zone management

Interest in precision agriculture, including yield mapping and satellite imagery, is rapidly increasing. Whilst the images themselves provide information, additional value can be gained from using them to target ground-truthing (eg. soil sampling) as a means of determining sources of paddock variation. Management strategies to address this variation through treating similar zones within a paddock according to their needs, rather than the paddock as a whole, may increase overall efficiency.

1. Zone Management of Subsoil Constraints

Project collaborators:
Felicity Gummer[1], John Angus[2], Guy McMullen[3], Kirrily Condon[1], Bernard Hart[4]
([1]FarmLink, [2]CSIRO, [3]NSW DPI, [4]Hart Bros Seeds)

Aim: To identify variable zones within paddocks using yield maps and electromagnetic (EM) surveys, and to manage the zones according to the source of variability (identified through subsoil sampling).

Method: In 2004, yield maps and EM surveys of 5 paddocks across the FarmLink region were collated. High and low yielding zones in each paddock were identified from the maps and grower experience. These were subsequently GPS located and ground-truthed by soil sampling to identify any subsoil constraints that may be causing the variable production within the paddock. The soil samples were taken to a depth of up to 1.5m, and divided into intervals for analysis.

Based on the subsoil constraints identified in 2004 (Table 1a), 4 treatments were applied to each zone before sowing in 2005 at 4 of the sites. The treatments, each covering 1ha per zone, consisted of:

- deep rip only (to ~35cm)
- deep rip + surface application of lime or gypsum
- deep rip + subsoil application of lime or gypsum
- surface application only of lime or gypsum

Table 1a - Site details (subsoil test results)

	Co-operators	zone 1 ('upslope')*	zone 2 ('downslope')*
Marrar	B & V Langtry	subsurface acidity	subsurface acidity
Morangarell	N Haddrill	sodic >80cm saline >60cm	sodic throughout; saline >40cm
Osborne	K & M Bender	sodic >60cm saline >40cm	slightly acid topsoil; sodium increasing at depth
Rand	R & S Trethowin	subsurface acidity	slightly acid topsoil; sodium increasing at depth
Barmedman	R McLaren	subsurface acidity	subsurface acidity

***these names were applied for consistency. There was no difference in elevation at Morangarell or Barmedman.**

Definitions used:
subsurface = 10-20cm
acid = pH_{CaCl2} < 5
sodic = >6% exch. sodium in topsoil, >15% in subsoil
saline = chloride > 600mg (moderate >300mg), EC>2dS

Figure 1a - Deep ripping tine on 'ripper/injector'

zone management

The treatments were applied using an innovative 'ripper/injector' developed specifically for the project by Hart Bros Seeds and Coolamon Steelworks (Figure 1b).

The implement is based on a 5-tine Yeomans Plow (kindly on loan from Yeomans Plow Co.), which has been modified with a fertiliser bin and air hoses. Air pressure is used to effectively blow the desired rate of soil ameliorant (eg. lime, gypsum) to depth, with 2 outlets located approximately 5 and 7cm above the tine (Figure 1a). Tines are spaced 60cm apart and rip to ~35cm. At this depth, the power requirement is ~60hp per tine, assuming heavy dry soil.

Results are being monitored over time using yield maps and in-crop measurements, including:

- plant establishment and tiller counts
- crop water use
- soil strength
- ameliorant distribution (lime)
- temperature

Results: As there are no immediate responses expected from the application of ameliorants, results apply to the effect of deep ripping (Table 1b). Please note that the trials are large scale demonstrations so paddock variability needs to be considered when interpreting results.

Plant/tiller counts:
There appeared to be a small effect of deep ripping on plant establishment at the Osborne site, with plant numbers 10% higher in the ripped areas. There was no effect on tiller numbers.

Crop water use:
Permanent wilting point (PWP), the point at which plant roots can no longer extract water, was measured at all sites. Soil water content post harvest in 2004 and at anthesis in 2005 was also measured to determine if plants were able to access all the 'available' soil moisture, or if factors, such as subsoil constraints, were limiting root growth:

Morangarell -

- there was no difference in PWP between the zones. The 2004 wheat crop actually

Figure 1b - 'Ripper/injector' developed for the project

Photo: F. Gummer

Table 1b - Results (soil water and soil strength)

Measurement	zone 1 ('upslope')	zone 2 ('downslope')
Marrar		
PWP	little difference between zones	
water use pre-treatment (2004)	both used near PWP	
water use post ripping (2005)	no effect of ripping; both zones used near PWP	
bulk density	NA	
penetrometer	NA	
Morangarell		
PWP	little difference between zones	
water use pre-treatment	both zones used below PWP (soil cracking at harvest?)	
water use post ripping	no effect of ripping	
bulk density	(too dry at sampling)	
penetrometer	lower resistance in ripped area	
Osborne		
PWP	118mm more	118mm less
water use pre-treatment	used close to PWP	unused water below ~80cm
water use post ripping	more water in ripped	no effect of ripping
bulk density	lower in ripped to ~70cm	no effect of ripping
penetrometer	lower resistance in ripped	no effect of ripping (higher soil strength)
Rand		
PWP	14mm more	14mm less
water use pre-treatment	used close to PWP	unused water ~60-100cm
water use post ripping	more water in unripped	no effect of ripping
bulk density	lower in ripped from ~40-70cm	no effect of ripping
penetrometer	lower resistance in ripped	higher resistance in ripped to 20cm - ponding?

zone management

extracted water *below* the PWP in both zones. This may have been due to the appearance of cracks at harvest causing further soil drying.

- after treatments were applied in 2005, deep ripping had little impact on water use by the field peas in either zone.

Osborne -

- there were large differences in PWP between zones, with the 'downslope' zone being 118mm less than 'upslope' due to lower clay content.
- It also appears the 2004 wheat crop was unable to access some water below ~80cm in the 'downslope' zone (Figure 1c). Although this may be a result of increasing sodium levels at depth, a similar pattern would also have been expected 'upslope' where sodicity (and chloride) was more severe (Figure 1d).
- deep ripping in 2005 appears to have had no effect on improving soil water use in this zone (Figure 1e). It does, however, appear to have increased available soil water in the other zone, perhaps due to greater infiltration with the opening up of the soil.

Rand -

- there was a small difference in PWP between zones, with the 'downslope' zone being 14mm less than 'upslope'.
- the 2004 canola crop was able to extract water to near PWP in the 'upslope' zone, but there appeared to be unused water from ~60-100cm depth in the 'downslope' zone (Figure 1f). This may be related to elevated levels of sodium found in this zone, although not defined as 'sodic' (Figure 1g).
- as with Osborne, deep ripping in 2005 had little effect on soil water use in this zone, but there still appeared to be water left unused by the wheat crop at 40-100cm (Figure 1h). In contrast, deep ripping in the 'upslope' zone appears to have increased water use at depth.

Figure 1c - Soil water post '04 harvest, Osborne ('downslope')

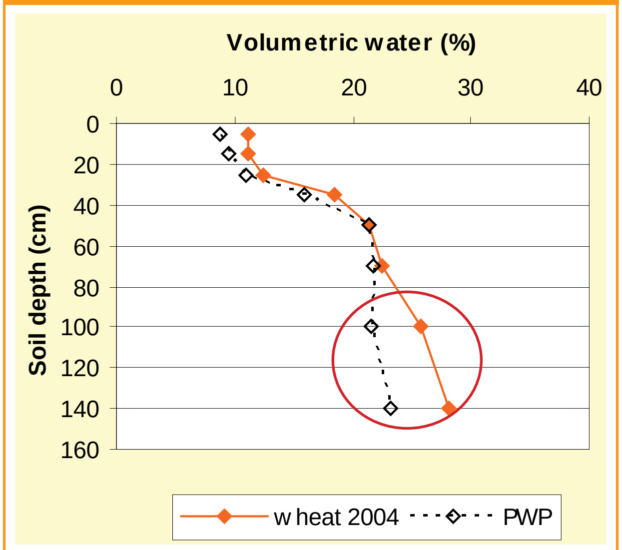


Figure 1d - Exchangeable Sodium % (ESP), Osborne

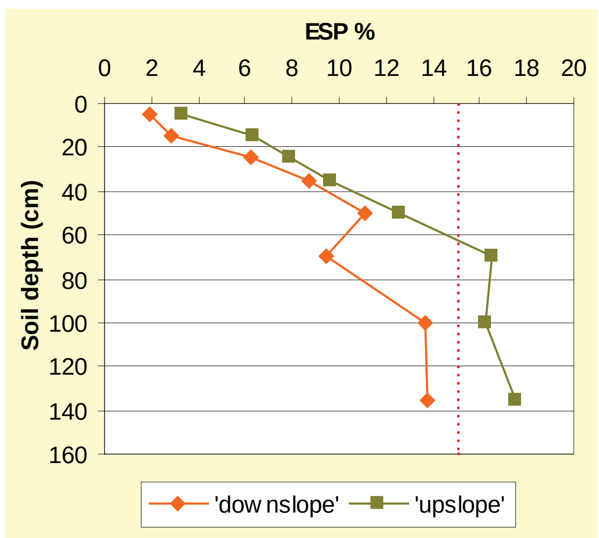
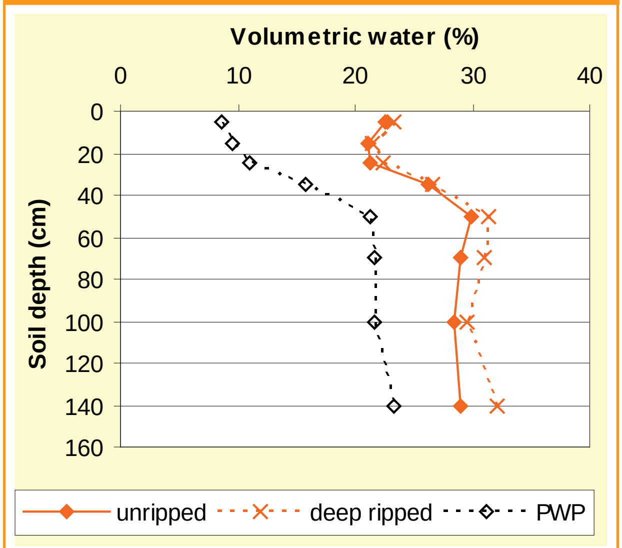


Figure 1e - Soil water post ripping '05, Osborne ('downslope')



zone management

Marrar -

- there was little difference in PWP between zones. The 2004 canola crop utilised water to near PWP in both zones.
- deep ripping in 2005 had no effect on soil water use, with the wheat crop extracting to PWP in both zones regardless of ripping.

Soil strength:

Soil strength was measured at 3 of the sites using a penetrometer and soil bulk density (as an indicator) to determine the impact of deep ripping. (Dry conditions prevented reliable measurements at Marrar):

Morangarell -

- deep ripped soil had lower penetrometer resistance than the un-ripped area, both above and below the ripping depth (35cm). This indicates that ripping may have allowed more rain to penetrate deeper, creating softer soil at depth.
- very dry soil at sampling meant bulk density measurements were variable, with no consistent differences after deep ripping.

Osborne -

- only the 'upslope' zone showed lower resistance from deep ripping. As with Morangarell, lower resistance was also found below the ripping depth, again indicating rainfall was able to penetrate deeper into the soil. The 'downslope' zone, which showed no difference in resistance, had much greater soil strength.
- bulk density measurements agreed with penetrometer results, with the 'upslope' zone showing lower bulk density in the ripped area to a depth of ~70cm (Figure 1i). There was no difference in the 'downslope' zone.

Rand -

- as with Osborne, only the 'upslope' zone showed lower resistance in the deep ripped area. However the opposite occured in the 'downslope' zone, with the ripped area having higher resistance in the top 20cm. This may have resulted from water ponding above a hard pan in the unripped area, leaving the soil softer and less resistant.

Figure 1f - Soil water post harvest '04, Rand ('downslope')

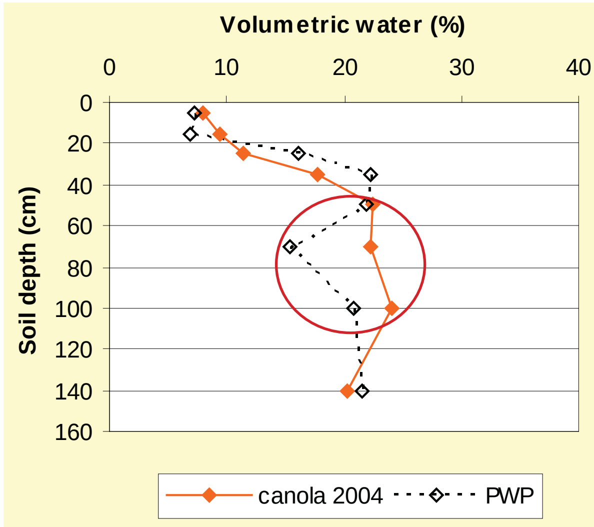


Figure 1g - Exchangeable Sodium % (ESP), Rand

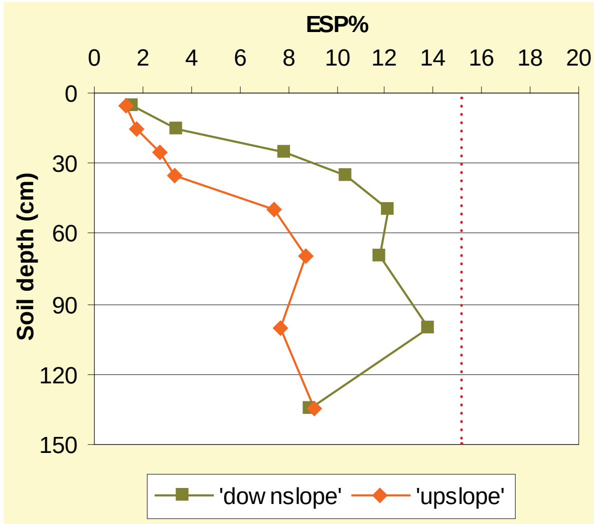
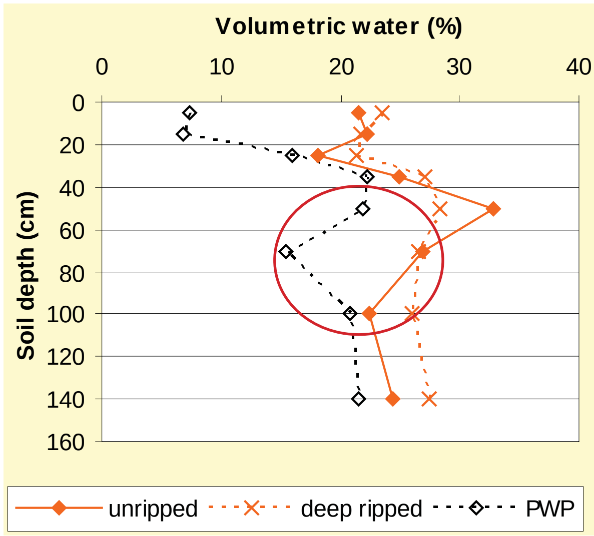


Figure 1h - Soil water post ripping '05, Rand ('downslope')



zone management

- bulk density measurements agreed with penetrometer results, with the 'upslope' zone showing lower bulk density from ~40-70cm (Figure 1j). There was no indication of higher bulk density in the ripped area of the 'downslope' zone.

At the 3 sites where penetrometer resistance was measured, the reduction in soil strength due to ripping was the same within and between the rip lines.

Lime distribution:
In spring 2005, soil pH was measured in 5cm layers within and between the rip lines where lime had been injected at the Marrar site. These results were compared with where lime had been topdressed. Surprisingly there was no evidence that lime had increased pH in the acid throttle at 10-20cm. This result will be re-examined in future studies.

Temperature:
Due to large differences in elevation between the zones at the Marrar site, temperature loggers were placed in each zone in 2004 to determine if frost was causing yield differences. As reported in the 2004 FarmLink Research Report, the lower zone 'downslope' recorded consistently lower temperatures throughout the season and is suspected to be the main cause of yield variation, rather than subsoil issues.

Yield:
Yield maps were produced from the 2005 harvest. Although there were no obvious treatment effects at any of the sites, visual responses were evident in the deep ripped treatments at Morangarell throughout the year. Whilst this hasn't translated into a general yield response, field pea yields were higher in the 'upslope' zone where deep ripping and gypsum topdressing occurred (Figure 1k), although this may just be a result of paddock variability. Responses will continue to be monitored over the next few years.

This project has been funded by the National Landcare Program.

Acknowledgements: *Yeomans Plow Co, Hart Bros Seeds, Coolamon Steelworks, Intersales Temora, all co-operators.*

Figure 1i - Soil bulk density, Osborne ('upslope')

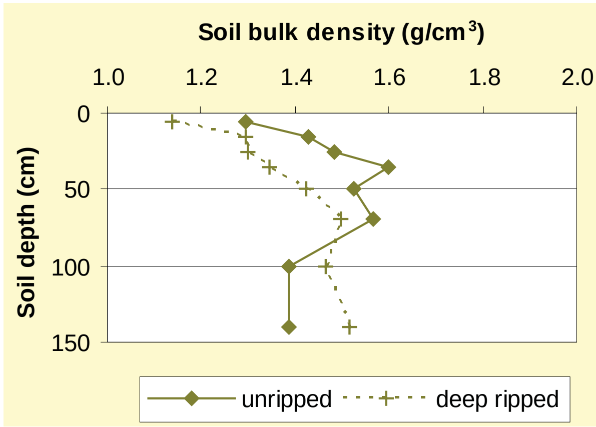


Figure 1j - Soil bulk density, Rand ('upslope')

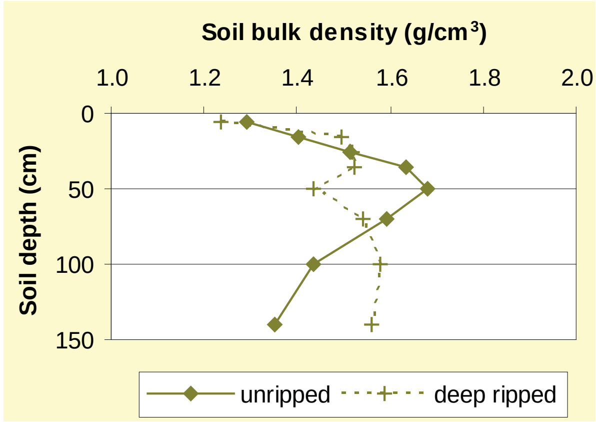


Figure 1k - 2005 yield map, Morangarell