

Sodium in Agricultural Soils

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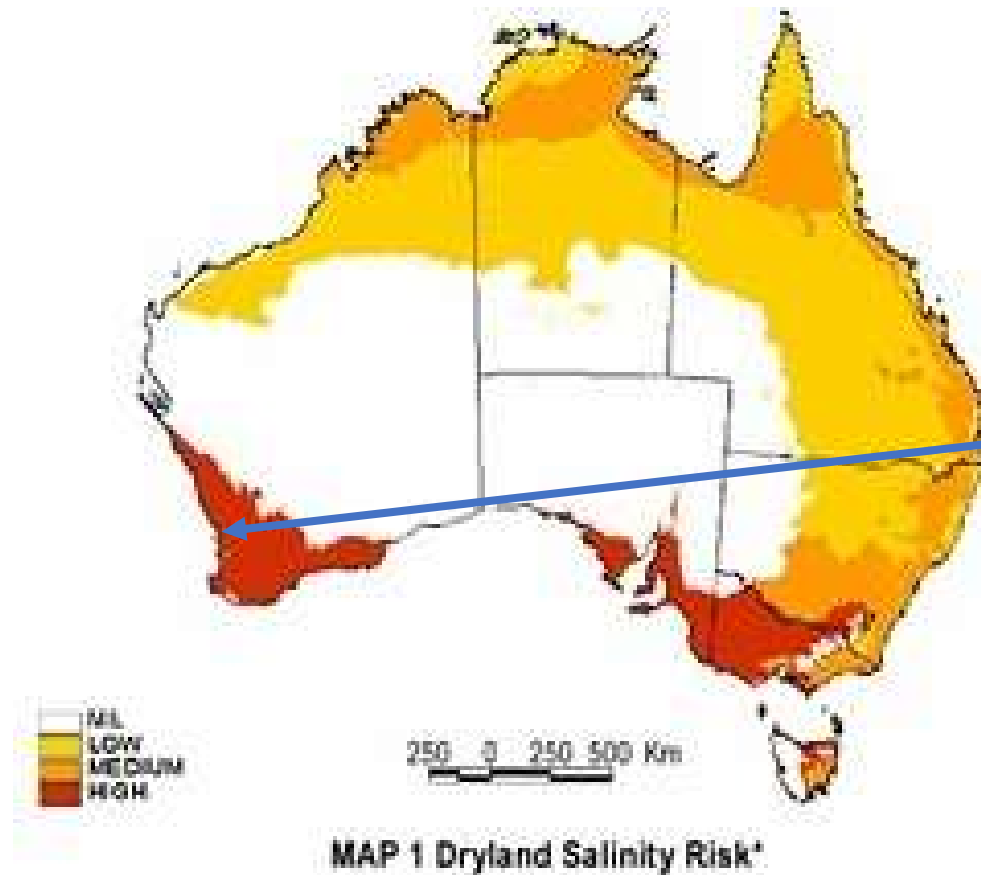
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Salinity in Western Australia





<http://www.rgbstock.com/photo/myXleag/saline>, <https://www.agric.wa.gov.au/soil-salinity/dryland-salinity-extent-and-impact>



<https://thewest.com.au/news/kalgoorlie-miner/land-sailors-make-most-of-weather-ng-b88969883z>



<https://www.showpo.com/us/showpoedit/life/8-of-the-most-beautiful-natural-wonders-of-the-world/attachment/lake-hillier/>





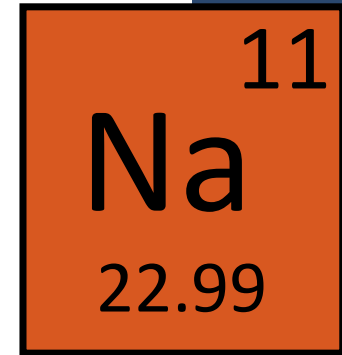
<https://www.agric.wa.gov.au/soil-salinity/dryland-salinity-western-australia-0>



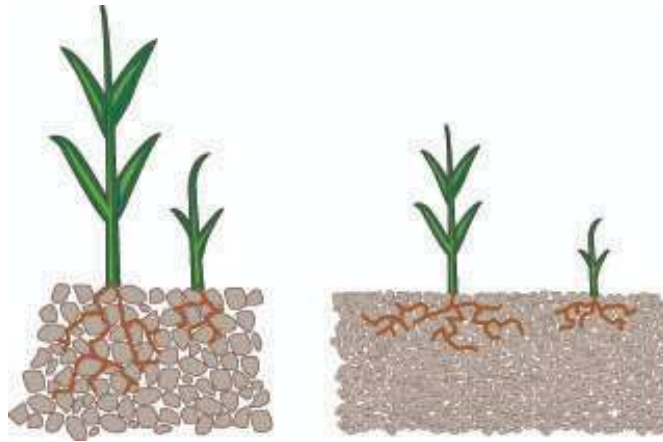
What is a Sodic (dispersive) Soil?



- A sodic soil occurs when the sodium in the soil is greater than the other salts present
- Creates a poor soil structure
- Alkaline in nature
- Results in inadequate water filtration and air exchange
- defined as a soil with an exchangeable sodium of
 - >6% of the cation exchange capacity (ESP)
 - or >15 sodium absorption ratio (SAR)



What effect does sodium have on plant growth?



- Deflocculation or dispersion of the clay particles increases density of soils
- Water tends to pool on the surface of the soil
- The roots of the plant are not able to grow deep into the soil
- Affects water absorption of the plant
- Causes stunted growth and leaf burn



Impact of salinity in Western Australia



- > 2.5 million acres or 7000 farms affected in south Western Australia
- Lost opportunity costs in agricultural > \$5 million dollars per year
- Can affect infrastructure such as roads
- Many plants species and birds are at risk of becoming extinct due to salinity



How is sodium currently measured?

Testing for sodicity in the field

1. Dispersion

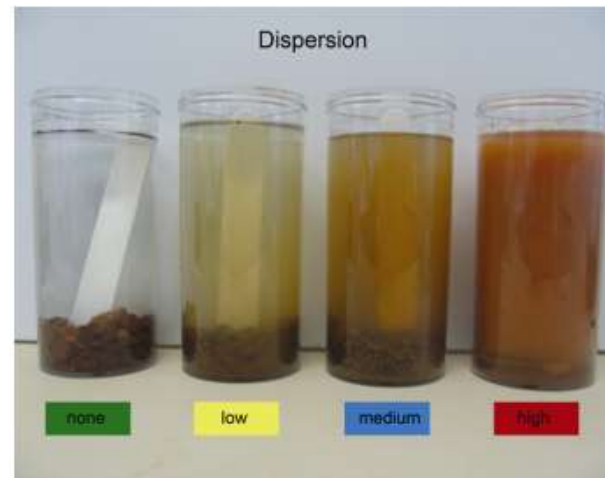
- Clear = non-sodic
- Slightly cloudy = low sodicity
- Moderately cloudy = medium sodicity
- Stick not visible = high sodicity

2. pH meter

- Soil is alkaline

3. EC Meter

- Shows an increase in electrical conductivity



Advantages and Disadvantages of Field Analysis

- **Advantages:**

- Low cost,
- immediate result

- **Disadvantages:**

- Very much a qualitative method.
- Does not distinguish between sodium and other salts



How is sodium currently measured?

Testing for sodicity in the laboratory

Elemental Analysis of soil

1. Exchangeable sodium percentage (ESP)

$$\text{ESP} = \frac{\text{Exchangeable sodium (meq100g}^{-1} \text{ soil)}}{\text{Cation exchange capacity (meq100g}^{-1} \text{ soil)}} \times 100$$

2. Sodium Adsorption Ratio (SAR)

$$\text{SAR} = \frac{[\text{Na}^+] \text{ (meq100g}^{-1} \text{ soil)}}{\text{SQRT } 1/2 ([\text{Ca}^{2+}] [\text{Mg}^{2+}]) \text{ (meq100g}^{-1} \text{ soil)}}$$



How is sodium currently measured?

Testing for sodicity in the laboratory

3. Electrical Conductivity (EC)

- Conductivity of soil increases as saline content increases
- Is not specific for sodium

4. pH measurement

- pH of soil increases as salinity increases
- A sodic soil will have a pH of around 8- 8.5



Advantages and Disadvantages of Laboratory Analysis

- **Advantages:**

- Quantitative reliable results
- Can get elements not available with pXRF such as boron
- Can analyse bulk sample

- **Disadvantages:**

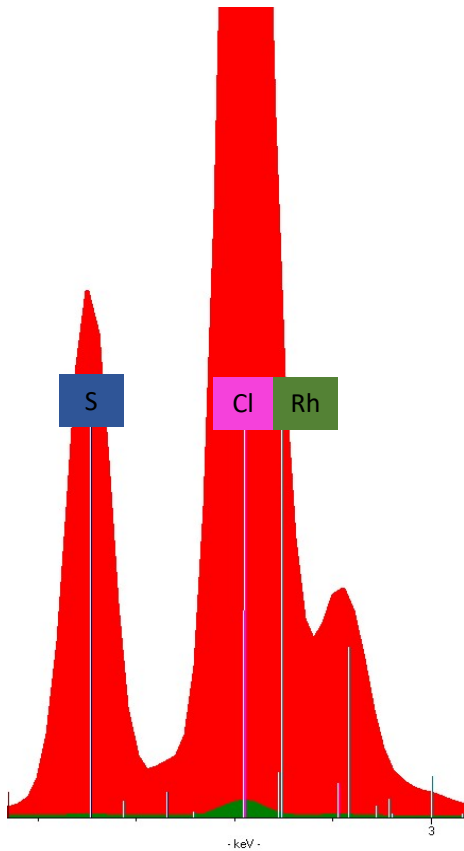
- High cost, so will take fewer measurements
- Result can take weeks to come back



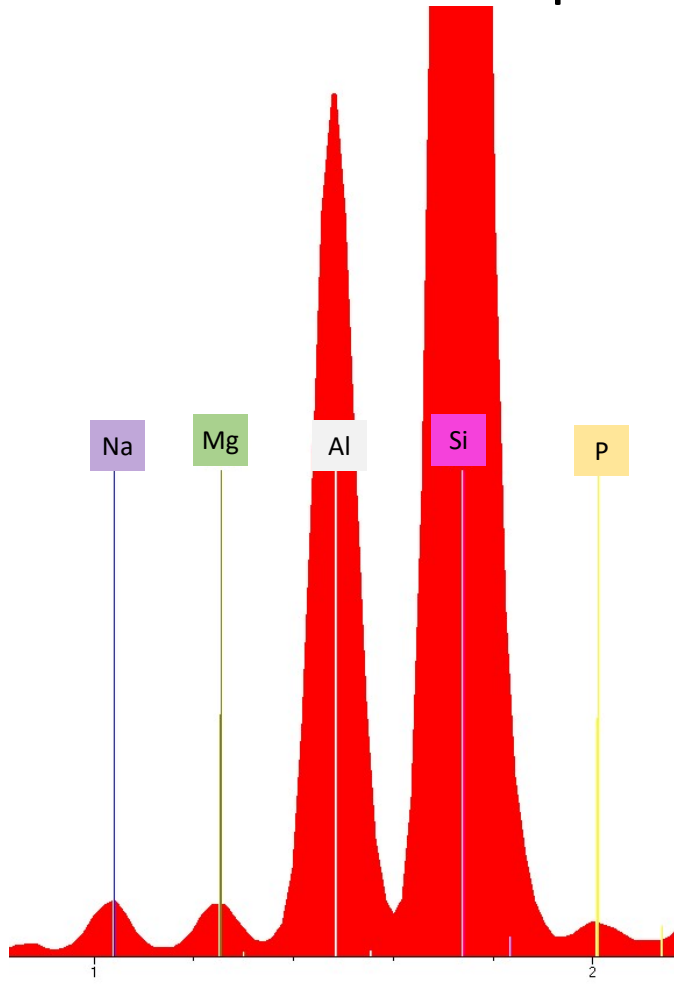
How Portable XRF has been used to calculate sodium until now

Sodium levels calculated from Cl results

- The Cl Ka1 peak overlaps with the Rh La1 peak
- This can be helped by using a Ti – Al filter to remove the Rh peak
- This presumes that the sodium is present as a chloride only when it could be there as a sulphate or carbonate



Sodium measured using the Tracer 5G with helium purge



- Using 10 KeV, no filter
- Remove window
- Helium atmosphere
- LOD down to as low as 500 ppm



Where samples were taken from

Soil Samples kindly provided by the University of Western Australia Agriculture Department from their farm in Western Australia. Preparation included sieving and placing into cups with 4 μ m prolene film



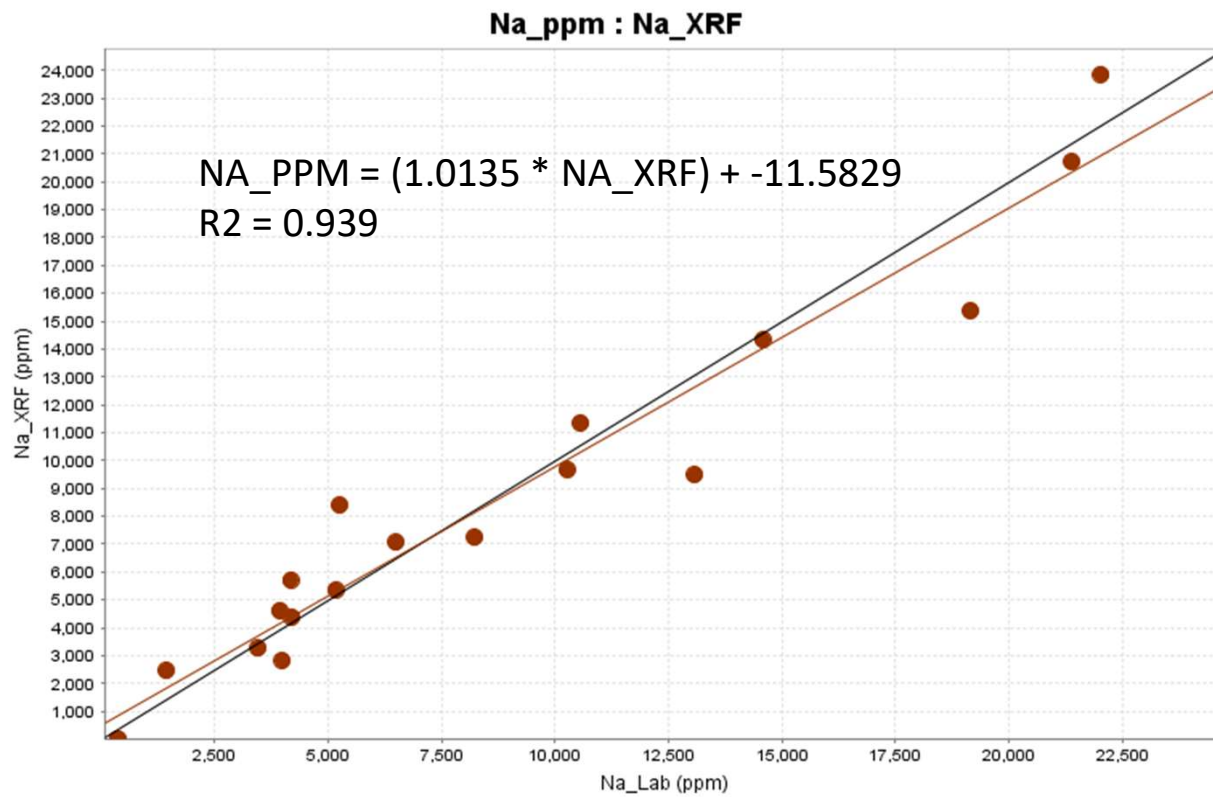
Measurement on Tracer 5G



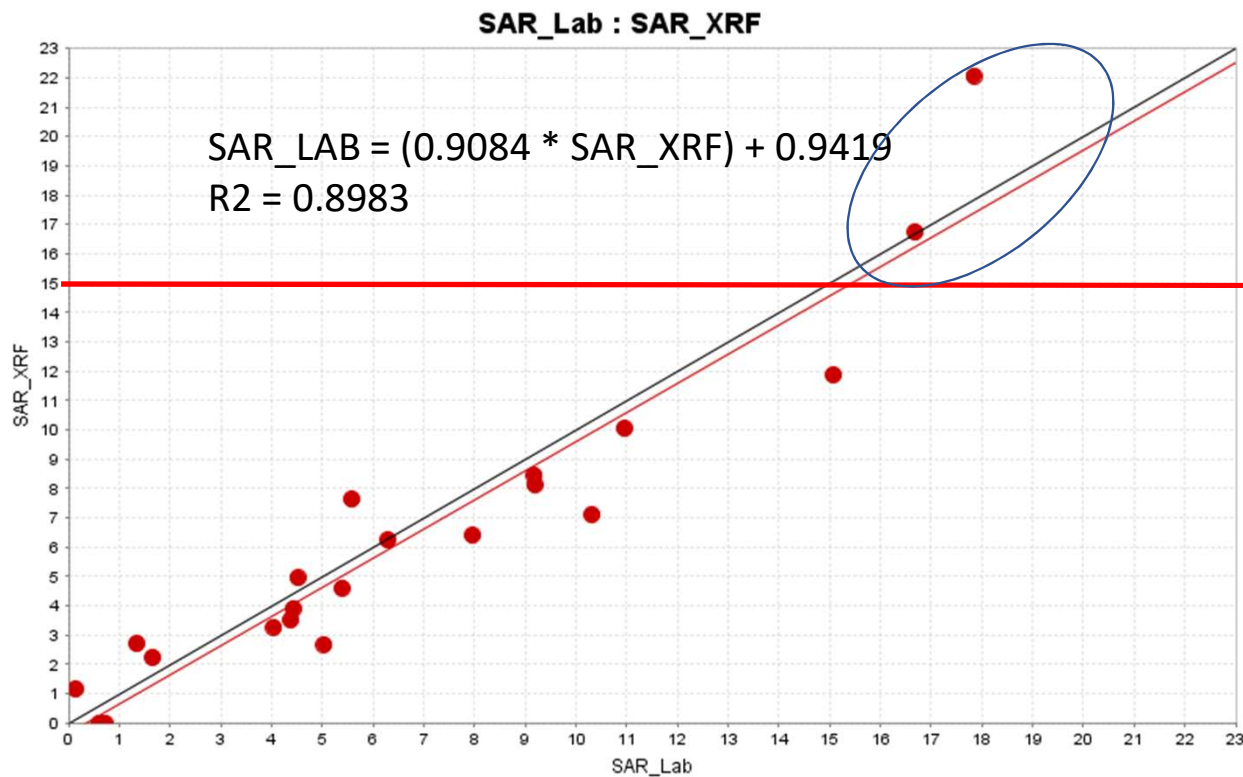
- 15 soil CRM's
- Subset of 20 soil samples used in the calibration
- Samples were measured at
 - 10 KeV, no filter, helium purge for 60 seconds
 - 30 KeV, Ti Al filter, helium purge for 60 seconds
- Instrument facing down with window removed
- Helium flow of 0.8 l/min²
- Calibration tested using another subset of 20 soil samples



Results Sodium ppm



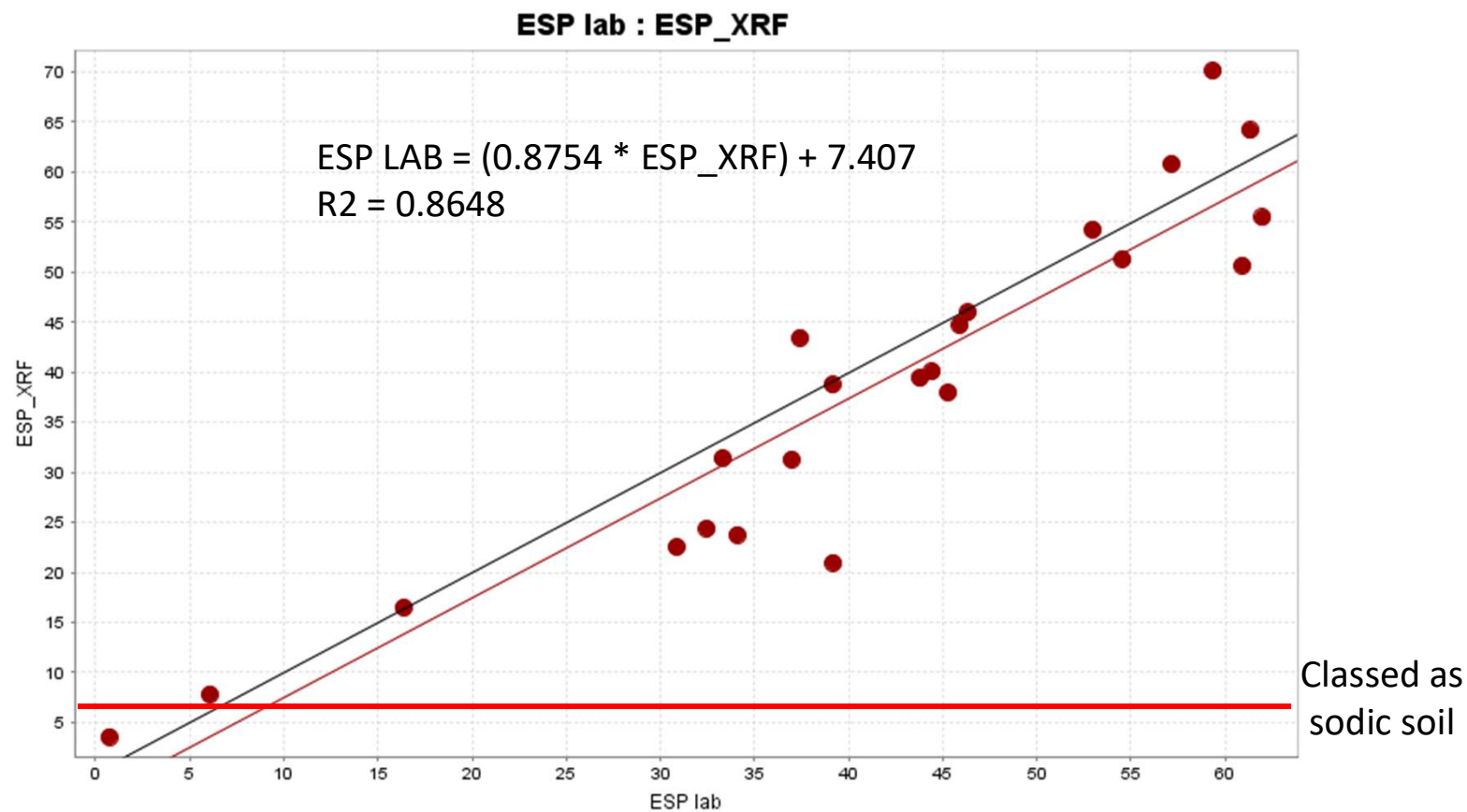
Results Sodium absorption Ratio (SAR)



Classed as
sodic soil

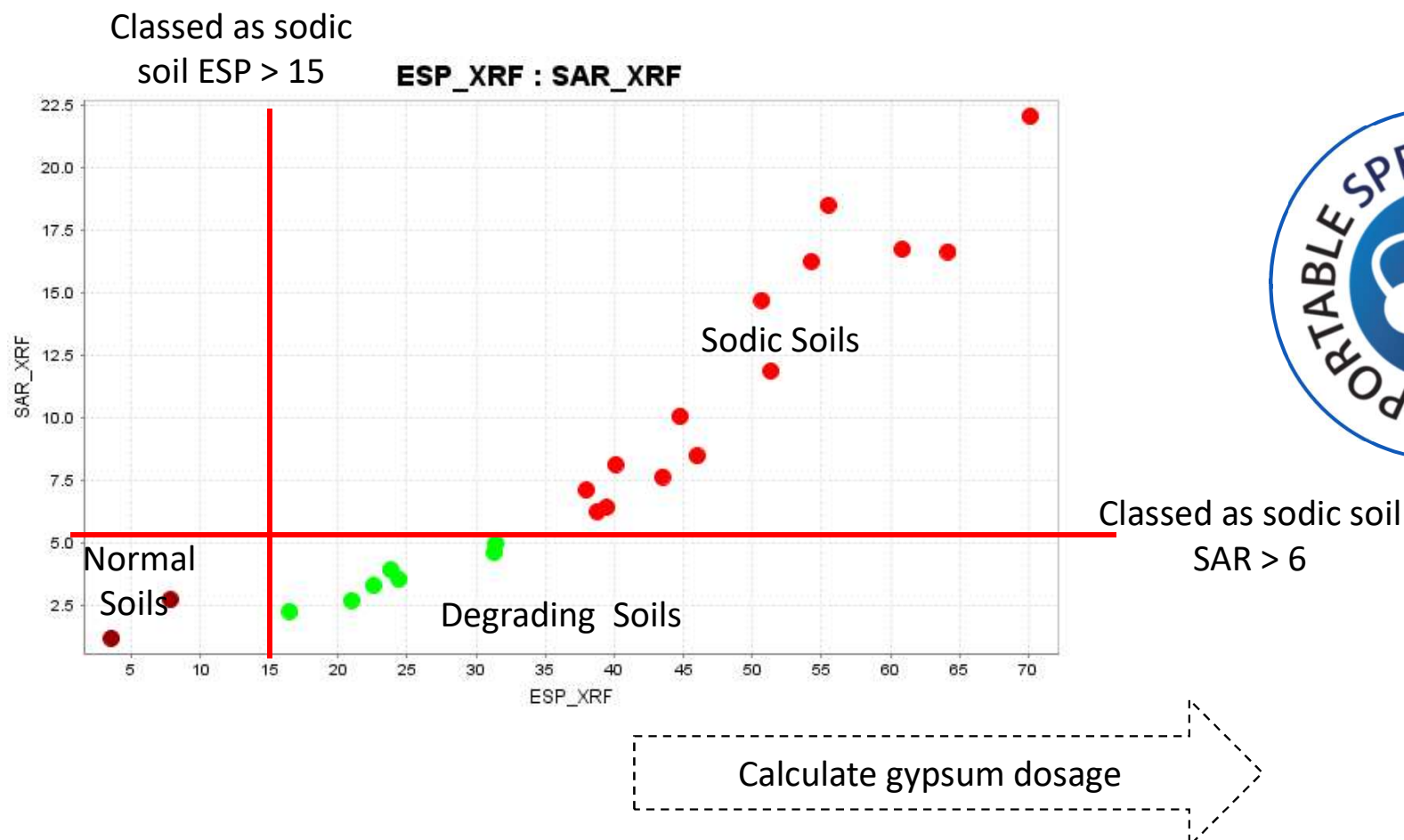


Results Exchangeable Sodium Percentage (ESP)

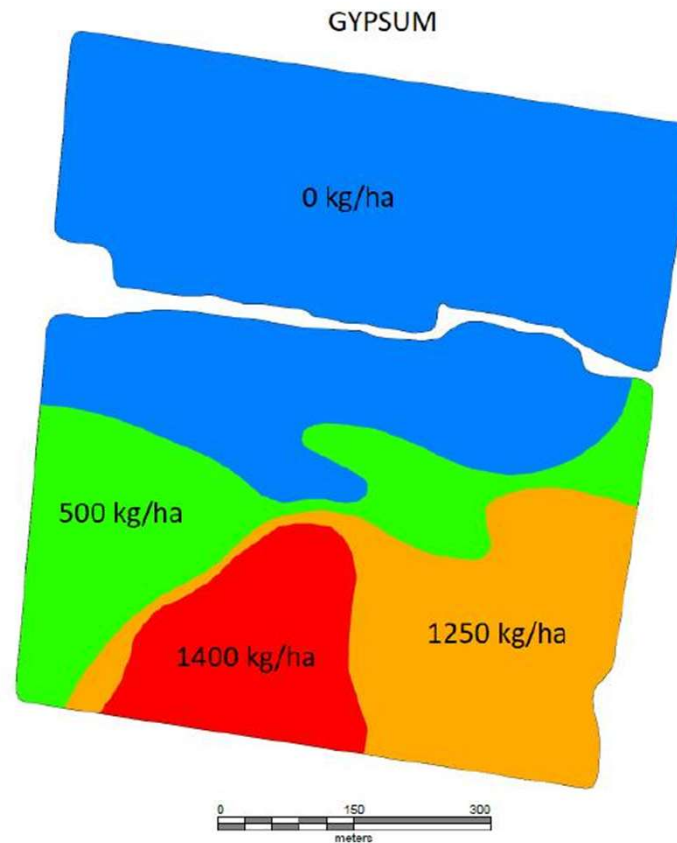
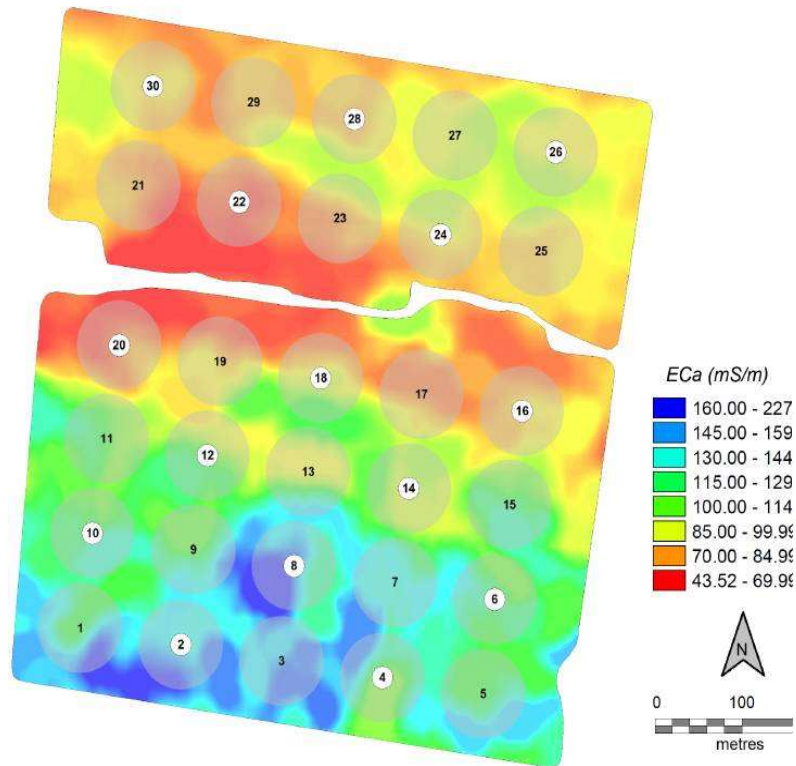


Results

Exchangeable Sodium Percentage (ESP) vs Sodium Absorption Ratio (SAR)



Applying technique to the farm



Conclusion

- The ability to measure sodium using handheld XRF has the potential to aid agricultural methods by:
 - Decreasing the cost of analysis
 - Real time information
 - Increasing the number of samples taken
 - Increasing the precision of how the land is remediated



Acknowledgements

- My wonderful staff at Portable Spectral Services
- University of Western Australia Agriculture Department
- Denver X-ray Conference

