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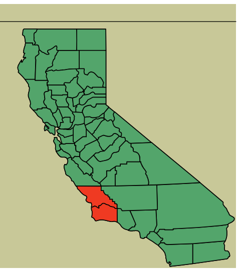
Grape Notes

San Luis Obispo & Santa Barbara Counties



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Paso Robles Soil Salinity Survey

In 2006 I evaluated the soil salinity status of mature vineyards east of Paso Robles by testing soil samples from 100 locations. The results indicate that soil salinity is at levels that can lead to appreciable, and in some cases significant, growth or yield reduction in some vineyards, while the majority of vineyards were below general threshold levels of concern. As the sampling occurred recently after a very high rainfall winter season; salinity conditions in drier years are likely to be more severe.

Background

A number of growers in areas east of Paso Robles have in recent seasons reported soil salinity levels that suggest that significant accumulation of salts have been occurring in area soils. These high levels of salts in some cases appear to cause foliar burn symptoms, while in other cases the primary symptoms are reduced vine growth and low productivity.

The environmental conditions of this particular area make the vineyards prone to salt accumulation; these conditions include irrigation with groundwater of variable salt content, the use of drip irrigation with limited leaching capabilities, the application of deficit irrigation regimes which do not include additional leaching fractions, and limited winter rainfall to flush salts from the rootzone. Some soils also have poor drainage characteristics, preventing the adequate leaching of salts even if water is available to do so. Over time, the above conditions can be expected to result in gradually increasing soil salinity levels, in particular if there are no occasional heavy rainfall seasons that leach years of accumulated salts.

The naturally-occurring salts in groundwater used for irrigation are the major source of salts being added to our vineyard soils. Most area groundwater can be classed as 'sodium bicarbonate' water, meaning that sodium (Na^+) is the dominant positively-charged ion (or cation) and bicarbonate (HCO_3^-) is the dominant negatively-charged ion (or anion) dissolved in the water. In addition to increasing the overall salt content of a soil, the addition of these two ions can also cause physical and chemical changes in a soil which lead to significant degradation of the quality of the soil as a growing medium. Soils which have levels of soluble salts sufficient to impact plant growth are referred to as 'saline' soils. Soils with high levels of exchangeable sodium relative to calcium and magnesium are referred to as 'sodic' soils. This distinction between saline and sodic is important because different management practices are required for the two conditions.

As sodium levels increase, sodium itself can exert direct toxic effects on vine growth. Additionally, high sodium levels impact soil physical properties. As soil cation exchange sites become increasingly dominated by sodium ions, the individual soil particles have a reduced tendency to group, or flocculate, together as stable aggregates. Instead, high sodium levels cause clay aggregates to disperse into smaller individual clay particles, and these dispersed clay particles clog the soil pores. This then creates more dense soils with reduced porosity and poor water infiltration and drainage characteristics, and also reduces the soil's capacity to store plant-available water to supply vine needs.

The bicarbonates added to the soil along with the sodium accelerate this process, especially under alkaline

Figure 1. Salts on the soil surface near Paso Robles. The drip emitter delivers water to the center of the dark circle. Sodium ions disperse soil particles and organic matter, darkening the circle. The outer white ring is indicative of accumulations of calcium and/or magnesium salts, likely from amendment applications.

conditions. Bicarbonates precipitate with calcium and magnesium to form insoluble carbonate solids, effectively decreasing the active amounts of calcium and magnesium on the soil cation exchange sites. By doing so, the proportion of exchangeable sodium relative to calcium and magnesium increases, thus increasing the deleterious effects of sodium in the soil. The relative impact of sodium on the soil physical properties is gauged by the Sodium Adsorption Ratio (SARe); the higher the SARe, the greater the proportion of sodium relative to both calcium and magnesium in the soil.

Managing soil salinity and sodicity require slightly different tactics. Alleviating either condition requires leaching the rootzone with enough water to remove the deleterious salts; adequate drainage to remove the resulting high-salt water is critical in both cases. For the sodic (high sodium) condition, the addition of gypsum serves as a calcium source to help displace the accumulated sodium and thus improve soil physical characteristics. Note however that gypsum itself is a salt; if it is added to a soil but is not sufficiently dissolved and leached through the rootzone, it will increase soil salinity. This issue creates management challenges for soils which are both saline and sodic; the gypsum required to alleviate the sodic condition will exacerbate the salinity condition.

Increases in soil salinity and sodicity occur slowly and often imperceptibly from season to season; thus changes in soil salinity may only become obvious when analyzed over a relatively long period of time. However, one very wet winter or large amounts of leaching irrigation can reduce salt levels appreciably in soils with adequate drainage.

Method

I began this survey project in 2006 to evaluate the current soil salinity levels in the area east of Paso Robles, with the intention that the sampling be repeated every three years at the same locations to assess any long term changes in salinity conditions.

Soil samples were taken at 100 mature vineyards within the region roughly encompassed by the cities of Paso Robles, San Miguel, Shandon and Creston. At each location, composite samples were made from 15 surface cores, with each core encompassing the surface 30 cm (12 inches) of the soil; all samples were taken from within the vine row. Any obvious non-dissolved residues of recent amendment applications (e.g. gypsum) on the soil surface were scraped away before taking the core samples, but otherwise no attempt was made to exclude amendments from the samples, as the goal was to document the soil conditions that the vines actually experience in the field. Sampling occurred in September and October 2006, prior to any significant fall rainfall. All samples were tested by the UC DANR Lab for the Saturation Percentage (SP), pH, Electrical Conductivity (ECe), Calcium, Magnesium, Potassium, Sodium, Chloride, Bicarbonates and Carbonates; the Sodium Adsorption Ratio (SARe) was calculated later. GPS coordinates were also recorded at each sampling location to permit follow-up sampling at the same locations in future years.

Results and Discussion

The average values of all parameters for the 100 sites are shown in Table 1.

A primary parameter of interest in this study is the soil electrical conductivity (ECe), because of its deleterious effects on overall vine growth and productivity. The average ECe value of all samples was 2.2 dS/m, approaching the standard threshold value of 2.5 dS/m, above which effects on growth and yield reduction are more likely to occur (Christensen et al. 1978) (Figure 2). Twenty-nine percent of the locations had soil ECe values between 2.5 and 4.1 dS/m, where growth can be appreciably reduced, with a yield reduction of 10-25%. Six percent of the locations had soil ECe values over 4.1 dS/m, where significant growth restrictions and leaf burn can be expected, together with yield reductions of 25-50%. The fact that these values were measured fairly soon after the very wet winter of 2004/2005 suggests that during extended dry weather cycles, such as the period of several years prior to the 2004/2005 winter season, that many area soils could have significantly higher soil ECe levels

Table 1. Summary soil test results for the 100 locations.

Item	Average	St. Dev.	Item	Average	St. Dev.
EC (dS/m)	2.2	1.2	HCO3 (meq/L)	3.1	1.1
pH	7.3	0.6	Ca (meq/L)	13.1	10.0
SARe	3.5	2.1	Mg (meq/L)	4.2	3.8
Na (meq/L)	9.1	6.5	K (meq/L)	16.4	16.1
Cl (meq/L)	3.3	3.3	SP (%)	39.5	10.2

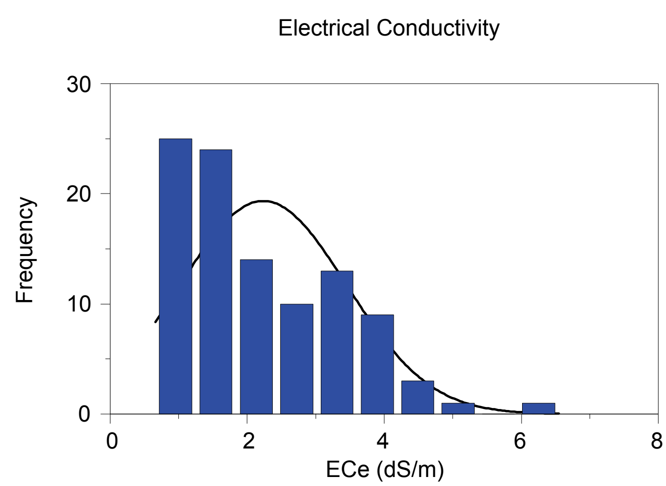

Figure 2. Electrical Conductivity (ECe) of the 100 locations. The ECe is an estimate of the total amount of soluble salts in a soil sample. There are different methods to measure soil electrical conductivity; ECe is measured on the solution extracted from a soil at saturation.

than were found during this survey. The improved growth noted in many area vineyards in 2005 and 2006 as compared to the preceding seasons can likely be attributed in part to the lower soil salinity levels due to the leaching effects of the high winter rainfall.

Note that many of our standard threshold values for assessing salinity impacts on growth and yield were developed primarily with own-rooted Thompson Seedless grown in the San Joaquin Valley. Other varieties, rootstocks and soil conditions may show impairment of growth or yield at different ECe levels. In Australian evaluations of the soil ECe values above which yield was impacted for various scions and rootstocks, threshold values ranged from 1.8 dS/m to 4.0 dS/m; the percentage decrease in yield for each 1 dS/m increase in ECe above the threshold ranged from 4.3% to 15% (Zhang et al. 2002).

The average SARe value of the 100 locations was 3.5 (Figure 3). Fifteen percent of the sites had SARe values above the standard threshold value of 6.0, above which sodium-related soil physical problems will generally tend to become evident. However, depending on the type and amount of clay in a given soil, physical problems due to sodium can be observed at lower SARe values as well. Coarser soils, due to their lower clay contents, are less prone to structural damage at a given SARe value as compared to soils with a higher clay content.

Only two of the 100 samples had sodium values that exceeded the 30 meq/L threshold, above which sodium toxicity is generally considered to become problematic (Figure 4). Likewise, only two of the samples had chloride levels above the 10 meq/L threshold (Peacock and Christensen 1978).

Maps showing the estimated levels of ECe and SARe for the entire area are shown in Figures 6 and 7 on page 5. Patterns of higher and lower EC and SAR are fairly distinct on the maps. Keep in mind that the estimated values for non-sampled areas may not necessarily correspond accurately to the actual conditions in those locations, as the factors that lead to higher ECe and SARe levels (groundwater chemistry, soil drainage characteristics, history of cultivation, and grower management practices) can vary greatly over very short distances, and are not necessarily correlated spatially.

The average pH of the 100 locations was 7.34, but with a wide range (Figure 5). Prior to being cultivated, many of the soils in this area had surface horizons with neutral to slightly acidic pH. Cultivation practices that mixed the surface layers with deeper, more alkaline layers, and the use of alkaline irrigation water, have over time raised the pH of the surface layer. There are some soils with acidic reaction; these tend to be coarser textured soils, and the vineyards may have long histories of using acid treatment of the irrigation water and/or acidifying fertilizers. As soil pH increases, the potential for sodic (sodium dominated) conditions increases, because the higher pH leads to greater bicarbonate activity, resulting in an increase in the precipitation of calcium and magnesium carbonates.

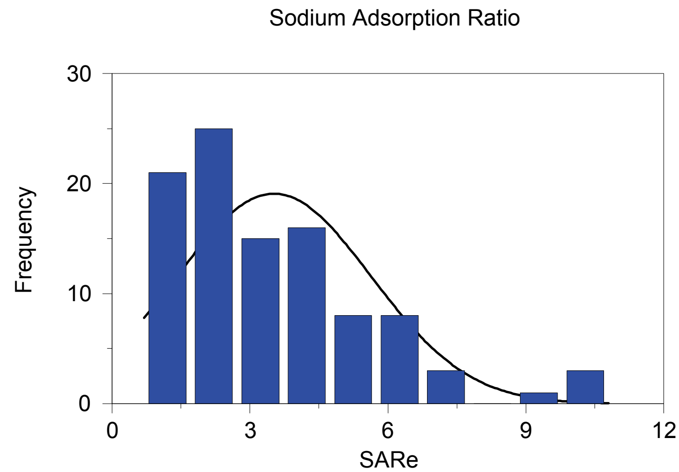

Figure 3. Sodium Adsorption Ratio values for the 100 locations.

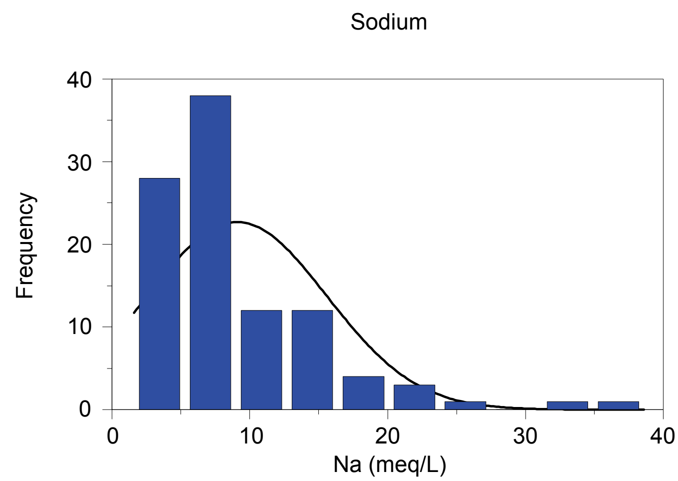

Figure 4. Sodium concentrations for the 100 locations.

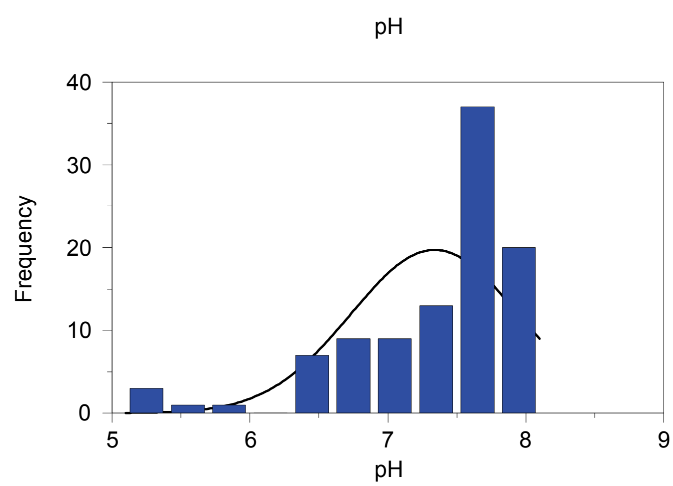

Figure 5. Soil pH of the 100 locations.

In the absence of sufficient leaching of the soil profile, over time it would be expected that the ECe, soil pH, sodium, and bicarbonate levels will all increase, while available calcium, magnesium, and the Saturation Percentage will all tend to decrease (unless amendments are added). In this area, winter rainfall, or in its absence, additional leaching irrigation, will play a important role in removing salts from the soil profile and preventing their accumulation to damaging levels. The historical winter rainfall amounts for the past 54 years for the city of Paso Robles (generally wetter than many of the vineyards to the east) are shown in Figure 8. The 2004/05 winter season rainfall was the third highest amount recorded over the past 54 years, exceeded only by the 1968/69 and 1994/95 winter seasons.

Conclusion

This research project has conducted the first comprehensive evaluation of soil salinity in the vineyard areas east of Paso Robles. It has identified that soil salinity conditions are at levels which can be expected to cause appreciable, and at some locations significant, reductions in growth and yield in numerous area vineyards. The salinity levels documented in this project represent the condition of the soils following significant leaching after a recent heavy rainfall season, suggesting that under prolonged drier conditions the salinity levels will likely be higher. Repeated sampling at the same locations at three-year intervals will indicate to what degree, if any, salinity conditions are changing over time in area vineyards.

References

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Peacock, W.L. and Christensen, L.P. 2000. Interpretation of soil and water analysis. In: Christensen, L.P., editor. Raisin Production Manual. University of California ANR Publication 3393. p. 115-120.

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Suggested further reading

Rengasamy, P. and J. Bourne. Managing Sodic, Acidic, and Saline Soils. Cooperative Research Centre for Soil & Land Management. Available online at:

http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/sodic_soils

Robinison, J.B. 2005. Practical Aspects of Managing Saline and Sodic Soils. In: Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium, June 29 & 30, 2004, San Diego, CA. (Available for purchase from ASEV).

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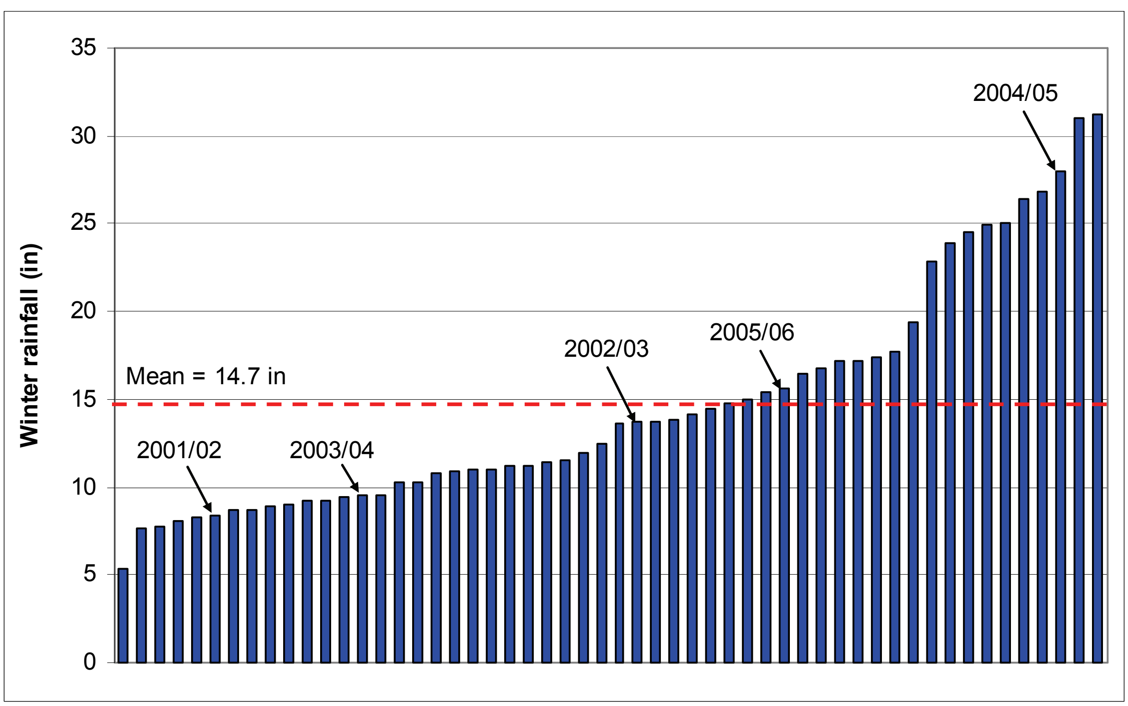

Figure 8. Paso Robles winter season rainfall, 1952/53 - 2005/06, ranked by the total amount for the winter season. The mean rainfall over the 54 seasons shown is 14.7 inches; most of the survey area receives less rainfall than this location. Source: Paso Robles City Water Department. Data available at the UC IPM website.

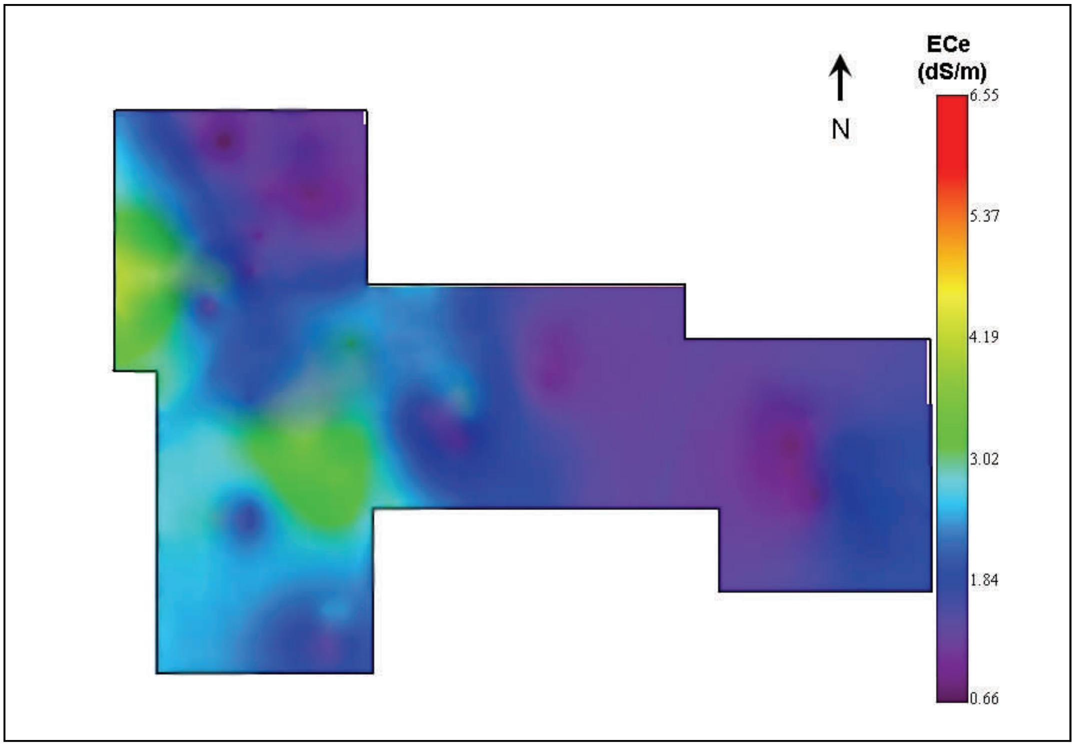

Figure 6. Estimated distribution of the Electrical Conductivity (ECe), based on the 100 sampling locations. The ECe is a measure of all the dissolved salts in a soil.

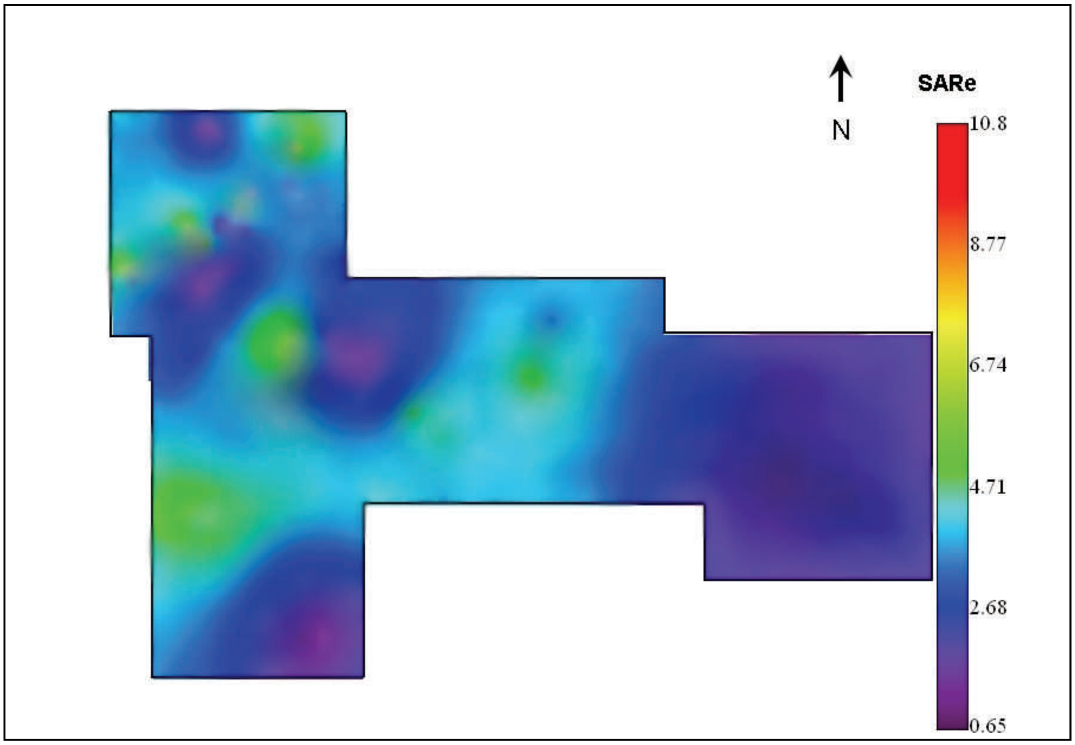

Figure 7. Estimated distribution of the Sodium Adsorption Ratio (SARe), based on the 100 sampling locations. The higher the SARe, the greater the risk for physical degradation of the soil due to sodium.

Note: the above two diagrams are shown without cities or roads, in the interest of anonymity for the participating landowners. The survey area was approximately bounded by the cities of Paso Robles, San Miguel, Shandon, and Creston.

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San Luis Obispo County: http://slocleanair.org/programs/ag-engine.asp

Santa Barbara County: http://www.sbcapcd.org/eng/atcm/dice/ag.htm

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This encyclopedic yet easy-to-use 2-volume set covers 262 individual entries, including a full description of 451 species and another 361 plants compared as similar species, representing 63 plant families. Includes shortcut ID tables, grass ID keys, and color photos of over 700 weeds including seeds, seedlings, flowers, and mature plants.

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