Dairy Manure-Derived Fertilizers for Use in Raspberry and Blueberry Cropping Systems: Evaluation for Agronomic, Soil Health, and Food Safety Efficacy
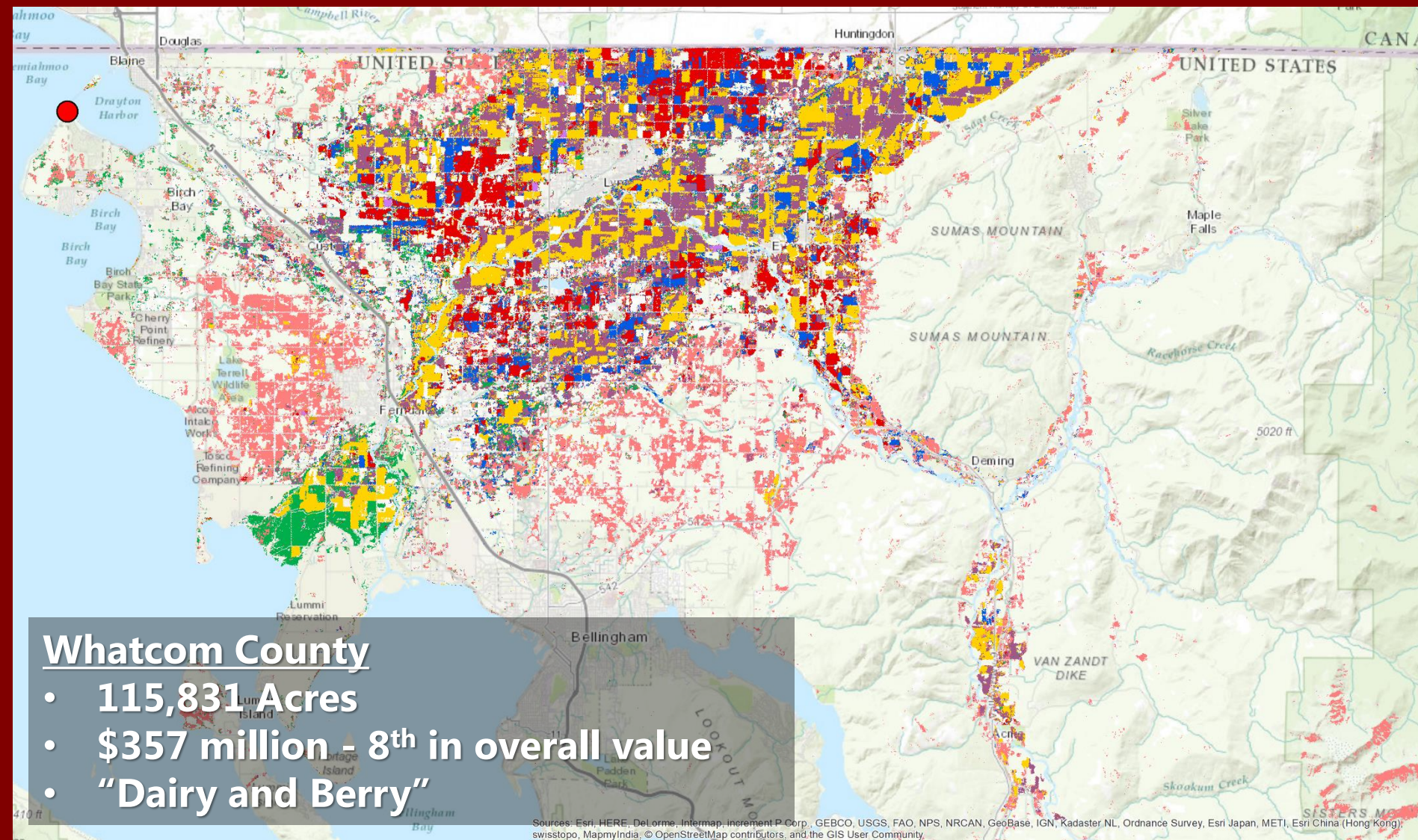
Chris Benedict, Meijun Zhu, Betsy Schacht, Chad Kruger, Georgine Yorgey

Overview

- **Context and Background**

- **Project Outline**

- **Agronomic Results**

- **Food Safety Results**
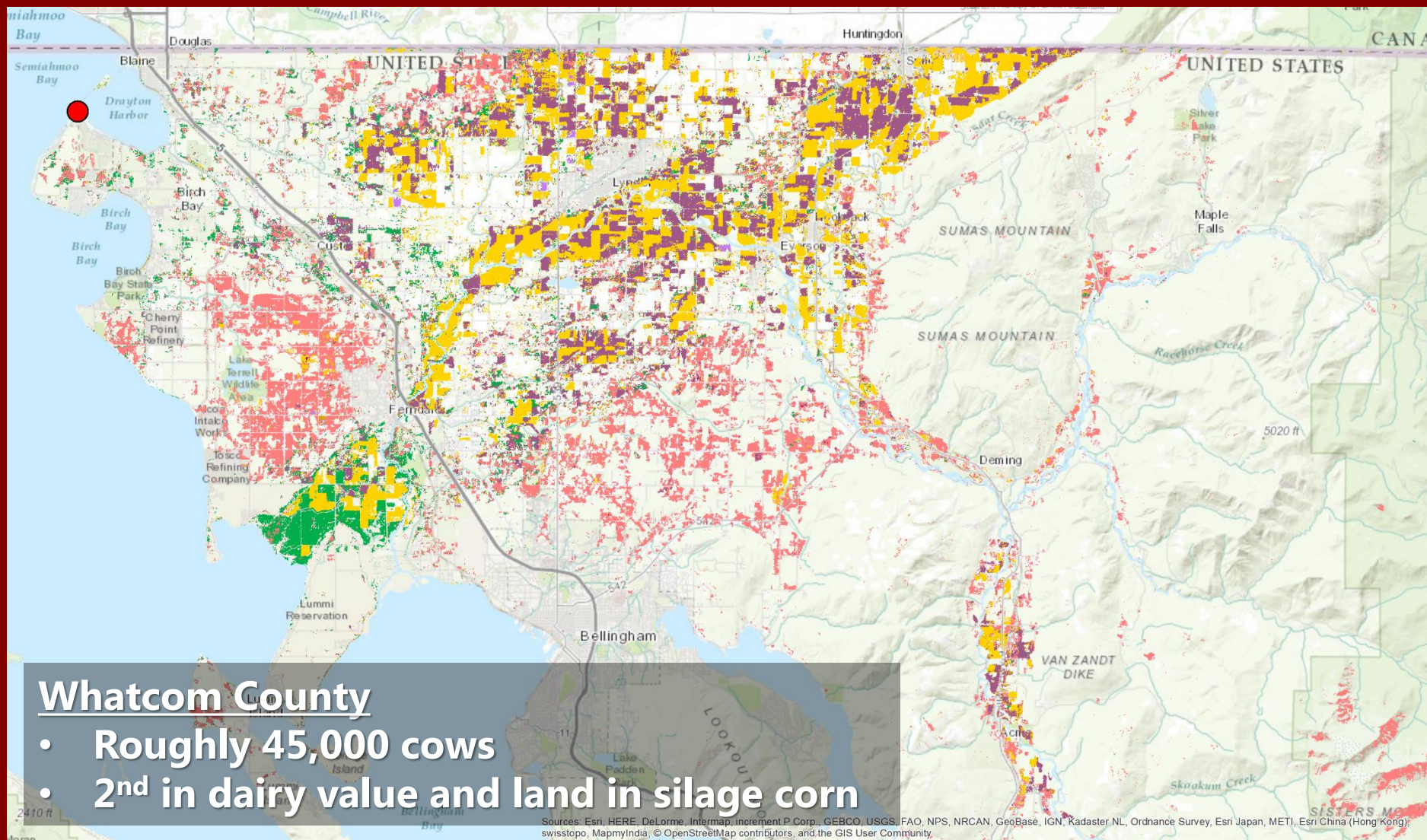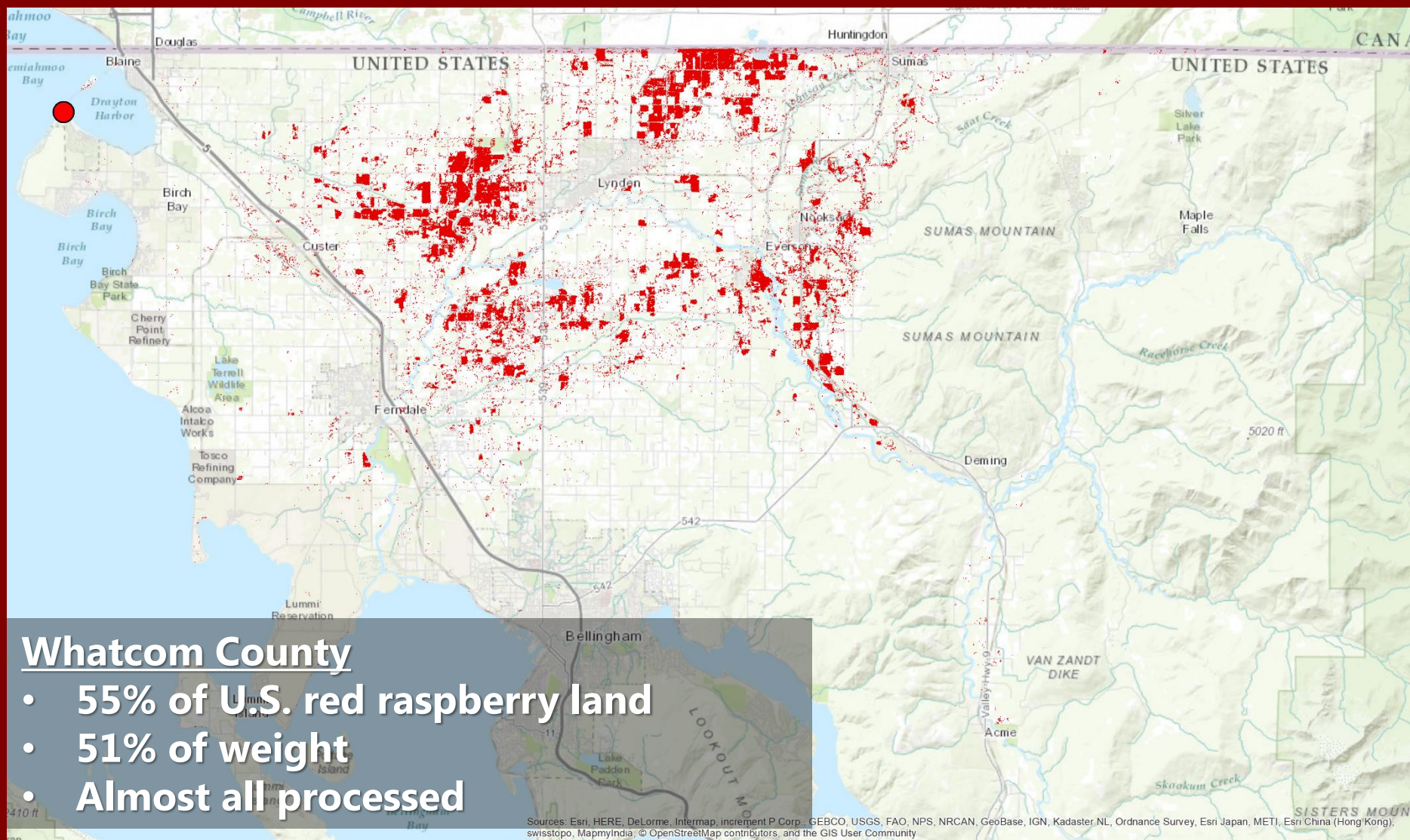
- **Implications for Practice**

Whatcom County
- **115,831 Acres**
- **$357 million - 8th in overall value**
- **"Dairy and Berry"**

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.

Whatcom County
- **Roughly 45,000 cows**
- **2nd in dairy value and land in silage corn**

(USDA 2017)

Washington State University
Whatcom County Extension

Whatcom County
- **55% of U.S. red raspberry land**
- **51% of weight**
- **Almost all processed**

(USDA 2017, WRRC)

Washington State University
WHATCOM COUNTY EXTENSION

Whatcom County
- **#1 state for blueberry production (~120 million pounds)**
- **Whatcom #1 acreage**

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
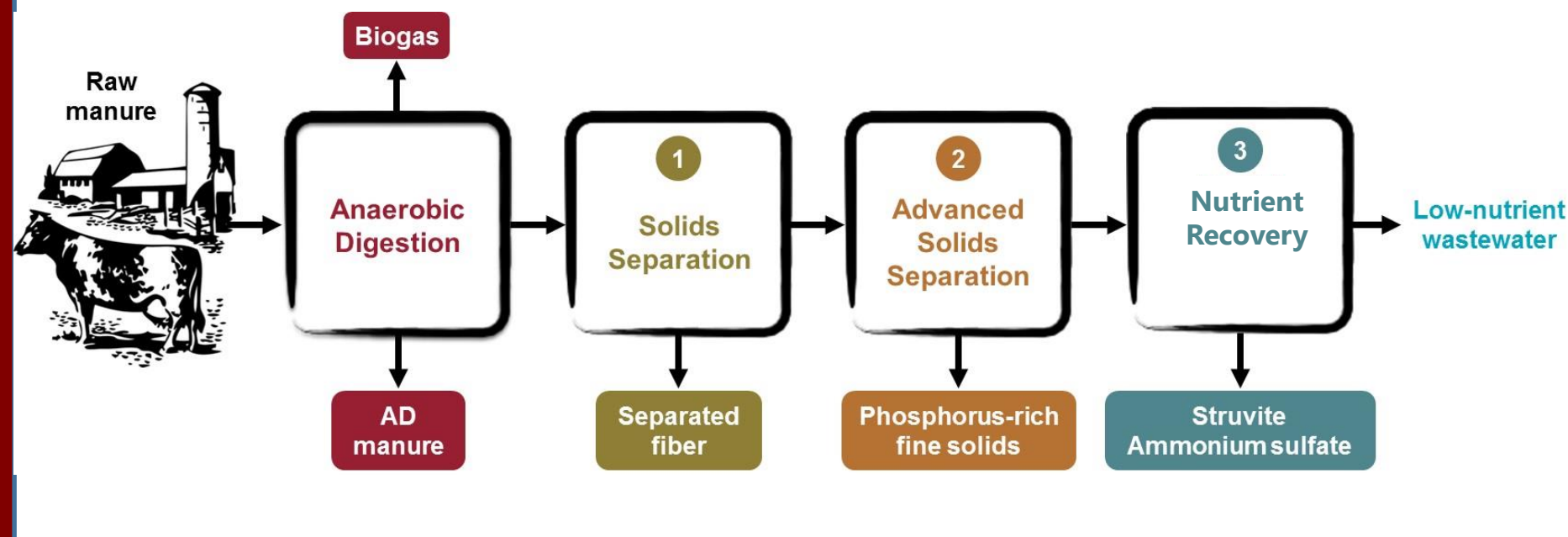
(USDA 2017, WBBC)

Anaerobic Digestion

- Produces renewable power
- Reduce odor, greenhouse gas emission, and pathogens in manure
- Co-digestion
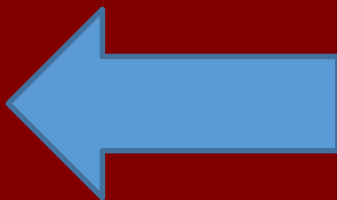- Can be coupled with nutrient recovery technology
- Four in Whatcom

Dairy Biorefinery Units and Products

Dairies to Berries

Areas of High Demand

Areas of High Concentration

Food Safety Concerns

E. coli O157:H7, *Salmonella*, and *Listeria monocytogenes* are important foodborne pathogens.

FSMA: Five Areas of Focus in Produce Rule

1. Agricultural water
2. Biological soil amendments of animal origin
3. Domesticated and wild animals
4. Personnel qualifications, training, and health and hygiene
5. Equipment, tools, buildings and sanitation

Project Activities

1. **Agronomic Trials: raspberries and blueberries**

2. **Food Safety Evaluation**

3. **Nutrient and Cost Impact Analysis**
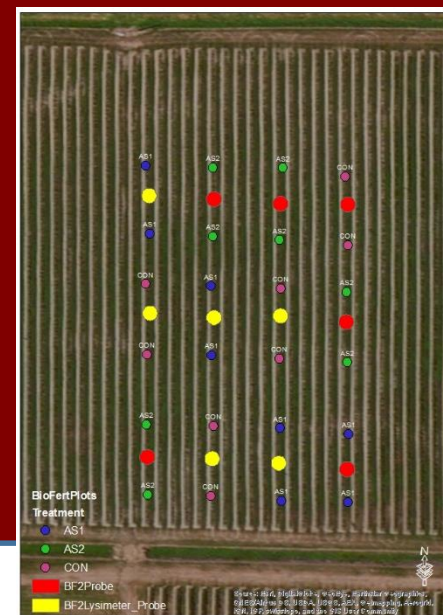
4. **Extension and Outreach**

Sites

Two Sites *(commercial farms)*

- 'Meeker' Red Raspberry (~4.6 A)
  - Seven Treatments
- 'Draper' Blueberry (~2.7 A)
  - Three Treatments

Treatment List

Raspberry

Ammonium Sulfate AS

Phosphorous Solids PS

Digested Liquid Effluent DLE

Raw Manure MA

Compost COM

Conventional Fertilizer CON

Non-Fertilized Check CHK

Blueberry

Ammonium Sulfate AS 1X

Ammonium Sulfate AS Split

Conventional Fertilizer CON

Treatment Characterization

|			% Carbon			Nitrogen		P_2O_5	K	C:N
			% Moisture	*100% Dry*	pH	NH_4-N	Total N			
Red Raspberry	1	AS	100.0%		1.7	483.0 lbs/1000 gal	483.1 lbs/1000 gals	0.01 lbs/1000 gal		
	2	PS	63.9%	19.6	8.5	6.0 lbs/ton	0.02 lbs/ton	38.3 lbs/ton	24.2 lbs/ton	9.7
	3	DLE	96.7%			11.0 lbs/1000 gal	18.8 lbs/1000 gal	3.4 lbs/1000 gal	13.9 lbs/1000 gal	
	4	MA	93.3%			9.2 lbs/1000 gal	18.9 lbs/1000 gal	3.4 lbs/1000 gal	27.1 lbs/1000 gal	
	5	COM	74.3%		8.4	0.17%	2.23%			16.5:1
	6	CON								
	7	CHK								
Blueberry	1	AS1	100.0%		1.7	483.0 lbs/1000 gal	483.1 lbs/1000 gals	0.01 lbs/1000 gal		
	2	AS2	100.0%		1.7	483.0 lbs/1000 gal	483.1 lbs/1000 gals	0.01 lbs/1000 gal		
	3	CON								

Project Assessments

- Products
  - Pre-Treatment Analysis
- Soils
  - Texture – *Randomization*
  - Nutrient (Macro/Micro, NO_3, NH_4, Soluble Salts)
    - Soil cores (pre-treatment/monthly)
    - PRS Probes (on-going, exchanged every 2-weeks)**
  - Moisture
    - Sensors

  - Quality
    - Bulk Density
    - Infiltration
    - Compaction
    - Pathogen – RLN, Phytophthora
- Plant
  - Cane Diameter
  - Primocane Height
  - SPAD Metering
  - Foliar samples
  - Yield
- Groundwater
  - Suction Cup Lysimeter ~ 18-24" (checked every 2-weeks (April-October)*
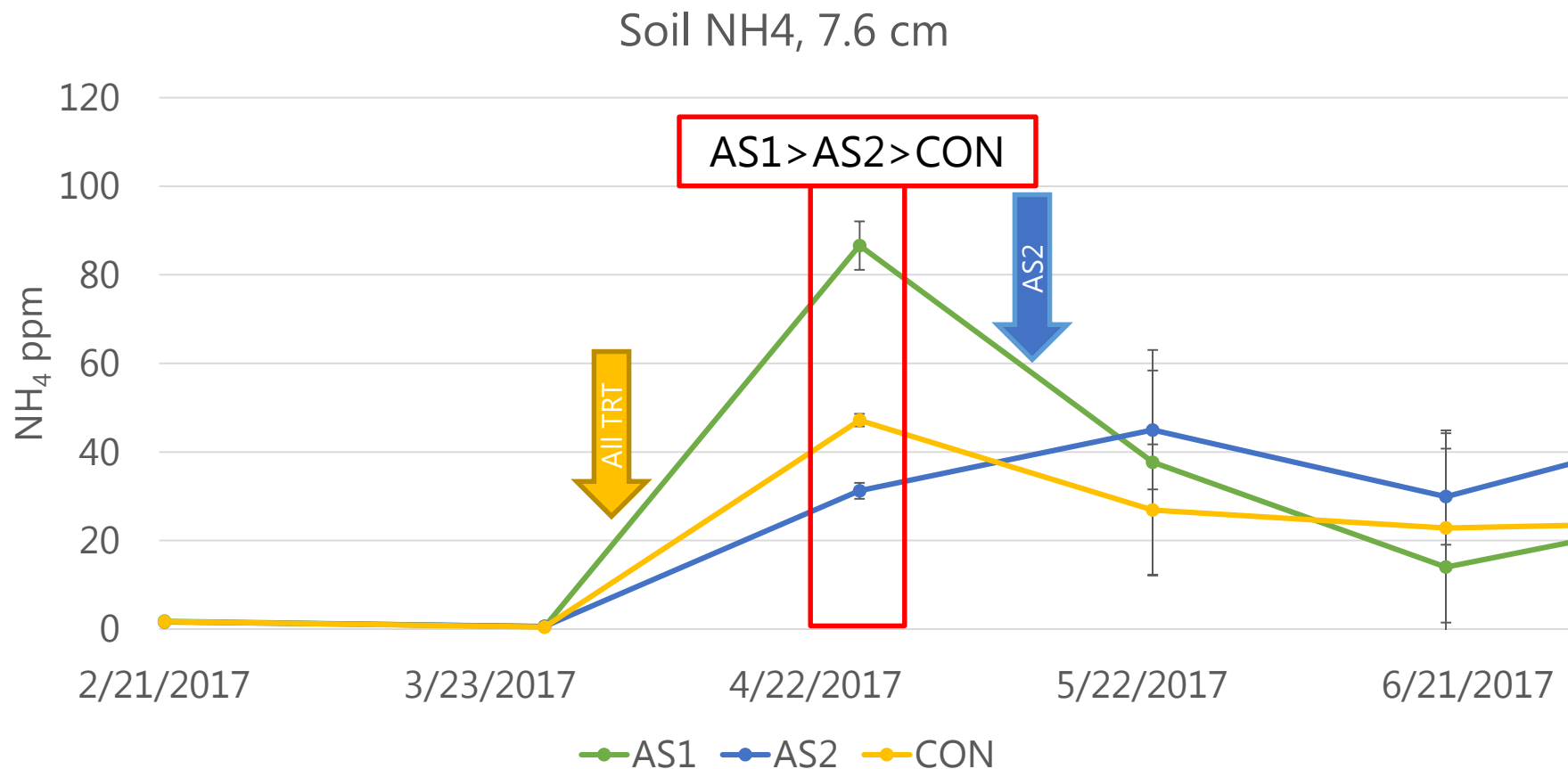
BF1 – AS and CON; **BF2** – AS1, AS2, and CON   *BF1** – AS and CON; **BF2** – AS1, AS2, and CON

Red Raspberry Soil (3") Nitrogen, 2017
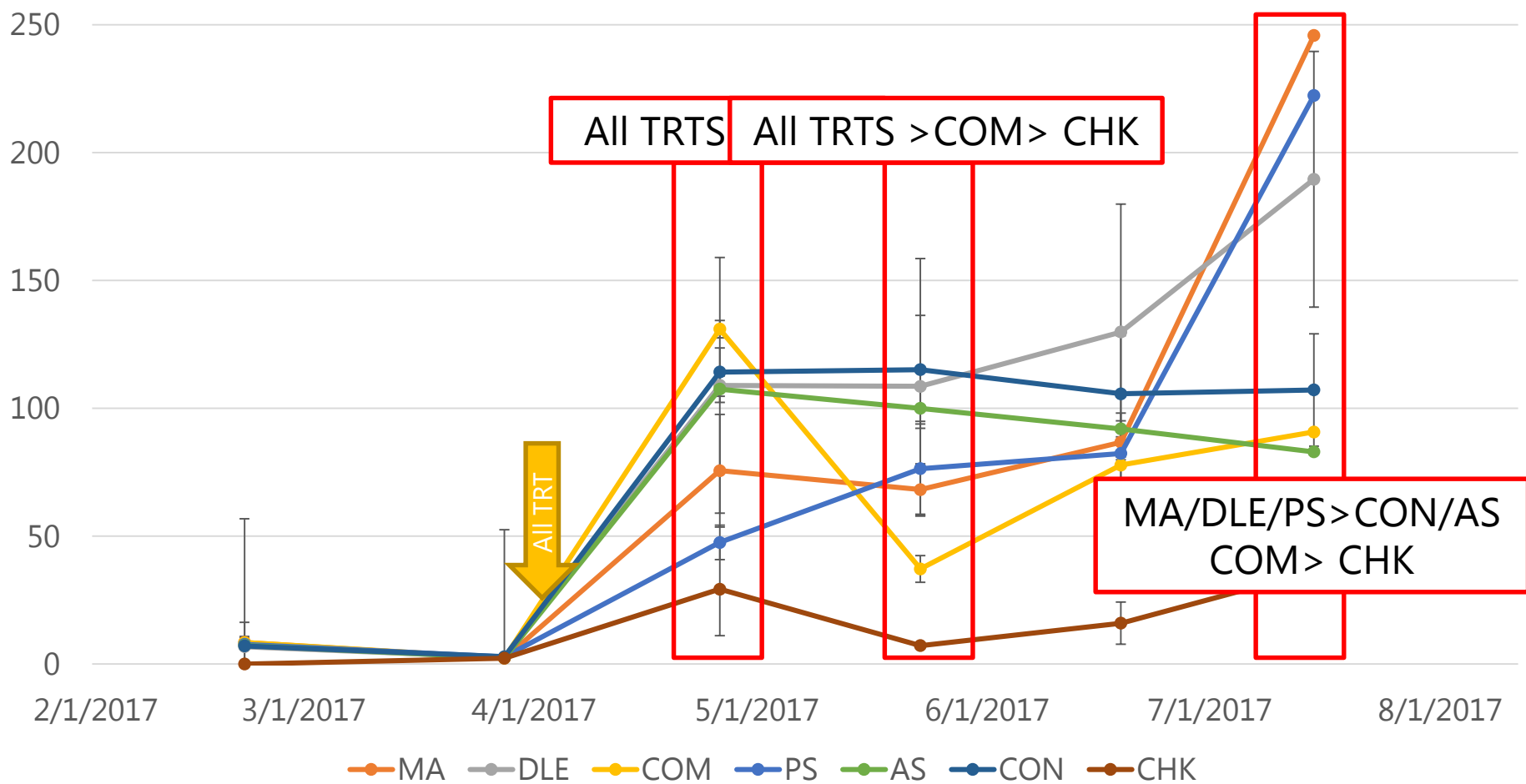
Red Raspberry Soil (3") Phosphorous, 2017
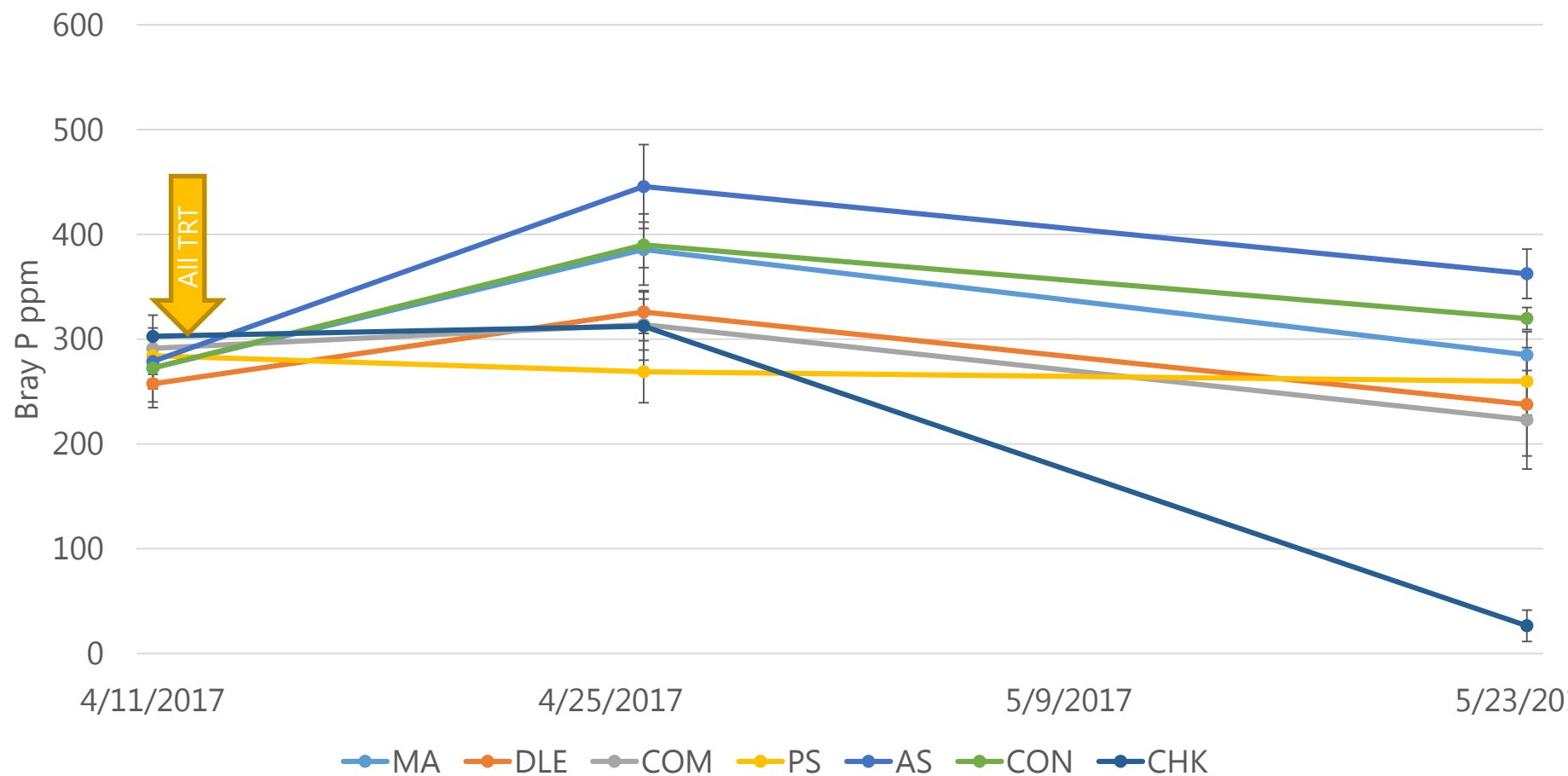
Blueberry (3") Nitrogen, 2017

Soil NH4, 7.6 cm

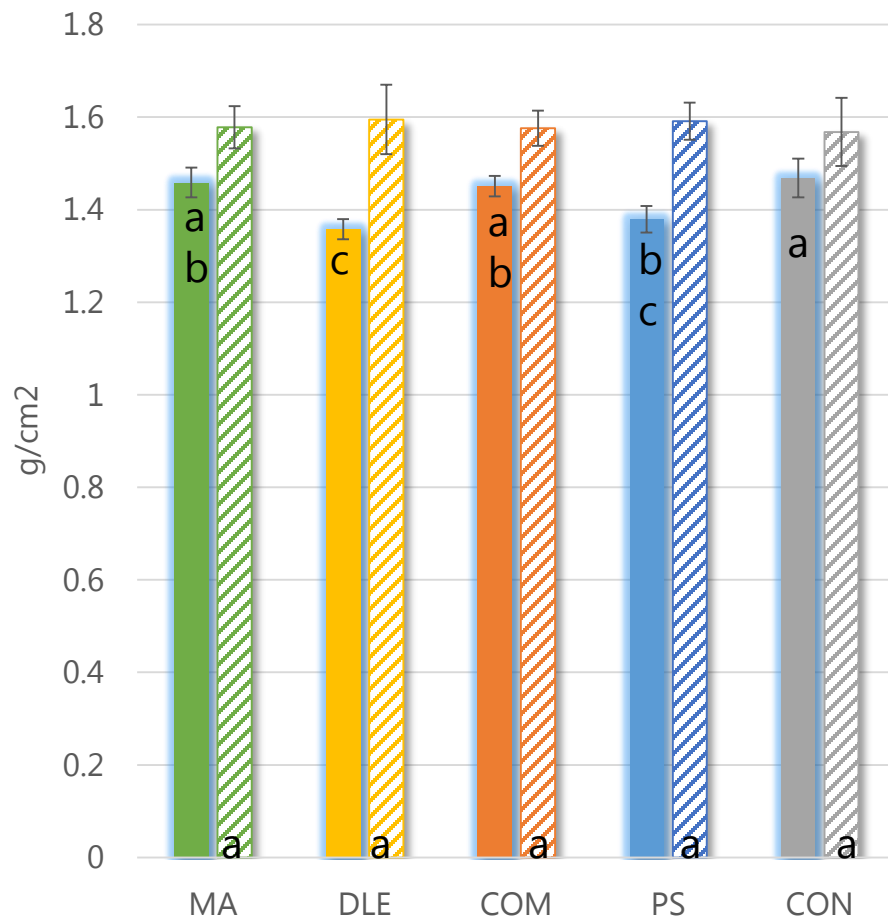# Red Raspberry Bulk Density

The weight of soil in a given volume
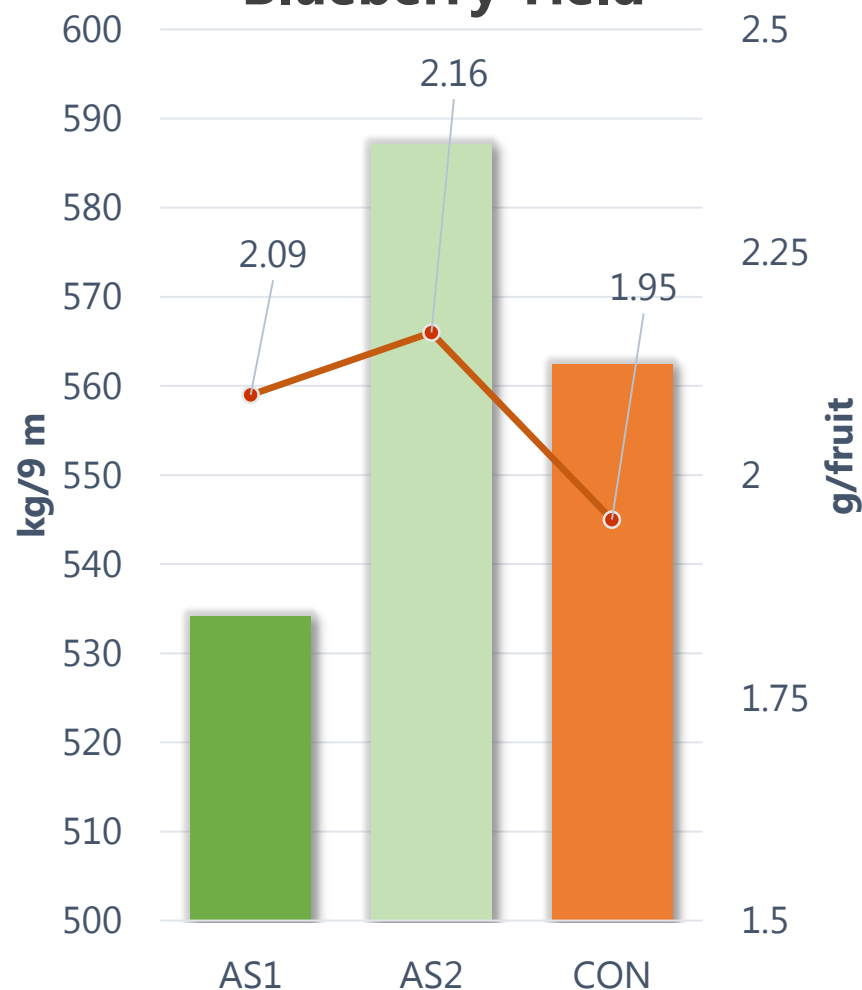
- Surface BD reduced in DLE and PS as compared to CON
- Subsurface BD was similar across treatments

FOOD SAFETY EVALUATION

Soil sampling
Soil sample (~500 g)
- 20-25 subsamples
- ~20 g/subsample

Pre-application   Post- application   Before fruit harvest   After fruit harvest

Feb	March	April	May	June	July	August

Foliar sampling

Fruit sampling

Fertilizer sampling

Fertilizer sample (~500 g)
- 8-10 subsamples
- 50 g/subsample

Foliar sample (~100 g)
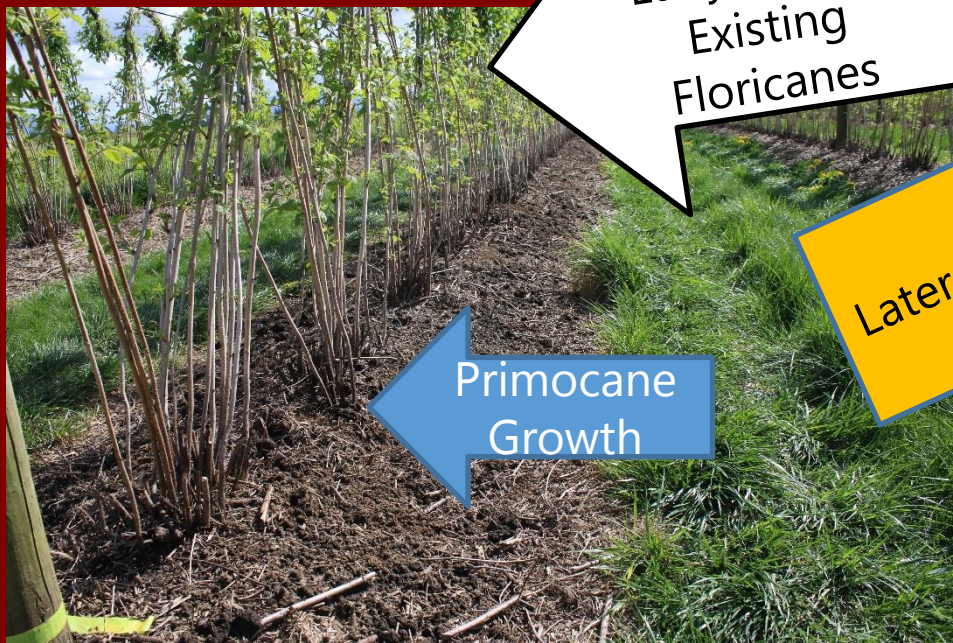- 200~250 subsamples

Fruit sample (~100 g)
- 10 subsamples
- 10 g/subsample
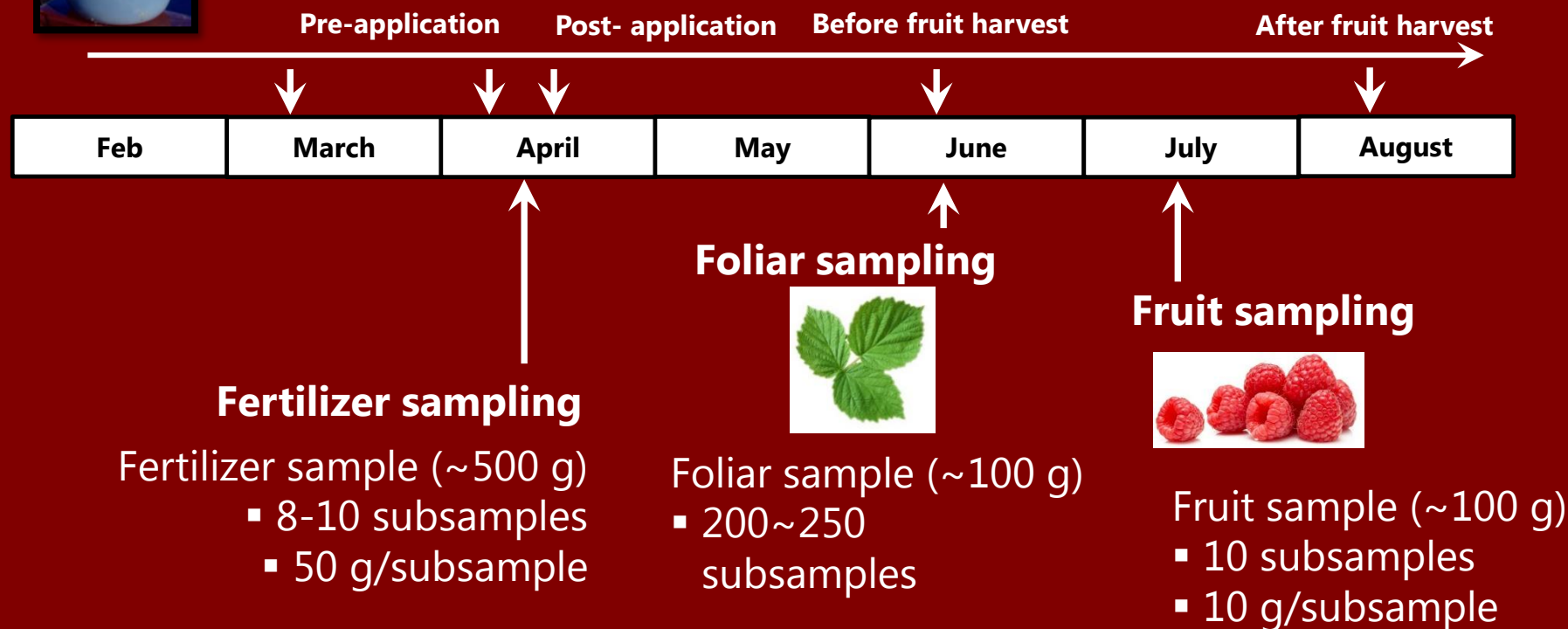
Treatment Application

Early Season Existing Floricanes

Later Season Canopy Transfer

Primocane Growth

Coliform and Generic *E. coli* (soil)
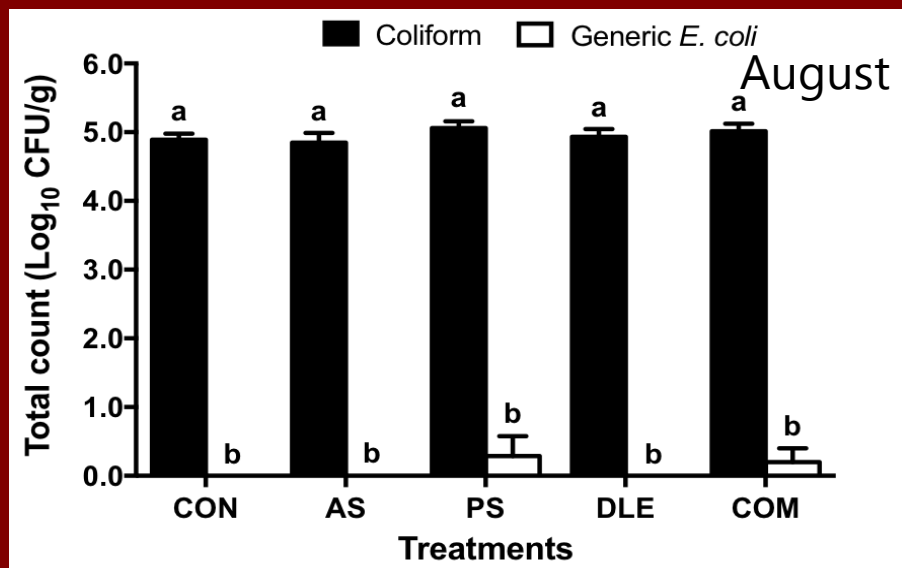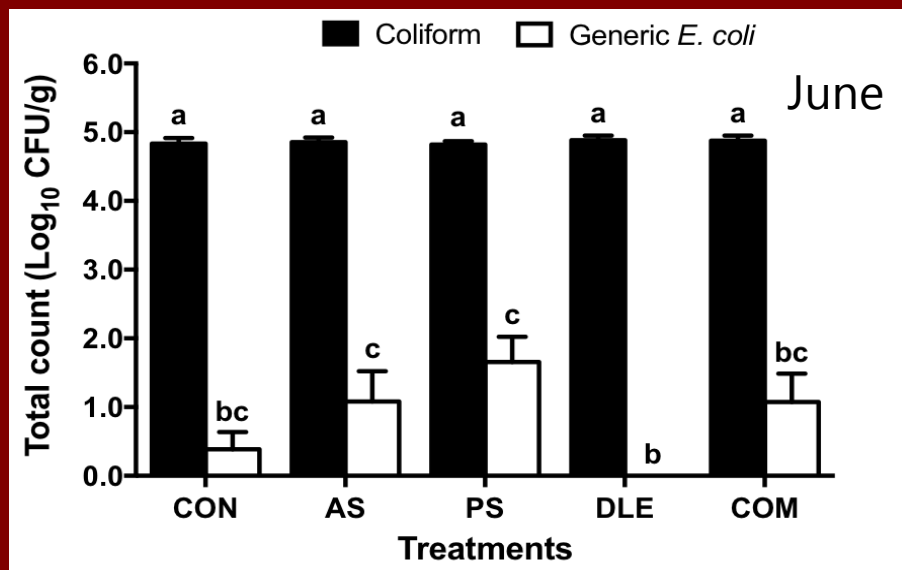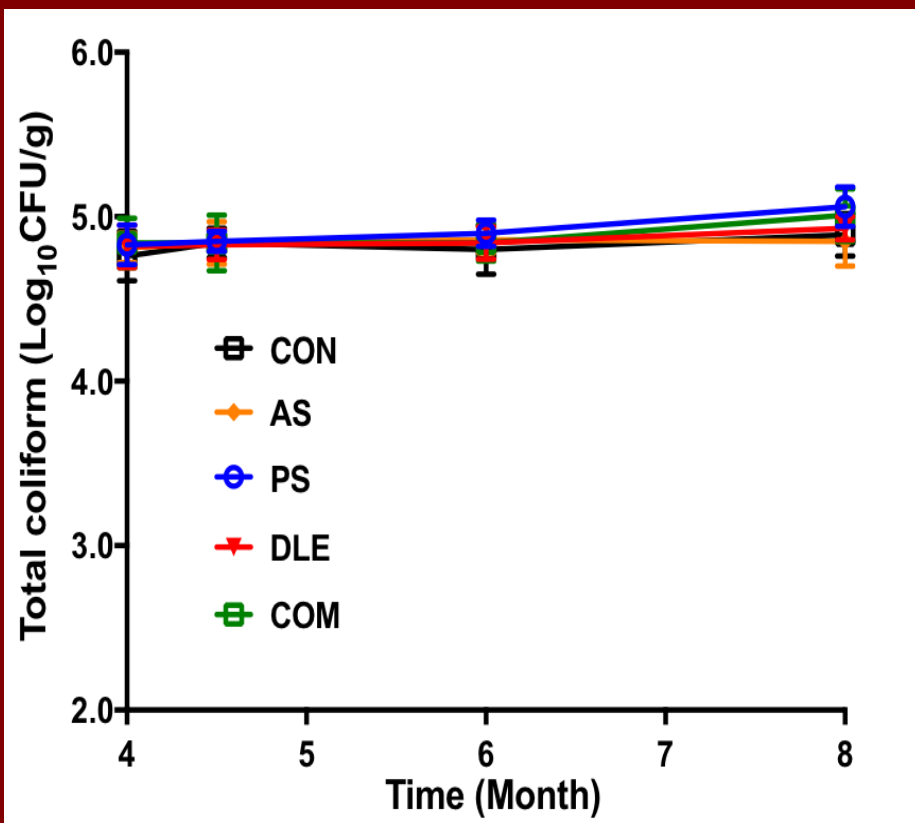
E. coli O157:H7

Treatment	Fertilizer	Soil				Foliar	Fruit
		April		June	August		
		Pre-app	Post-app				
CON	0/5	0/4	0/4	0/4	0/4	0/4	0/4
AS	0/5	0/4	0/4	0/4	0/4	0/4	0/4
PS	0/5	0/4	0/4	0/4	0/4	0/4	0/4
DLE	0/5	0/4	0/4	0/4	0/4	0/4	0/4
COM	0/5	0/4	0/4	0/4	0/4	0/4	0/4

Salmonella

Treatment	Fertilizer	Soil				Foliar	Fruit
		April		June	August		
		Pre-app	Post-app				
CON	0/5	0/4	0/4	0/4	0/4	0/4	0/4
AS	0/5	0/4	0/4	0/4	0/4	0/4	0/4
PS	5/5	0/4	1/4	0/4	0/4	0/4	0/4
DLE	0/5	0/4	0/4	0/4	0/4	0/4	0/4
COM	0/5	0/4	0/4	0/4	0/4	0/4	0/4

Listeria monocytogenes

Treatment	Fertilizer		Soil										Leaf		Fruit	
			April				June		August							
			Pre-app		Post-app											
	MOX2	CL	MOX2	CL	MOX2	CL	MOX2	CL	MOX2	CL	MOX2	CL	MOX2	CL	MOX2	CL
CON	0/5	0/5	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4			0/4	0/4	0/4	0/4
AS	0/5	0/5	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4			0/4	0/4	0/4	0/4
PS	0/5	0/5	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4			0/4	0/4	0/4	0/4
DLE	0/5	0/5	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4			0/4	0/4	0/4	0/4
COM	0/5	0/5	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4			0/4	0/4	0/4	0/4

Preliminary Results

Agronomic

- Raspberry treatment differences for N and P, but did not impact plant growth or yield
- Blueberry early season N higher in AS1, by mid-season similar, but no yield or plant growth difference
- Bulk density lower at surface in some treatments
- No differences in soil compaction, infiltration, plant parasitic nematodes.

Food Safety

- No *E. coli* O157:H7 or *L. monocytogenes* was detected from fertilizer, soil, foliar, or fruit sample
- *Salmonella* was detected from soil samples from PSOLIDS treated plots, but not from foliar or fruit

Overall

- Perceived vs. real food safety threat
- Current nutrient sources could prevent adoption

Acknowledgements

- Randy Honcoop Farm
- Curt Maberry Farm
- CHS Northwest
- Regenis