

Sustainability of Irrigation with EM Induction Technique

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November 8, 2017

Irrigation Association Technical Session

Abstract

Assessing Sustainability of irrigated agriculture using the Electromagnetic Induction technique

Short title: Sustainability of Irrigation with EM Induction Technique

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Sustainability of irrigated agriculture in Central California is threatened by increased salinization of land and water resources. Intensive irrigation and fertilization, use of saline water and inadequate drainage have resulted in the salinity build up. Increase in soil salinity has been observed in many cropping systems including orchards. Therefore, there is a need to use rapid and cost-effective tools to assess the extent of salinization for developing adequate crop production and land management practices. We applied an electromagnetic induction (EM) technique to map soil salinity through non-invasive and rapid measurements of electrical conductivity. The survey results demonstrated that the EM method could accurately and reliably describe the large spatial and temporal variability in salinity observed across the lands. By identifying the precise locations and levels of salt loading, the EM surveys could help in the development of irrigation and soil management strategies.

Keywords: Salinity, Irrigation, EM survey, Conductivity

OUTLINE

Background/Research Activities

EM Salinity Mapping

Case Studies



Research activities

- **Use of remote sensing technologies: EM, satellite/aerial imagery, GIS**
 - Soil and water resources management
 - Precision agriculture
- **Agronomic studies**
 - Fertilizers
 - Barrier crops
 - Seeds
- **Environmental studies**
 - Land application of effluent and drainage waters

Evidence of Soil Salinity



Field Variability – Salinity/Sodicity



Near Lemoore, CA

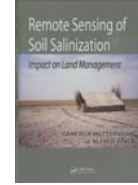
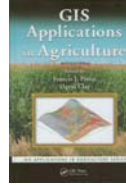
Soil salinity mapping



- **Objective:** Assessing soil salinity in agricultural fields
- Use of **Electromagnetic induction** (EM) technique
- Develop salinity **maps using GIS**

References on Theory

EM technology and GIS



8 Soil Salinity Mapping Using ArcGIS
Florence Casel S.

11 Mapping Soil Salinity Using Ground-Based Electromagnetic Induction Technique*
Florence Casel S., Steve Crockett, David Johnson, and Dharma Kulkarni

Steps in EM salinity mapping

- **Data acquisition**
- **Data calibration**
 - ESAP software
 - Ground truthing
 -
- **Mapping soil salinity from point data using GIS and other software**

Survey equipment



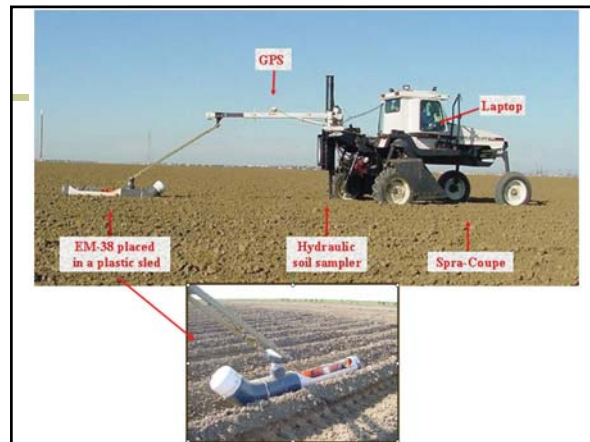
Mobile conductivity Assessment System



EM sensor

- Length (intercoil spacing)= 3.3 ft
- Weight = 6.6 lb
- Operating frequency= 14.6 kHz
- Depth of measurement
 - Horizontal = 3 ft
 - Vertical = 6 ft
- Measurement accuracy = $\pm 5\%$ at 30 mS/m





<http://www.ars.usda.gov/Services/docs.htm?docid=8918>

Products & Services

ESAP Model

The full version of the program, and examples and manual, can be downloaded from the software download area.

Year: 2006
Version: 2.35 (Windows XP Edition)

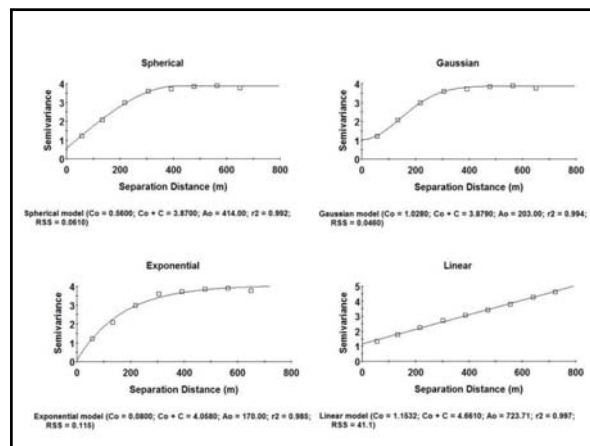
Abstract:

The ESAP software package currently contains five programs:

- ESAP-ESSD: Designed to generate optimal soil sampling designs from bulk soil electrical conductivity survey information
- ESAP-Calibrate: Designed to estimate both stochastic (regression model) and deterministic (soil theory based) calibration equations; i.e., the equations which you will ultimately use to predict the spatial values of one or more soil variables from your EM survey data.

Data acquisition - mobile

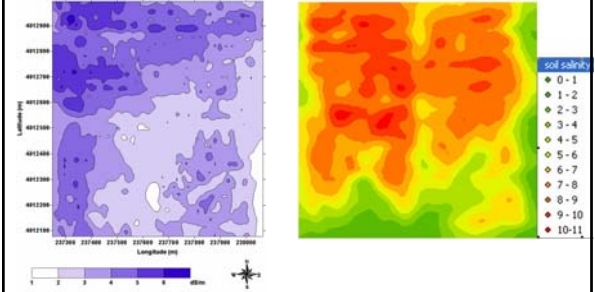
- EM and GPS data recording along furrows: every 30-40 ft
- 10-15 measurements per acre
- Total of 1500-2250 measurements per field
- Survey time: 2½ - 3 hours (150 ac)
- Calibrate EM data: soil sampling at 6-12 locations



Soil salinity mapping

- Generate soil salinity maps, based on calibrated EM data
- GIS: Spatial analysis
- Surface maps of soil salinity
- In addition, maps of boron, gypsum, and moisture distribution

Soil salinity mapping



1. Effects of Irrigation Drainage

Agricultural fields subjected to IFDM practices (sequential drainage reuse)

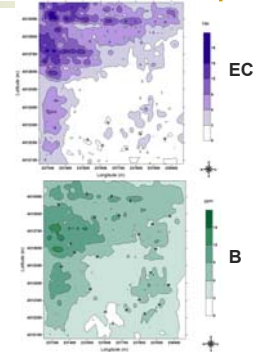
- Survey every year
- Salinity variability across farm
- Recommendations on cropping rotation and drainage applications



2. Variable rate application

Variable seeding and gypsum application rates based on salinity and boron levels

- Survey before planting
- Variable seeding rate
- Variable amendment applications

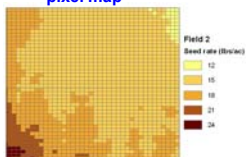


Variable rate equipment

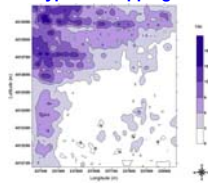
- Guidance System
- Raven controller
- GPS
- Delivery system



Seed application rate - pixel map

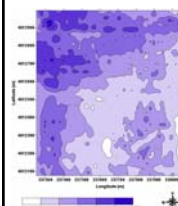


Gypsum mapping

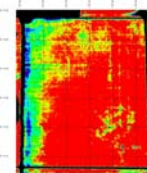


Data comparison

EM survey

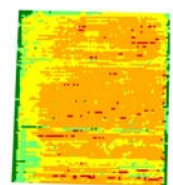


Aerial imagery



Plant growth (NDVI) map

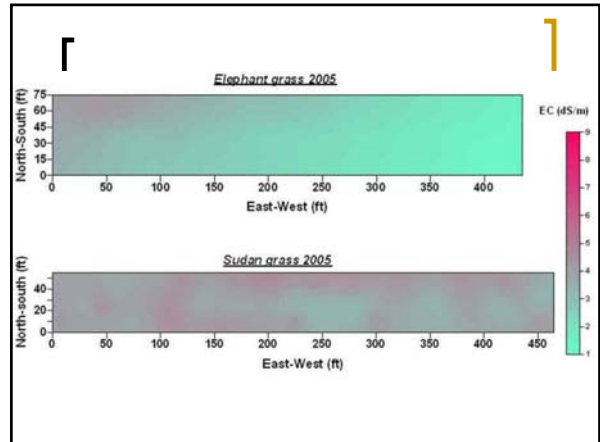
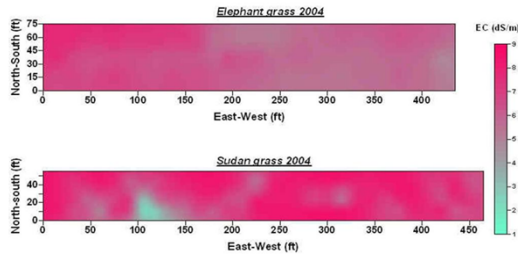
Yield monitor



3. Assessing a bio-filter crop



- Objective: Compare effectiveness of elephant grass vs Sudan/Bermuda grass in controlling N and P contamination



4. Assessing yield potential

Salinization and Yield Potential of a Salt-Laden Californian Soil: an In Situ Geophysical Analysis

Thomas Cassel · Dera Goorahoo · Shashank Sharmasarkar

Received: 13 August 2015 / Accepted: 6 November 2015
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Abstract Salinization is a global problem, including in California, USA, where over two million hectares of irrigated lands have deteriorated due to salt loading. Because of freshwater shortage, some farmers are also irrigated with agricultural drainage water, which further exacerbates the salinization process. With the objectives of rapidly quantifying spatial and temporal progression of salinization and identifying yield potential for a high-value crop, we conducted 2-year salinity surveys in a salt-affected farm in California by utilizing a dual dipole electromagnetic induction technology (EM38). The EM38-predicted conductivity (EC_e) was consistent with the ground-truth soil data (EC_e) and increased with depth. About 90 and 25 % of the EC_e data in moderately (A) and severely (B) affected salinity zones surpassed 500 and 1000 ms^{-2} levels, respectively. In the southern part of the top to 70 % samples remained within 500–1000 ms^{-2} range. There was enhanced salt loading in the northern and western parts of A. With respect to

salinity showed spatial dependence up to 500 m lateral distance. The shifts in salinity could be due to dispersion and leaching of solutes. High crop yield reduction was observed in the southeastern and northeastern parts of the field that had typically elevated EC_e . Annual 43 % surveyed area was conducive to obtaining 80 % of full yield potential, and the central part of the field was determined to be most suitable for crop growth. Coupling of EM results with production values indicate that under elevated saline condition, it would be feasible to grow a high-value tomato crop.

Keywords Electromagnetic induction (EMI) · Salinity · Conductivity · Yield potential · Tomato

1 Introduction

Soil salinization and water shortage continue to pose

Cassel, T., Goorahoo, D., & Sharmasarkar, S. (2015). Salinization and Yield Potential of a Salt-Laden Californian Soil: an In Situ Geophysical Analysis. *Water, Air, & Soil Pollution*, 228(12), 1–8.

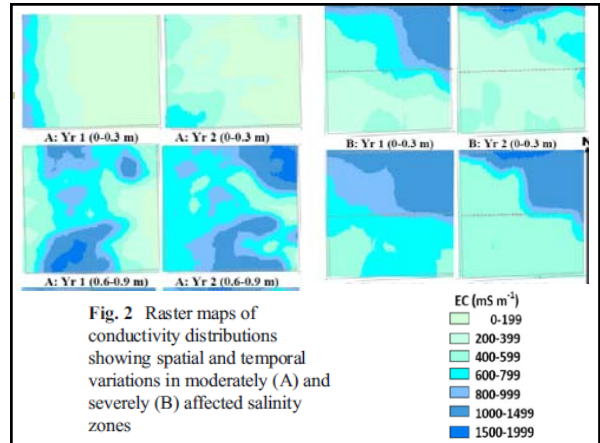


Fig. 2 Raster maps of conductivity distributions showing spatial and temporal variations in moderately (A) and severely (B) affected salinity zones

Concluding Remarks

Electromagnetic induction technique:

- Precisely assess levels of salinity and moisture across surveyed fields.
- Great potential for quick evaluation of soil properties for irrigation over large areas
- Cost-effective alternative to extensive sampling
- Valuable tool to assess salt problems and effectiveness of irrigation and salt management strategies

