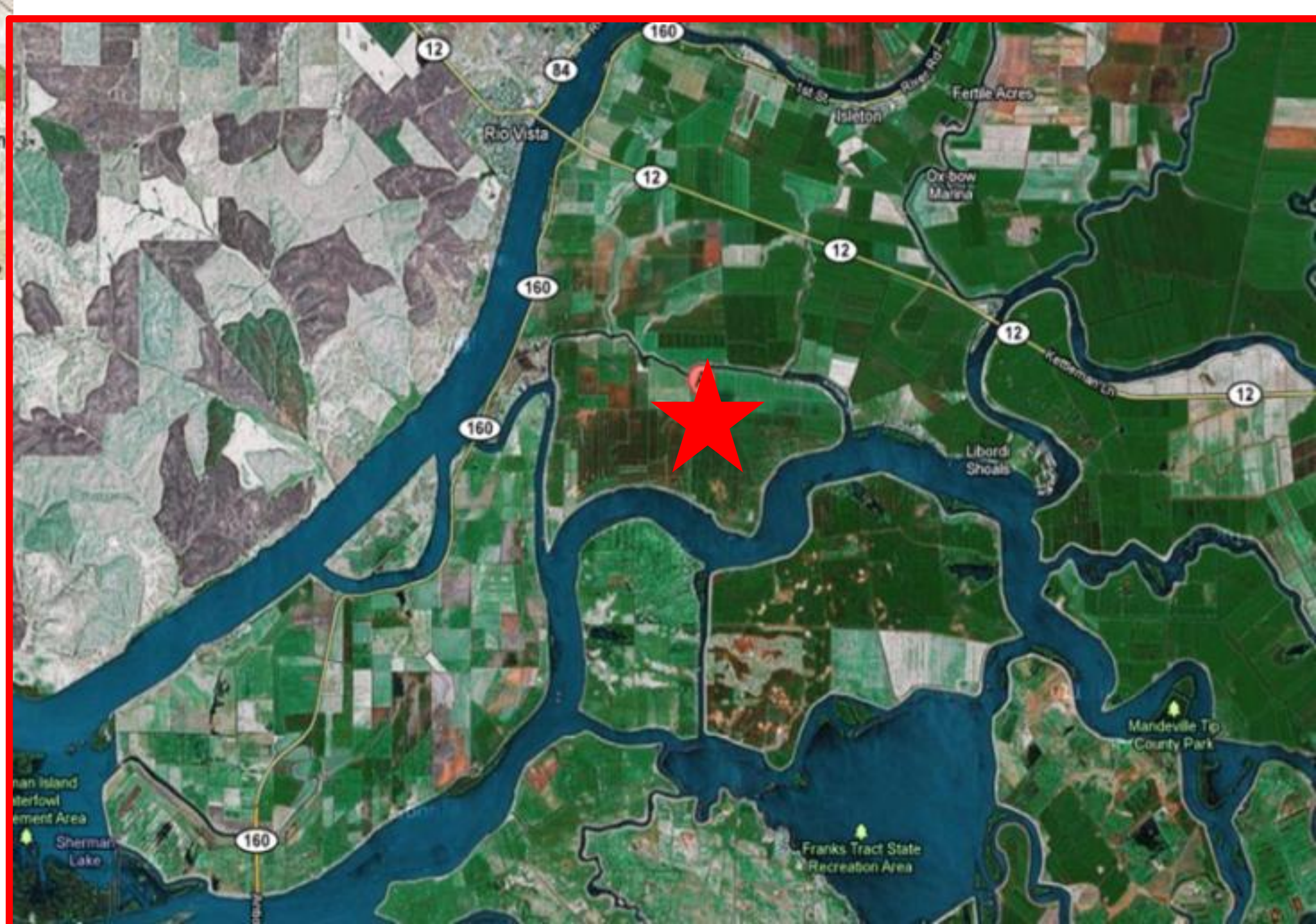
Measuring Subsidence in a Degraded Peat Soil: Nitrogen Mineralization under Rice Cultivation

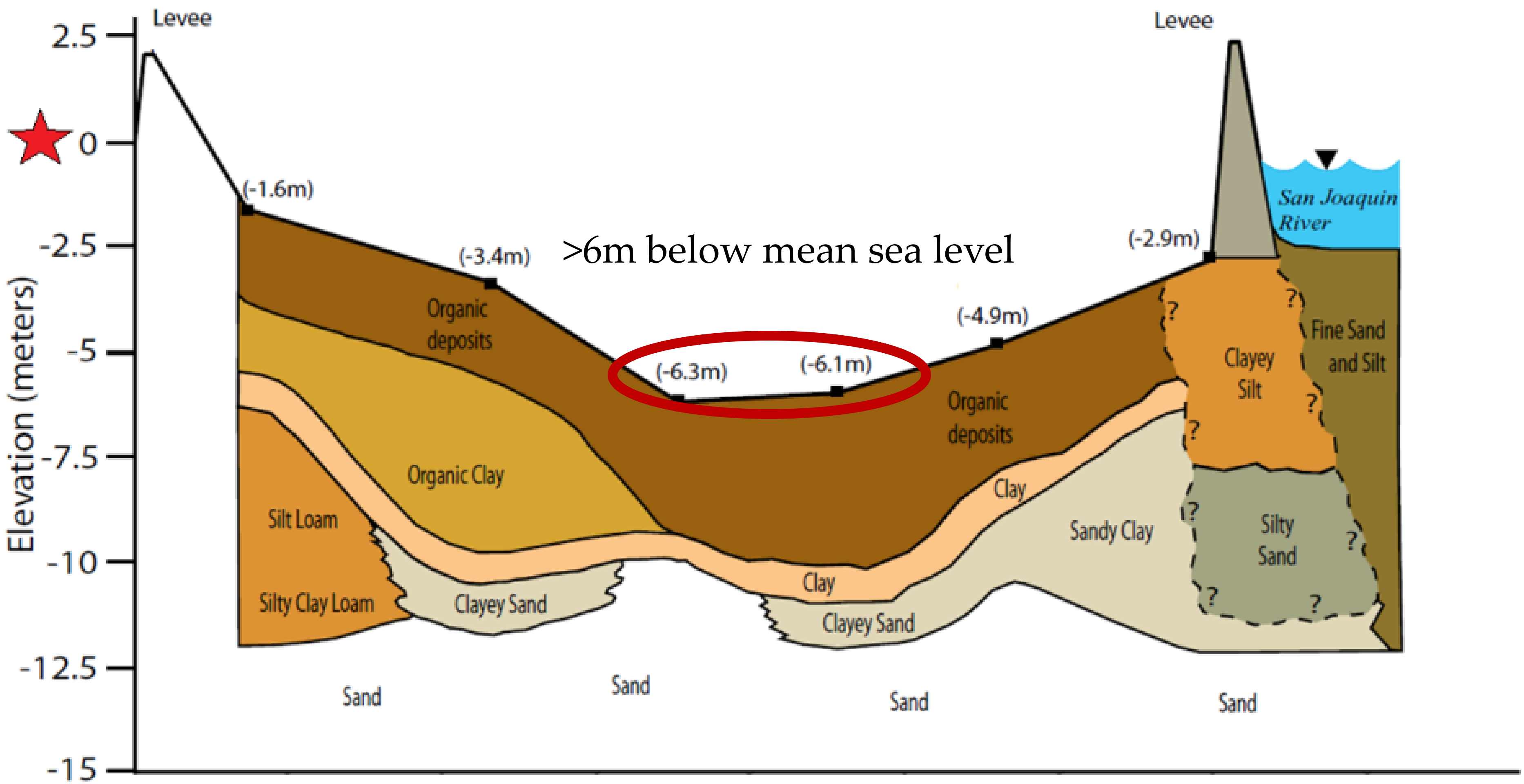
Emilie Kirk
Bruce Linquist
Chris van Kessel
University of California, Davis

Sacramento - San Joaquin River Delta

Aragon, 2013



Cross-section of Twitchell Island



Average soil loss of 1-3 cm per year!!

Deverel et al., 2007

160 levee failures in the last century in California

DWR, 2007

Why grow rice in the Delta?

- Slow or reverse soil subsidence
- Maintain flooded conditions most of the year, mimicking seasonal wetlands
  - Anaerobic soil should reduce microbial activity
- Agriculture continues in Delta

N Fertilizer Study

- 180 kg N/ha average uptake with no N fertilizer!

- N uptake in well-fertilized CA rice ~140 kg N/ha
  Linquist et al., 2009

Nitrogen Budget Objectives

- Quantify the environmental sources of N under rice production on Twitchell Island
- Use N mineralization as a proxy to estimate subsidence

Nitrogen Budget Hypotheses

1. Majority of plant-available N from peat mineralization
2. A small amount of N from previous year's crop residue
3. N from water sources are negligible

Materials & Methods: Site Setup

- RCBD experiments with 4 blocks
- Replicated in 2 fields
- Soils are Typic Haplosaprists
    - 13-15% C in the upper 30cm
- Conventionally managed paddy rice fields

Materials & Methods

Residue

- ^{15}N-tracer method for growing season
- Field residue sampled over-winter

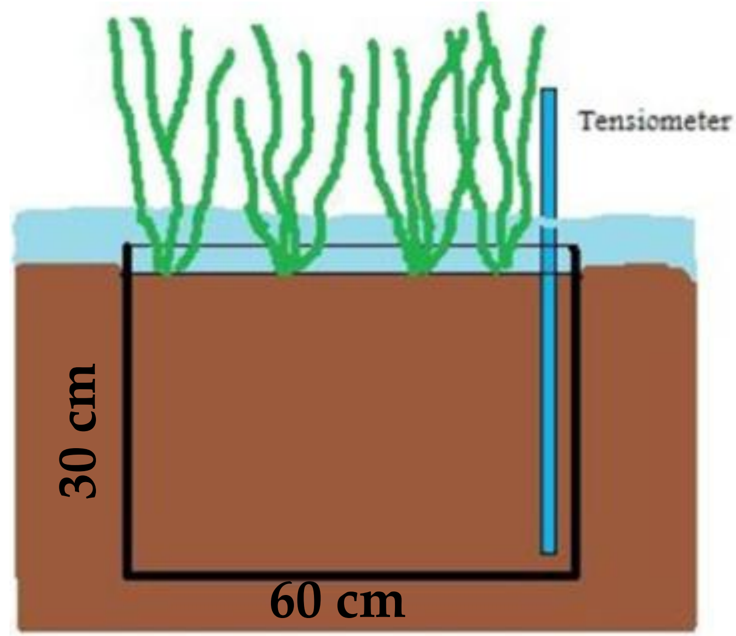
Water

- *In situ* mesocosms

  + H_2O

  - H_2O

- Surface water sampled for growing season

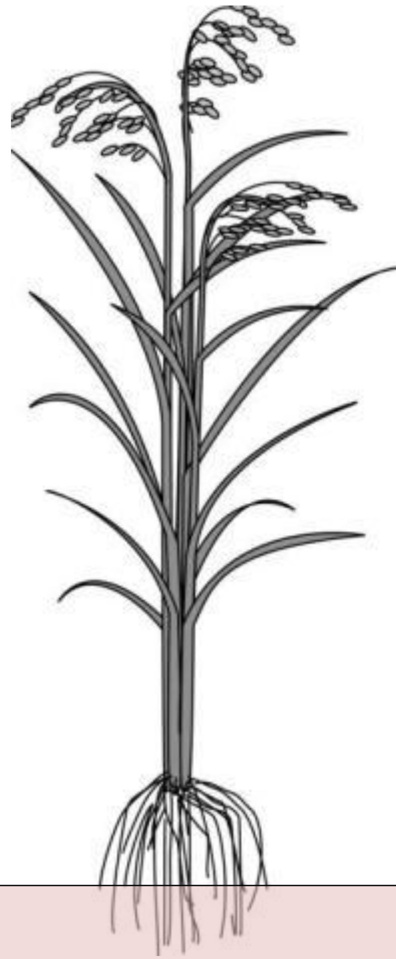


Annual N Budget Components

Growing Season	Over-winter
Peat + Residue + Subsurface Water + Irrigation Water	Peat + Residue

Growing Season N Budget: Surface water

Unfertilized N Uptake = 167 kg N/ha



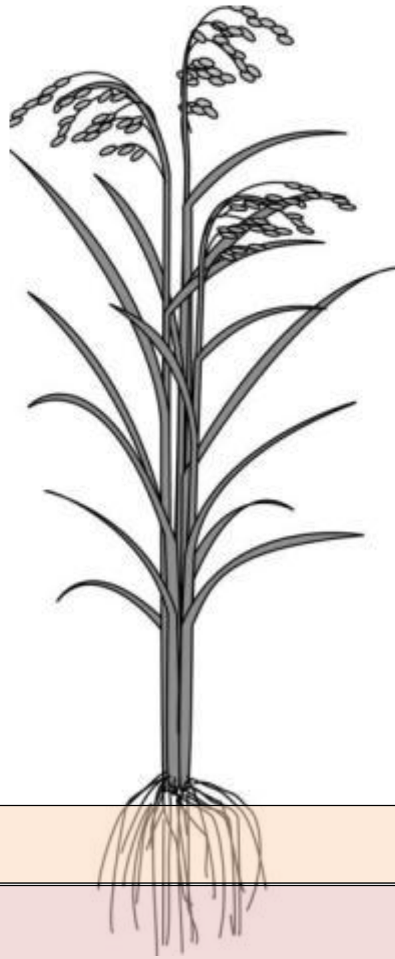
Methods:

[Inlet N] * ET

Irrigation water	3 kg N/ha

Growing Season N Budget: Crop residue

Unfertilized N Uptake = 167 kg N/ha



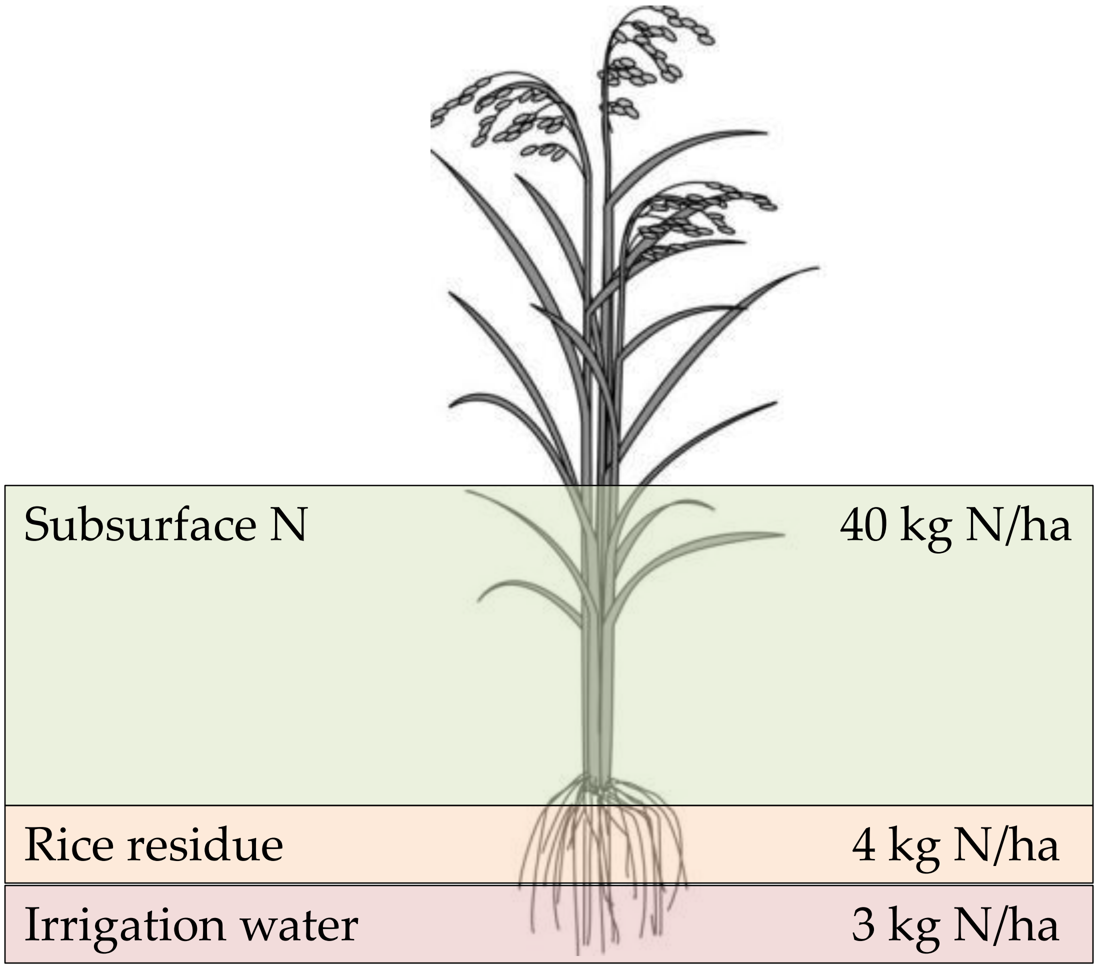
Rice residue	4 kg N/ha
Irrigation water	3 kg N/ha

Methods:

^{15}N-labeled rice residue tracer study

Growing Season N Budget: Subsurface N

Unfertilized N Uptake = 167 kg N/ha

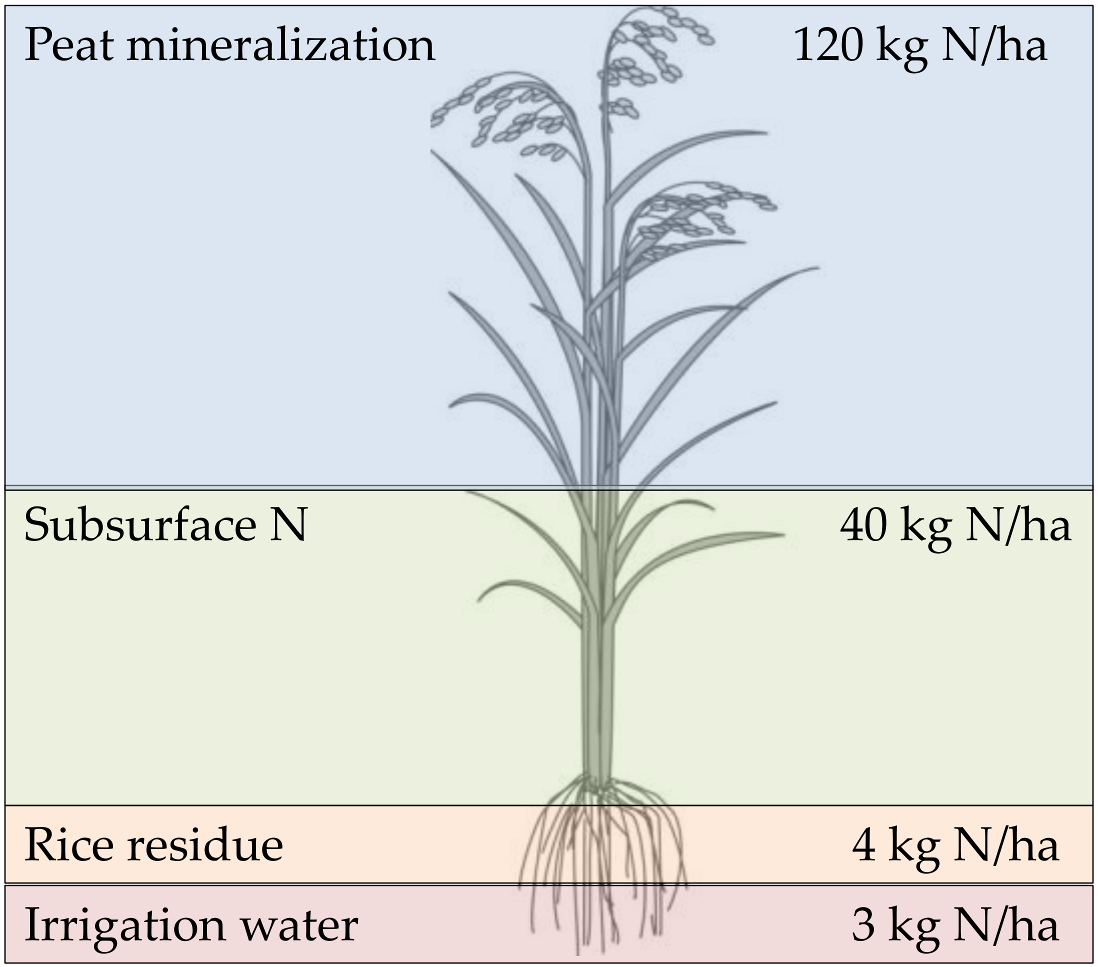


N assumed from peat mineralization!

- Peat layer extends several meters
- NH_4^+ enriched groundwater
- No difference in d[15]N between treatments

Growing Season N Budget: Peat

Unfertilized N Uptake = 167 kg N/ha

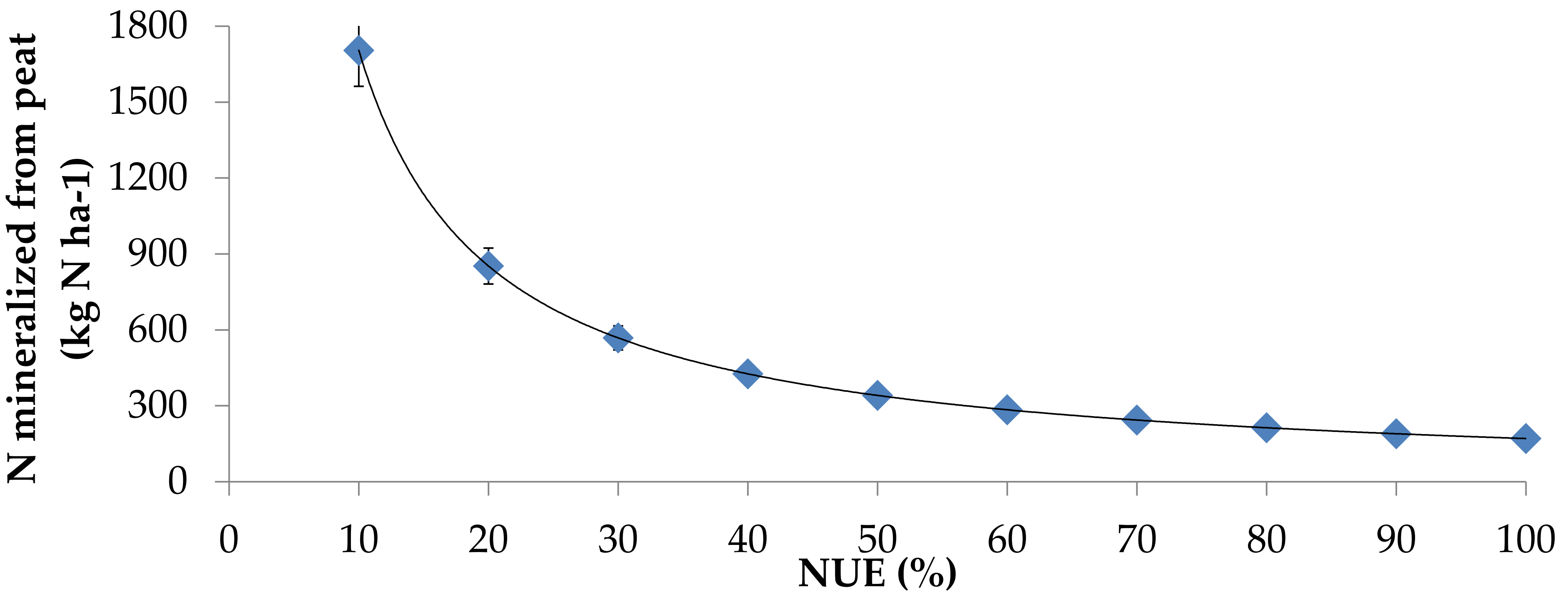


Methods:

By difference – remaining N from surface peat mineralization

Growing Season Mineralization

Section 1: Plant N derived from source	Field 1
N uptake from peat (kg N ha^{-1})	**160 (12)**
N uptake efficiency (NUE) (%)	**0.50**
Total N mineralized from peat (kg N ha^{-1})	**320 (25)**



Over-winter Mineralization

Section 2: Overwinter mineralization	Field 1
Spring soil NO_3-N (kg N ha^{-1})	**42 (0.5)**
N mineralized from straw over-winter (kg N ha^{-1})	**21 (2)**
Over-winter peat N mineralization (kg N ha^{-1})	**21 (2)**

Spring soil NO_3 – rice straw mineralization N

= over-winter peat mineralization N

Mineralization → Subsidence

Growing season mineralization

320 kg N ha^{-1}

+

Over-winter mineralization

21 kg N ha^{-1}

=

Total N mineralized from peat

341 (44) kg N ha^{-1}

Factors for calculations:

- C:N
- Carbon input from straw
- Soil C%
- Bulk density

Mineralization → Subsidence

Field 1

Mass soil lost

-24300 (5103) kg soil ha^{-1}

↓ Bulk density 0-30cm

78200 (2000) (kg cm^{-1} ha^{-1})

Estimated Subsidence

- 0.31 (0.03) cm

Field 2

Mass soil lost

-22440 (4264) kg soil ha^{-1}

↓ Bulk density 0-30cm

55500 (2500) (kg cm^{-1} ha^{-1})

Estimated Subsidence

- 0.40 (0.05) cm

The Big Picture

Corn

Soil loss

- 2.5cm/year

(Hatala et al. 2012)

Rice

Soil loss

- 0.3 - 0.4cm/year

Wetlands

Soil gain

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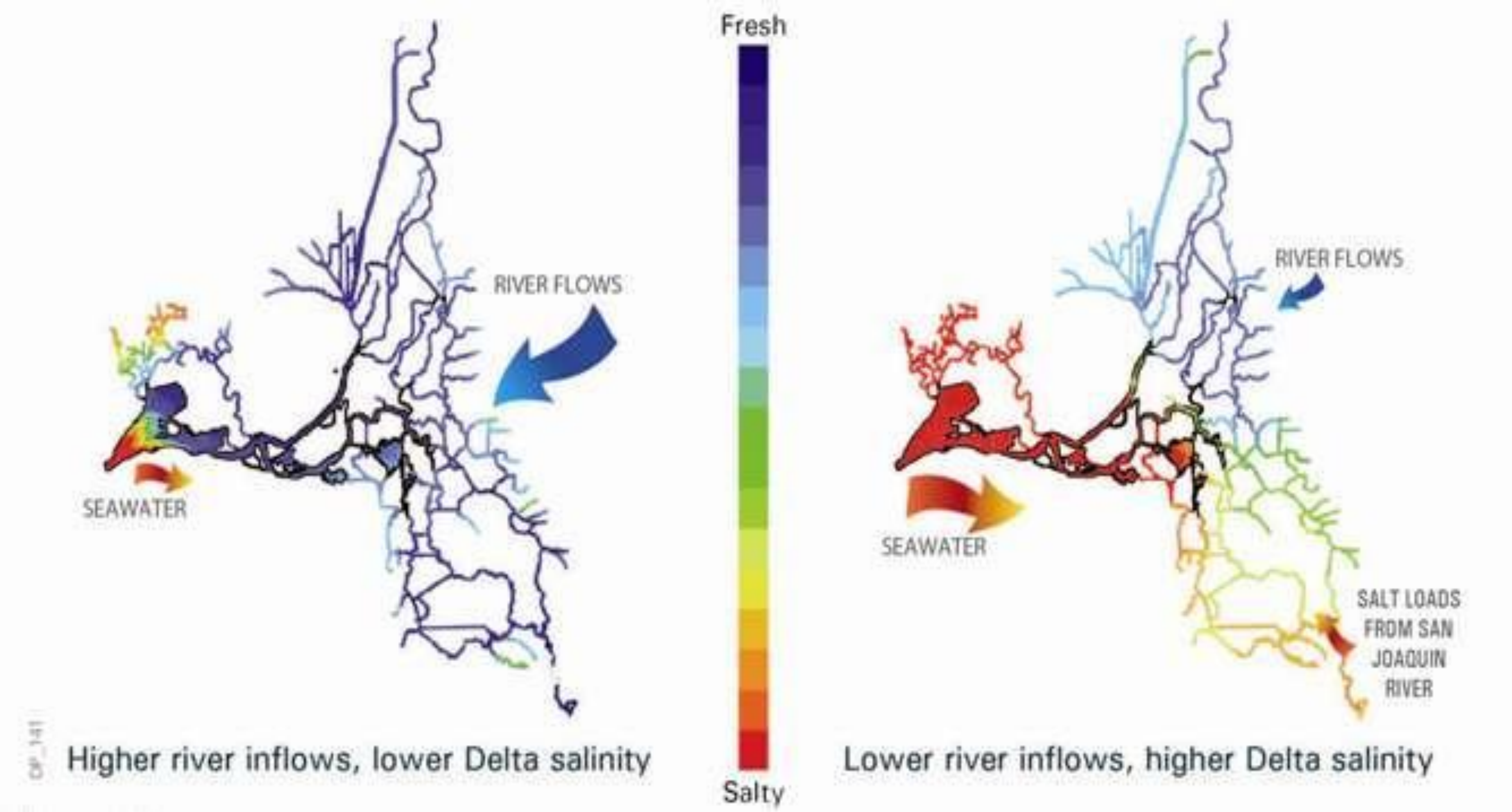
UCD Dept. Plant Sciences

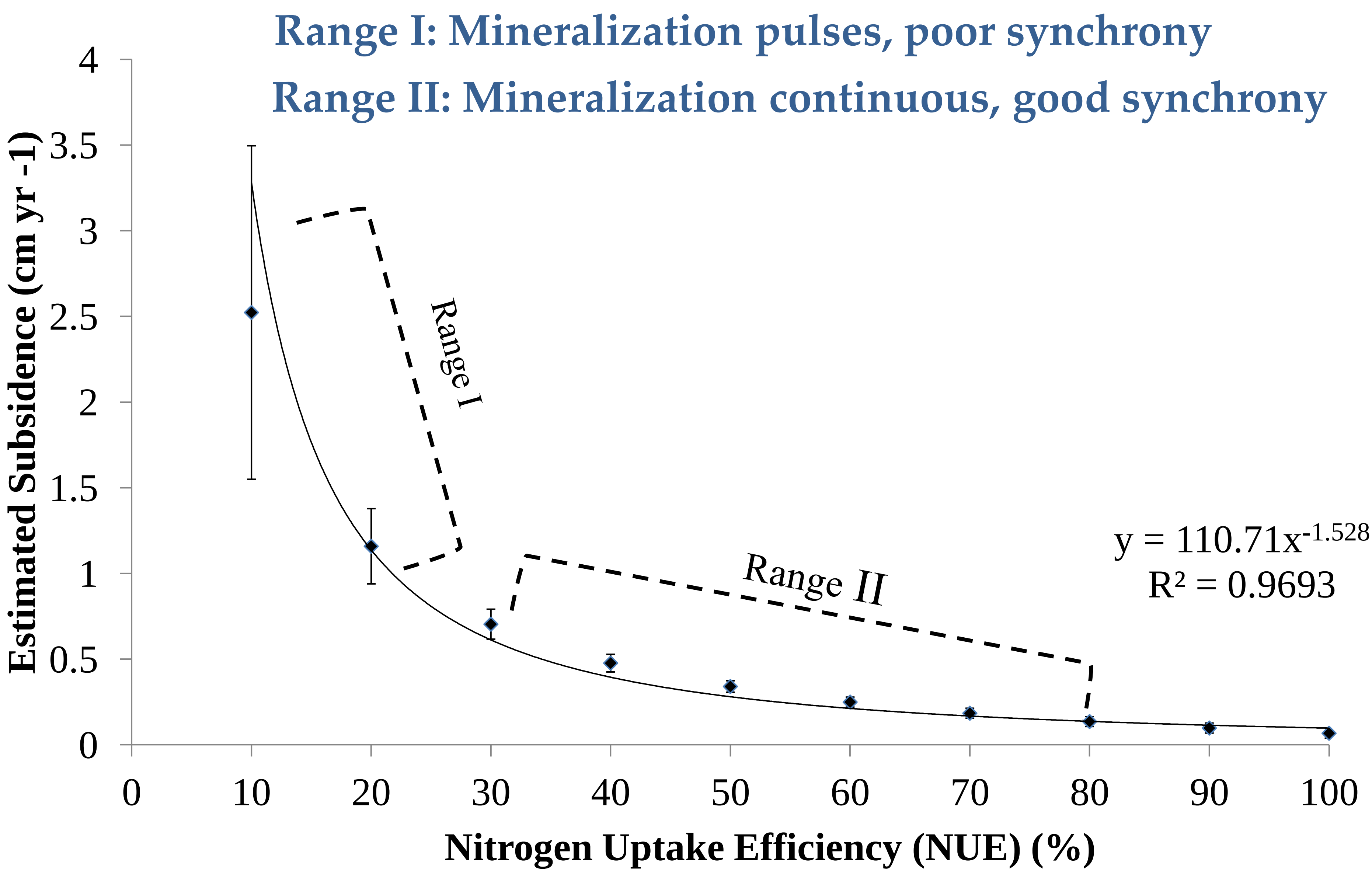
Emilie Kirk
MSc. Candidate, Soils & Biogeochemistry
erkirk@ucdavis.edu
530 – 204 – 9030

Threat to fresh water supply

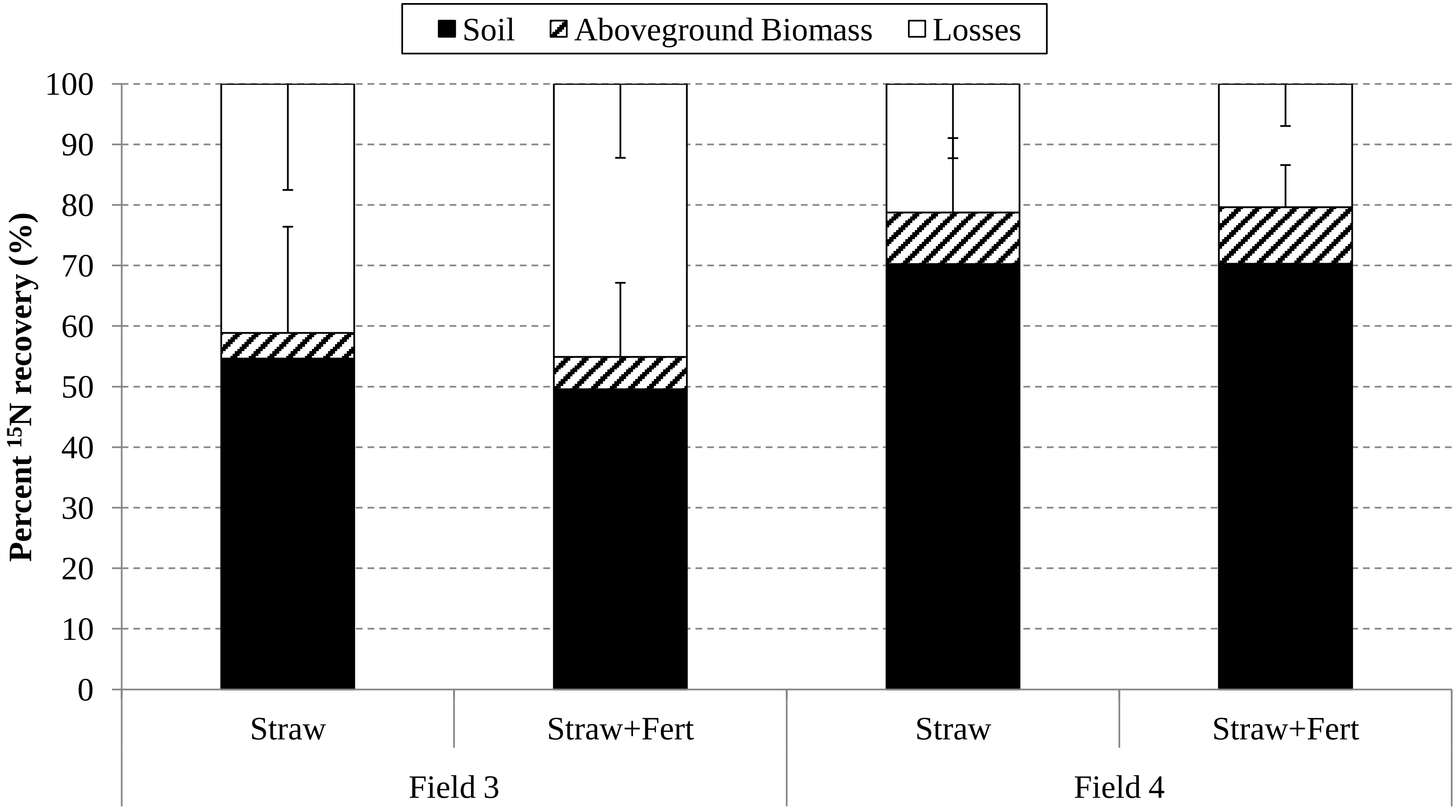


RMA, in CALFED 2007

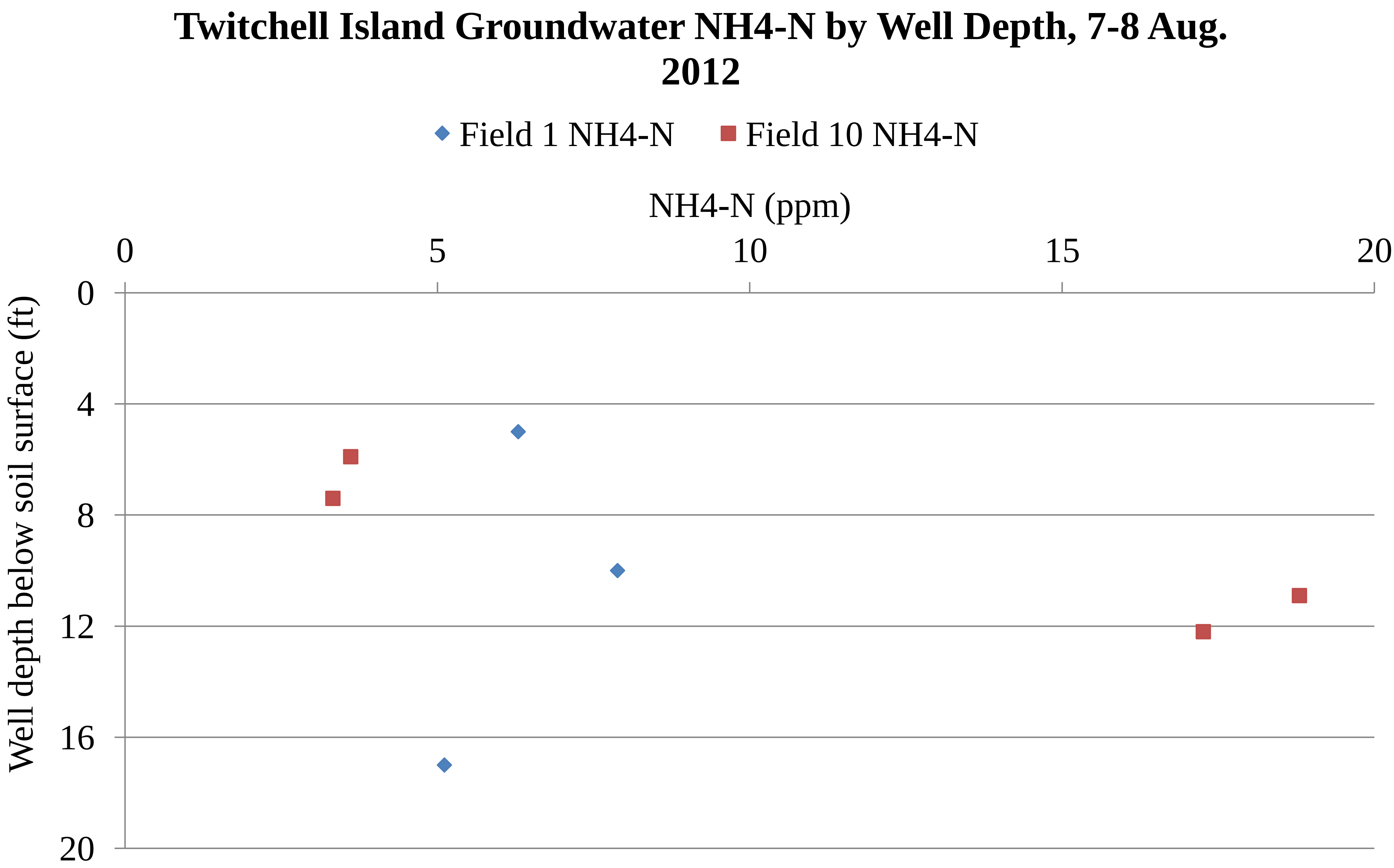
NUE Assumptions and Subsidence



15N recovery – only a small proportion was accumulated in the AGB



Subsurface N Discussion



Response to N fertilization: grain yield and N uptake across 4 siteyears