Mapping Soil Salinity at Field Scale Using Geophysical Techniques

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General Topics Covered

- Review of soil salinity basics
- Introduction to geophysical techniques: electromagnetic induction (EMI), basic concepts, mobile equipment
- Methodology, guidelines, and protocols for measuring soil salinity in the field: apparent soil electrical conductivity (EC_a) directed soil sampling
- Case study: mapping soil salinity (and other soil properties) at field scale

Soil Salinity Basics

- What is soil salinity? What are its effects? And what causes it to accumulate?
  - Definition: Concentration of salts in soil solution. Major dissolved inorganic solutes (e.g., Na^+, K^+, Mg^{+2}, Ca^{+2}, HCO_3^-, Cl^-, NO_3^-, SO_4^{-2}, and CO_3^{-2})

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  - Effects:

    (1) reduces crop yield by limiting plant water uptake

    (2) specific ion toxicity (e.g., Na) or upsets plant nutrient balance

    (3) influences soil permeability
  - Salts accumulate in soil primarily due to: (1) evapotranspiration, (2) poor drainage or shallow water table, (3) poor irrigation water quality, and (4) topography

Dynamic Nature of Soil Salinity

- Soil salinity is both spatially and temporally dynamic.
- Exhibits complex spatial patterns.

- Mapping and monitoring at field scales requires a rapid, reliable, and easy means of taking geospatial measurements.

Methods of Soil Salinity Measurement from Laboratory to Field Scale

- In situ soil solution extracts (EC_w)
- In situ salinity sensor (EC_w)
- Soil samples (EC_w, EC_e, $EC_{1:1}$, $EC_{1:5}$, EC_p)
- Geophysical techniques:
  - electrical resistivity (ER)
  - electromagnetic induction (EMI)
  - time domain reflectometry (TDR)

} EC_a

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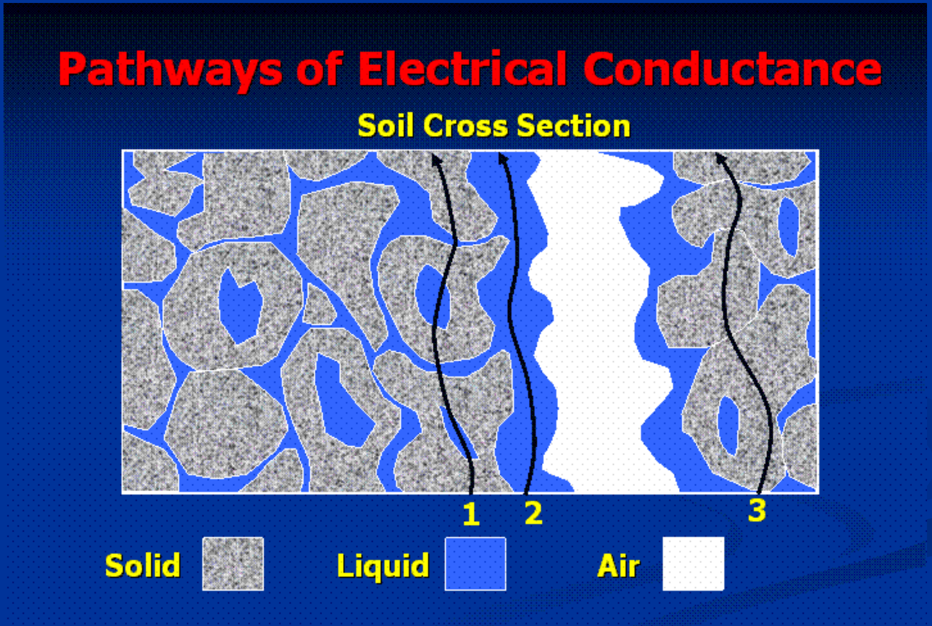
Apparent Soil Electrical Conductivity (EC_a)

- EC_a is a rapid, easy but complex measurement, influenced by several soil properties:
  - salinity
  - texture
  - water content
  - bulk density
  - organic matter
  - clay mineralogy
  - temperature

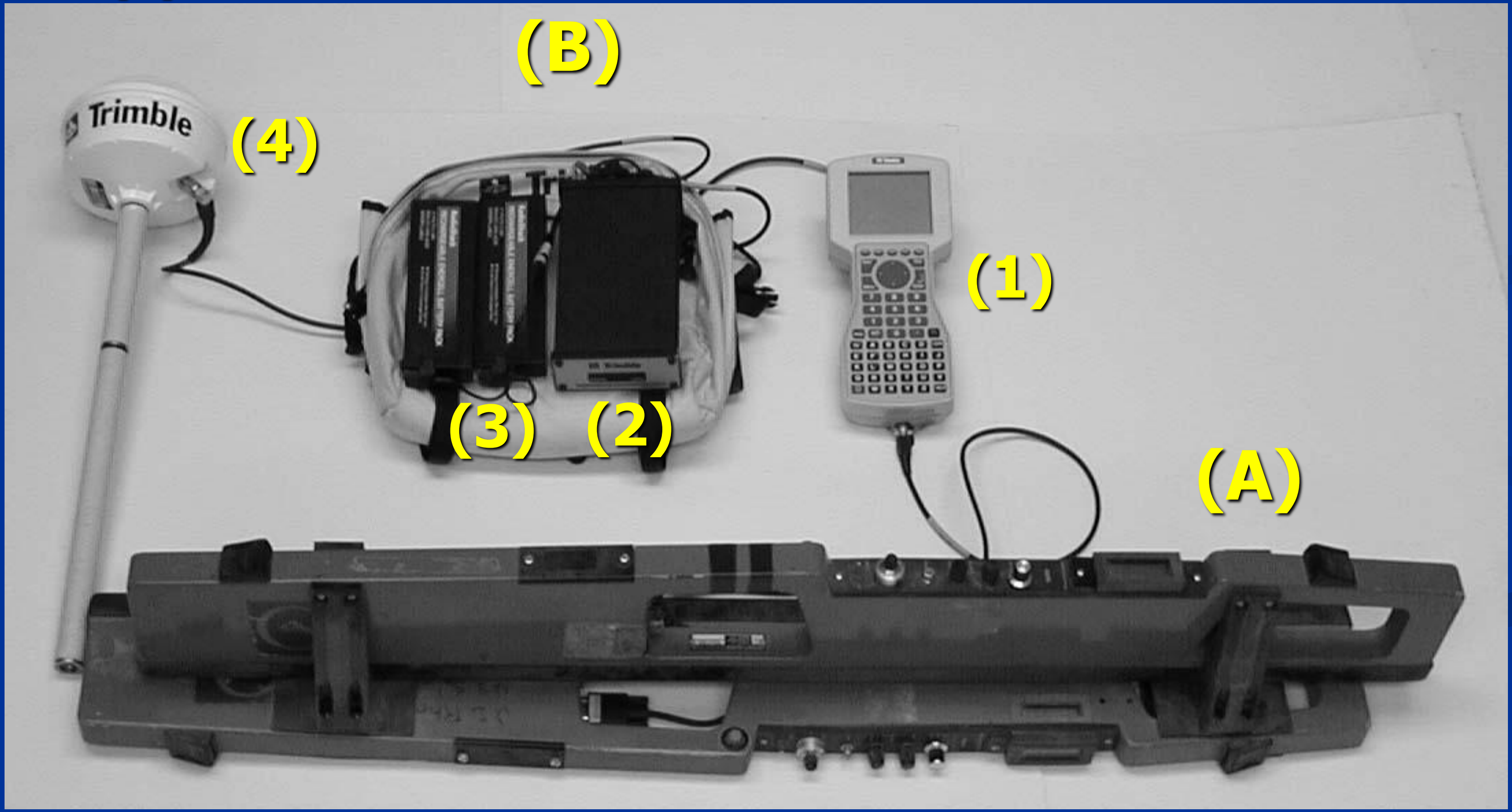


Basic EMI EC_a System w/ GPS

(A) Dual-dipole EM-38 conductivity meter

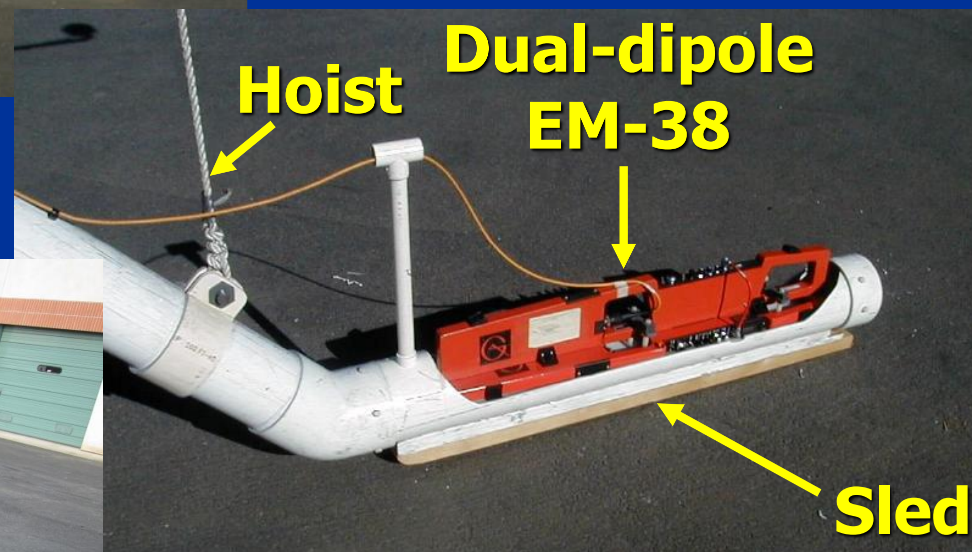
Basic EMI EC_a System w/ GPS

(A) Dual-dipole EM-38 conductivity meter
(B) Trimble MC-V Pro-XL system consisting of
 (1) MC-V datalogger
 (2) TANS receiver
 (3) battery pack
 (4) dome antenna



Salinity Lab Mobile EMI Rig

Sled w/ Dualem-2



Sled w/ Dual-dipole EM-38

All Price Ranges of EMI Rigs

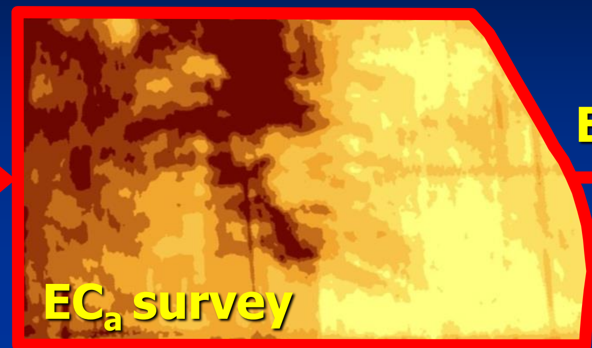
Poor Man's Mobile EMI Rig

Graduate Student's Mobile EMI Rig

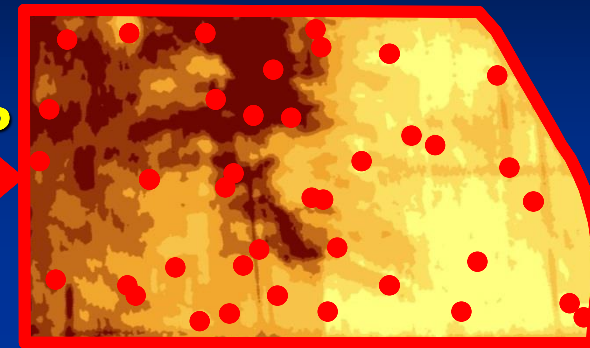
Conceptual Approach to Field-scale Mapping of Salinity

- Geospatial EC_a measurements are used as a surrogate to characterize spatial variability of soil salinity (or any soil property correlated with EC_a).
- Use spatial EC_a information to develop a soil sampling plan that identifies sites reflecting the range and variability of soil salinity and/or other soil properties correlated with EC_a.
- Soil samples are used to 'calibrate' EC_a.
- Referred to as "EC_a-directed soil sampling".

Integrated System: Protocols, Mobile EC_a Equipment, and ESAP Software

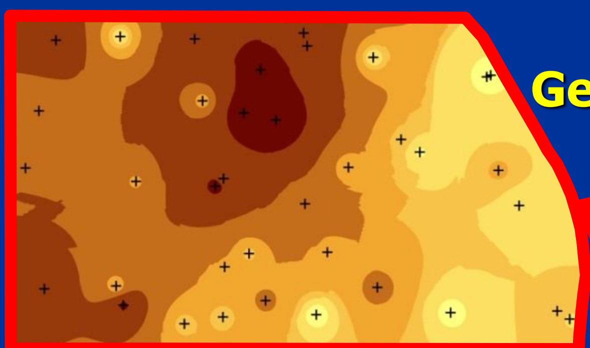


ESAP



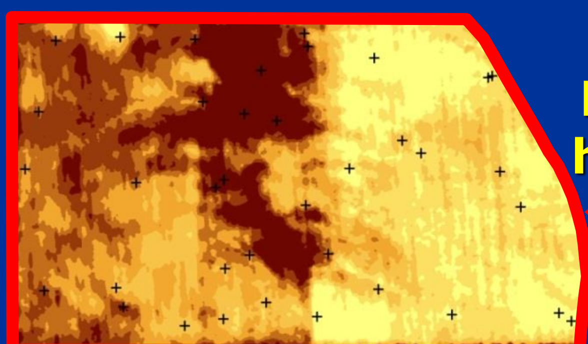
Lab analyses & GIS

- Spatial stat analysis
- Calibration models
- Basic stats etc.



Geostatistically interpolated map of hard data (e.g., salinity)

Maps of Soil Salinity



Map derived from hard and soft data

$$EC_e = b_0 + b_1(EM_V) + b_2(EM_H) + b_3(x) + b_4(y)$$

Mapping Soil Salinity (and other Soil Properties) at Field Scale

Monitor Spatio-temporal Changes during Soil Reclamation

- *Objective:* Monitor spatial and temporal changes during reclamation of a saline-sodic soil.

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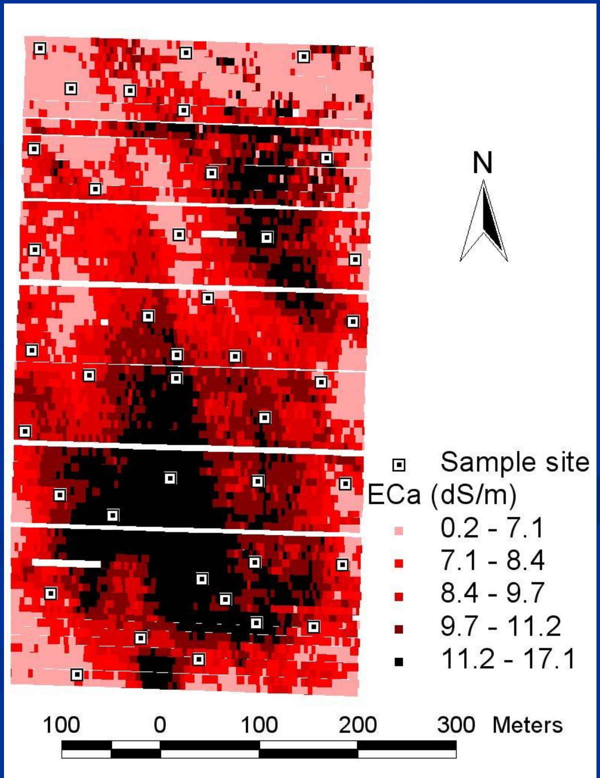
- *Intensive EC_a survey:* EC_a taken at 7288 locations.



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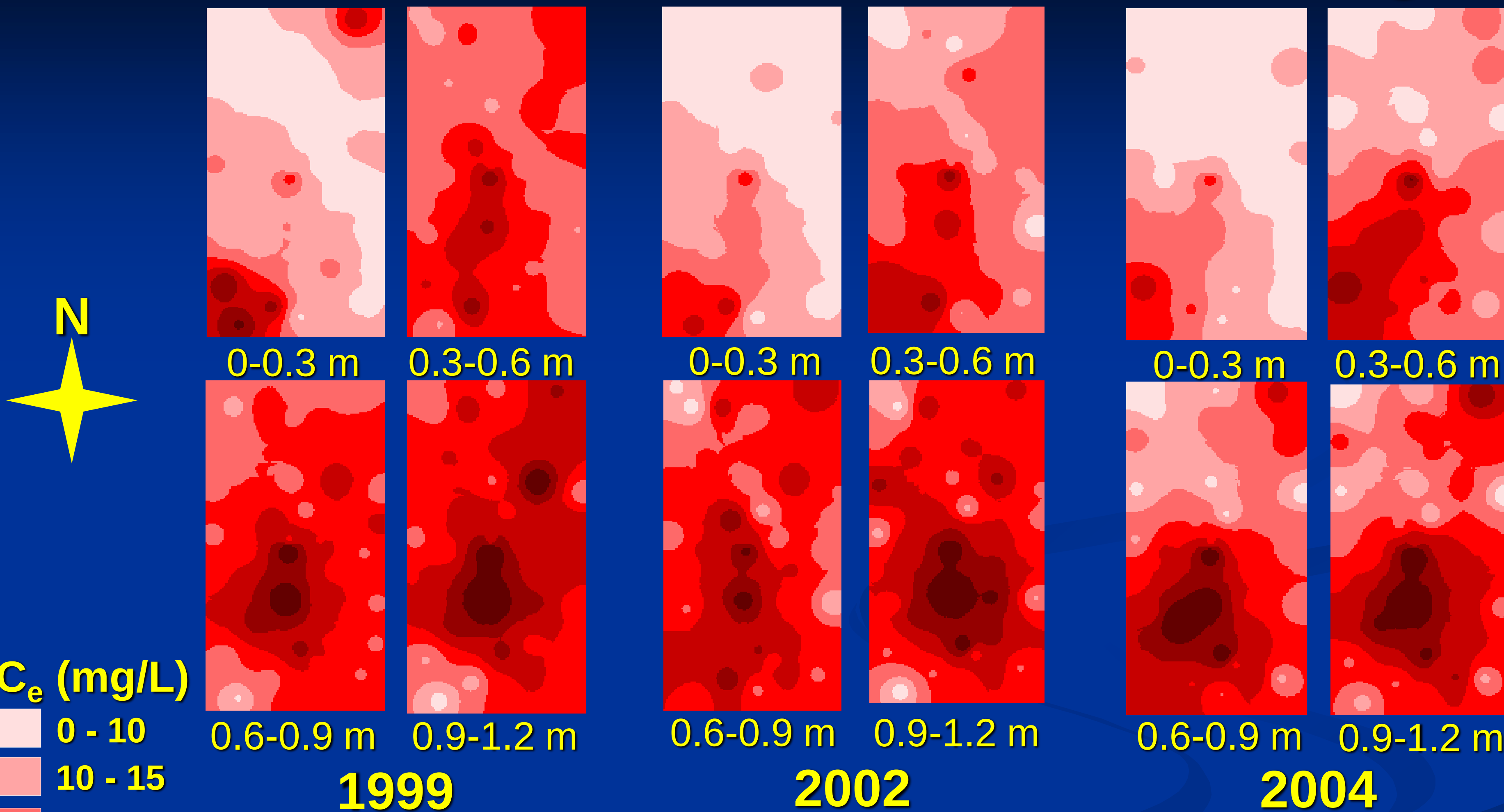
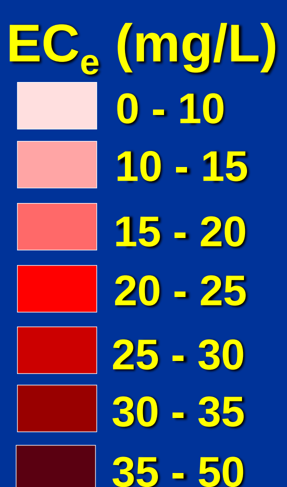
- *Study period:* 1999-2004.
- *Intensive EC_a survey:* EC_a taken at 7288 locations.
- *Soil core sampling:* 40 soil core sites with samples taken 0.3-m increments to 1.2 m. Analyzed for 4 soil properties that influenced Bermuda Grass yield and quality for 1999, 2002, 2004: salinity (EC_e), sodium (SAR), B, Mo.

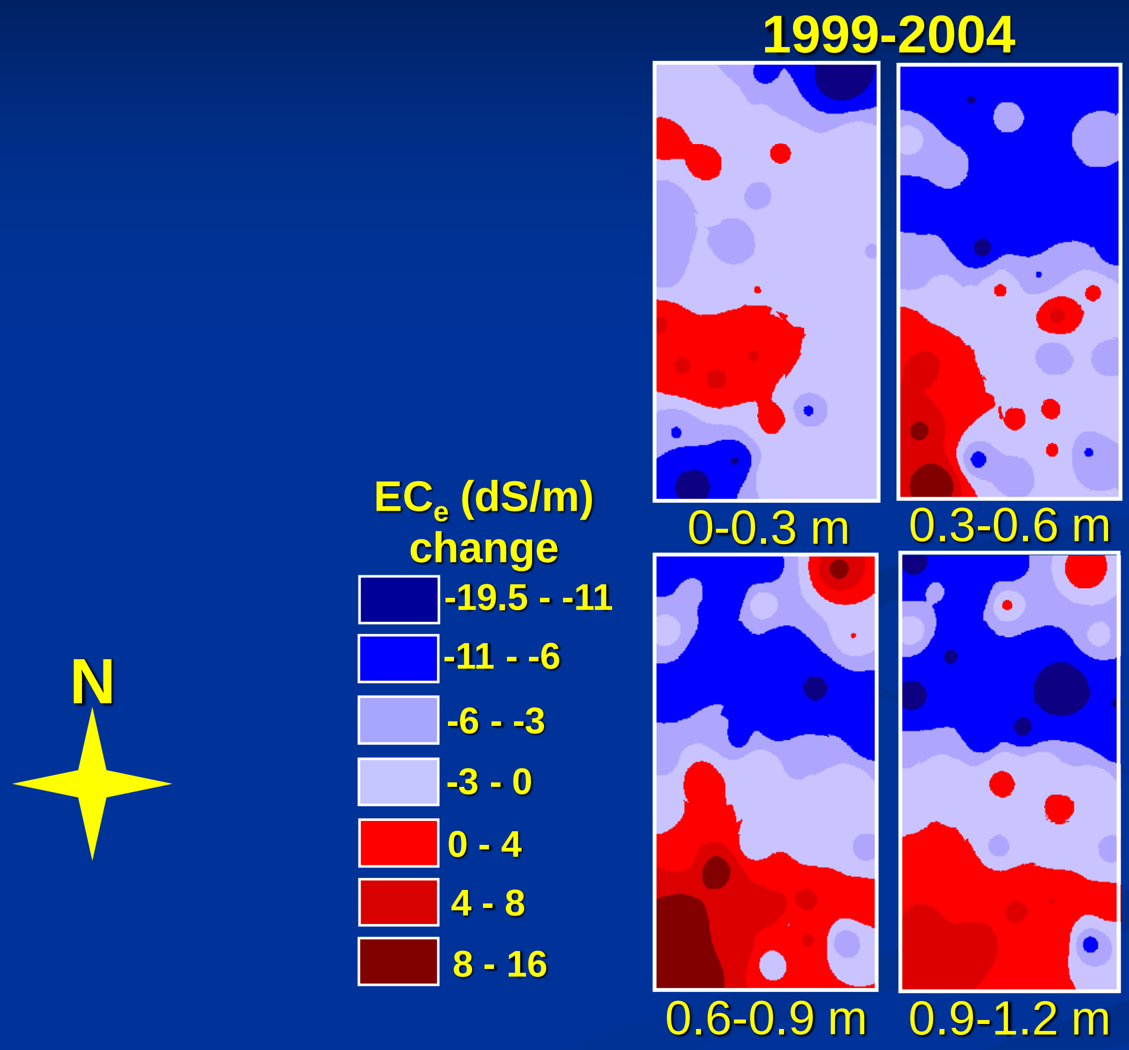
Spatio-temporal Change in EC_e



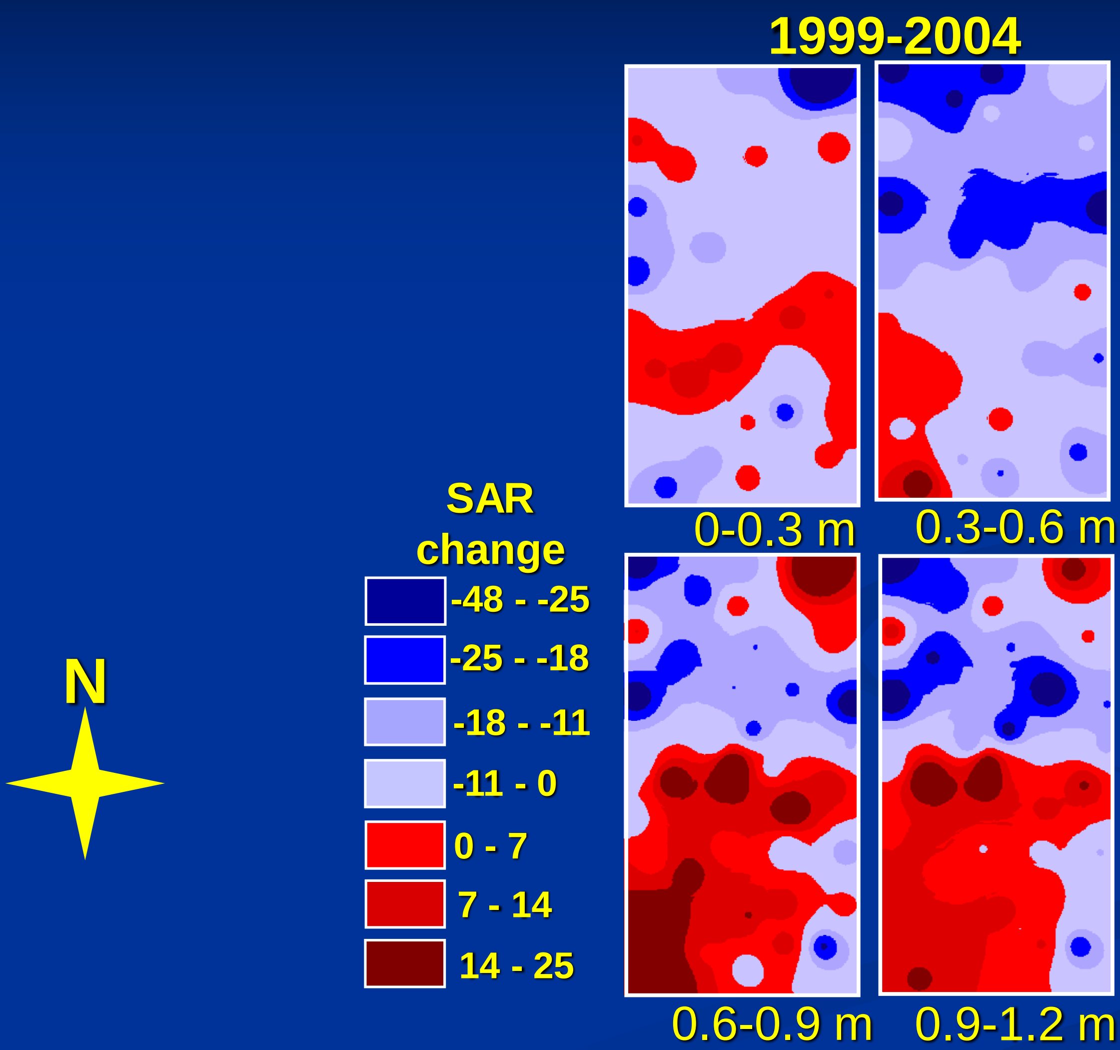


- **EC_e decreases with depth and decreases over time**
- **Leaching is decreasing EC_e particularly in top 0.6 m and in the north**

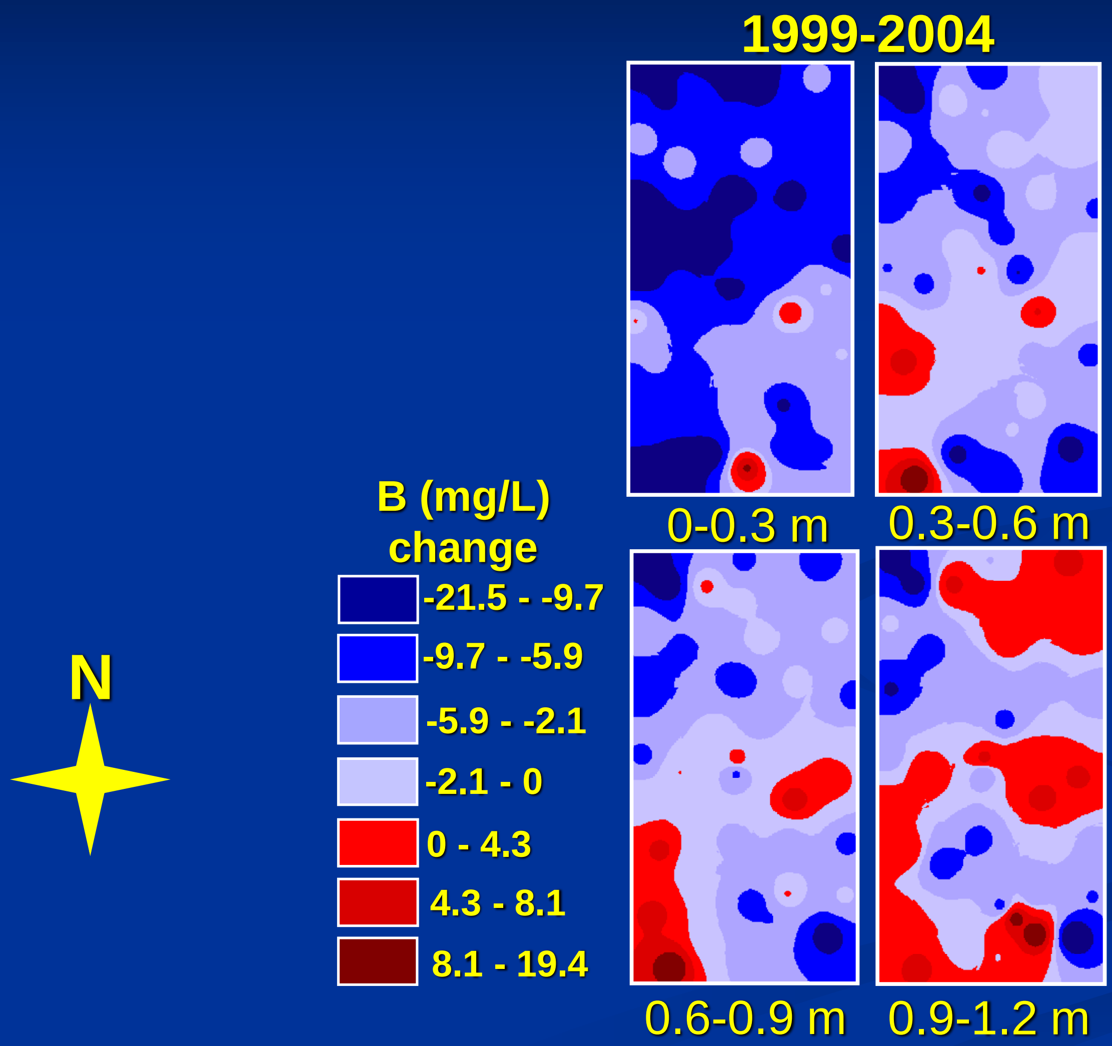
Spatial Gain & Loss in EC_e



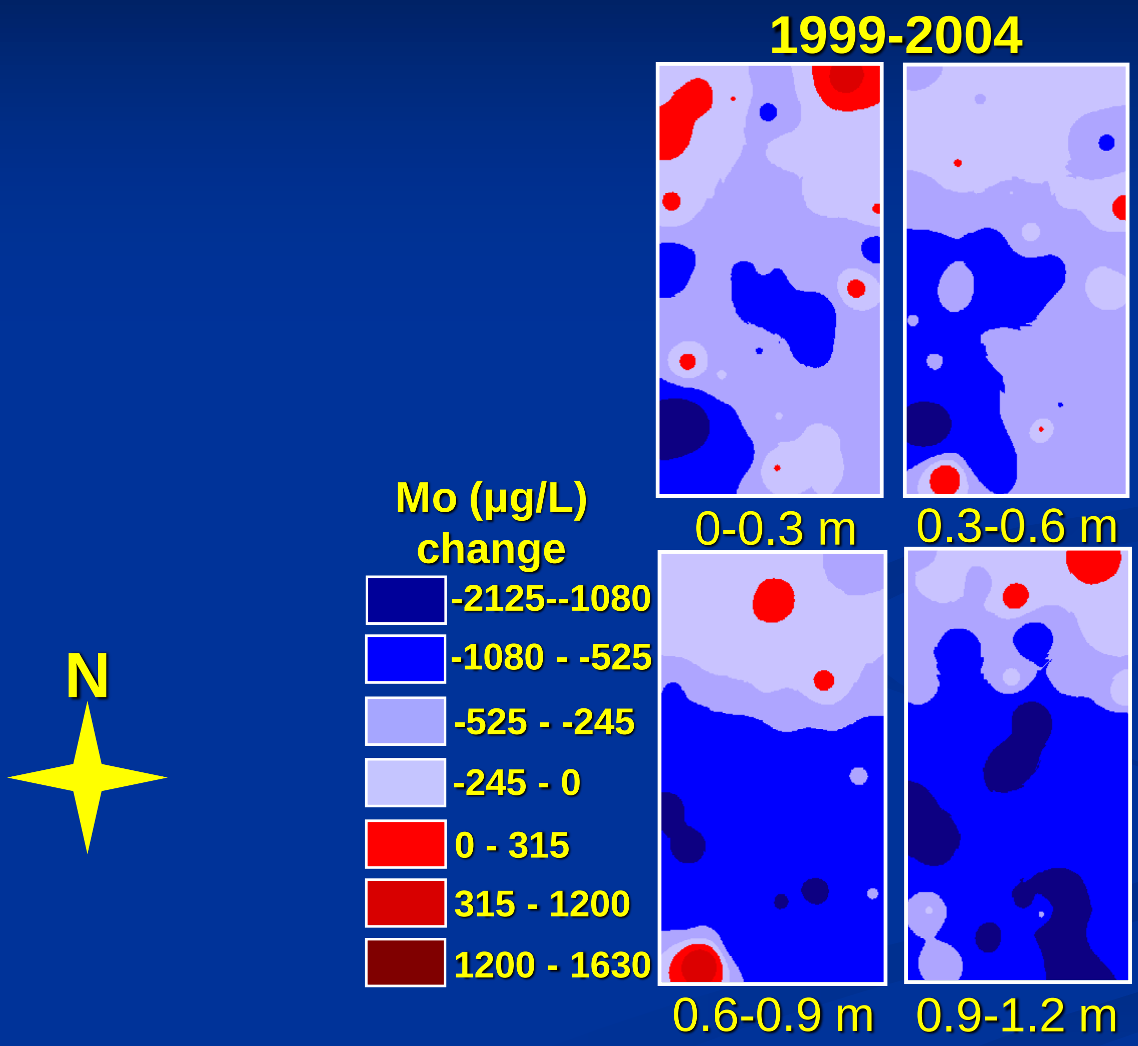
Spatial Gain & Loss in SAR



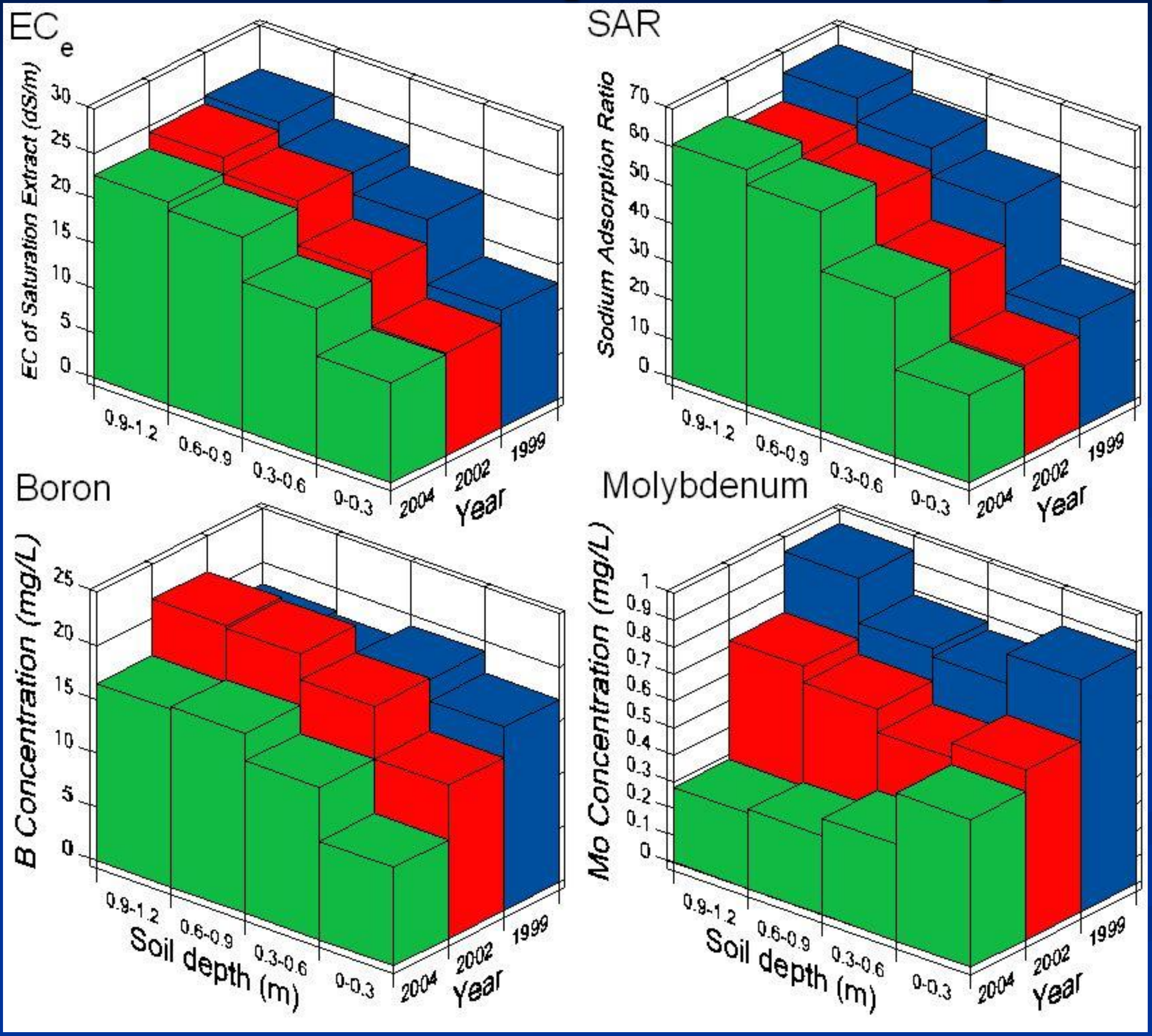
Spatial Gain & Loss in B



Spatial Gain & Loss in Mo



Temporal Change of Field Mean by Depth (1999-2004)



- **EC_e: 11% decrease**
- **SAR: 11% decrease**
- **B: 21% decrease**
- **Mo: 56% decrease**

Monitoring of Reclamation

- **Reclamation of saline-sodic soil**
  - **EC_e from top 1.2 m, especially 0-0.6 m**
  - **SAR from top 1.2 m, especially 0-0.6 m**
  - **B from top 0.6 m**
  - **Mo from top 1.2 m**

Thank You