Characterization of Cranberry Field Decline in British Columbia Cranberry Beds

BC Cranberry Congress
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Rebecca Harbut, KPU
Les Lavkulich, UBC
Peter Oudemans, Rutgers

What is Cranberry Field Dec

Previous Efforts on CFD:

- Pest damage: Dr. Sheila Fitzpatrick, AAFC, Dr. Peter Oudemans, Rutgers
- Chemical residue analysis: Brian Mauza, OS
- Nematode analysis: Dr. Siva Sabaratnum, MOA
- Virus screening: Bob Martin, USDA-ARS

What's So Special About B

- BC is unique compared to other cranberry producing regions:
  - Production systems used
  - Climate
  - Soil conditions
  - Economics of the region

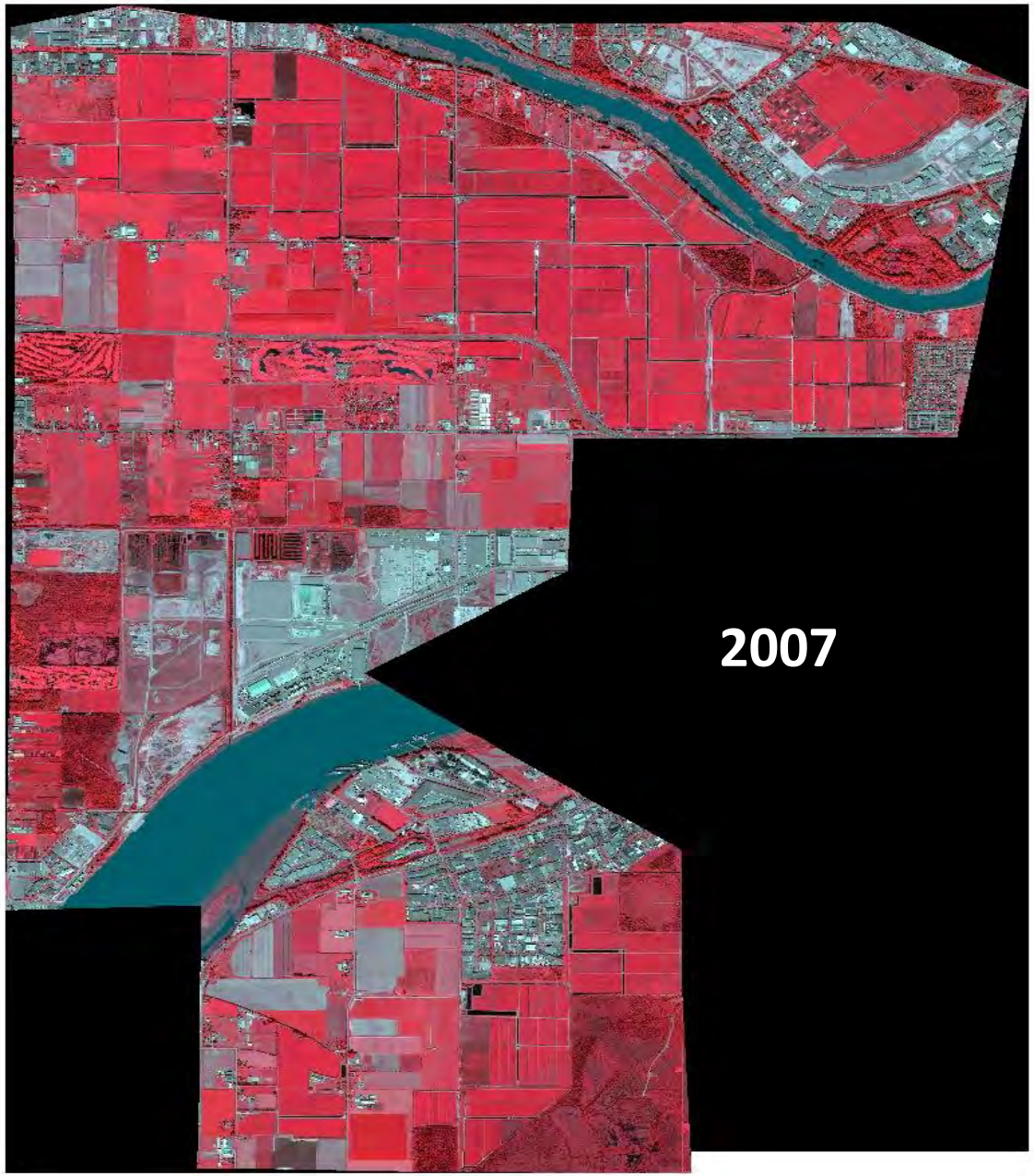
- Therefore, many of the challenges growers face are also unique.

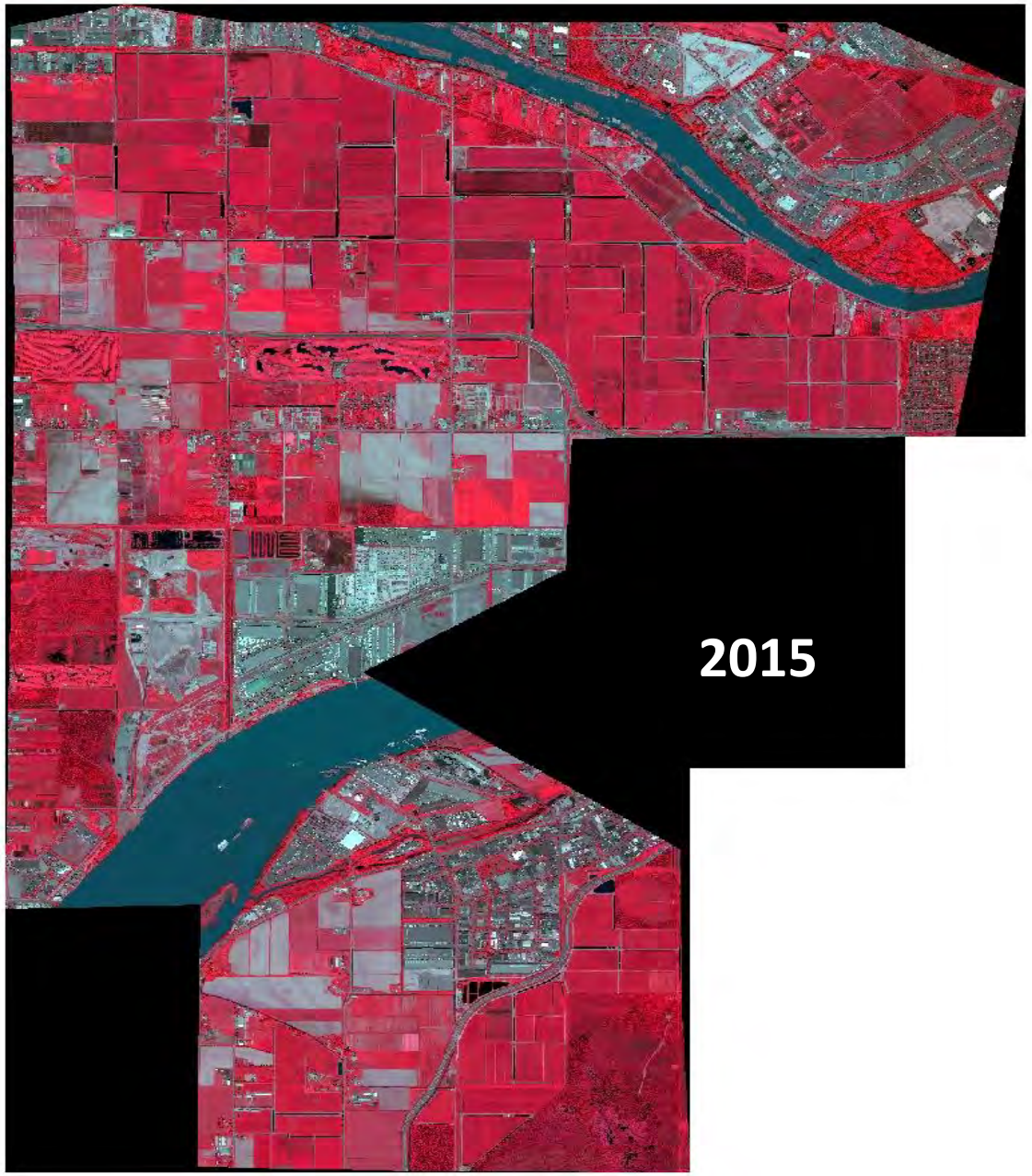
The Project

- Characterize 6 cranberry beds with CFD affected and non-symptomatic areas to identify conditions associated with CFD
  - Soil characteristics
    - Chemistry
    - Physical properties
  - Plant characteristics
    - Canopy components and architecture
    - Rooting characteristics
- Use imagery to determine the spread and patterns associated with CFD
- Develop tools that may assist in assessing fields for risk factors associated with CFD
- Generate data to inform the development of management practices that can remediate beds affected by field decline and prevent development of CFD

Imagery

Area of Interest





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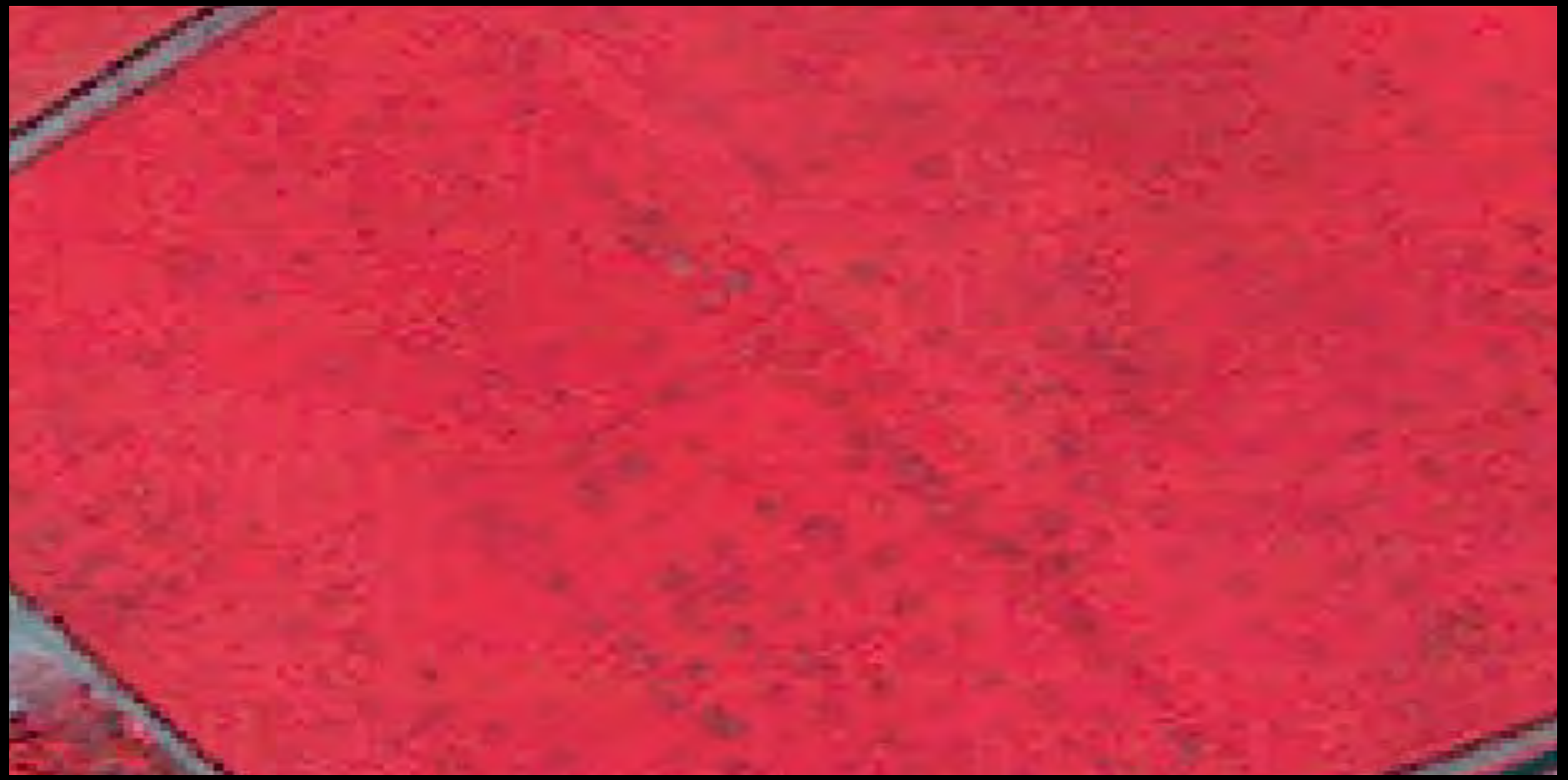


2008

2009

2009 sat

2010

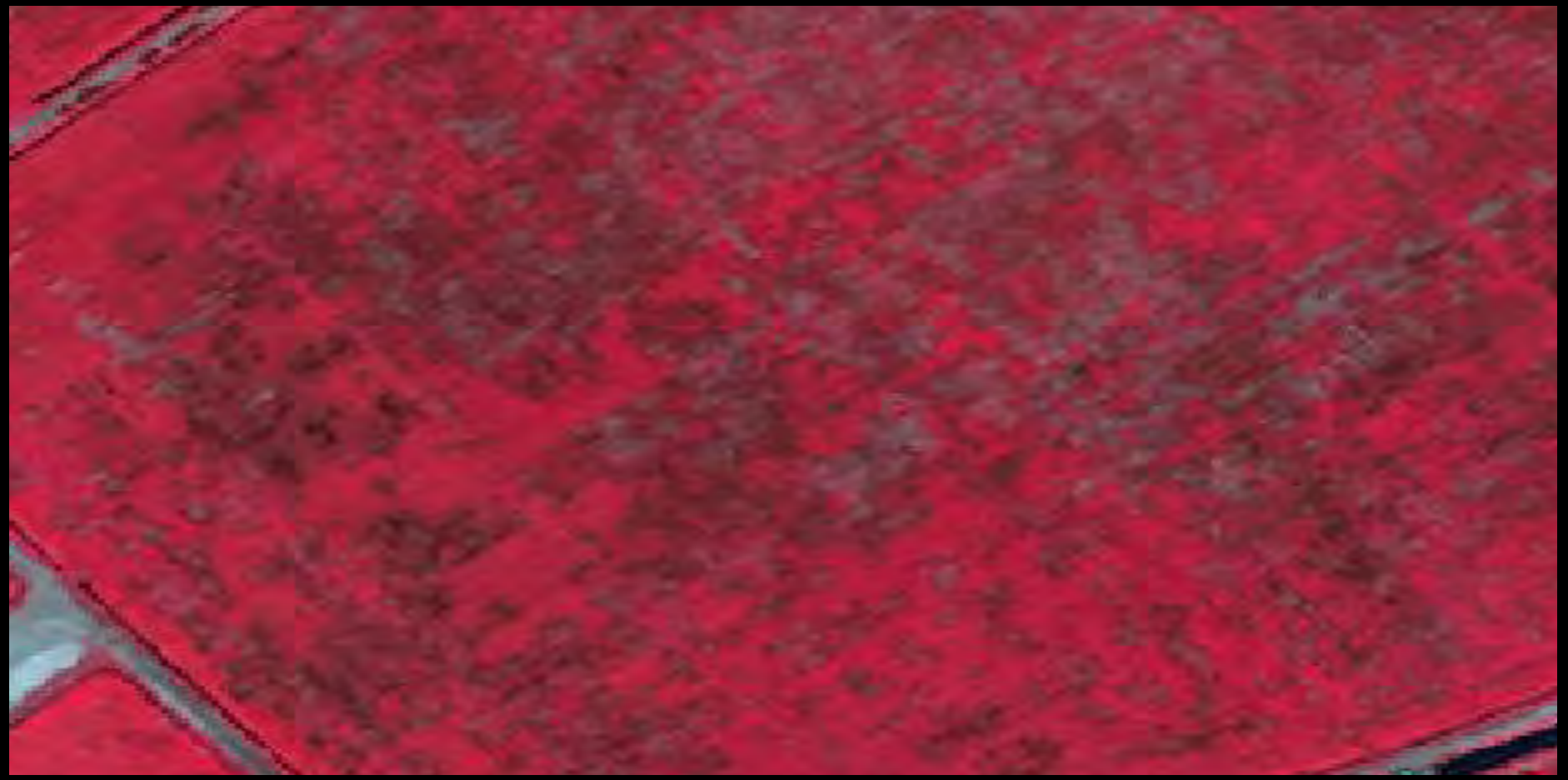
2011

2012

2013

2014

2015



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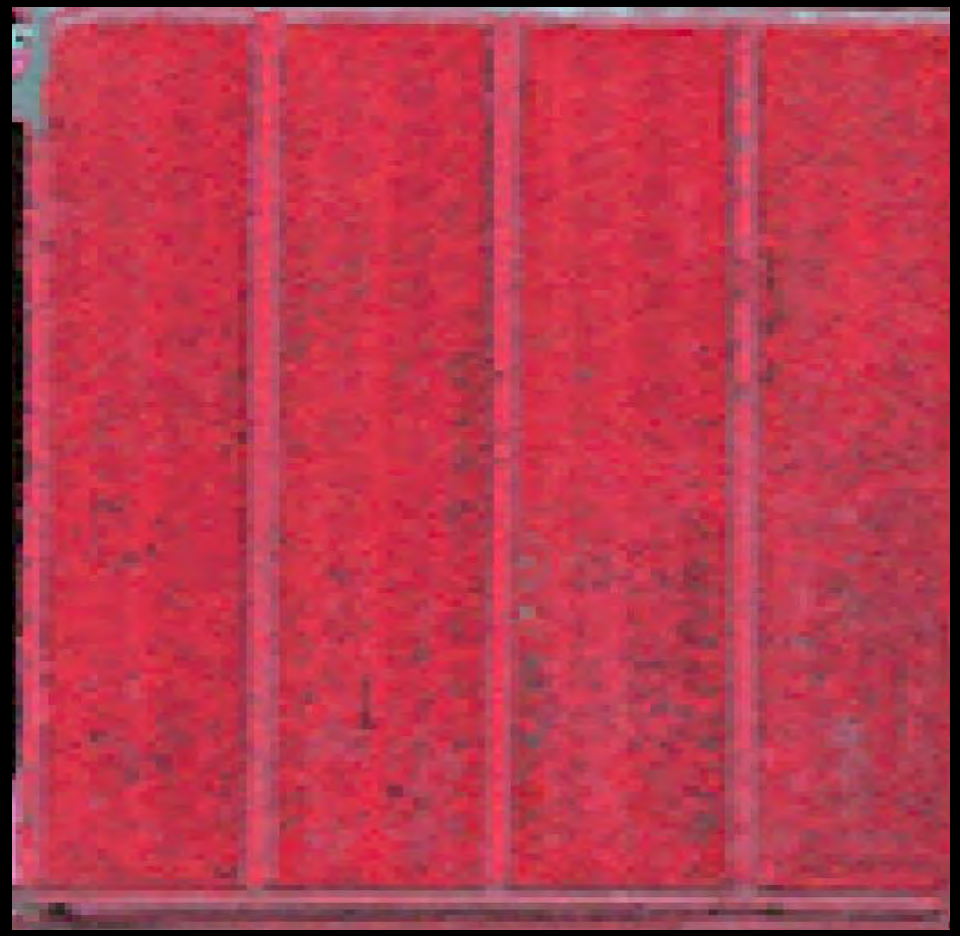

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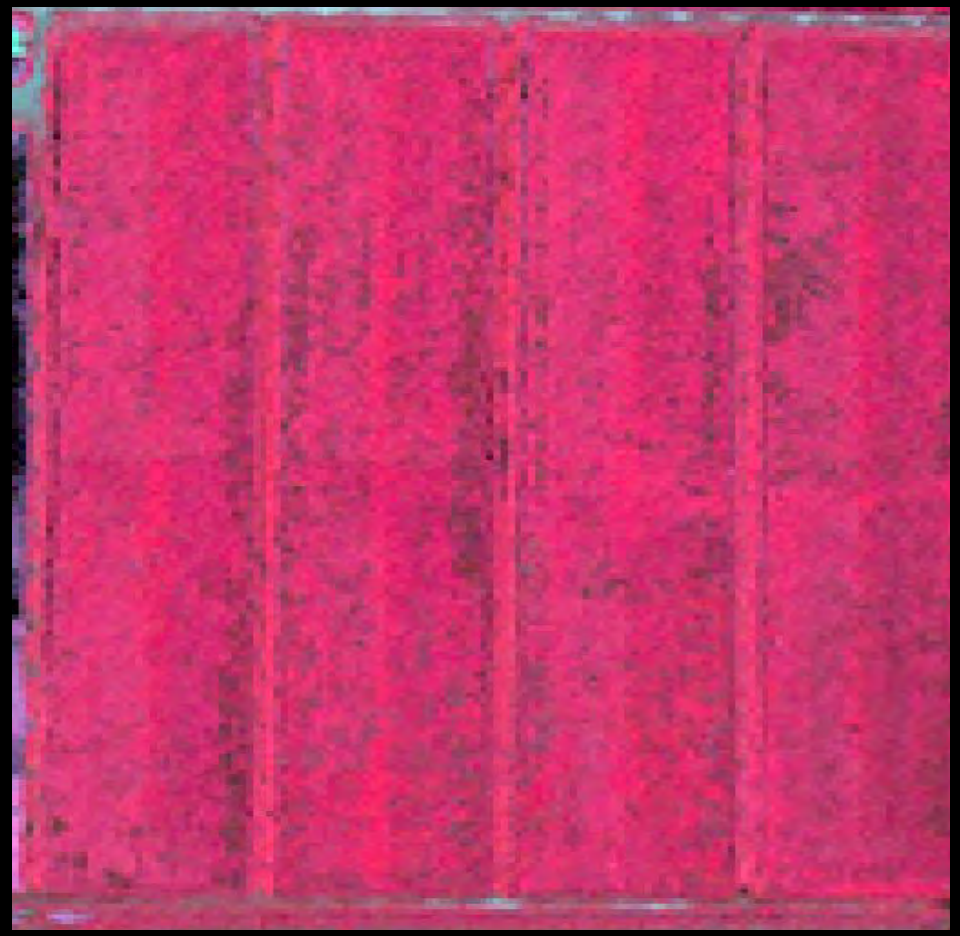

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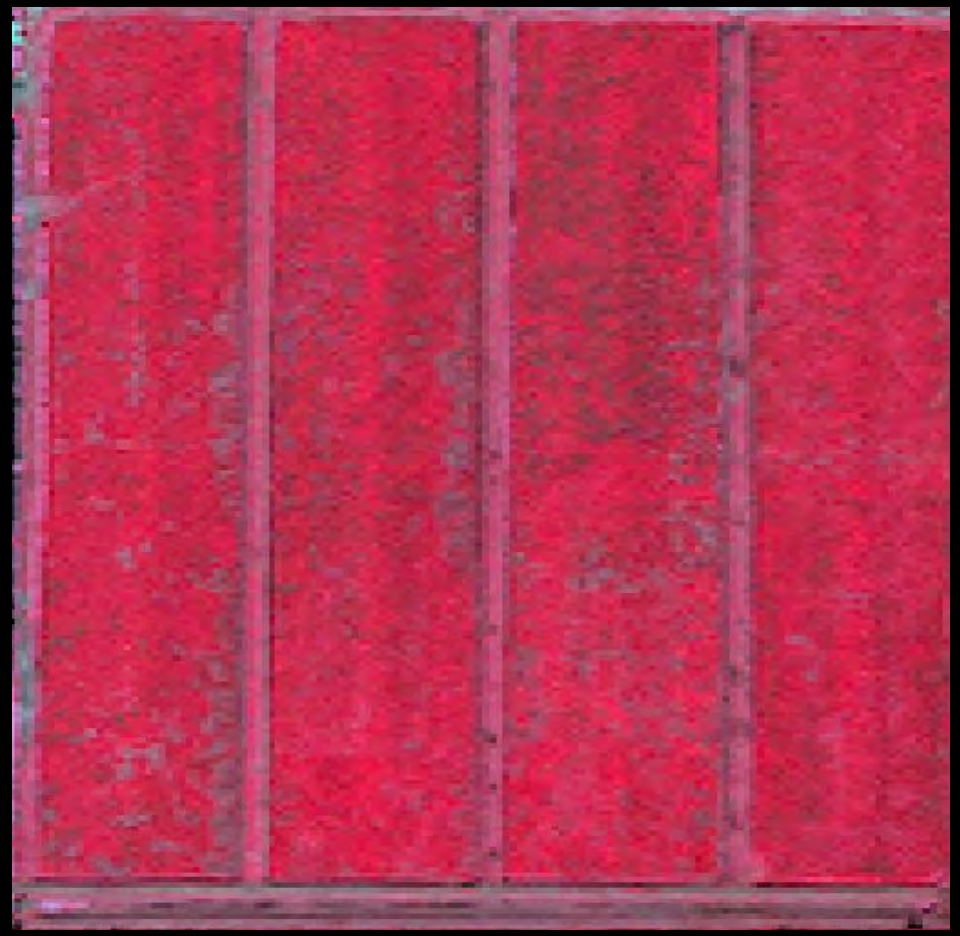

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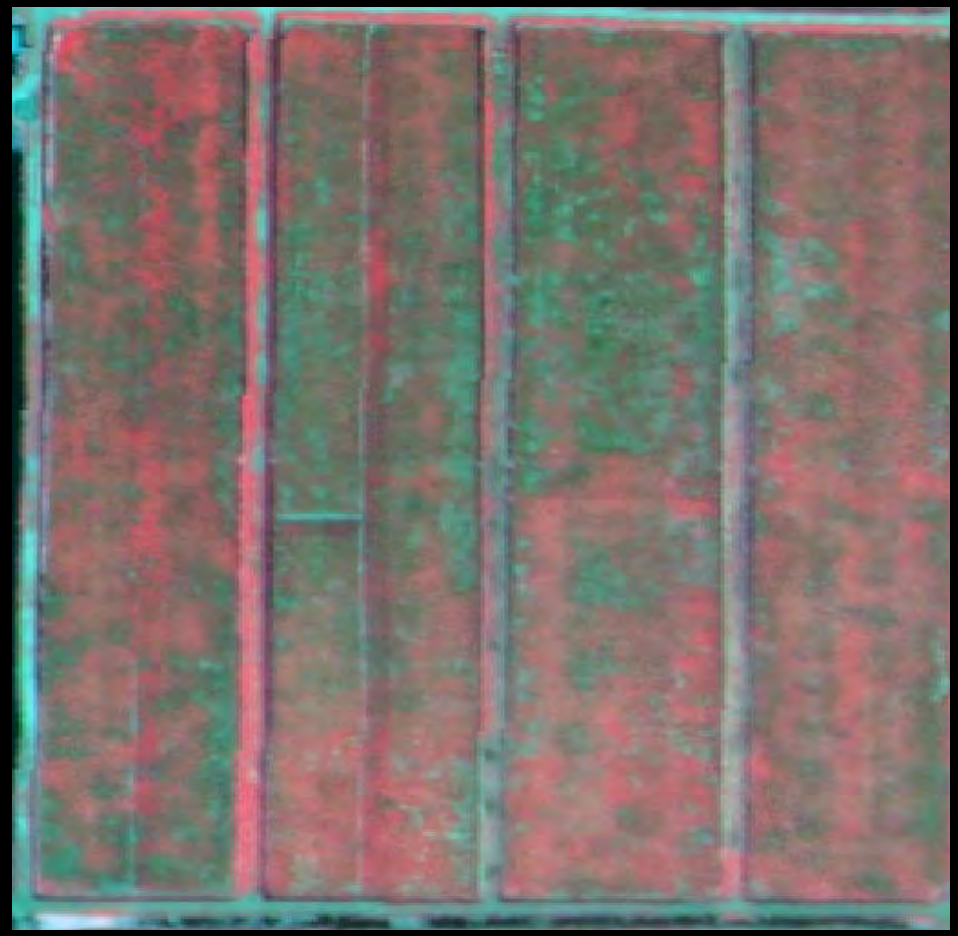

2013

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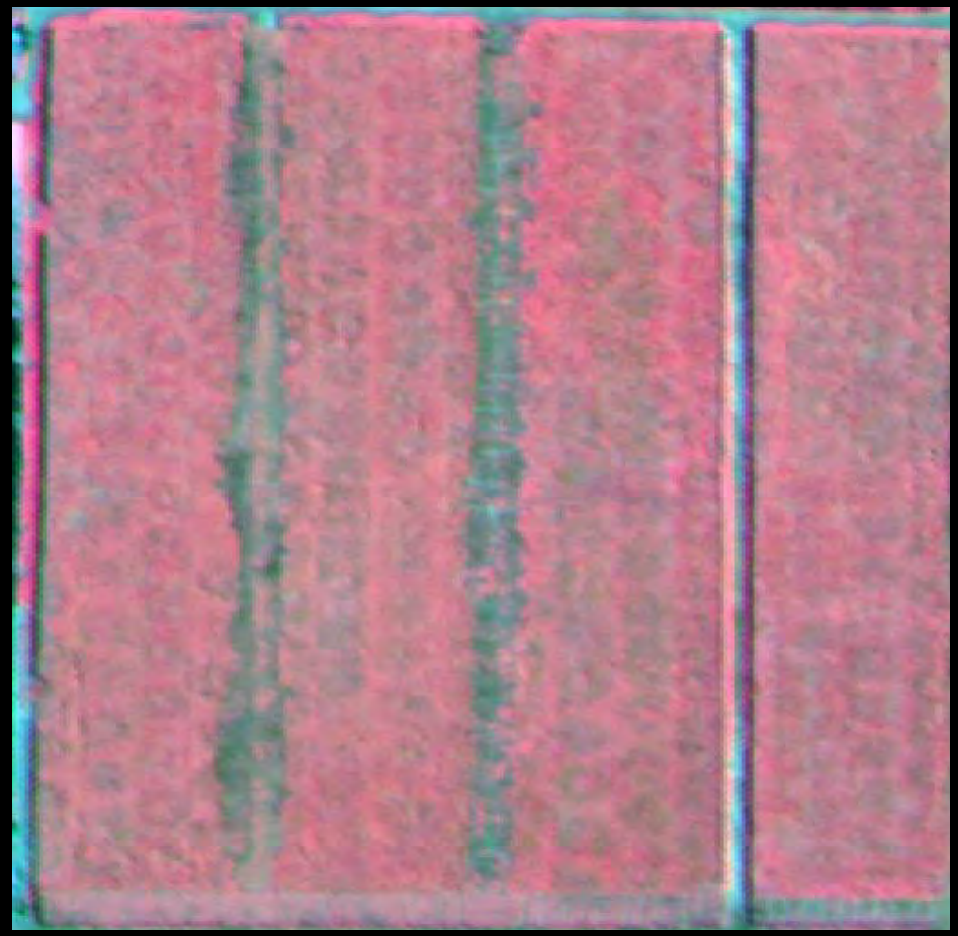

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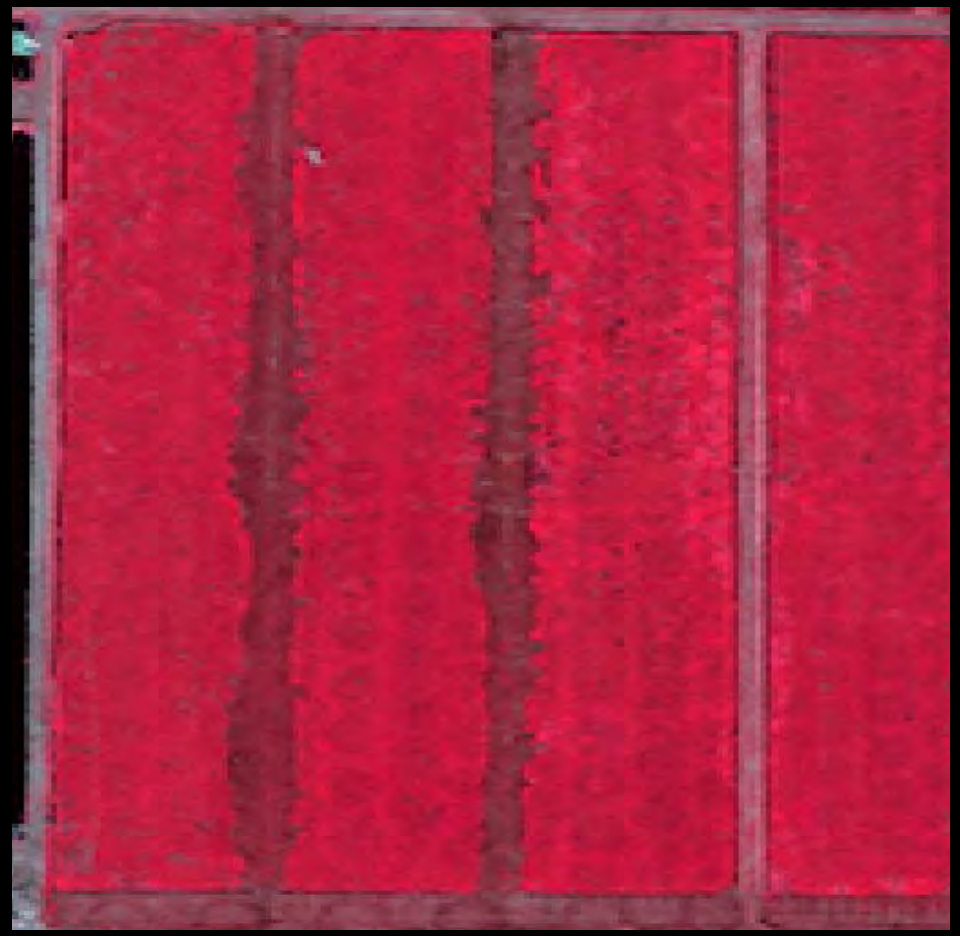

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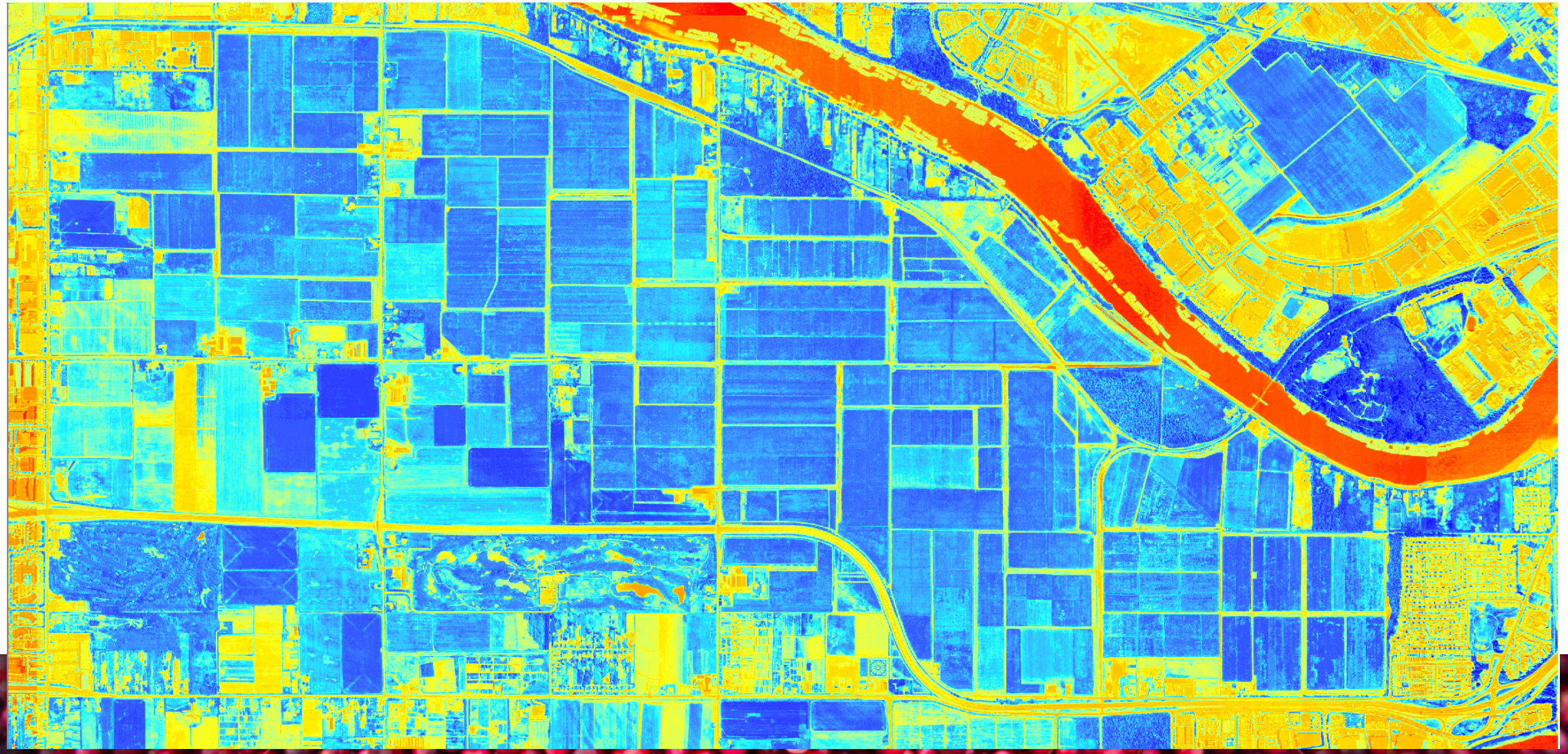
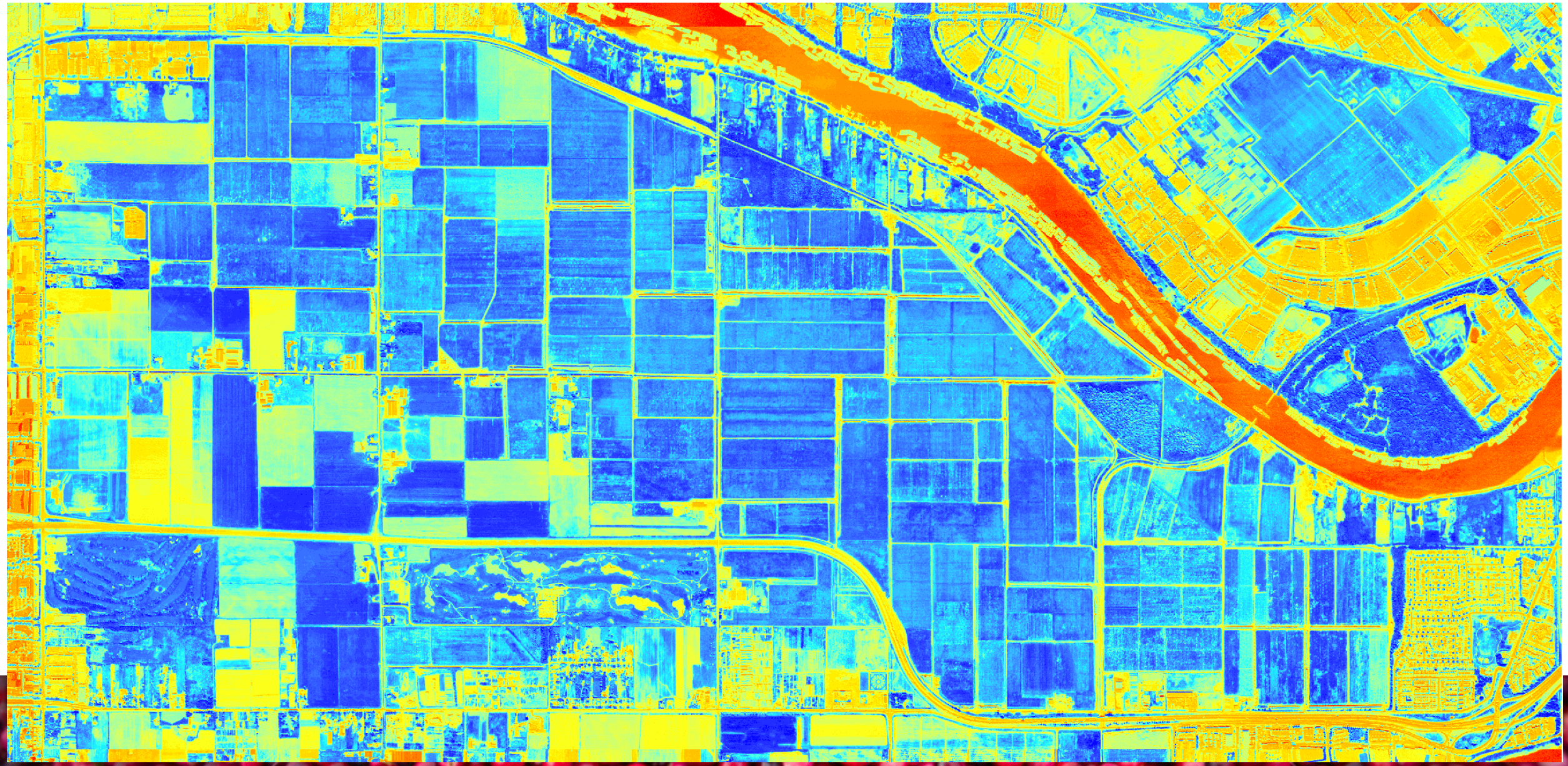
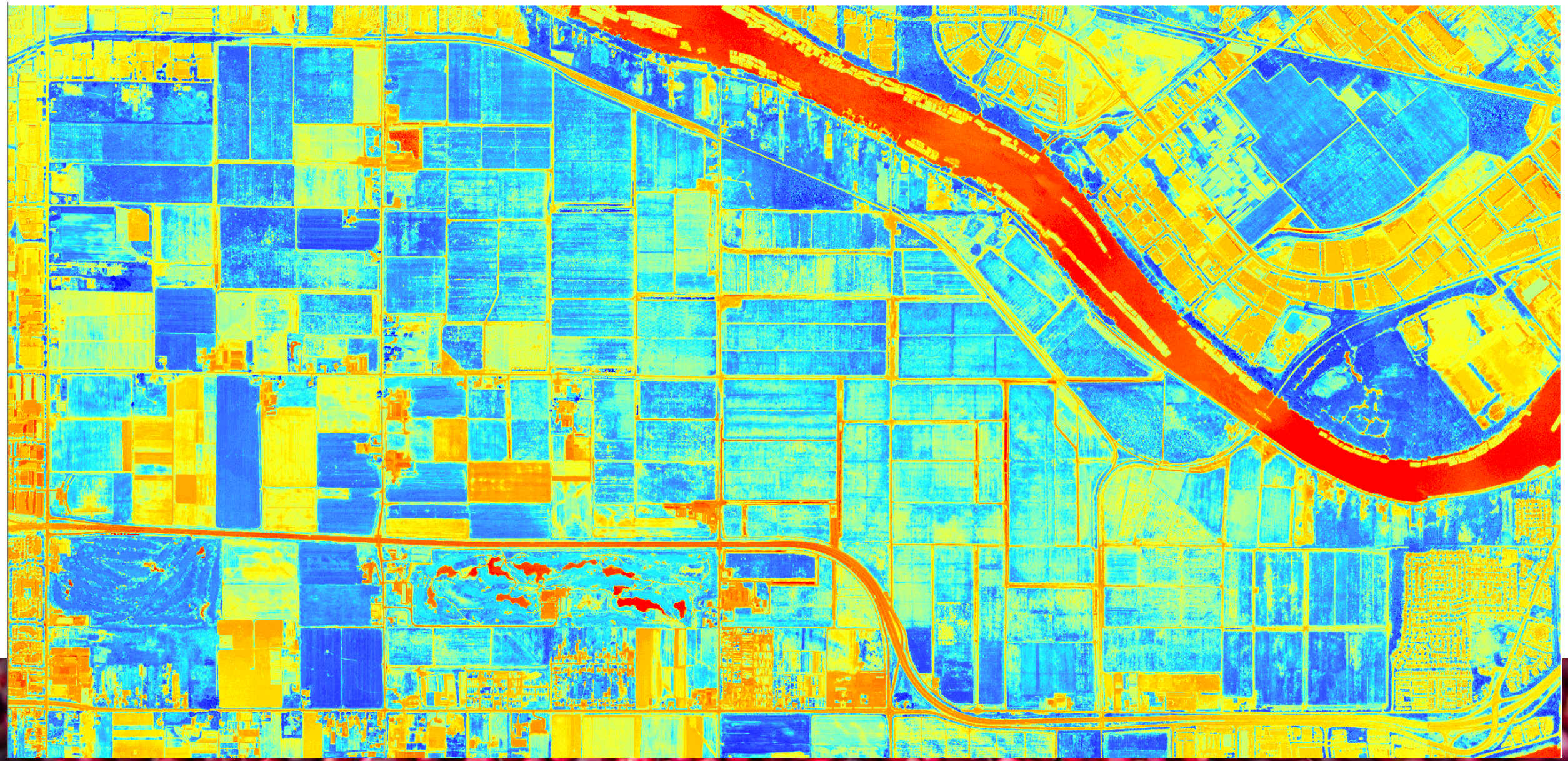


2010



2012



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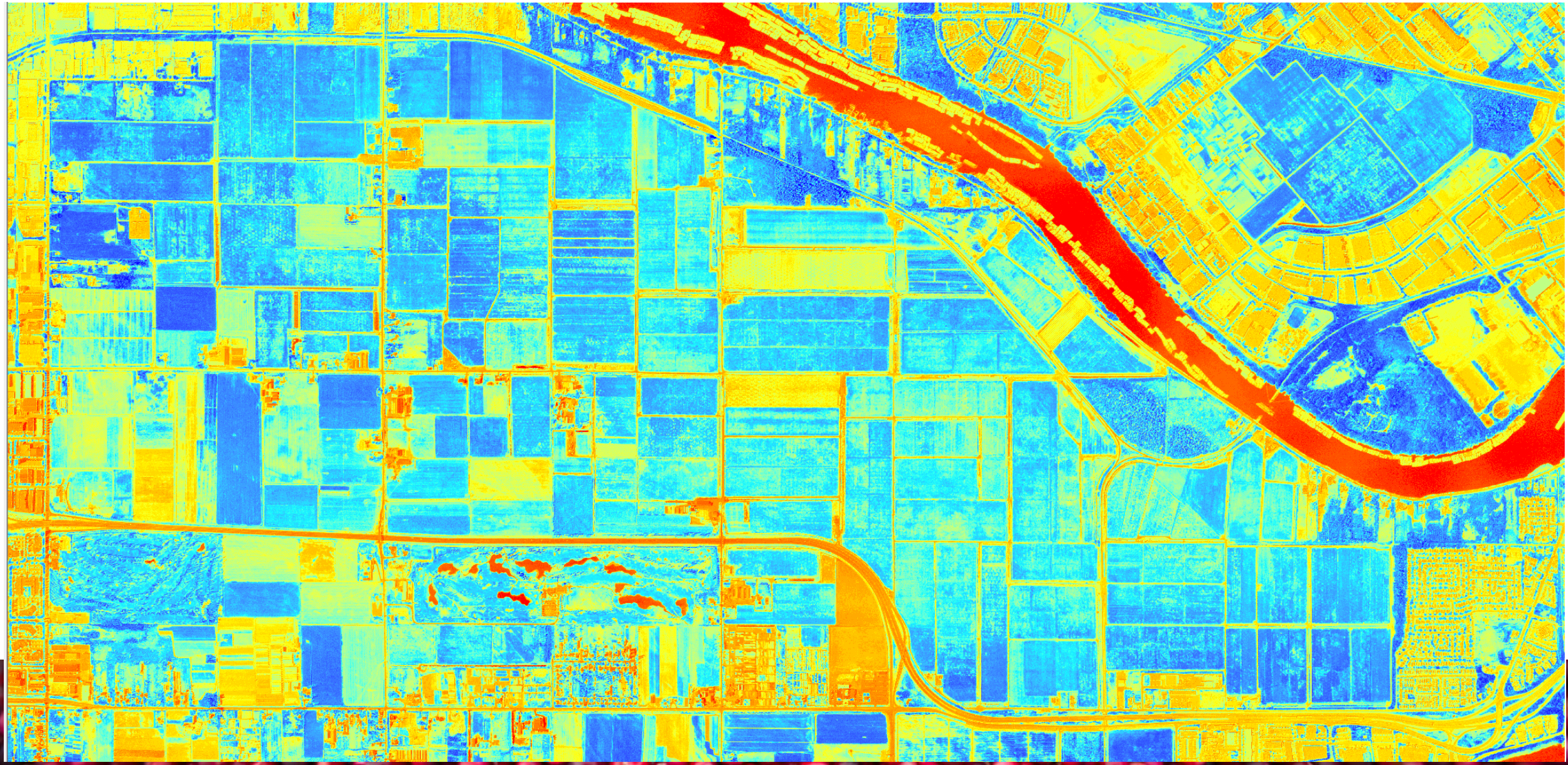


Progress and Next Steps

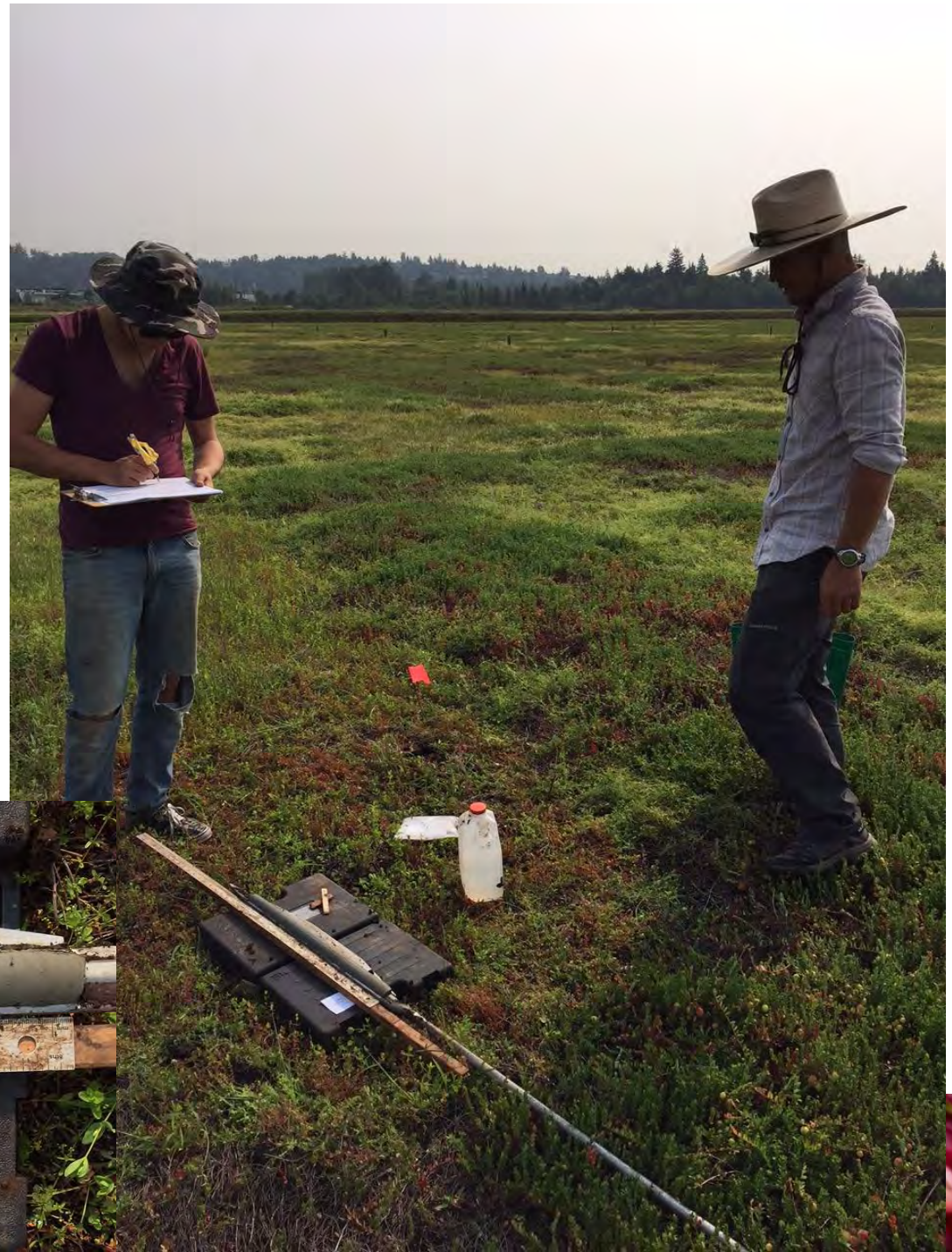
- Various conditions lead to CFD
  - Irrigation pattern
  - Drainage pattern
  - Undetermined
- Fields exhibit distinct timing (not synchronous)
- NDVI shows changes over large areas
- Some beds remain healthy

- Compare history of study sights with imagery
- Utilize satellite imagery to compare using NDVI
- Quantify NDVI changes to establish temporal patterns

Plant and Soil Assessment

Soil Profile Characterization

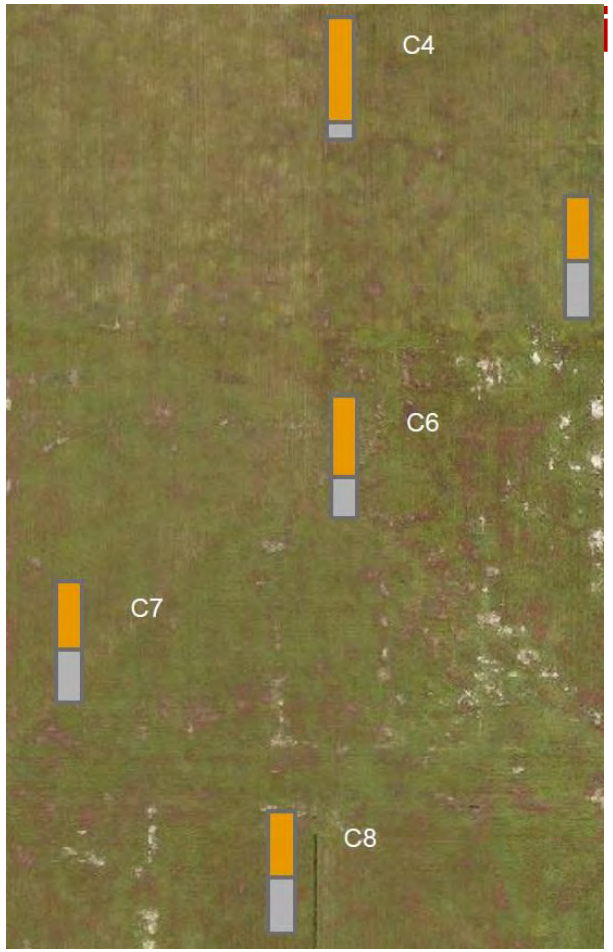
- Took 1meter soil cores throughout the study bed
- Photographed the core and measured the horizons
- Used Vanpost Scale to measure humification

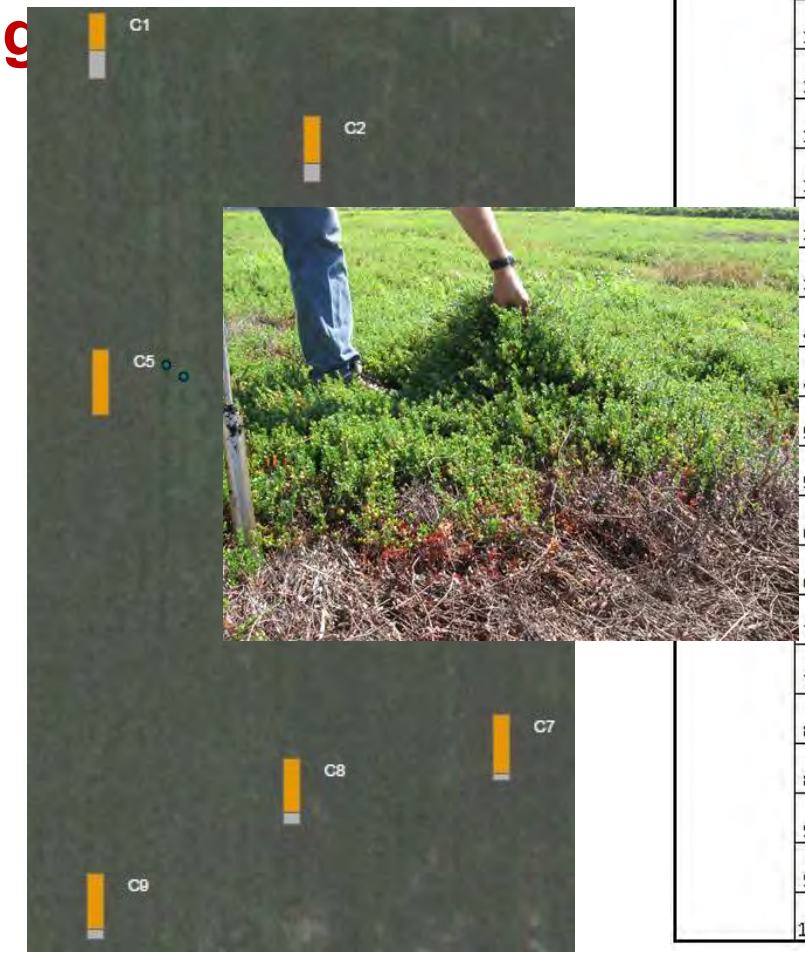


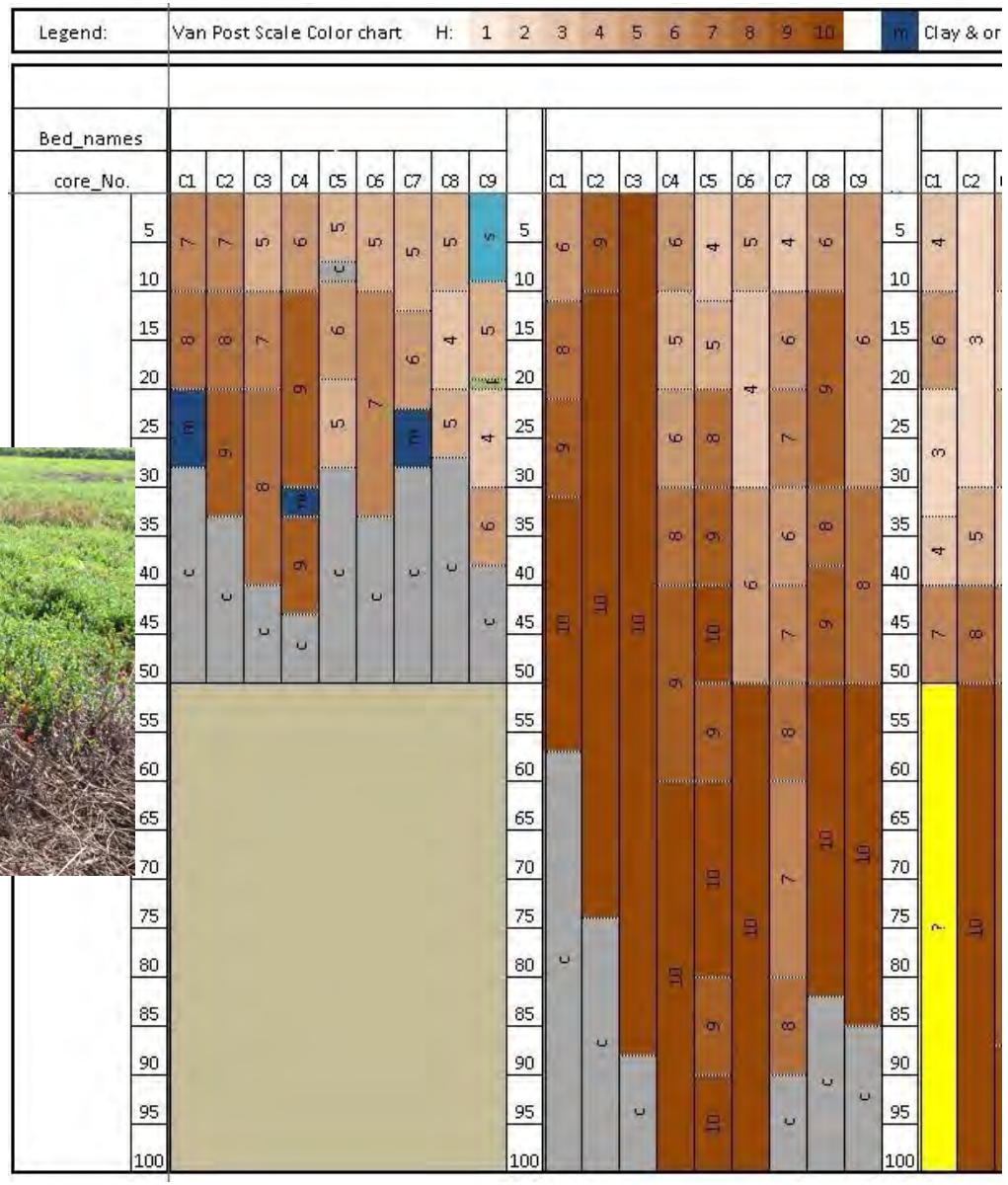
Detailed soil core sampling

- Color assessment with Munsell color chart
- pH and organic contents test (UBC soil lab)

Depth of Organic Layer:



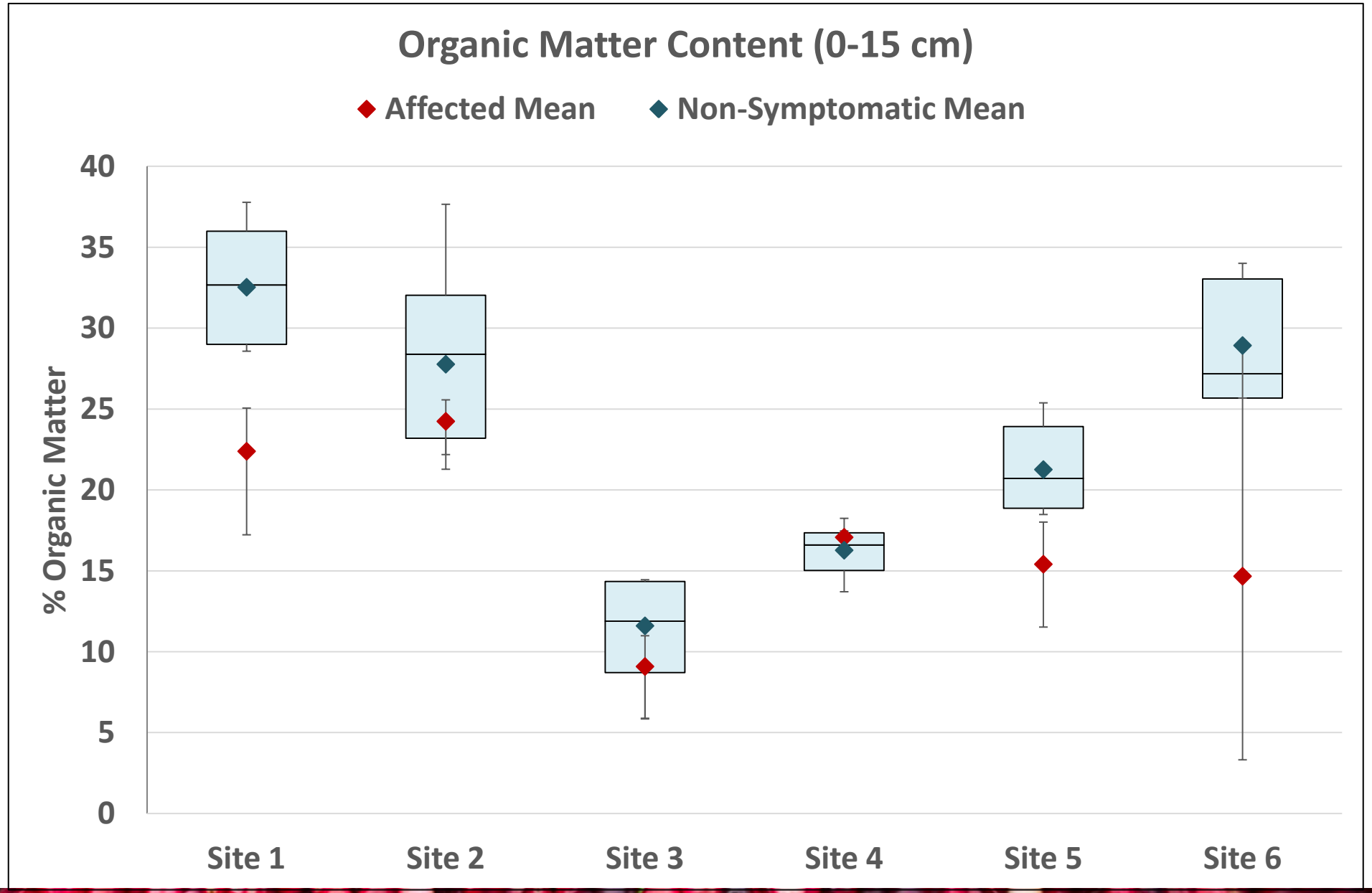




Humification Test

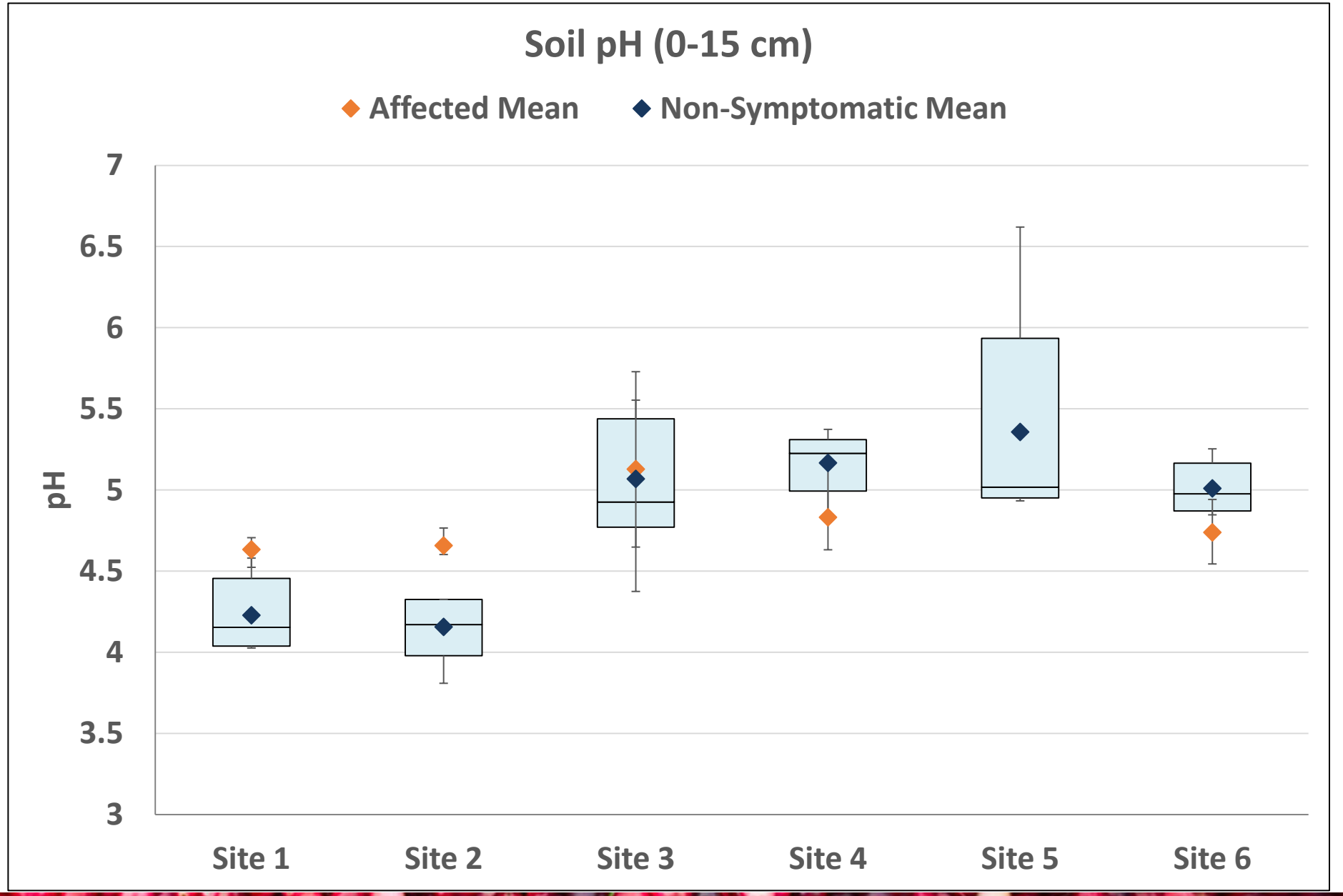
Soil Organic Matter (Rooting zone)

- On average, OM was lower in decline samples
- Values also influenced by presence of mineral soil layers (clay)
- Some sites showed high variability



Soil pH (Rooting zone)

- At some fields, pH was much higher in decline samples
- At other fields, pH was equal or lower in decline samples
- High pH variability between fields



REDOX POTENTIAL

- **Lower redox values in affected (decline) samples**
- *Preliminary soil data collected from Affected (A) and Non-Symptomatic (NS) patches at Site 1.*

Sample Number	REDOX in water (mV)	pH in water	Ammonia (mg/kg)	Nitrate (mg/kg)
A1a	**210**	4.15	0.73	1.14
A1b	**211**	4.20	0.70	1.26
A2a	**207**	4.26	0.55	2.90
A2b	**205**	4.28	0.40	2.70
A3a	**198**	4.47	0.47	0.46
A3b	**198**	4.44	0.52	0.47
NS1a	**203**	4.42	0.18	0.12
NS1b	**201**	4.39	0.15	0.13
NS2a	**211**	4.24	-	-
NS2b	**212**	4.20	0.13	0.12
NS3a	**227**	3.90	0.14	0.13
NS3b	**229**	3.94	0.18	0.13

Site 2 - NS

Sample ID	Interval (cm)	pH in water	% OM
S2-H4-A	0-22	4.17	28.39
S2-H4-B	22-26	4.25	18.12
S2-H4-C	26-31	4.43	23.24
S2-H4-D	31-33	4.45	21.43
S2-H4-E	33-51	4.50	22.63

Site 2: Non-Symptomatic Core

- **Dominated by peat**
- **More homogeneous soil conditions in rooting zone**
- **High OM content**

Site 2 - A

Sample ID	Interval (cm)	pH in water	% OM
S2-A1-A	0-14	4.78	22.28
S2-A1-B	14-22	4.56	20.79
n/s	22-23	n/s	n/s
S2-A1-C	23-32	4.55	23.19
S2-A1-D	32-39	4.65	17.32
S2-A1-E	39-51	4.75	17.97

Site 2: Affected Core

- **More layers**
- **Lower OM content near surface**
- **Higher pH**

Site 4 - NS	Sample ID	Interval (cm)	pH in water	% OM
	S4-H4-A	0-10	5.22	20.00
	S4-H4-B	10-13	5.20	18.03
	S4-H4-C	13-24	5.29	2.29
	S4-H4-D	24-28	5.54	1.72
	S4-H4-E	28-40	5.87	1.03
	S4-H4-F	40-51	5.41	1.61

Site 4: Non-Symptomatic Core

- **Dominated by clay at depth**
- **Low OM content**
- **Higher pH**

Site 4 - A	Sample ID	Interval (cm)	pH in water	% OM
	S4-A2-A	0-11	5.23	19.60
	S4-A2-B	11-16	4.93	14.52
	S4-A2-C	16-20	5.23	14.21
	S4-A2-D	20-26	5.06	12.71
	S4-A2-E	26-32	5.11	10.50
	S4-A2-F	32-42	5.18	12.64
	S4-A2-G	42-51	5.69	13.00

Site 4: Affected Core

- **Many layers**
- **Lower OM content near surface**
- **Clay layer at depth**

- **Higher average number of soil layers in the top 30 cm of affected (decline) samples**

Affected Samples

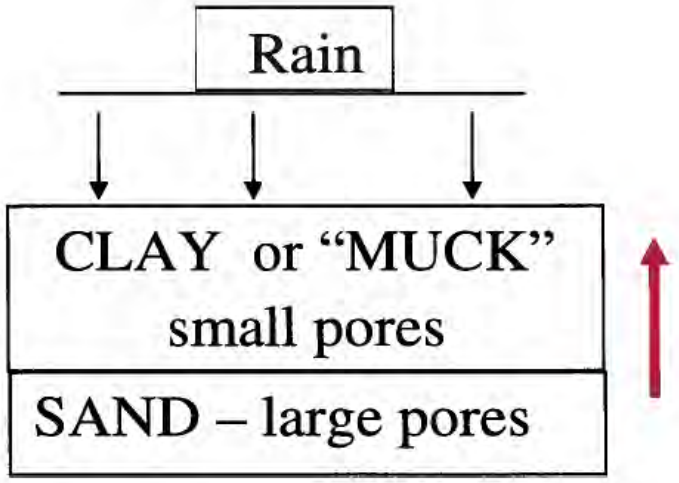
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Average layer number	3.33	4.33	5.33	5	3.33	6
Overall Average	**4.56**					

Non-Symptomatic Samples

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Average layer number	3.6	4	4.2	4.2	2.8	5.8
Overall Average	**4.1**					

Some background theory…

WATER & AIR MOVEMENT
1) Small Pores over Large Pores

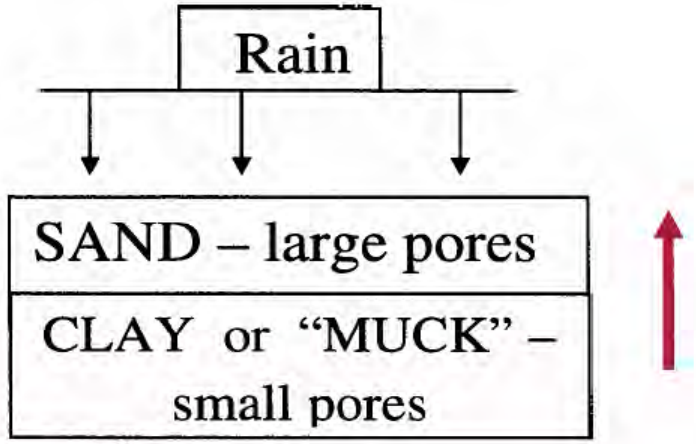


↓ Rain enters slowly and will NOT enter the sand until the clay/"muck" is saturated (ponding!)

↑ ONCE the sand is saturated water move slowly upward in liquid form

WATER & AIR MOVEMENT

2) Large Pores over Small Pores



RAIN (AIR) WILL ENTER THE SAND, WILL STOP DOWNWARD MOVEMENT AND SLOWLY ENTER THE CLAY OR THE "MUCK"

WATER (ENTRAPPED AIR , O_2) WILL MOVE INTO THE SAND ONLY BY THE WATER EVAPORATING AND THEN MOVES AS A GAS

REDOX (Reduction and Oxidation)

Two ways of thinking about redox reactions:

1. Reduction is the **removal** of oxygen from a substance, and
2. Oxidation is the **addition** of oxygen.

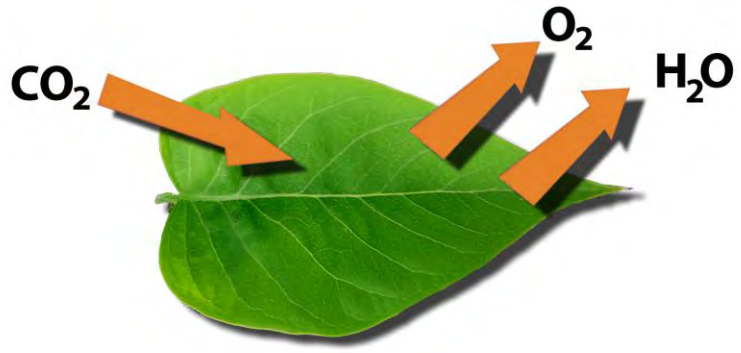
Reduction is the addition of electrons (e^-)

$$2H^+ + O_2 + e^- \rightarrow H_20$$

Oxidation is the removal of electrons (e^-)

$$H_20 - e^- \rightarrow 2H^+ + O^{2-}$$

WHY REDOX?



PHOTOSYNTHESIS is a redox reaction!

REDOX: One substance loses electron(s) and anot
electron(s)

- **Water** (H_20) reacts with **Carbon Dioxide** (CO_2) to form a **Carbohydrate** (sugar)
- A (+) charge is split from water:

  H_20 + energy → H^+ + OH^- (oxidation)
- Energy from sunlight increases the energy of the electrons in the OH^-
- Electrons are transferred from water to carbon dioxide → Sugar! (reduction)

RESPIRATION - ALSO REDOX

TWO KINDS OF RESPIRATION WITH ORGANIC COMPOUNDS*

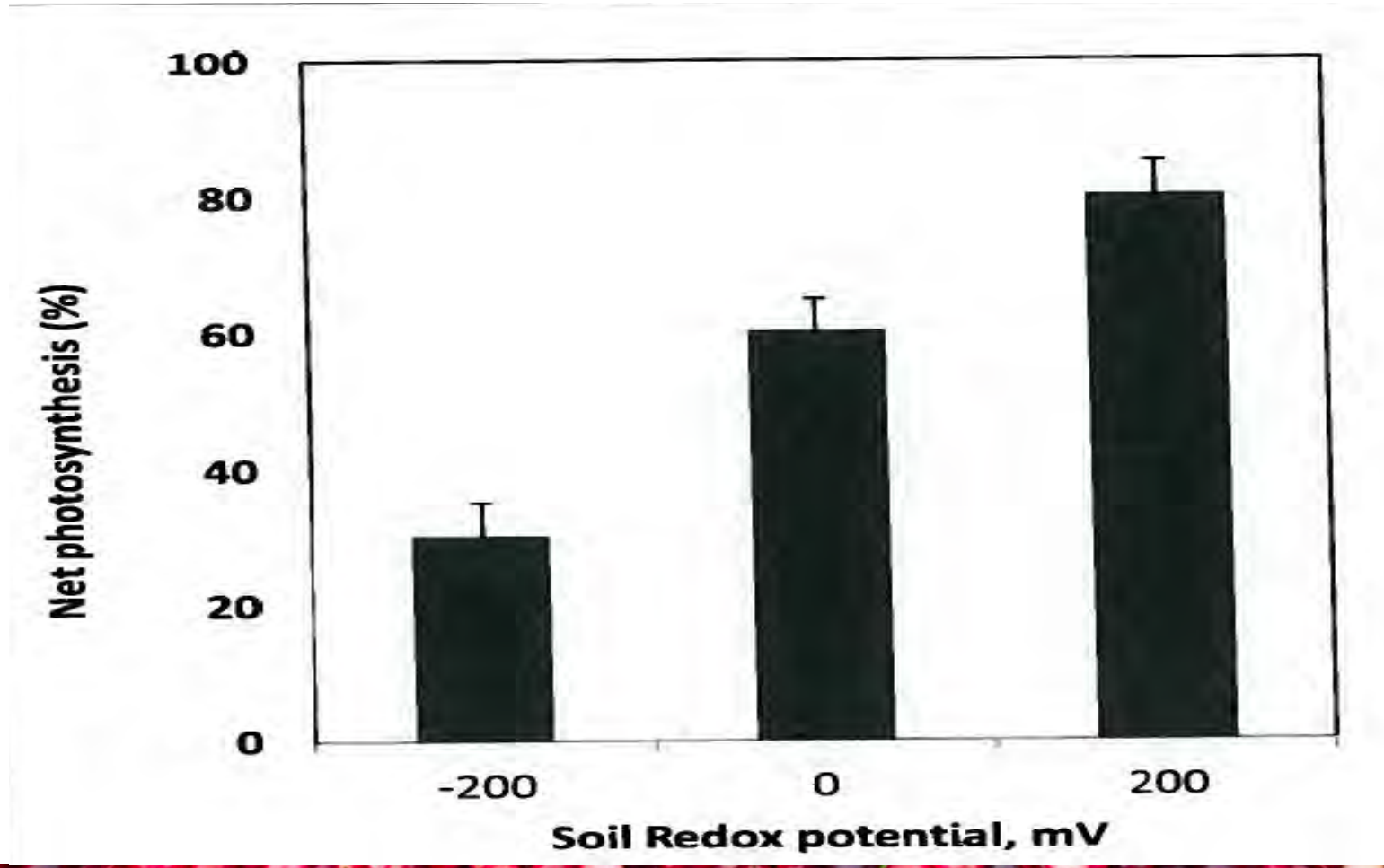
- **Aerobic** **requires oxygen** and releases lots of energy

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

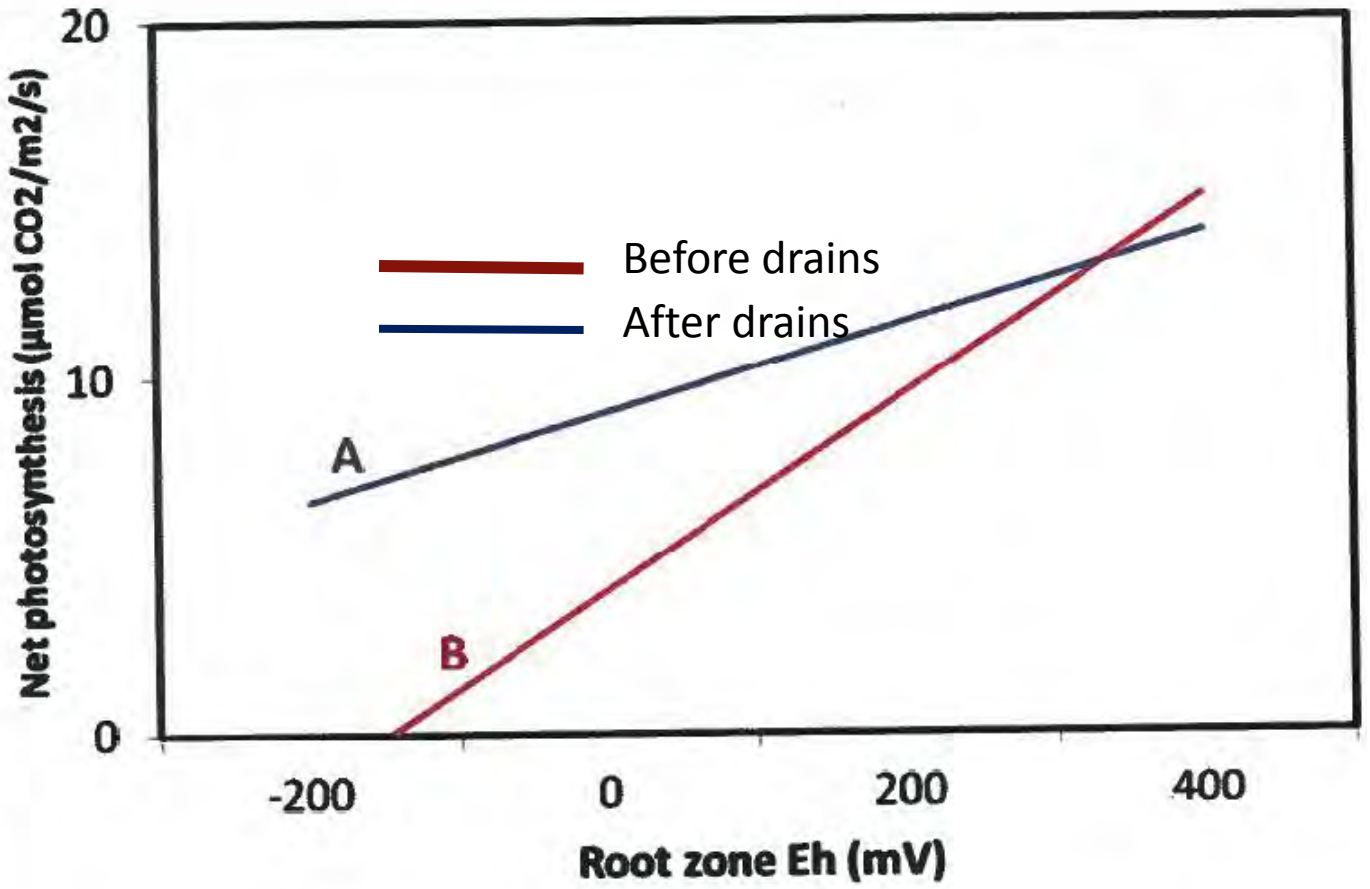
- **Anaerobic** **no oxygen** but releases much less energy

*Examples are oxidation of glucose (simplest sugar).

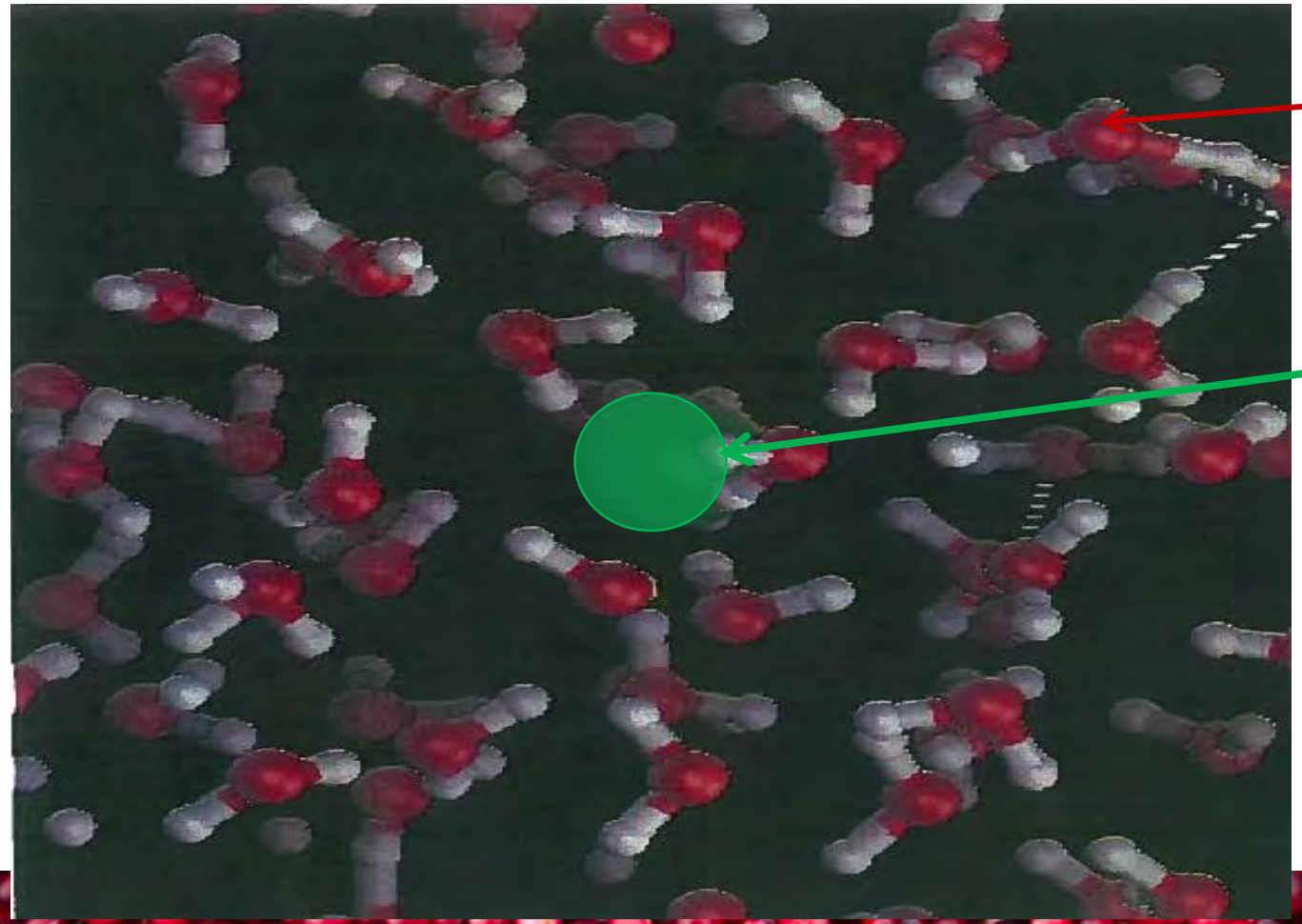
Relationship between Soil Redox and Net Photosynthesis (e.g. Sedge)



DRAINAGE EFFECTS ON PHOTOSYTHESIS



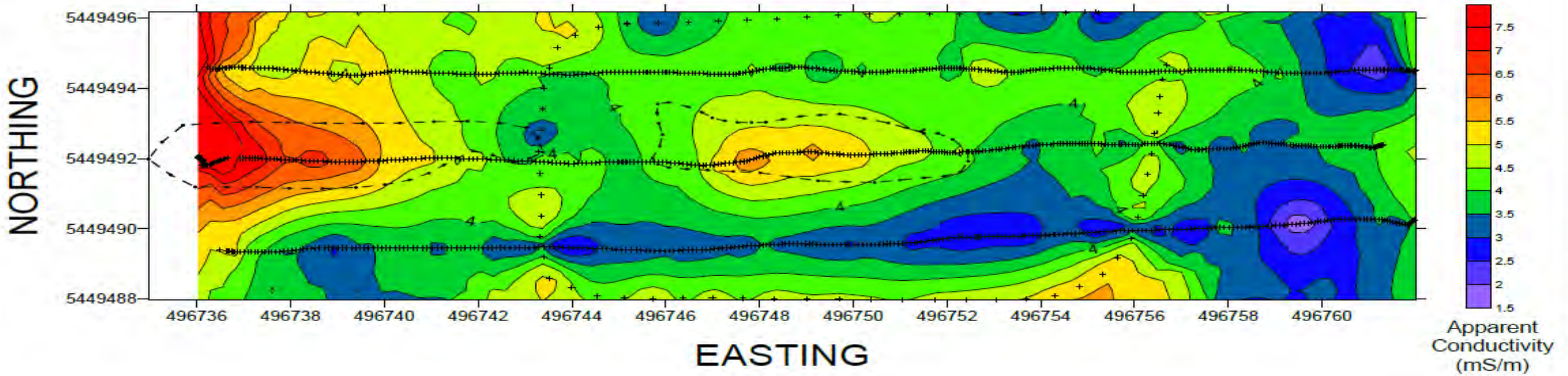
OXYGEN CAUGHT IN SATURATED SOIL



O_2 moves 10,000 x slower in water than in air!

Ground Penetrating Radar

SINGLE FIELD SCAN



Notes:
1. Dashed lines indicate unhealthy patch areas
2. Plus symbols indicate survey points.

CLIENT: CRANBERRY FIELDS - UBC/KWANTLEN

CONSULTANT: Golder Associates

YYYY-MM-DD: 2015-7-31
PREPARED: DMAXWELL
DESIGN: MAX
REVIEW: MAX
APPROVED: MAX

PROJECT: CRANBERRY FIELDS GEOPHYSICS RICHMOND/DELTA/BURNABY

TITLE: APPARENT CONDUCTIVITY EM38 QUADRATURE ORIENTATION: VERTICAL 0.5

PROJECT No: IP14190001
SCALE: 5500
Rev: A

FIGURE 1

Plant Analysis

Upright Count

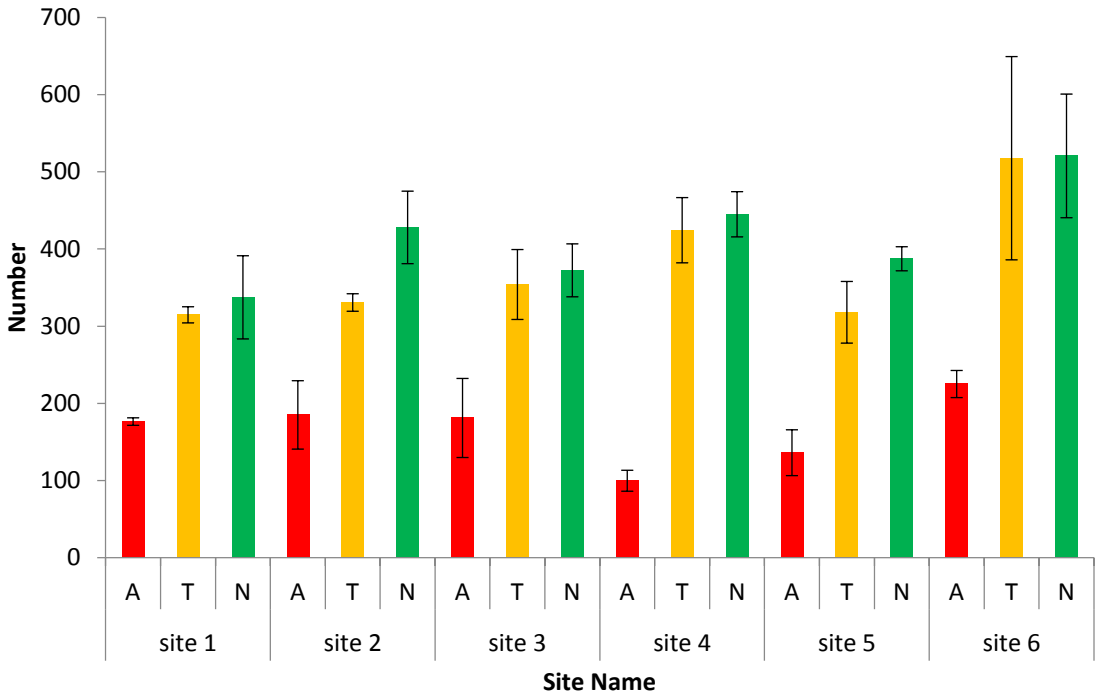


Fig.1: Mean total upright count per ft^2 for each condition (A: affected, T: transition, N: non-symptomatic) at each study field (site 1 to 6). Error bars indicate standard error around the mean.

Canopy Characterization

- Measured canopy depth
  - ‘green’ vs. ‘brown’ canopy
  - Pull test/rooting capacity

Growth Analysis Cores

Canopy Depth

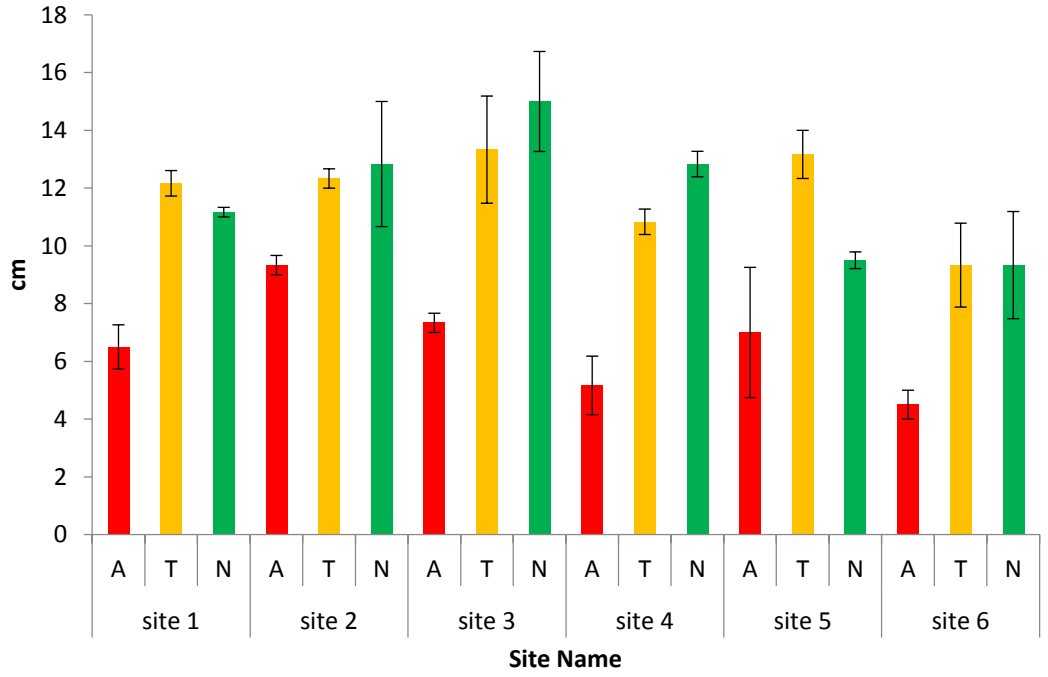


Fig.2: Green canopy depth for each condition (A: affected, T: transition, N: non-symptomatic) at each study field (site 1 to 6). Error bars indicate standard error around the mean.

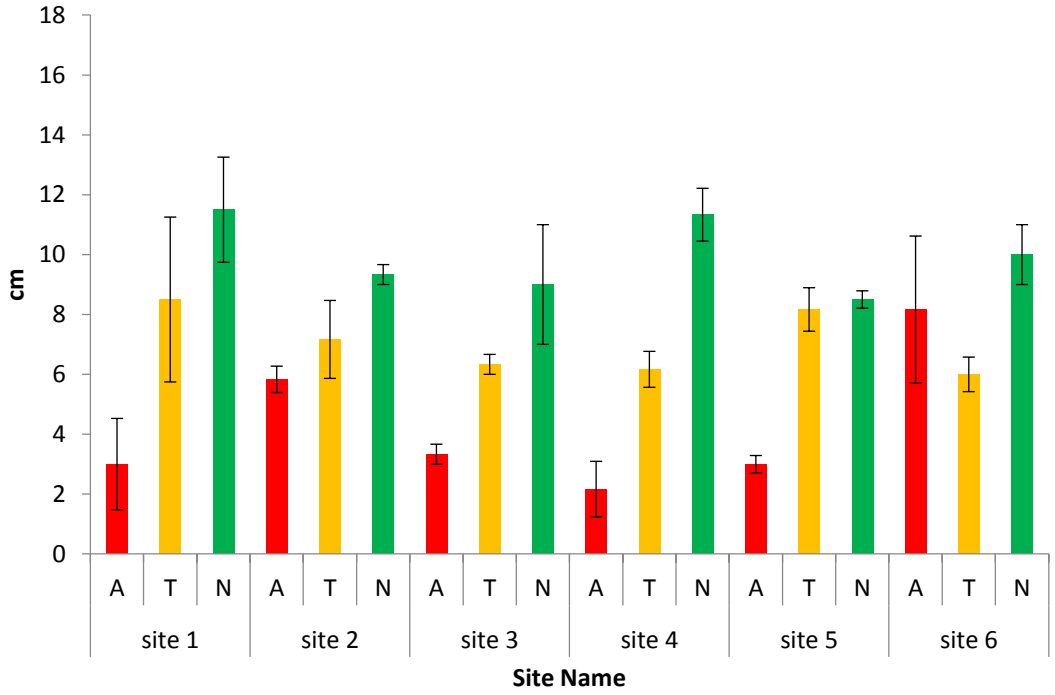
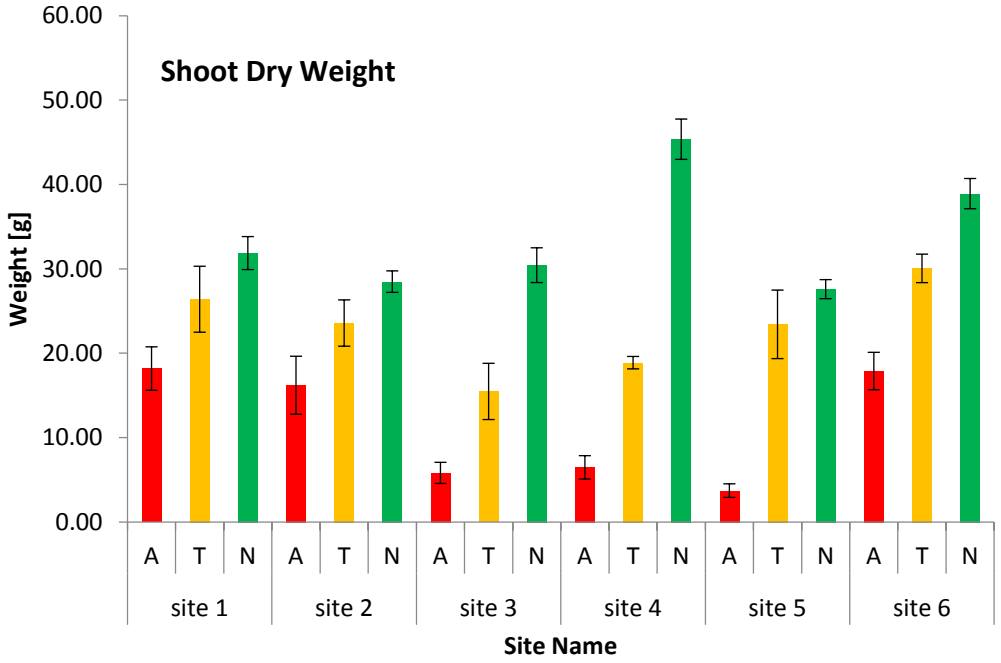
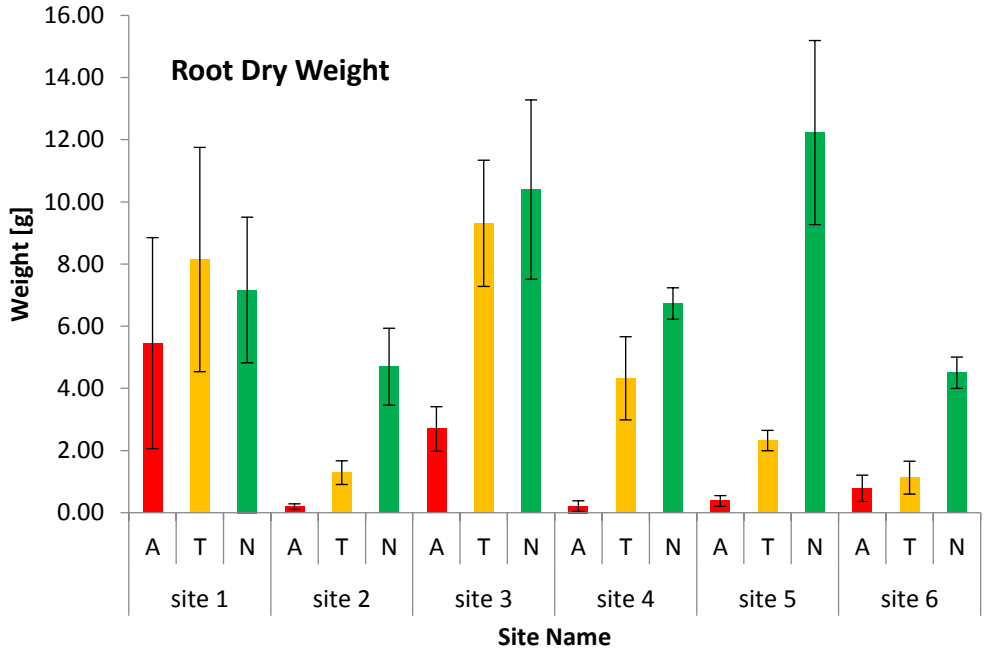


Fig.3: Brown canopy depth for each condition (A: affected, T: transition, N: non-symptomatic) at each study field (site 1 to 6). Error bars indicate standard error around the mean.

Growth Analysis



(a)



(b)

Fig. 4. dry weight of (a) shoot and (b) root for each condition (A: affected, T: transition, N: non-symptomatic) at each study field. Error bars indicate standard error around the mean.

Total Yield

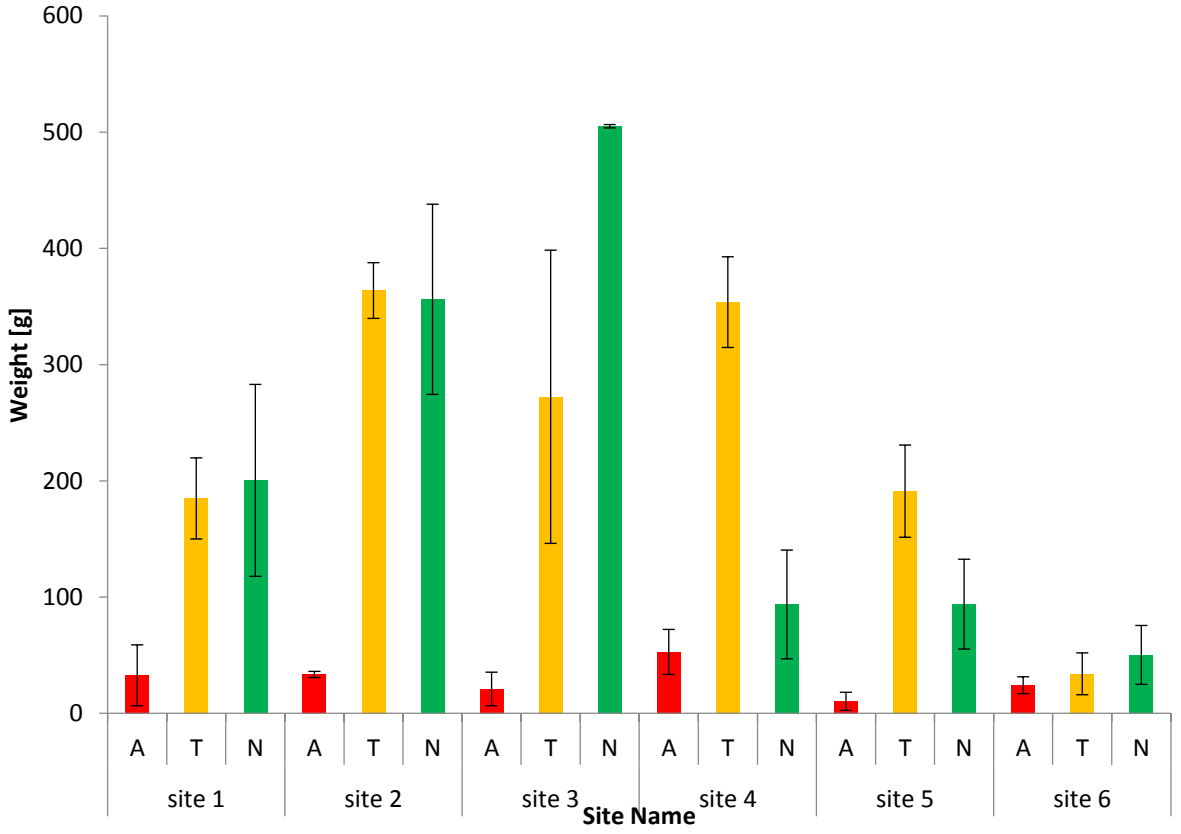


Fig. 8. Mean and total yield per ft^2 for each condition at each study field. Error bars indicate standard error around the mean.

Components of a Resilient Cranberry Plant

1. Well established root system
   - Required for nutrient and water uptake
   - Early establishment

2. Healthy Brown Canopy
   - Function: provides a carbohydrate reserve to the green canopy
     - Especially important in a climate where winter temperatures may not accommodate full dormancy – continuous respiration
     - Provides ‘buffer’ when summer conditions are not ideal – reduced water uptake = reduced nutrient uptake

3. Healthy Green Canopy
   - Source of carbohydrates via photosynthesis
   - Not always a good indicator the canopy health!

Summary

- Soil Characteristics of CFD areas:
  - Increased ‘layering’ of soil horizons
  - Higher rates of organic matter decomposition
  - Higher soil pH
  - Redox values < 250mv

- Plant Characteristics in CFD areas:
  - Reduced rooting
  - Reduced brown canopy depth and health
  - Increased variability in yield in the transition canopy, but sudden drop in affected area

Future Efforts…

- Evaluate the impact of soil amendments and management strategies
- Evaluate diagnostic tools
- Understanding impact of inputs on soil
- Examine the carbohydrate status of vines
- Examine the impact of soil moisture management (irrigation and drainage)

Acknowledgement

- Cranberry Growers!
- Funding
  - BCCMC
  - Ocean Spray
- KPU and UBC students

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