Exploring Field Scale Variability with Remote Sensing and EMI Sensors

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Motivation:

- **Precision Agriculture:**

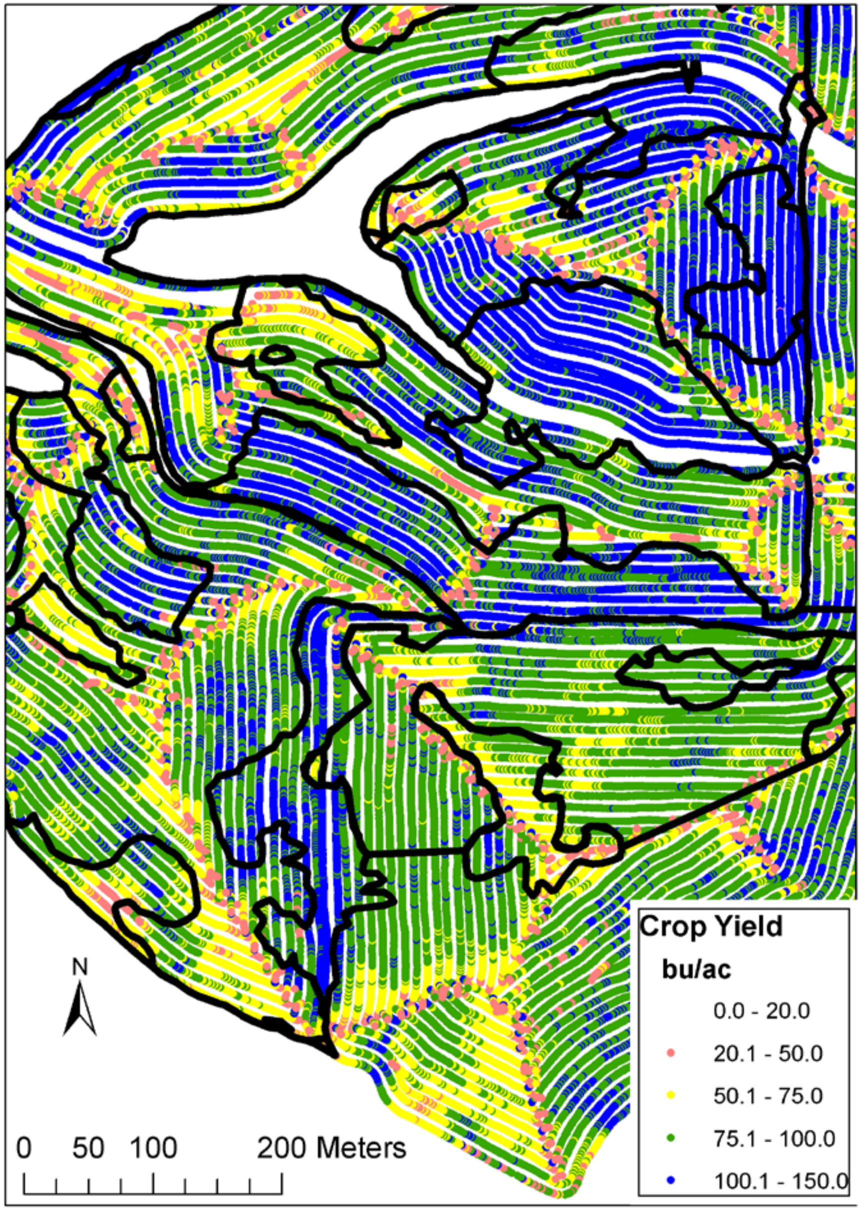
  utilizes information technologies to modify land management practices in a site-specific manner as conditions change spatially and temporally (van Schilfgaarde, 1999) for optimum profitability, sustainability, and protection of the environment (NRCS)

- 5 R's of Precision Agriculture
  - **Right** input
  - **Right** amount
  - **Right** place
  - **Right** time
  - **Right** manner

- **Challenges – delineating management zones and rates**

Data Available to Farmers

- Soil Survey
- Crop Yield Map



Data Available to Researchers

- Point-source soil data
  - Soil Sensors
  - Soil Cores
  - Time Domain Reflectometry
  - Giddings probe

Variability in crop yield and soil moisture

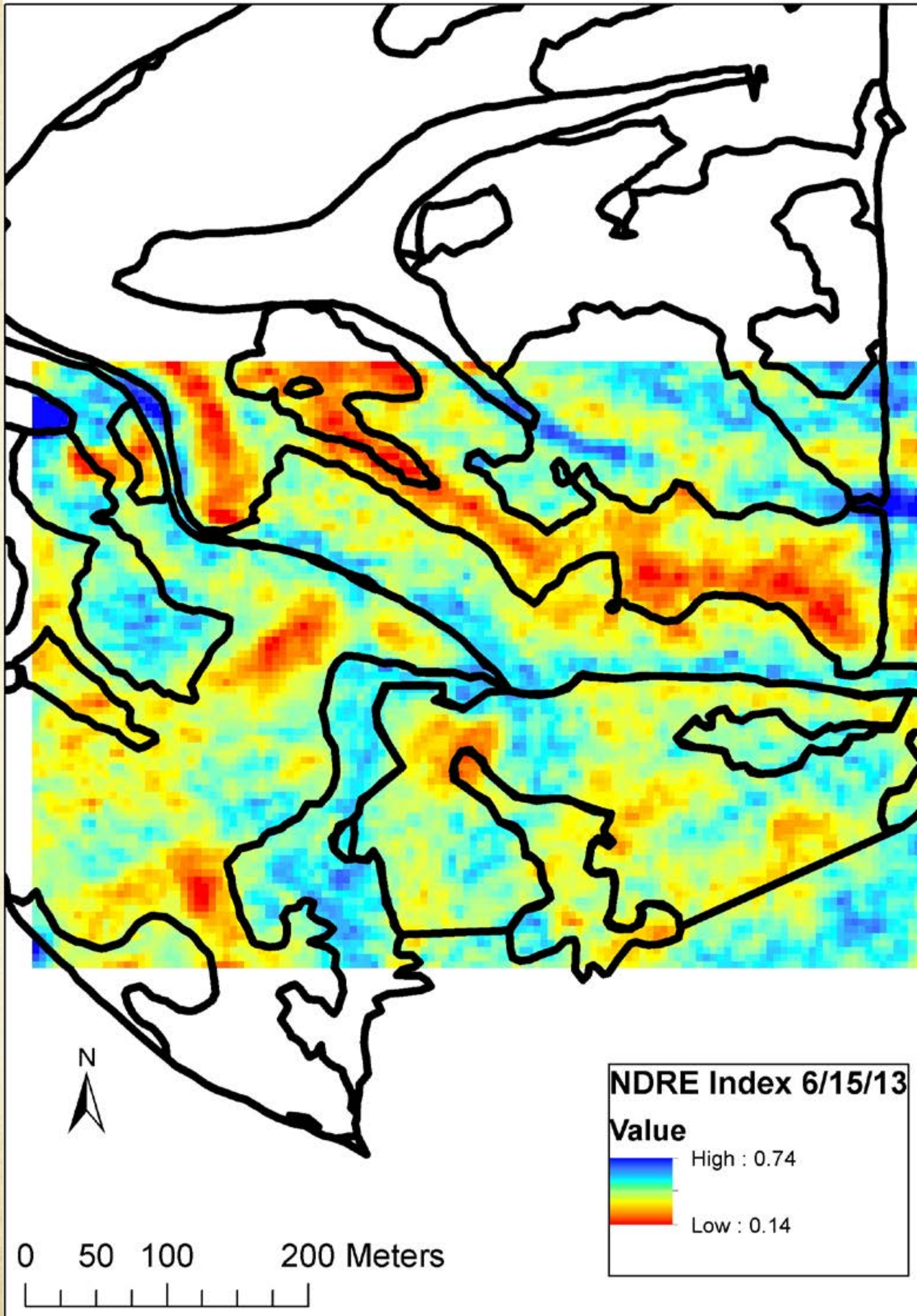
- Spatial variability in a field is highly significant
  - Amounts to a factor of 3-4 or more for crops (Birrel et al., 1995)
  - Up to an order of magnitude more for soils (Corwin et al., 2003)
- For a relatively flat 1.6-acre field up to 33 samples needed to predict mean soil moisture with 95% confidence (Hupet and Vanclooster 2002)
  - Varying topography makes comparisons of point scale data difficult (Tromp-van Meerveld and McDonnell, 2009; Robinson et al., 2012)
  - Invasive, time intensive

New Technology

- Rapid Eye Satellite Imagery – 5m resolution
  - Every 15 days
  - Near infrared bands more sensitive to chlorophyll
- Electromagnetic Induction
  - Soil Electrical Conductivity
- **Spatial and temporal mapping**

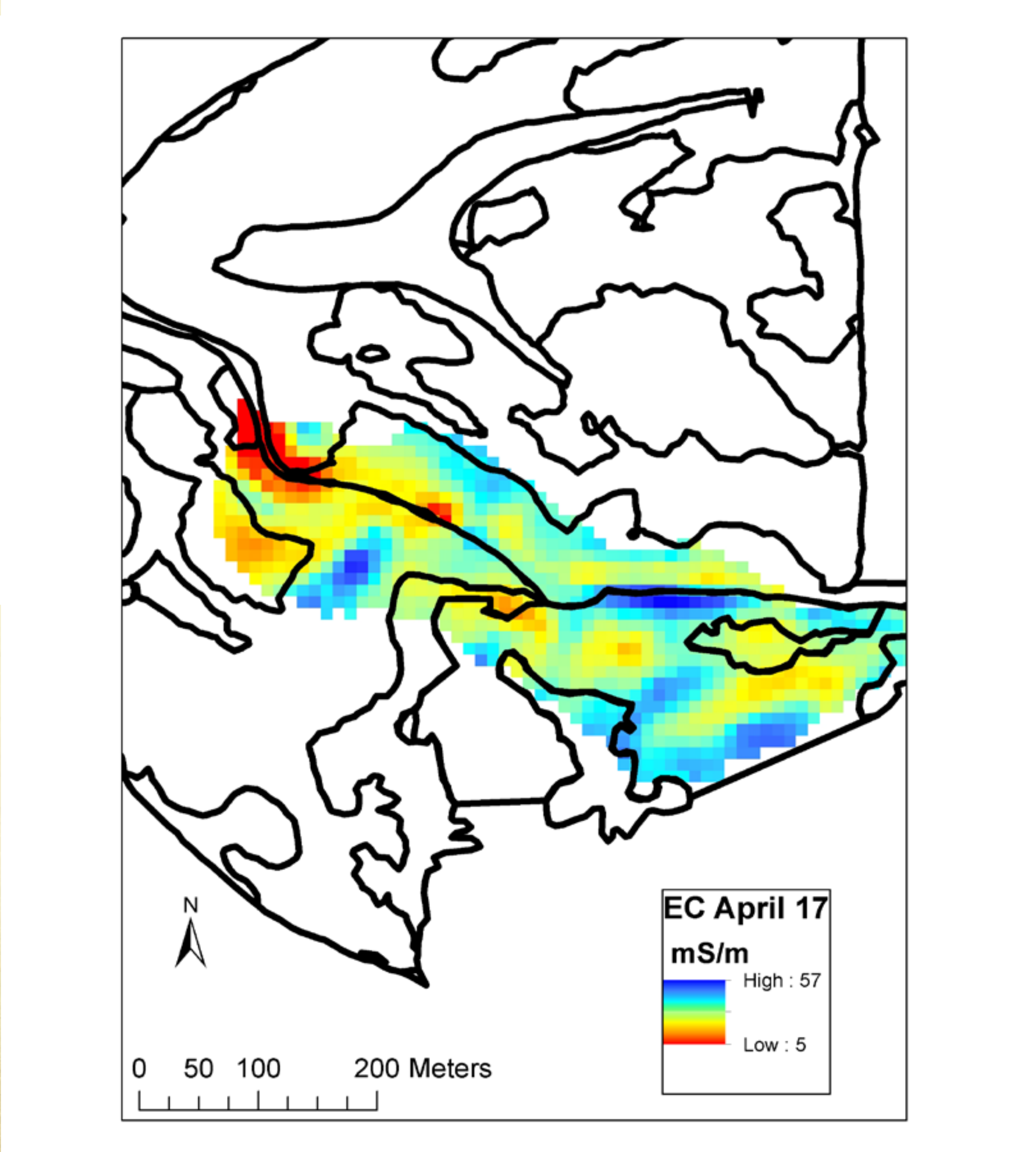
NDRE

- Rapid Eye Satellite Imagery
- Normalized Difference Red Edge Index
- Sensitive to chlorophyll content



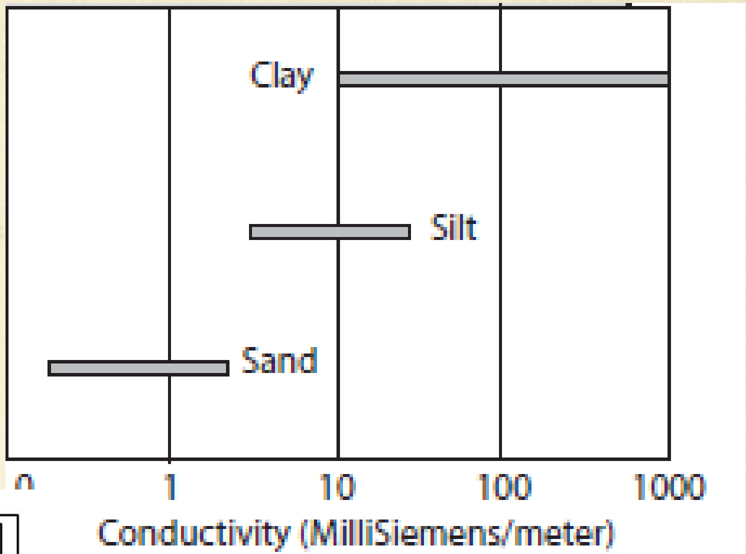
Electromagnetic Induction (EMI)

- Non-contact Electrical Conductivity (EC) readings
- Transmitting and receiving coils
- Strength of electromagnetic field proportional to soil EC
- Higher clay content, higher moisture, higher EC

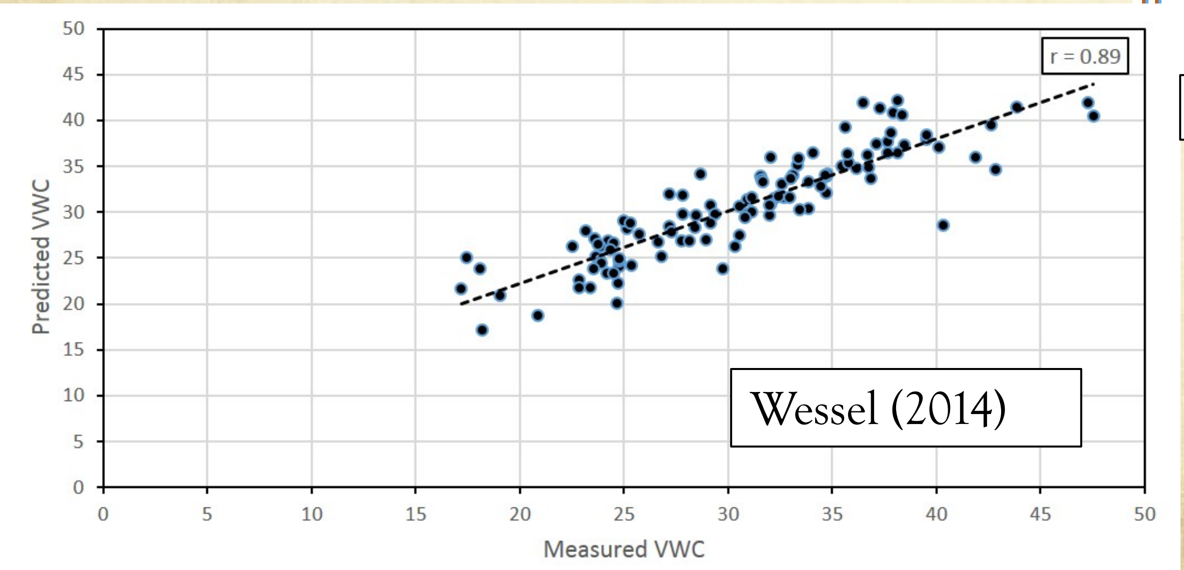


Factors affecting Electrical Conductivity

- Soil Texture
- Bulk soil density
- Water content
- Soil Salinity
- Soil Freezing



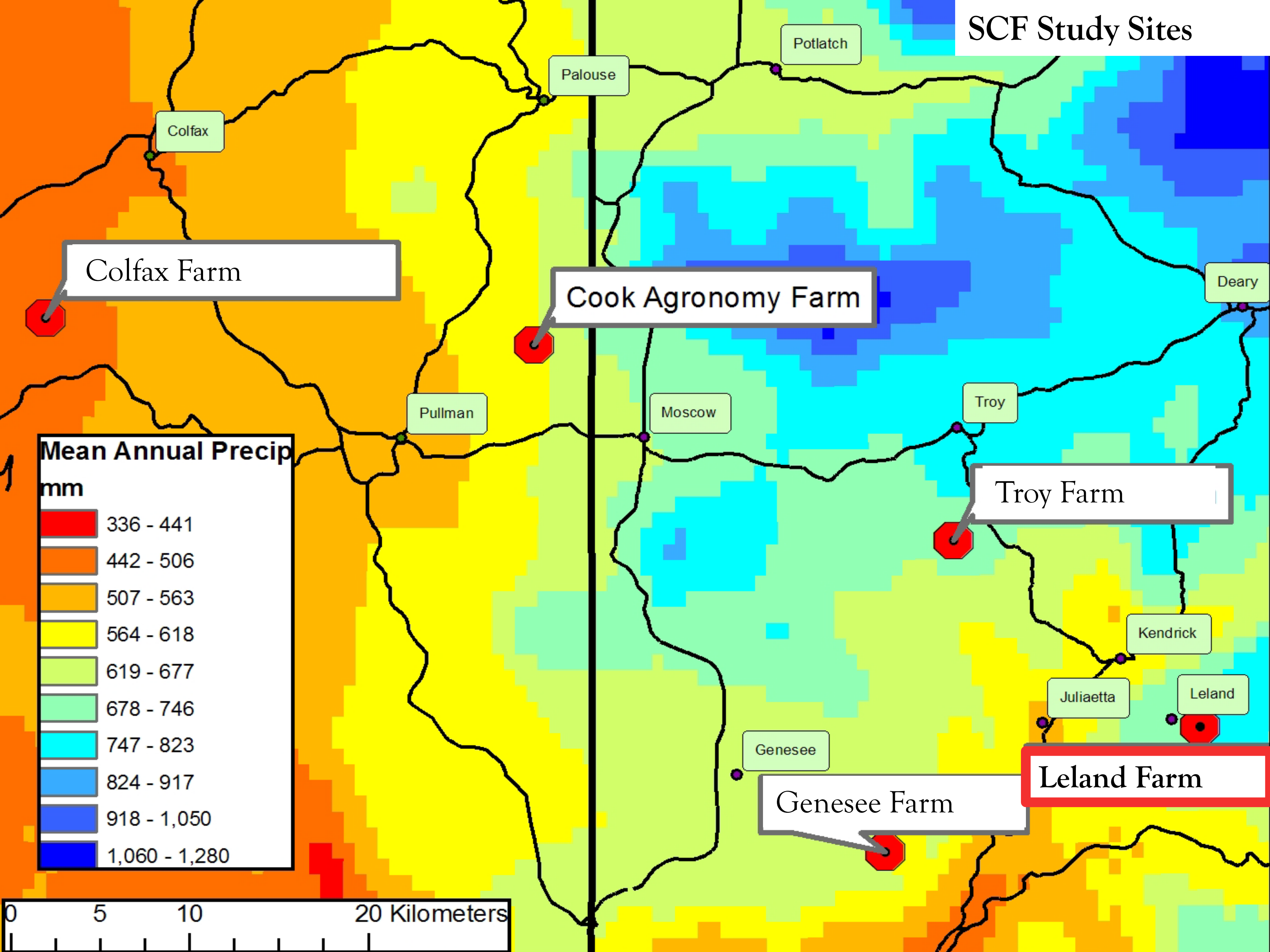
Grisso (2014) Virginia Cooperative Extension



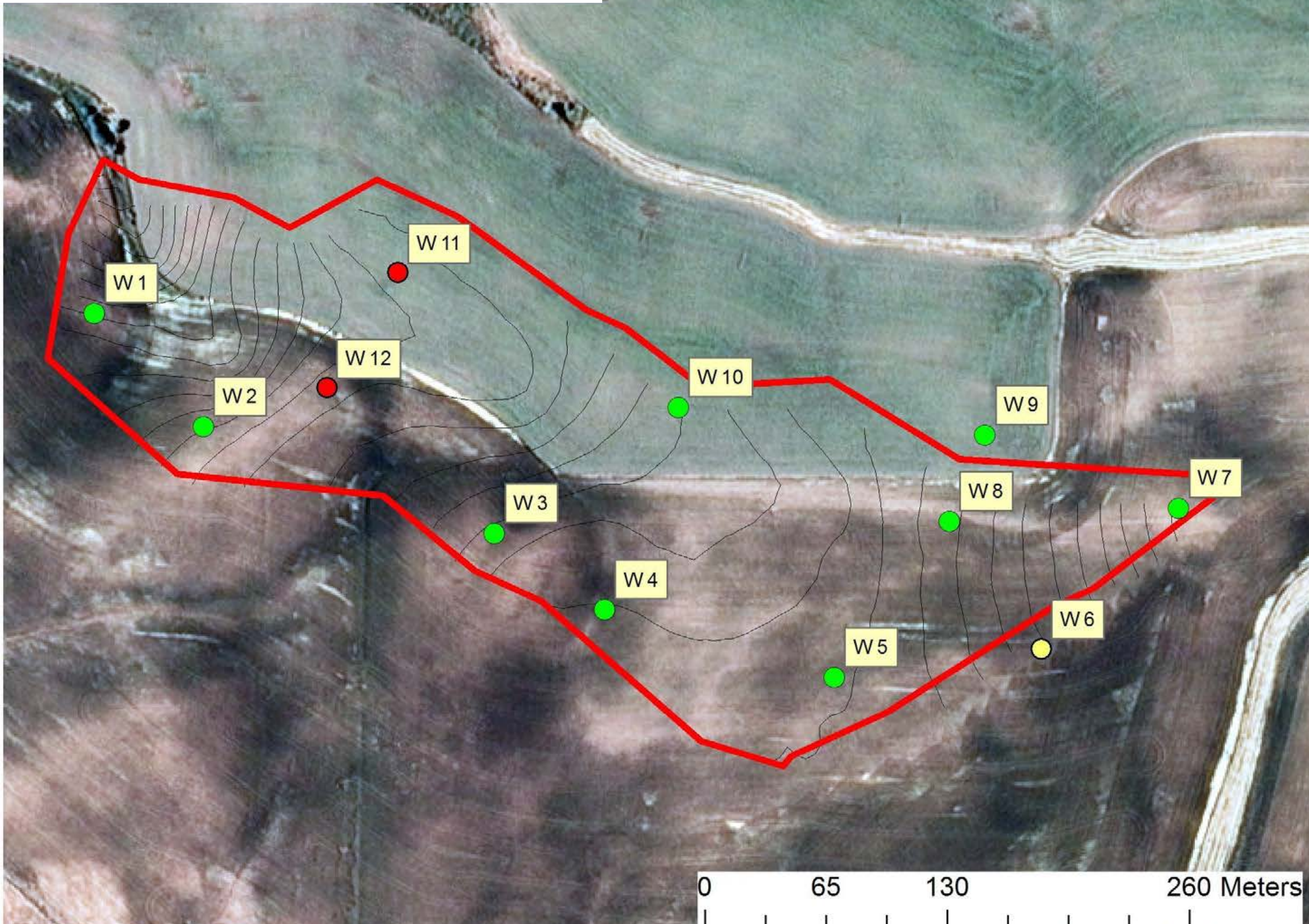
Wessel (2014)

Objectives

1. Identify factors contributing to field-scale variability in bulk electrical conductivity
2. Assess correlation between changes in bulk electrical conductivity and soil moisture
3. Assess potential of bulk electrical conductivity to delineate management zones


SCF Study Sites
Potlatch
Palouse
Colfax
Colfax Farm
Cook Agronomy Farm
Deary
Pullman
Moscow
Troy
Troy Farm
Kendrick
Juliaetta
Leland
Genesee
Leland Farm
Genesee Farm
Mean Annual Precip mm
336 - 441
442 - 506
507 - 563
564 - 618
619 - 677
678 - 746
747 - 823
824 - 917
918 - 1,050
1,060 - 1,280
0
5
10
20 Kilometers

Leland Instrumentation



Methods

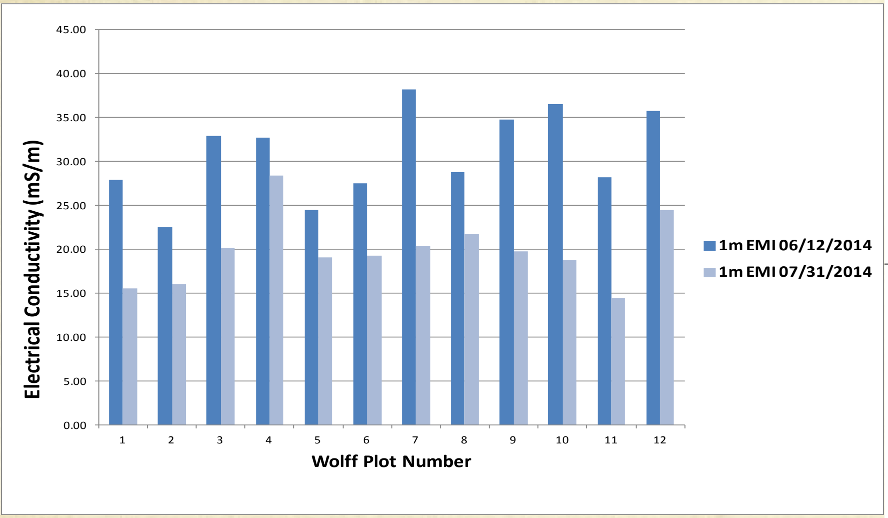
- Weekly EMI measurements at Leland field site
- Create maps based on point measurements
- Examine relationships to available data using Pearson correlation coefficients and linear regression

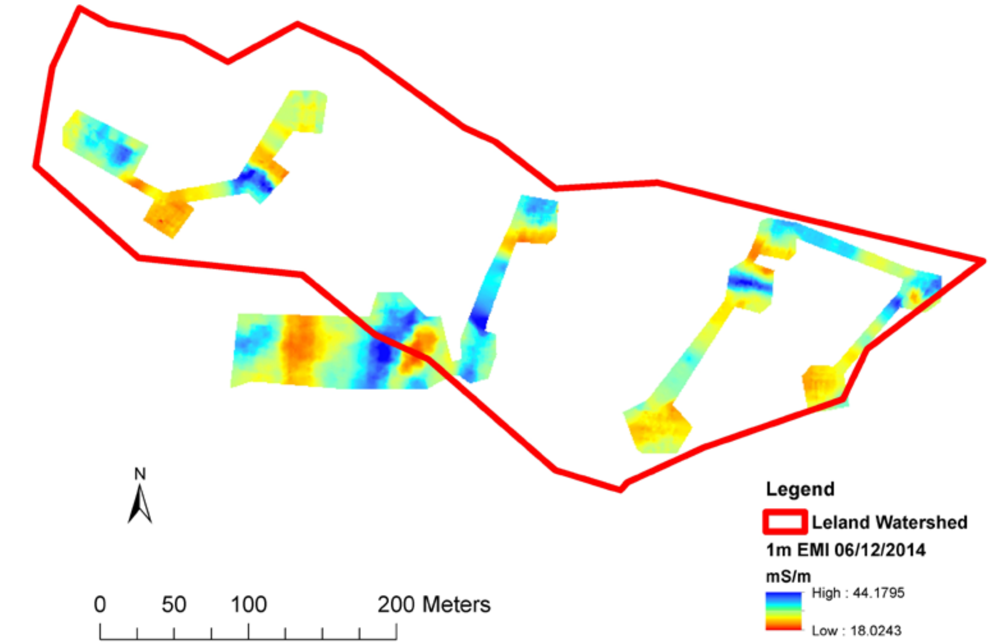
Factors examined

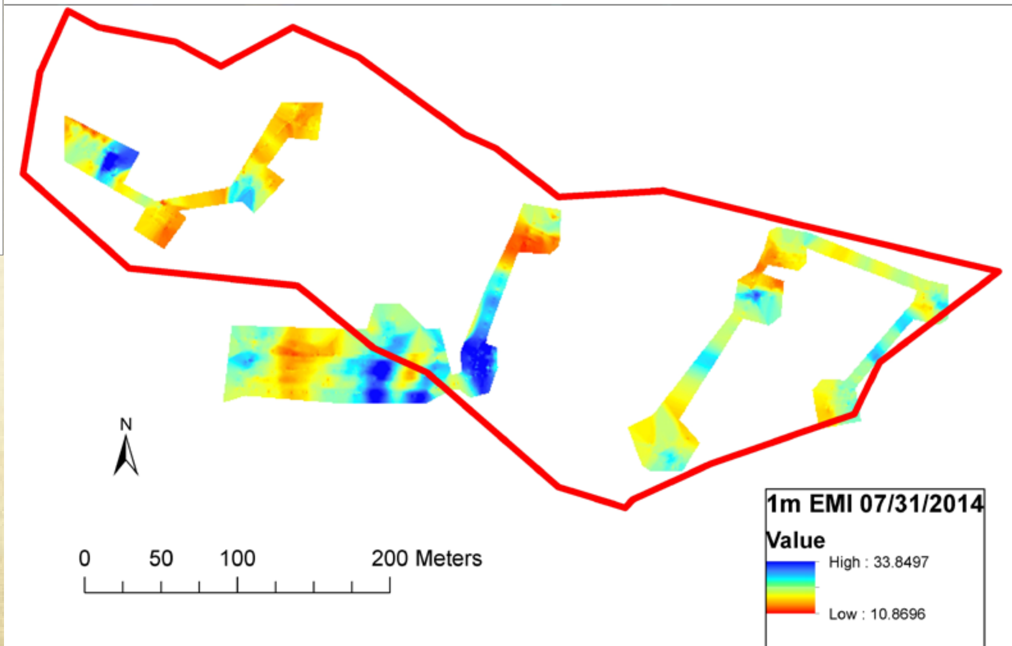
- Soil properties
  - Clay content
  - Bulk density
  - Volumetric water content over time
- Topographic properties
  - Slope
  - Aspect
  - Curvature
  - Wetness Index
- Satellite Imagery (Rapid-Eye)
  - Multiple dates during growing season
- Crop Yield Data

Results

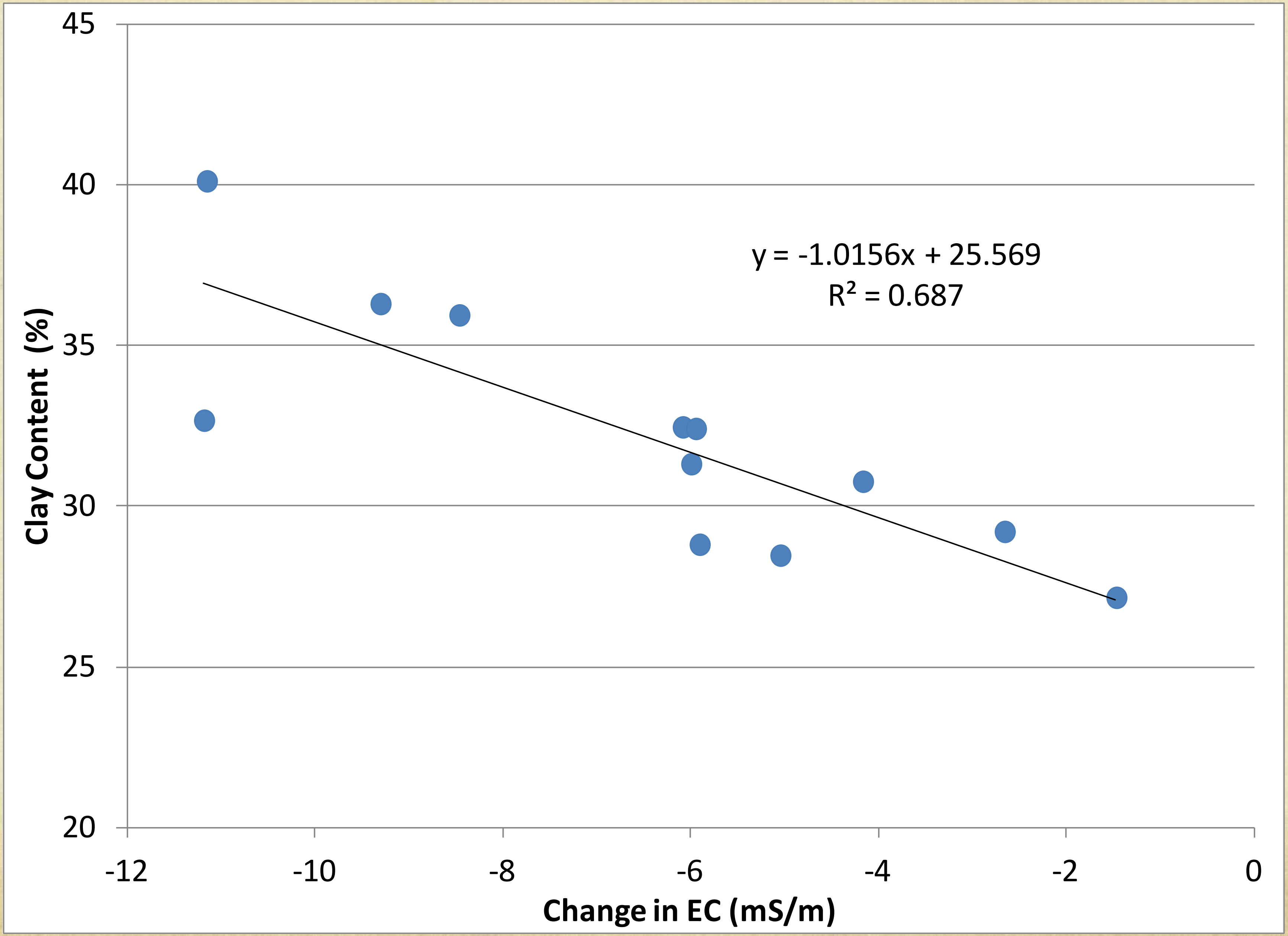
EMI maps


45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Electrical Conductivity (mS/m)
1
2
3
4
5
6
7
8
9
10
11
12
Wolff Plot Number
1m EMI 06/12/2014
1m EMI 07/31/2014

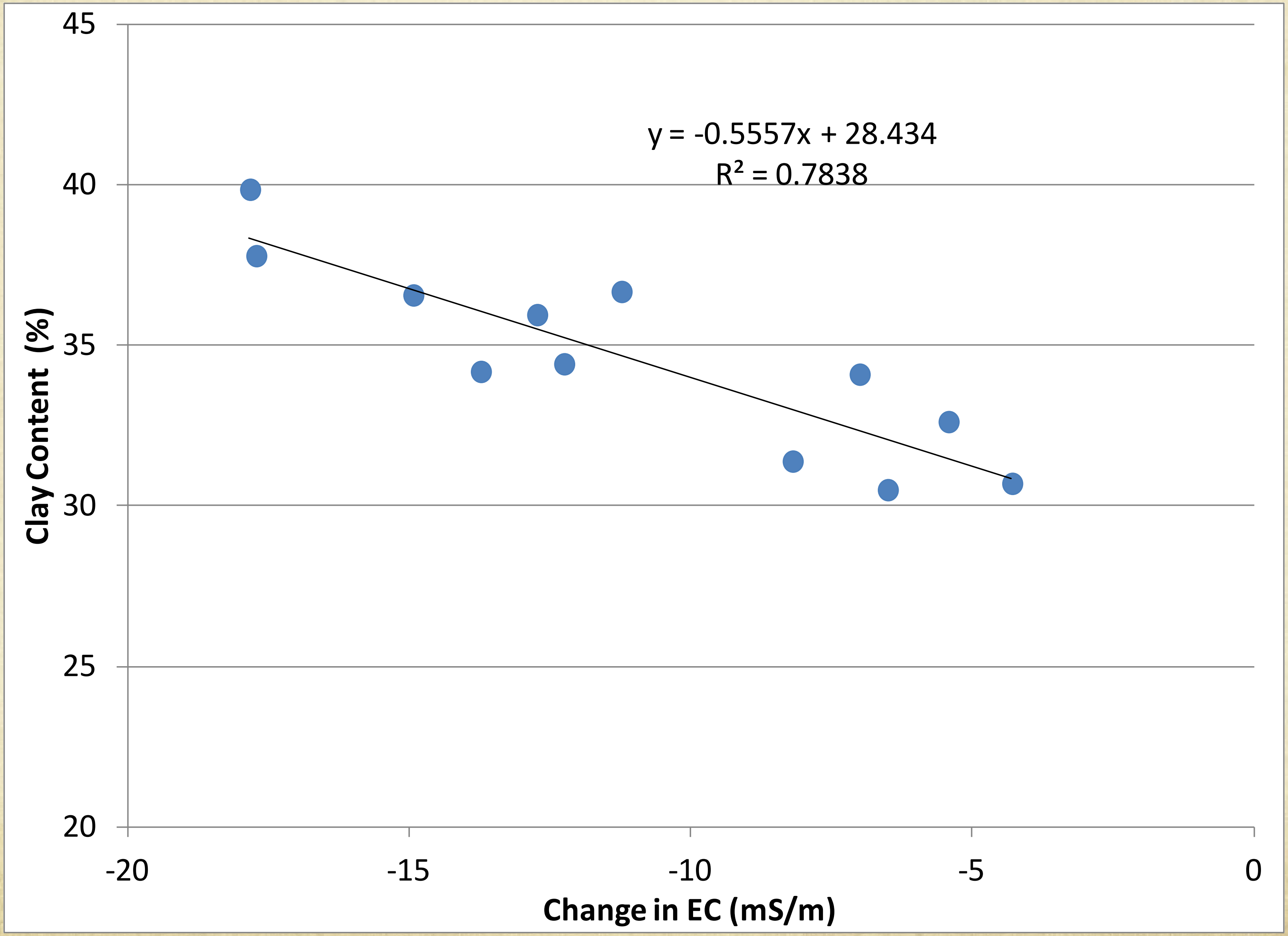

N
0
50
100
200 Meters
Legend
Leland Watershed
1m EMI 06/12/2014
mS/m
High : 44.1795
Low : 18.0243


N
0
50
100
200 Meters
1m EMI 07/31/2014
Value
High : 33.8497
Low : 10.8696

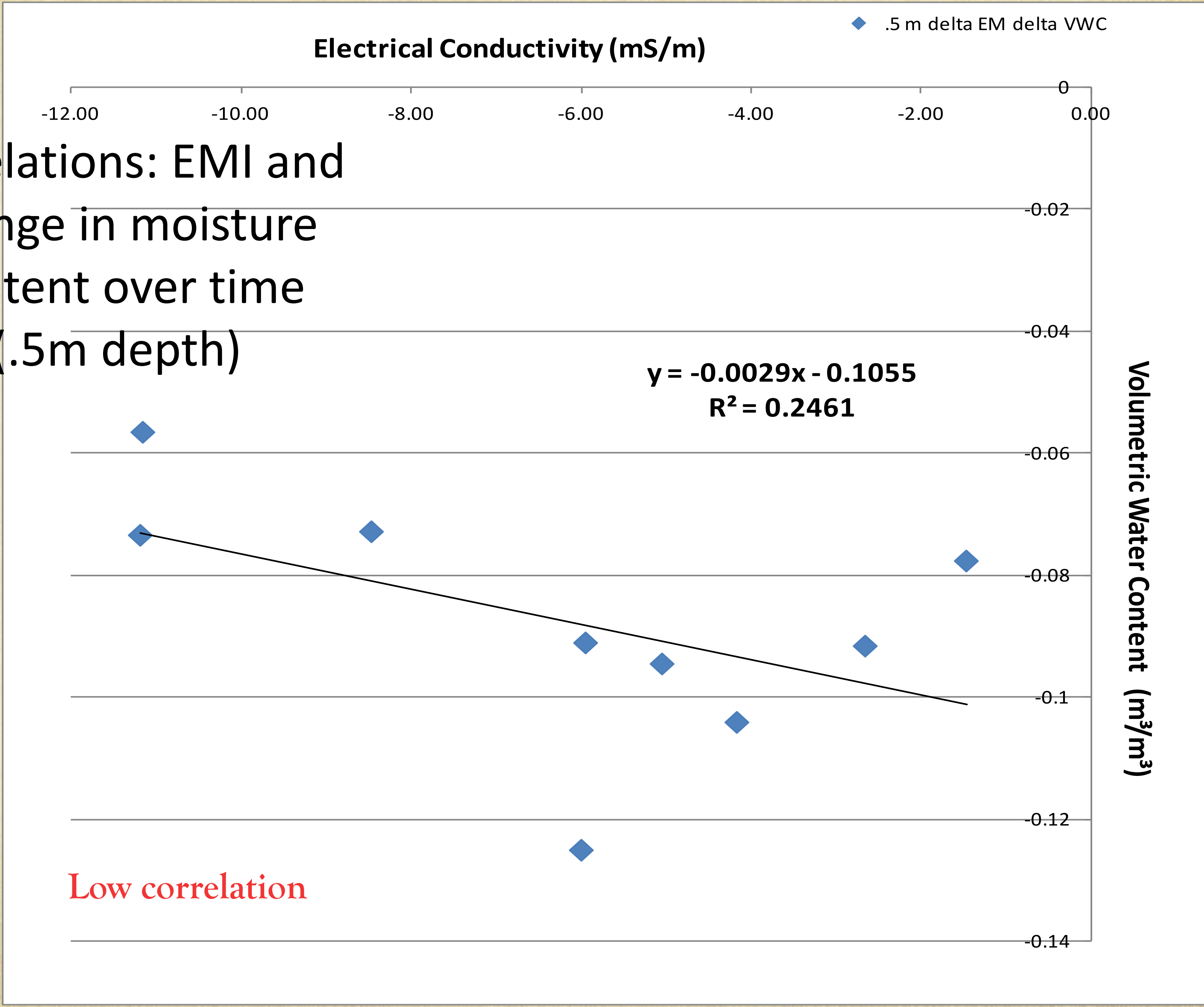
Correlation between Δ EC and Clay Content at .5 m depth



Correlation between Δ EC and Clay Content at 1 m depth

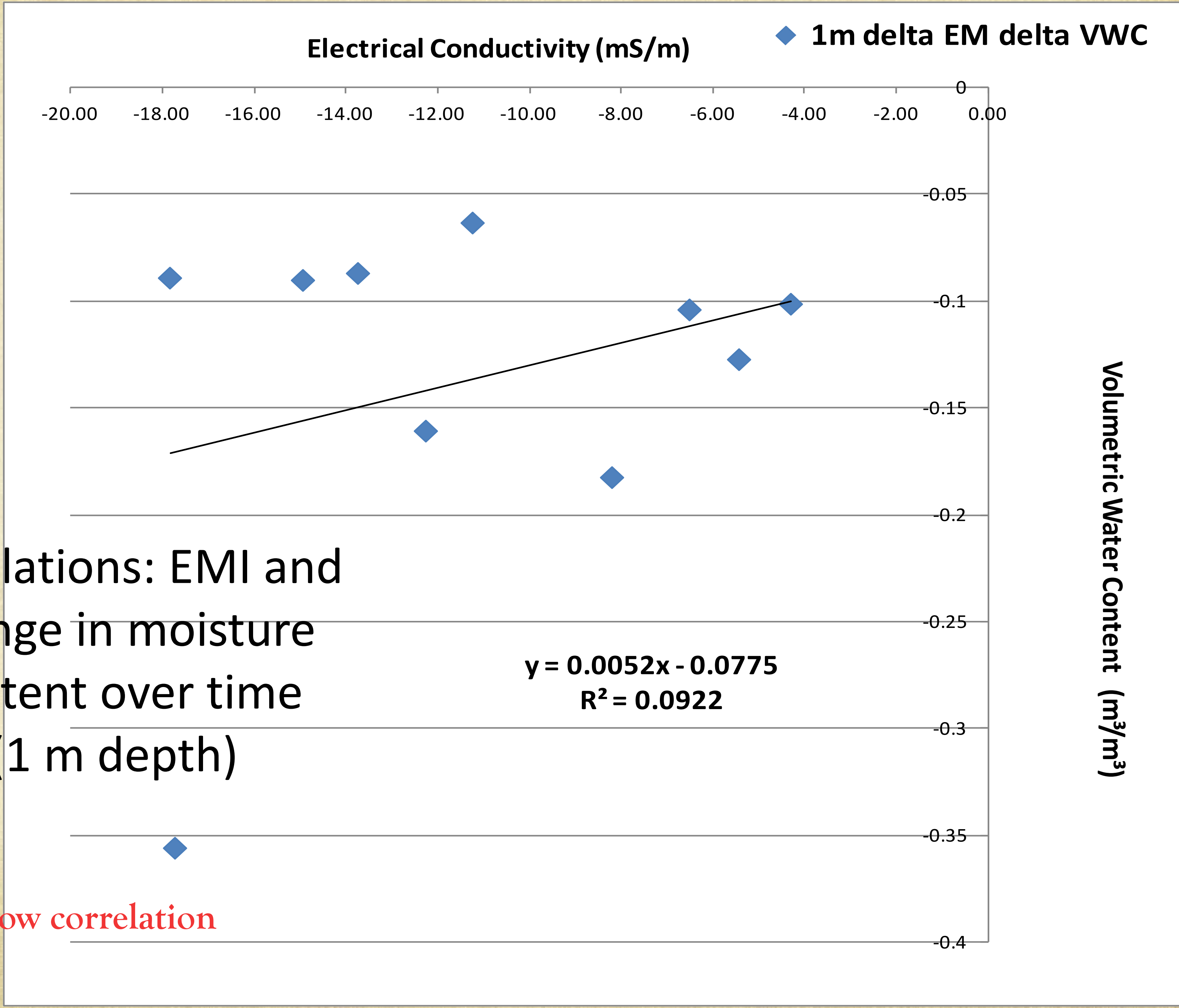


Correlations: EMI and change in moisture content over time (.5m depth)

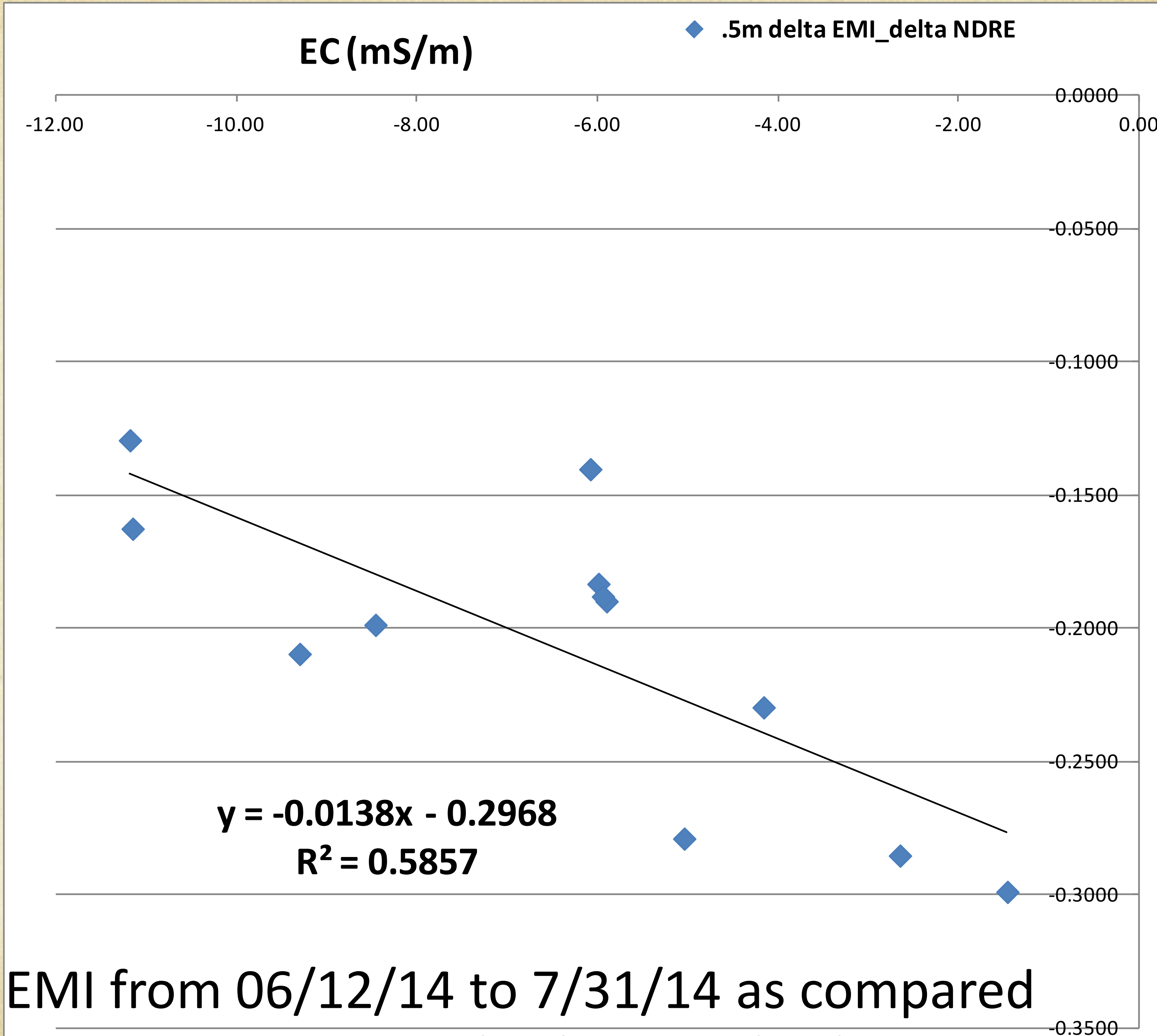


Low correlation

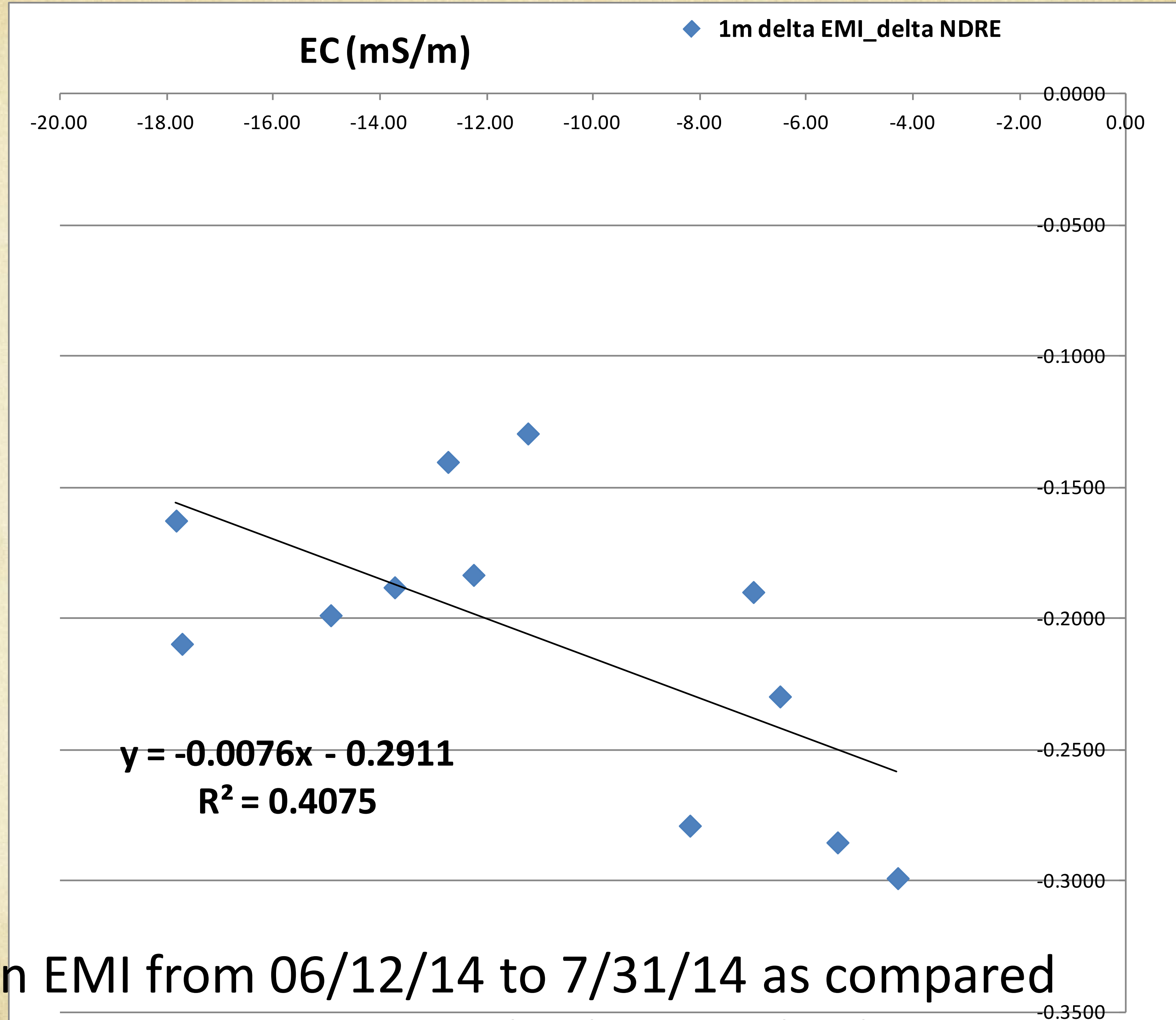
Correlations: EMI and change in moisture content over time (1 m depth)



Low correlation



Change in EMI from 06/12/14 to 7/31/14 as compared change in NDRE from 06/15/14 – 06/27/14



Change in EMI from 06/12/14 to 7/31/14 as compared change in NDRE from 06/15/14 – 06/27/14

Correlation with Crop Yield

- Crop yield had a very low correlation with:
  - Change in EC data from EMI
  - Change in NDRE
  - Change in VWC data
  - Clay content

Discussion

- **Δ** EMI strongly correlated with clay content – expected changes in EC in response to moisture
- Weak correlation between **Δ** EMI and **Δ** VWC
  - Past studies have shown strong correlation between EMI and VWC (Wessel 2014)
- Weak correlation between VWC and clay content
  - Expected changes in moisture content to be correlated with clay content
  - VWC data may be more accurate after calibrating soil moisture probes
- EC and NDRE both showed weak correlation with crop yields
  - Must be used in conjunction with other tools to delineate precision agriculture decisions

Moving Forward

- Preliminary results
- EC and NDRE must be used in conjunction with other tools to delineate precision agriculture management zones (Brooks et al 2014)
- Continue to explore the information both NDRE and EMI can provide in the Site-specific Climate-Friendly Farming project
- Incorporate crop modeling with CropSyst to further understand crop and hydrologic responses of different management zones

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