Chapter 1

Soils of the dryland cropping regions of Victoria and South Australia.

The dryland cropping (< 450mm annual rainfall) regions of Victoria and South Australia are dominated by neutral and alkaline soils that have many distinctive features, in particular constraints to crop growth within the subsoils. The following chapter will provide a description of some of the major soil types from these regions and some useful inferences about the subsoil characteristics of each soil type and how they may affect crop growth. Some management considerations are provided for each soil type as a general guide which can be used in conjunction with other critical information such as cropping and management history and recent climate.

Soils of the Mallee and Wimmera regions of Victoria

There are three major soil groups in the Mallee and Wimmera regions of Victoria: the Vertosols (cracking clay soils), Sodosols (soils with a strong texture contrast between surface and subsurface horizons and with subsoil horizons that are sodic) and Calcarosols (gradational textured soils with an abundance of carbonate [lime] in the profile).

Vertosols

Vertosols are often called cracking clay soils. They have a clay texture (>35% clay) throughout the profile; display strong cracking when dry, and shrink and swell considerably during wetting and drying phases. In *Australian Soil Classification* (Isbell 1996), Vertosols can be distinguished based on the nature of the surface horizon and the colour and chemical properties of the subsoil horizons. Based on colour of the upper 50 cm of the soil profile, they can be grouped into suborders. Grey Vertosols are the most common in the Wimmera, with minor occurrences of Red and Brown Vertosols.

The map of Vertosols in the Wimmera and Mallee regions (Fig. 1.1a) is based on the Land Systems of Victoria (1:250,000). It shows areas where Vertosols are most likely to occur within the region however other soil types may also occur within these mapped areas and minor areas of Vertosols may occur in areas not mapped here.

Vertosols in northwestern Victoria usually occur on level to gently undulating gilgai plains (Fig. 1.1b). The parent sediments are mainly alluvial and aeolian clayey materials that blanket some of the higher ridges, but occur mainly in the intervening fluviatile plains. On alluvium along creeks and rivers and on lakebed deposits, there are usually coarsely structured (Epipedal) grey Vertosols (Fig. 1.1c). Self-mulching Vertosol soils are common in the Horsham and Kaniva regions. An example of a Grey Vertosol is given below.

Landscape description

Location:	Murtoa
Soil Type:	Kalkee Clay
Soil Classification:	Epicalcareous-Endohypersodic, Self-mulching, Grey VERTOSOL
Landscape Description:	Mid-slope of a long gentle slope on the gently undulating plains landscape.

Figure 1.1b: Landscape of a Vertosol at Murtoa

Soil profile description:

Topsoil

0 – 5 cm	Dark greyish brown (10YR4/2); light clay; subplastic cracking and self-mulching surface condition; moderate granular structure; weak consistence dry; contains very few (< 2 %) hard carbonates; pH 8.6; sharp and wavy change to:

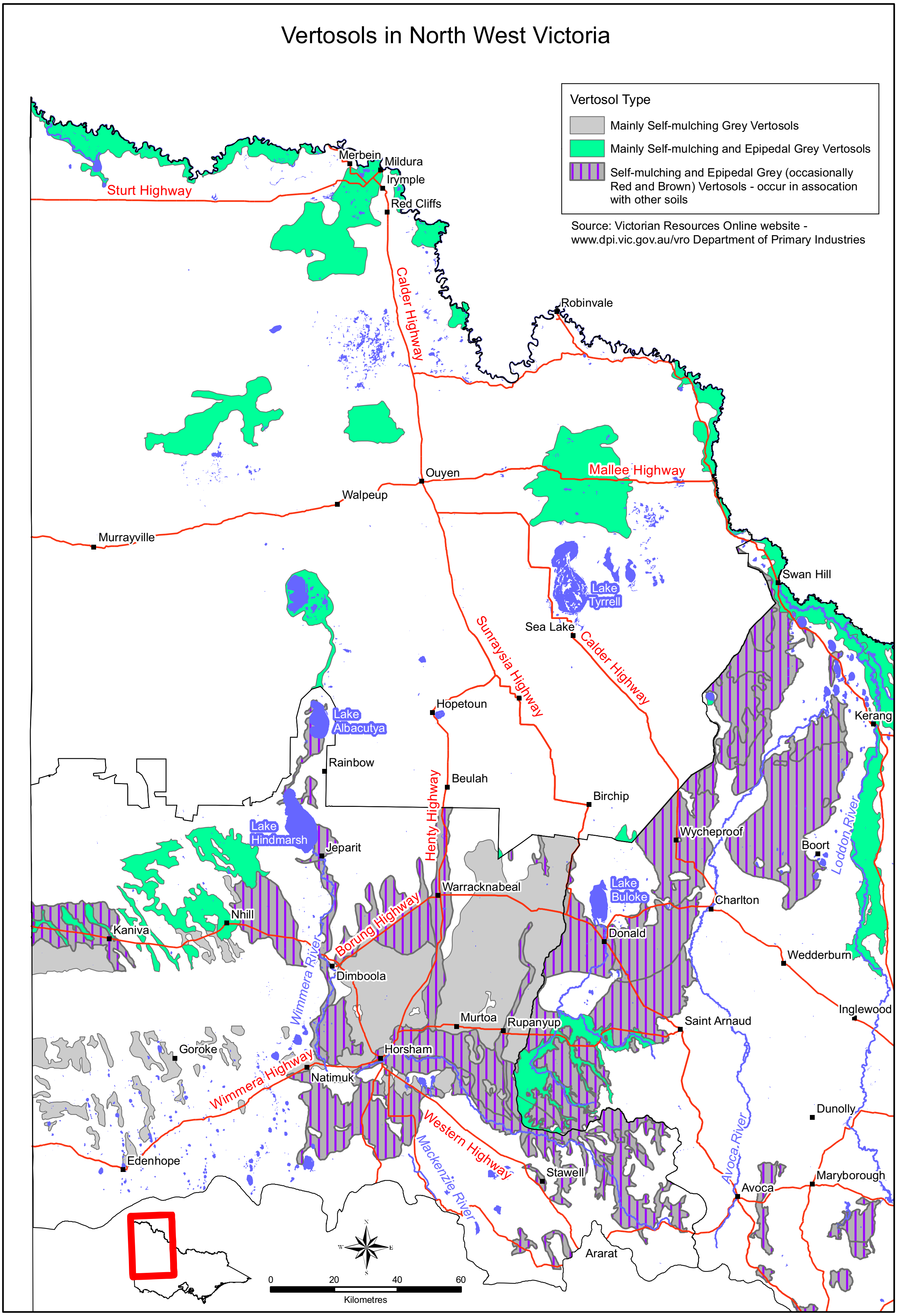

Figure 1.1a: Distribution of Vertosols in North West Victoria.

Subsoil horizons

5 – 25 cm	Dark greyish brown (10YR4/2); light medium clay; plastic; moderate very coarse prismatic structure; strong consistence dry, slightly sticky consistence wet; contains very few (< 2 %) hard carbonate; pH 9.1:
25 – 60 cm	Dark greyish brown (10YR4/2); heavy clay; plastic; moderate very coarse prismatic structure; strong consistence dry, slightly sticky consistence wet; contains very few (< 2 %) hard carbonates; pH 9.3:
60 – 85 cm	Greyish brown (10YR5/2); heavy clay; plastic; weak, very coarse subangular blocky structure; slickensides present; strong consistence dry, slightly sticky consistence wet; contains very few (< 2 %) hard carbonates; pH 9.3:
85 – 120 cm	Greyish brown (10YR5/2); heavy clay; plastic; weak, very coarse subangular blocky structure; slickensides present; strong consistence dry, slightly sticky consistence wet; contains very few (< 2 %) hard carbonates; pH 9.2;

Subsoil management Considerations

Plant Available Water Capacity (PAWC) is considered to be medium, ca. 105 mm, based on available laboratory data and assuming an effective rooting depth of 60 cm. Rooting depth will be restricted by the strongly sodic subsoil and increasing soluble salts. The availability of moisture to the plant will depend on soil structure and consistency and will be most available in the more friable surface horizon. In dense and coarsely structured subsoils it is likely that there will be a large amount of unused moisture at depth.

The strongly alkaline profile suggests that some nutrients (e.g. iron, manganese, zinc and copper) may be sparingly available to plants and that deficiencies are likely to occur. The high alkalinity of the soil profile will reduce the potential of the soil to support some crops (e.g. lupins).

The upper subsoil is sodic but does not disperse. As a result, root and water movement into the subsoil may not be as restricted as for other strongly dispersive soils.

The high levels of exchangeable calcium contribute to reducing dispersion. The deeper subsoil (from 60 cm depth) becomes strongly sodic and root and water movement is likely to be restricted there. The high level of exchangeable sodium in the subsoil may result in nutrient imbalances and have a toxic effect on some plants. The salinity rating becomes medium at 85 cm depth. This may restrict the growth of deeper-rooted salt sensitive species.

The subsoil displays strong vertic properties, indicating that significant shrinking and swelling occurs with wetting and drying cycles. This may disturb the roots of some plant species and has engineering implications.

Figure 1.1c: Soil profile of a grey Vertosol from Horsham

Soil Profile Characteristics

	pH	Salinity rating	Sodicity	Boron
Surface (A1 horizon)	Strongly alkaline	Low	Non-sodic	Low
Subsurface (B21 horizon)	Very strongly alkaline	Low	Sodic	Low
Subsurface (>1m)	Very strongly alkaline	Medium	Very strongly sodic	Low

Calcarosols

Calcarosols do not have a strong texture contrast between surface and subsurface horizons and are calcareous throughout. They often contain calcium carbonate (lime) as soft or hard fragments. They are most common in the north-east of the region. Calcarosols (often called 'mallee loams', 'mallee sands' or 'calcareous earths') are soils formed on calcareous aeolian sediments of variable texture. They generally have a small, gradual increase in clay content with depth. Lime is abundant in subsoils, occurring in soft form, nodules and sometimes as hard blocks. The soil profile is alkaline throughout and sodicity and salt are often high in the deeper subsoils. Heavier textured Calcarosols are more fertile and less erodible than sands, but more prone to salting and to hardsetting when over-cultivated.

The map of Calcarosols in the Wimmera and Mallee regions (Fig. 1.2a) is based on the Land Systems of Victoria (1:250 000). It shows areas where Calcarosols are most likely to occur within the region however other soil types may also occur within these mapped areas and minor occurrences of Calcarosols may occur in areas not mapped here.

Calcarosols vary quite considerably in terms of soil texture, ranging from those dominated by sands to those that are clayey throughout, and this has a big influence on the agronomic properties of the land. Three kinds of Calcarosols are shown on the map (Fig. 1.2a): light textured (sandy to loamy), heavy textured (clay loamy to clay) and stony (shallow profiles over calcrete).

Landscape description

Location:	Berriwillock
Soil Type:	Birchip Clay Loam
Soil Classification:	Epihypersodic, Pedal, Hypercalcic, CALCAROSOL
Landscape Description:	Level plain, with some low rises.

Soil profile description:

Topsoil

0-13 cm	Brown (7.5YR4/4); heavy fine sandy clay loam; weak coarse blocky structure; weak consistence (dry); highly calcareous; pH 8.6; abrupt change to:

Subsoil horizons

13-25 cm	Yellowish red (5YR5/6); light medium clay; moderate-strong coarse to medium to fine blocky structure; firm to strong consistence (dry); slightly-moderately calcareous; pH 9.2; gradual change to:
25-50 cm	Yellowish red (5YR5/6); light medium clay; moderate coarse to very coarse prismatic, parting to medium-strong coarse blocky structure; common (20%) fine earth carbonates; very highly calcareous; pH 9.6; gradual change to:
50-75 cm	Strong brown (7.5YR5/8) with some yellowish red (5YR 5/6) root channel infills; light medium clay; weak moderate coarse to very coarse prismatic, parting to moderate coarse to medium blocky structure; fine earth carbonates common (20%); highly calcareous; pH 9.6; gradual change to:
75-100 cm	Yellowish red (5YR5/6) with dark red (2.5YR4/8) mottles; medium clay; moderate coarse to medium prismatic structure; non-calcareous; manganese flecks in a continuous band between 80 – 100 cm depth, pH 9.4; gradual change to:
100+ cm	Yellowish red (5YR5/6); light medium clay; structured; non-calcareous; pH 5.8.

Figure 1.2b: Landscape of a Calcarosol at Birchip, Victoria.

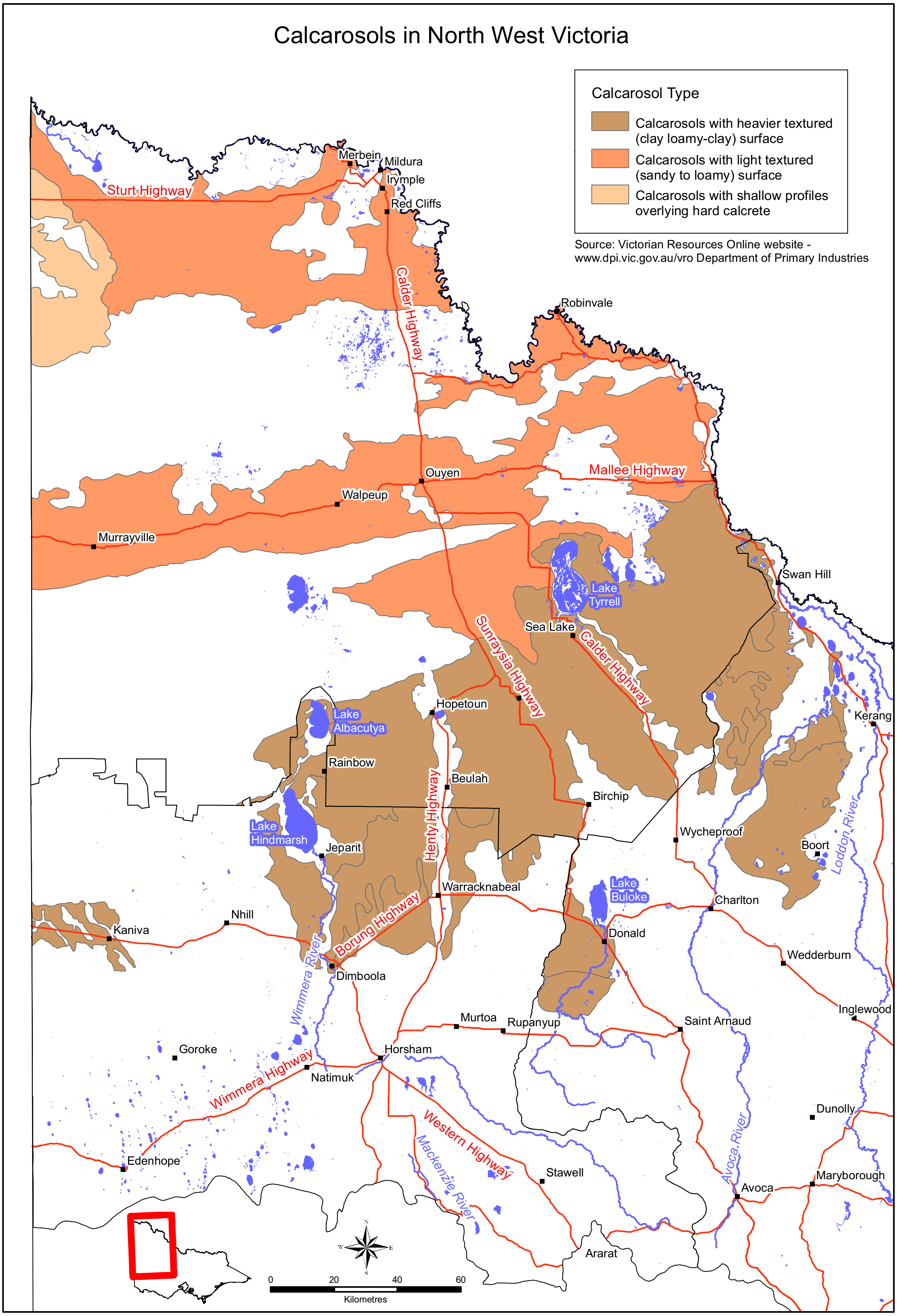

Figure 1.2a: Distribution of Calcarosols in North West Victoria.

Subsoil management Considerations

The soil profile is strongly to extremely alkaline throughout the upper 1 metre. This indicates that phosphorus and trace elements such as iron, manganese, copper and zinc may be poorly available to plants. The upper subsoil is strongly sodic but does not disperse. It is also relatively well structured compared to many of the strongly sodic upper subsoils in the region (parting well to medium to fine size blocky peds). It will provide fewer restrictions to root growth than the more coarsely structured horizons in the region. The deeper subsoil (i.e. from 25 cm depth), however, becomes more coarsely structured (and disperses after remoulding). This will result in more restricted root and water movement.

Boron concentrations can be toxic to plant growth. At this one pit site boron concentrations are highest in the 25 –100 cm depth range, being 19 – 27 mg/kg. This is quite high and may affect boron-sensitive species including cereals, pulses, pasture legumes. For example, concentrations as low as 10 ppm can reduce lentil yield. Limited data indicates that the threshold for level of soluble boron for cereals is 15 mg/kg (Cartwright *et al*, 1984). Other work at VIDA indicates that without the presence of significant levels of soluble salts, boron tolerance can be higher, with little reduction in wheat yield at up to 45 ppm (Quinlan, 2001). Boron tolerant lines may need to be considered. More extensive sampling across the paddock would give a better indication of boron concentrations.

The level of soluble salts increases with depth and becomes high enough to restrict the growth of salt sensitive species from 50 cm deep in the soil profile. The subsoil is strongly sodic (but does not disperse – unless remoulded when it disperses strongly). Dispersion may be restricted by the high level of soluble salts in much of the subsoil. The deeper subsoil (i.e. from 100 cm depth) becomes acid. This is the part of the soil profile that developed on the Tertiary Parilla Sandstone material prior to the deposition of windblown clays and carbonates that occurred during the Quaternary period.

Figure 1.2c: Soil profile of a Calcarosol near Birchip, Victoria.

Soil Profile Characteristics

	pH	Salinity rating	Sodicity	Boron
Surface horizon (Ap)	Strongly alkaline	Low	Non sodic	Low
Subsurface (13-25 cm)	Very strongly alkaline	Low	Strongly sodic	Moderate
Subsurface (at 50-75 cm)	Extremely alkaline	High	Strongly sodic	High
Subsurface (100+ cm)	Moderately acid	High	Strongly sodic	Low

Sodosols

Sodosols have a strong texture contrast between loamy surface (A) horizons and clayey subsurface (B) horizons. The subsoils are sodic (ie. Exchangeable Sodium Percentage (ESP) is 6 or greater) and not strongly acid (ie. pH 5.5 or greater). Sodosols can be separated on the basis of the colour of the upper 20 cm of the subsoil into Red, Brown, Yellow, Grey and Black groups. Sodosols (Fig. 1.3a) occur on a wide range of landforms (from gently undulating plains and rises to undulating low hills). Surface soil textures and depths vary considerably and have significant implications for management affecting: soil workability and permeability, crop establishment, moisture availability and erodibility. The subsoils are sodic, generally quite dense and coarsely structured (characterised by coarse prismatic, columnar or blocky peds) and disperse when wet, resulting in restricted root and water movement through the profile.

The distribution of Sodosols throughout the Wimmera and Mallee regions of Victoria is shown in Figure 1.3a. Sodosols tend to be found mainly in the southern, eastern and western Wimmera with smaller areas in the northern Mallee and east of Birchip.

Landscape description

Location:	Sea Lake/Watchupga Rd
Soil type:	Sodic Red Mallee Clay loam
Classification:	Vertic (& Calcic), Red SODOSOL
Landscape Description:	Lower slopes of broad subdued N/S trending ridges.

Soil profile description:

Topsoil

0-10 cm	Brown (7.5YR4/4); sandy clay loam; hardsetting surface; firm consistence (dry); non-calcareous; pH 6.8; abrupt change to:

Subsoil horizons

10-20 cm	Reddish brown (5YR4/4) with many yellowish red (5YR5/8) mottles; medium heavy clay; moderate strong coarse blocky, parting to medium blocky structure; slickensides present; slightly calcareous; strong consistence (dry); pH 8.7; clear change to:
20-50 cm	Yellowish red (5YR5/8); medium clay; moderate-strong blocky, parting to moderate blocky structure; slickensides present; moderately calcareous; few (5%) fine earth carbonates; strong consistence (dry); pH 9.1; clear change to:
50-80 cm	Yellowish red (5YR5/8) and reddish yellow (5YR6/8); light medium clay; weak coarse prismatic, parting to moderate-strong blocky structure; fine earth carbonates common (15%); very highly calcareous; weak consistence (slightly moist); pH 9.2; clear change to:
80-120 cm	Reddish yellow (5YR6/6); medium clay; weak prismatic to polyhedral structure (with some patches of strongly structured material); weak consistence (slightly moist); highly calcareous; pH 9.2;

Figure 1.3b: Landscape of a Sodosol in the southern Mallee.

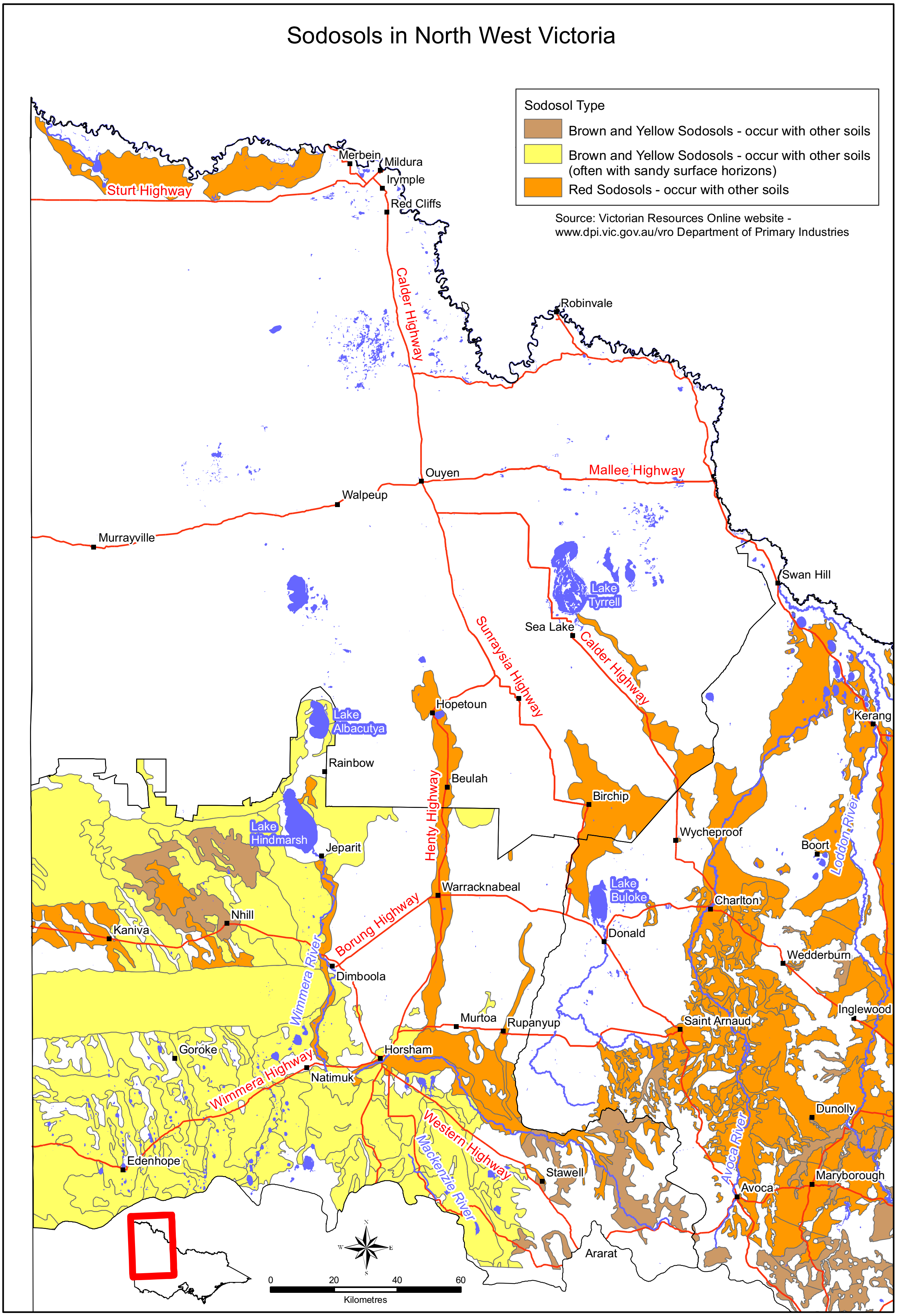

Figure 1.3a: Distribution of Sodosols in North West Victoria

Subsoil management considerations

Management strategies for all soils should aim to: increase organic matter in the surface soil, minimise the degradation of soil aggregates and porosity, promote the development of stable biopores, improve the calcium status of the cation exchange complex (particularly when sodium is a significant part) and break up any hardpans. Less frequent tillage, using less aggressive implements and working the soil at optimum moisture content can all assist in maintaining soil aggregation and porosity as well as reducing the breakdown of organic matter.

The subsoil is mainly very strongly alkaline, which indicates that in this zone phosphorus and trace elements such as iron, manganese, zinc and copper may be poorly available for plants. Boron toxicity can also occur in strongly alkaline soils. Boron levels measured in the deeper very strongly alkaline subsoil (i.e. from 50 cm depth) are reasonably high at this pit site and may affect boron-sensitive species (including cereals, pulses, pasture legumes). The level of soluble salts becomes high in the deeper subsoil (from 50 cm depth) and this is likely to restrict the growth of deeper-rooted salt sensitive species.

Figure 1.3c: Soil profile of a Sodosol from the southern Mallee, Victoria.

Soil profile description

	pH	Salinity rating	Sodicity	Boron
Surface (0-10cm)	Slightly acid	Low	Sodic	Low
Subsurface (10-20cm)	Moderately alkaline	Low	Strongly sodic	Low
Subsurface (50-80cm)	Very strongly alkaline	High	Strongly sodic	High
Subsurface (at 120cm)	Slightly acid	Very high	Strongly sodic	Low

Dryland cropping soils of South Australia

There are three major soil groups in South Australian cropping zone that are neutral to alkaline: the Sodosols (soils with a strong texture contrast between surface and subsurface horizons and with subsoil horizons that are sodic), the Calcarosols (gradational textured soils with an abundance of carbonate ('lime') in the profile) and Chromosols (soils with a strong texture contrast between surface and subsurface horizons and with subsoil horizons that are not sodic and have a alkaline reaction trend). Unlike north-western Victoria, cracking clay (Vertosols) soils are uncommon.

Chromosols

There are a wide variety of Chromosols in South Australia but one group, those with surfaces that set hard on drying and which have alkaline subsoils, are by far the most commonly cropped. This group occupies 20% of the potential rain-fed cropland area of South Australia (Fig. 1.4a).

General Description

Hard setting reddish brown stony sandy loam to clay loam overlying a strongly structured dark reddish brown clay with soft calcareous segregations at depth, forming in gravelly fine grained alluvium. Lower slope of a gently inclined alluvial fan. Hard setting surface with 10 – 20% quartzite stones and a slope of 4%.

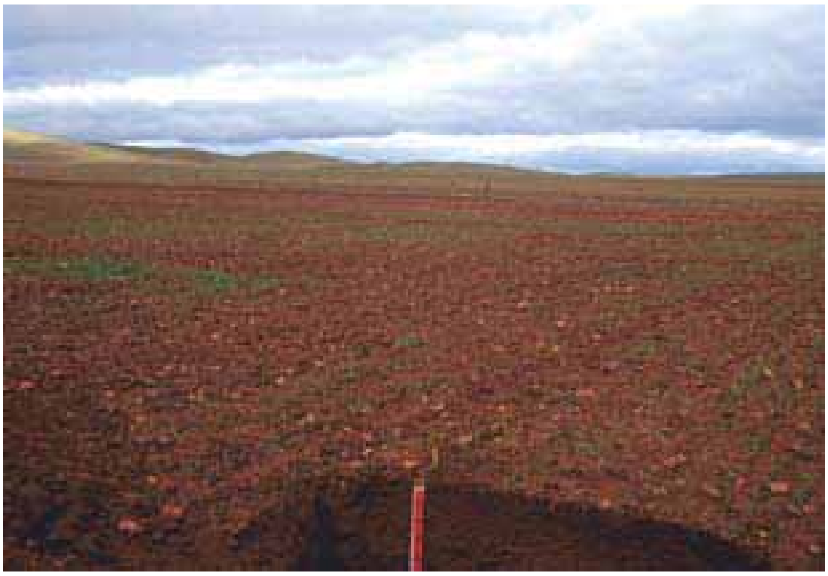

Figure 1.4b: Landscape of a Chromosol in the mid-north of South Australia.

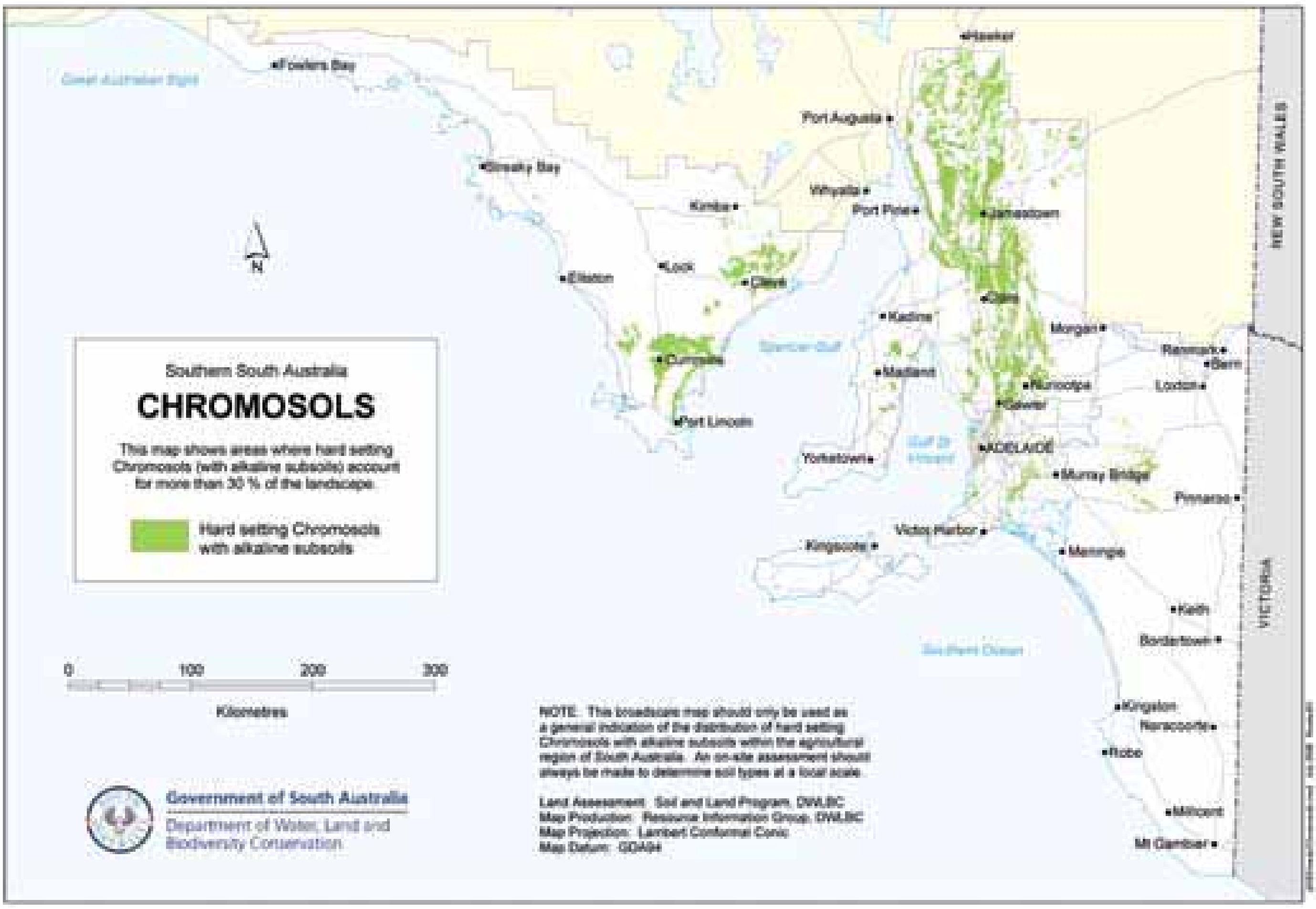

Figure 1.4a: Distribution of hard setting Chromosols with alkaline subsoils in South Australia.

Soil profile description:

Topsoil

0 – 11 cm Reddish brown hard setting loam with weak granular structure and 2-10% shale gravel. Clear to:

Subsoil horizons

11 – 27 cm Red clay loam with weak polyhedral structure and 2 – 10% shale gravel. Clear to:

27 – 40 cm Red clay loam with weak polyhedral structure and 10 – 20% shale gravel. Abrupt to:

40 – 70 cm Dark red medium heavy clay with strong coarse prismatic breaking to angular blocky structure and 2 – 10% shale gravel. Gradual to:

70 – 130 cm Dark red and orange light clay with strong subangular blocky structure, 2 – 10% shale gravel and 2 – 10% soft and nodular (Class I) carbonate.

Figure 1.4c: Soil profile of a typical Chromosol in South Australia.

Management considerations

Soil water storage is variable in Chromosols, ranging from 100 – 200 mm. Usually well drained but dense clay subsoils may impede drainage and restrict root penetration at depth. Subsoil boron levels in some Chromosols may be considerable, but not in the example provided below.

Soil Profile Characteristics

	pH	Salinity rating	Sodicity	Boron
Surface horizon (0-11cm)	Neutral	Low	Low	Low
Subsurface (11-27 cm)	Neutral	Low	Low	Low
Subsurface (27-40 cm)	Slightly alkaline	Low	Low	Low
Subsurface (40-70 cm)	Slightly alkaline	Low	Low	Low
Subsurface (40-70 cm)	Moderately alkaline	Low	Moderately sodic	Low

Calcarosols

Some 40% of the soils in the dryland cropping zone of South Australia consist of two predominate types of Calcarosol: shallow soils over calcrete – usually less than 50cm deep, or deeper soils (≥ 50cm) which tend to have a massive structure at depth and high levels of boron and sodium that affect root growth.

General Description

Calcareous sandy loam grading to a very highly calcareous sandy clay loam with abundant rubble, over heavy clay at depth. Low rise with a slope of 2%. Firm surface with minor calcrete stones.

Figure 1.5b: Typical landscape for a calcarosol.

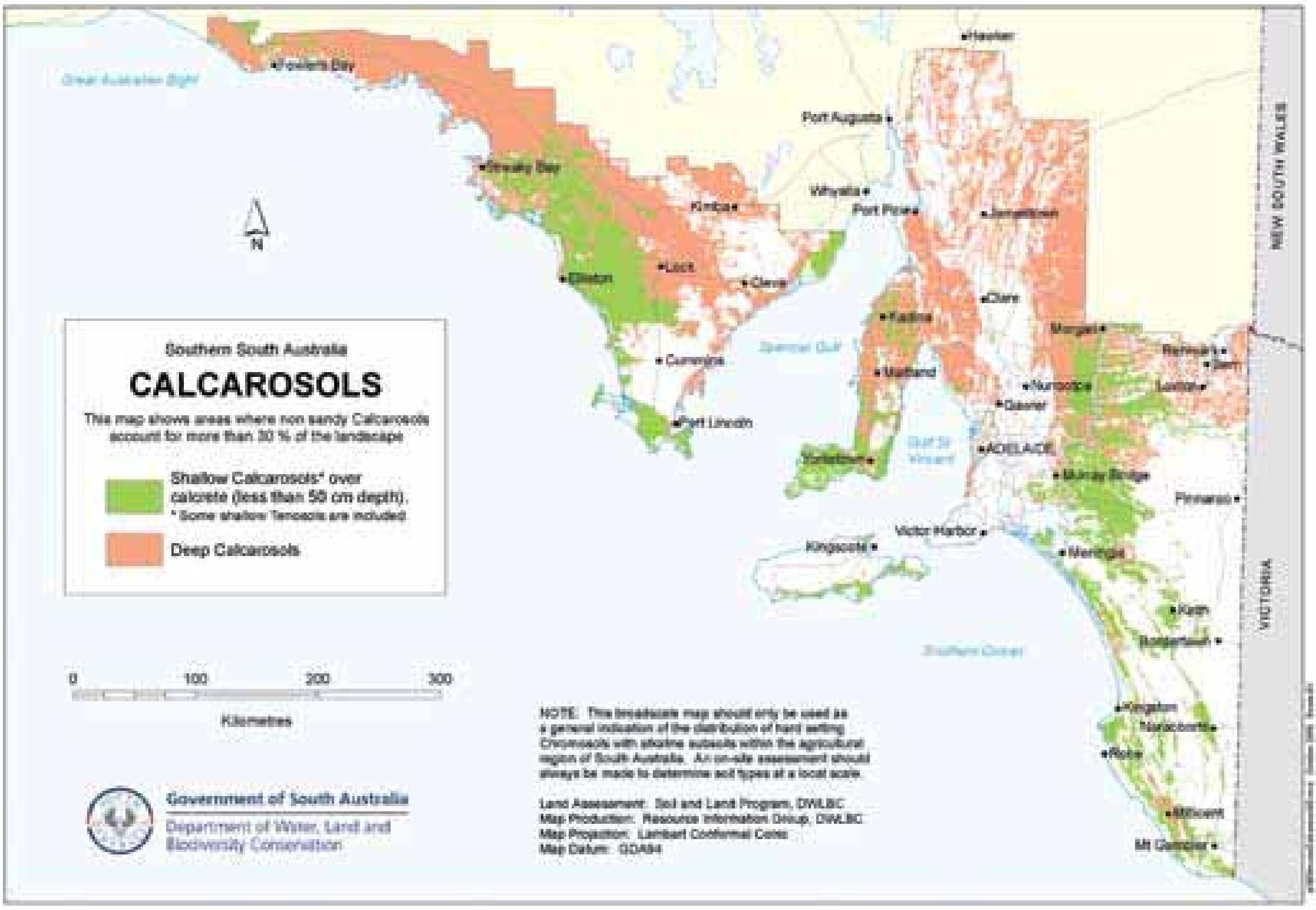

Figure 1.5a: Distribution of Calcarosols in South Australia.

Soil profile description:

Topsoil

0 – 9 cm Dark brown firm highly calcareous sandy loam with 2% carbonate nodules. Abrupt to:

Subsoil horizons

9 – 20 cm Dark brown highly calcareous light sandy clay loam with 2% carbonate nodules. Clear:

20 – 45 cm Brown very highly calcareous sandy clay loam with more than 50% carbonate nodules (6 – 20 mm). Diffuse to:

45 – 72 cm Pink very highly calcareous light clay with 2 – 10% carbonate nodules (6 – 20 mm). Diffuse to:

72 – 100 cm Orange highly calcareous medium clay with weak coarse prismatic structure. Diffuse to:

100 – 140 cm Orange and light grey highly calcareous medium clay with moderate coarse prismatic structure.

Management considerations

Soil water availability is generally low within the root zone, 50 – 100 mm. The soil is well drained and rarely remains saturated for any considerable length of time. Root penetration may be limited by the presence of calcrete fragments in deeper Calcarosols, or completely on shallow Calcarosols due to the presence of a calcrete layer. Nutrient availability is very low and the use of fertilisers, particularly zinc and phosphorus, is considered essential. The presence of toxic concentrations of boron and excess sodium will impede root growth at depth (highlighted in yellow).

Figure 1.5c: Soil profile of a deep Calcarosol in South Australia.

Soil Profile Characteristics

	pH	Salinity rating	Sodicity	Boron
Surface horizon (0-9cm)	Slightly Alkaline	Low	Low	Low
Subsurface (9-20 cm)	Moderately alkaline	Low	Low	Low
Subsurface (20-45 cm)	Alkaline	Low	Low	Low
Subsurface (45-72 cm)	Highly alkaline	Highly Saline	Highly sodic	Low
Subsurface (72-100 cm)	Highly alkaline	Highly Saline	Highly sodic	High

Sodosols

A large proportion of the cropping soils of South Australia have sodic properties. Those that have sufficient sodicity to qualify for the Sodosol category have:

- Surface horizons sandy, subsoils shallow (<30cm thick)
- Surface horizons sandy, subsoils deep (≥30cm)
- Hardsetting surface horizons over alkaline subsoils
- Pedaric Sodosols (Sodosols with friable subsurface horizons)

Those soils with sandy surface horizons overlying deep subsoils are by far the most common (almost 50%).

General Description:

Medium thickness sand with a bleached A2 layer, abruptly overlying a coarse-structured dispersive red clay, calcareous with depth.

Figure 1.6b: Example landscape for a Sodosol in South Australia

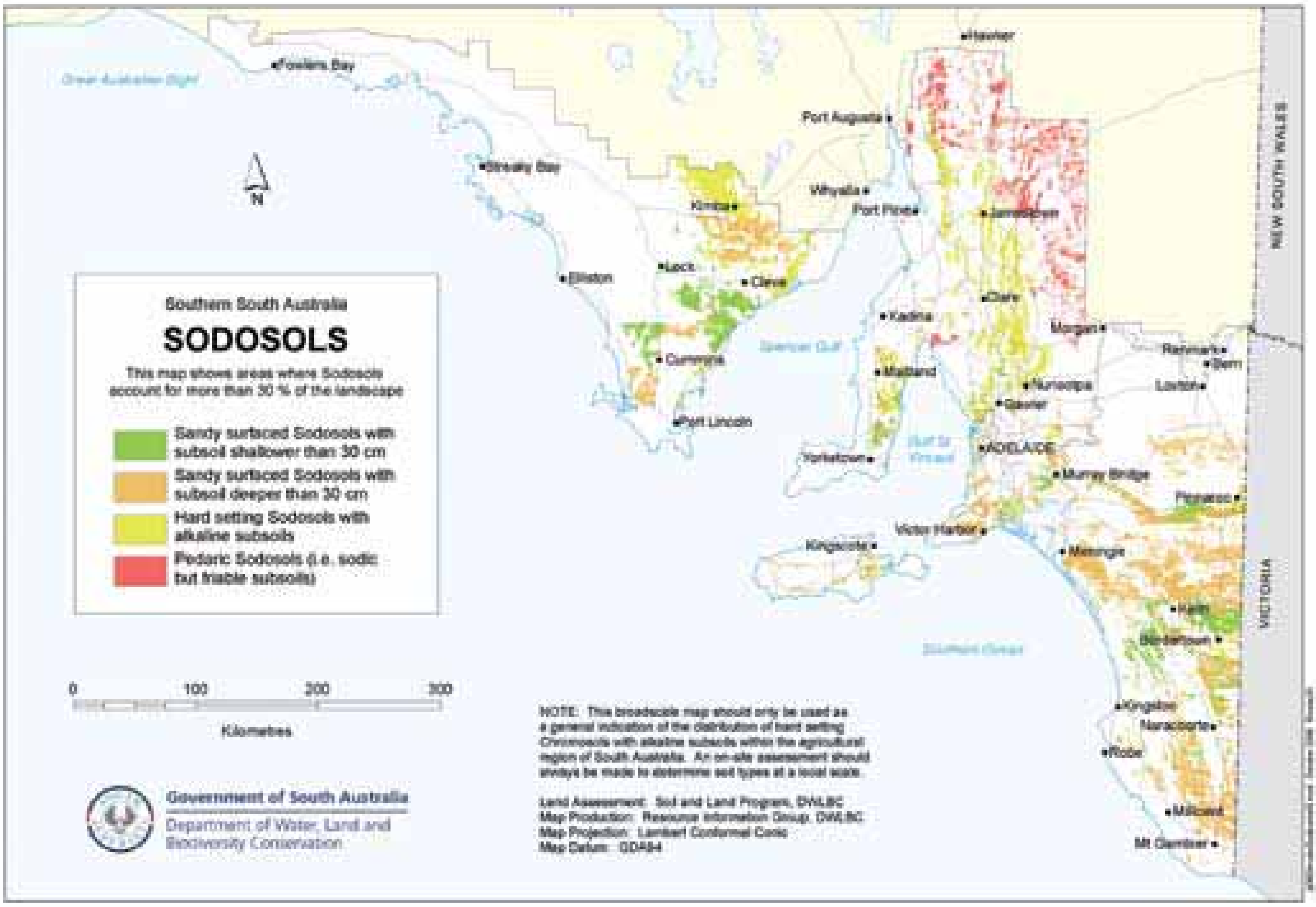

Figure 1.6a: Distribution of the various types of Sodosols in South Australia.

Soil profile description:

Topsoil

0 – 9 cm Dark greyish brown soft loamy sand. Abrupt to:

Subsoil horizons

9 – 18 cm Brown soft loamy sand. Clear to:

18 – 23 cm Bleached soft sand. Sharp to:

23 – 38 cm Yellowish red and yellowish brown hard sandy clay with coarse columnar structure. Gradual to:

38 – 54 cm Red and yellowish brown hard medium clay with coarse columnar structure and minor fine carbonate. Gradual to:

54 – 135 cm Yellowish red and brownish yellow massive calcareous sandy clay with 10 – 20% carbonate nodules.

Figure 1.6c: Soil profile for a Sodosol in South Australia.

Management considerations

Water availability is low to moderate depending on the depth of the topsoil horizon. Clay spreading is often used to counter any water repellent surface soils. Drainage is imperfect, with a saturated zone occurring temporarily over the dense clay subsoil horizon. The high soil strength of the clay subsoil restricts root penetration. Nutrient availability is very low in the bleached horizon overlying the clay subsoil, which may be sodic and moderately saline.

Soil Profile Characteristics

	pH	Salinity rating	Sodicity	Boron
Surface (0-9cm)	Slightly acidic	Low	Low	Low
Subsurface (9-18cm)	Slightly acidic	Low	Low	Low
Subsurface (18-23cm)	Neutral	Low	Low	Low
Subsurface (23-38 cm)	Alkaline	Low	Highly sodic	Very high
Subsurface (38-54 cm)	Highly alkaline	Saline	Highly sodic	Very high
Subsurface (54-90 cm)	Highly alkaline	Highly saline	Highly sodic	Very High

Further Reading

Quinlan, J. (2001). Sorting out the boron problem. Wimmera farming and landcare Newsletter pp. 19-20. Victorian Department of Natural Resources and Environment (Horsham).

Cartwright, B. Zarcinas, B.A. and Mayfield, A.H. (1984). Toxic concentrations of boron in a red-brown earth at Gladstone, South Australia. *Aust. J. Soil Res.* **22**, 261-272.