

PRECISION AGRICULTURE TECHNOLOGIES FOR WILD BLUEBERRY

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Agricultural
College

Farm Meeting – Farming To Maximize Crop
February 2nd, 2011



Outline

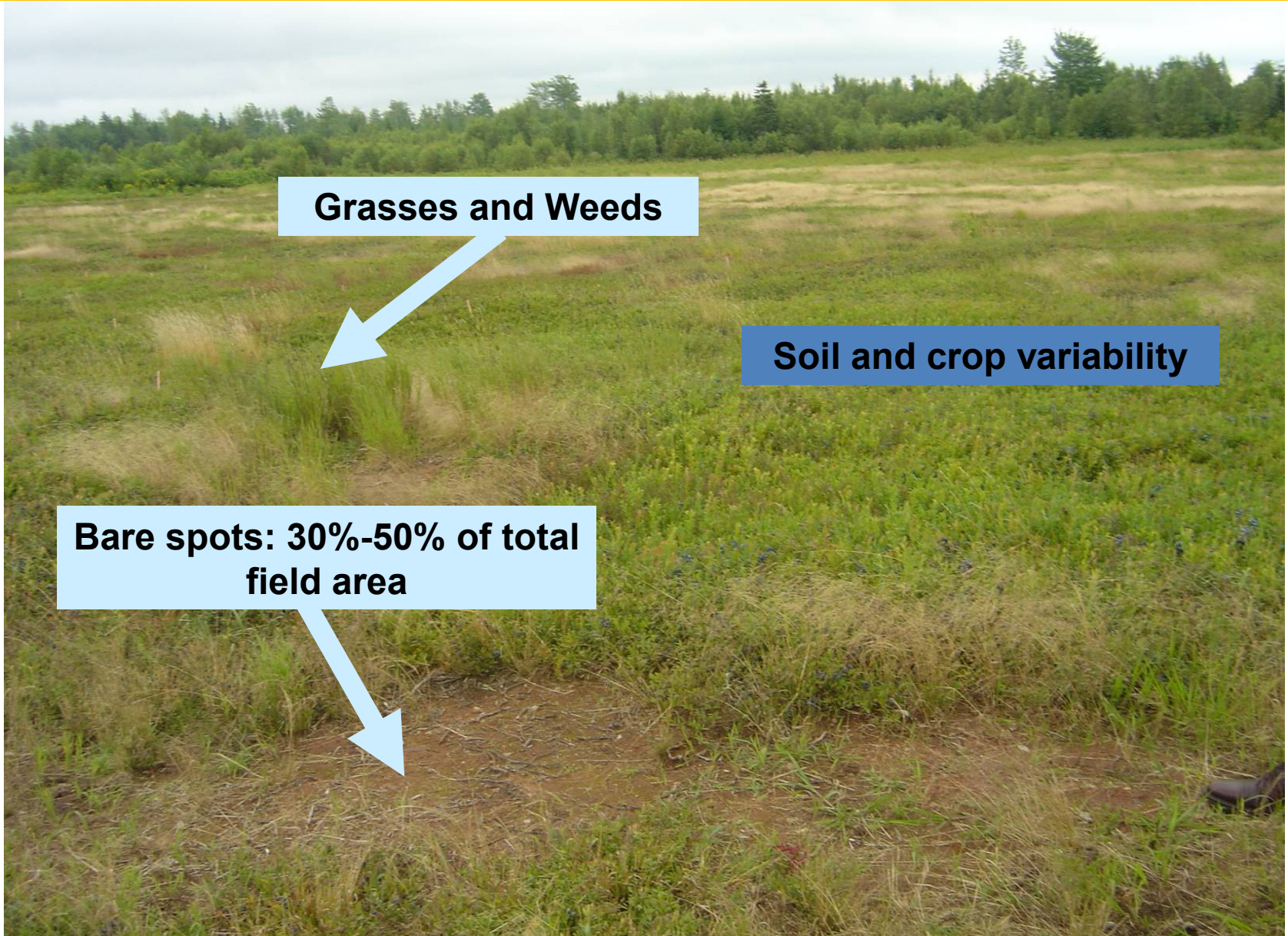
- **Precision Agriculture Objectives**
- **Overview of Precision Agriculture Research
(On-Going Projects)**
 - **Site-Specific Fertilization**
 - **Spot-Application of Pesticides**

Precision Agriculture (PA)

PA covers a research area with the goal to optimize agricultural production systems in both time and spatial dimensions.

In practice, PA changes the way a farmer works

Wild Blueberry fields need to be managed site-specifically using Sensors, DGPS, Digital photography, GIS, VRT



Grasses and Weeds

Soil and crop variability

Bare spots: 30%-50% of total field area

Objectives of Precision Agriculture

- **Reduce the amounts of inputs required to grow crops = LOWER COST**
- **Increase the efficiency of agrochemical utilization by crops = LOWER ENVIRONMENTAL IMPACT**
- **Automate and log farm operations = DATA ANALYSIS, EFFICIENCY & CONVENIENCE**

Background of PARP and On-Going Research Projects

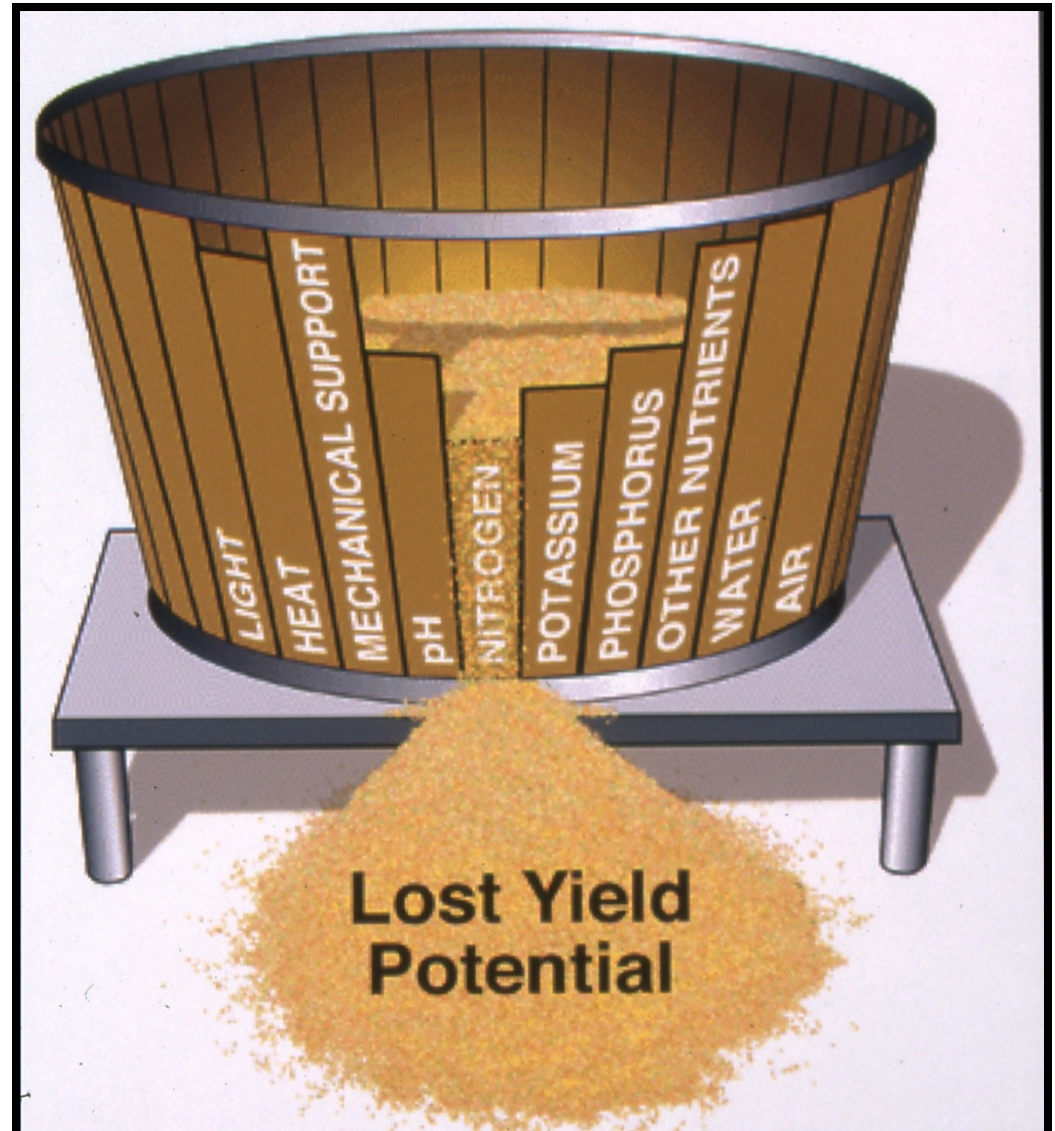
PARP have been developing:

- **Cost-Effective Automated Variable Rate Sprayer for Spot-Applications**
- **Automated Variable Rate Spreader for Site-Specific Fertilization**
- **Cost-Effective Automated Yield Monitoring System**
- **An Automated Slope Sensing System**
- **Cost-Effective Automated Machine Vision Systems to Map Bare Spot/Vegetation**
- **Site-specific Technologies using Electromagnetic Induction Methods**
- **Evaluate Environmental Impact of VR Technologies**
- **Assess the Cost/benefit of the New PA Systems**

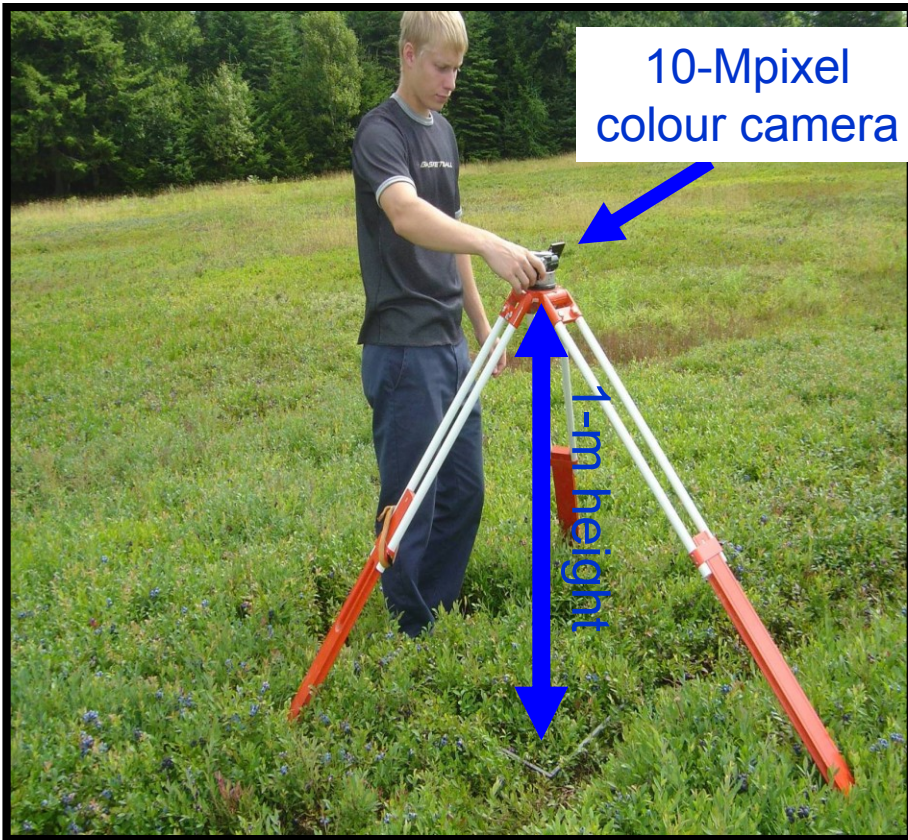
Site-Specific Fertilization

Limiting Factor Restricts Yields

- Find Limiting Factors
- Remove Their Restrictions



Photographic Technique for Fruit Yield Estimation



Custom Software

ID	Recurber	Comment	GPSstatus	Date	TimeGMT	Row#1	Image name	Northing	Easting	GPSTrack	Speed	CameraAC	Distance_cen	Orange#	Mask#
28004	0	blueberry14Aug07					0 3.JPG	0.00	0.00	0.00	0.00	0	0.0	0.029	1
28005	0	blueberry14Aug07					0 4.JPG	0.00	0.00	0.00	0.00	0	0.0	2.973	1
28006	0	blueberry14Aug07					0 5.JPG	0.00	0.00	0.00	0.00	0	0.0	0.016	1
28007	0	blueberry14Aug07					0 6.JPG	0.00	0.00	0.00	0.00	0	0.0	0.101	1
28008	0	blueberry14Aug07					0 7.JPG	0.00	0.00	0.00	0.00	0	0.0	4.928	1
28009	0	blueberry14Aug07					0 8.JPG	0.00	0.00	0.00	0.00	0	0.0	3.827	1
28090	0	blueberry14Aug07					0 9.JPG	0.00	0.00	0.00	0.00	0	0.0	6.226	1
28091	0	blueberry14Aug07					0 10.JPG	0.00	0.00	0.00	0.00	0	0.0	0.170	1
28092	0	blueberry14Aug07					0 11.JPG	0.00	0.00	0.00	0.00	0	0.0		
28093	0	blueberry14Aug07					0 12.JPG	0.00	0.00	0.00	0.00	0	0.0		
28094	0	blueberry14Aug07					0 13.JPG	0.00	0.00	0.00	0.00	0	0.0		
28095	0	blueberry14Aug07					0 14.JPG	0.00	0.00	0.00	0.00	0	0.0		
28096	0	blueberry14Aug07					0 15.JPG	0.00	0.00	0.00	0.00	0	0.0		

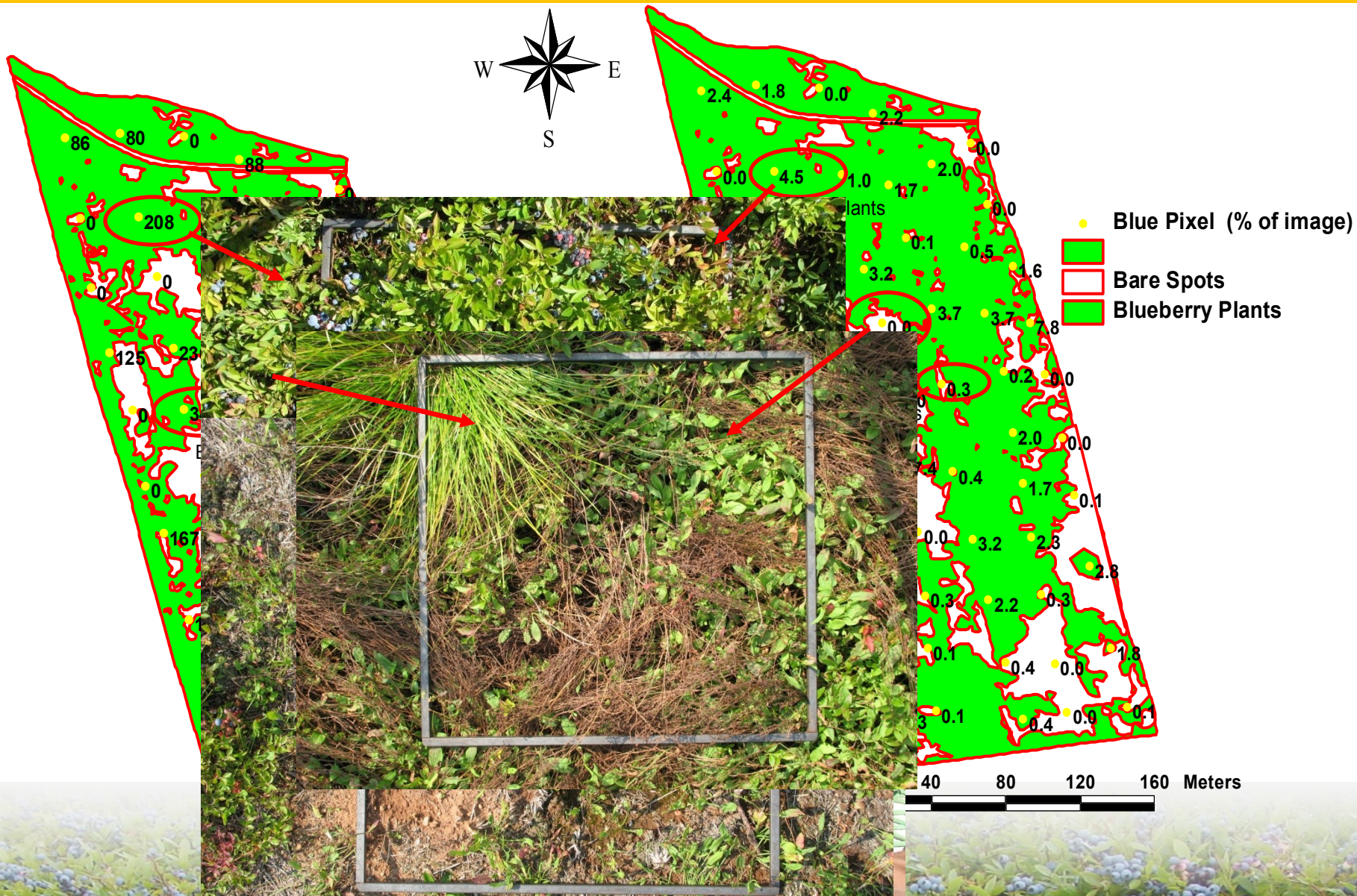
Blue pixels: 317565 = 5.77%

Green pixels: 5932 = 0.1%

Blue as percentage of blue

% fruit pixels

Blue Pixels Ratio vs Fruit Yield

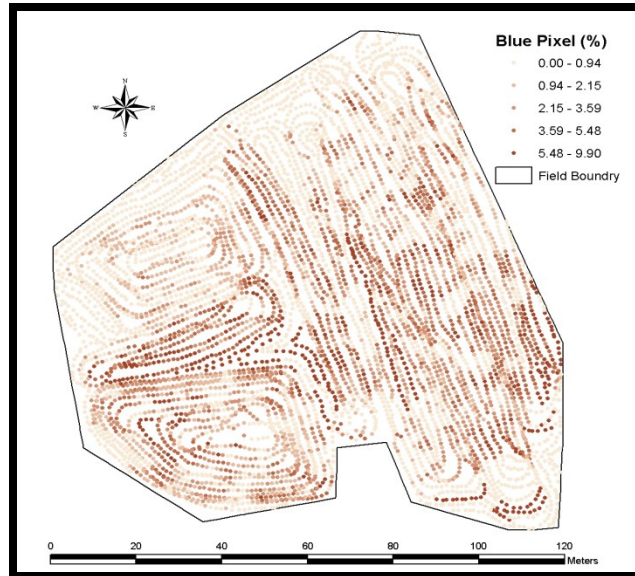


Automated Real-Time Yield Monitoring System

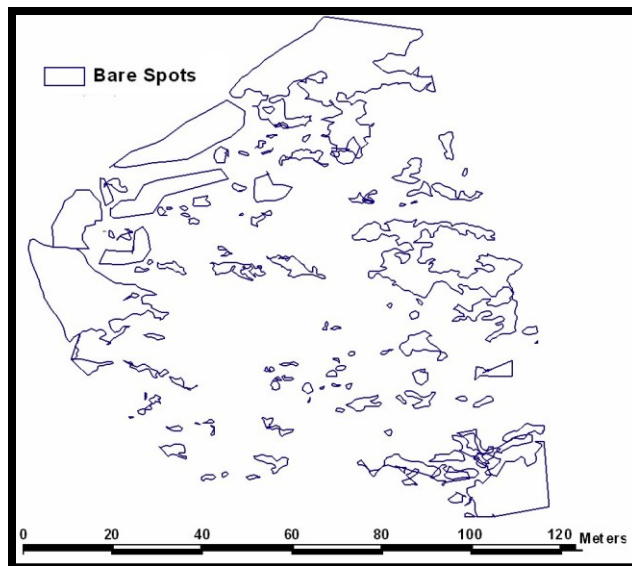


Fruit Yield and Bare Spot Map

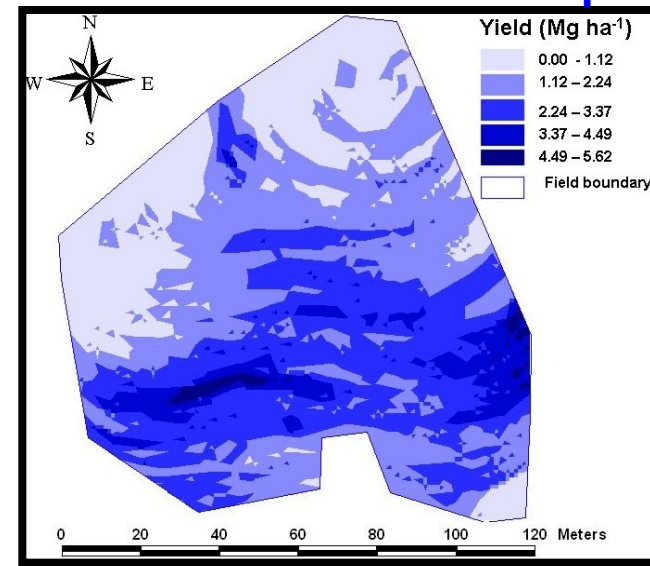
Raw Data



Bare Spot Map

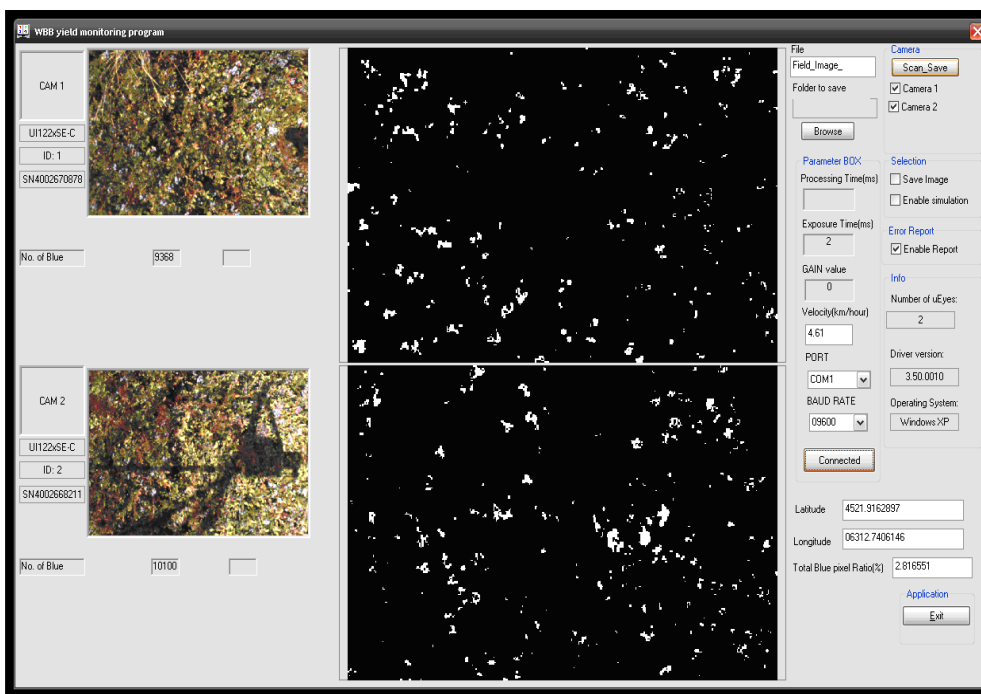


Smooth Fruit Yield Map

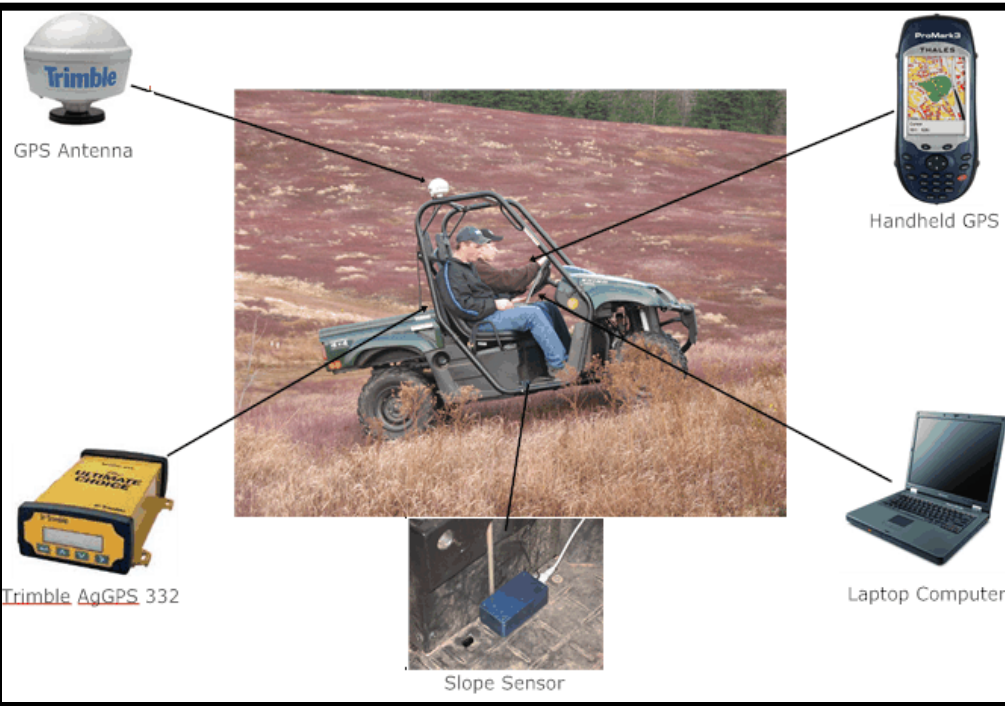


Yield Monitoring System μ Eye for Double Head Harvester

Custom Software



Cost-effective automated slope sensing system



Custom Software

The screenshot shows the 'Slope Sensor 2007' software interface. It features a 'Data Capture' tab and a 'Database' tab. The 'Setup' section includes fields for 'Job description' (Trial), 'Separation (m): 3.00', and 'Starting speed (m/s): 0.50'. A 'Calibrate' button is present with the note '(Calibrate on level ground only)'. The 'Start when moving' checkbox is checked.

The main display area shows the following data:

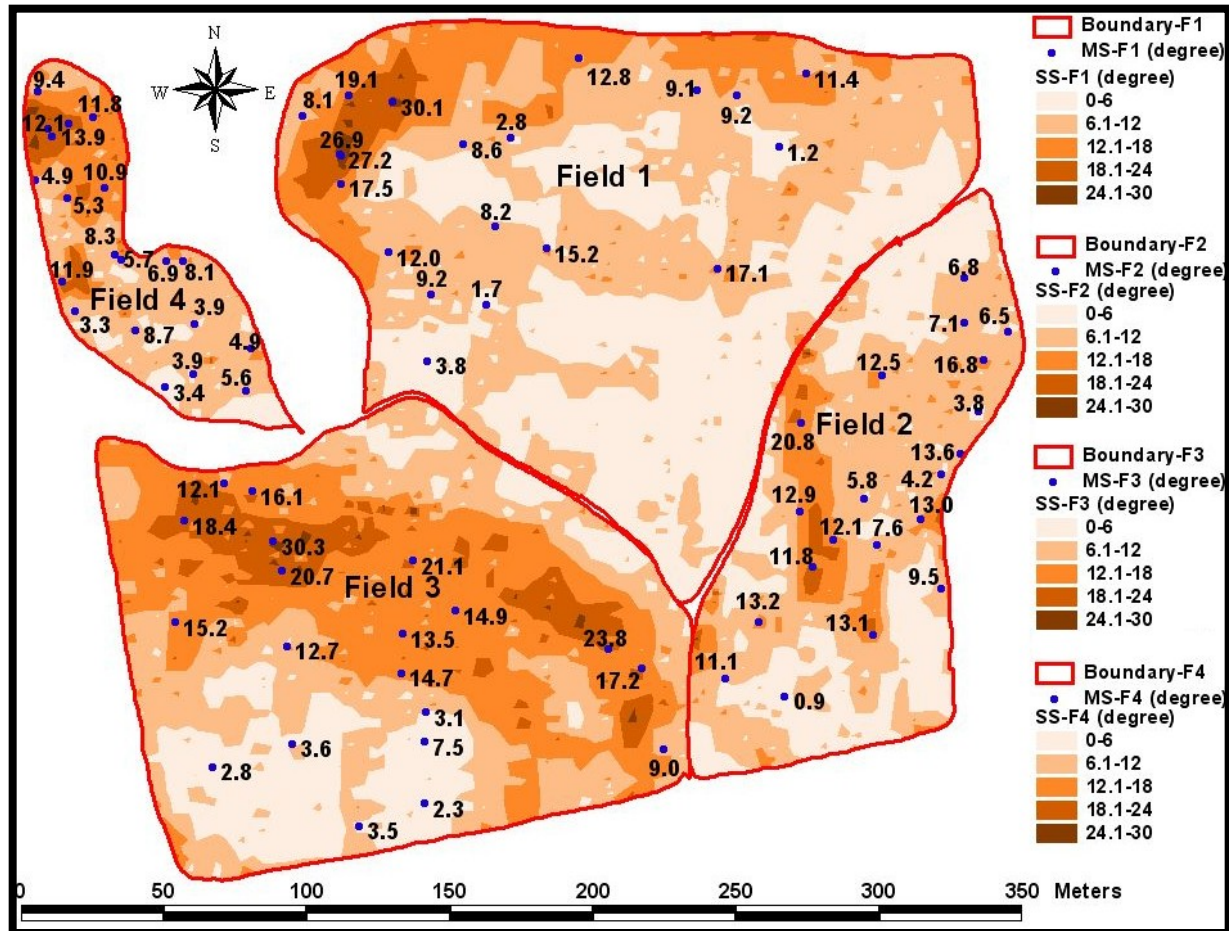
- GPS**: GPS Fix: A, Track (deg): 20.4
- Slope (degrees)**: 1.5
- Speed (m/s)**: 0.1
- Database**: Records: 122, Interval(s): 44.8

A small map window shows the current location on a grid. A 'GPS error' section on the right lists three entries, each with the text 'GPS error'.

Automated Slope Sensing System - Video



Sensed-slope and manually measured slope



Electromagnetic Induction Method for Soil Properties Mapping

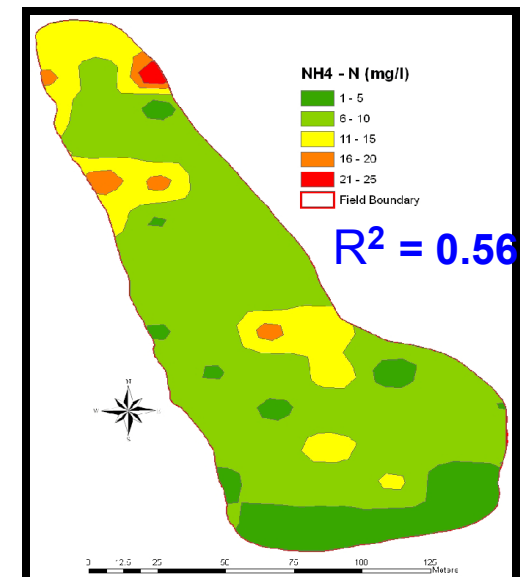
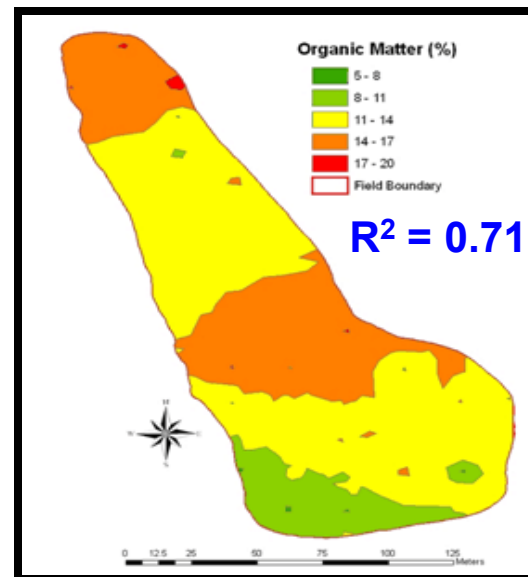
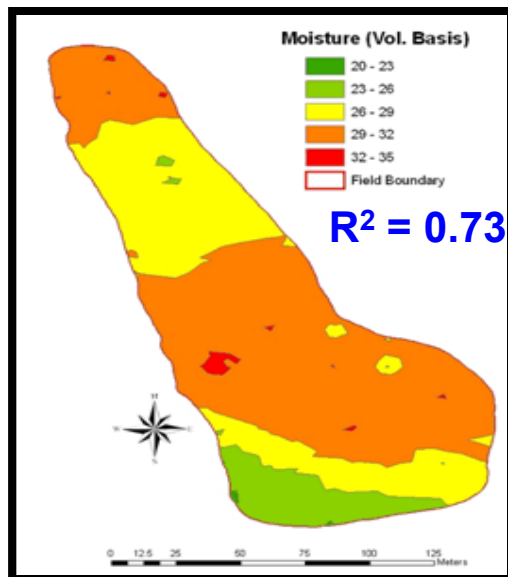
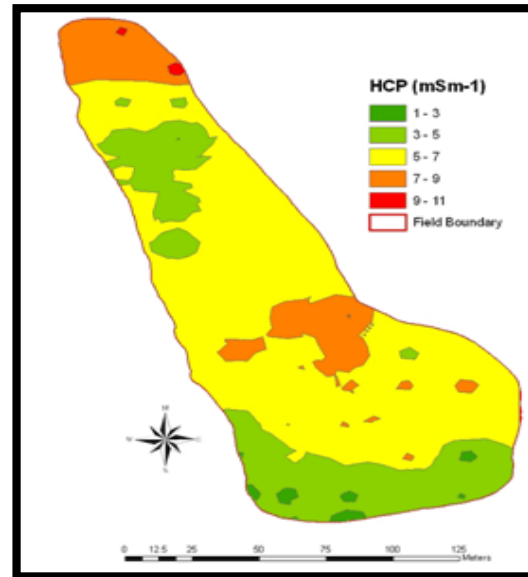
DualEM-2

Soil Sensing:

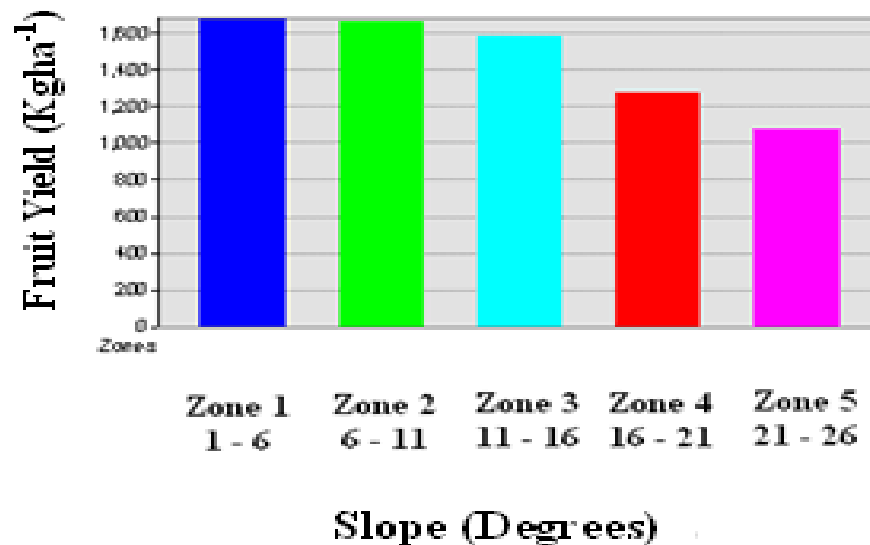
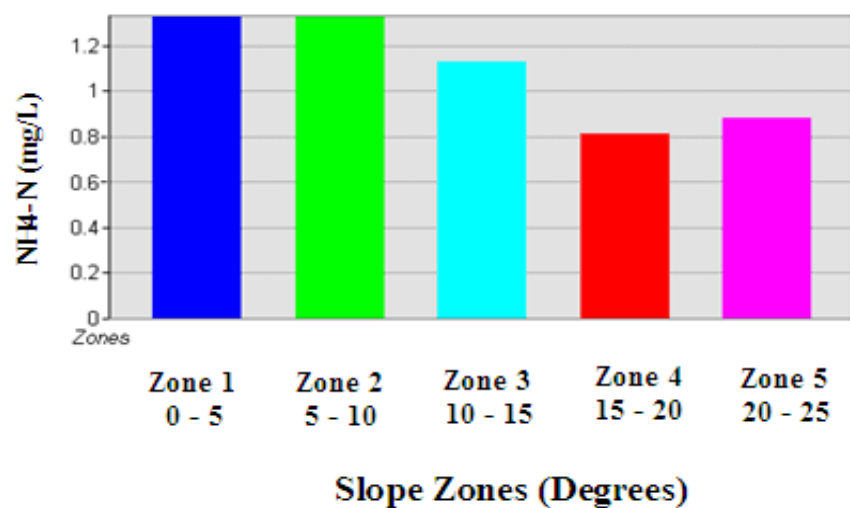
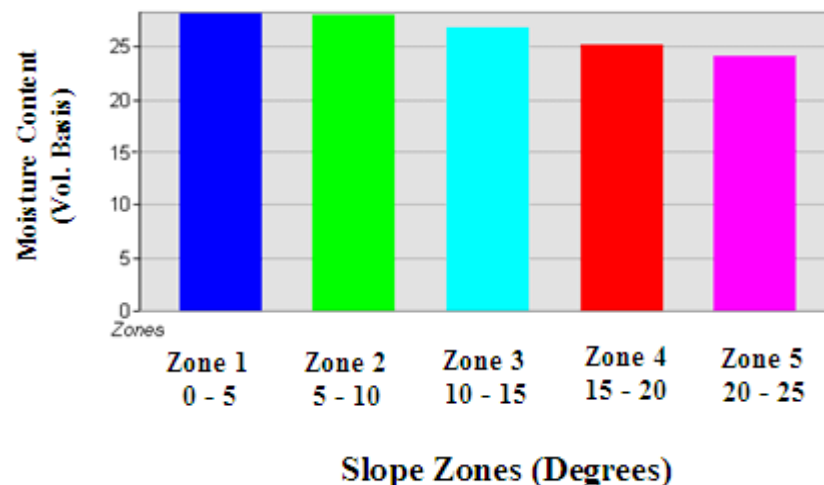
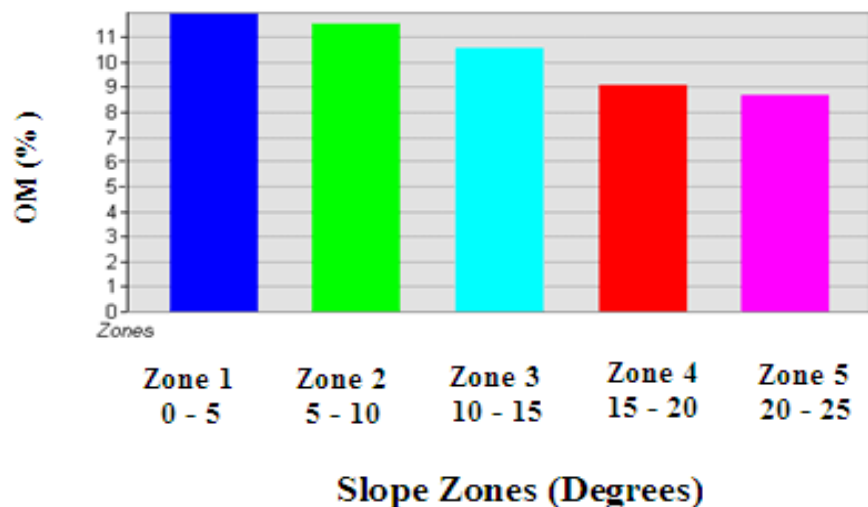
- 3 m below soil surface
- 1 m horizontal



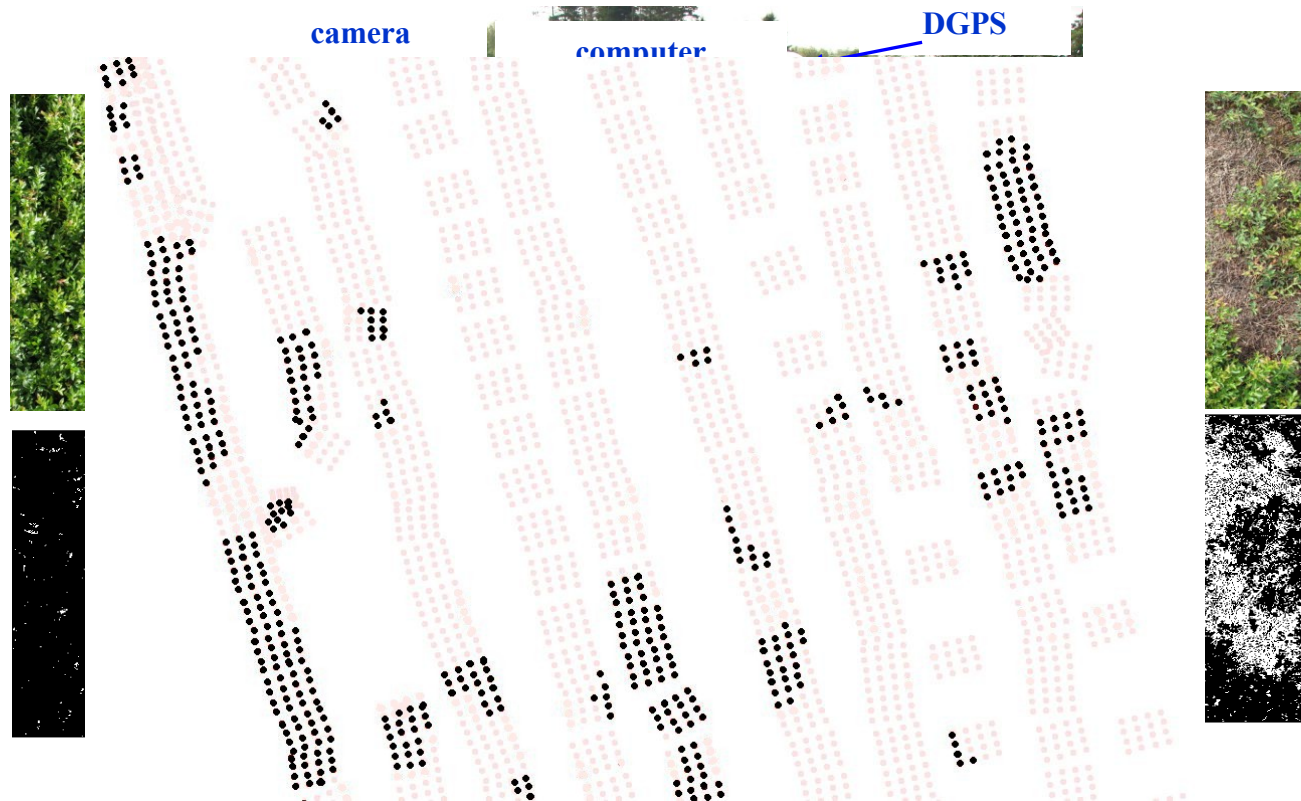
Soil Properties and Nutrient Maps using DualEM



Soil Properties, Nutrients Fruit Yield in Different Slope Zones

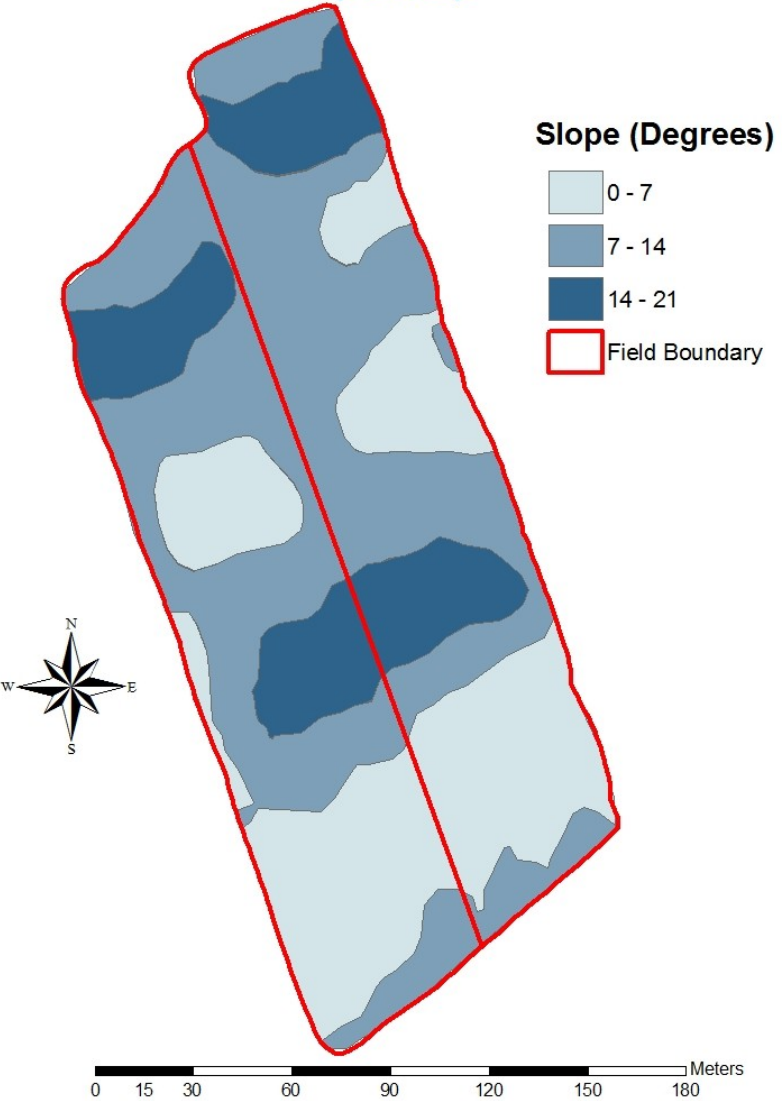


Automated Machine Vision System for Bare Spot Mapping

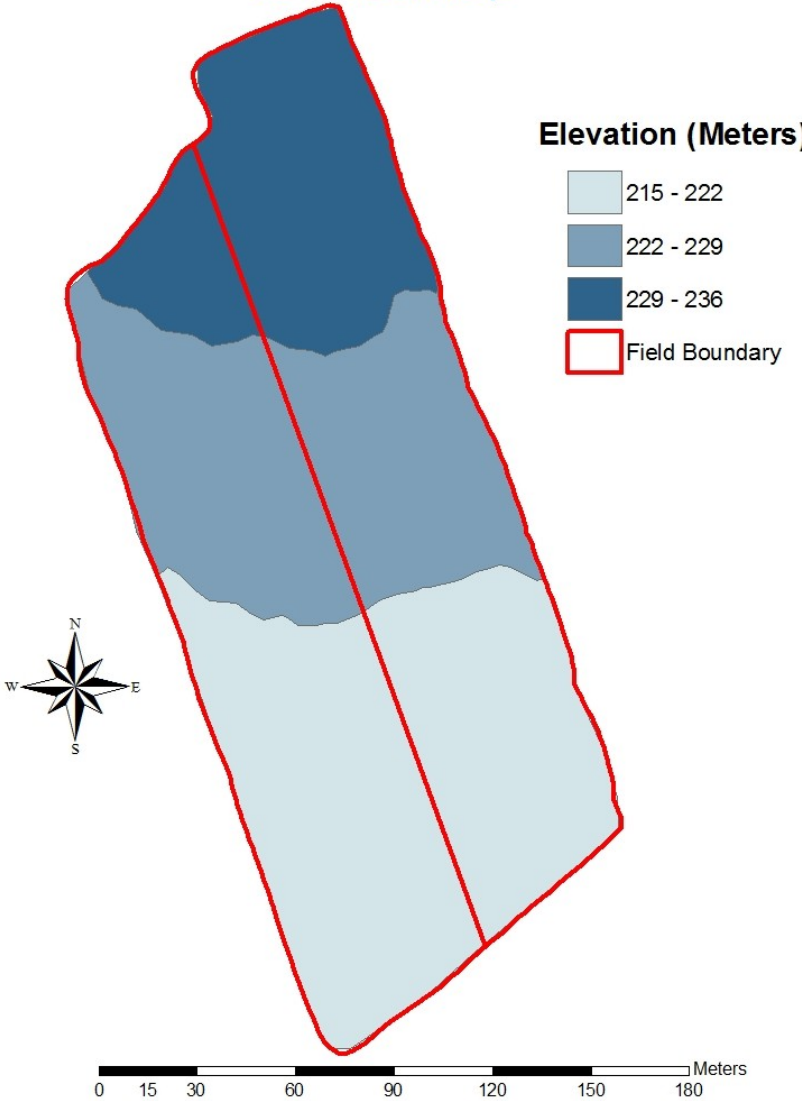


Slope and Elevation Map for Site-Specific Fertilization

Slope Map



Elevation Map



VRA Can Reduce Agrochemical Usage and Environmental Impacts

Growers Uniform Rate = 200 kg/ha

Area -Site-specific = 1.48 ha

Area- Uniform = 1.37 ha

Bare spot Area (UA) = 0.17 ha

Bare spot Area (SA) = 0.26 ha



GPS

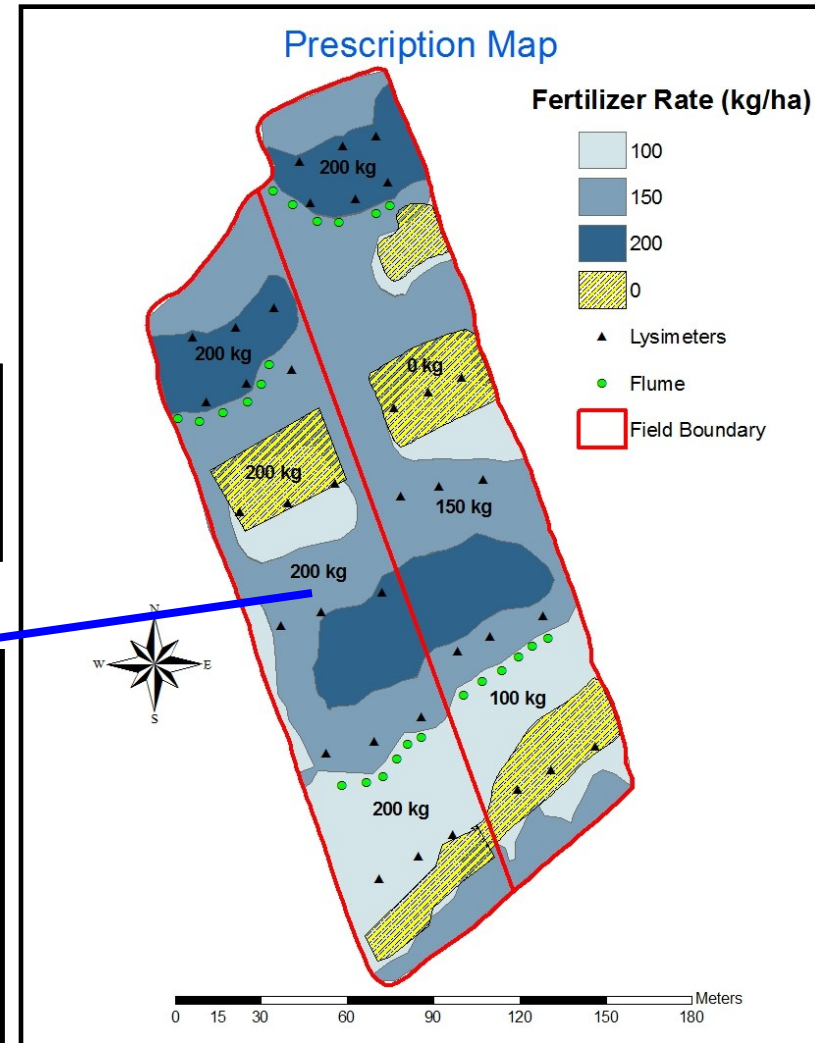
1%



Metering Drive Unit



VR Controller



Video- Prototype VR Spreader



Spot-Application of Pesticides-VR Sprayer Technology

Testing/Evaluation Sensors/Cameras – Custom Software Development



Custom Software - 2 cameras

The screenshot shows the uEyeMultipleCameraScan software interface. It features two camera feeds at the top, labeled CAM 1 SAT and CAM 2 SAT. Below the feeds is a data table with columns for Sprayer 1, Sprayer 2, Sprayer 3, and Sprayer 4. The table contains numerical values for parameters like wBB, wEED, and BARE SPDT. On the right side, there are controls for Camera 1 and Camera 2, including ID, S/N, and checkboxes for Camera 1 and Camera 2. Below these are controls for the Parameter BOX, including Processing Time (ms) and Exposure Time (ms). At the bottom right, there is an Application button and a footer for NSAC Precision Agriculture Lab.

	Sprayer 1				Sprayer 2			
wBB	1	0	0	0	0	0	0	
wEED	0	1	1	1	1	1	1	
BARE SPDT	0	0	0	0	0	0	0	

	Sprayer 3				Sprayer 4			
wBB	0	1	1	1	1	1	1	
wEED	1	0	0	0	0	0	0	
BARE SPDT	0	0	0	0	0	0	0	

Testing/Evaluation of Controllers - VR Sprayer Technology

Dickey-john Controller Flow Test



Computerized 8-Channel VR Controller- Response Time Test



Cost-Effective Prototype Variable Rate Sprayer

Boom width = 20 ft

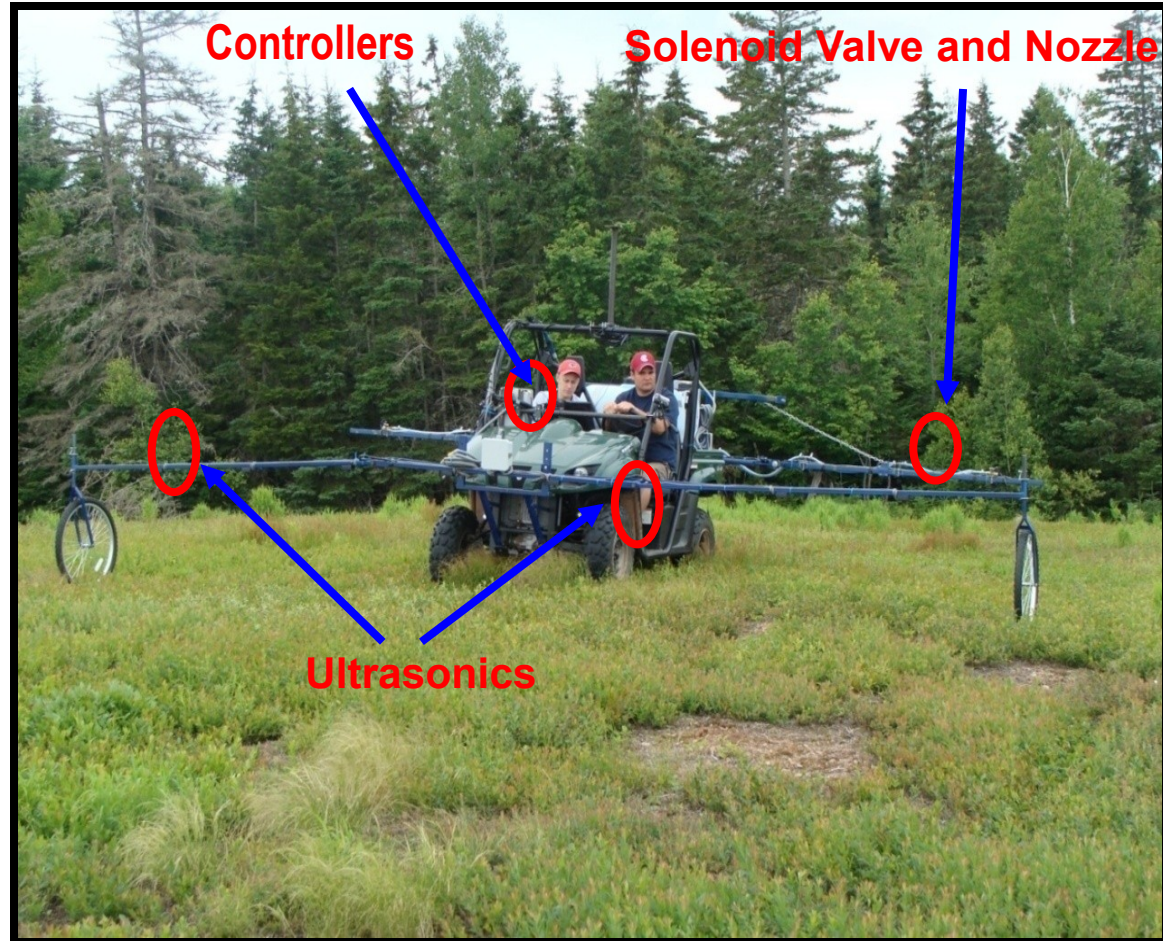
Boom sections = 8, each = 2.5 ft

Boom height = 30 in.

Each section = one ultrasonic

8-channel computerized controller

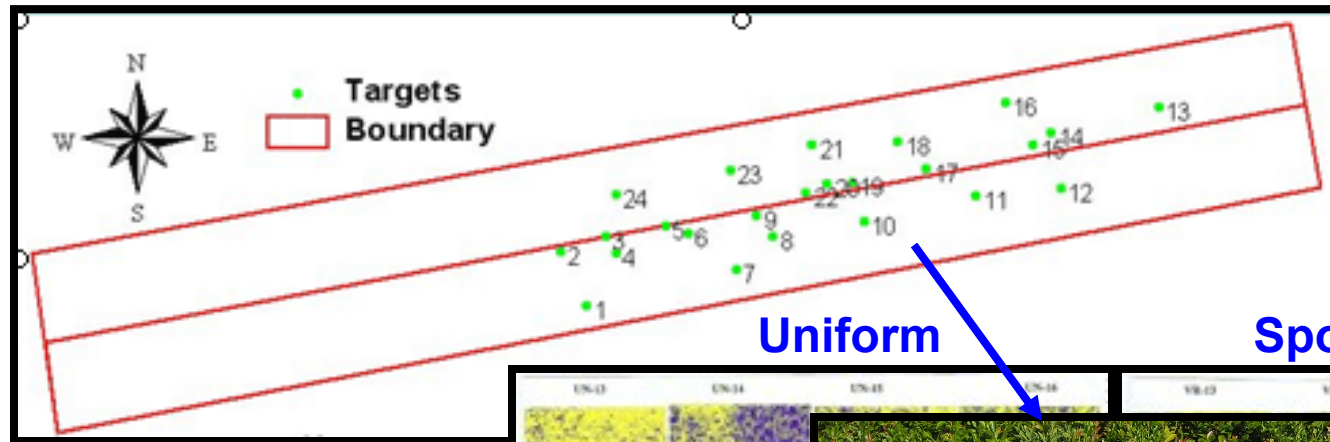
DJ *Land Manager II* controller



Video- Prototype Sprayer Test in Hay Field

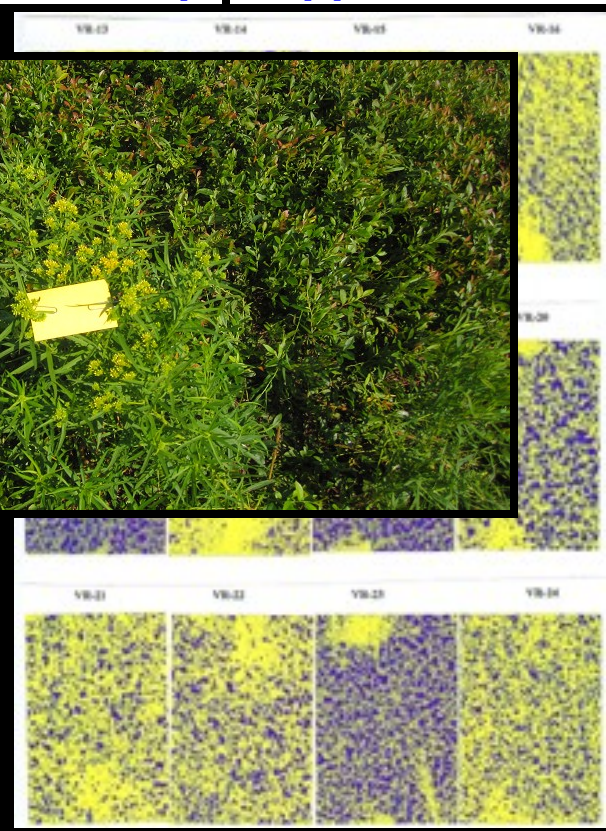
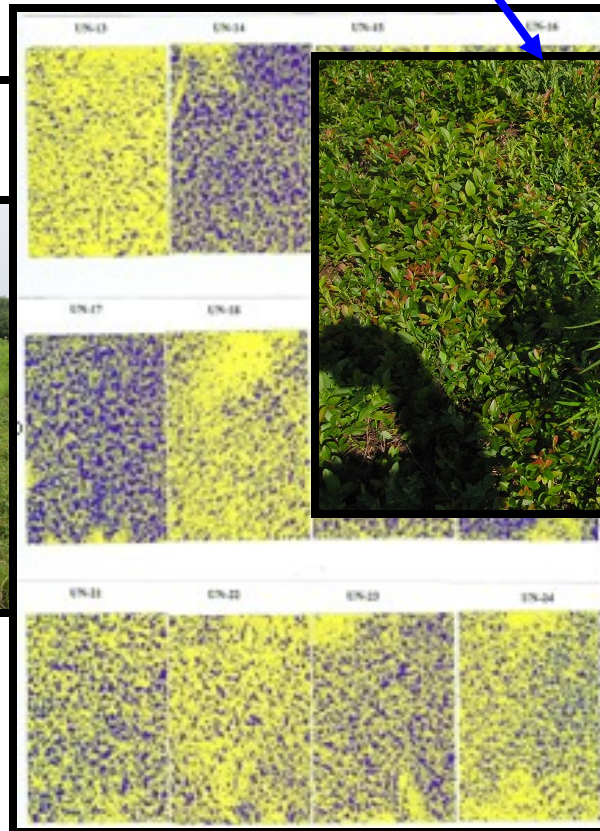


Water Sensitive Papers in Uniform and VR side of the field



Uniform

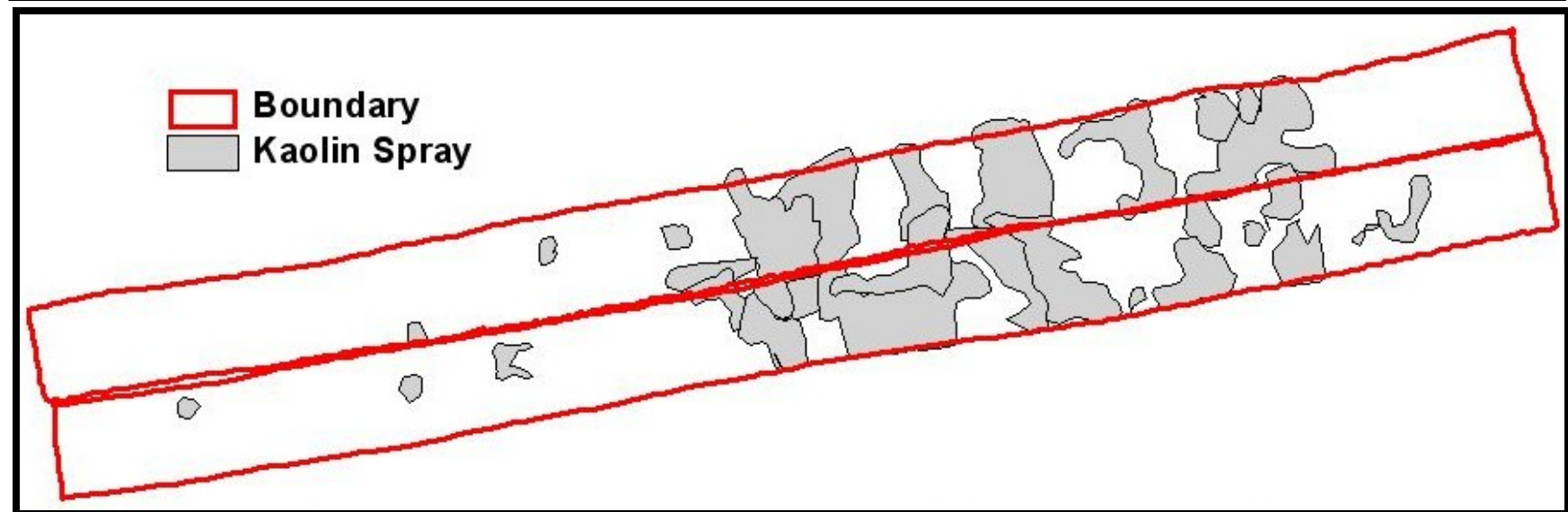
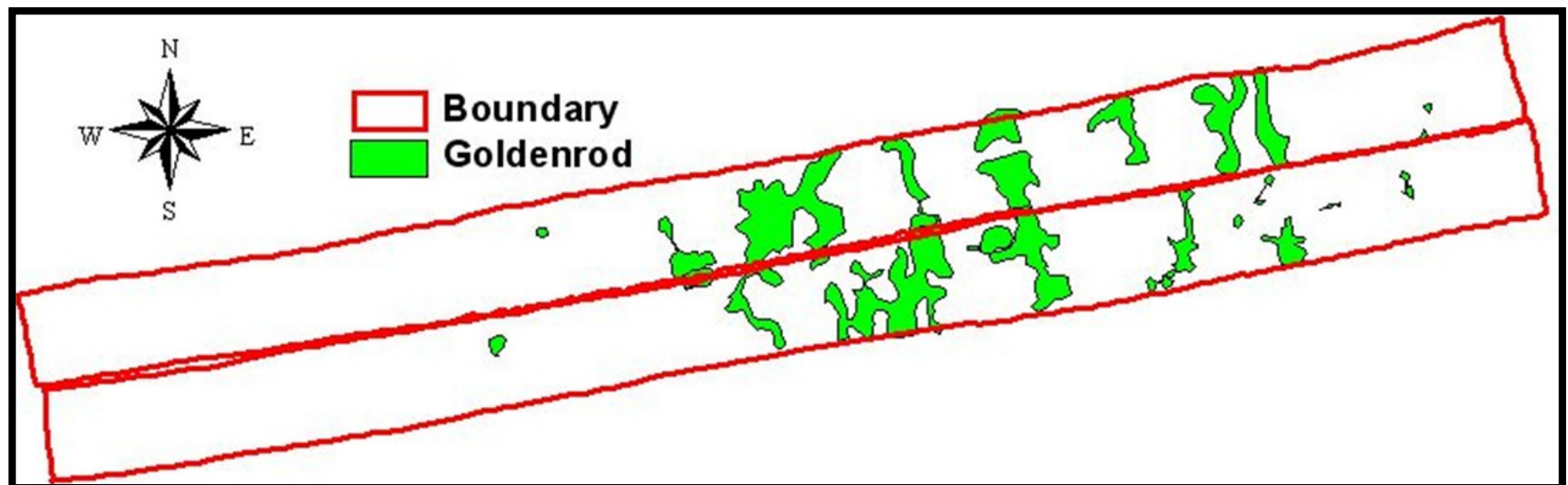
Spot-Application



Commercial Prototype VR Sprayer



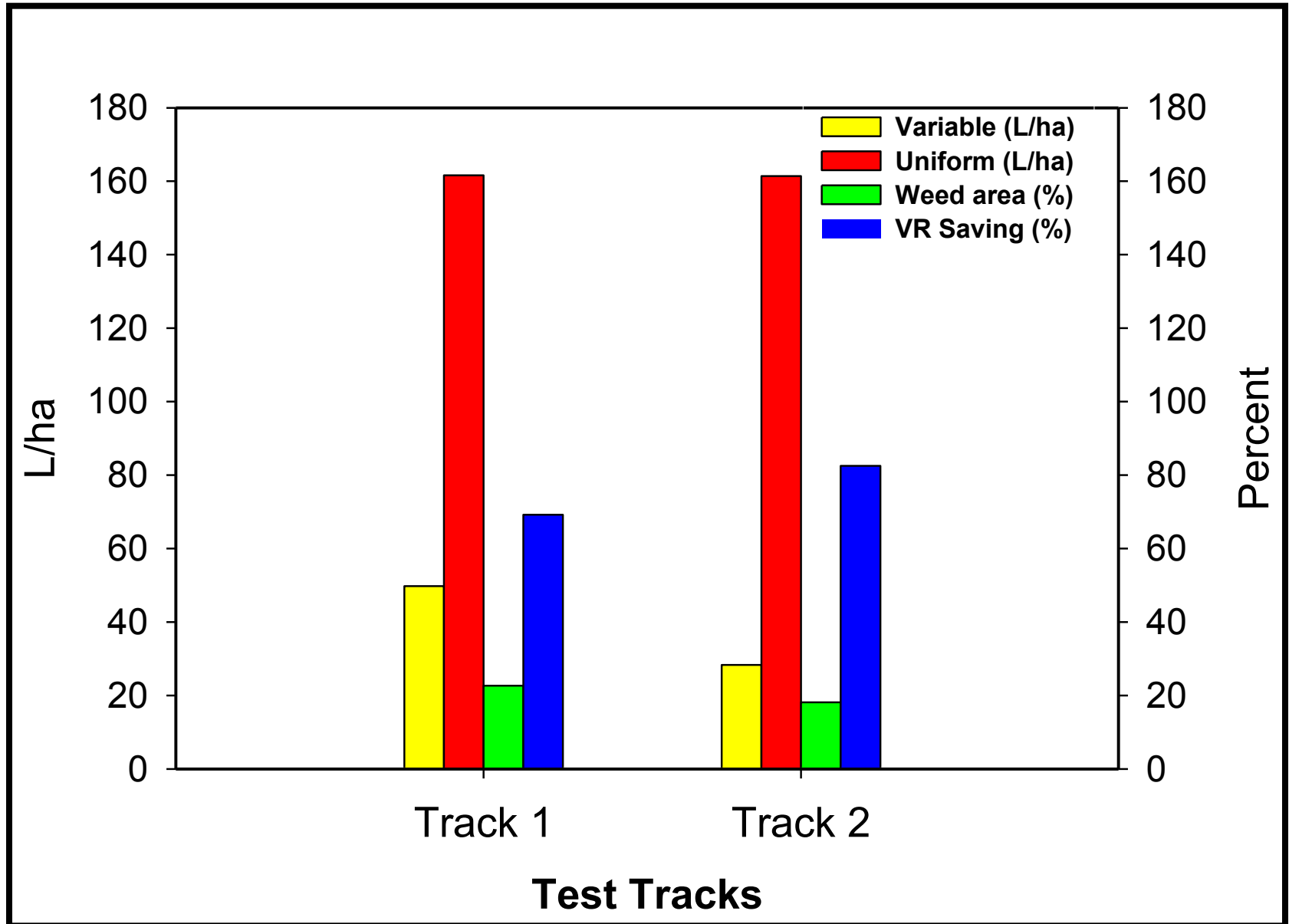
Weed and Spray Maps (Goldenrod)



0 20 40 60 80 100 Meters



Chemical Saving with Spot-Application



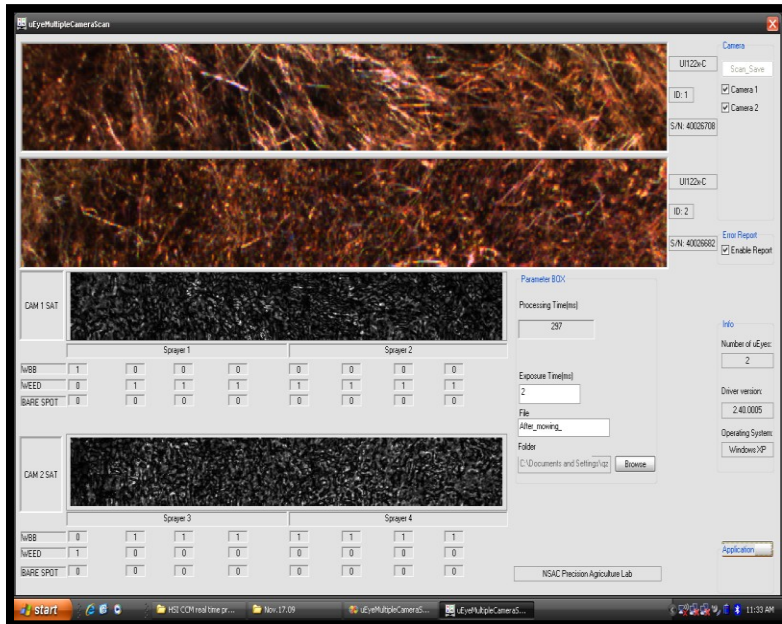
April-May



June- August

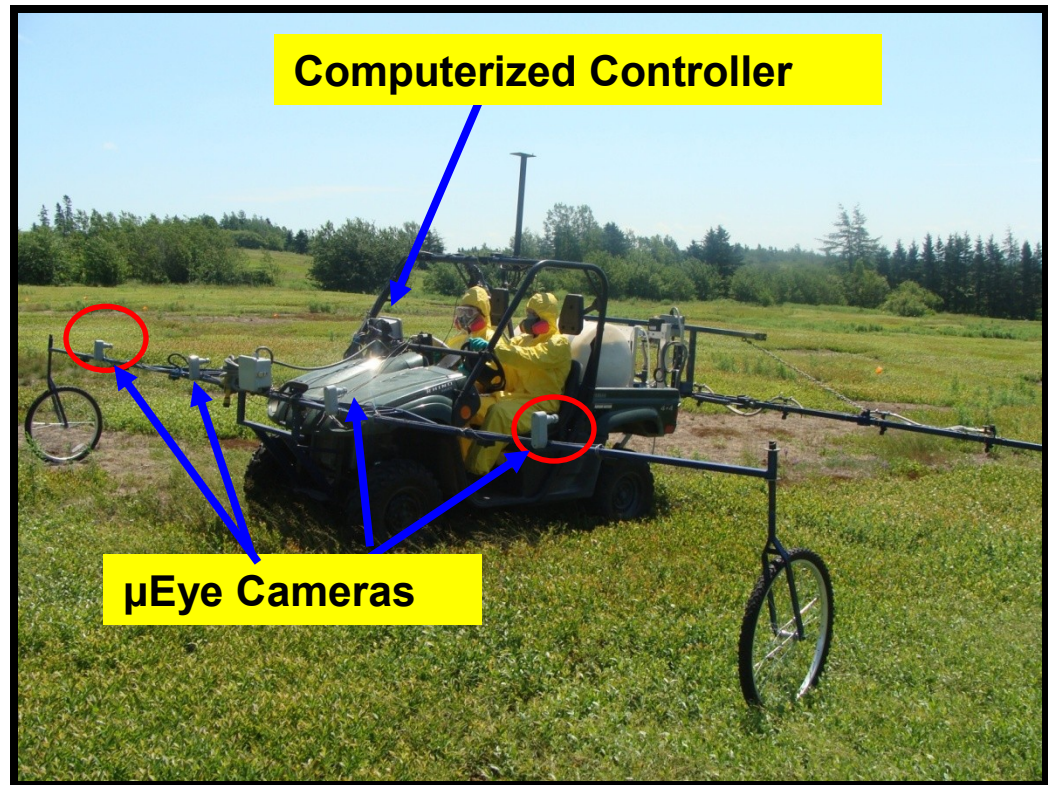


October-November



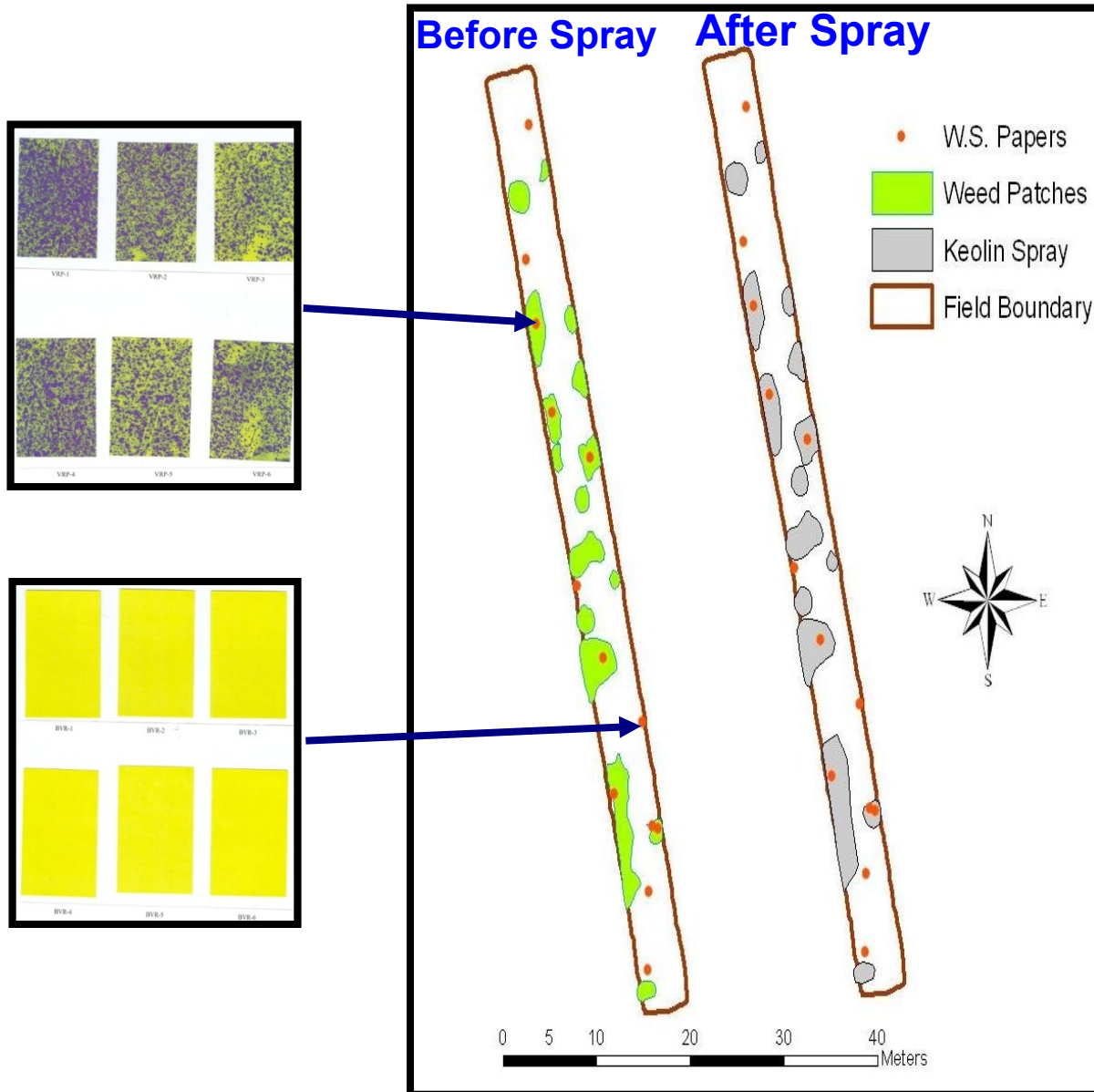
Customized Software for Weed, Bare Spot and Plant Detection

Computerized Controller



uEye Cameras

Sheep sorrel, Fescue Grasses, Moss and Spray Maps



Video-Spray on Sheep sorrel, Fescue grasses and Moss



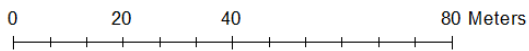
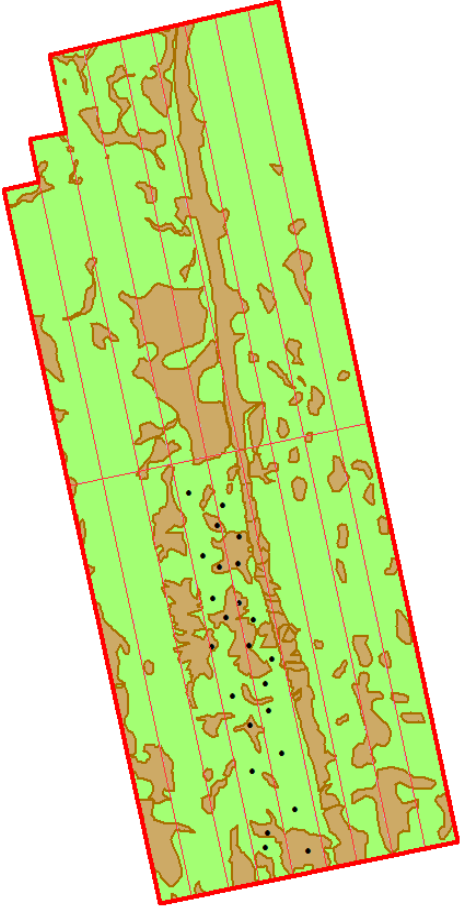
Spot-Application of Bravo – VR Sprayer with μ Eye Cameras

Before Spray



Legend

- Boundary
- Plots
- Bare Soil
- Foliage
- Water Sensitive Paper

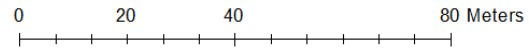
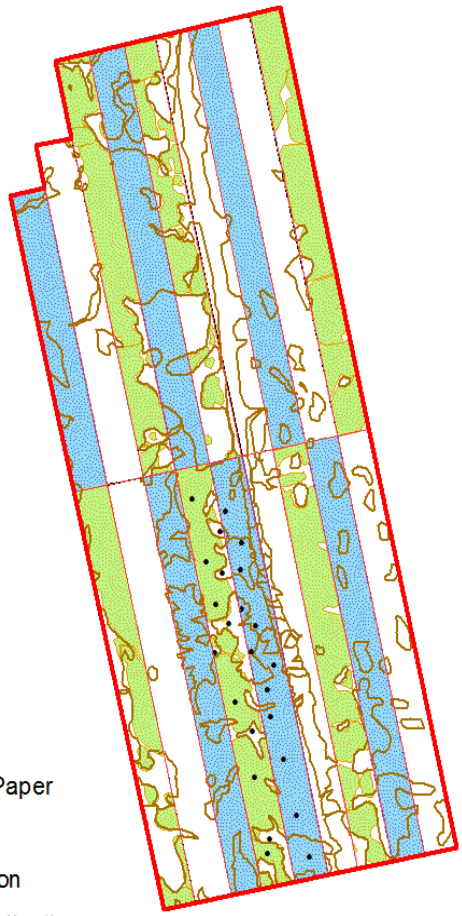


After Spray



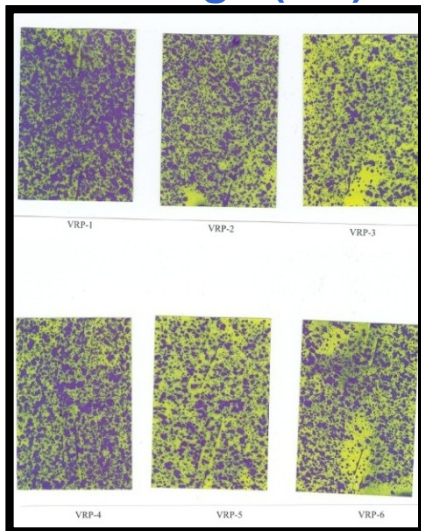
Legend

- Boundary
- Plots
- Bare Soil
- Water Sensitive Paper
- Control
- Uniform Application
- Variable Rate Application

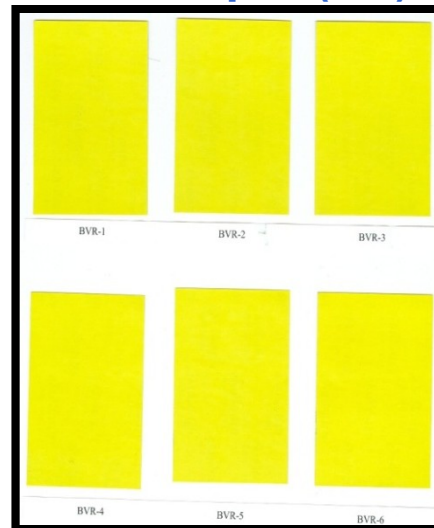


Spot Application of Bravo with Prototype VR Sprayer

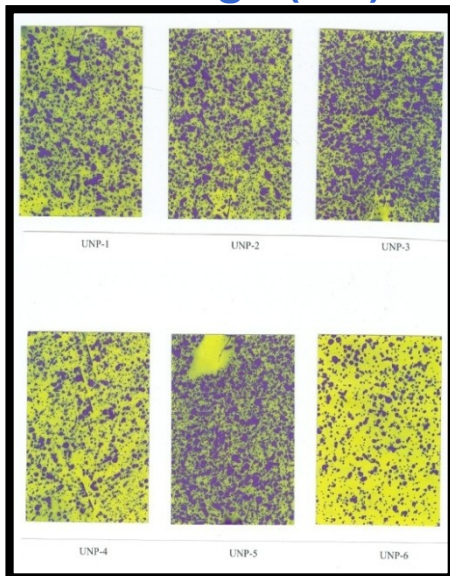
Foliage (SA)



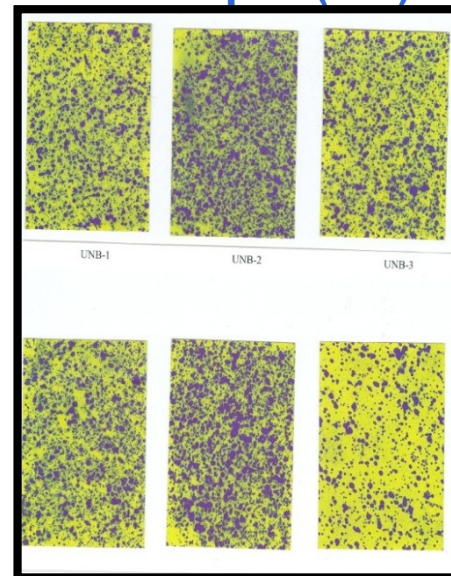
Bare Spot (SA)



Foliage (UA)



Bare Spot (UA)

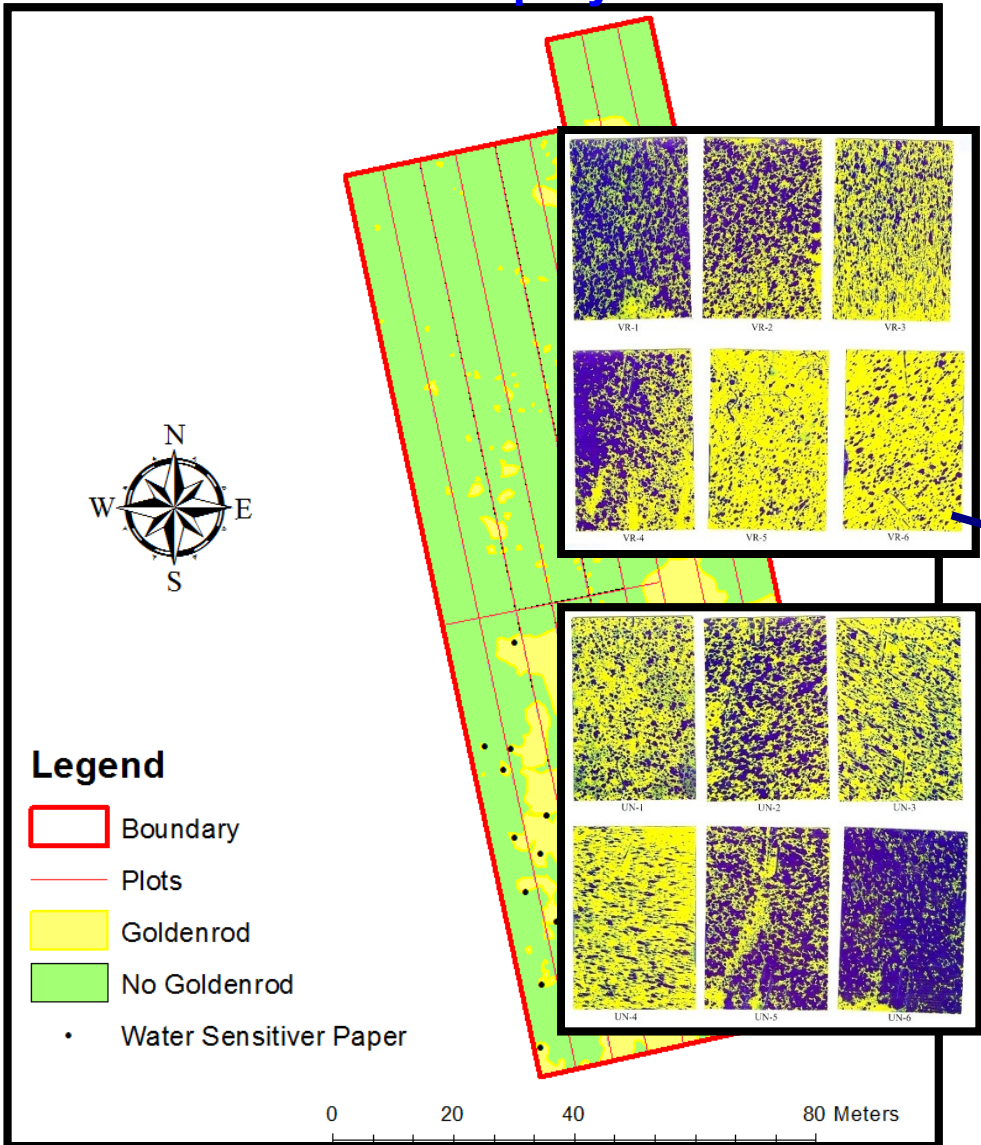


Savings with Spot-Application (Bravo)

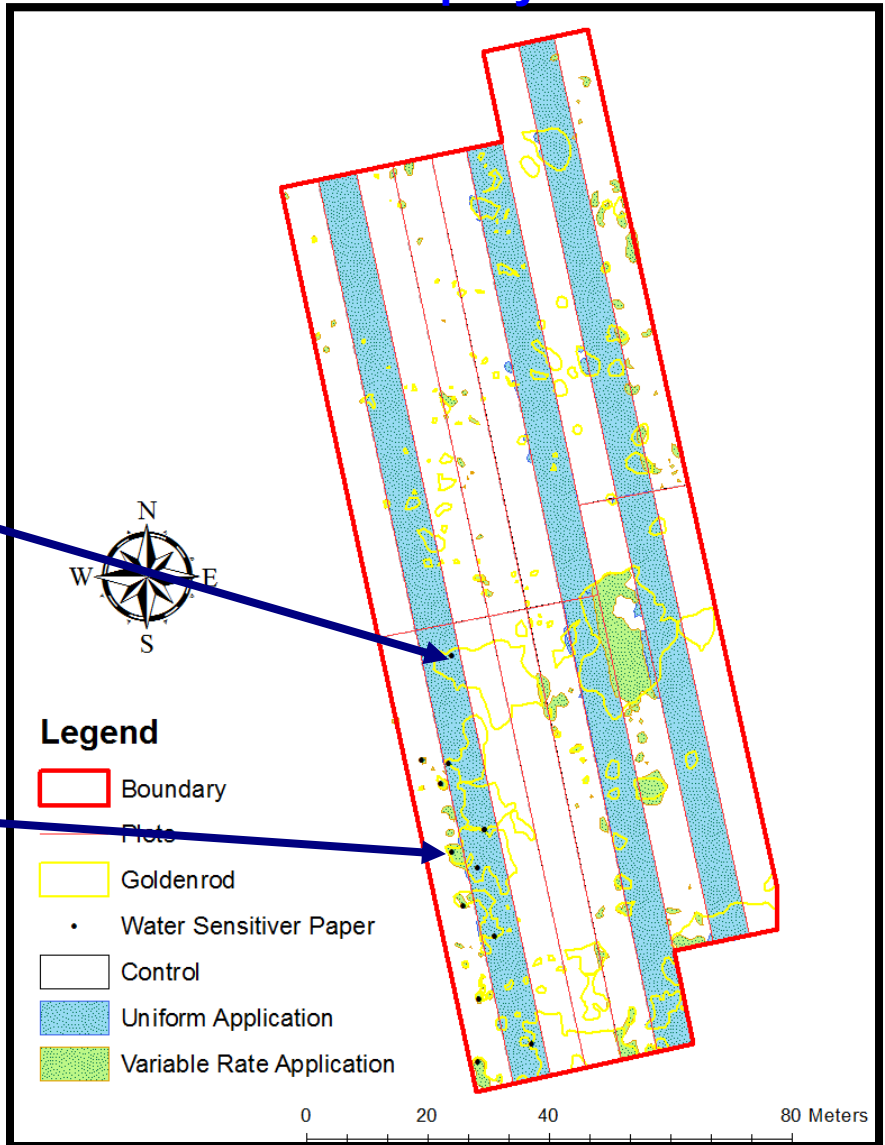
Plot No.	Total Area (m ²)	B. S. Area (m ²)	Saving (%)
1	523.67	188.21	35.94
2	497.25	102.13	20.53
3	502.39	44 .86	8.92
4	505.96	86.00	16.99
5	489.40	189.53	38.71
6	480.32	53.57	11.15

Spot-Application of Callisto- Prototype VR Sprayer

Before Spray



After Spray



Savings with Spot-Application (Callisto)

Plot #	Total Area (m ²)	Weed Area (m ²)	Sprayed Area (m ²)	Actual Savings (%)
1	476	40	45	90
5	462	32	58	87
7	488	170	177	64
10	466	3	5	98
13	500	4	35	93
18	442	16	54	88
Total	2834	265(9.3%)	374(13%)	
Ave. Saving				87

Commercial Prototype Variable Rate Sprayer



Controllers



**Solenoid Valve
& Nozzle**

**Height
Sensor**

Camera

Commercial Prototype VR Sprayer during Field Operation



Nozzle activated

Nozzle deactivated

Commercial Prototype VR Sprayer - Video



Spot-Application of Kerb-Commercial Prototype VR Sprayer

Total area = 6.13 Acres

Total required (UA)@20 Gal/ac= 122.5 Gal.

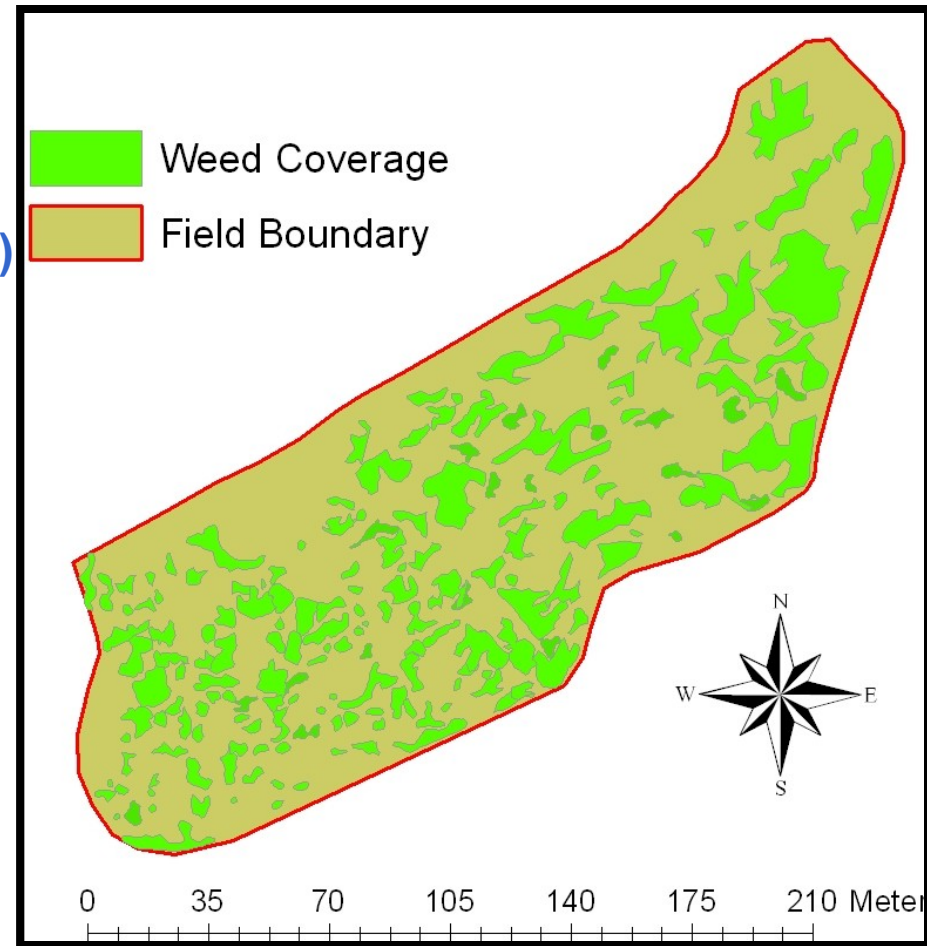
Weed coverage = 1.7ac (27.7% of field area)

Coverage (10" buffer before/after) = 2.0 ac

Saving with SA using GIS = **67.4 %**

Actual chemical applied (DJ) = 37.5 Gal.

Saving with SA (DJ Controller) = **69%**



Cost Analysis- Conventional vs Spot-Application (for one application only)

- Target: **Sheep Sorrel**
- Chemical: **Kerb**
- Area sprayed = **300 acres**
- Assume weed cover = **25%**
- Application cost = **\$180/acre**
- Total cost (Uniform application) = **300 X 180 = \$54,000**
- Cost of Spot- application = **\$13,500**
- Chemical cost saving with Spot- application = **\$40,500**

- Fewer trips to set water for sprayer
- Saves time (10 hours) + fuel, and labor
- Less impact on **ENVIROMENT**

Additional cost of converting commercial to VR sprayer:

- Computerized variable rate 8-channel controller
(Controller + Sensors/Cameras + GPS) = **\$4,000.00**
- Dickey John *Land Manager II* controller
(Controller + GPS + linear flow control valve, flow meter) = **\$2,600.00**
- Wiring etc. = **\$400.00**
- Total initial cost: **(Prototype Sprayer)** = **\$7,000.00**
- **Commercial Prototype Sprayer** = **\$14,000.00**

Precision Agriculture Research Team - HQP



ACKNOWLEDGEMENTS

