Mapping salinity variability of a discharge site on Calala Creek, North-West Slopes of New South Wales

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Saline sites tend to have high spatial variability both vertically and laterally. Ground-based geophysical instruments (EM38 or EM31) are a rapid assessment tool that can map this variability and indicate levels of conductivity which can be related to soil salinity following ground truthing. Both instruments use electromagnetic induction to generate a magnetic field from a primary electric current in a coil held above the soil surface, with the strength of the magnetic field being proportional to the electrical conductivity (EC) of the soil (Anon 1997).

This paper reports a study conducted to determine the variability in salinity levels across a discharge site on the North-West Slopes of NSW. This work was undertaken as part of a national field evaluation program within the Cooperative Research Centre for Plant-based Management of Dryland Salinity (CRC PMDS).

Materials and methods

Soil at a 0.5 ha saline discharge site located 7 km SE of Tamworth (31.18°S 150.98°E, elevation 435 m, 674 mm AAR) was cored (5 cm diameter) on a 5 by 5 m grid at depths of 0-10 cm and 10-20 cm in March 2003. Soil samples were air dried, ground to pass through a 2 mm sieve and analysed for EC (1:5 soil:water suspension, dS/m). These values were multiplied by 7, the conversion factor for a medium textured clay soil (Taylor 1996) to give actual soil salinity levels (EC_e).

An EM38 (Geonics Ltd) unit was used in both horizontal (70 cm) and vertical (140 cm) dipole modes at 99 positions across the site in May 2003. For each position, an easting and northing GPS reading was taken so that it could be mapped. At 14 positions that corresponded to both the EM38 and 5 m grid sampling, the observed apparent conductivity (EC_a) from the EM38 were calibrated using soil cores (5 cm diameter) sampled to a depth of 140 cm (at intervals of 0-10, 10-20, 20-40, 40-60, 60-70, 70-80, 80-100, 100-120 and 120-140 cm), covering the range in expected EC values. Soil samples for these depths were processed and analysed as described above.

The relationship between EC_a and EC_e values was examined for 70 and 140 cm soil depths (corresponding to the EM38 horizontal and vertical dipole modes) by graphical representation of the data and linear regression. For each depth, two data sets were examined; one for EC_e 60-80 cm and 120-140 cm, and, another for EC_e 0-70 cm and 0-140 cm. For these data sets the regression with the highest correlation (*r* value, see Figures 1 and 2) was used to convert EC_a readings to EC_e values for the study area. Salinity maps for the site were produced for the EC_e (70 cm) and EC_e (140 cm) data, and the 0-10 cm and 10-20 cm data collected on the grid using Surfer® (Golden Software, Inc.).

Results

EC_e values ranged from 0.7-16.2 dS/m across the site. In general, EC_e was lowest at the soil surface, increasing down the soil profile to a depth of about 70-100 cm.

The relationship between EC_a in horizontal dipole mode was positive and the *r* values highest with EC_e values at 70 cm (Figs. 1*a* and *b*), and at 140 cm when the EM38 was in the vertical dipole mode (Figs. 2*a* and *b*).

Salinity maps at 70 cm and 140 cm soil depths (Figs. 3*a* and *b*) clearly showed a distinct north-south line that corresponded to the edge of the cultivated area in the paddock. The area to the left of the line had been regularly cropped, with a sorghum crop removed 3 months prior to the EM38 survey. The area to the right of the cropping line consisted of naturalised pasture dominated by couch grass (*Cynodon dactylon*). Maps of the EC_e levels (EC_a times 7) at soil depths of 0-10 cm and 10-20 cm (Figs. 4*a* and *b*, respectively) also highlighted 'hot

Figure 1. Relationship between ECa at 70 cm (horizontal dipole mode) and ECe at (a.) 70 cm and (b.) 0-70 cm soil depths.

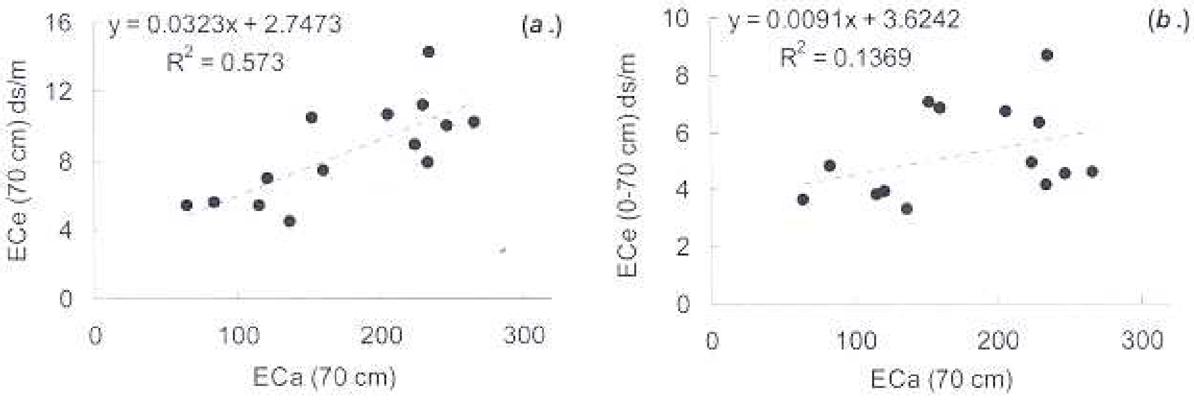
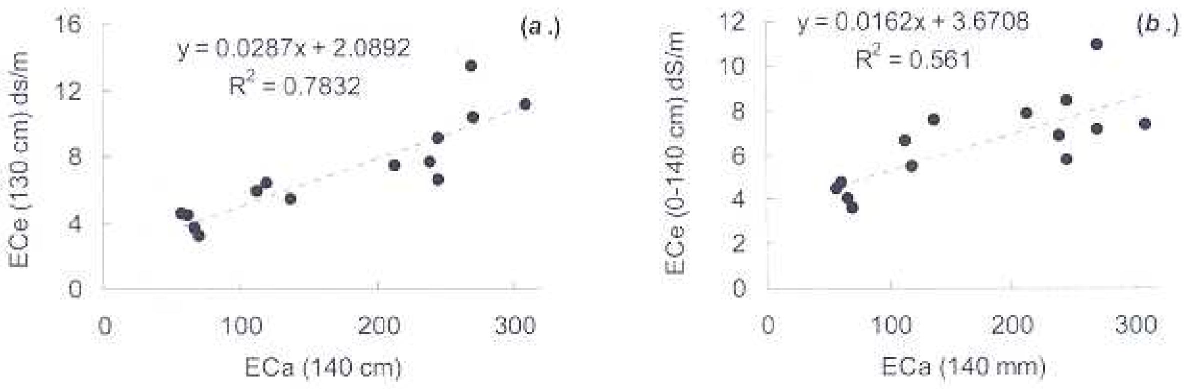


Figure 2. Relationship between ECa at 140 cm (vertical dipole mode) and ECe at (a.) 130 cm and (b.) 0-140 cm soil depths.



spots' (light shaded areas) with high EC_e values that corresponded with bare, scalded areas in the naturalised pasture.

Discussion

In the vertical dipole mode, the EM38 signal is maximum at 100-120 cm, while in the horizontal dipole mode its signal is strongest at the surface, decreasing with depth (McNeill 1980). Commonly EM38 EC_a values are calibrated using average EC_e values for soil depths of 0-70 cm and 0-140 cm for horizontal and vertical dipole modes, respectively (McNeill 1980). However, our results strongly indicated that using EC_e values for the depth at which the signal was strongest gave a better estimate of EC_e.

Given that the edge of the cultivation resulted in such a distinct line on the soil salinity maps there is a need for some care to be taken when calibrating and interpreting the results of an EM38 survey. Readings from electromagnetic induction meters are dependent on soil conductivity and soil resistivity. Besides salinity, conductivity varies with clay content, soil moisture, temperature, porosity, organic matter, depth to parent material and mineralogy of the terrain (Taylor 1996). Test boring and sampling are recommended to confirm EM38 readings (Taylor 1996).

At this site the edge of cultivation was a distinct line at both 70 cm and 140 cm depths, indicating that soil water was probably influencing the EM38 readings. We suggest that soil sampling to calibrate the EM38 readings be conducted at the same time as the EM38 values are taken and that both soil moisture content (gravimetric percentage) and soil texture be recorded.

An EM38 survey has the advantage of being a rapid means of collecting data in spatially variable sites and so is useful for monitoring salinity in the root zone of small sites such as the study area. However, this study has indicated some of the limitations of these data and highlighted the importance of soil samples being collected at the same time as the EM readings. Sampling, together with knowledge of

Figure 3. Salinity levels (ECe, dS/m) at a discharge site located on Calala Creek near Tamworth, NSW at soil depths of (a) 70 cm, and, (b) 140 cm using an EM38. The broken line indicates the edge of the cultivation. Each point denotes an EM38 position.

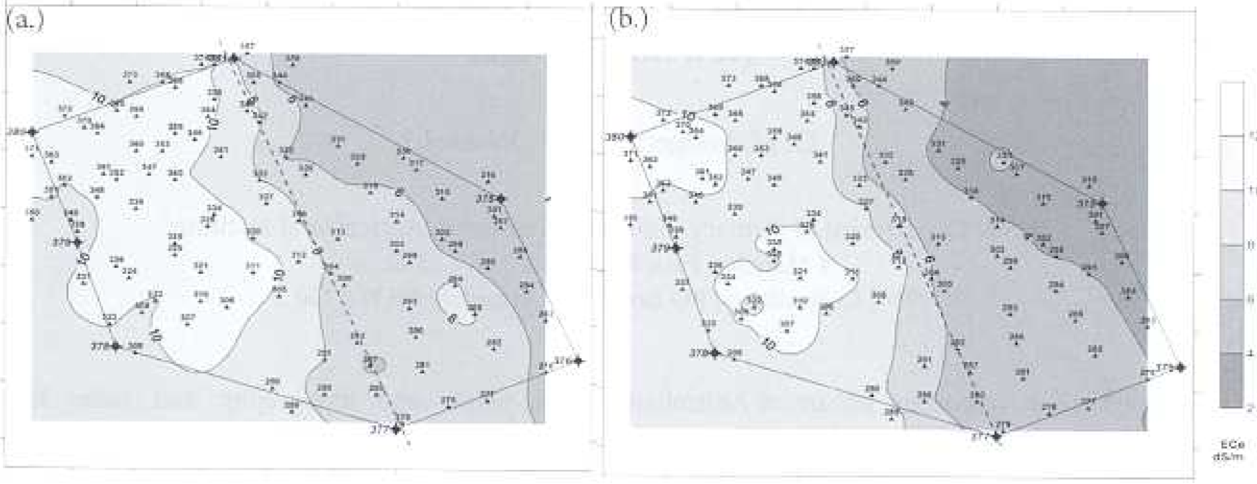
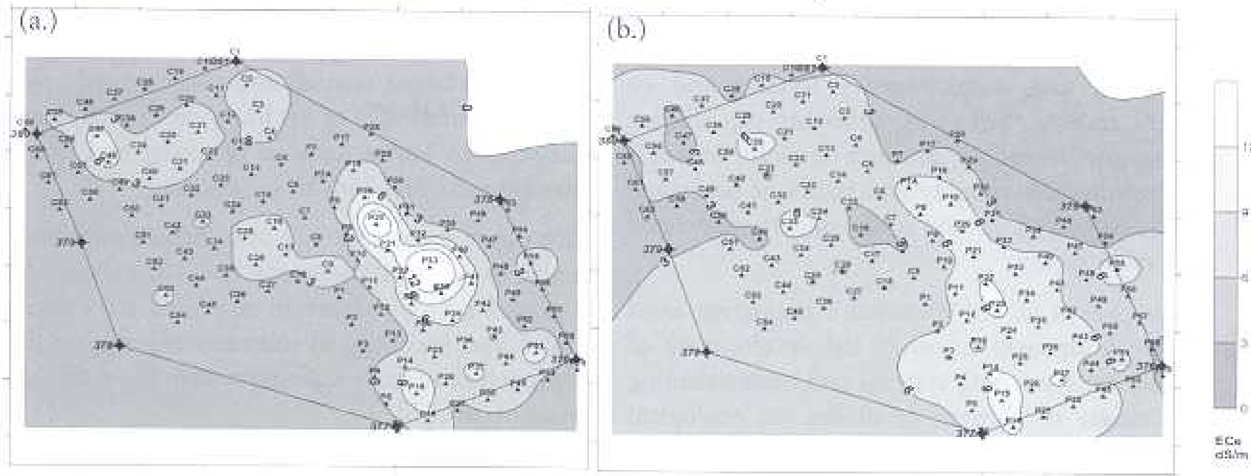


Figure 4. Salinity levels (ECe, dS/m) at a saline site located on Calala Creek near Tamworth, NSW at soil depths of (a) 0-10 cm and (b) 10-20 cm. Each point denotes a sampling position on the 5 x 5 m grid.



both soil moisture status and soil texture will assist in more accurate interpretation of EM38 maps and the calculation of EC_e values.

Acknowledgments

These studies were conducted as part of the national plant evaluation program funded by NSW Department of Primary Industries, GRDC and the CRC for Plant-based Management of Dryland Salinity. We thank Brian Roworth for his technical assistance in collecting the samples, Michael Honess for processing the samples, Bruce Haigh for plotting the data, George Truman, Namoi Catchment Management Authority for assistance with data manipulation, and Bob and Kathy Cameron of "Craigmore" for use of the site.

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