Variable Rate Application of Phosphate Update

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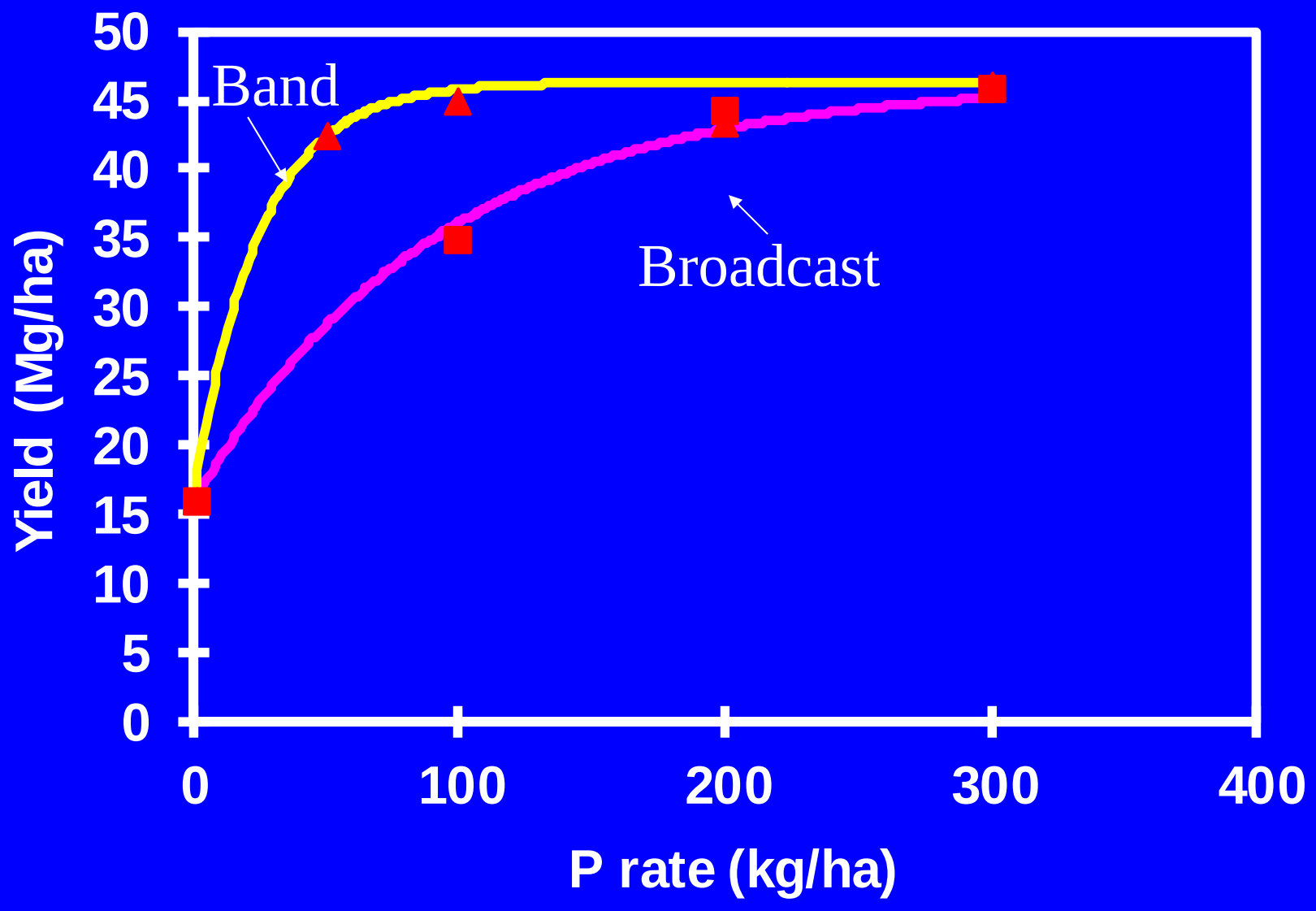
Concerns

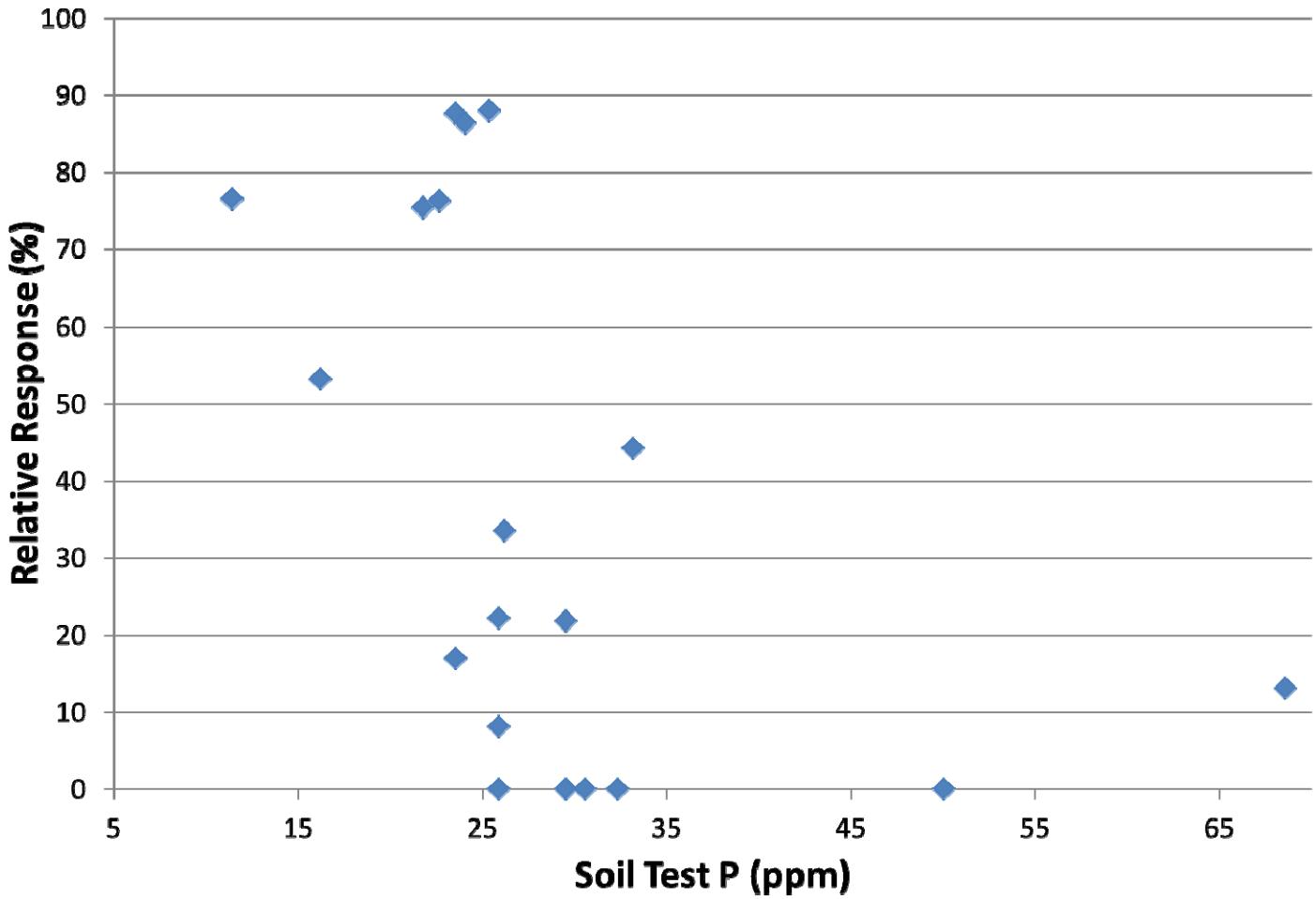
- World P reserves are rapidly declining and there is concern that a shortage of P fertilizers will ultimately compromise world food production (Vaccari, 2009).
- P in runoff and drainage often has adverse ecological impacts on surface waters.
- P fertilizer reserves are concentrated in a few nations.

Strategies for Improving P Efficiency

- P Placement
- Fertilizer technology
- Genetic modification
- Soil Testing and Plant Analysis



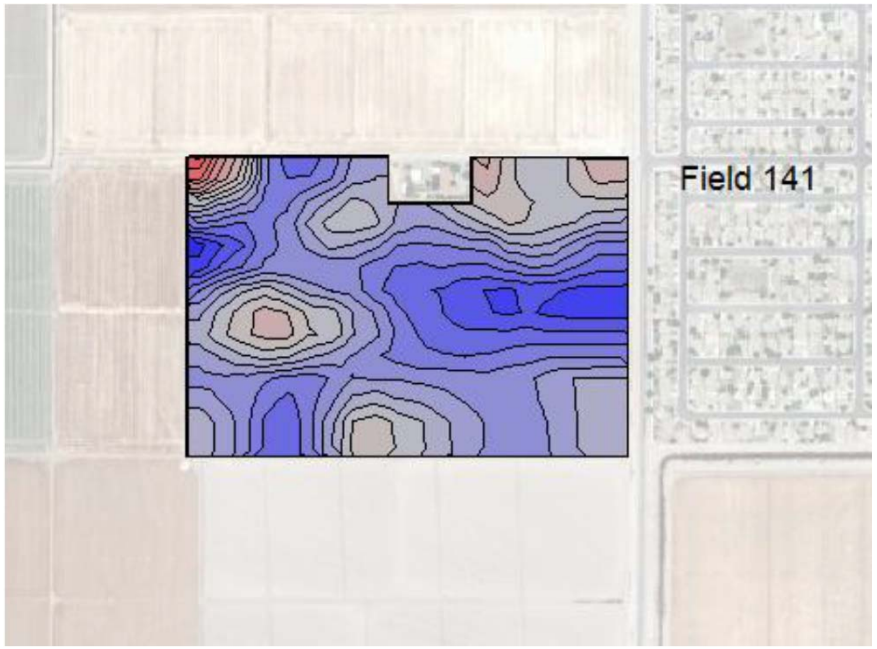
Sanchez et al. 1990



Relationship between soil test P and relative response of lettuce in the low desert.

Current P fertilizer recommendations for desert lettuce.

Soil Test P	Broadcast Fertilizer Recommendation[a]
< 10 mg/kg	550 lbs MAP/acre
10 to 15 mg/kg	500 lbs MAP/acre
15 to 20 mg/kg	450 lbs MAP/acre
20 to 25 mg/kg	400 lbs MAP/acre
25 to 30 mg/kg	350 lbs MAP/acre
30 to 35 mg/kg	300 lbs MAP/acre
>35 mg/kg	Starter only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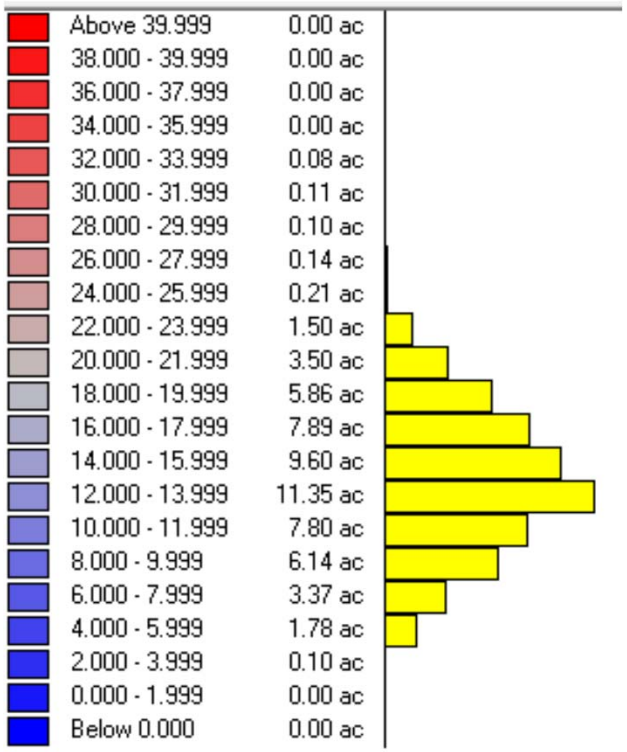
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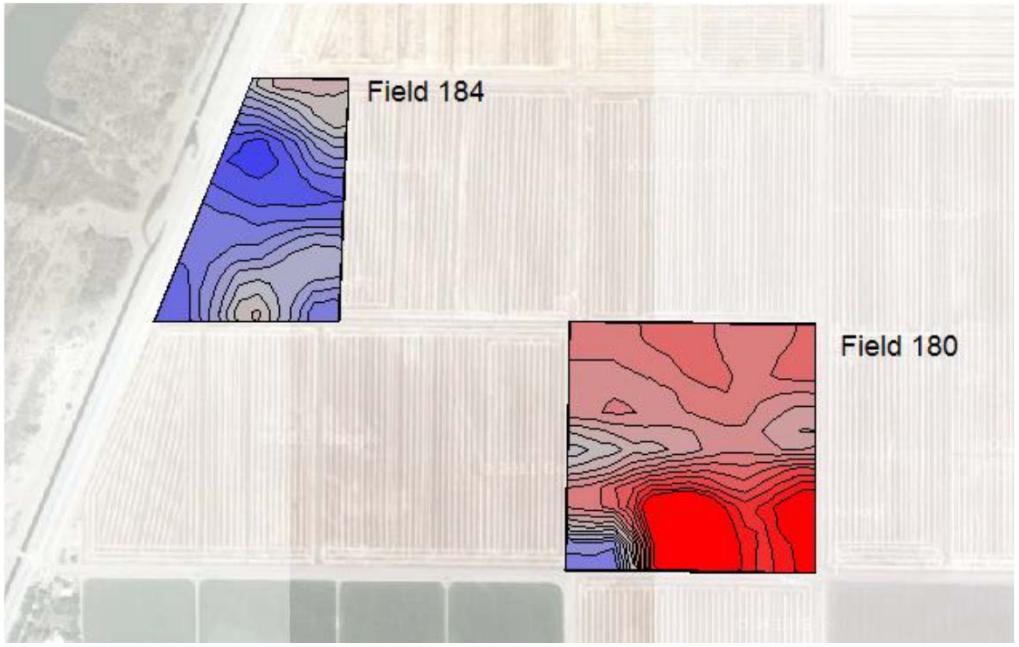
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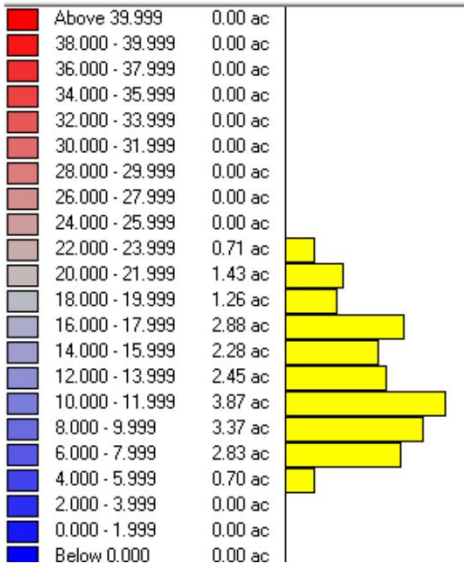
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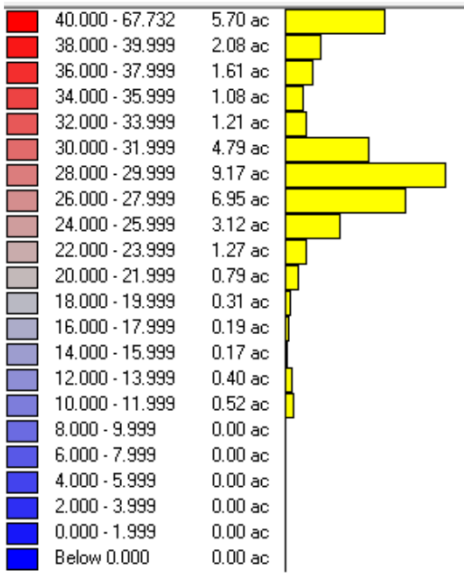
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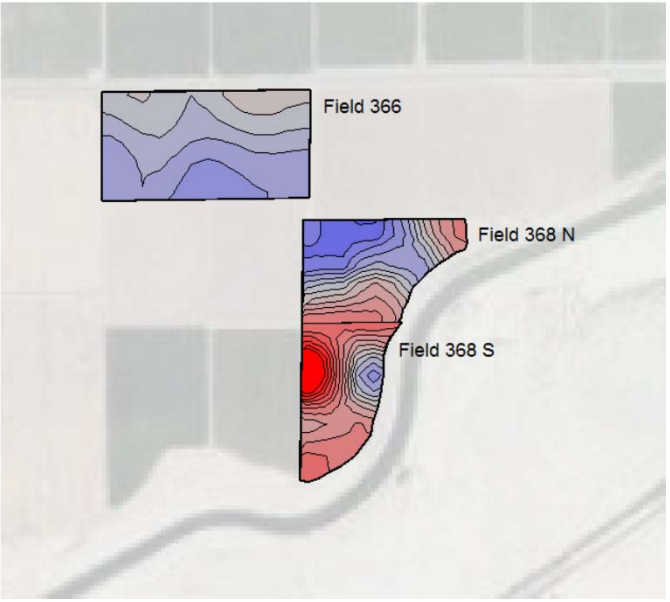
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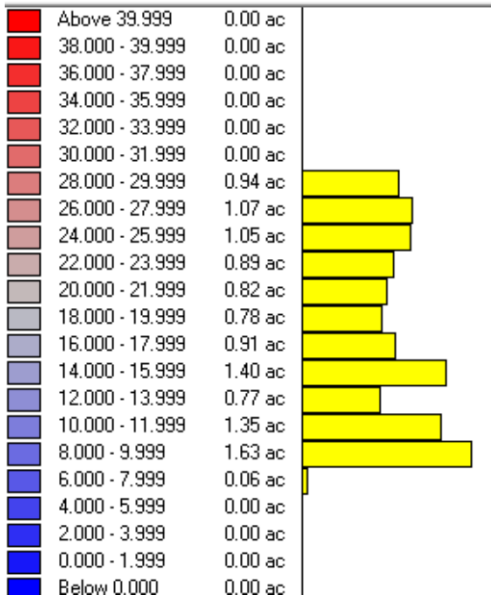
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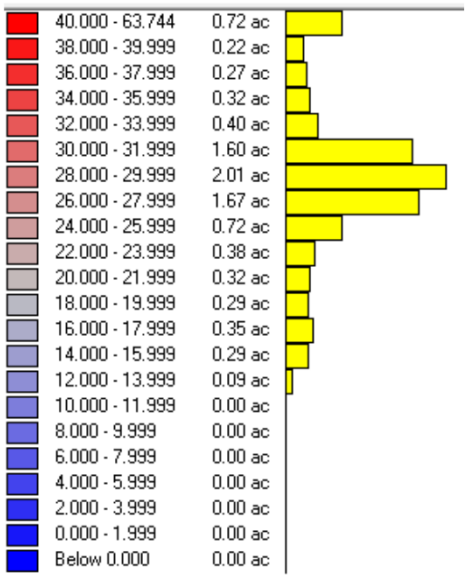
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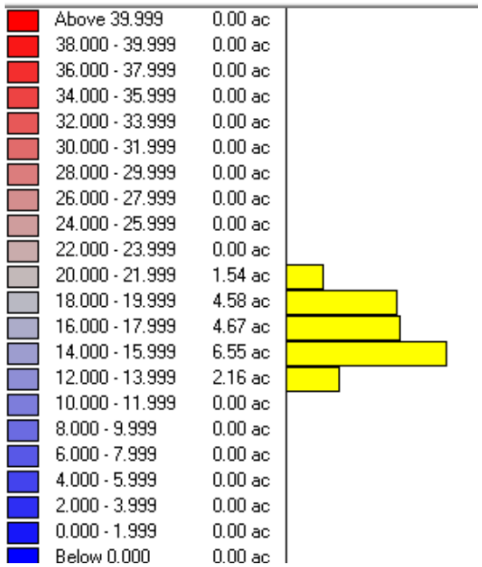
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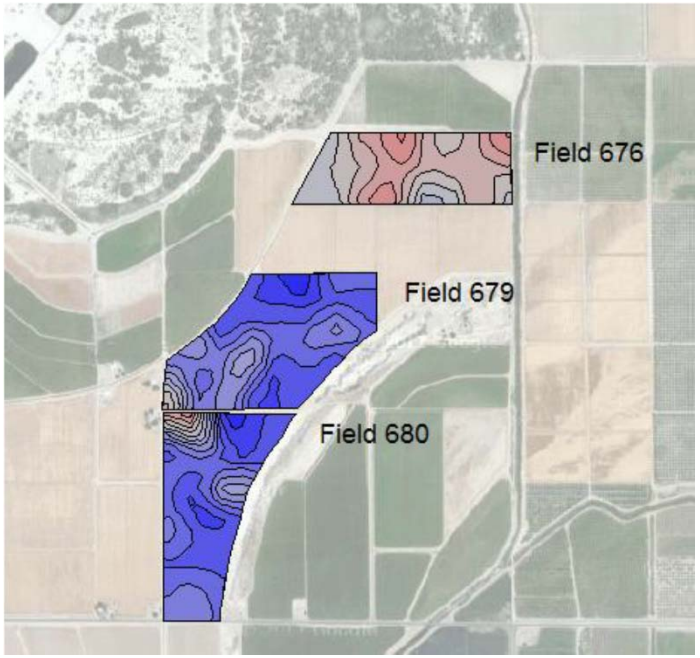
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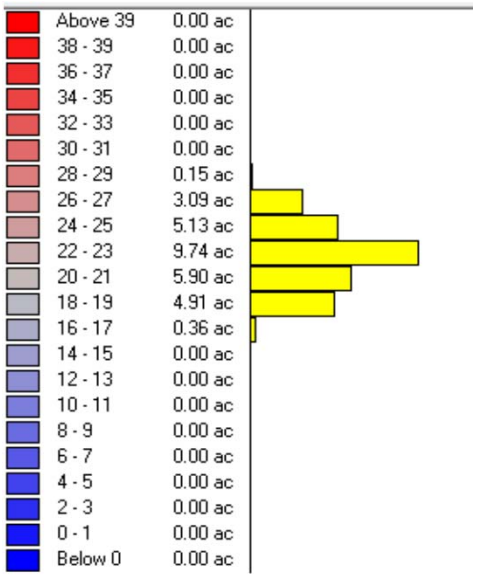
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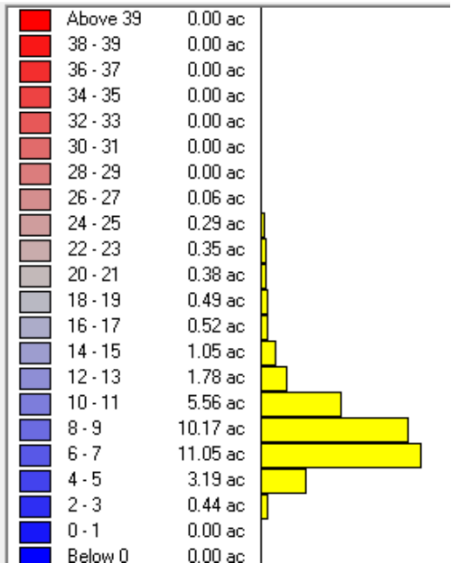
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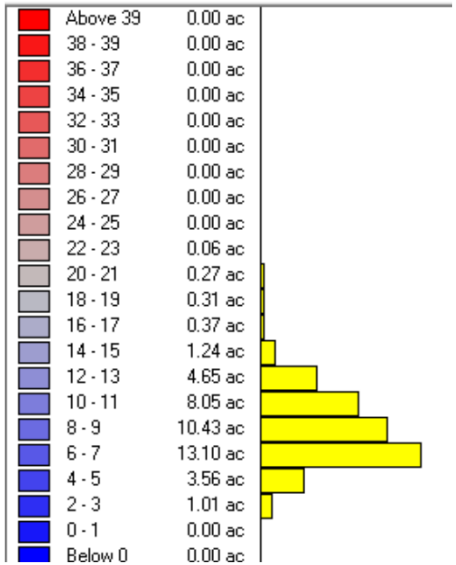
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Estimated area of field under fertilized by 50 and 100 lbs MAP/acre when comparing CSTU and VRT5 to VRT1.

Field	Area of field (%) under fertilized by >50 lbs MAP/acre		Area (%) under fertilized by >100 lbs MAP/acre	
	CSTU	VRT5	CSTU	VRT5
141	19	26	0	0
180	23	16	7	0
184	31	45	0	10
358	7	58	0	0
360	17	21	0	10
366	45	14	0	0
368N	5	46	2	32
356S	2	2	1	1
676	5	29	0	0
679	0	7	0	0
680	0	11	0	3

Estimated area of field over fertilized by 50 and 100 lbs MAP/acre when comparing GSPU, CSTU, and VRT5 to VRT1.

Field	Area of field (%) over fertilized by >50 lbs MAP/acre			Area of field (%) over fertilized by >100 lbs MAP/acre		
	GSPU	CSTU	VRT5	GSPU	CSTU	VRT5
141	81	49	16	29	9	0
180	100	24	16	98	24	0
184	68	29	46	29	10	0
358	82	33	57	33	0	0
360	83	12	20	12	9	0
366	100	8	14	55	0	0
368N	86	41	55	55	17	0
356S	100	37	37	96	13	0
676	100	11	29	100	0	0
679	35	35	7	2	6	0
680	14	14	12	1	6	0

Estimated fertilizer costs savings to soil testing including composite sample, VRT on one acre grid, and VRT on five acre grid.

	Soil Test P (mg/kg)		Fertilization cost savings ($/acre)[a]		
Field	Mean	Range	CSTU	VRT1	VRT5
141	14.0	1.9 to 35.5	18.4	6.2	18.1
180	31.1	7.2 to 67.7	93.2	85.3	106.8
184	12.6	0.1 to 25.7	17.8	0.05	15.9
358	13.5	0.7 to 23.0	18.3	1.51	8.5
360	13.0	6.4 to 85.8	18.2	2.88	18.8
366	16.7	11.3 to 22.2	36.5	10.6	30.2
368N	18.2	5.2 to 30.4	35.7	17.3	30.2
368S	29.1	0.2 to 63.7	72.9	68.5	75
676	22.7	16.5 to 30.6	55.6	34.9	56
679	9.0	1.8 to 22.5	-0.47	-12.9	7.1
680	9.1	1.4 to 29.3	-0.57	-15.8	3.4

Development of Economically Viable Variable Rate P Application Protocols for Desert Vegetable Production Systems

Project funded by CDFA FREP in 2012

Methods

High Resolution sampling and testing

Generation of prescription maps

Variable rate application

Yield Monitoring

Economic analysis

Project specifics

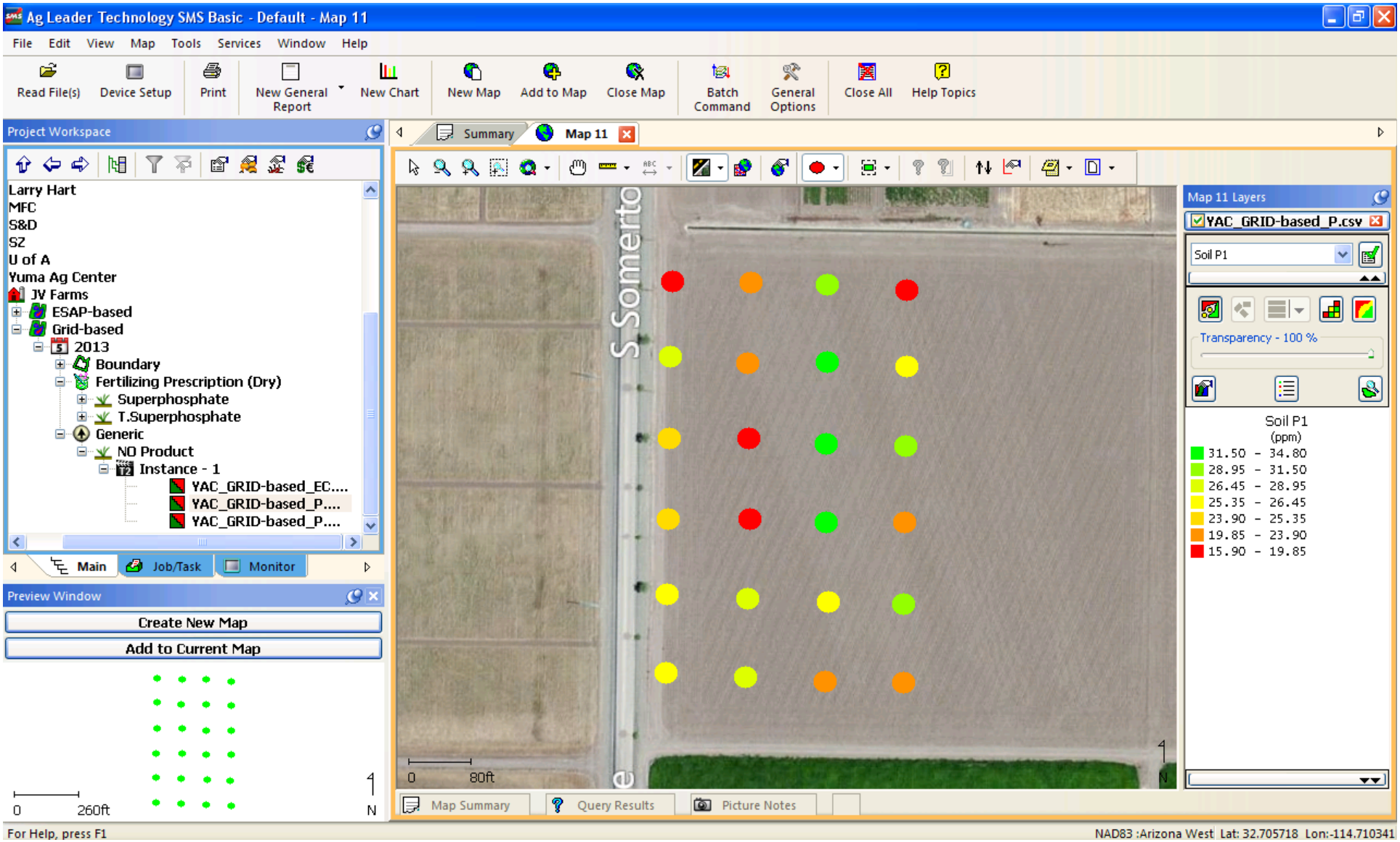
Variable-rate management of P_2O_5

- Multiple locations/crops
  - Coachella Valley CA – Broccoli 2013-14 and 2014=14
  - Yuma Valley AZ – Romaine lettuce 2012-14
  - Yuma Valley AZ –Iceberg lettuce 2014-15
  - Bard Valley CA – Iceberg lettuce 2013-14 and 2014-15
  - Maricopa AZ – Potatoes 2014 and 2015

- Two soil sampling protocols
  - Regular grid (100 x 100 ft)
  - Zones (based on EC_a surveys)

Soil Sampling - Grid

Location of soil samples in 100 x 100 ft square grid (n=24)



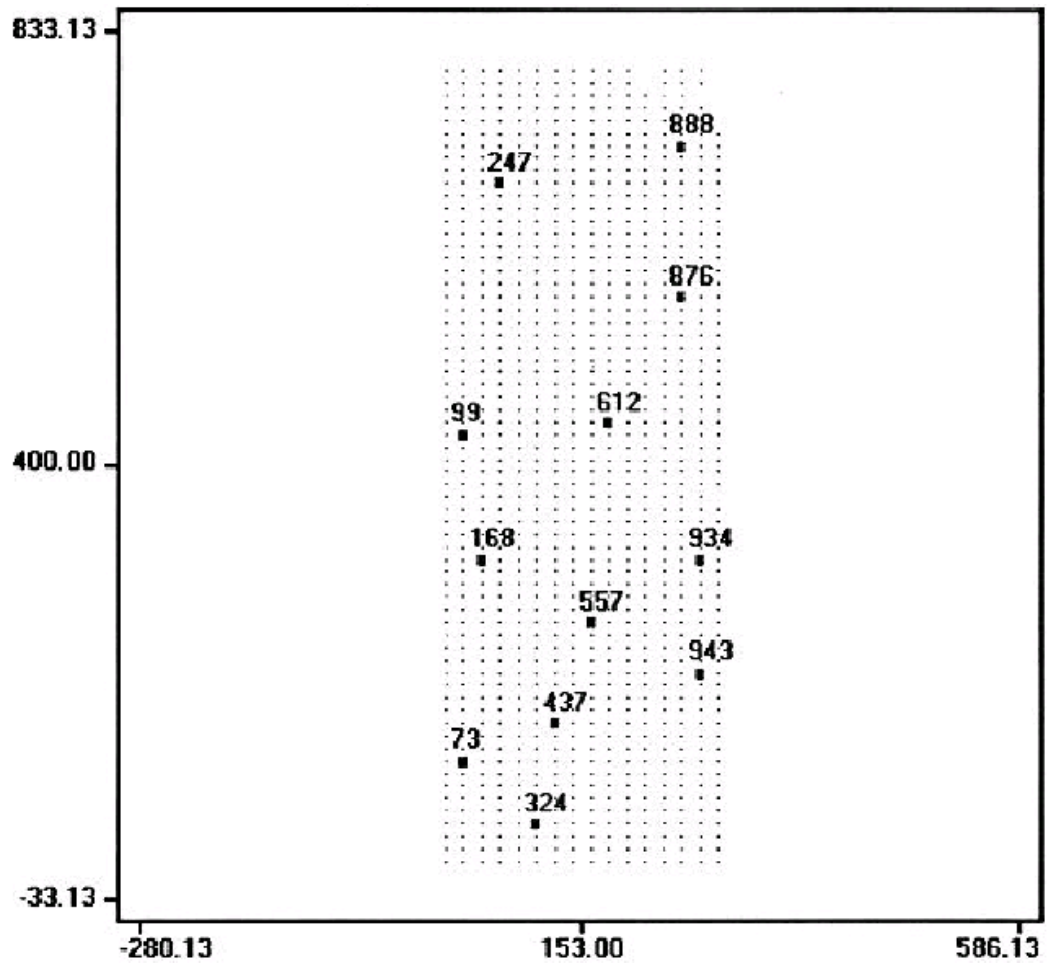
Soil Sampling - Zone

Electrical conductivity field surveys – Veris 3100 and EM-38

Electrical Conductivity Field Surveys

ESAP-95 v2.35 software

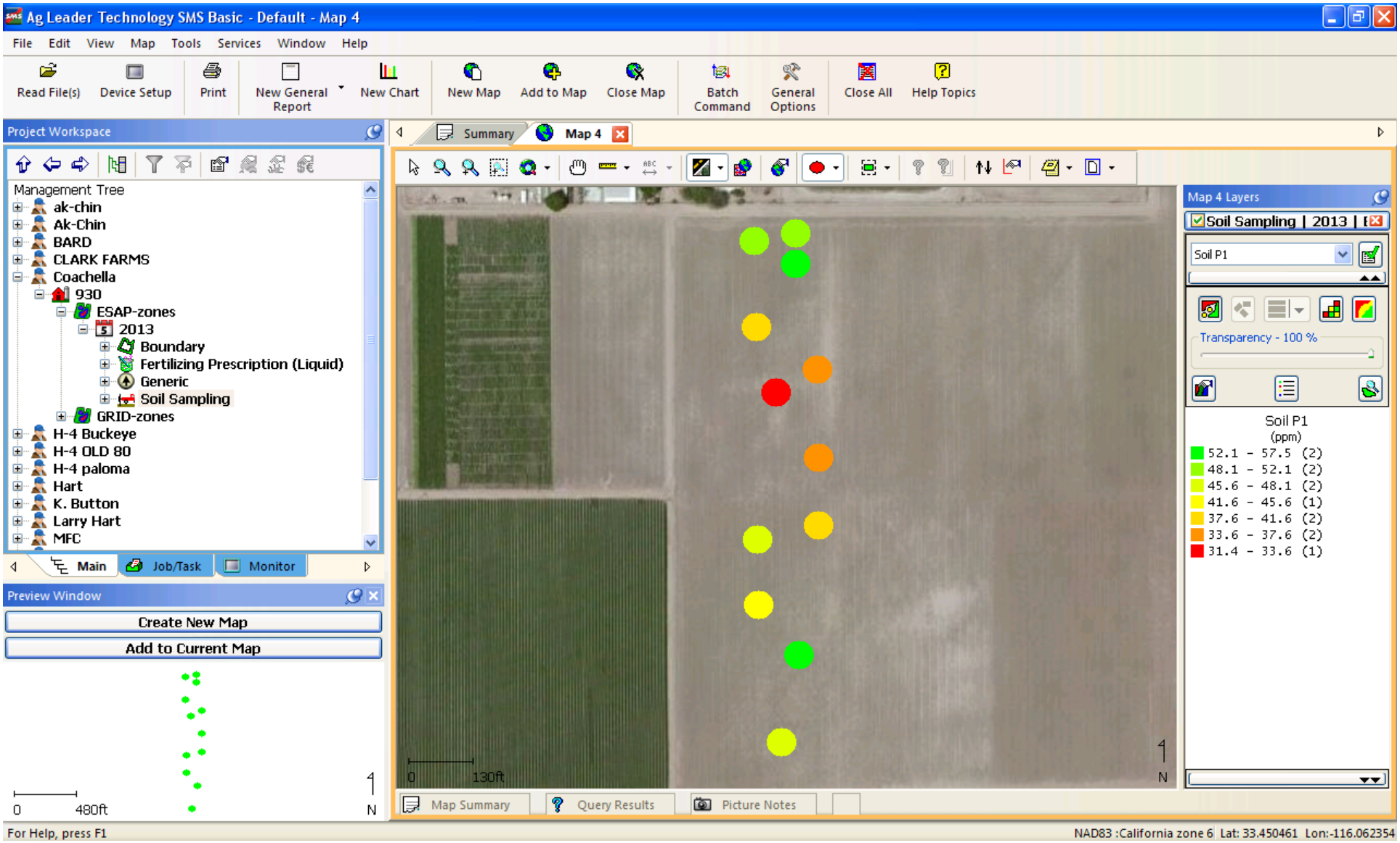
- Uses ECa input data
- Outputs sampling design for stochastic calibration models
- n = 12

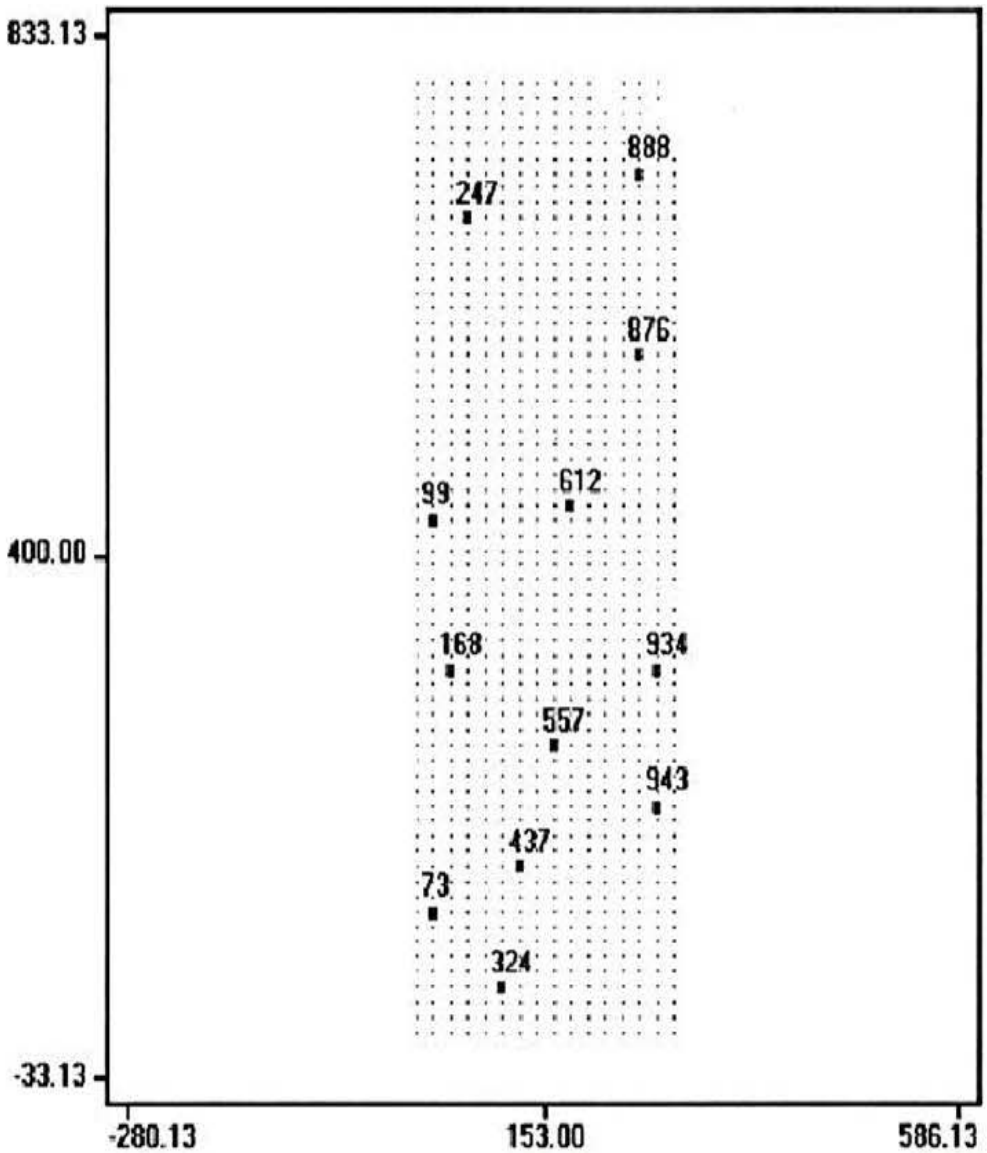


Credit: Scott M. Lesch, James D. Rhoades, and Dennis L. Corwin – USDA Salinity Lab (http://www.ars.usda.gov/services/docs.htm?docid=8918)

Soil Sampling - Zone

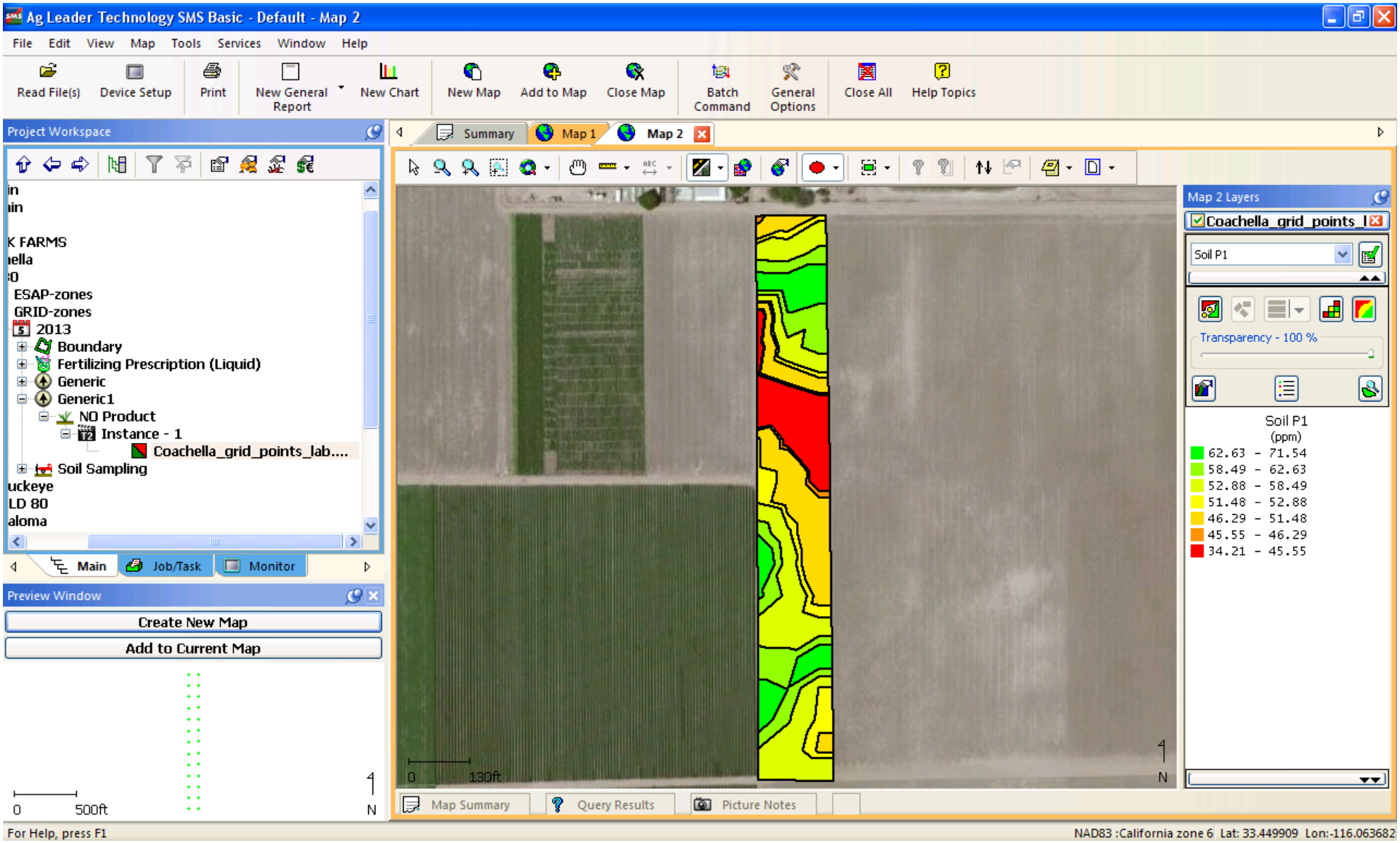
Location of soil samples in ESAP-generated zone (n=12)





Map of ESAP optimized sampling design (left) and resulting management zone map (right). Yuma, AZ

Prescription File Generation



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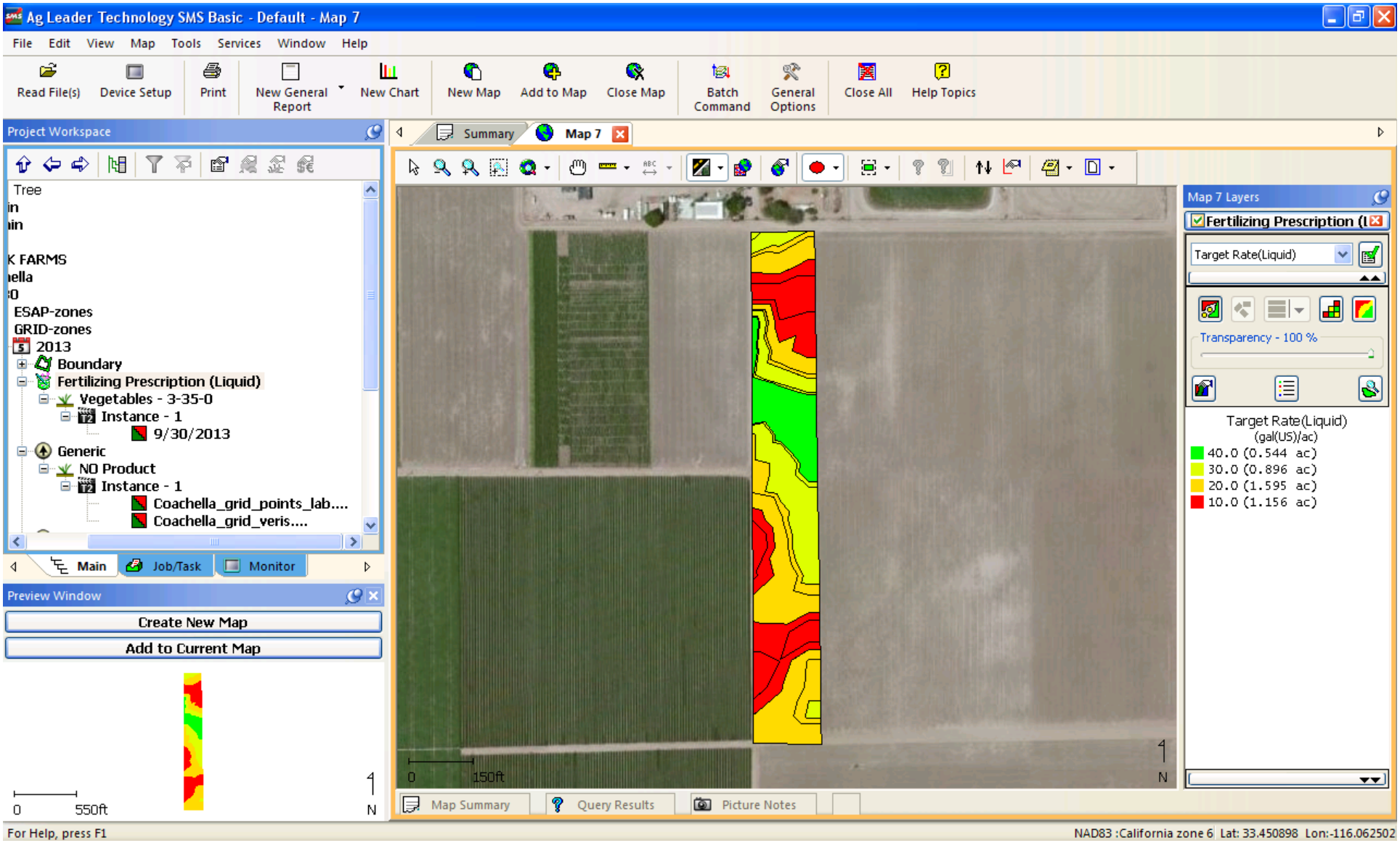
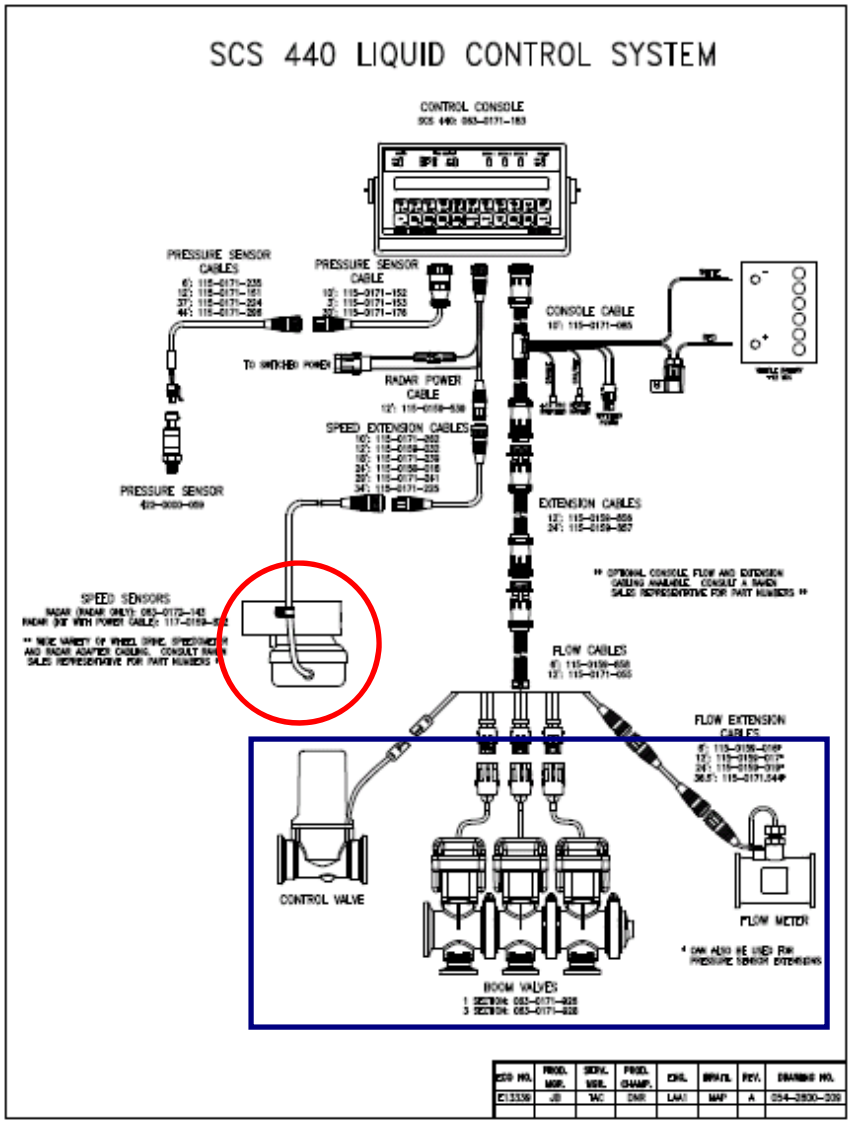


Development of Application Equipment

Rate controllers for speed compensation



Development of Application Equipment

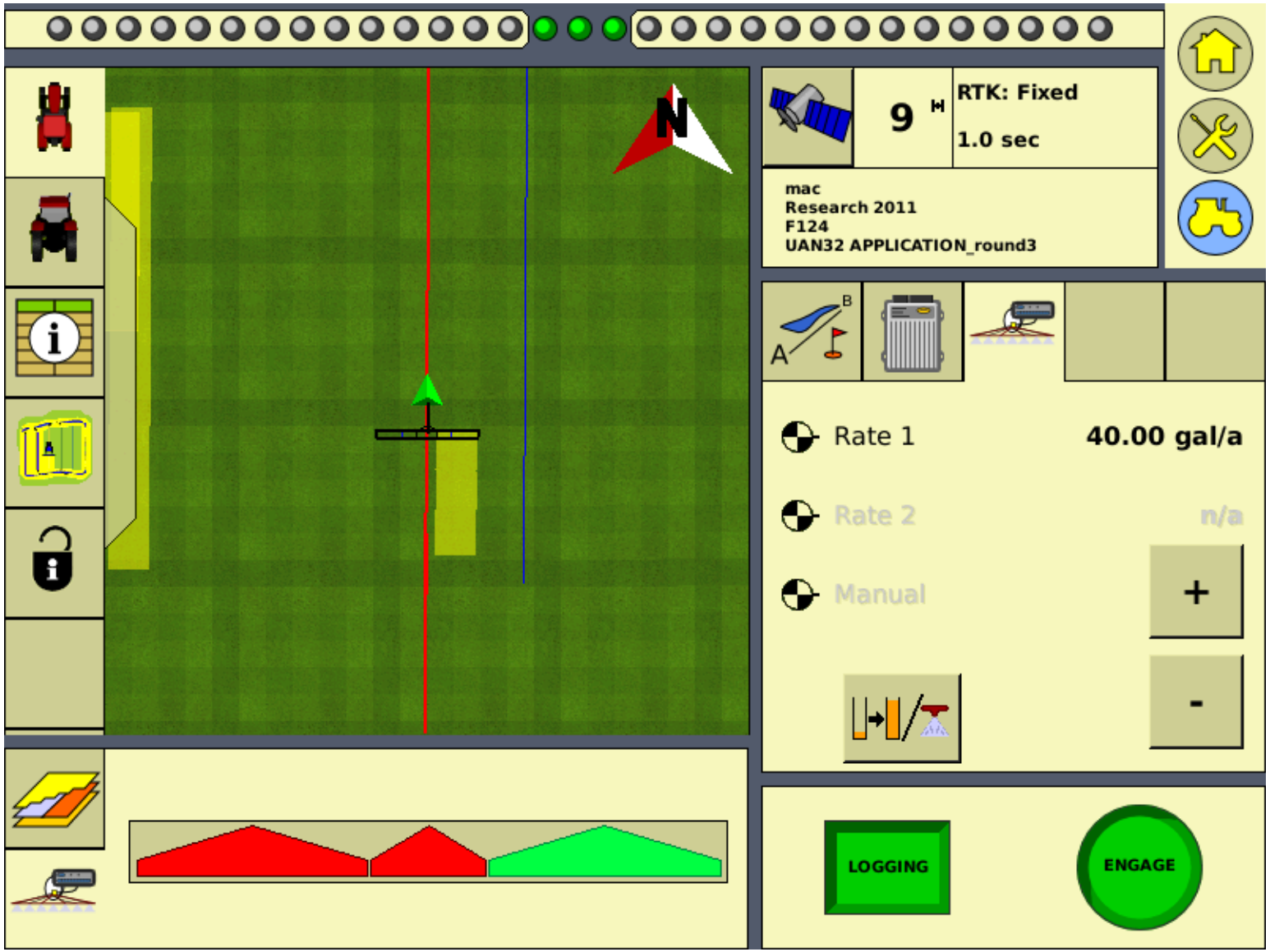
JohnDeere GS3 2630

Trimble FMX

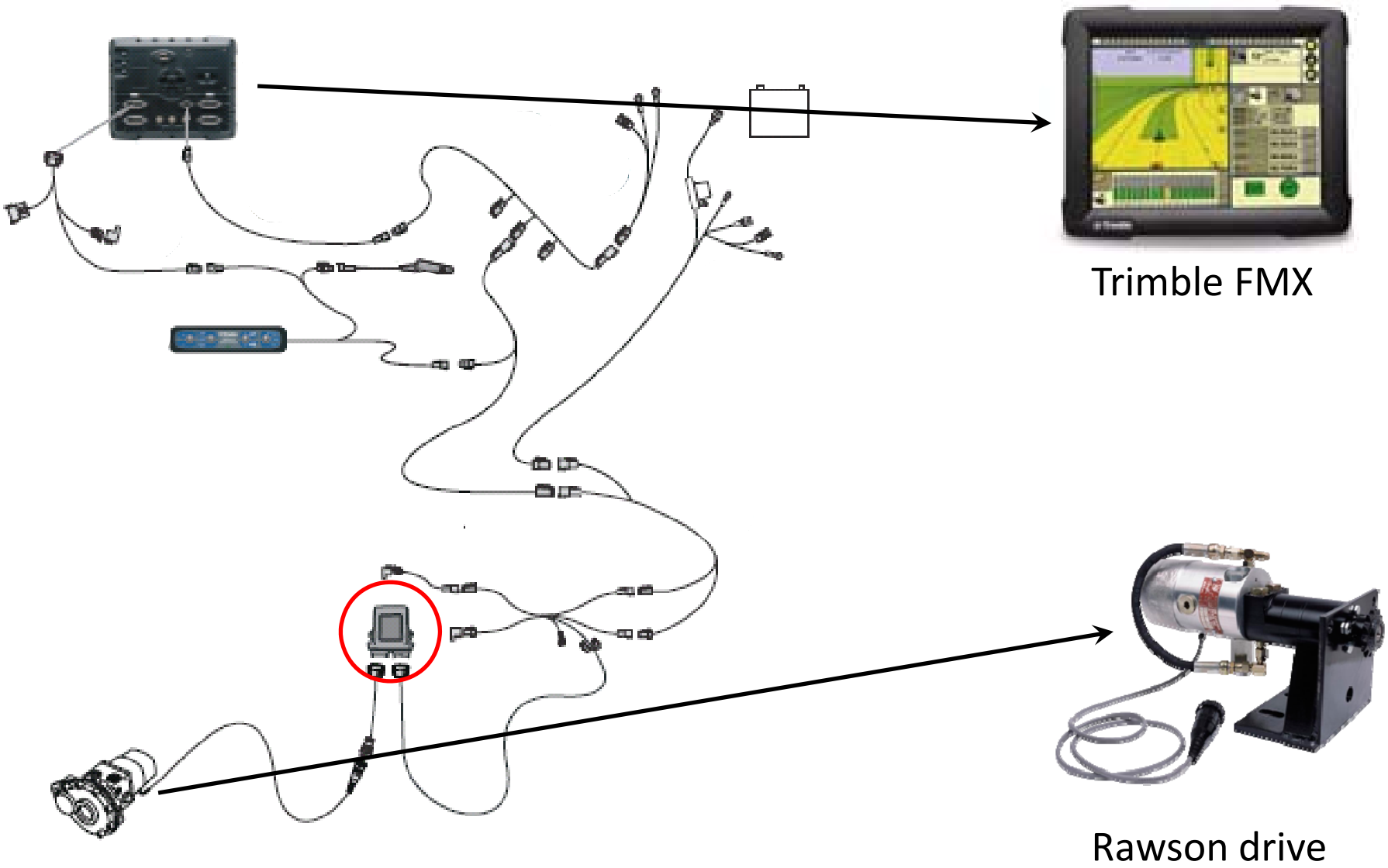
AgLeader Integra

Development of Application Equipment

Trimble FMX display for steering, application rate, and boom section control



P Fertilizer VR Application

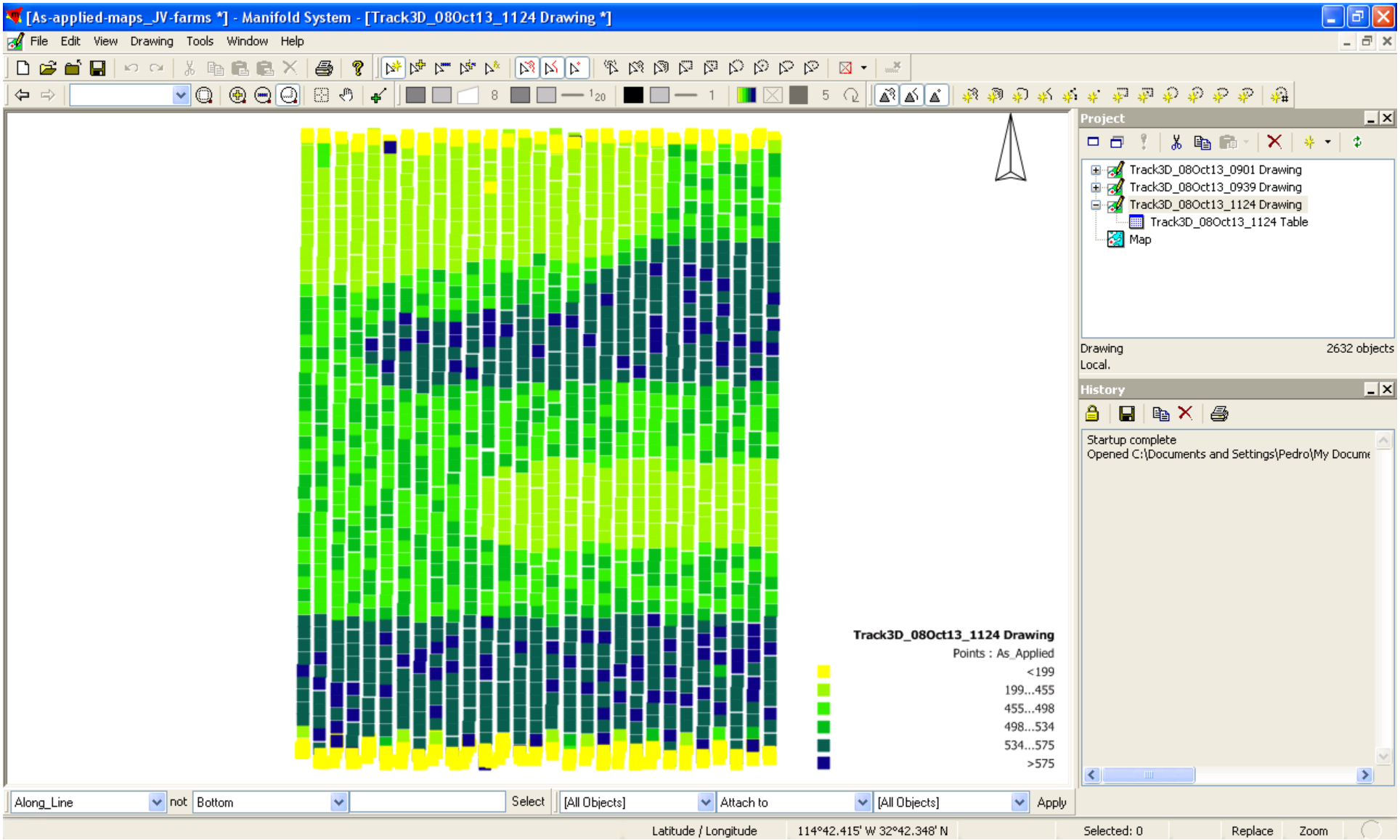


P Fertilizer VR Application

Trimble FMX/Rawson setup. Liquid and granular application rig

P Fertilizer VR Application

Automatic generation of field documentation - As-applied map



Challenges

Grower Shipper Coordination

Data Resolution

Harvest machines

Crop maturity

Yield Monitoring

GPS

Data loggers

Hand Counters

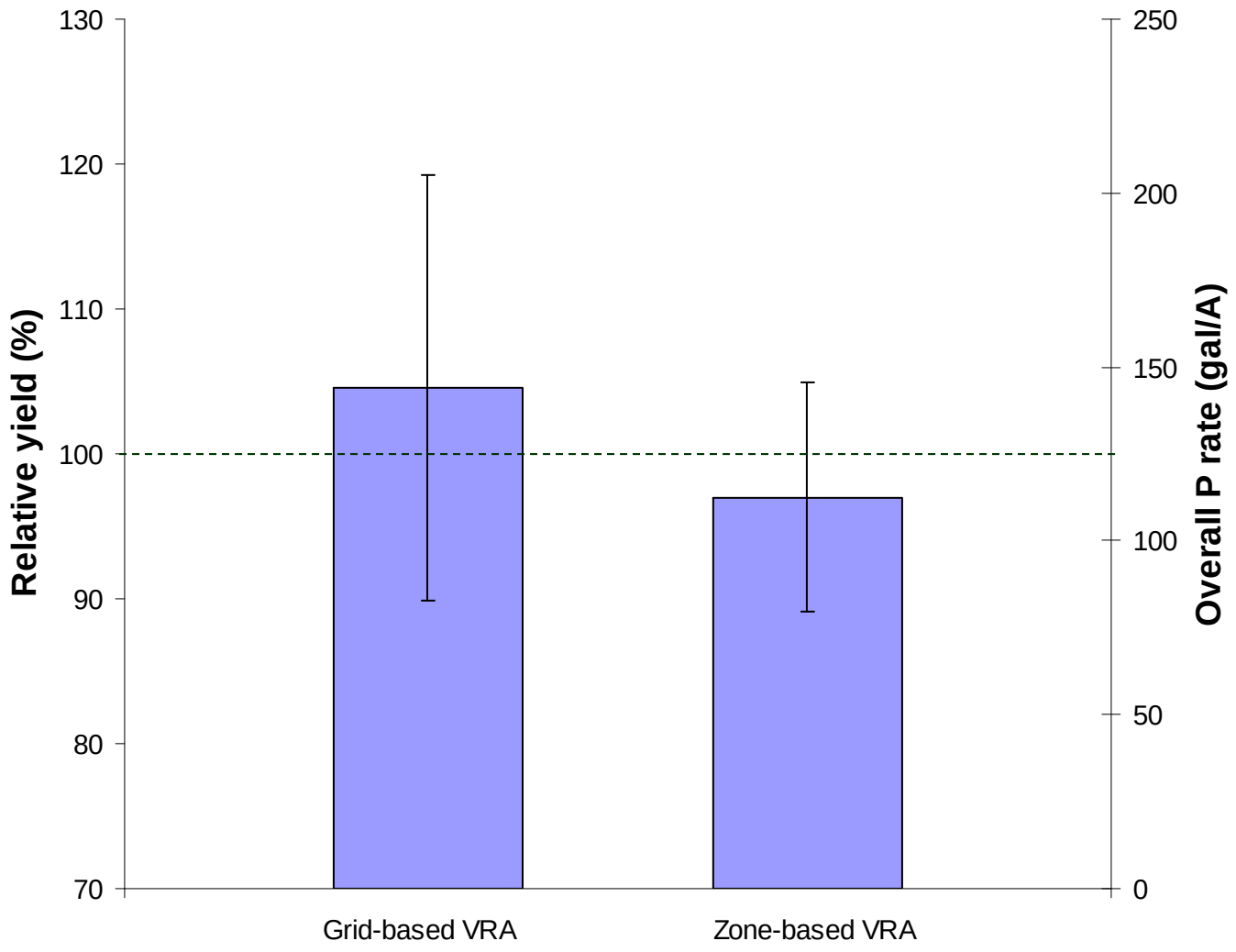
Lasers

Cameras

Figure 2. Yield monitoring.
a. GPS system,
b. laser based counting
c. camera bix counting

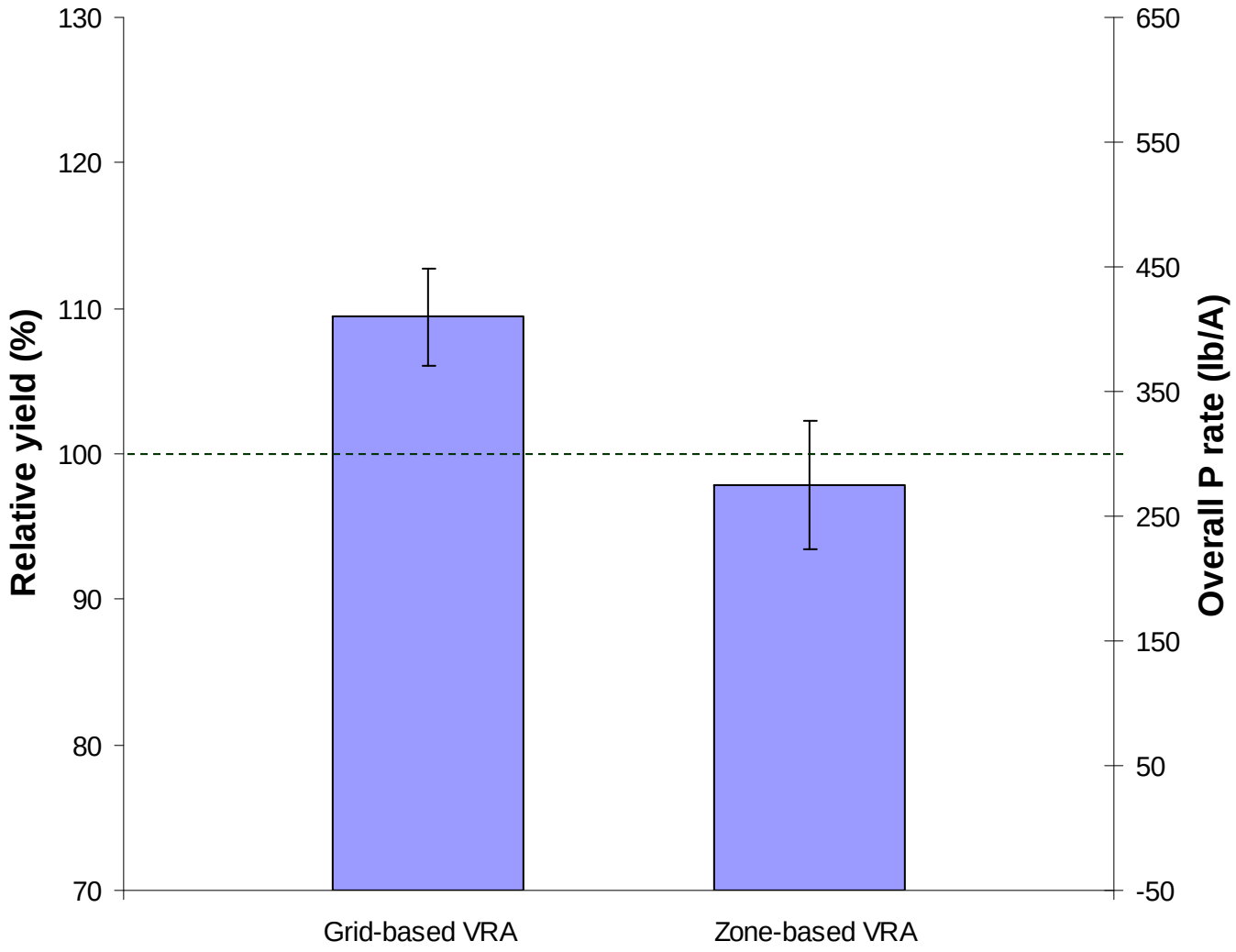
Yield Evaluation

Yield comparisons relative to Grower's practice. Coachella Valley - Broccoli



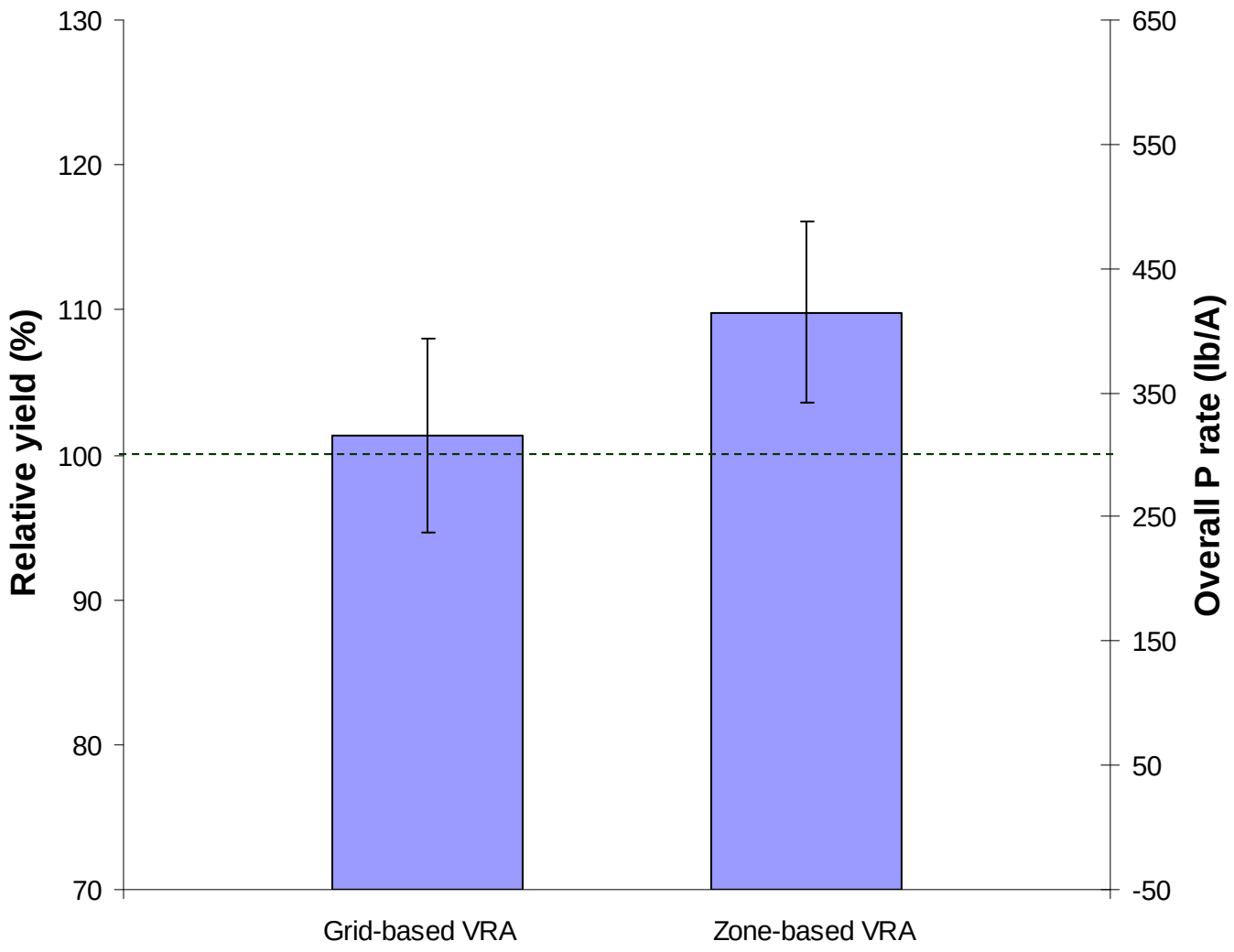
Yield Evaluation

Yield comparisons relative to Grower's practice. Yuma – Romaine lettuce



Yield Evaluation

Yield comparisons relative to Grower's practice. Bard – Iceberg lettuce



Final Remarks

- Significant P fertilizer savings are feasible with VR technology
- Integration of auto-steer and application equipment is key
- Work in progress. Expect to make progress in:
  - Sampling protocols
  - Sensor-based algorithms
  - Economics of VR technology

What about Nitrogen?