Balkuling	15
De3 Dellyanine 3 Subsystem (66,963 ha)	Mid to upper slopes and crests 1-15% gradient 20-70 m relief	Grey deep sandy duplex	Warup	15
		Brown deep sand	Boyaminning	15
		Bare rock	Granite; dolerite; gabbro	10
		Grey deep sandy duplex	Tarwonga 1	10
		Grey deep sandy duplex	Moojebin	10
		Grey shallow sandy duplex	Tarwonga 3	10
		Grey deep sandy duplex	Indinup	5
		Red deep loamy duplex	Hensman	5
		Red deep sandy duplex	Lowdon	5
			Other red soil: Four Acre; Ferndale 1; Filmer 1; Winspear	5
			Main others: Balkuling; Lifflie 1; Warup 3; Eastwood 1; Indinup 1; Moojebin 3; Eulanda; Moodiarup; Cundinup 1; Beelerup 2	10

Dellyanine System

Subsystem	Landform description	WA Soil Group	Soil Series	% of unit
De4 Dellyanine 4 Subsystem (29,214 ha)	Footslopes, drainage lines, rarely lower and mid slopes 1-5% gradient 10-60 m relief	Grey deep sandy duplex	Moojebin	20
		Grey deep sandy duplex	Warup	15
		Grey deep sandy duplex	Indinup	10
		Grey deep sandy duplex	Eulanda	10
		Grey deep sandy duplex	Tarwonga	10
		Duplex sandy gravel	Lennard 1	10
		Saline wet soil	Brynie	5
		Alkaline grey shallow sandy duplex	Fairclough	5
			Main others: Kibbleup 1; Gibbs; Cumming; Boyaminning 2; Ravenscliffe; Eastwood 2; Malebelling; Warup 2; Brynie 2	15
De5 Dellyanine 5 Subsystem (4,748 ha)	Valley flats (100 300 m wide) 0-1% gradient	Saline wet soil	Brynie	25
		Saline wet soil	Brynie 3	20
		Grey shallow sandy duplex	Indinup 1	15
		Grey deep sandy duplex	Indinup	10
		Grey deep sandy duplex	Eulanda	10
			Main others: Warup 3; Lennard; Cumming	20
De6 Dellyanine 6 Subsystem (13,921 ha)	Valley flats and plains (300-1500 m), dunes and stream channels 0-2% gradient	Brown deep sand	Yowangup	15
		Grey deep sandy duplex	Moojebin	15
		Alkaline grey shallow sandy duplex	Fairclough	15
		Grey deep sandy duplex	Indinup	10
		Grey deep sandy duplex	Tarwonga	10
		Grey deep sandy duplex	Warup	10
		Grey deep sandy duplex	Eulanda	5
		Saline wet soil	Brynie	5
		Alkaline grey deep sandy duplex	Ballard 2	5
			Main others: Peterson; Kibbleup; Warup 3	10
De7 Dellyanine 7 Subsystem (2,119 ha)	Dunes and some footslopes 0-3% gradient 1-10 m relief	Brown deep sand	Yowangup	45
		Brown deep sand	Yowangup 1	20
		Brown deep sand	Yowangup 2	20
		Grey deep sandy duplex	Eulanda	10
			Main other: Brynie	5
De8 Dellyanine 8 Subsystem (5,250 ha)	Mid to upper slopes, hill crests and breakaways 4-6% gradient 30-70 m relief	Grey deep sandy duplex	Eulanda	40
		Bare rock	Granite; dolerite; ferricrete	20
		Duplex sandy gravel	Lennard 1	15
		Shallow gravel	Worsley	5
			Main others: Boyaminning; Hensman; Lowdon; Indinup; Warup; Moojebin; Balkuling	20

Dongolocking System Do

67,121 ha 4.6% of survey area

Gently undulating and undulating rises and occasional undulating low hills with some narrow alluvial plains. The system is named after the locality of Dongolocking and the Dongolocking Nature Reserve.

The main soils are grey deep sandy duplex es with sodic grey and yellow mottled subsoils. Others are shallow and deep sandy gravels, often yellow-brown in colour. Grey shallow sandy duplex soils, with hardsetting surfaces and often with alkaline subsoils, commonly occur on the slopes. The system includes small areas of aeolian soils on rises derived from lakes to the north of the survey area, including Lake Toolibin.

Soils in the Dongolocking 5 Subsystem were only identified to soil group level rather than soil series and are studied in greater detail in the Corrigin land resource survey (in prep).

Geology: Mainly colluvium with minor deposits of alluvium (*Qc*) and some areas of gneiss, granite, adamellite (*Ang, Apg, Age*) and dolerite and gabbro dykes (*d*). Small areas of laterite (*Czl*) and reworked sandplain (*Czs*) usually correspond to the Dongolocking 1 Subsystem (Chin and Brakel 1986).

Native vegetation: Dumbleyung Vegetation System (Beard 1980)

- **Dominant trees:** wandoo (*Eucalyptus wandoo*) and rock sheoak (*Allocasuarina huegeliana*) woodland or mixed communities of mallee *Eucalyptus* spp. and trees
- **Other trees:** York gum (*E. loxophleba*), red morrel (*E. longicornis*), salmon gum (*E. salmonophloia*) and jam (*Acacia acuminata*); less commonly Christmas tree (*Nuytsia floribunda*) and slender banksia (*Banksia attenuata*)
- **Shrubs:** various *Dryandra* spp., a range of heath species, teatree (*Leptospermum erubescens*), blackboys (*Xanthorrhoea* sp.) and poison (*Gastrolobium* spp.).

Present land use and land management

- Rotations of cereals (wheat, barley, oats), canola, lupins and other pulse crops such as faba beans and chickpeas and annual pasture, structure of rotations is highly variable
- Nature conservation in reserves such as the Dongolocking Nature Reserve
- Salinity and waterlogging limit production, particularly on lower slopes and valley flats
- Water and wind erosion risk.

Similar systems

- The Kukerin and East Katanning Systems have similar soils and landforms to Dongolocking but more extensive areas of gravel uplands with pockets of pale deep sands. The gravels occur mainly on the crests and upper slopes on the East Katanning System, but are dominant in the Kukerin System, often extending to the lower slopes. These systems do not include aeolian deposits on rises to the south-east of lakes.
- The Datatine System contains less gravel than the Dongolocking System and a higher proportion of soils formed on weathered gneiss, granite, dolerite and gabbro. These include red loamy calcareous earths and alkaline red duplexes. Datatine System includes broad valley flats with dominantly red loamy soils.

Dongolocking System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Do1 Dongolocking 1 Subsystem (17,879 ha)	Mid and upper slopes, hill crests and breakaways 0-5% gradient 10-40 m relief	Deep sandy gravel	Gibbs	20
		Shallow gravel	Worsley	20
		Loamy gravel	Cumming	10
		Gravelly pale deep sand	Kauring	15
		Grey deep sandy duplex	Moojebin	10
		Deep sandy gravel	Gorn	5
		Deep sandy gravel	Yalanbee	5
			Other gravel soil: Gorn 1; Gorn 2; De Campo 2; Worsley 1, Wahkinup 1	10
			Main other: Jarrahwood	5
Do1s Dongolocking 1 Subsystem sandy phase (622 ha)	Mid and upper slopes 1-5% gradient 30-40 m relief	Gravelly pale deep sand	Kauring	40
		Pale shallow sand	Kauring 1	40
		Pale deep sand	Ravenscliffe	10
		Yellow deep sand	Jarrahwood	10
Do2 Dongolocking 2)Subsystem (35,189 ha	Lower to upper slopes, hill crests and breakaways 0-5% gradient 10-45 m relief	Grey deep sandy duplex	Eulanda	10
		Grey deep sandy duplex	Indinup	10
		Grey deep sandy duplex	Warup	10
		Grey shallow sandy duplex	Warup 3	10
		Alkaline grey shallow sandy duplex	Fairclough 2	10
		Alkaline grey shallow sandy duplex	Wishbone	5
		Alkaline grey deep sandy duplex	Ballard 2	5
		Alkaline grey shallow loamy duplex	Peterson	5
		Alkaline red shallow loamy duplex	Winspear	5
		Red deep sandy duplex	Lowdon 2	5
		Calcareous loamy earth	Filmer	5
			Main others: Moojebin; Lifflie; Lennard 1; Lennard 3; Cumming; Boyaminning; Eastwood	20
Do3 Dongolocking 3 Subsystem (10,501 ha)	Mid and upper slopes and hill crests 0-4% gradient 15-40 m relief	Grey deep sandy duplex	Moojebin	30
		Self-mulching cracking clay	Filmer 1	15
		Red shallow loamy duplex	Muradup 1	10
		Bare rock	Granite; dolerite	10
		Alkaline red shallow loamy duplex	Winspear	5
		Brown deep sand	Boyaminning	5
			Other red soils: Ferndale 1; Hensman 1; Lowdon 1; Filmer; Filmer 2	10
			Main others: Eulanda; Warup; Moodiarup; Eastwood 2	15
Do4 Dongolocking 4 Subsystem (2,506 ha)	Valley flats and narrow plains (200-1000 m wide) 0-1% gradient	Saline wet soil	Brynie	30
		Alkaline grey deep sandy duplex	Ballard 2	20
		Grey deep sandy duplex	Warup 2	20
		Calcareous loamy earth	Filmer	5
		Undifferentiated		25
Do5 Dongolocking 5 Subsystem (424 ha)	Lower to upper slopes, hill crests 0-5% gradient 10-30 m relief	Shallow gravel		20
		Deep sandy gravel		20
		Deep pale sand		15
		Deep yellow sand		15
		Grey deep sandy duplex		10
		Yellow sandy earth		5
		Undifferentiated		15

Eulin Uplands System Eu

82,559 ha 5.7% of survey area

Lateritic plateau remnants form gently undulating to undulating rises with extensive poorly drained flats formed on Eocene sediments. The system was first described in the Wellington-Blackwood survey (Tille 1996) and is named after the Eulin railway siding located between Kulikup and Qualeup on the abandoned railway from Donnybrook to Katanning. Comprehensive descriptions of each subsystem are presented in Tille (1996).

The main soils are duplex sandy gravels and loamy gravels with significant areas of grey deep sandy duplexes.

Geology: Extensive areas of lateritic Eocene sedimentary deposits (*Tg*) with laterite (*Czl*) and lateritic colluvium (*Qrc*) on plateau remnants. Small areas of sand over laterite (*Czs*), colluvial and alluvial sand (*Qrcs, Qas*), alluvium (*Qra*) and swamp deposits (*Qrw*). Granite and adamellite (*Age, Agv, Agg*), migmatite (*Am*) and gneiss (*Ans*) often obscured by colluvial deposits. Dolerite and quartz dykes also occur (Wilde and Walker 1982).

Native vegetation: Bridgetown Vegetation System (Smith 1974)

- **Dominant trees:** jarrah (*Eucalyptus marginata*) and marri (*E. calophylla*) forest or woodland, often associated with wandoo (*E. wandoo*)
- **Other trees:** bull banksia (*Banksia grandis*), Christmas tree (*Nuytsia floribunda*), flooded gum (*E. rudis*), *E. decipiens*, snotty gobble (*Persoonia longifolia*) and paperbark (*Melaleuca preissiana*)
- **Shrubs:** blackboys (*Xanthorrhoea* sp.), *Hakea* spp., teatree (*Leptospermum erubescens*) and *Dryandra* spp. including parrot bush (*D. sessilis*).

Present land use and land management

- Sheep and some cattle grazing of improved annual pastures
- Cropping in long rotations with annual pasture, mainly cereals, particularly oats, and canola with some lupins
- Tasmanian blue gum (*E. globulus*) plantations and alley plantings for fibre production
- Some areas of forestry and nature reserves
- Waterlogging limits production on the poorly drained Qualeup and Kulikup Subsystems
- Salinity further limits production on valley floors and hillside seeps
- Wind erosion risk is high on the deep sand.

Similar systems

- The Eulin Uplands System merges into the Darling Plateau System in the Western Darling Range Zone. The Wellington-Blackwood catchment divide has been used as a convenient boundary separating the two. The Darling Plateau consists mainly of a continuous plateau surface, while the Eulin Upland System contains many isolated plateau remnants. The soils are similar, although Eulin Uplands contains extensive areas of poorly drained upland flats developed on Eocene sediments.
- Soils in the Qualeup and Kulikup Subsystems within the Eulin Uplands System are similar to Boscabel. Eulin Uplands consists of plateau remnants rather than rises separated by valley flats, as occur in Boscabel.

Eulin Uplands System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
DM	Ridges and	Duplex sandy gravel	Lennard	20
Dalmore	hill crests	Loamy gravel	Cumming	10
Subsystem	5-15% gradient	Yellow/brown deep sandy duplex	Malebelling 1	10
(8,386 ha)	2-40 m relief	Duplex sandy gravel	Wahkinup	5
		Loamy gravel	Cunningham	5
		Loamy gravel	Cundinup	5
		Brown deep loamy duplex	Mulukine 1	5
		Deep sandy gravel	Yalanbee	5
		Shallow gravel	Worsley 1	5
			Main others: Beelerup; Beelerup 1; Cundinup 1; Jarrahwood; Goldfields; Katterup; Brockman; Brookhampton	30
DMi	Ridges and	Duplex sandy gravel	Lennard	20
Dalmore	crests	Duplex sandy gravel	Wahkinup	10
Subsystem	5-15% gradient	Yellow/brown deep sandy duplex	Malebelling 1	10
gravelly	5-40 m relief	Loamy gravel	Cumming	10
phase		Loamy gravel	Cunningham	5
(15,817 ha)		Loamy gravel	Cundinup	5
		Deep sandy gravel	Yalanbee	5
		Shallow gravel	Worsley 1	5
		Brown deep loamy duplex	Mulukine 1	5
			Main others: Brockman; Balkuling; Jarrahwood; Goldfields; Gibbs; Beelerup; Beelerup 1; Cundinup 1; Katterup	25
DMs	Ridges and	Duplex sandy gravel	Wahkinup	20
Dalmore	hill crests	Duplex sandy gravel	Lennard	15
Subsystem	5-15% gradient	Grey deep sandy duplex	Moojebin 1	10
sandy phase	5-40 m relief	Deep sandy gravel	Yalanbee	5
(1,055 ha)		Grey deep sandy duplex	Malebelling	5
		Yellow sandy earth	Goldfields	5
		Yellow deep sand	Katterup	5
		Yellow deep sand	Jarrahwood	5
		Gravelly pale deep sand	Kauring	5
		Loamy gravel	Cumming	5
			Other pale deep sand: Leecherup; Ravenscliffe	10
			Main others: Gibbs; Cundinup; Worsley; Worsley 1; Malebelling 1	10
KUi	Plain formed over	Duplex sandy gravel	Lennard	40
Kulikup	Eocene sediments	Duplex sandy gravel	Wahkinup	10
Subsystem	0-5% gradient	Loamy gravel	Cundinup	10
ironstone	2-15 m relief	Semi-wet soil	McAlinden	5
gravel flats		Semi-wet soil	Yourdamung 1	5
phase		Loamy gravel	Cumming	5
(18,368 ha)			Main others: Brynie 1; Eulanda 1; Witchcliffe; Cunningham	25

Eulin Uplands System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
KUw Kulikup Subsystem wet flats phase (3,530 ha)	Poorly drained plain 0-2% gradient 2-5 m relief	Duplex sandy gravel Wet soil Wet soil Wet soil Semi-wet soil Loamy gravel Duplex sandy gravel Saline wet soil	Lennard Jasper Noggerup Pindalup 1 Yourdamung 1 Cundinup Wahkinup Brynie 1 Main others: Witchcliffe; Tutunup	15 15 10 10 5 5 5 5 30
LK Lukin Subsystem (6,438 ha)	Shallow minor valleys 3-20% gradient 5-40 m relief	Duplex sandy gravel Duplex sandy gravel Grey deep sandy duplex Loamy gravel Loamy gravel Loamy gravel Saline wet soil	Lennard Wahkinup Malebelling Cumming Cunningham Cundinup Deadman Main others: Pindalup 1; Indinup; Brynie 1; McAlinden 1; Goldfields; Yourdamung 1; Beelerup; Beelerup 1; Cundinup 1; Malebelling 1	20 10 10 10 5 5 5 35
LKd Lukin Subsystem downstream valleys phase (1,246 ha)	Shallow minor valleys 5-20% gradient 20-40 m relief	Loamy gravel Loamy gravel Duplex sandy gravel Friable red-brown loamy earth Loamy gravel Grey deep sandy duplex Brown loamy earth Brown loamy earth Brown deep loamy duplex Brown deep loamy duplex	Cumming Cundinup Lennard Ferguson 1 Cunningham Malebelling Brooklands Brookhampton Beelerup Mulukine 1 Main others: Deadman; Wahkinup; Ferndale; Balkuling; Beelerup 1; Cundinup 1; Malebelling 1; Goldfields; outcrop	15 10 10 10 5 5 5 5 5 5 25
LKk Lukin Subsystem valleys Kulikup phase (4,783 ha)	Shallow minor valleys formed on Eocene sediments 3-10% gradients 5-20 m relief	Duplex sandy gravel Loamy gravel Duplex sandy gravel Duplex sandy gravel Grey deep sandy duplex Loamy gravel Loamy gravel Saline wet soil Wet soil	Lennard Cumming Wahkinup Lennard 1 Indinup Cunningham Cundinup Deadman Jasper; Noggerup; Pindalup 1 Main others: Goldfields; Brynie 1; Eulanda 1; Tutunup; Deadman 1; Beelerup; Beelerup 1; Cundinup 1; Malebelling 1	20 10 10 5 5 5 5 5 5 30

Eulin Uplands System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
LKu Lukin Subsystem upstream valleys phase (3,321 ha)	Shallow minor valleys 3-10% gradient 5-20 m relief	Duplex sandy gravel Duplex sandy gravel Loamy gravel Loamy gravel Loamy gravel Grey deep sandy duplex Saline wet soil Wet soil Gravelly pale deep sand	Lennard Wahkinup Cumming Cundinup Cunningham Indinup Deadman Pindalup 1 Kauring Main others: McAlinden 1; Yourdamung 1; Witchcliffe; Beelerup; Beelerup 1; Cundinup 1; Malebelling 1; Goldfields	20 10 10 10 5 5 5 5 5 25
QU Qualp Subsystem (4,494 ha)	Plain formed on Eocene sediments 0-5% gradient 2-15 m relief	Duplex sandy gravel Duplex sandy gravel Duplex sandy gravel Wet soil Wet soil Saline wet soil Grey deep sandy duplex	Lennard Wahkinup Lennard 1 Jasper Pindalup 1 Brynie 1 Eulanda 1 Main others: Indinup; McAlinden 1; Yourdamung 1; Witchcliffe	20 20 15 10 5 5 5 20
QUs Qualeup Subsystem sandy flats phase (564 ha)	Plain formed over Eocene sediments 0-5% gradient 2-15 m relief	Gravelly pale deep sand Pale deep sand Semi-wet soil Pale deep sand Wet soil Yellow deep sand	Kauring Leecherup Shotts Ravenscliffe Jasper Jarrahwood Main others: Wahkinup; Lennard , Indinup; Eulanda 1	20 15 15 10 10 10 20
QUv Qualeup Subsystem valleys phase (400 ha)	Valley flats	Wet soil Wet soil Saline wet soil Saline wet soil Brown deep sand Gravelly pale deep sand	Jasper Pindalup 1 Deadman Brynie 1 Dudinyillup Kauring Main others: Noggerup; Shotts; Leecherup; Ravenscliffe; Tutunup	20 20 15 15 10 5 15
QUw Qualeup Subsystem wet flats phase (7,461 ha)	Poorly drained plain with swamps and small lakes 0-2% gradient 2-5 m relief	Duplex sandy gravel Wet soil Wet soil Saline wet soil Saline wet soil Duplex sandy gravel Grey deep sandy duplex soil	Lennard Jasper Pindalup 1 Deadman Brynie 1 Wahkinup Eulanda 1 Main others: McAlinden 1; Yourdamung 1; Tutunup	15 15 15 10 10 5 5 25

Kukerin System Kk

28,855 ha 2.0% of survey area

Gently undulating to undulating rises and occasional undulating low hills. The system is named after the town of Kukerin which is just east of the survey area.

The main soils on the rises are shallow gravels, yellowish brown loamy and deep sandy gravels with minor areas of duplex sandy gravels. Where the gravels have been eroded, the soils are grey shallow or less often deep sandy duplex soils. The grey deep sandy duplex soils usually have a layer of ferruginous gravel above yellow or grey clay subsoil. Alkaline grey shallow sandy duplexes, with grey or brown sodic subsoils, are also common.

Geology: Laterite (*Czl*), colluvium and minor alluvium (*Qc*) with small areas of gneiss and granodiorite (*Ans, Anb*). The regional geology mapped by Chin and Brakel (1986) indicates large areas of reworked sandplain (*Czs*) in this system. However, within the Katanning survey area this was found to correspond to areas of hardsetting grey shallow sandy and loamy duplex rather than to the gravel or sand usually found on areas mapped as sandplain (*Czs*).

Native vegetation: Hyden Vegetation System (Beard 1980)

- **Dominant trees:** various mallee *Eucalyptus* species commonly associated with heath species
- **Other trees:** salmon gum (*E. salmonophloia*), York gum (*E. loxophleba*), red morrel (*E. longicornis*), wandoo (*E. wandoo*) and rock sheoak (*Allocasuarina huegeliana*)
- **Shrubs**: heath species, teatree (*Leptospermum erubescens*), and various *Melaleuca* shrubs, poison (*Gastrolobium* spp.) and *Dryandra* spp.

Present land use and land management

- Rotations of cereals (wheat, barley, oats), canola, lupins and other pulse crops such as faba beans and annual pasture; structure of rotations is highly variable
- Hardsetting grey shallow sandy and loamy duplex are difficult to manage
- Wind erosion risk, particularly on the pale deep sand
- Water erosion risk on and below breakaways.

Similar systems

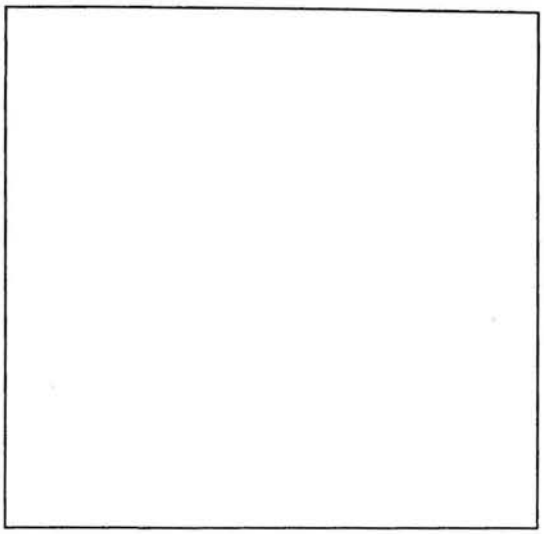
- The East Katanning System is similar to Kukerin having extensive areas of gravel uplands with pockets of pale deep sand common. In East Katanning, the gravels occur mainly on the crests and upper slopes, but are dominant in Kukerin, often extending to the lower slopes.
- The Dongolocking System has a higher proportion of grey sandy duplex soils than Kukerin and much less extensive areas of gravels and pale deep sands. The Dongolocking System also includes aeolian deposits on rises to the south-east of lakes.
- The Datatine System has much less gravel than Kukerin. This system is associated with rises and low hills of gneiss and granite with dolerite and gabbro dykes common. The soils include red loamy calcareous earths and alkaline red duplexes as well as grey deep sandy duplexes.

Kukerin System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Kk1dg Kukerin 1 Subsystem deep gravel phase (10,712 ha)	Mid and upper slopes, summit surfaces, hill crests and breakaways 1-4% gradient 12-40 m relief	Deep sandy gravel Shallow gravel Loamy gravel Shallow gravel Duplex sandy gravel Deep sandy gravel	Gibbs 2 Worsley 1 Cumming 1 Worsley Lennard 4 Yalanbee Main others: Kauring,; Jarrahwood; Moojebin 3; ferricrete	25 25 15 10 5 5 15
Kk1s Kukerin 1 Subsystem sandy phase (832 ha)	Lower to upper slopes 3-4% gradient 35-40 m relief	Pale shallow sand Gravelly pale deep sand Pale deep sands Yellow deep sand Undifferentiated	Kauring 1 Kauring Ravenscliffe Jarrahwood	30 30 10 10 20
Kk3dd Kukerin 3 Subsystem deep duplex phase (12,309 ha)	Drainage lines, lower to upper slopes 1-3% gradient 12-30 m relief	Grey deep sandy duplex Alkaline grey shallow sandy duplex Alkaline grey shallow sandy duplex Alkaline grey deep sandy duplex	Moojebin 3 Fairclough Wishbone Ballard 2 Main others: Winspear 1; Gibbs; Moodiarup 1; Brynie; granite outcrop	35 20 20 10 15
Kk3sd Kukerin 3 Subsystem shallow duplex phase (3,992 ha)	Drainage lines, lower to upper slopes and hill crests 0-2% gradient 10-25 m relief	Alkaline grey shallow sandy duplex Grey deep sandy duplex Calcareous loamy earth Saline wet soil	Fairclough Moojebin 3 Warren 2 Brynie	40 30 15 15
Kk4 Kukerin 4 Subsystem (1,010 ha)	Valley flats and narrow plains (200-1000 m wide) 0-1% gradient	Alkaline grey shallow sandy duplex Alkaline grey shallow sandy duplex Alkaline grey shallow loamy duplex Saline wet soil Undifferentiated	Fairclough Fairclough 1 Peterson Brynie 9	30 30 20 10 10

Norring System No

27,546 ha 1.9% of survey area



Broad (usually 1 to 3 km), level to very gently inclined lacustrine plains, alluvial plains and gently undulating sand plains. The lacustrine plains feature lakes, swamps and associated lunettes. The system is named after Lake Norring.

Saline wet soils and salt lake soils predominate. Grey deep sandy duplex soils and soils with hardsetting grey loamy topsoils grading to alkaline, often calcareous clay subsoils are also common. The duplex soils have mottled grey or yellow brown, sodic clay subsoils. Brown deep sands occur on lunettes on the east and south-east of lakes and the sandplain (Norring 4) east of the lake chain has significant areas of pale deep sands.

Geology: Alluvial deposits of sand, silt and clay (*Cza*), lacustrine deposits (*Ql*), aeolian and alluvial deposits of quartz sand (*Qd*) with small areas of reworked sand plain (*Czs*) from Chin and Brakel (1986).

Native vegetation: Wagin Vegetation System in valleys (Beard 1980)

- **Dominant trees:** swamp sheoak (*Casuarina obesa*) near lakes, swamps and stream channels, otherwise wandoo (*Eucalyptus wandoo*) and/or salmon gum (*E. salmonophloia*) woodland
- **Other trees:** York gum (*E. loxophleba*), rock sheoak (*Allocasuarina huegeliana*), jam (*Acacia acuminata*), flat-topped yate (*E. occidentalis*) and Christmas tree (*Nuytsia floribunda*) on deep sand
- **Shrubs**: *Melaleuca* spp. shrubs and paperbark (*Melaleuca* sp.)
- Salt-tolerant vegetation including samphire and introduced grasses such as barley grass (*Hordeum* spp.) dominate the saline soil.

Present land use and land management

- Grazing of salt-tolerant vegetation and improved pastures with limited cropping of oats or barley in long pasture dominated rotations
- Common rotations on lunettes include wheat, barley, oats, canola and lupins
- Nature conservation around the lakes and swamps
- High soil salinity is the main limitation to production
- Frost, waterlogging and flooding further limit production mainly to grazing, except on the more elevated lunettes and sand plain
- Wind erosion is a hazard, particularly on the pale and brown deep sand.

Similar systems

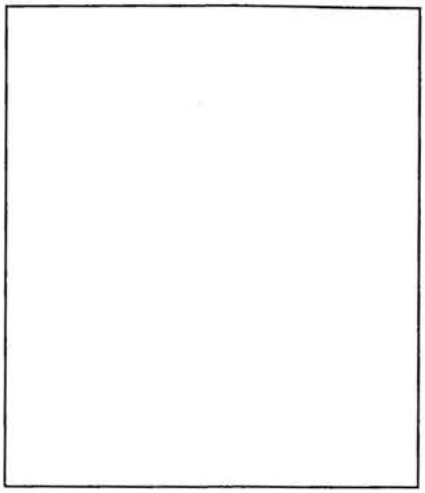
- Generally Norring System is a lacustrine plain with a much higher proportion of salt lake soils than the other alluvial plain systems: Arthur River, Beaufort and Coblinine
- The Coblinine and Arthur River Subsystems with salt lakes and lunettes are most similar to the Norring System. These include the salt lakes in Coblinine 4, Arthur River 4 and Beaufort 4 as well as the lunettes and dunes in Coblinine 5 and sandplain in Coblinine 6.
- Beaufort 1 is similar to Norring 1 Subsystem.

Norring System

Subsystem	Landform description	WA Soil Group	Soil Series	% of unit
No1	Valley flats and	Brown loamy earth	Warren 1	25
Norring 1	plains	Alkaline grey shallow loamy duplex	Peterson	15
Subsystem				
(8,114 ha)	(300–3000 m wide)	Alkaline grey shallow sandy duplex	Fairclough	15
	<1% gradient	Saline wet soil	Brynie 5	15
	1-5 m relief	Grey deep sandy duplex	Moojebin	10
		Alkaline grey deep sandy duplex	Ballard	5
		Alkaline grey shallow sandy duplex	Ballard 1	5
		Grey shallow sandy duplex	Indinup 1	5
		Undifferentiated		5
No2	Valley flats and	Saline wet soil	Brynie 6	30
Norring 2	plains	Saline wet soil	Brynie 2	20
Subsystem	(300-3000 m wide)	Saline wet soil	Brynie 7	20
(3,866 ha)	<1% gradient	Other saline wet soils	Brynie; Brynie 8;	15
	1-2 m relief		Brynie 9	
			Main others:	15
			Eastwood 1; Warren 1	
No3	Lakes, swamps,	Salt lake soil		70
Norring 3	plains, dunes	Saline wet soil	Brynie 4	10
Subsystem	and lunettes	Alkaline grey deep sandy duplex	Ballard 2	10
(7,719 ha)	0-3% gradient		Main others: Yowangup;	10
	0-8 m relief		Eastwood 1; Brynie 2	
No4	Lunettes, dunes	Brown deep sand	Yowangup	30
Norring 4	and swales	Grey deep sandy duplex	Indinup	20
Subsystem	0-3% gradient	Alkaline grey deep sandy duplex	Ballard 2	20
(2,813 ha)	5-8 m relief		Main others: grey deep sandy duplexes, some with alkaline subsoils; Brynie 2; Brynie 4	30
No5	Sandplain and	Gravelly pale deep sand	Kauring	20
Norring 5	valley flats	Grey deep sandy duplex	Indinup	20
Subsystem	0-3% gradient	Grey deep sandy duplex	Warup	20
(4,085 ha)	1-15 m relief	Grey deep sandy duplex	Eulanda	10
		Grey shallow sandy duplex	Warup 3	5
			Main others: Ravenscliffe; Tarwonga; Moojebin 2; Brynie	25
No5s	Sandplain	Gravelly pale deep sand	Kauring	80
Norring 5	0-2% gradient	Grey deep sandy duplex	Eulanda	20
Subsystem	5-15 m relief			
sandy phase				
(949 ha)				

Whinbin System Wb

63,824 ha 4.4% of survey area



Gently undulating and undulating rises and some low hills drained by the Arthur and Buchanan Rivers. The system is named after Whinbin Rock.

The main soils are grey deep sandy duplex soils with mottled yellow, grey or brown clay subsoils. Other soils are yellowish brown moderately deep and deep sandy gravels and small areas of alkaline shallow red loamy duplex associated with shallow dolerite and gabbro bedrock.

Geology: Mainly colluvial deposits with minor alluvium (*Qc*) but does have a significant are of mixed granite rocks (*Agm*) and small areas of granite, adamellite and granodiorite (*Agv, Agp, Age*) with dolerite and gabbro dykes. Laterite (*Czl*) and reworked sandplain (*Czs*) occur on the crests and also beside the alluvial plain of the Arthur River (Chin and Brakel 1986).

Native vegetation: Wagin and Dumbleyung Vegetation Systems (Beard 1980)

- **Dominant trees**: wandoo (*Eucalyptus wandoo*) and rock sheoak (*Allocasuarina huegeliana*)
- **Other trees:** York gum (*E. loxophleba*), often associated with jam (*Acacia acuminata*), salmon gum (*E. salmonophloia*), brown mallet (*E. astringens*) on breakaways and less commonly red morrel (*E. longicornis*) and Christmas tree (*Nuytsia floribunda*)
- **Shrubs:** *Dryandra* spp., poison (*Gastrolobium* spp.), *Callitris* sp., and blackboys (*Xanthorrhoea* sp.)
- Salt-tolerant vegetation including samphire and introduced species such as barley grass (*Hordeum* spp.) are common on saline soil particularly on the Whinbin 5 Subsystem.

Present land use and land management

- Rotations of cereals (wheat, barley, oats), canola and lupins
- Grazing of annual pastures based on subterranean clover
- Salinity and waterlogging limit production, particularly on lower slopes and valley flats
- Water erosion and wind erosion are also hazards in this system.

Similar systems

- The Carrolup System features dominantly grey deep sandy duplex soils formed on weathered granitic rock and truncated laterite profile with a significant proportion of soils formed on colluvial deposits derived from weathered rock and/or laterite soil. The relief is similar with rises dominant. The Carrolup System has small areas of aeolian sand deposits on the slopes and it does not have low granite hills with dolerite dykes which have alkaline loamy red duplex soils.
- The Dellyanine and Farrar Systems have many similar soils but greater relief and rock outcrop.

Whinbin System

Subsystems and phases	Landform description	WA Soil Group	Soil Series	% of unit
Wb1 Whinbin 1 Subsystem (9,297 ha)	Mid and upper slopes and hill crests 0-4% gradient 15-45 m relief	Shallow gravel Deep sandy duplex Duplex sandy gravel Loamy gravel Pale deep sand	Worsley 1 Gibbs Lennard 2 Cumming 1 Kauring 2 Main others: Ferricrete; Worsley; Gorn 2; Gorn; Kauring; Ravenscliffe; Jarrahwood	25 20 20 10 10 15
Wb1s Whinbin 1 Subsystem sandy phase (544 ha)	Mid and upper slopes 2-3% gradient 20-40 m relief	Pale deep sand	Kauring 2 Main others: Kauring; Ravenscliffe	90 10
Wb2 Whinbin 2 Subsystem (33,177 ha)	Lower to upper slopes and crests 0-5% gradient 12-35 m relief Sandy gravels occur on low rises next to the Arthur River	Grey deep sandy duplex Grey deep sandy duplex Grey deep sandy duplex Deep sandy gravel Grey shallow sandy duplex Alkaline grey shallow sandy duplex Alkaline grey deep sandy duplex Loamy gravel	Warup Eulanda Moojebin 1 Gibbs Warup 3 Ballard 1 Ballard Cumming 1 Main other gravels, pale and yellow deep sand: Yalanbee; Lennard 2; De Campo; Kauring 1; Jarrahwood Main others: Muradup 1; Winspear; Lowdon 2; Fairclough; Brynie 1; Brynie 4; Boyaminning; Kibbleup 1	20 10 10 10 5 5 5 5 10 20
Wb3 Whinbin 3 Subsystem (16,081 ha)	Mid and upper slopes and crests 0-5% gradient 12-50 m relief	Grey deep sandy duplex Alkaline red shallow loamy duplex Grey shallow sandy duplex Bare rock Acid shallow duplex Grey deep sandy duplex Grey deep sandy duplex Red deep sandy duplex Red deep loamy duplex	Tarwonga Winspear Warup 3 Dolerite; granite Lifflie Indinup Eulanda Lowdon 2 Hensman Main others: Tarwonga 2; Malebelling; Fairclough 2; Boyaminning 1; Filmer	20 20 10 5 5 5 5 5 5 20
Wb4 Whinbin 4 Subsystem (2,366 ha)	Footslopes, lower slopes and drainage lines 0-3% gradient 12-50 m relief	Grey shallow sandy duplex Grey shallow loamy duplex Undifferentiated	Eastwood 1 Moodiarup 1	30 40 30
Wb5 Whinbin 5 Subsystem (2,359 ha)	Valley flats and narrow plains (300-1500 m wide) <1% gradient	Grey deep sandy duplex Saline wet soil Alkaline grey shallow sandy duplex Grey deep sandy duplex Alkaline grey shallow loamy duplex	Warup Brynie Fairclough Eulanda Peterson 1 Main others: Warren; Beelerup 2; Malebelling	25 15 15 10 10 25

Reference Glossary

Glossary

Adamellite: A form of granite with roughly equal calcium and potassium-bearing minerals.

Alluvium: Material transported and deposited by flowing water such as rivers.

Colluvium: Materials transported and deposited by gravity.

Craton: Major structural unit of the Earth's crust, consisting of a large stable mass of rock.

Crystalline rock: An igneous or metamorphic rock such as granite or gneiss.

Dolerite: A medium grained basic igneous rock that has crystallised near the surface, typically occurring as a dyke, sill or plug.

Diorite: A granular igneous rock consisting essentially of felspar and hornblende.

Duplex soil: A soil with a sudden increase in texture between the topsoil and subsoil, e.g. a sand over a clay.

Dyke: A sheet-like body of igneous rock cutting across the bedding or structural planes of the host rock. They typically appear on the surface as relatively narrow, linear features.

Ferricrete: A layer of material strongly cemented by iron which looks like rock. Formed in laterite and often called sheet laterite, ironstone caprock or duricrust.

Gabbro: A coarse-grained basic igneous rock similar to dolerite.

Gneiss: Banded rocks which are generally coarse-grained and formed through high grade regional metamorphism.

Granite: A coarse-grained igneous rock consisting essentially of quartz (20 to 40%), feldspar and very commonly a mica.

Granulite: A metamorphic rock of regional origin having granular texture; usually consisting of feldspars, pyroxenes and garnets.

Horizons: A term used to describe individual layers in a soil profile. Each horizon has morphological properties different from those above and below it.

Igneous rock: Formed from magma which has cooled and solidified at the earth s surface or within the earth s crust.

Indurated layer: A layer of material hardened by cementation or pressure.

Laterite:. The lateritic profile typically consists of sand or gravel on top of a ferruginous duricrust where the iron oxides have accumulated. This overlies a mottled clay and then a pallid zone (white clay) from which the leaching has occurred.

Loam: A medium-textured soil of approximate composition 10 to 25% clay, 25 to 50% silt and less than 50% sand.

Metamorphic rocks: Rocks such as gneiss which have been altered by heat and/or pressure.

Migmatite: Rock composed of two sources: the metamorphic host rock and an invading granitic material.

Pallid zone: White to pink kaolinitic clay formed in the lower part of the lateritic profile..

pH: A measure of the acidity or alkalinity of the soil which can range from 1 to 14. Most plants grow best when the soil pH is in the range of 5.5 to 8.0.

Plateau: A level to rolling landform pattern of plains, rises or low hills standing above a cliff or escarpment.

Rooting condition: Refers to the soil volume available for plant roots and the mechanical impedance to root development. Soil volume can be reduced by rock and gravel content, by dense pans and clay layers. Plants have varying ability to explore the soil profile. Restrictions to root growth reduce moisture and nutrient availability.

Saprolite: Soft, more or less decomposed rock remaining in its original place.

Schlerophyll: Hard-leaved evergreen trees and shrubs adapted to Mediterranean climates.

Sedimentary deposits: Materials which have been moved from their site of origin by the action of wind, water, gravity or ice and then deposited. When these materials become consolidated and hard they are known as sedimentary rocks.

Silcrete: Strongly indurated siliceous material.

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EON/ERA	PERIOD	YEARS BEFORE NOW	EVENT
ARCHEAEN		2500+ mil	Yilgarn block formed, basic dykes
PROTEROZOIC		580+ mil	Formation of Pinjarra/Albany Fraser orogens Basic dykes, Kojonup Fault Stirling Range/ Barrens metasediments
SILURIAN		410+ mil	Darling Fault uplift . Rift valley between W coast and India which fills with sediments over next 200 m years
PERMIAN		250+ mil	Glaciation (precursor of Mingenew soils) Collie, Wilga, Boyup basins. Coal laid down Drainage pattern from east to west, and inland , from north to south
JURASSIC		131+ mil	Darling Fault uplift India leaves WA leaving the rift sediments (coastal plain) Faulting and a rift valley formed between S coast and Antarctica
CRETACEOUS		66+mil	Rift opens up a seaway between S coast and Antarctica Jarrahwood axis, and Ravensthorpe Ramp (coastal sagging) formed. Jarrahwood uplift causes reversal of Yilgarn drainage to flow north and "burst out" westwards at Mt Caroline and join the Avon.
TERTIARY	PALAEOCENE	54+mil	Slumping of Perth basin south of Gingin Scarp and west of Darling Range
	EOCENE	38+mil	Sea level rise Sediments formed on S coast, SW Subsidence and marine sedimentation in Eucla basin Major laterite formation Uplift of Darling Range alters direction of Moore, Mortlock, Avon, and Arthur and Beaufort rivers.
	OLIGOCENE	27+mil	Antarctica leaves S coast Blackwood plateau formed near then sea level Arid climate, low sea level downcutting of coastal streams, and into rejuvenated zone (?)
	LATE MIOCENE/ PLIOCENE/	10 - 15mil	Uplifts of the Perth basin and Yilgarn block. Erosion to leave Blackwood, Dandaragan, Victoria plateaus Downwarping of coastal plains – coastal limestone Start of cycles of increasing aridity, reduced flow and clay deposition in wheatbelt valleys.
	PLEISTOCENE	2.5mil	Swan, Scott coastal plains formed
		700,000	Saline & calcareous deposits in wheatbelt Bassendean dunes
			Marked climatic changes coastal and inland dunes (sand and saline loams) form in dry periods. Colluvial washing of materials and laterisation in wetter periods to form present landscape.
	HOLOCENE (RECENT)		Gradual drying climatic trend but with wet and dry cycles

HOW WAS OUR LATERITIC LANDSCAPE FORMED?

MOST COMMON THEORY

The laterite profile was formed by fluctuating groundwater levels in moist humid conditions on a level landscape between 1 and 100 million years ago.

Subsequent erosion of the lateritic profile created present sandy and gravelly soils

HOW WAS OUR LATERITIC LANDSCAPE FORMED?

THEORY USED IN THIS MODULE

- Most laterites were, and still are being formed by biological action from some native vegetation and a soil bacteria.

- The plants have adapted to low P levels in soils by excreting citric acid from proteoid roots, which dissolves the P, iron (Fe) and aluminium (Al).

- Citrobacter feeds on the organic acid and precipitates the P,Fe and Al,in layers.

FACTORS REQUIRED FOR LATERITE FORMATION

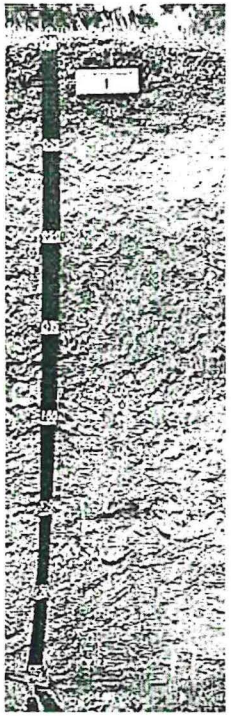
- **Low phosphate (P) soils**
- **Leaching (acid) soil conditions**
- **A source of iron in the soil**
- **Plants with proteoid roots**

These roots release citric acid which dissolves soil iron, aluminium and phosphate

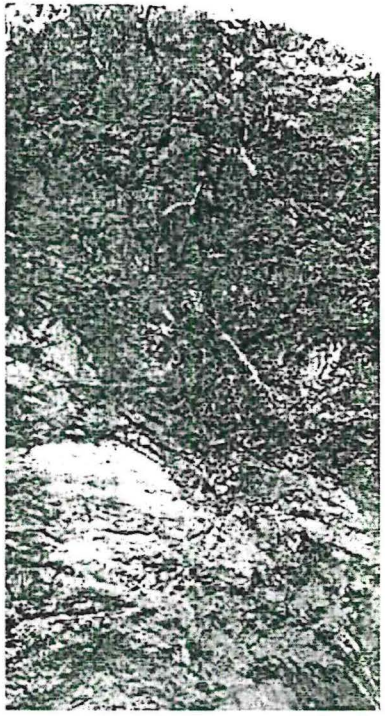
- **Soil bacteria which precipitate the dissolved minerals**
- **Enough rainfall to move the dissolved minerals down the soil**

Laterites form on a range of materials

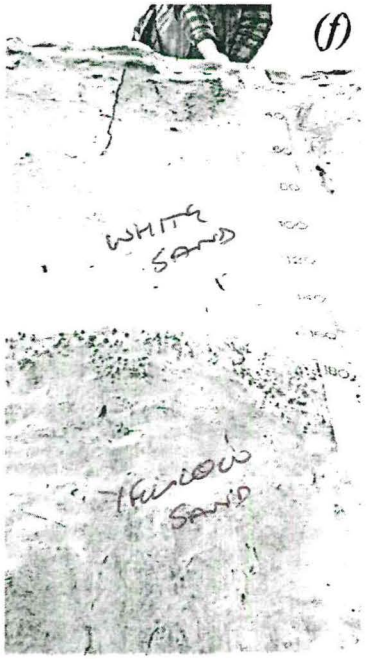
Granite



dolerite



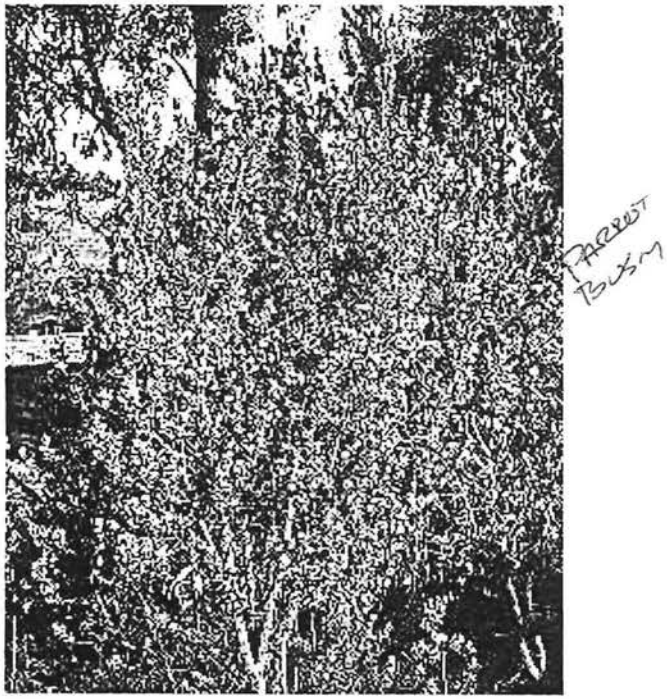
colluvial or aeolian deposits



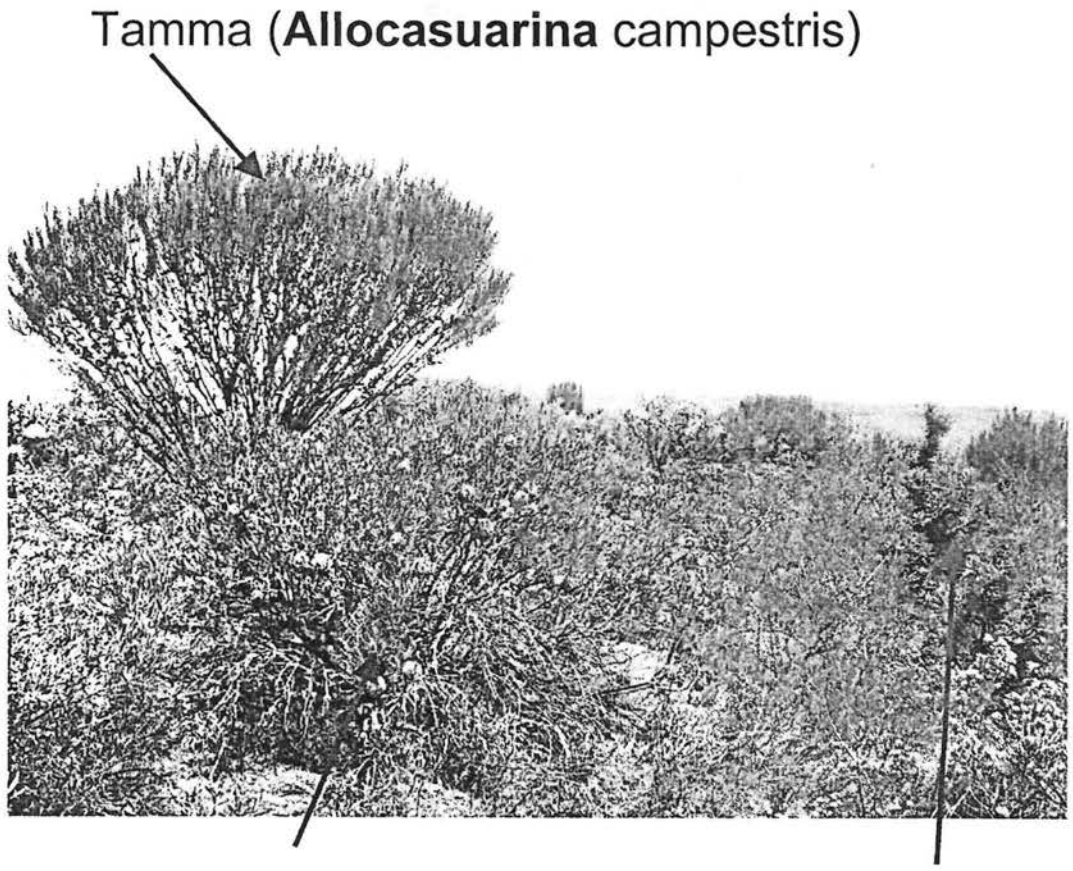
FACTORS REQUIRED FOR LATERITE FORMATION

- **Plants with proteoid roots (mainly Proteaceae)**

These roots release citric acid which dissolves soil iron, aluminium and phosphate



Dryandra sessilis

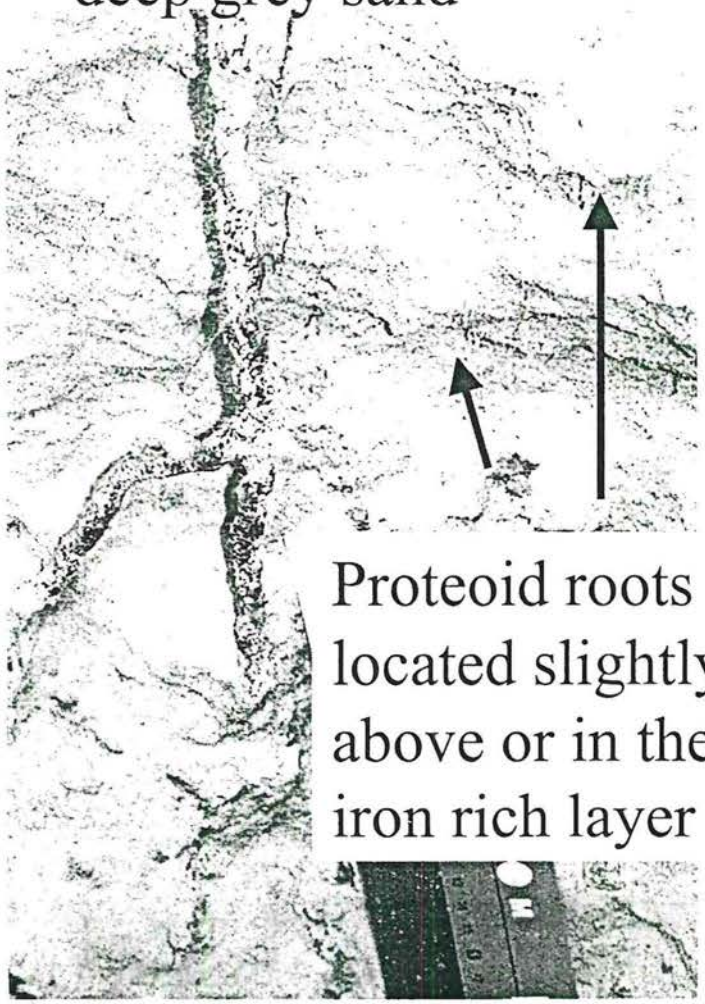


Banksia sphaerocarpa

A **Dryandra**

Proteoid roots secrete citric acid which dissolves silica, iron, aluminium and phosphate so the plant can can access "fixed" P

Banksia prionotes
deep grey sand



Proteoid roots located slightly above or in the iron rich layer

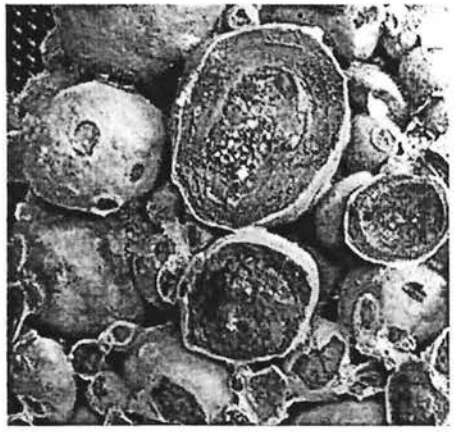
Dryandra
yellow sand over gravel

FACTORS REQUIRED FOR LATERITE FORMATION

- **Enough rainfall to move the dissolved minerals down the soil**
- **Soil bacteria which precipitate the dissolved minerals**

Citric acid is carried down the soil profile, dissolving Fe, Al as it goes

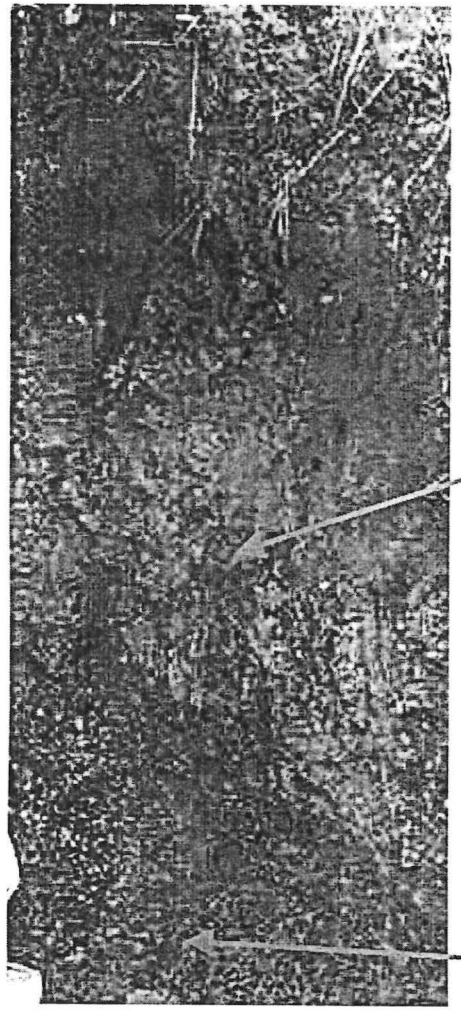
The bacteria precipitates Fe - near the proteoid roots to form gravels

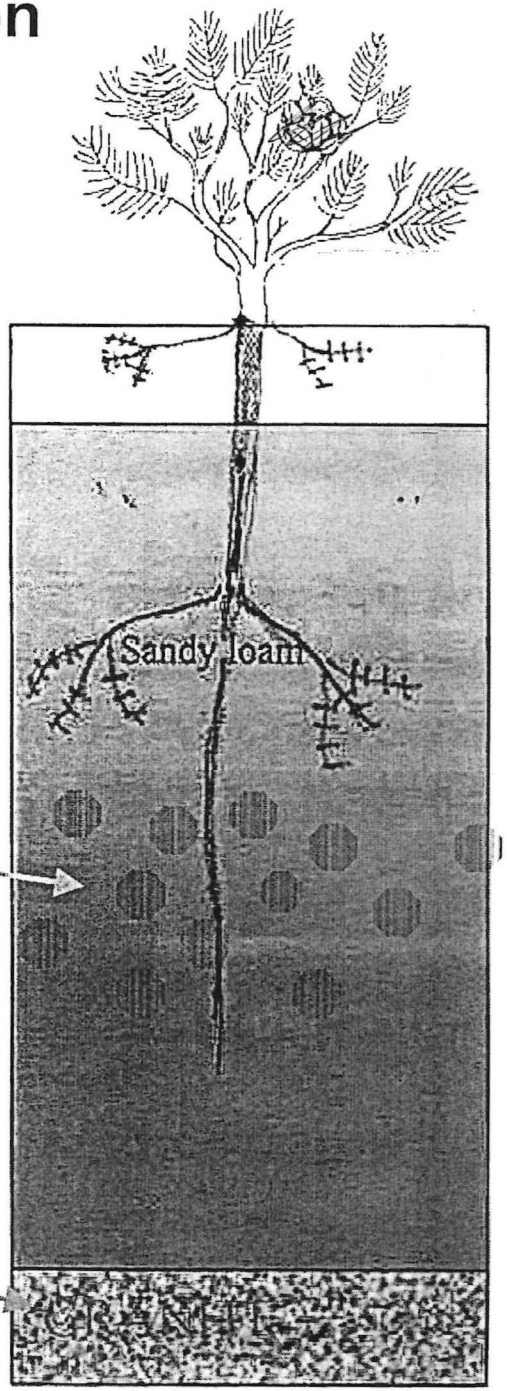


Over time the topsoil and gravel zone becomes sandier as minerals are leached out, and the gravel stones become smooth and hard from continued bacterial precipitation.

•-and in root channels below the gravel area

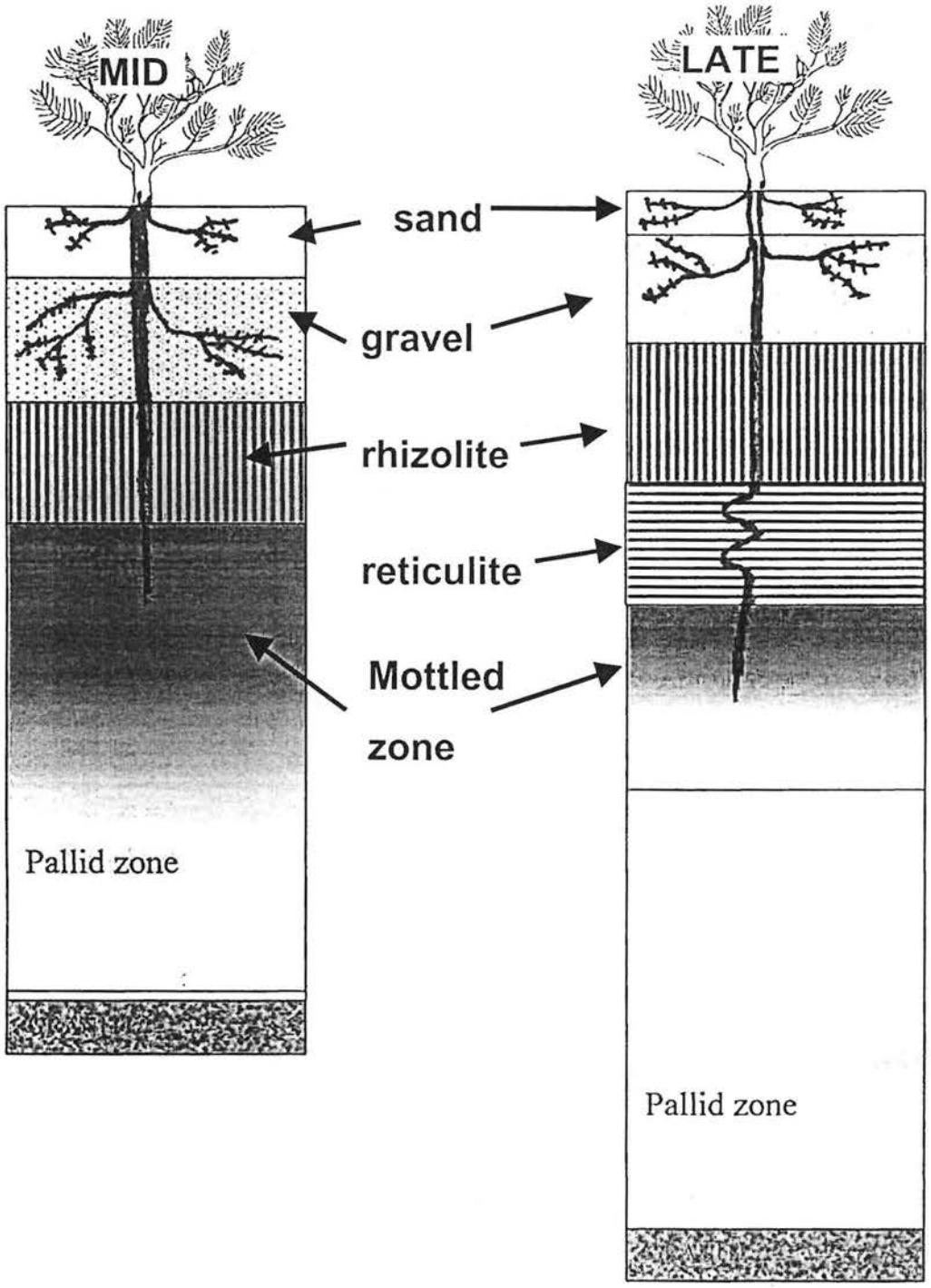
Early stage of laterite formation (on granite)





Soft mottles forming

Weathered granite



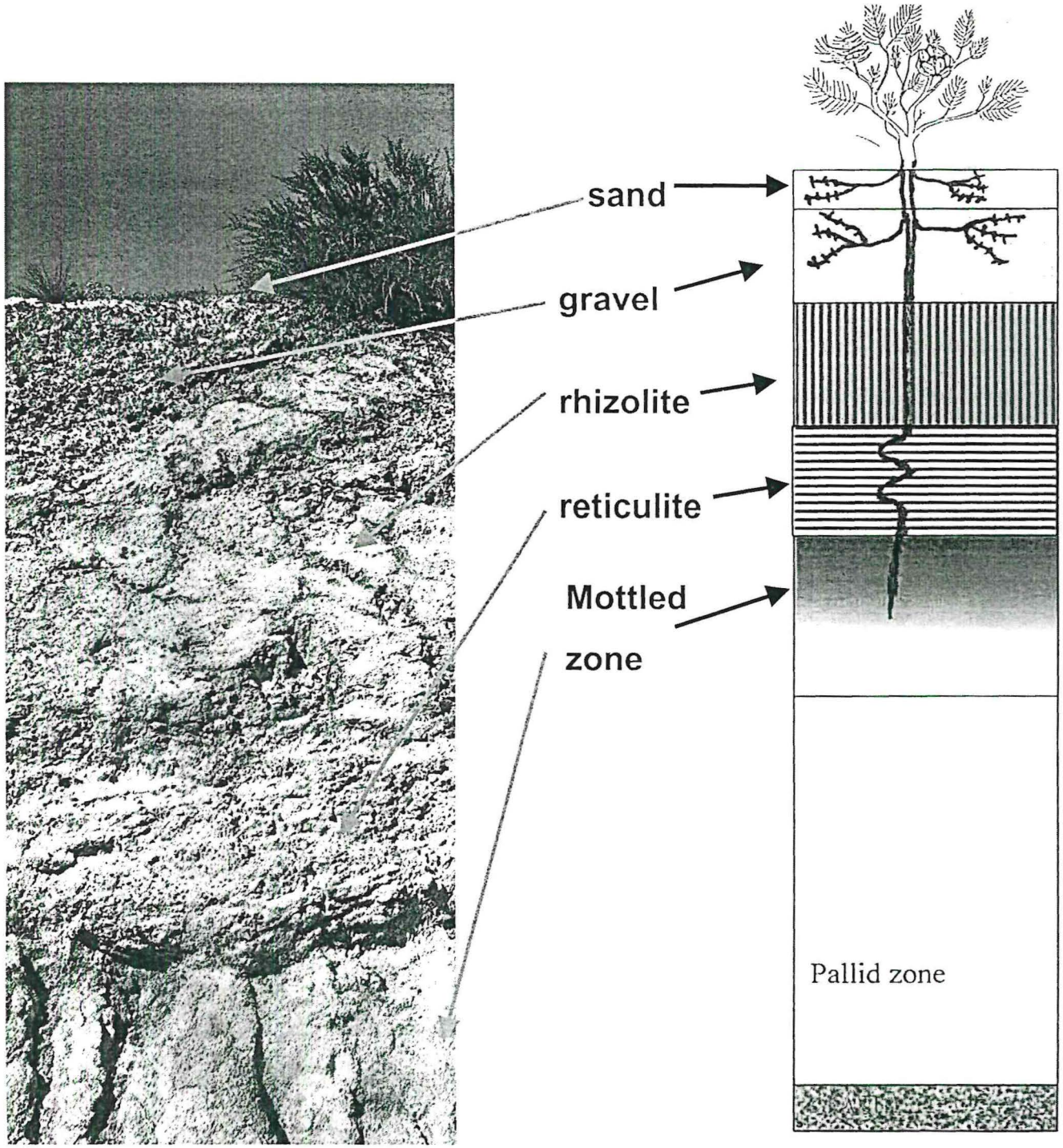
The A horizon gets sandier and paler with finer sand

Gravels get hard and smoother, in a sandier matrix

Rhizolite formed by clay loss and iron precipitation on root channel surfaces - vertical pattern

Reticulite formed by silica loss from rhizolite until the profile collapses with horizontal pattern

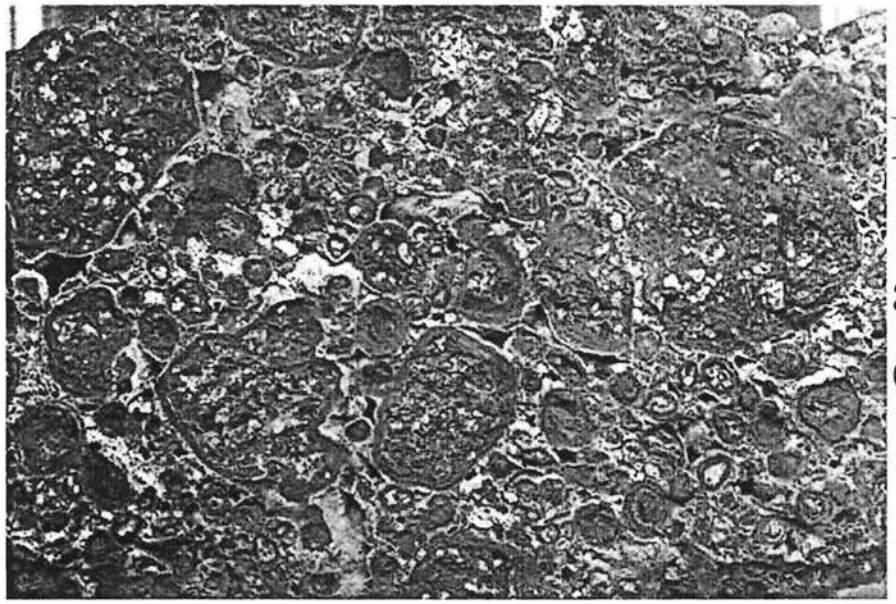
Mottled zone formed by iron, aluminium and silica leaching into pallid clays


sand
gravel
rhizolite
reticulite
Mottled
zone
Pallid zone

RULES OF THUMB

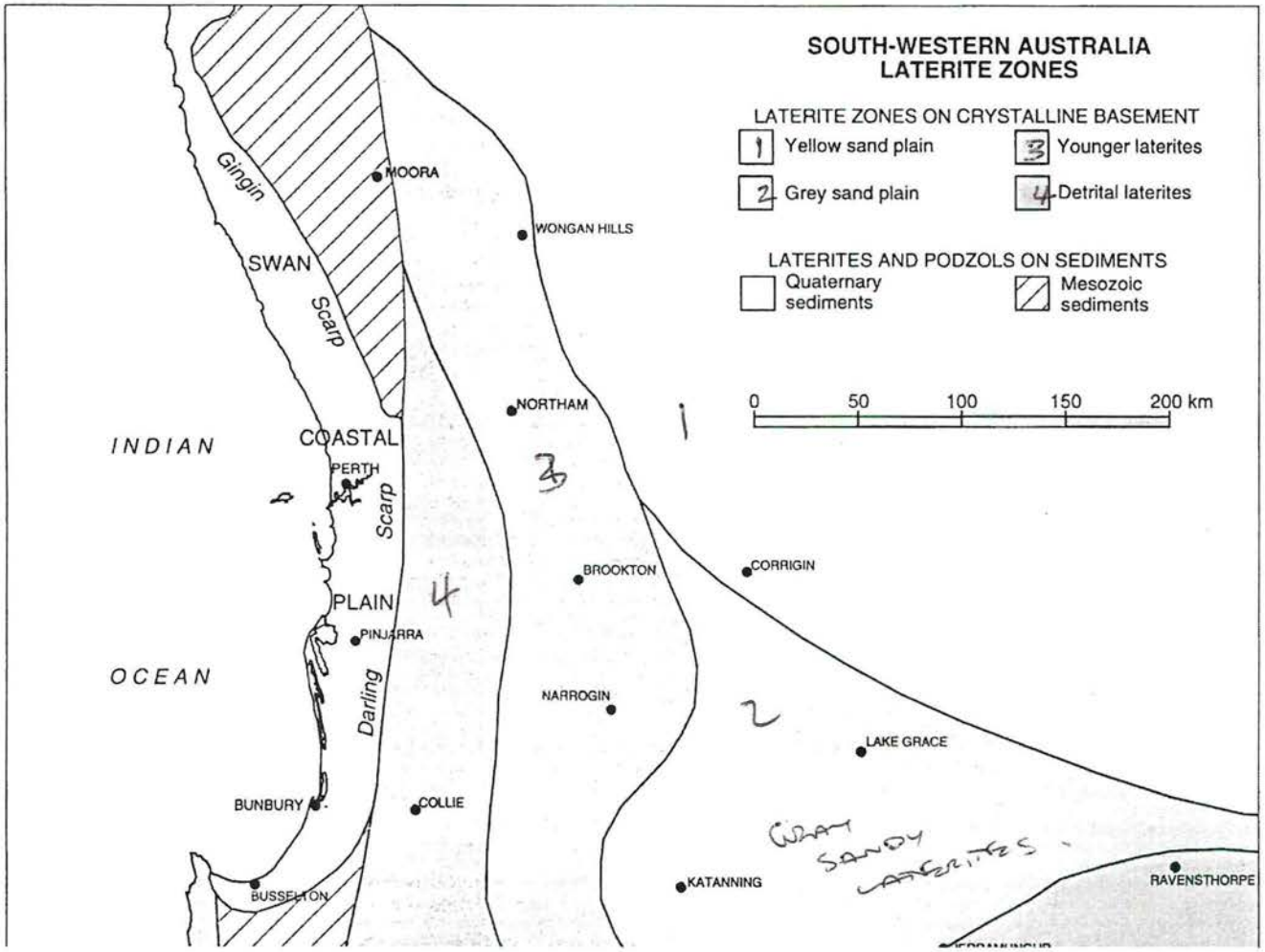
Laterite profiles form faster and are more indurated (harder) in

- **More iron rich soils**
- **Wetter and longer growing seasons**

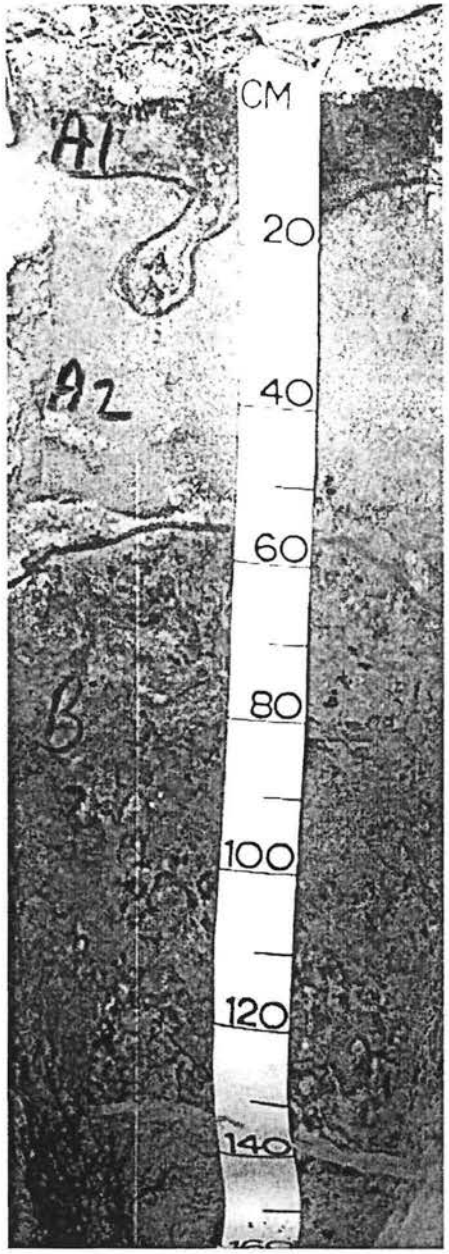


Laterites formed off granites or sandy/ gravelly colluvium are sandier and develop pallid zones faster.

MOST YEAST LATERITES ARE SOURCED DUE TO LACK OF RAIN.

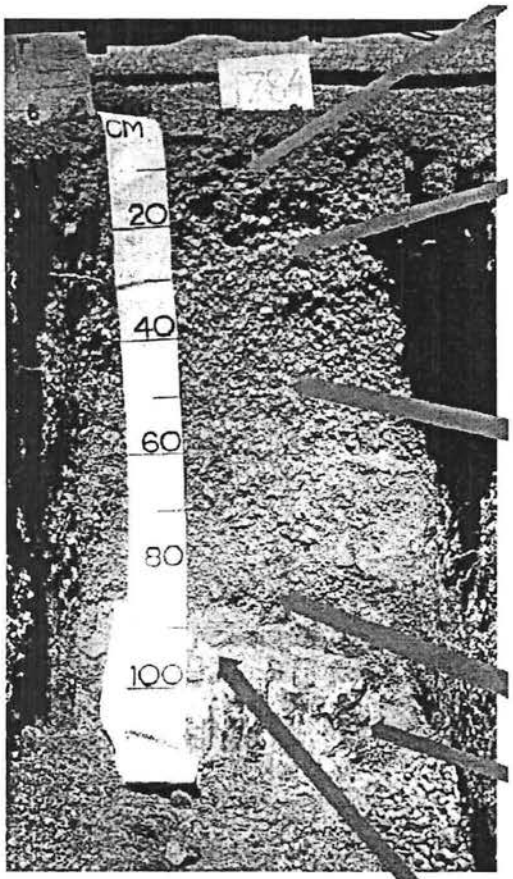


Laterite evolution on sandy (colluvial) soils



older soil or in area favouring more rapid development

Ferrallite (from basic rocks):A laterite without pallid zone



Pisoliths

Aggregates developing to pisoliths

Reddish brown clod

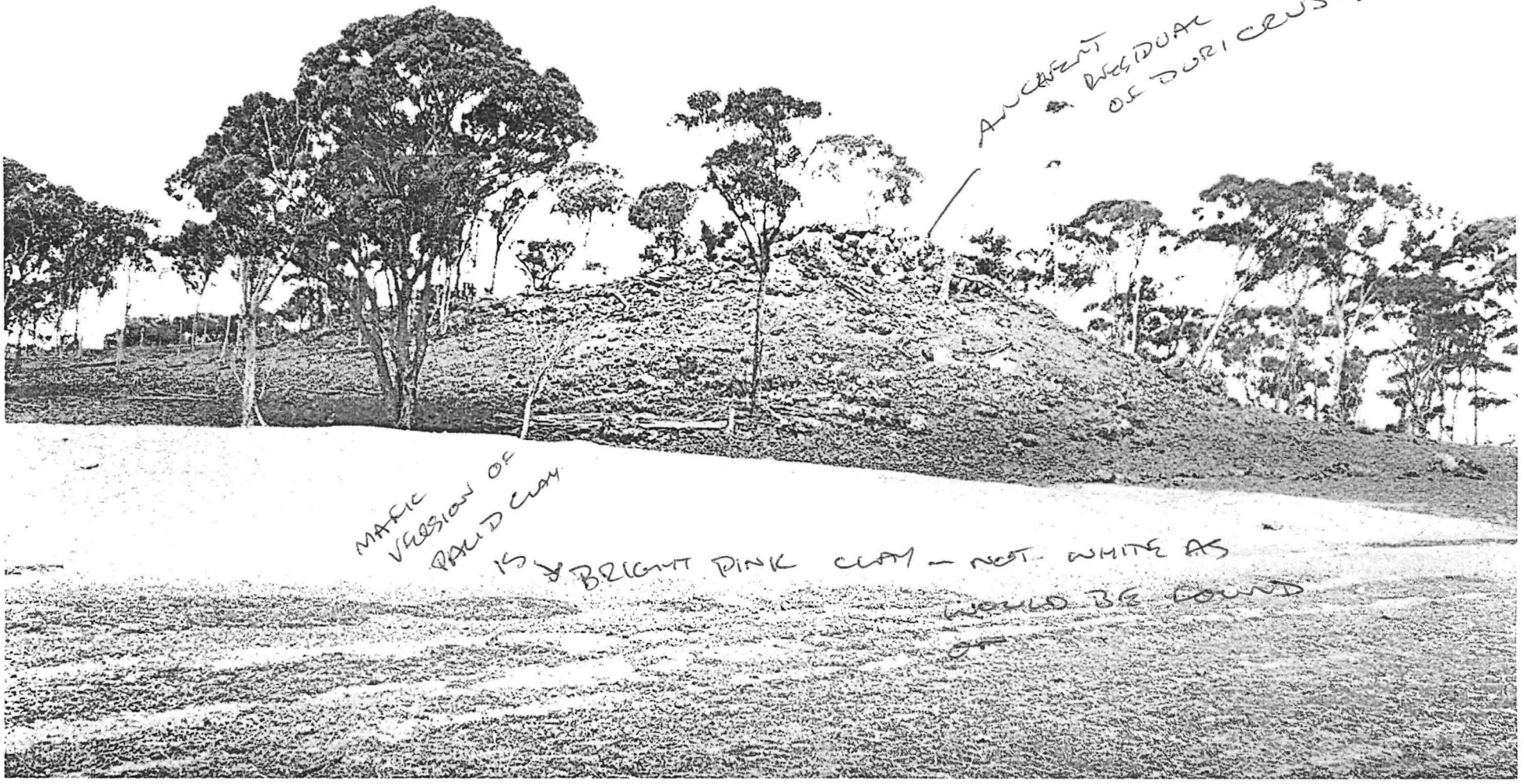
Weathering
dolerite at base

Aggregates indurating (to rhizolite)

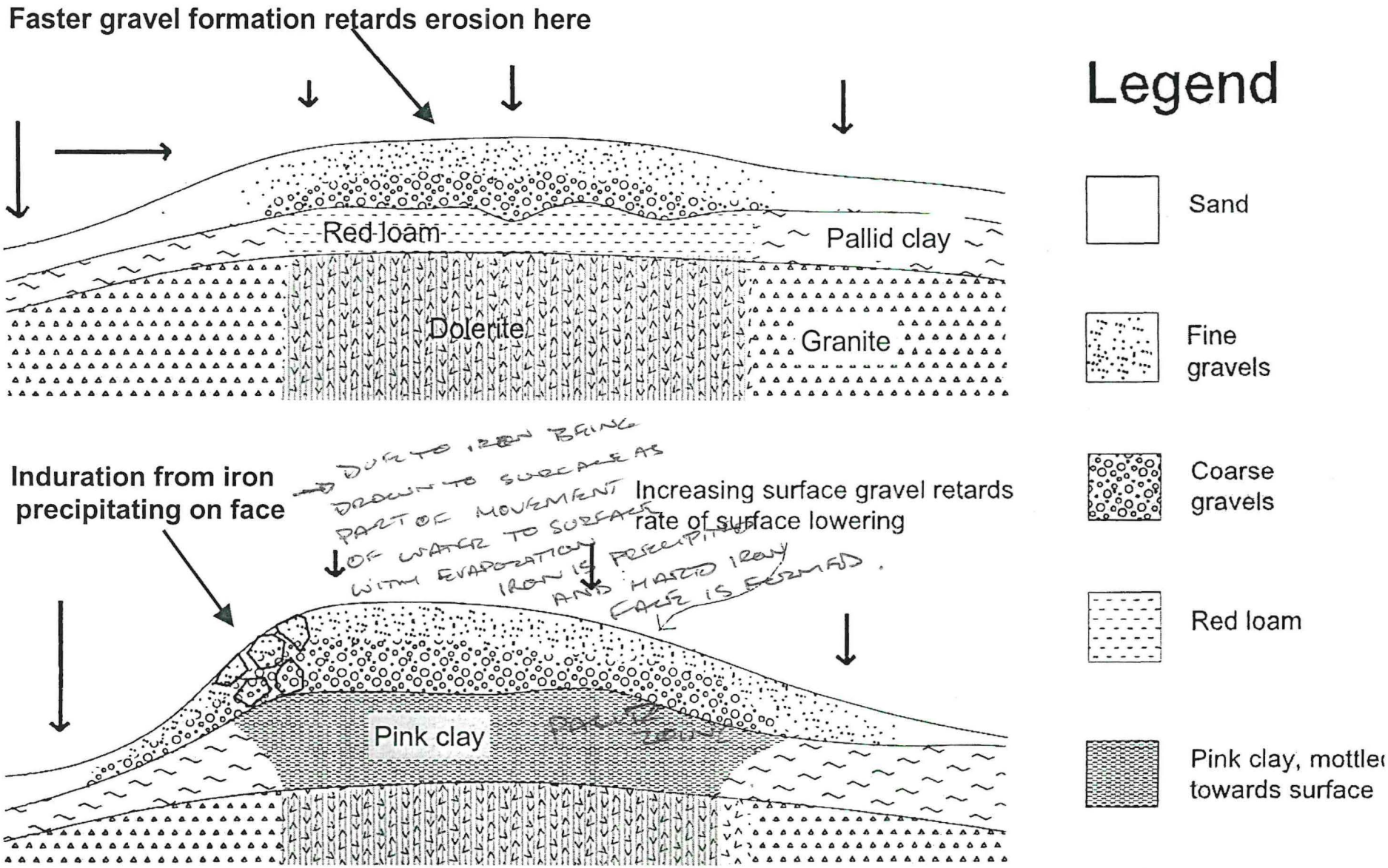
DOLERITE RIDGES ARE DOMINENT IN LANDSCAPE FORM ~20% OF SOILS.

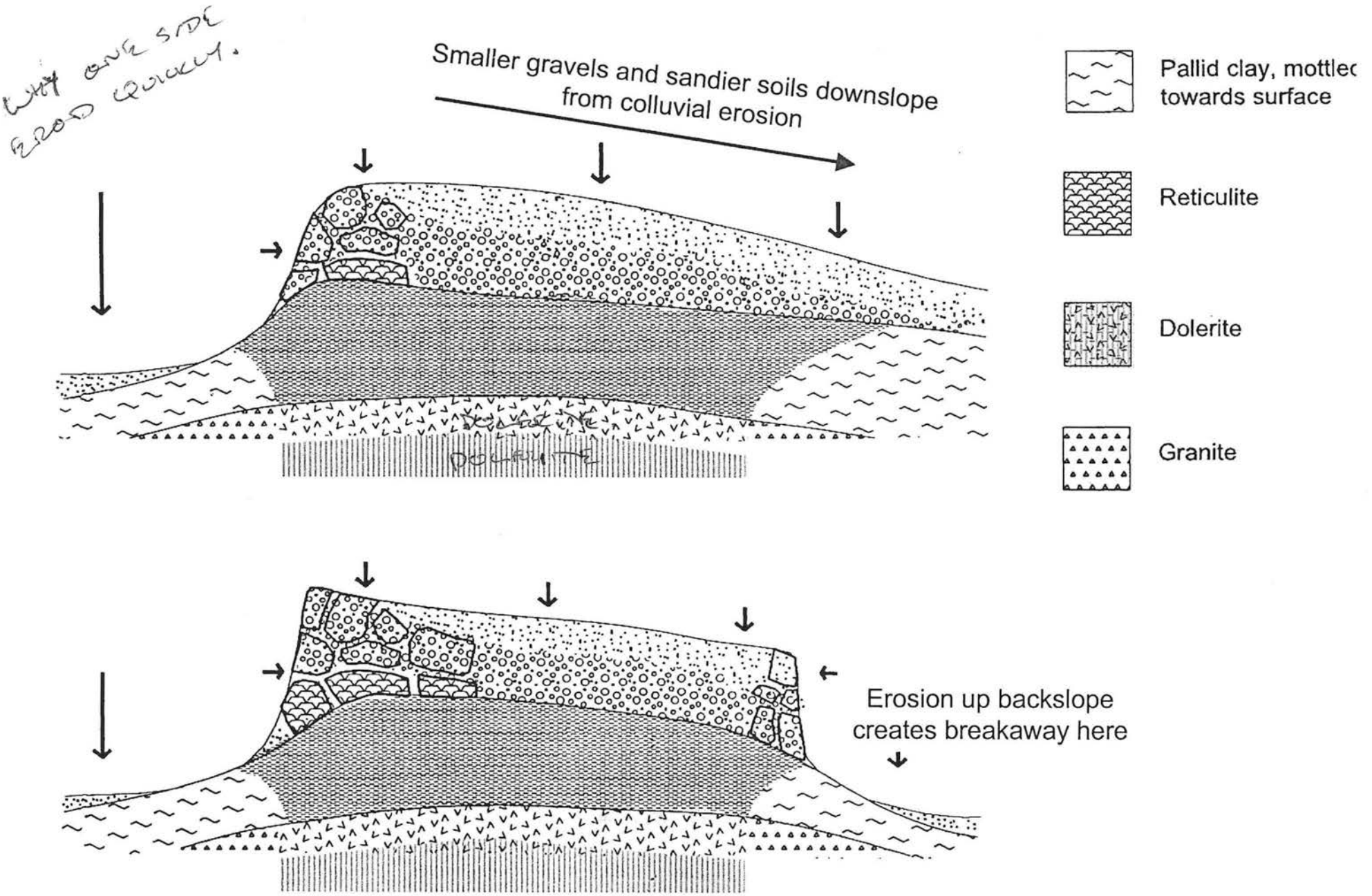
DOLERITE IS IRON RICH SO LATERITES FORM QUICKLY.

Breakaway on mafic soil at Jitarning



Breakaway formation on ridges

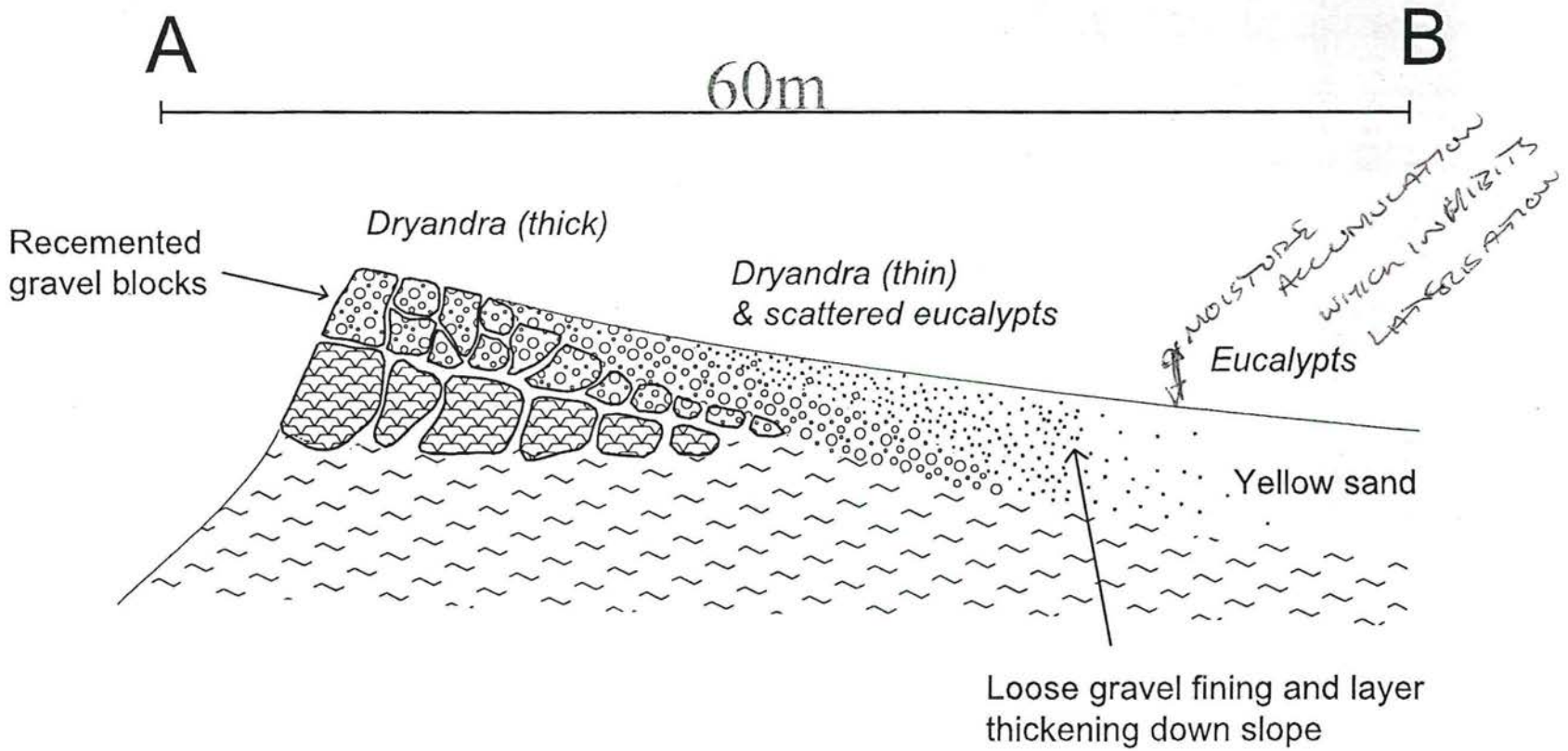




Horizontal vectors represent rate of headward incision by rain wash
Vertical vectors represent rate of surface lowering by rain wash

Narrogin Mesa: Full section.

Cross sections



Soil / Landscape Investigation

Drainage zone (tick cor rect one)	**Darling Range** **Rejuvenated Drainage** **Ancient Drainage**
AGWEST Land system (see from map)	
Landscape position and features	**Ridge**_____ **breakaway (top or pediment)** _____ **upper slope**_____ **mid slope**_____ **aeolian deposit** sandy_____ loam_____ **valley**_____
Surface clues	**Fragments on surface** Granite_____ quartz ____ mafic (dark)_____ laterite boulders_____ gravel_____ mottled zone_____ kaolinite_____ lime nodules_____ **soil surface** - loose sand _____ - loamy sand_____ - hard setting loamy sand_____ - loam_____ clay
Indicator vegetation	
your conclusion re the **Soil Landscape Unit(s)**	
(after investigation) your conclusion re the **Soil Type**	

SOIL-LANDSCAPE SYSTEMS OF THE NARROGIN DISTRICT

117°15'E
118°00'E
32°30'S
33°00'S
N
5 0 5 10 15 20 25 kilometres

Landscapes, Vegetation + Soils of Ngn District. BUS TOUR

Stop 1. Mafic breakaway
- formed from dolerite rock.
- brown soils.
- wandoo - sandy soils over clays.
- red morrel. - rough bark, glossy leaves.
- brown mallet.

Stop 2.
- well drained soil.
- Allocasuarina heugliana. - indicator of well drained soil
  - colonizer.
  - range of diff. soils.
- rocky outcrop
- jams
- wandoo.

Stop 3
casuarina obesa - wet, saline soils.

Stop 4.
Salmon gum - glossy leaves at top, rounded buds
Wandoo - dull leaves. long thin buds.

Stop 5
Sand dune. - smooth landscape.
- Banksia, sheoak. - poor sandy areas. - low in nutrients

Stop 6.
Kaolin. mine.

Stop 7
Proteacea - B sphaerocarpa.
Tamma.

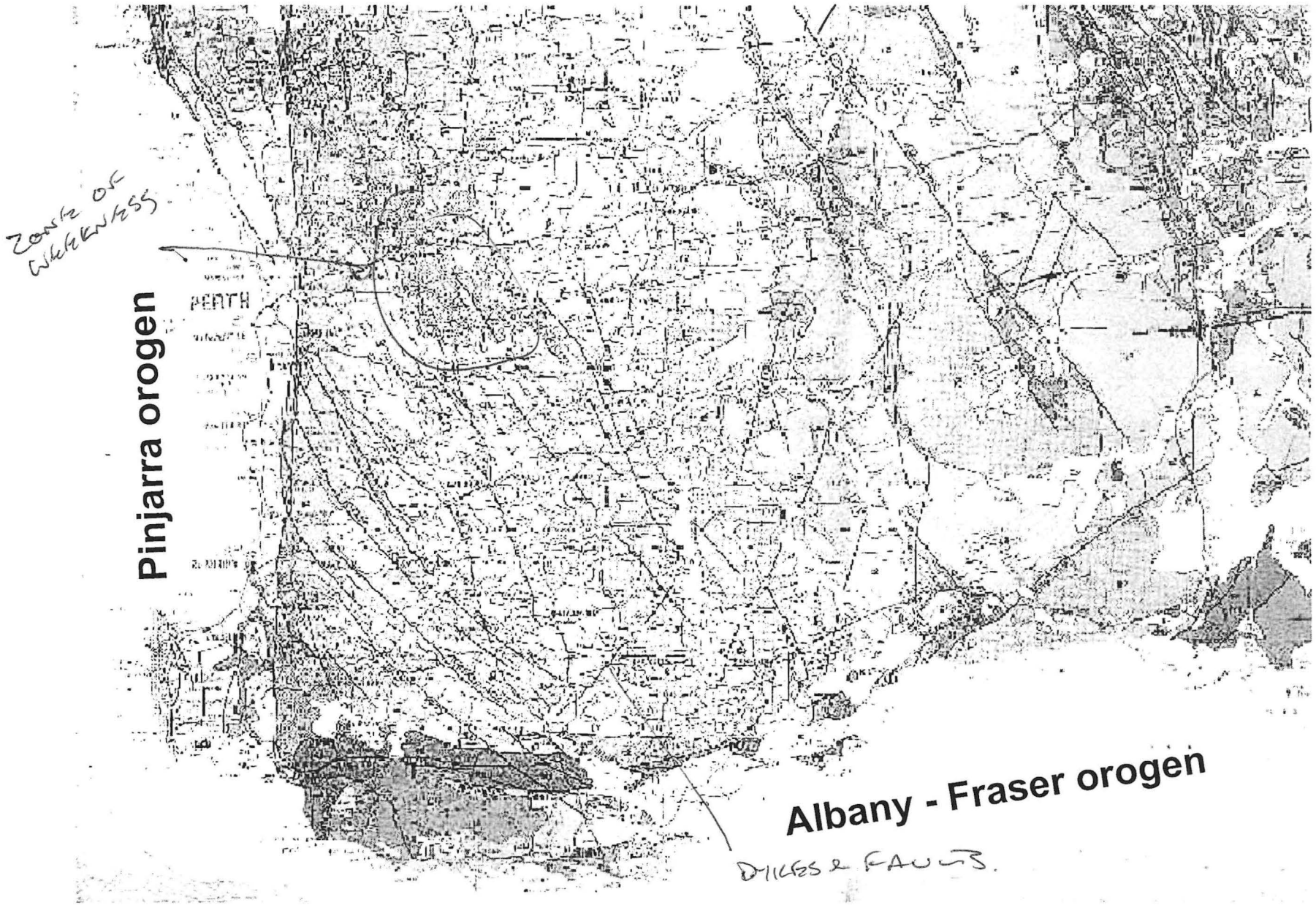
(8) Kandihin Valleys
- red clays.

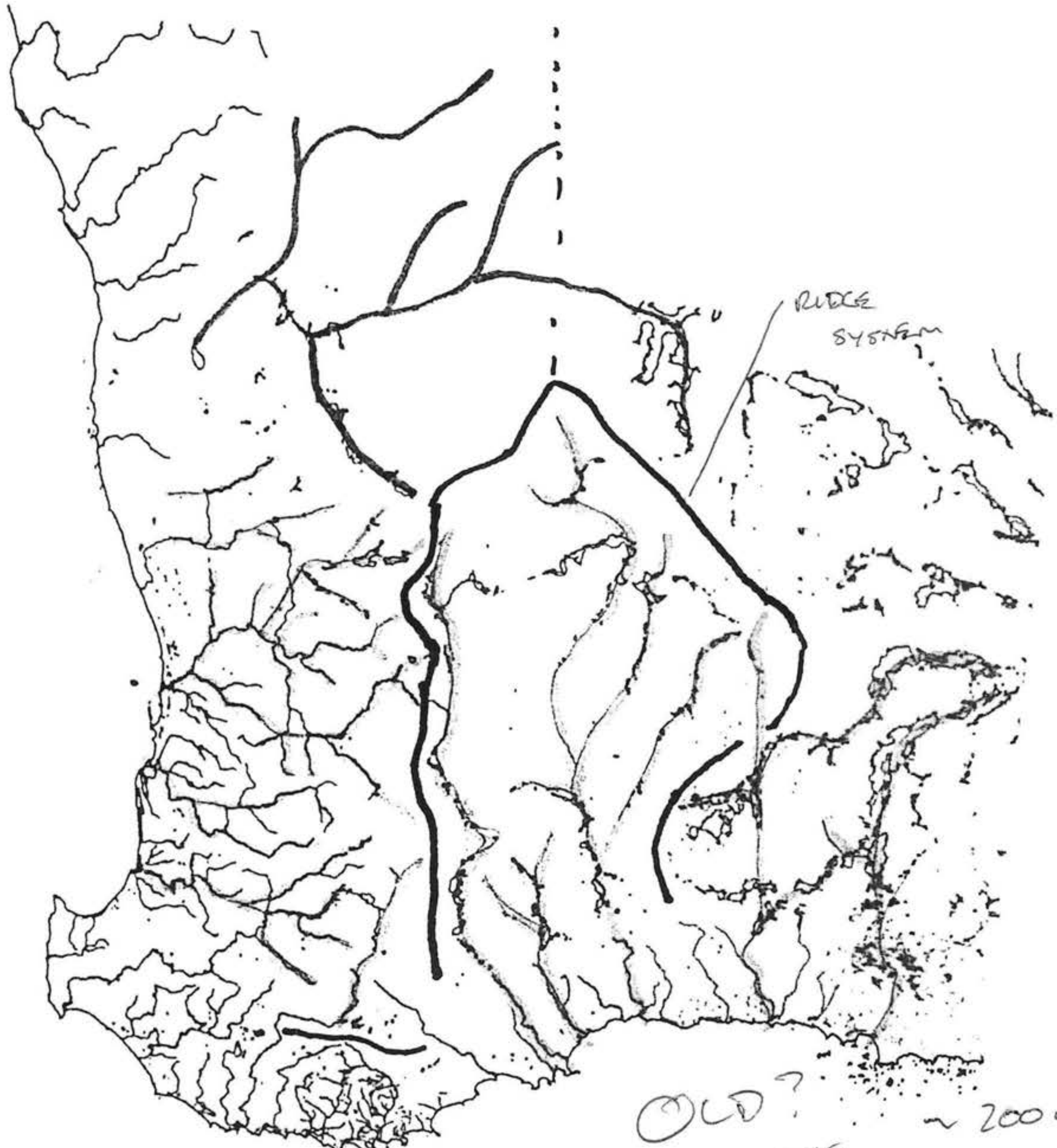
(9) Coblinine valleys.
Duplex soils.

(10) Mafic breakaway.
soils get coarse towards edge of breakaway.

(11) Dryanda
- lots of misas - laterite backslopes
- lots of weathering.
- less ~~locals~~ dissecting.

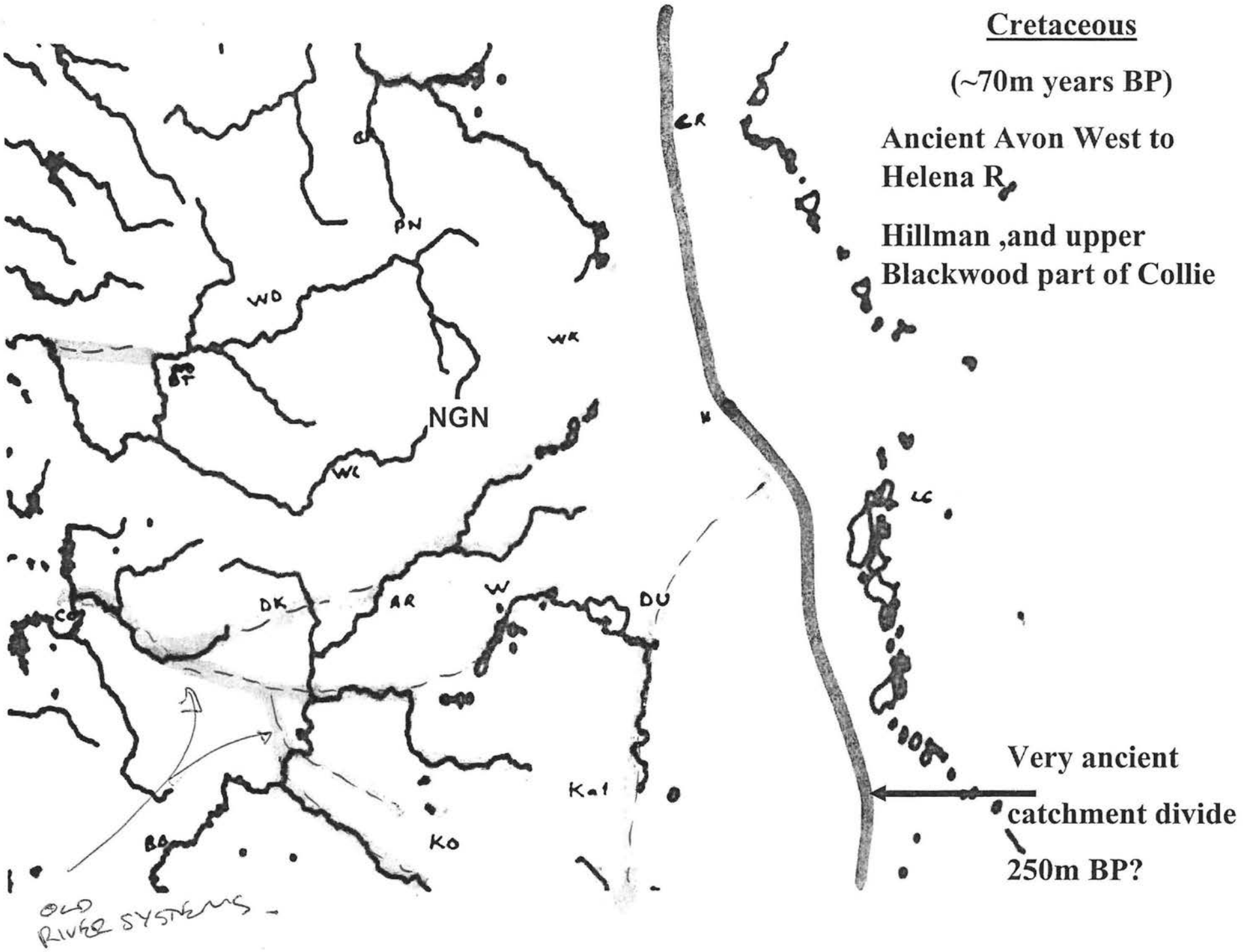
Most faults, dykes, drainage, igneous rocks trend ↘↖ **and** ↔

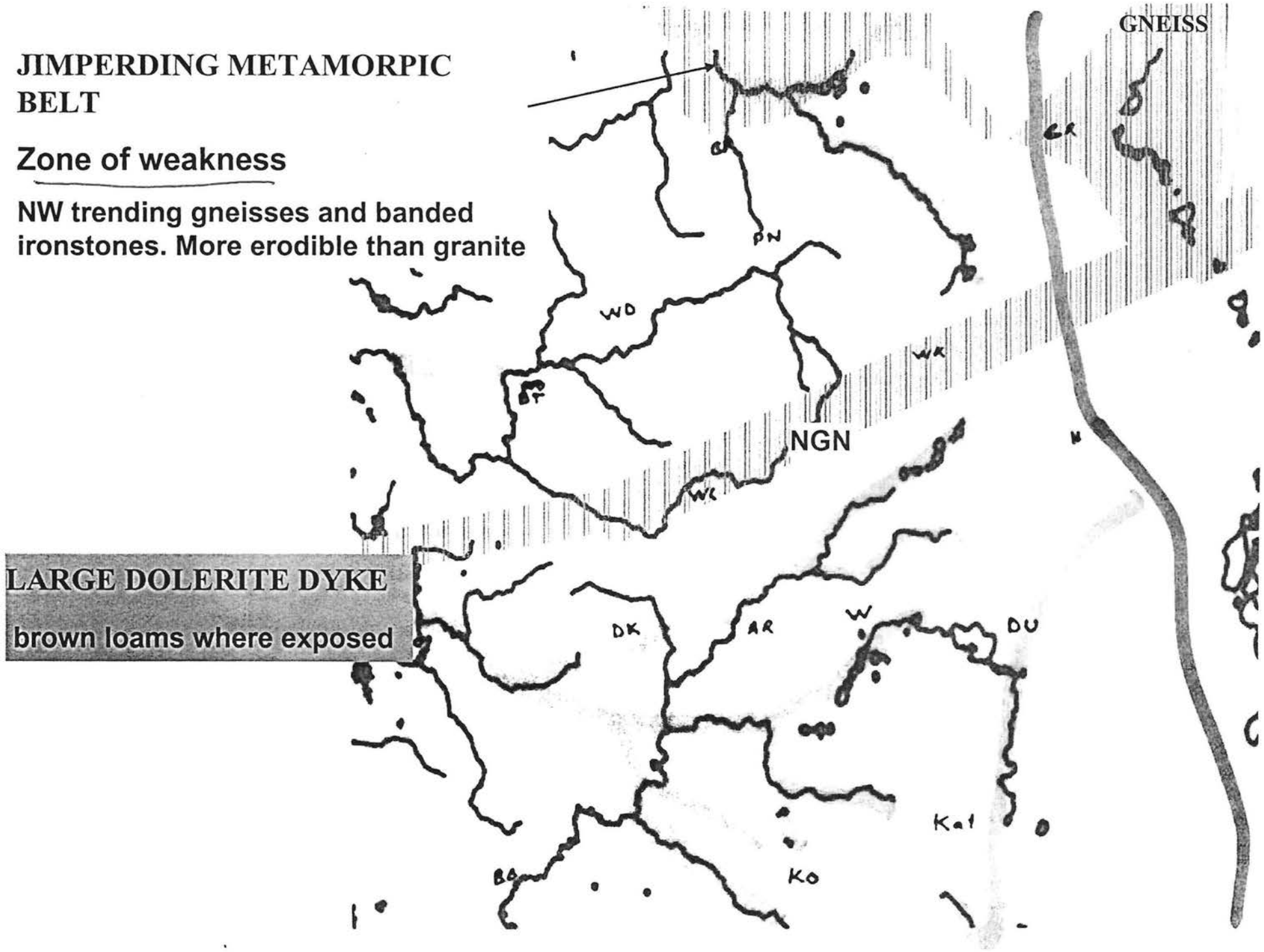




OLD? DRAINAGE SYSTEM

~ 200 MILLION YEARS AGO


Cretaceous
(~70m years BP)
Ancient Avon West to Helena R.
Hillman ,and upper Blackwood part of Collie
Very ancient
catchment divide
250m BP?
NGN
PN
WD
WK
WL
DK
AR
W
DU
CO
K-1
KO
BO
CR
LC
OLD RIVER SYSTEMS


JIMPERDING METAMORPIC BELT
Zone of weakness
NW trending gneisses and banded ironstones. More erodible than granite
LARGE DOLERITE DYKE
brown loams where exposed
GNEISS
NGN
DK
AR
DU
KO

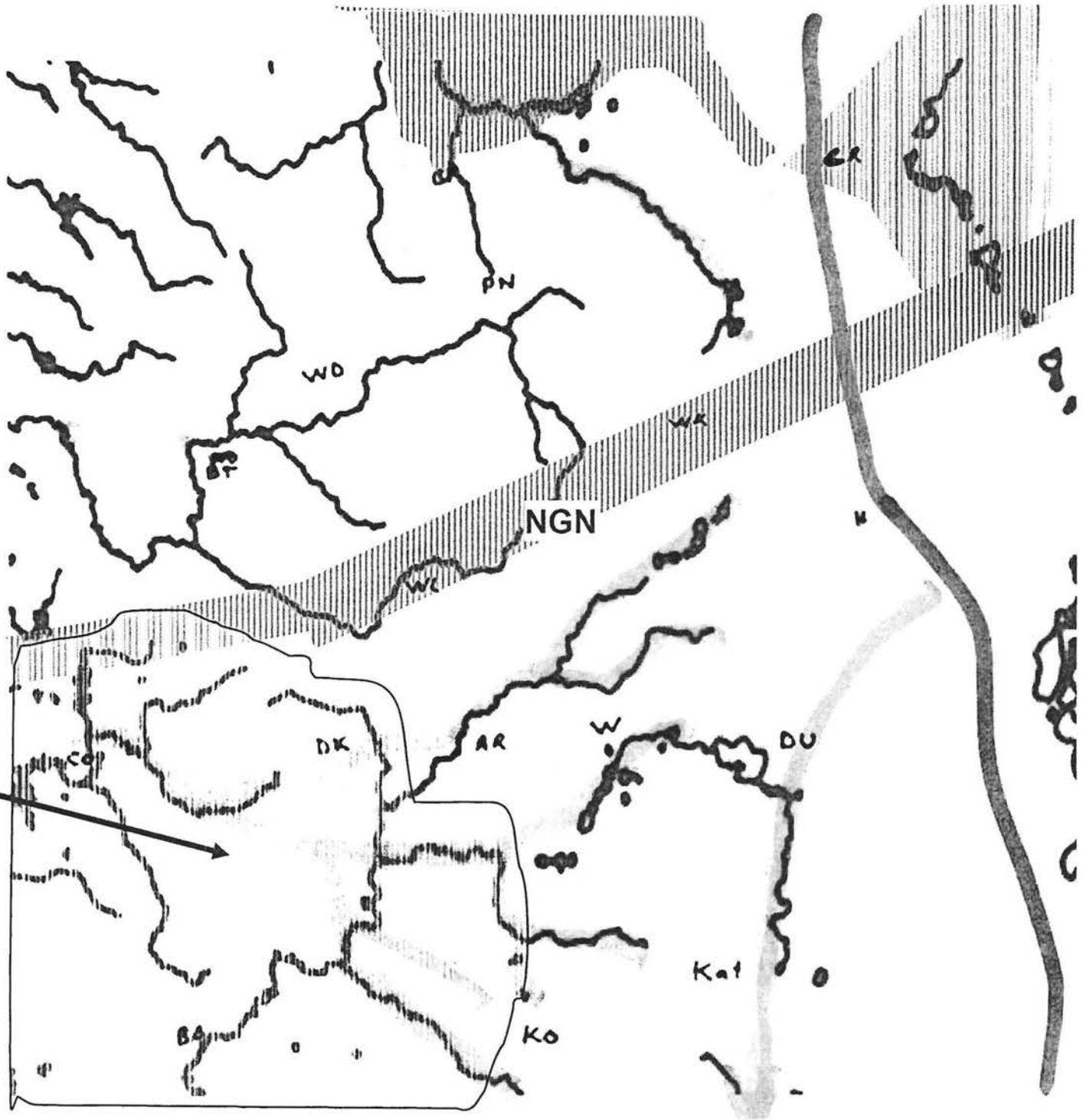
EOCENE

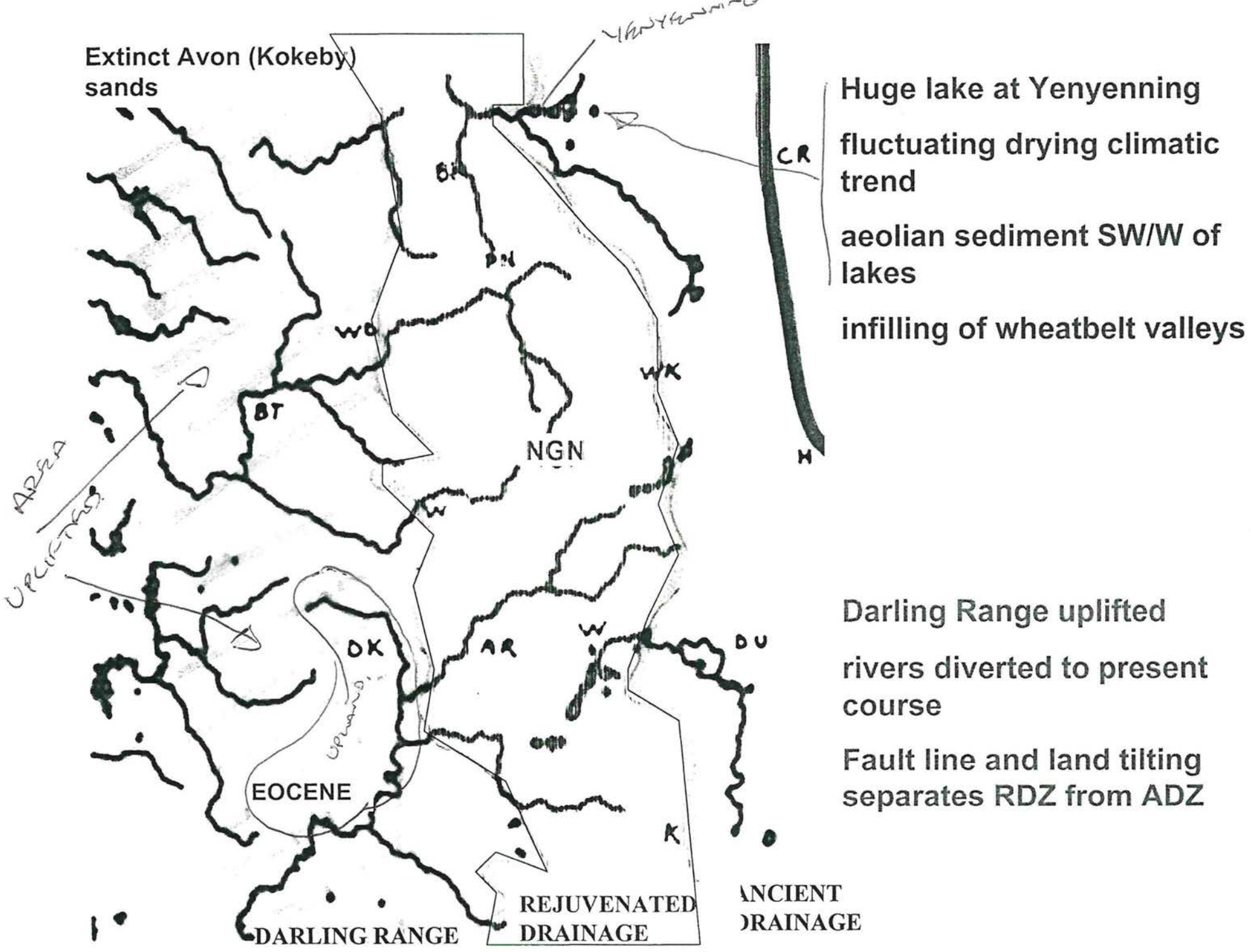
(38-54m years BP)

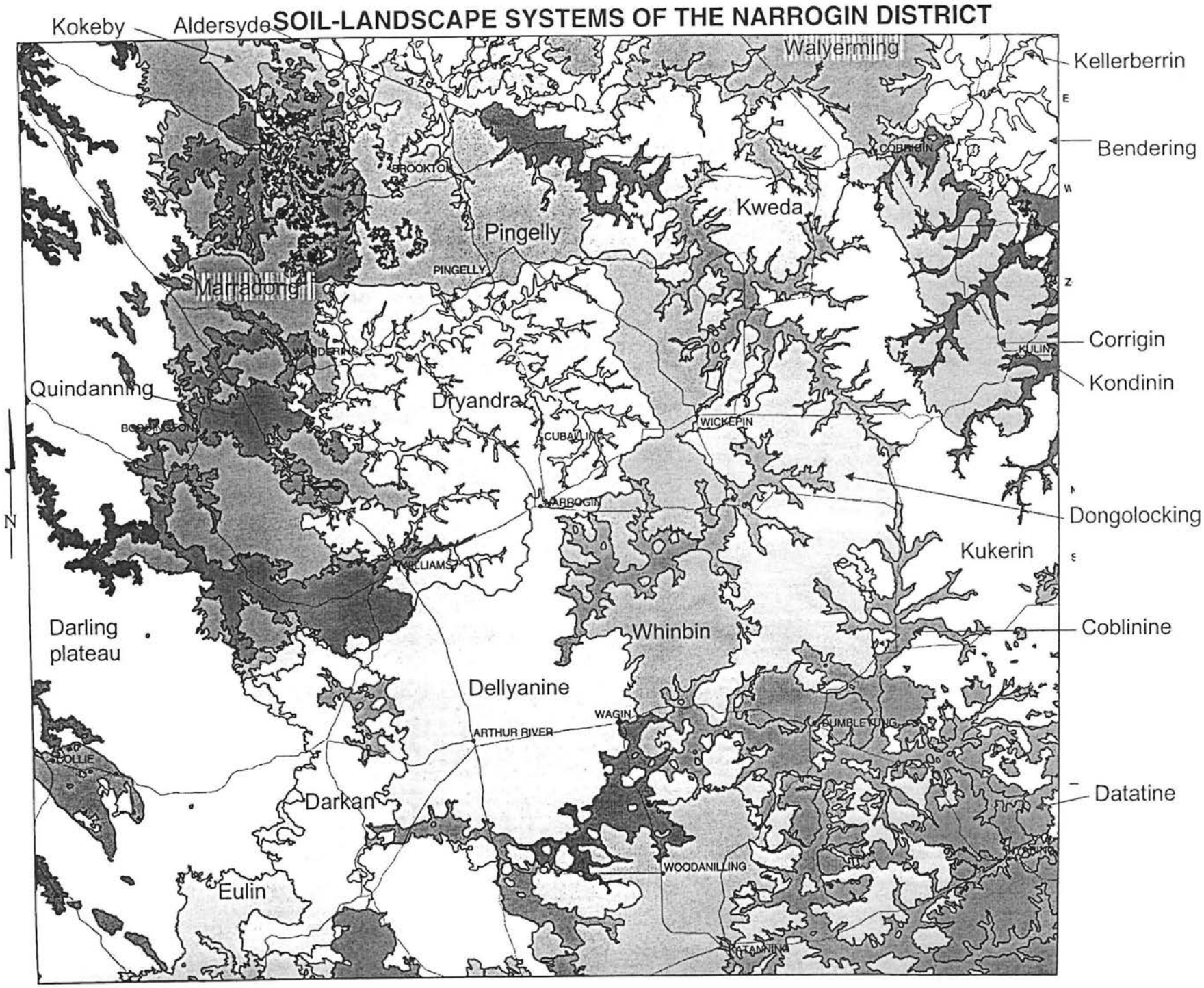
extensive laterite formation

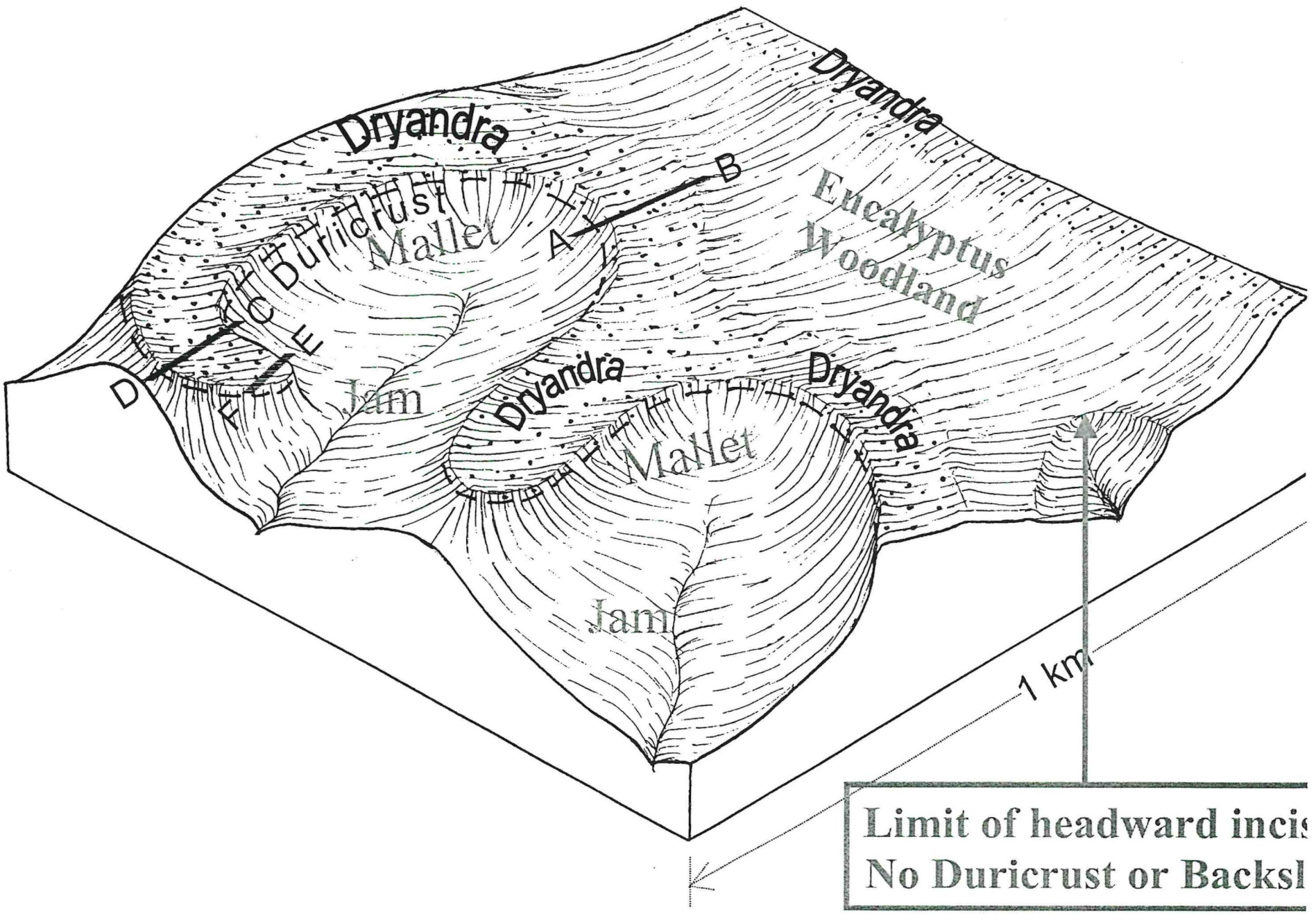
sea level rise

lake sediments form in old Collie river area




Extinct Avon (Kokeby) sands
CR
H
NGN
BT
WK
DK
AR
DU
EOCENE
DARLING RANGE
REJUVENATED DRAINAGE
ANCIENT DRAINAGE
Huge lake at Yenyenning
fluctuating drying climatic trend
aeolian sediment SW/W of lakes
infilling of wheatbelt valleys
Darling Range uplifted
rivers diverted to present course
Fault line and land tilting separates RDZ from ADZ


SOIL-LANDSCAPE SYSTEMS OF THE NARROGIN DISTRICT
Kokeby
Aldersyde
Walyerming
Kellerberrin
Bendering
Kweda
Pingelly
Marradong
Corrigin
Kondinin
Quindanning
Dryandra
Dongolocking
Kukerin
Darling plateau
Whinbin
Coblinine
Dellyanine
Darkan
Datatine
Eulin
BROOKTON
PINGELLY
CORRIGIN
KULIN
WICKEPIN
CUBALLING
NARROGIN
WILLIAMS
WAGIN
ARTHUR RIVER
WOODANILLING
TAMMIN
N


Dryandra
Dryandra
Duricrust
Mallet
A
B
Eucalyptus
Woodland
C
D
E
Jam
Dryandra
Dryandra
Mallet
Jam
1 km
Limit of headward incis
No Duricrust or Backsl

A guide to eucalypt species identification

There are approximately 900 species of Eucalyptus, Corymbia and Angophora. On a handful, there can be characters that are so distinctive, that an accurate diagnose can be achieve with minimal effort. However, with there being so many species, several parts of a plant must be examined before a correct identification can be attained.

Some features and growth habits need to be viewed cautiously as they can vary over time e.g. leaf size and bark texture, while others may be influenced by environmental conditions e.g. form. Mature leaf size of *E. occidentalis* can vary from 5 - 14cm long.

All portions of the plant selected in the identification process must be fully formed.

1. Buds

Most flowers (either in singles or multiples) are arranged on the top of a stalk (peduncle). Each of the multiple flowers is further arrayed on their own stalk (pedicle) such as *E. falcata*. These flowers without pedicles (and or peduncles) are refereed to as sessile (*E. phenax*). Peduncles can be straight (*E. subangusta*) or recurved (*E. oligocorma* ms).

Individual flowers have no obvious petals or sepals. The lower part of the bud becomes the cup of the flower, enlarging or hardening to become the hypanthium or calyx tube. Petals are probably present fused together to form the bud cap or operculum.

Usually there are two opercula, one of which falls of as the bud develops, leaving a distinctive scar. However, there are some species where this does not happen (*E. marginata*). Operculum characters can be very important, both in their shape but in relationship to the size of the hypanthium

2. Flowers

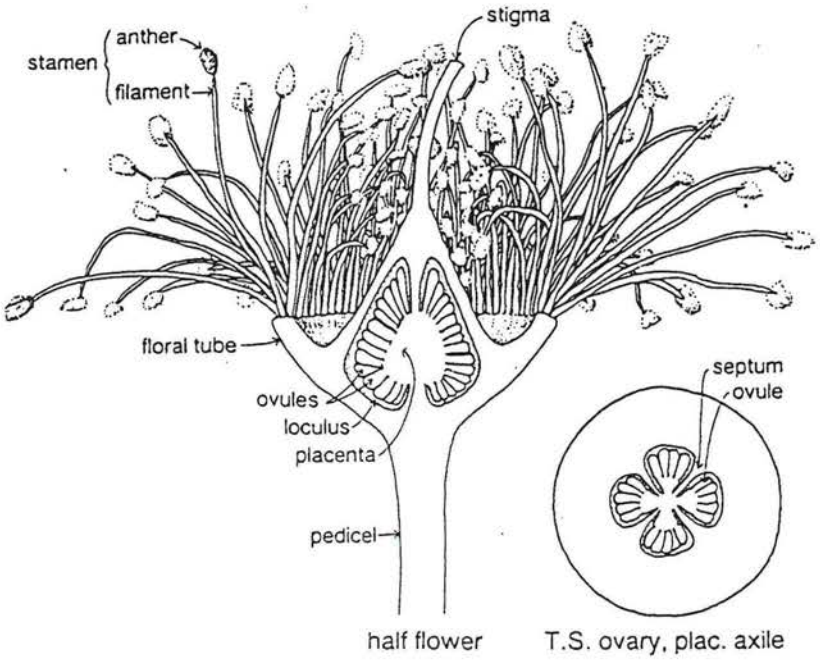
When the operculum falls off at anthesis or flowering time, the stamens are exposed. In some cases, the stamens are curled in on themselves or inflexed, other times they are straight (*E. eremophila*) and in a few instances can be a mixture of both (*E. recondita*)

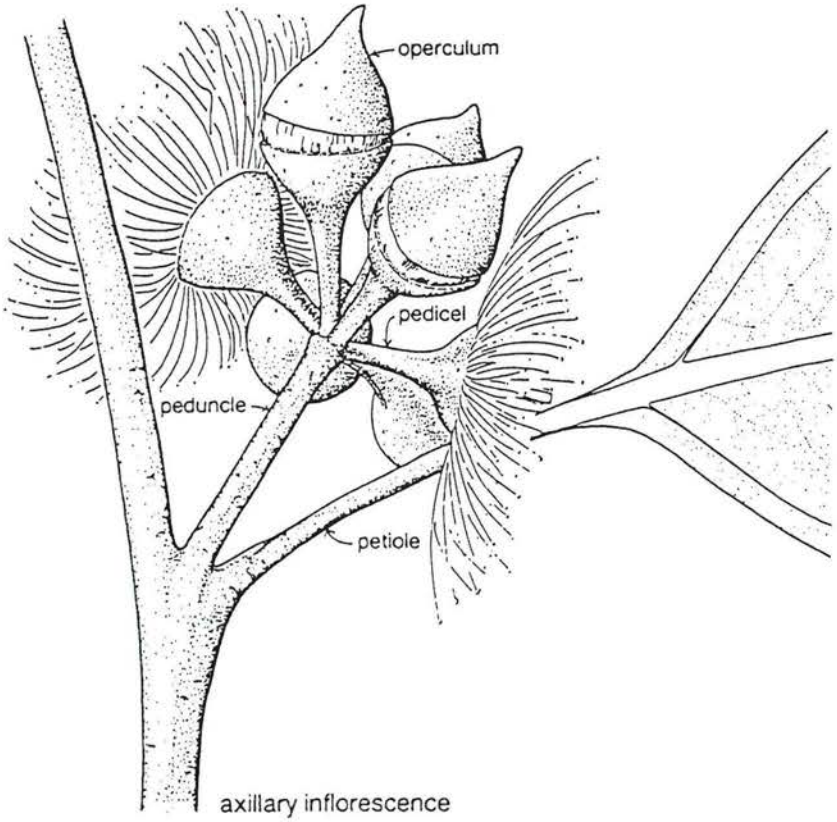
The stamen consists of the filament or stalk, at the end of which are the pollen bearing anthers. How the anthers are attached to the filament is important with some being attached at the base (basifixed) such as with *E. hypochlamydea*, or attached at the back, where it is dorsifixed or versatile. On a few species, such as *E. calycogona*, the outer stamens are without anthers (staminoids).

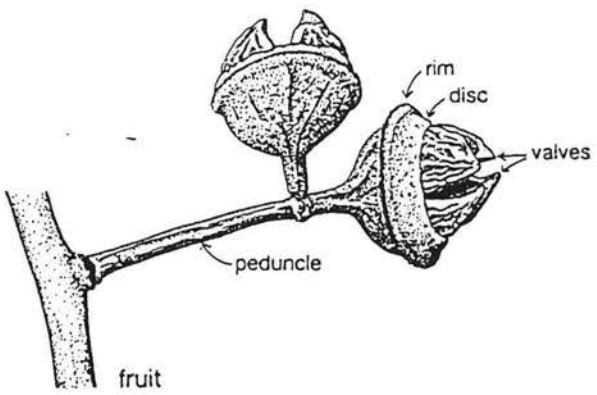
The style or the pollen tube protrudes from the centre to the flower and is usually straight. However, a few species have a distinctively twisted style (*E. albida*)

2. Seed capsules

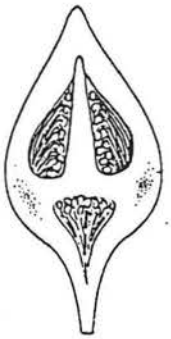
The stamens wither and fall off once the flower has been pollinated and fertilization has taken place. The calyx tube undergoes modification to form a woody capsule, which contains the seed. The capsule has a series of valves which open to release the seed.



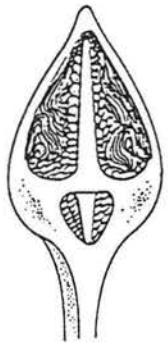




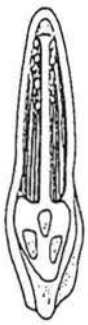
FLORAL DETAILS OF EUCALYPTUS



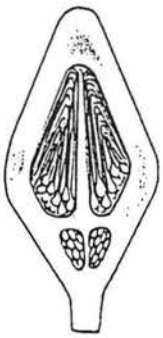
Stamens oblique in bud



Stamens variously flexed in bud

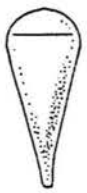


Stamens erect in bud



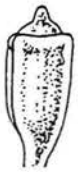
Stamens inflexed in bud

STAMEN CONFIGURATION



Clavate bud

Ovoid bud



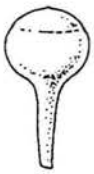
Oblong bud

Cylindrical bud

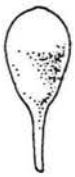
Fusiform bud

Elongated bud

Double-conic bud



Globose bud



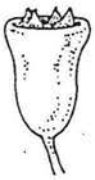
Pyriform bud

Figure 41 Beaked operculum

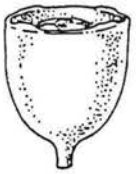
Conical operculum

Hemispherical operculum

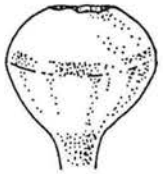
EUCALYPT BUD SHAPE



Fruit with exserted valves

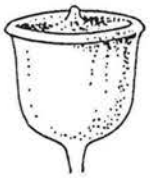


Disc of fruit level

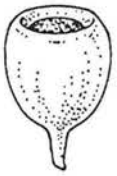


Disc of fruit ascending

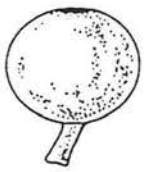
Urceolate fruit



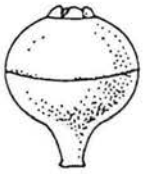
Campanulate fruit



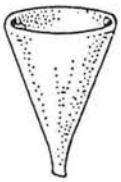
Barrel-shaped fruit



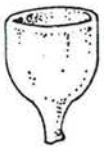
Truncate-globose fruit



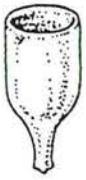
Hemispherical fruit
(base only, surmounted by ascending disc and slightly exserted valves)



Obconical fruit



Cupular fruit



Cylindrical fruit

EUCALYPT FRUIT SHAPE

Glossary of terms

Aggregated	clustered together
Attenuate	narrowed
Axils	the angle between the leaf or bract and the stem.
Budcap	a cap or lid. syn. operculum, calyptra
Caylx-tube	the outer whorl of a flower, consisting of free or united sepals. syn. hypanthium, seed capsule, fruit.
Concolourous	usually of leaves - the same colour on both surfaces of the leaf
Connivant	meeting but not fusing
Decurved	bending backwards
Discolourous	usually of the leaves - a different colour on each surface of the leaf.
Dome shaped	in reference to the curved shape of the top of the calyx tube.
Exerted	in reference to the valves protruding beyond the rim of the fruit.
Glabrous	smooth
Glaucous	a pale bluish tint - often on leaves and buds as a "bloom" or whitish substance which rubs off.
Incurved	bending inwardly
Inflorescence	the flower-bearing part of the plant including the flowers themselves.
Lanceolate	lance-shaped, long, widening above the base and tapering to a point.
Ovate	roughly egg shaped with the broader end towards the point of attachment.
Pedicels	the stalk of an individual flower of an inflorescence.
Peduncles	the main stalk of an inflorescence or of an individual flower when only one is present.
Petiole	leaf stalk.
Rostrate	in refernece to shape of bud cap
Recurved	curved downwards or backwards.
Sessile	without a stalk, applied to flowers and leaves which arise from the stem.
Striate	with fine parallel lines, grooves or ridges.
Terete	cylindrical and slightly tapering.
Truncate	cut off abruptly
Umbel	an inflorescence in which the stalked flowers all arise from the same point.
Valves	one of the pieces formed by the vertical splitting of capsular fruit to allow the seed to escape.

Soil / Landscape Investigation

Drainage zone (tick cor rect one)	**Darling Range** **Rejuvenated Drainage** **Ancient Drainage**
AGWEST Land system (see from map)	
Landscape position and features	**Ridge**_____ **breakaway (top or pediment)** _____ **upper slope**_____ **mid slope**_____ **aeolian deposit** sandy_____ loam_____ **valley**_____
Surface clues	**Fragments on surface** Granite_____ quartz ____ mafic (dark)_____ laterite boulders_____ gravel_____ mottled zone_____ kaolinite_____ lime nodules_____ **soil surface** - loose sand _____ - loamy sand_____ - hard setting loamy sand_____ - loam_____ clay
Indicator vegetation	
your conclusion re the **Soil Landscape Unit(s)**	
(after investigation) your conclusion re the **Soil Type**	

Sometimes these valves are quite pronounced and persistant (*E. longicornis, E. argyphea*), other species are inserted, e.g., *E. myriadena*. As with the buds, the capsules are sessile or pedicillate. The tops of the fruit can be a distinctive shape (*E. macrocarpa*), be partially masked by the staminophore, which is where the stamens connected to the capsule (*E. eremophila*) or a range of other options.

3. Foliage

Eucalypt leaves are simple, entire, and have a central midrib. Lateral veins diverge from the midrib, may be parallel or form a network with one another (anastomose). Intramarginal veins are often present close to the leaf margin (*E. loxophleba*). Leaves are commonly lanceolate or broadly lanceolate. However, leaf size and shape can vary considerably in the same plant as it matures (*E. loxophleba, E. flocktoniae, E. albida, and E. uncinata*). Juvenile, intermediate and adult foliage can all assist with the diagnostic process.

Leaves consist of a leaf blade (lamina) usually attached to the branchlet by a leaf stalk (petiole). Sometimes the leaf is stalkless (sessile) or may have opposite leaves that are joined or connate (*E. uncinata*). Leaves are usually arranged alternately along the branchlet or in a few cases can be opposite. Leave arrangement can change as the plant matures.

Oil glands are imbedded in the surface of many species, but not present in all species of eucalypt. Some are surrounded by the anastomese (island), others are linked (intersectional).

Leafs are usually have a glossy sheen, but can be matt (*E. hebetifolia*). Amounts of leaf gloss can alter at the plant ages (*E. phaenophylla*). Leaves are usually the same colour on either side (concolorous) but can be dark on the surface and paler beneath (discolorous) such as *Corymbia calophylla*. However, plants do not exhibit both conditions simultaneously.

Leaves are usually glabrous (without hairs) and can have a pale white powdery covering (glaucous). *E. wandoo* and *E. capillosa* are easily distinguished by absence or presence of leaf hairs. *E. neutra* is often characterised by the glaucous bloom on the leaves and the buds.

4. Bark

Bark can be a deceptive feature if not looked at correctly. In many cases it is the qualitative expression that is important rather than the quantitative. For example, the fact that a tree may have rough basal bark and smooth upper bark is more important than how far the rough bark goes up the stem.

Bark types common found in the Wheatbelt include;

- Persistent to and including small branches - *Corymbia calophylla*
- Persistent to lower limbs - *E. loxophleba* subsp *loxophleba.*
- Smooth over entire trunk - *E. salubris*
- Peeling or basal accumulation - *E. phaenophylla* subsp. *phaenophylla*

Bark texture can be very variable within a species e.g. juvenile *E. wandoo* has rough bark which changes to smooth as the tree ages.

5. Form

How a plant grows can be a useful guide for identification, but care must be exercised in many instances e.g. *E. marginata* at Dwellingup is a large trees whereas at Wellstead it is reduced to a low sprawling bush.

Changes in form can be induced by site quality, crown competition, mechanical damage, insect attack, fire etc.

Various attempts have been made to define the growth habit (or regenerative requirements) of eucalypts. Contemporary descriptions are;

Sprouters

- Mallee. A plant with a distinctive lignotuber, which is usually multi-stemmed and resprouts from the lignotuber after fire. However, in the absence of fire, mallees can grow as a single stem plant, e.g. *E. myriadena.*
- Tree. Usually a single stemmed upright plant which while lignotuberous, usually resprouts along the trunk from dormant or epicormic shoots (*E. marginata*).

Non sprouters

- Mallet. Usually a single stemmed upright tree, but with no lignotuber or epicormic shoots. This form dies outright after a fire and regenerates from seed. This name includes the term "marlock".

Several species have been separated recently based on the absence / presence of the lignotuber;

Mallets	Mallees
E. argyphea	*E. falcata*
E. astringens	*E. oligocorma*
E. gardneri	*E. pluricaulis*
E. prolixa	*E. calycogona*
E. urna	*E. flocktoniae*

End notes.

When referring to books remember several things;

- There will always be problems with name changes - the most recent work should be consulted. Sometimes general texts e.g. vegetation handbooks, are compiled from existing data (Beard's and Muir's work for example), but this does not represent a treatment of the flora. Previously widespread species quoted from these works now only occur in very limited distributions e.g. *E. redunca* is restricted to south of the Stirlings and *E foecunda* is now called Fremantle mallee!!
- Distribution maps are a guide
- Read all the description listed not just the first few lines
- Photographs are a guide only. Colour will vary between collected specimens and photographs. The portions of plants photographed are not always a truly representative sample, especially on species that have a wide distribution - read the text!