1-2-1992

Soils of the East Beverley annex of the Avondale Research Station

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ISSN 0729-3135
February 1992

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Resource Management Technical Report No. 129

Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

Contents

1. Introduction

1.1 Location and Research Aims of the Annex

In early 1988, the Department if Agriculture secured a 10 year lease on 120 hectares of land for use as an annex to Avondale Research Station. The soils found on the Annex are representative of the large area of duplex soils found throughout the Central and Great Southern agricultural areas.

The Annex is located 30 km east of Beverley on Ewerts Road (see Appendix 1), comprising Avon Location numbers 8365,8394 and 11601. The slope gradient on the Annex varies from 3-4% in the top paddock to less than 1% in the two lower paddocks. In addition to the arable land, the Annex also contains a few hectares of wandoo (*Eucalyptus wandoo*) woodland. There are four dams.

Research on the Annex will be a joint effort between the Department of Agriculture and CSIROs Dryland Crops and Soil Research Unit. One of the primary aims of research at the Annex is to explain the under-achievement of crop and pasture yields on this soil type in the medium rainfall zone. In particular, the problems of waterlogging, nitrogen losses and root penetration will be examined. Variety, nutrition and herbicide trials will also be conducted on the Annex.

1.2 Climate

The East Beverley Annex has an average rainfall of about 380 mm/year. The average monthly rainfall figures for the Beverley Post Office are given in Table 1. These figures will be marginally higher than those at the Annex, which is 30 km to the east. Table 1 also shows the mean daily maximum temperature for each month.

Table 1. Average monthly rainfall and mean daily maximum temperature for each month at the Beverley Post Office (1886-1988)

	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Rain (mm)	9	13	17	23	56	82	79	60	36	23	14	9	421
Temp (°C)	34.1	33.3	30.6	25.8	21.1	17.8	16.7	17.5	20.2	24.2	27.8	32.0	

1.3 Previous surveys

The majority of the Annex occurs on Mulcahy and Kingston's (1961) Malebelling Surface and belongs to the Malebelling 2 soil series. The series is described as a light brown, gritty loamy sand over a bleached A2 horizon overlying a clayey B horizon, above which waterlogging is common in winter. The gravel ridges on the Annex (mapped as soil type C) belong to Belmunging Surface, while the small area of red soil formed from fresh rock (soil type H) is an example of the York Surface.

The Annex occurs within the study area of Lantzke and Fulton's (1993) broadscale soil landform mapping. The Annex is mapped within the Ewert's soil landscape unit

which is described as "hillslopes containing predominantly sandy and loamy sand surfaced over yellowish clay soils with some gravel ridges".

Volume 2 of "Soils of the Northam Advisory District" (Lantzke, 1992) provides yield and capability information for the soils of the area.

2. Soil mapping procedure

An enlarged black and white aerial photograph at a scale of 1:5,000 was used as a base map upon which soil boundaries were drawn.

Fieldwork was conducted in December 1987. 110 auger holes were dug on a 100 metre grid across the Annex.

The standard Western Australian Department of Agriculture profile and site description card was used to record information on soil characteristics such as texture, colour, mottles, horizons, structure, fabric, consistence, presence of pans, segregations, coarse fragments and pH. Landform information was also recorded. This information is stored in the Division of Resource Managements databank in WARIS format. Each soil was classified according to its Principle Profile Form (Northcote, 1979).

At the conclusion of the survey, 8 backhoe pits were dug, one in each soil type, and samples taken for laboratory analysis (see Appendix 2). The pits were left open as demonstration sites.

The soil map of the Annex is attached to this report. Researchers using the soil map should be aware of the mapping accuracy and describe additional profiles where necessary.

3. Soils

Eight different soils were recognized. The distinguishing criteria were primarily potential to waterlog, the rooting conditions and moisture availability.
The soils are:

- Soil A Deep sandy duplex.
- Soil B Shallow sandy duplex.
- Soil C Deep gravelly duplex.
- Soil D Shallow gravelly duplex.
- Soil E Shallow gravelly duplex with an iron pan.
- Soil F Very shallow gravelly duplex.
- Soil G Deep yellow sandy duplex.
- Soil H Red sandy loam.

3.1 Soil A - Deep sandy duplex

This soil consists of a surface layer of dark grey or brown, medium to coarse sand over a pale, sand to clayey sand, which overlies a mottled sandy clay at 40 to 60 cm. The percentage of ironstone gravel in the sandy surface horizons is ususally less than 10%. This is a common soil type on the Annex.

A1 Horizon

From surface to approximately 12 cm depth.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Usually dark greyish brown (10YR 4/2), dark grey (10YR 4/1) or very dark grey (10YR 3/1).
- pH ranges from 5.5 to 6.5.
- Small amounts of ironstone and quartz gravel.
- Can be water repellent.
- Abrupt or clear boundary to

A2 Horizon

Extends to a depth of approximately 35 cm.
(Note this layer may be absent with the A1 horizon directly over the A3 horizon.)

- Medium to coarse sand.
- Single grained, sandy fabric.
- Commonly very pale brown (10YR 7/3), light grey (10YR 7/2) or light brownish grey (10YR 6/3).
- pH ranges from 6.0 to 7.0.
- Small amounts of ironstone and quartz gravel.

A3 Horizon

Extends to a depth of 40-60 cm.
(Note this layer may be absent if an A2 is present).

- Medium to coarse light clayey sand.
- Usually massive with a sandy fabric.
- Commonly light yellowish brown (10YR 6/4) light brownish grey (10YR 6/2) or very pale brown (10YR 7/3).
- Distinct or faint orange mottles may be present (less than 10%).
- pH ranges from 6.0 to 7.0.
- Ironstone gravel percentage is usually less than 10% but can be as high as 20%.
- Small amounts of quartz gravel are present.
- Abrupt or gradual boundary to

B2 Horizon

Extends to more than 100 cm.

- Sandy clay (or on rare occasions a sandy clay loam grading into a sandy clay with depth).
- Moderately pedal.
- Most commonly brownish yellow (10YR 6/6,10YR 6/8), but can be light grey (10YR 7/1) or pale yellow (2.5Y 7/4).
- Pale or orange mottles (to 50%) often present.
- pH ranges from 6.0 to 7.0.
- The gravel percentage is lower than in the A3 horizon above and is usually less than 5%.
- Little or no quartz gravel is present.

Drainage:	imperfectly drained;
Permeability:	moderate;
Runoff:	slow;
P.P.F.'s:	Dy5.42, Dy4.41.

3.2 Soil B - Shallow sandy duplex

This soil consists of a surface horizon of grey-brown sand over a pale, clayey sand overlying a clay subsoil at a depth of 20 to 30 cm. There is less than 10% of ironstone gravel in the profile. This is the most common soil type on the Annex.

A1 Horizon

From the surface to a depth of around 12 cm.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Greyish brown (10YR 5/2.), dark greyish brown (10YR 4/2) to dark brown (10YR 3/3).
- pH ranges from 5.5 to 6.5.
- Small amounts of ironstone and quartz gravel.
- Abrupt to clear boundary to

A3 Horizon

Extends to a depth of 20 to 30 cm.

- Ranges from a coarse sand to a sandy loam but is most commonly a clayey sand.
- Usually massive with a sandy fabric.
- Pale brown (10YR 6/3), light greyish brown (10YR 5/3), light yellowish brown (10YR 6/4) or very pale brown (10YR 6/4).
- Faint or distinct orange mottles may be present.
- pH ranges from 6.0 to 7.0
- Less than 10% of ironstone gravel and less than 5% of quartz gravel.
- Abrupt boundary to

B2 Horizon

Extends to more than 100 cm.

- Sandy clay to light clay.
- Moderately pedal.
- Most commonly yellowish brown (10YR 6/4) or very pale brown (10YR 7/3), but can be brownish yellow (10YR 6/6).
- 0 to 50%, pale or orange mottles.
- pH ranges from 6.0 to 7.0.
- Small amounts of ironstone or quartz gravel.

Drainage:	poorly drained;
Permeability:	moderately slow;
Runoff:	moderately rapid;
RP.F.'s:	Dy4.22, Dy5.12, Dy5.42.

3.3 Soil C - Deep gravelly duplex

This soil is a very gravelly, deep duplex soil. It has a deep bleached A2 horizon and often a transitional A3 horizon, with a sandy clay loam to sandy clay B horizon at a depth of 40 to 80 cm. It occurs on two ridges in the top paddock.

A1 Horizon

From the surface to around 12 cm depth.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Usually dark greyish brown (10YR 4/2), very dark greyish brown (10YR 3/2) or brown (10YR5/3).
- pH is almost always 6.0.
- Between 10% and 50% ironstone gravel, small amounts of quartz gravel.
- Water repellent.
- Abrupt or clear boundary to

A2 Horizon

Extends to a depth of 25 to 60 cm.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Usually light grey (10YR 7/1), pale brown (10YR 6/3) or occasionally grey (10YR 5/1).
- pH ranges from 6.0 to 6.5.
- Usually 10% to 50% ironstone gravel.
- Gradual boundary to an A3 layer if present, or if absent an abrupt boundary to the B2 horizon.

A3 Horizon

(If present) - extends to a depth of 30 to 40 cm.

- Clayey sand.
- Massive or single grained, sandy fabric.
- Very pale brown (10YR 7/5), light brownish grey (10YR 6/2) or yellow (10YR 7/6).
- Usually there are no mottles.
- pH ranges from 6.0 to 7.0.
- Usually 2% to 20% ironstone, little quartz gravel.
- Abrupt boundary to

B2 Horizon

Extends to over 100 cm depth.

- Sandy clay loam to sandy clay.
- Moderately pedal.
- Most commonly brownish yellow (10YR 6/6), but can be yellow (10YR 7/6), very pale brown (10YR 7/3) or yellowish brown (10YR 5/6).
- Between 5% and 50% orange, red or pale mottles.
- pH is usually between 6.0 to 7.0.
- 2% to 10% ironstone gravel, some quartz gravel.

Drainage: moderately well drained;
Permeability: moderately rapid;
Runoff: slow;
P.P.F.'s: Dy5.21, Dy2.41, Dy3.22.

3.4 Soil D - Shallow gravelly duplex

This soil consists of shallow sand over a mottled clay at around 20 to 35 cm with large amounts of ironstone gravel throughout. The brown-grey surface horizon is often underlain by an A3 horizon with a slightly heavier texture and/or a transitional B1 horizon.

A1 Horizon

From the surface to about 12 cm depth.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Usually dark greyish brown (10YR 4/2), dark brown (10YR 3/3) or dark grey (10YR 4/1).
- pH ranges from 5.0 to 6.5.
- Between 2% and 20% ironstone gravel.
- Small amounts of quartz gravel.
- Can be water repellent.
- Abrupt boundary to

A3 Horizon

Extends to a depth of 20 to 35 cm.

(Note in some cases a thin bleached A2 horizon may be present).

- Medium to coarse sand or clayey sand.
- Single grained or massive, sandy fabric.
- Usually pale brown (10YR 6/3), very pale brown (10YR 7/3,10YR 7/4) or brown (10YR5/3).
- Ironstone gravel, (10% to more than 50% by volume).
- Gradual to abrupt boundary to

B1 Horizon

Extends to a depth of 30 to 35 cm.

(Note this horizon is often absent).

- Usually a sandy clay loam.
- Weakly pedal.
- Common colours include very pale brown (10YR 7/3), pale yellow (2.5Y 7/4) and pale brown (10YR 6/3). Orange and red mottles present.
- pH is 6.0 to 6.5.
- Usually between 10% and 50% ironstone gravel.
- Small percentage of quartz gravel.

B2 Horizon

Extends to more than 80 cm depth.

- Sandy clay
- Moderately pedal.
- Most commonly very pale brown (10YR 7/3), but can be pale brown (10YR 6/3) or pale yellow (2.5YR 7/4).
- 2% to 40% orange and red mottles.
- pH is between 6.0 and 7.0.
- Ironstone gravel content ranges from 2% to 30%.
- Small amounts of quartz gravel.

Drainage:	poorly to imperfectly drained;
Permeability:	moderately slow;
Runoff;	moderately rapid;
P.P.F.'S	Dy4.42, Dg3.12.

3.5 Soil E - Shallow gravelly duplex with an iron pan

This soil has a grey-brown surface horizon over a moderately cemented, continuous, massive iron pan beneath which (at a depth of about 25 cm) is a mottled sandy clay. Ironstone gravel occurs throughout the profile. There is only a small area of this on the Annex.

A1 Horizon

Extends to a depth of about 10 cm.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Brown (10YR 4/3) or dark greyish brown (10YR 4/2).
- pH is usually 6.0.
- Between 2% and 10% ironstone gravel.
- Small amount of quartz gravel.
- Sharp or abrupt boundary to

B1 Horizon

Extends to a depth of about 25 cm.

- Moderately cemented, continuous, massive iron pan.
- Clayey sand or sandy loam.
- Yellowish brown (10YR 5/4) to greyish brown (10YR 5/2).
- Usually with 2%-10% orange mottles.
- pH is 6.0.
- More than 50% ironstone gravel.
- Abrupt boundary to

B2 Horizon

Extends to more than 50 cm depth.

- Sandy clay.
- Moderately pedal.
- Most commonly pale brown (10YR 6/3), but can be yellow (10YR 8/6) or brown (10YR 5/3).
- 10% to 20% fine, prominent orange mottles.
- pH is 6.0 to 6.5.
- Contains from 1% to 20% ironstone gravel.

Drainage: imperfectly drained;
Permeability: moderate;
Runoff: moderately rapid;
P.P.F.'s Dy5.42, Dy4.12.

3.6 Soil F - Very shallow gravelly duplex

This soil consists of brown-grey sand over sandy loam to sandy clay loam at 5 to 15 cm, which in turn overlies mottled sandy clay at about 20 cm. Often there are large amounts of gravel throughout the profile. There is only a small area of this soil on the Annex.

A1 Horizon

Extends to a depth of 5 to 15 cm.

- Medium to coarse sand to loamy sand.
- Apedal, massive, with a sandy fabric.
- Dark greyish brown (10YR 4/2), very dark greyish brown (10YR 3/2) or brown (10YR 5/3).
- pH ranges from 5.5 to 6.0.
- Up to 20% ironstone gravel.
- Small amounts of quartz gravel.
- Abrupt or clear boundary to

B1 Horizon

Extends to a depth of about 20 cm.

- Sandy loam to sandy clay loam.
- Yellowish brown (10YR 5/4) or light yellowish brown (10YR 6/4).
- Apedal massive, earthy fabric.
- May contain a large percentage of orange mottles.
- pH ranges from 6.0 to 6.5.
- Contains 2% to 20 % ironstone gravel.
- Small amounts of quartz gravel.
- Clear to gradual boundary to

B2 Horizon

Extends to more than 50 cm depth.

- Sandy clay.
- Moderately pedal.
- Light yellowish brown (10YR 6/4) or brownish yellow (10YR 6/6).
- Up to 50% orange mottles may be present.
- pH is 6.0 to 6.5.
- Up to 20% ironstone gravel may be present. Some quartz gravel.

Drainage:	imperfectly drained;
Permeability:	slowly permeable;
Runoff:	moderately rapid;
P.P.F.'s	Dy5.42, Dy4.12

3.7 Soil G - Deep yellow sandy duplex

This soil consists of a brown sand over yellow sand with a sandy fabric overlying a mottled sandy clay subsoil. This soil type occurs in two pockets in the lower end of the bottom paddock.

A1 Horizon

From the surface to about 12 cm depth.

- Medium to coarse sand.
- Single grained, sandy fabric.
- Usually brown (10YR 5/3), dark brown (10YR 3/3) on dark greyish brown (10YR 4/2).
- pH ranges from 5.5 to 6.0.
- Less than 2% ironstone gravel.
- Less than 2% quartz gravel.
- Abrupt or clear boundary to

A3 Horizon

Extends to a depth of between 45-70 cm.

- Medium to coarse sand.
- Single grained with a sandy fabric.
- Very pale brown (10 YR 7/4), brownish yellow (10 YR 6/6) or yellowish brown. (10 YR 5/4) 2-20% orange mottles are often present.
- pH ranges from 6.0 to 7.0.
- Less than 2% ironstone gravel.
- Less than 2% quartz gravel.
- Generally abrupt boundary to

B2 Horizon

Extends to more than 90 cm depth.

- Sandy clay.
- Moderately pedal.
- Most commonly light yellowish brown (10YR 6/4) but can be light grey (10YR 7/1), yellow (10YR 7/6,10YR 7/8).
- 20%-50% orange or pale mottles.
- pH ranges from 6.0 to 7.5.
- Less than 2% ironstone gravel.
- Less than 2% quartz gravel.

Drainage:	imperfectly drained;
Permeability:	moderate;
Runoff:	slow;
P.P.F.'s	Dy5.12, Dy5.22

3.8 Soil H - Red sandy loam

This soil consists of a red brown, coarse loamy sand to sandy loam A1 horizon over an intermediate B1 horizon at about 25 cm. These layers overlie a reddish clayey B2 horizon at 45 to 60 cms. Large dolerite rocks are often present.

The soil occupies a small area in the top paddock.

A1 Horizon

Extends to a depth of 15 to 30 cm.

- Coarse loamy sand to sandy loam.
- Usually massive, hardsetting.
- Colours are strong brown (7.5YR 4/6), dark brown (10YR 3/3) and brown (7.5YR 4/4).
- pH 6.0.
- Less than 2% ironstone gravel.
- Often 2-10% quartz gravel.
- Abrupt to gradual boundary to

B1 Horizon

Extends to a depth of 45 to 60 cm.

(Note - an intermediate A3 horizon may be present).

- Coarse sandy loam to clay loam.
- Strongly pedal.
- Strong brown (7.5YR 4/6), light yellowish brown (10YR 6/4).
- 2-20% faint to prominent orange mottles.
- pH ranges from 6.0 to 6.5.
- Less than 2% ironstone gravel.
- Often 2-10% quartz gravel.
- Clear boundary to

B2 Horizon

Which extends to a depth of more than 100 cm.

- Sandy clay to light medium clay.
- Strongly pedal.
- Most commonly red (2.5YR 4/8) or strong brown (7.5YR 4/6) but can be very pale brown (10YR 7/4).
- May contain red mottles.
- pH ranges from 6.5 to 7.0.
- Contains less than 2% ironstone gravel.
- Usually no quartz gravel.

Drainage:	imperfectly drained;
Permeability:	moderately slow;
Runoff:	rapid;
P.P.F.'s	Dr2.12, Dr2.13, Dr3.12.

4. Discussion

The eight soils were distinguished primarily on their potential to waterlog, rooting conditions and their moisture availability.

With the exception of the Deep gravelly duplex (soil C) and the Red sandy loam (soil H) all soils on the Annex suffer from some degree of waterlogging in wet years.

The clay subsoil of the duplex soils on the Annex is sodic (Appendix 2). As a result it disperses when wet, greatly reducing the permeability. After heavy rainfall events, a 'perched' watertable develops on top of the clay. These anaerobic conditions reduce plant growth and, if severe enough, can result in death of crop and pasture species. In addition to this, the pruning of roots due to winter waterlogging often results in crop and pasture species becoming prematurely drought stressed in spring. There does appear to be considerable variation in the structure of the clay across the Annex (Belford *et al*.). In some areas the clay has a greater hydraulic conductivity allowing more rapid movement of water into the clay, and as a result, experiences less frequent, shorter periods of waterlogging.

Many of the soils on the Annex have a bleached A2 horizon, indicating that leaching of nutrients has occurred due to periodic waterlogging. The yellow A3 horizon in soil G indicates that this soil is better drained. The presence of mottles in the A3 and B1 horizons of most soils on the Annex is due to the oxidation and reduction of iron compounds by seasonal waterlogging. The amount of mottles increases with the frequency and duration of waterlogging.

Duplex soils with a shallower depth to the clay layer generally become more severely waterlogged than deeper duplex soils. Their surface horizons fill up quicker because of the smaller volume of topsoil.

Sub-surface seepage flow along the clay layer of these soils also plays a major role in waterlogging. Where the clay layer occurs closer to the surface and at breaks in slope seepage water is forced closer to the surface. The flatter, bottom half of the Annex can become severely waterlogged in wet years (H. Morrel, land owner. Pers. comm.).

The clay subsoils of the duplex soils on the annex have high clod densities (Appendix 2) which would greatly hinder root development). It would be expected that most of the roots would grow and extract moisture in cracks between peds and clods.

The presence of an iron pan at a depth of about 25 cm in soil E could be expected to impede root growth of most species.

5. Acknowledgements

I would like to thank Harry Lauk, Martin Revell and Anne Revell for each assisting in the field.

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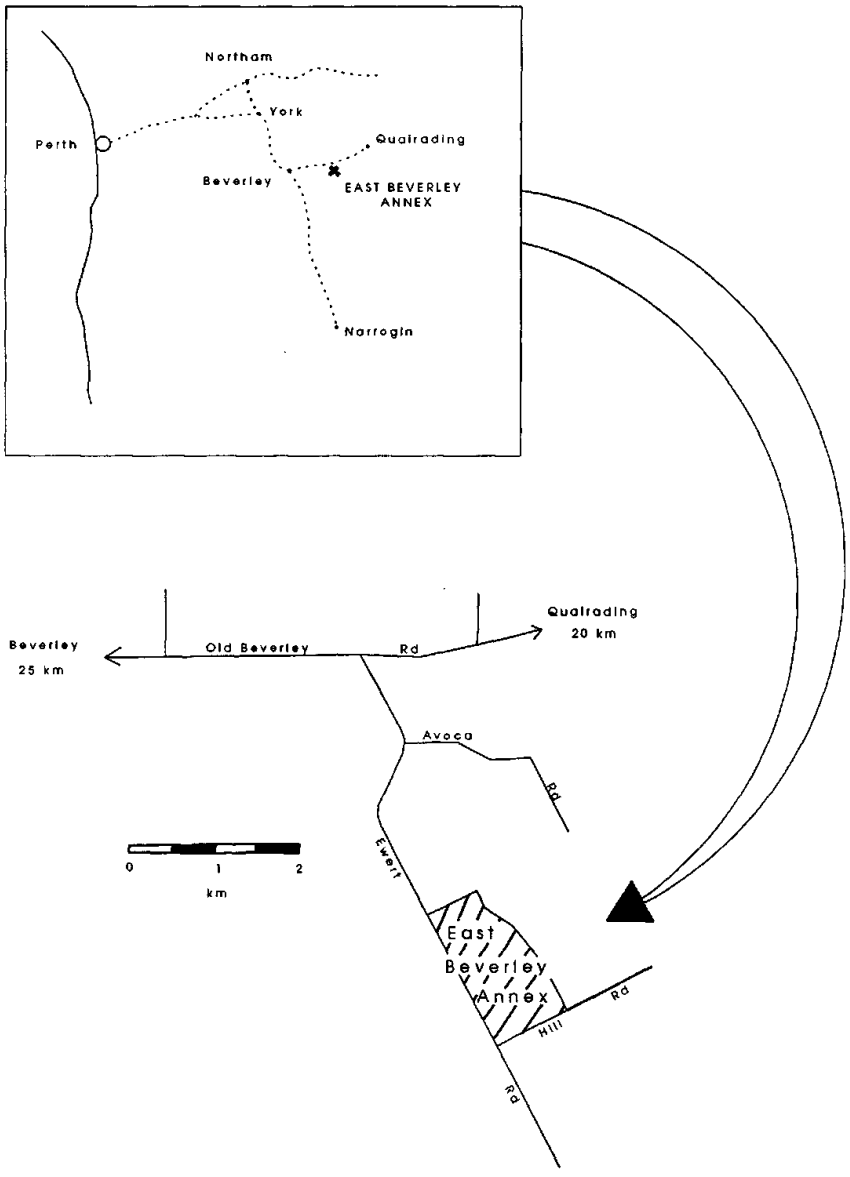
7.0 Appendices

Appendix 1 - Location of the East Beverley Annex to Avondale Research Station



Appendix 2. Physical and chemical properties of selected soils

Table 7.1. Exchangeable cations and organic carbon

Soil	Horizon	% Exchangeable cations m.e./100 g				C.E.C. m.e./100g	Exchangeable sodium %	O.C. %
		Ca	Mg	K	Na		Na	
Soil A	A1	1.29	0.14	0.10	0.07	2.8	3	1.38
	A2CB	0.19	0.10	0.03	0.06	1.1	5	0.19
	A3	0.26	0.62	0.05	0.07	1.5	5	0.15
	B21	0.18	2.39	0.14	0.29	3.3	9	0.11
	B22	0.10	1.89	0.21	1.80	4.2	43	0.06
Soil B	A1	0.93	0.33	0.12	0.10	2.4	4	1.26
	A3	0.40	0.31	0.08	0.02	1.7	1	0.35
	B2	0.29	2.90	0.05	0.88	4.1	21	0.06
Soil E	A1	0.98	0.23	0.10	0.03	1.8	2	1.21
	B1	0.75	1.64	0.03	0.10	3.3	3	0.10
	B2	0.48	3.35	0.05	0.49	4.4	11	0.05
Soil G	Al	0.65	0.33	0.08	0.03	2.3	1	0.94
	A3	0.30	0.18	0.05	0.02	1.1	2	0.17
	B2	4.65	0.93	0.10	2.37	8.6	28	0.07
Soil H	A1	1.58	1.49	0.14	0.34	5.7	6	1.78
	B21	0.44	3.14	0.05	0.48	5.2	9	0.50
	B22	0.25	3.06	0.05	0.99	5.2	19	0.35

Table 7.2. Clod density, pH and salinity

Soil	Horizon	Clod density	pH 1:5 H20	Ece mS/m
Soil A	A1	1.70	6.0	68
		1.77		
	A2	N/A	6.4	13
	A3	2.16	6.3	54
		2.01		
	B21	1.96	7.0	104
		1.77		
	B22	2.01	7.4	407
		1.99		
Soil B	A1	1.74	5.9	53
		1.64		
	A3	2.02	5.6	25
		2.01		
		1.93		
		1.92	N/A	
	B2	2.02	N/A	191
		2.00		
		2.00		
		1.99		
Soil E	A1	1.79	5.8	72
		1.57		
	A3	1.91	6.2	19
		1.90		
		2.25		
		2.22		
	B1	2.04	6.6	48
		2.04		
		2.02		
	B2	2.04	6.7	49
		2.10		
Soil G	A1	N/A	5.7	59

	A3	1.77	6.1	18
		1.74		
	B2	1.97	7.3	216
		1.96		
		1.95		
Soil H	A1	1.77	6.4	209
		1.76		
	B21	1.71	6.4	63
		1.70		
		1.99		
		1.98		
	B22	1.95	6.7	98
		1.77		

N/A = Not available.

Table 7.3. Particle size analysis

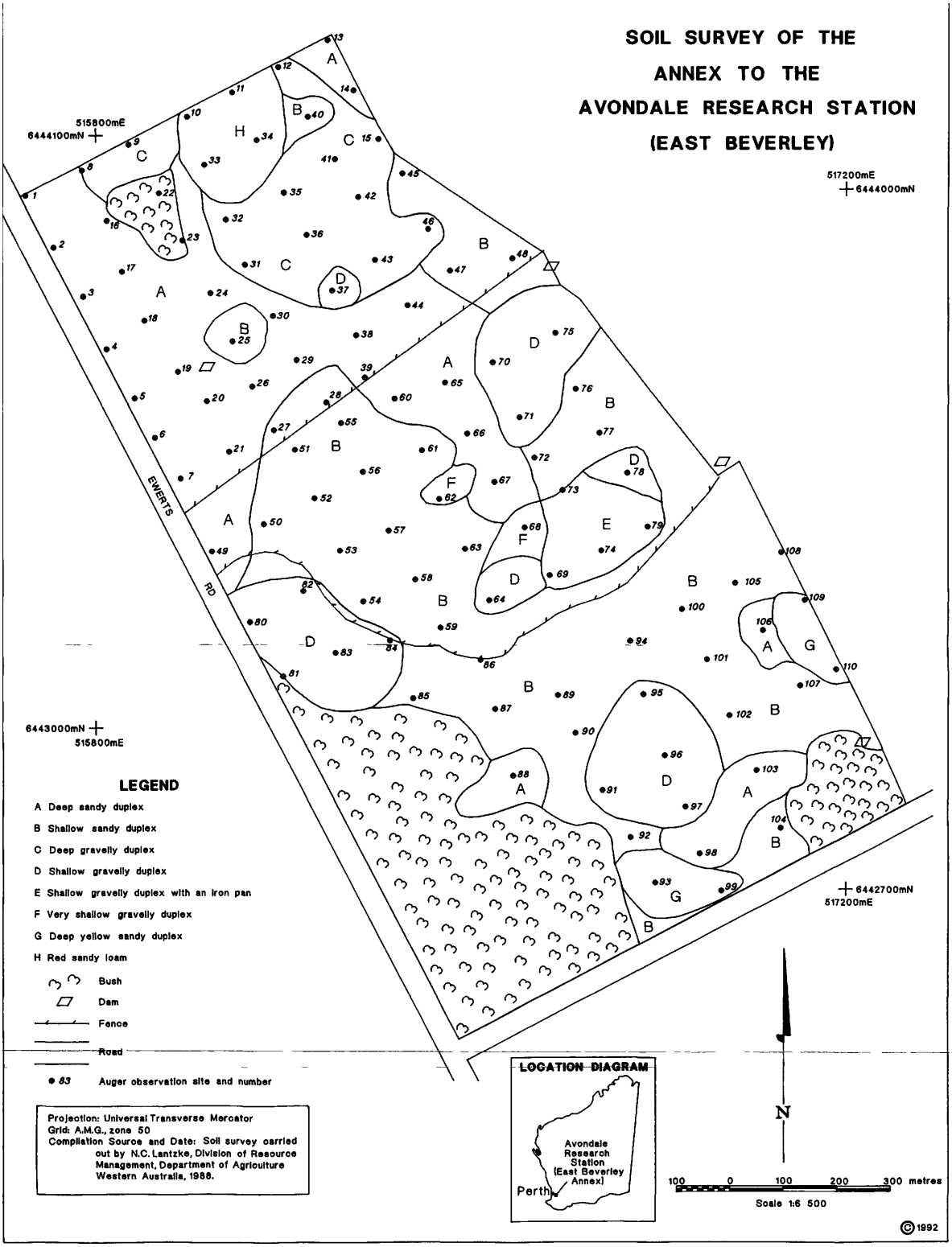
Soil	Horizon	Clay%	Silt%	Fine sand %	Coarse sand %	Gravel %
Soil B	A1	6.6	2.8	30.2	60.5	2.9
	A3	18.7	8.7	24.4	48.5	25.1
	B2	40.2	15.1	26.7	19.2	0.9
Soil D	A1	11.8	7.8	29.4	51.3	38.7
	A2	12.5	6.9	23.7	57.3	67.6
	B21	55.1	14.0	10.4	22.4	5.6
	B22	39.4	17.0	13.3	32.0	0.9
Soil E	A1	8.7	5.9	32.3	52.9	19.2
	A3	32.4	4.8	21.3	42.3	30.7
	B2	50.0	20.6	10.3	20.9	2.4
Soil H	B21	70.8	8.1	8.9	13.9	0.6
	B22	64.9	11.5	12.7	12.2	4.9

Table 7.4. Soil moisture retention results

Soil	Horizon	% Moisture (gravimetric)		Available
		1/3 bar	15 bars	
Soil B	A1	5.2	3.0	2.2
	A3	9.0	5.4	3.6
	B2	11.5	8.2	3.3
Soil D	A1	7.1	3.0	4.1
	A2	5.8	3.0	2.8
	B21	16.0	12.9	3.1
	B22	11.2	8.4	2.8
Soil E	A1	6.9	3.2	3.7
	A3	10.0	7.0	3.0
	B2	13.6	10.6	3.0
Soil H	B21	20.4	15.2	5.2
	B22	20.0	14.8	5.2

Analytical methods used were:

- Exchangeable cations: Modified Tucker method used by the Department of Agriculture, Western Australia and the Government Chemical Laboratories. (1M NH4Cl, pH = 7.0).
- Organic carbon: Walkley-Black method.
- Clod density, pH, salinity, particle size analysis and soil water retention: Loveday, J. (1974).


SOIL SURVEY OF THE
ANNEX TO THE
AVONDALE RESEARCH STATION
(EAST BEVERLEY)
515800mE
6444100mN
517200mE
6444000mN
6443000mN
515800mE
6442700mN
517200mE
EWERTS RD
LEGEND
A Deep sandy duplex
B Shallow sandy duplex
C Deep gravelly duplex
D Shallow gravelly duplex
E Shallow gravelly duplex with an iron pan
F Very shallow gravelly duplex
G Deep yellow sandy duplex
H Red sandy loam
Bush
Dam
Fence
Road
83 Auger observation site and number
Projection: Universal Transverse Mercator
Grid: A.M.G., zone 50
Compilation Source and Date: Soil survey carried out by N.C. Lantzke, Division of Resource Management, Department of Agriculture Western Australia, 1988.
LOCATION DIAGRAM
Avondale Research Station (East Beverley Annex)
Perth
N
100 0 100 200 300 metres
Scale 1:6 500
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