Fertility and water holding capacity of Liverpool Plains cropping soils

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Introduction

Some concerned landholders have asked me to give a presentation on the cropping soils of the Liverpool Plains. The PAC office advised that the purpose of these presentations is to specifically address issues raised in the Addendum SSDA-Watermark Coal Project (SSD-4975). This presentation is in support of any proposal to strengthen existing arrangements to protect these soils (Recommendations 1, 2 in Addendum SSD-4975, November 2014).

Recommendations

The arable basaltic soils (Vertosols) of the Liverpool Plains are rare in higher rainfall areas and have exceptional properties for the long term production of food and fibre. In my view the Watermark Coal project poses the following threats to these soils from which they should be protected:

1. *Physical encroachment*
2. *Undermining that may lead to subsidence*
3. *Compaction by vehicular traffic, machinery or other factors that may limit infiltration of rainfall, plant establishment and normal growth.*
4. *Disturbance that will promote concentration of flood water and gully erosion*
5. *Chemical contamination or physical disturbance that will lessen or compromise the existing inherent desirable physical and chemical characteristics of these soils.*
6. *Contamination with salt or saline water.*
7. *Contamination with heavy metals or other toxic substances.*
8. *Contamination via fuel spillage and poor containment of drilling fluids or similar substances.*
9. *Contamination with material from excavation.*
10. *Contamination with dust that may reduce crop productivity or reduce the value of crop product.*

Soils of the Liverpool Plains

Most simply, the soils of the Liverpool Plains fall into three groups:

1. Light textured soils on the hills which are derived from old sediments and now are seldom cropped.

Heavy textured soils derived from volcanic material particularly basalt:

2. Shallow soils on steep country such as on the Liverpool Ranges.
3. Deeper, arable soils on lower slopes and the alluvial plains (Vertosols).

It is the last group, **the Vertosols**, which concern us here.

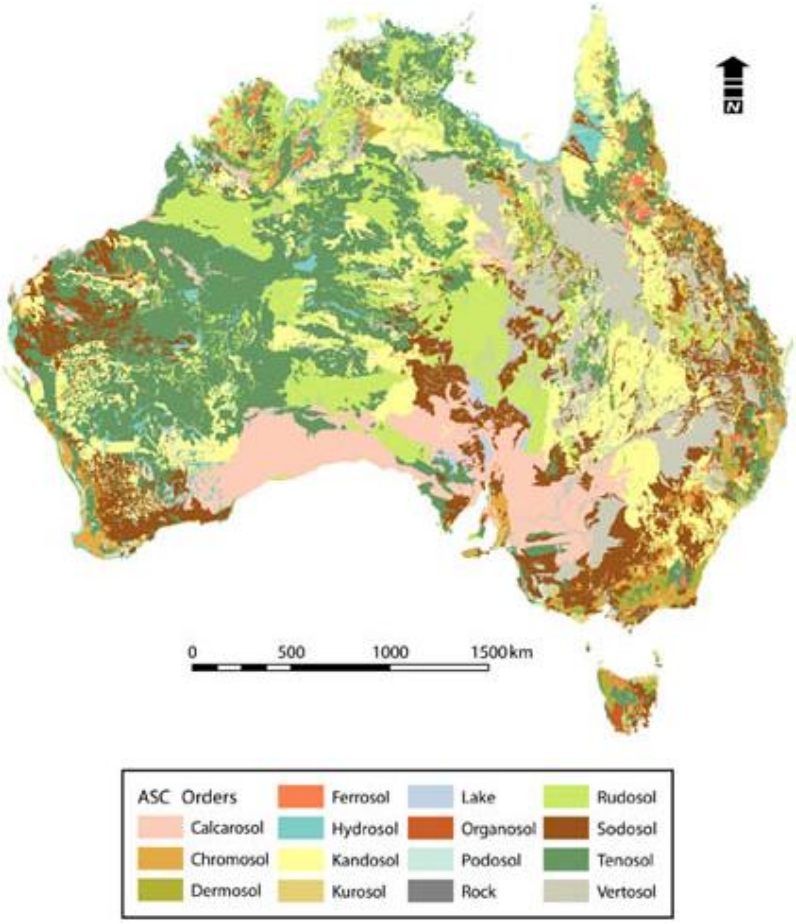
These soils are variously known as Black, Grey, or Brown Vertosols (or vertisols), cracking clays, black earths and black cotton soils. They are deeply coloured, are mildly to strongly alkaline, have a high cation exchange capacity, are well endowed with plant nutrients in their native state and are rich in moisture reactive clay which is self mulching on the surface with deep cracks forming down the profile as it dries, shown in Picture 1 below.

Picture 1. Black Vertosols. Self mulching surface soil (left) and deep cracking of dry profile (right)

Globally, Vertosols cover approximately 257 million ha of the earth's surface. They occur extensively in India (72 million ha), northern Australia (71 million ha), Sudan (63 million ha) and other African regions, the Americas and parts of eastern China.

The natural vegetation of Vertosols is grassland and grassy woodland. The heavy texture and unstable behaviour of the soil makes it difficult for many tree species to grow, and forest is uncommon. The shrinking and swelling of Vertosols can lead to extensive subsidence with damage to buildings and roads.

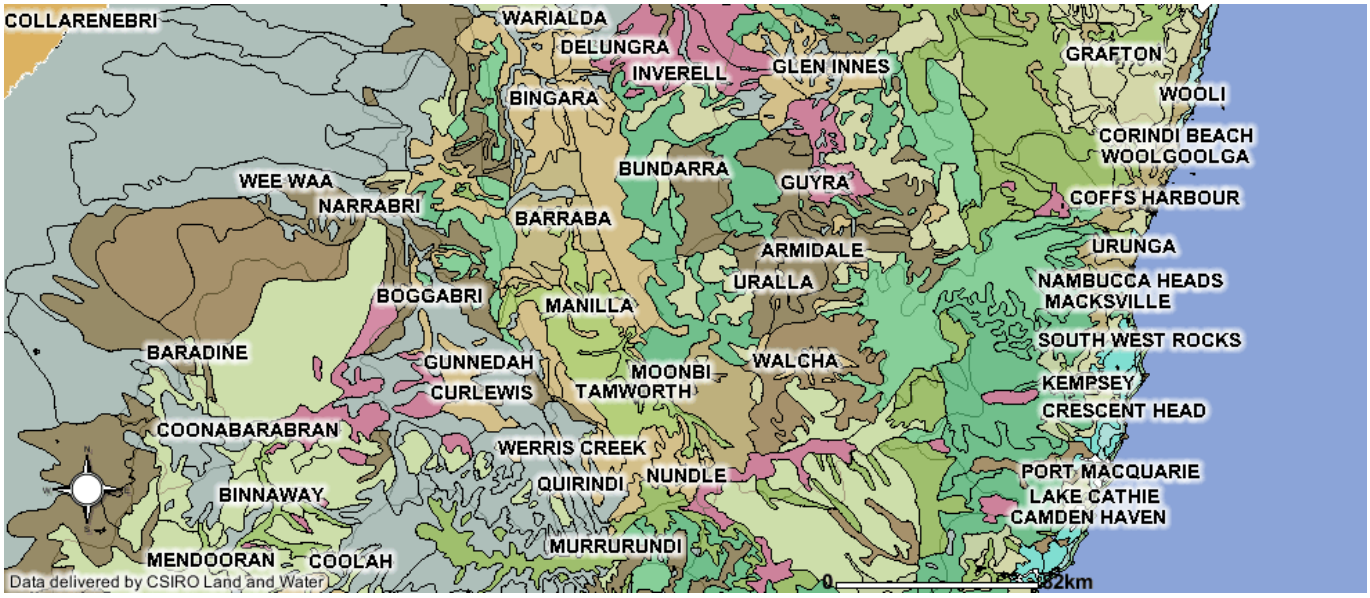
In Australia, they constitute only a small proportion of the arable land which receives sufficient rainfall for reliable and profitable annual cropping and should be viewed as an elite and valuable resource to be conserved. Vertosols are shown in grey on the maps (1, 2) below:



Map 1. Map of Australian soils

Vertosols receiving sufficient and reliable rainfall to grow rainfed crops occur sporadically in a narrow N-S band from Emerald (Queensland) to Quirindi-Coolah (NSW) and in parts of the Wimmera region in western Victoria. (http://www.asris.csiro.au)

Map 2. Map of soils of northern NSW. Vertosols are shown as grey and occur on the Liverpool Plains (south and west of Quirindi and north to Boggabri), around Warialda and Coolah, and the drier areas to the west. (http://www.asris.csiro.au)



Why are Vertosols such a valuable resource?

1. These are elite soils which are relatively rare in the cropping regions of Australia (Maps 1, 2).
2. They are eminently suited to zero tillage and response cropping (see end note) and their large water holding capacity enables successful rainfed cropping in areas of variable rainfall.
3. Basaltic soils in their virgin state are rich in plant nutrients and do not suffer acute deficiency in phosphorus like most other arable soils in Australia.
4. When managed properly using zero tillage technology, which has now been widely adopted (Young and Schwenke 2013), these soils are well structured and provide an excellent medium in which to grow crop plants.
5. These soils are highly reactive to moisture — they shrink when dry leaving large cracks sometimes metres deep (picture 1) and swell when wet increasing their volume by up to 20%.
6. This capacity to shrink and swell confers an ability to (i) store rainfall extractable by crop plants, (ii) recover from compaction without the need for cultivation.
7. The self mulching surface soil and water storage capacity of the soil profile enables farmers growing rainfed (dryland) crops to plant up to two crops in a year should there be sufficient water stored in the soil (response or opportunity cropping).

The fertility of the alluvial soils of the Liverpool Plains was acknowledged in SSDA-Watermark Coal Project (SSD-4975). But even these fertile soils ultimately are mined of nutrients which need to be replaced by mineral fertilisers or organic amendments to maintain crop yield (Young *et al.* 2014).

However, it is the exceptional water holding capacity of these soils when properly managed using zero tillage technology that distinguishes them from most other cropping soils in Australia. This has been amply demonstrated by recent field research on the Liverpool Plains (Ringrose-Voase *et al.* 2003, Young *et al.* 2008).

Vertosols have the ability to absorb rainfall at one time and hold it for extraction by crop plants up to many months, even years, later. A review of research literature has shown that these soils have few peers in their ability to conserve rainfall. Measurements of crop water use, both in field plots and on commercial crops on

the Liverpool Plains and elsewhere have shown that wheat, sorghum, sunflower and chickpea crops can extract over 250 mm of stored water from these soils (Young *et al.* 2008).

For example, in a detailed study of a Liverpool Plains farmer's wheat crop with a dry finish to the growing season, the crop yielded 8 t/ha while using 450 mm of water of which 260 mm was stored soil water. That is, more than ½ the water needed by the crop was stored in the soil before it was planted (Young *et al.* 2008). Similarly, the grain sorghum crop shown in Picture 2 used a total of 400 mm of water, of which 66% was stored soil water, to produce 7 t/ha.

Picture 2. Measuring the water use of grain sorghum on Vertosols on the Liverpool Plains. This crop yielded 7 t/ha mostly on water stored in the soil before planting.

The yield potential of wheat crops grown on these soils compared to a range of Australian cropping soils is illustrated by the schematic graph (Fig. 1) below. A survey of crop yields (vertical axis) in many regions over many seasons with large variation in rainfall (horizontal axis) yielded a scatter of grain yield/rainfall points represented by the blue shaded area. The commercial Liverpool Plains crops in the recent study (red diamond) were positioned amongst the most water efficient elite crops to the left.

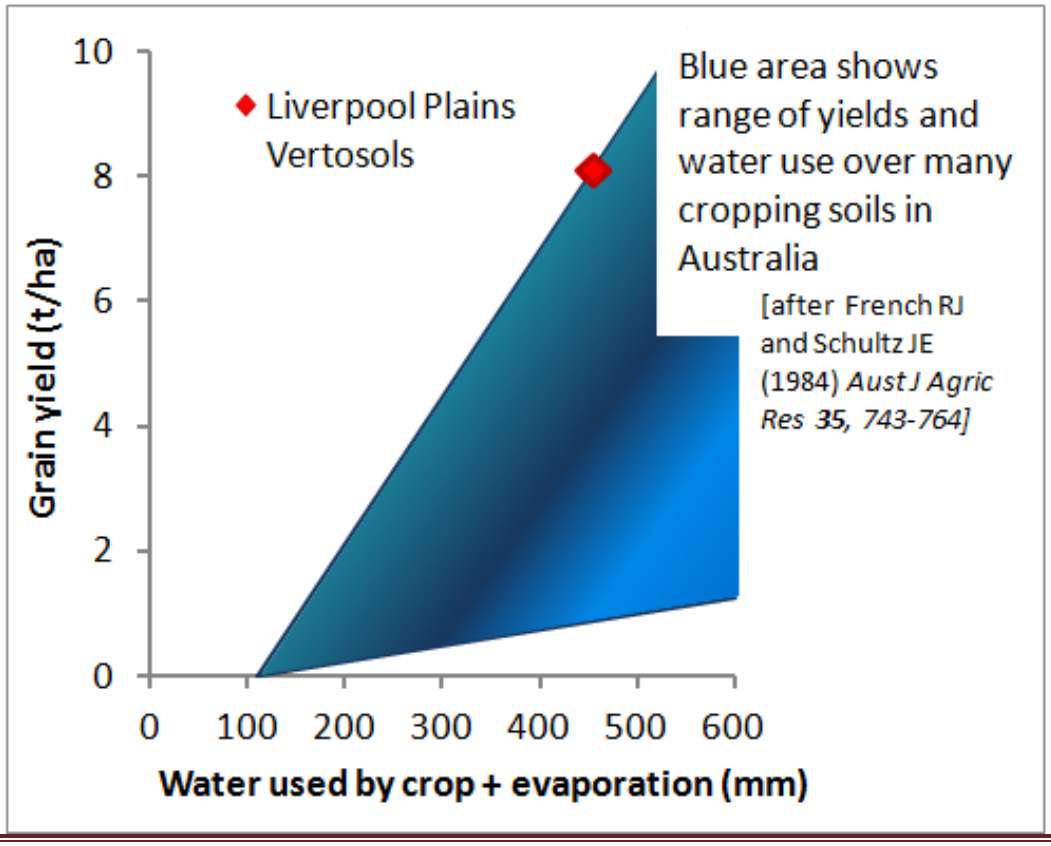


Fig. 1. Well managed Liverpool Plains Vertosols enable very efficient use of water for grain production

Conclusion

Vertosols are elite soils and are relatively rare in the higher rainfall cropping zones of Australia. It is their exceptional water holding capacity and excellent structure when properly managed that distinguishes them from most other Australian cropping soils. When managed using zero tillage technology, Vertosols are an excellent medium in which to grow crops in a climate with variable rainfall such as the Liverpool Plains. Up to 250 mm of water can be stored in the soil profile which is available on demand to crop plants. Zero tillage cropping on these soils allows farmers to take advantage of good seasons by response or opportunity cropping. Field research has shown that healthy rainfed crops grown under systems of zero tillage response cropping are able to make near maximum possible use of available water for grain production. Any proposal to strengthen existing arrangements to protect these soils (Recommendations 1, 2 in Addendum SSD-4975, November 2014) should be strongly supported.

References

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2. Young RR, Derham P-J, Dunin FX, Bernardi AL, Harden S (2008) High crop productivity with high water use in winter and summer on the Liverpool Plains, eastern Australia. *Australian Journal of Agricultural Research* **59**, 303–320.
3. Young Rick, Huth Neil, Harden Steven, McLeod Ross (2014) Impact of rain-fed cropping on the hydrology and fertility of alluvial clays in the more arid areas of the upper Darling Basin, eastern Australia. *Soil Research* **52**, 388–408.
4. Young, Rick and Schwenke, Tina (2013). Transition to Zero Tillage: A Survey of Farming Practices up until 2003 on the North West Slopes and Plains of NSW. 56 pp. Addendum to Final Report to the GRDC for project DAN 00027 'By how much can water use efficiency be increased and deep drainage reduced by optimal cropping system management on Vertosols in North Western NSW'. NSW Department of Primary Industries Tamworth Agricultural Institute Tamworth NSW Australia.

Note on zero tillage cropping. Traditional continuous winter cereal cropping, mostly wheat, and long fallow wheat-sorghum rotation meant burning of crop residues for disease control and passage of cultivation and planting implements. The repeated cultivation needed for weed control and seedbed preparation produced widespread compaction of the soil which impeded root growth and infiltration of rainfall. Zero tillage cropping in its mature form comprises retention of crop stubble, chemical weed control, planting and fertiliser placement with minimum disturbance of soil and crop residue using specialised machinery and restriction of the wheels of tractors and machinery to permanent wheel tracks to confine compaction to about 10% of the cropped land. Livestock are often excluded from cropped land to preserve standing stubble and reduce compaction.

An example of zero tillage response cropping is shown in the photograph below. A crop of mung bean (a summer crop) was planted into the stubble of the previous season's wheat crop as the soil profile had been sufficiently recharged with rain after wheat harvest.

Picture 3. Summer growing mung bean planted into last season's wheat stubble. (photographs by the author)