Applications of Precision Agriculture and Remote Sensing

Richard Plant

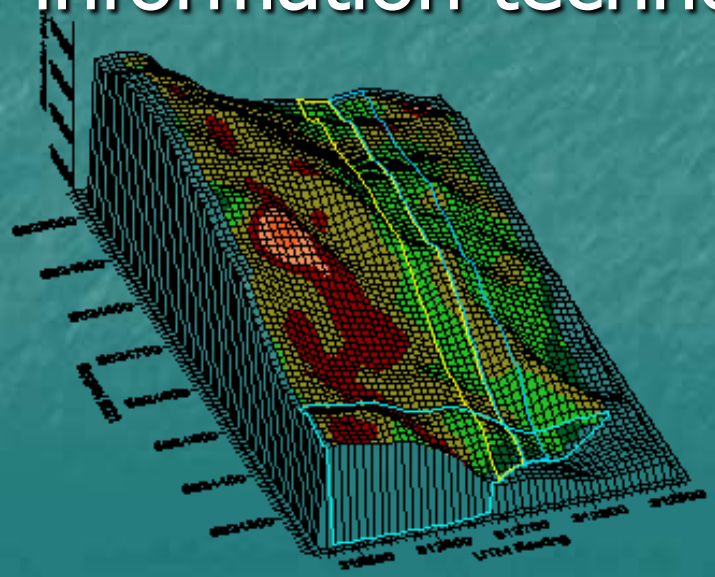
Depts. of Biological and Agricultural Engineering and Plant Sciences

Thanks to

- Randy D. Horney
- Alvaro Roel
- Jorge Perez
- Julie Young
- Dan Munk
- Bruce Roberts
- Brock Taylor
- Stu Pettygrove

Site-Specific Management (SSM) and Precision Agriculture

- SSM is the management of the crop at a spatial scale less than that of the entire field
- PA is the use of information technology to achieve SSM



Premises on which adoption of SSM is based

- Significant within-field variability exists in factors that influence crop yield.
- The causes of this variability can be identified and measured.
- Information from these measurements can be used to effectively modify crop management practices.
- The improvement in economic yield justifies the cost.

Dealing with Salt Affected Soil

Sources of variability in irrigated production systems

- Soil texture
- Salinity
- Soil depth

Factors influencing soil salinity in the western San Joaquin Valley

- Re-use of irrigation water from other fields
- Pre-existing fossil salts from seabed deposits
- Elevated water table
- Seepage from drainage canals

Classification of salt-affected soils

- Saline: EC > 4 dS/m, ESP < 15
  - Can be ameliorated by leaching
- Saline-sodic: EC > 4 dS/m, ESP > 15
  - Leaching alone converts to sodic
  - Requires amendments in addition
- Sodic: EC < 4 dS/M, ESP > 15
  - Prone to breakdown in structure
  - Poor infiltration properties

Most common soil amendments

- Gypsum
- Sulfur
- Sulfuric acid

Reclamation of saline-sodic soils is well suited to site-specific management

- Amendments are relatively expensive
- Salt-affected areas tend to be distributed in patches within a field
- Calculation of amount of amendment to apply is fairly exact

Linking EM38 and NDVI measurements to detect and quantify stress

http://www.ar.nrcs.usda.gov/soils/images/em_38.jpg

NIR -> R
R -> G
G -> B

Lillesand, T.M. and Kiefer, R.W. (1994) Remote Sensing and Image Interpretation

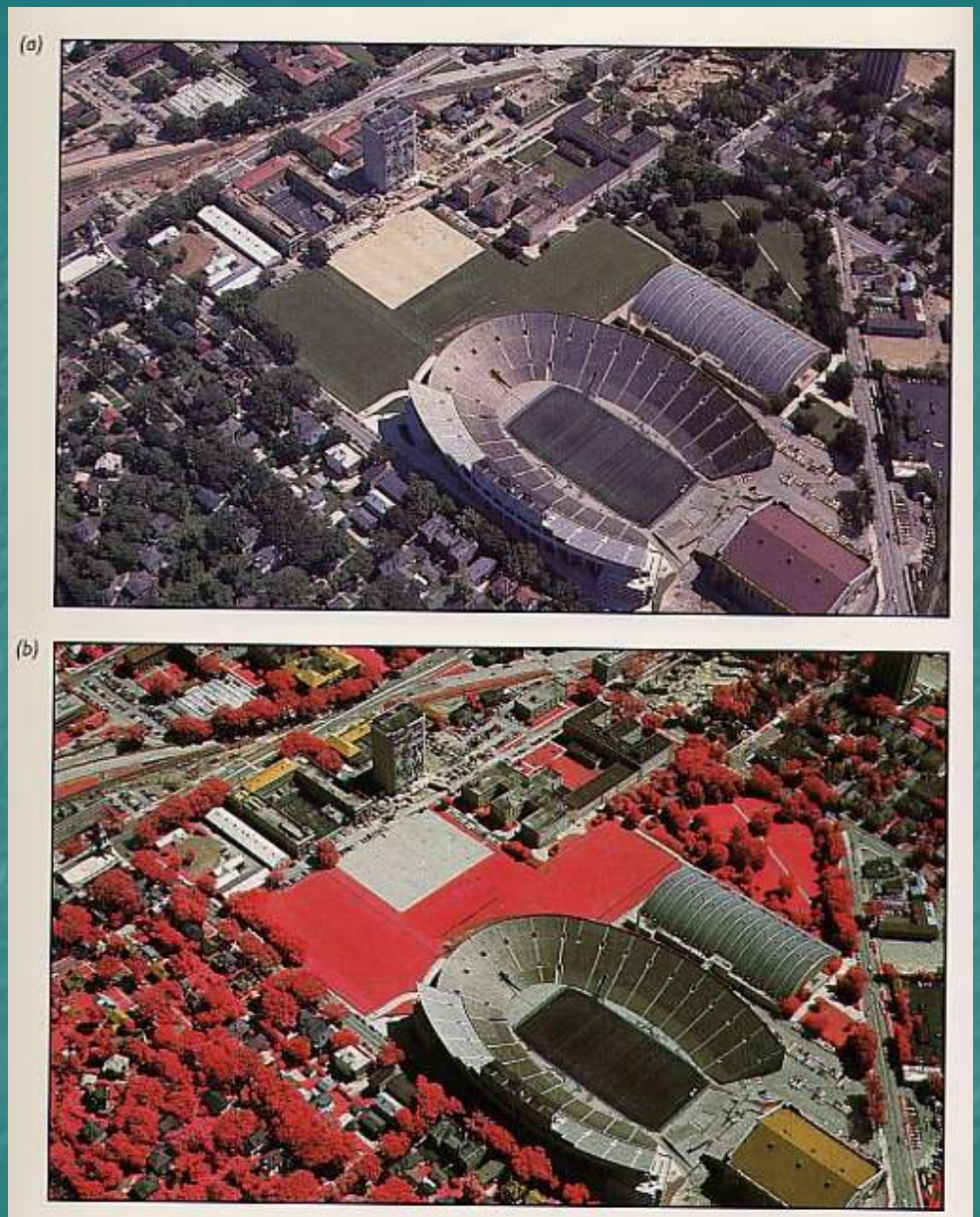


PLATE 2 Oblique normal color *(a)* and color infrared *(b)* aerial photographs showing a portion of the University of Wisconsin — Madison campus, June 27, 1968, 11:00 A.M. The football field has artificial turf with low near-infrared reflectance. (For major discussion, see Section 2.9.)

Normalized Difference Vegetation Index

NDVI = (IR-R)/(IR+R)

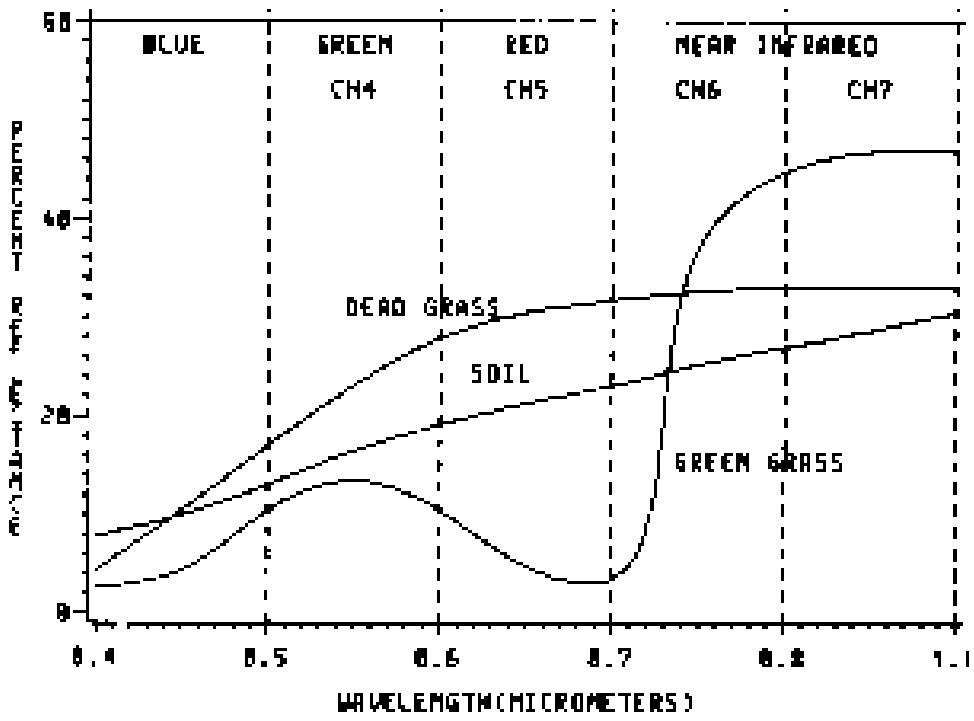


FIGURE 1 Idealized reflectance patterns of herbaceous vegetation and soil from 0.4 to 1.1 μm (Deering et al., 1975).

Examples of NDVI

NIR -> R
R -> G
G -> B

$$\text{NDVI} = \frac{25 - 40}{25 + 40} = -0.23$$

R: 25 (IR)
G: 40 (R)
B: 140 (G)

R: 175 (IR)
G: 20 (R)
B: 20 (G)

$$\text{NDVI} = \frac{175 - 20}{175 + 20} = 0.79$$

Linking Soil EC_a, NDVI, and Yield

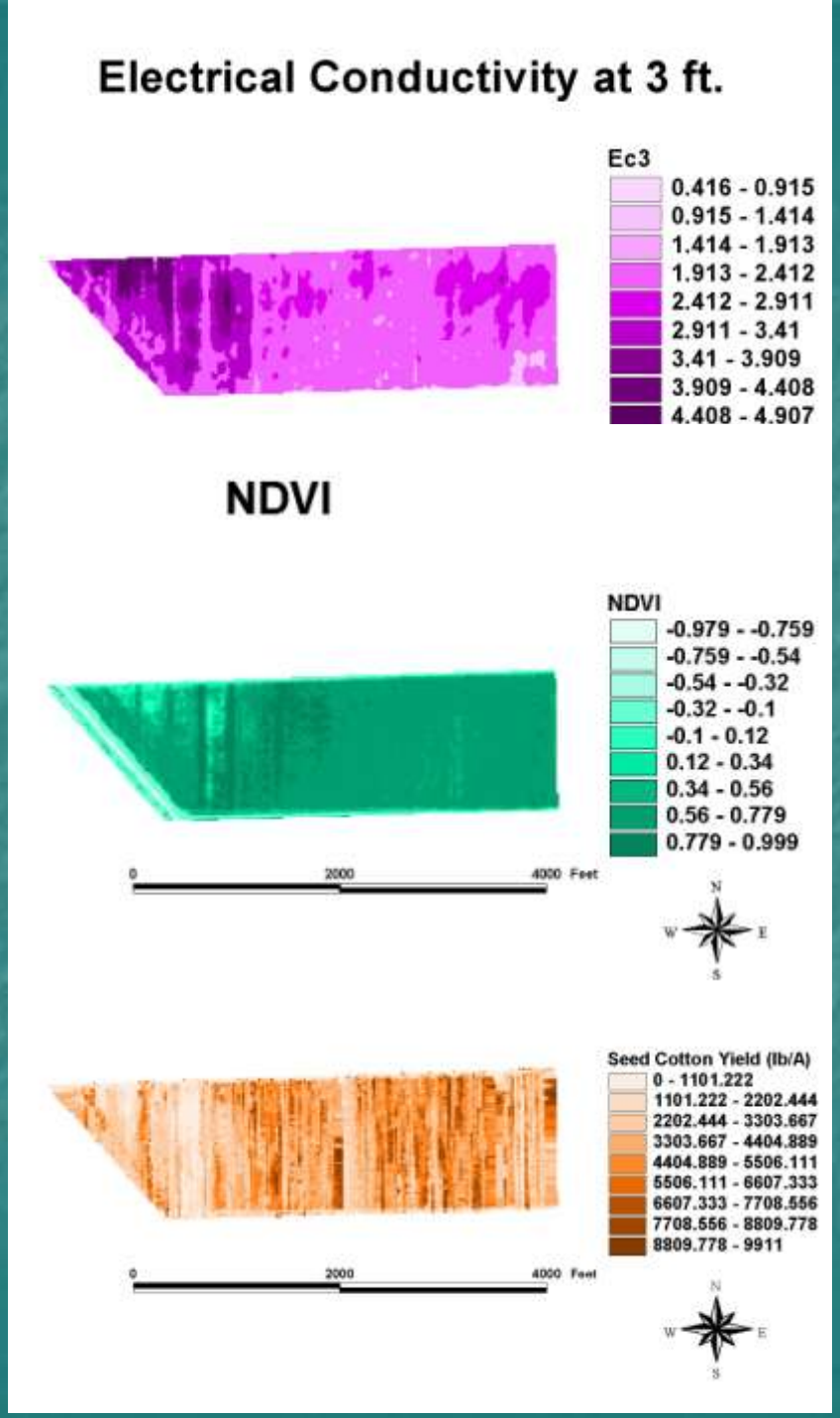
Soil Quality

↓

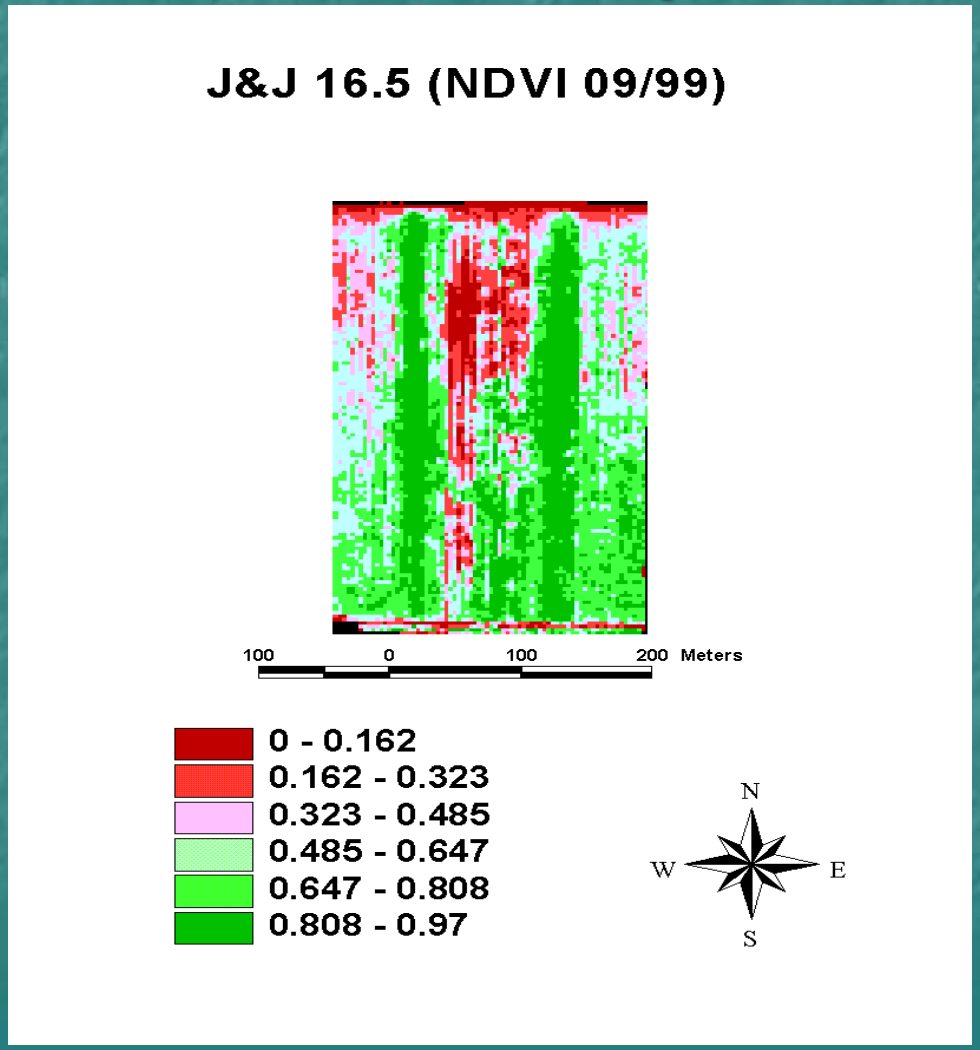
Vegetation

↓

Yield



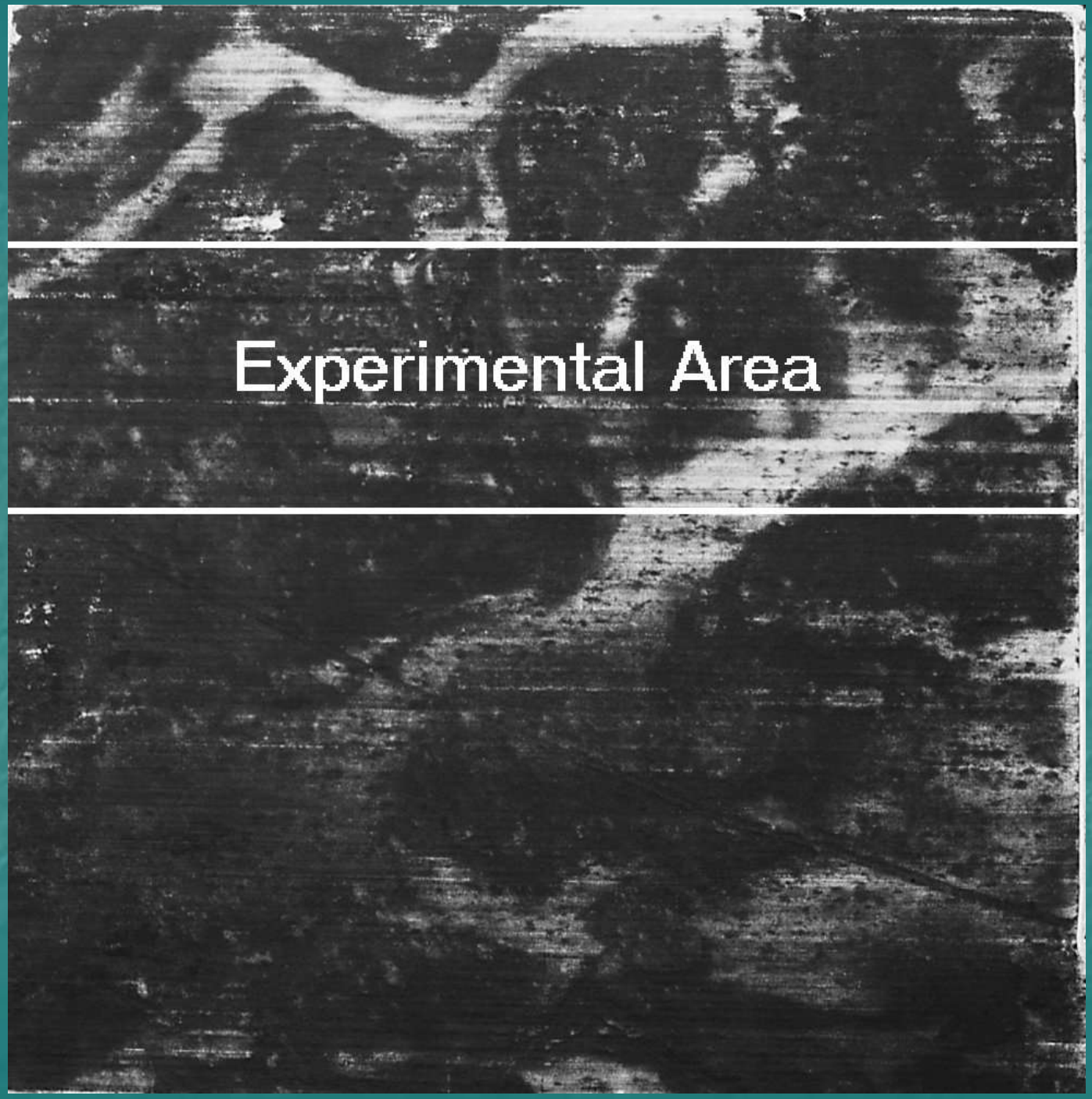
Close-up


J&J 16.5 (NDVI 09/99)
100
0
100
200
Meters
0 - 0.162
0.162 - 0.323
0.323 - 0.485
0.485 - 0.647
0.647 - 0.808
0.808 - 0.97
N
W
E
S

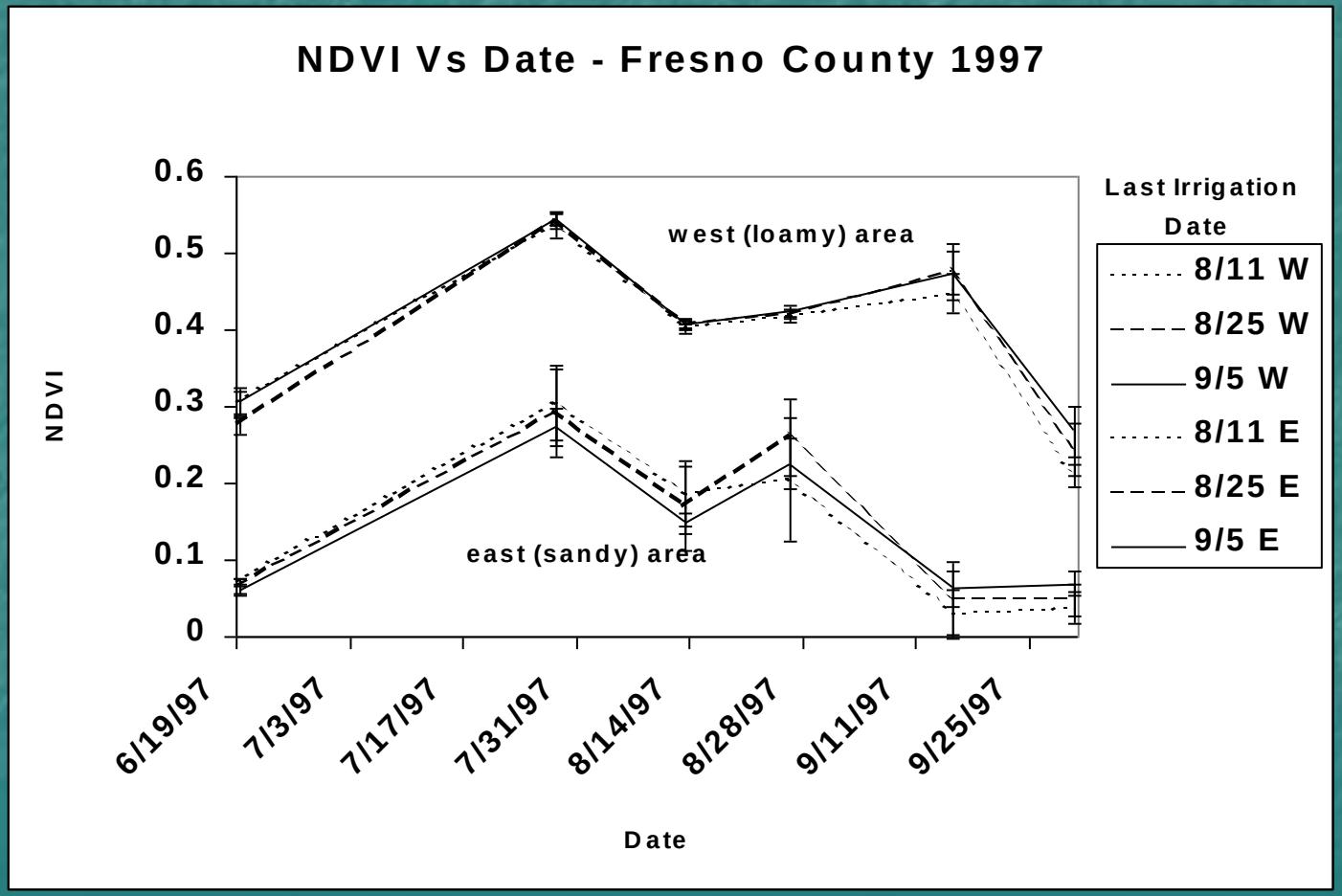
NDVI can be used to detect other types of stress

- Water stress trials at WSREC

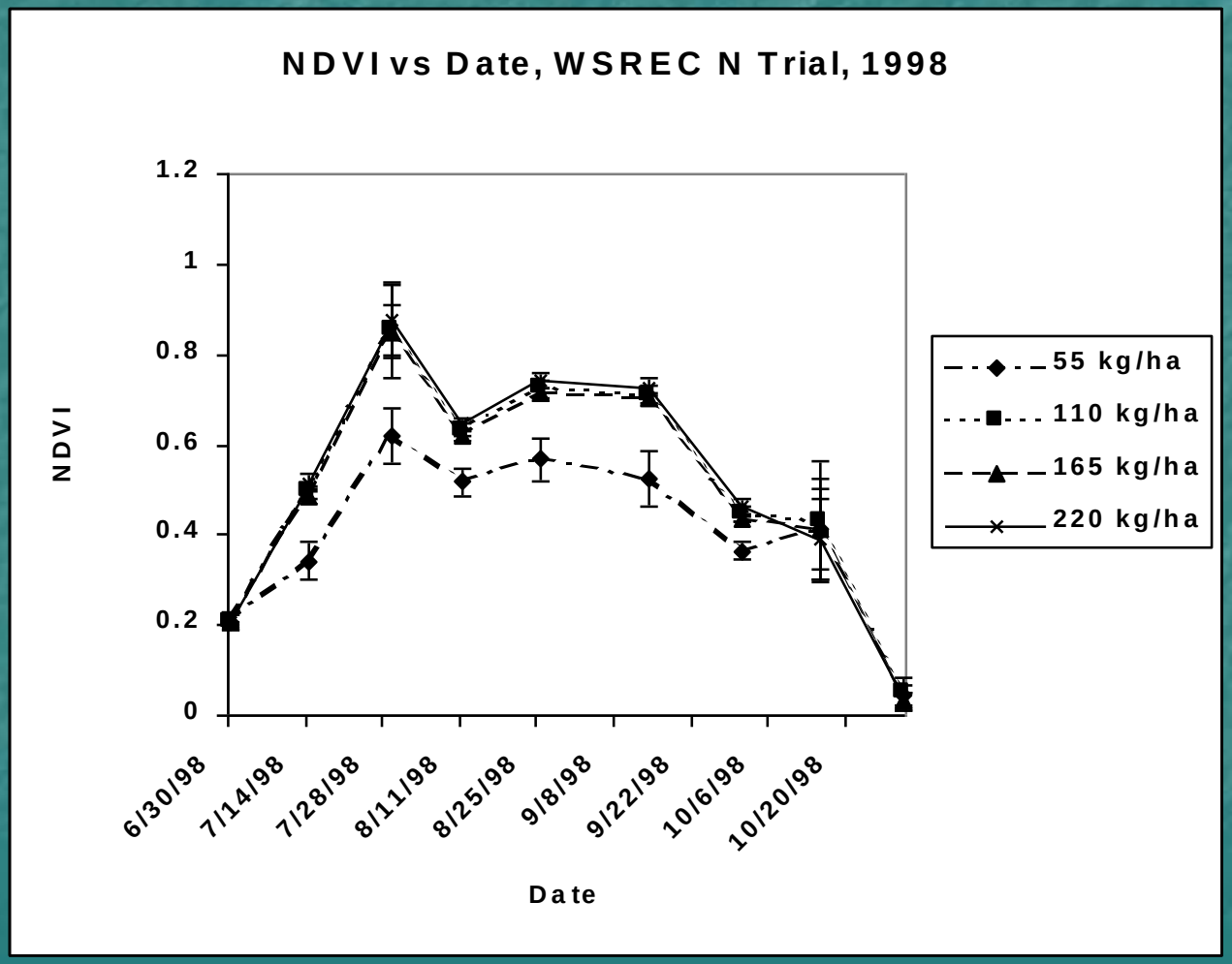
Fresno County Site 9-15-97


Experimental Area

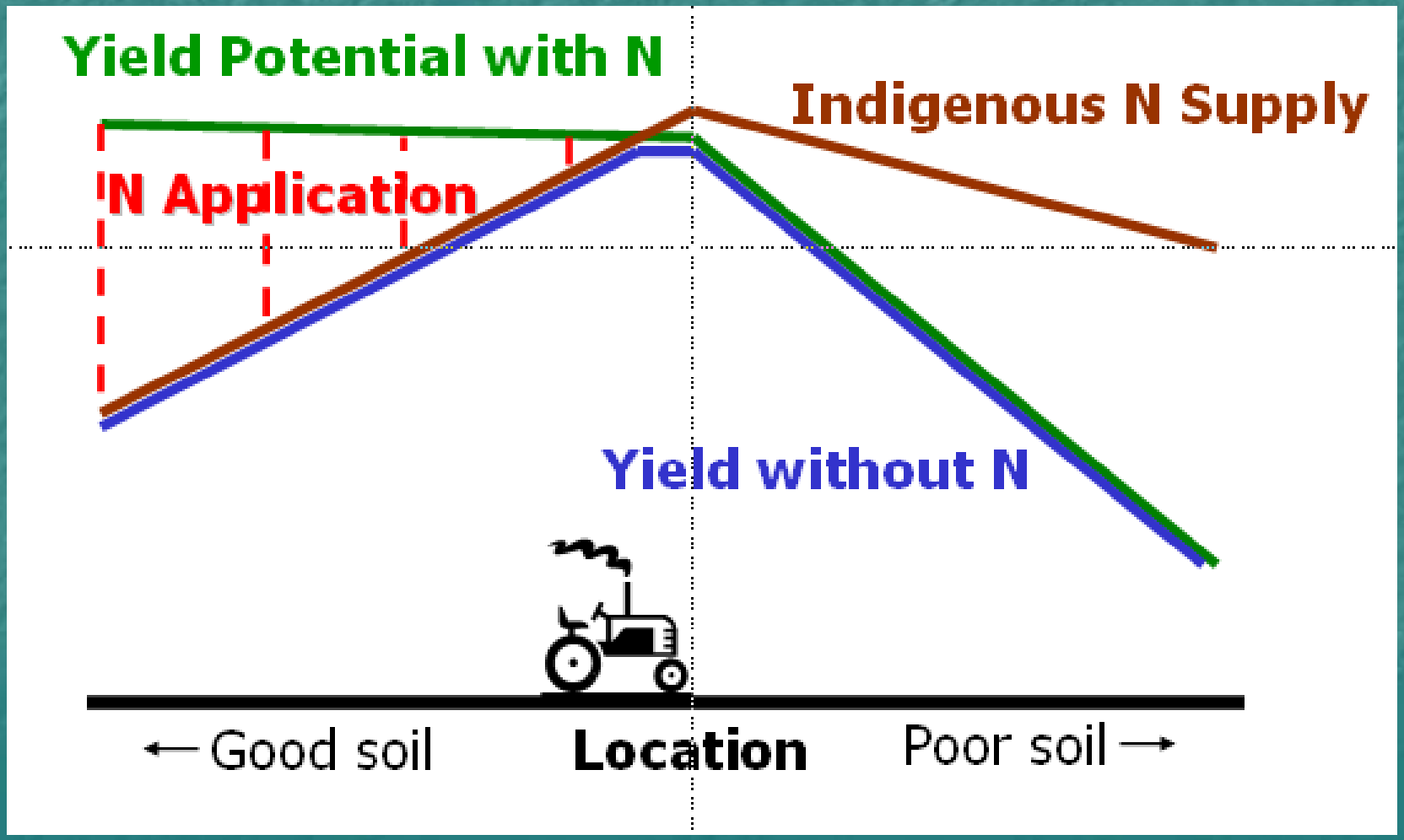
NDVI on East (Sandy) and West (Loamy) Sides



Remote Sensing of Nitrogen Stress



Example of the use: variable rate N application



Improving profit with VRT

- *Increase income*
  Apply N where needed to increase yields
- *Cut costs*
  Don’t apply N where it’s not needed
- VRT N is profitable when the sum of increased income and savings is greater than the cost of the VRT program.

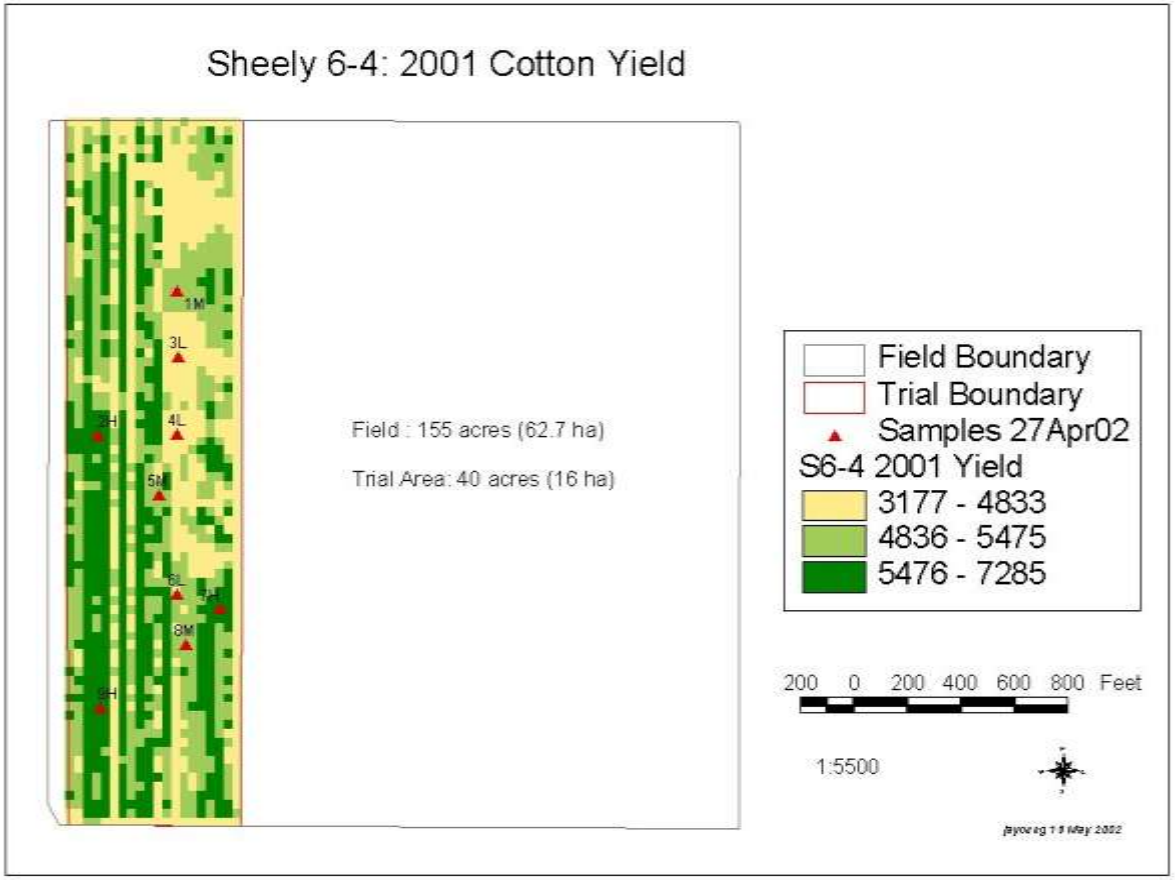
Steps of site-specific N management program

- On a location by location basis:
  - Estimate yield potential
  - Estimate available soil N
  - Use variable rate technology to adjust the N application rate

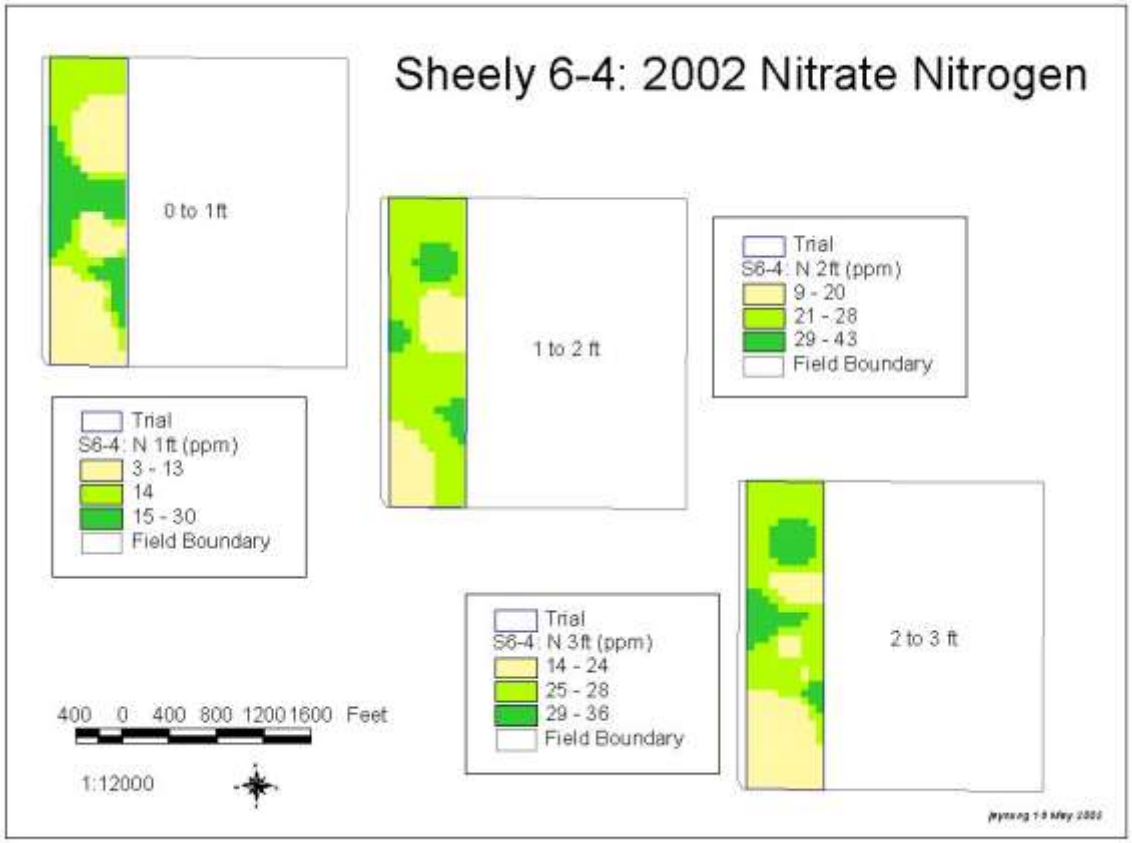
Directed soil sampling

- Based on previous year's yield map, divide the field into 3 zones (high, medium, low yield).
- Take soil samples at 3 widely scattered locations in each zone (9 total).
- Test sample for residual N (and Ec if salinity is suspected).

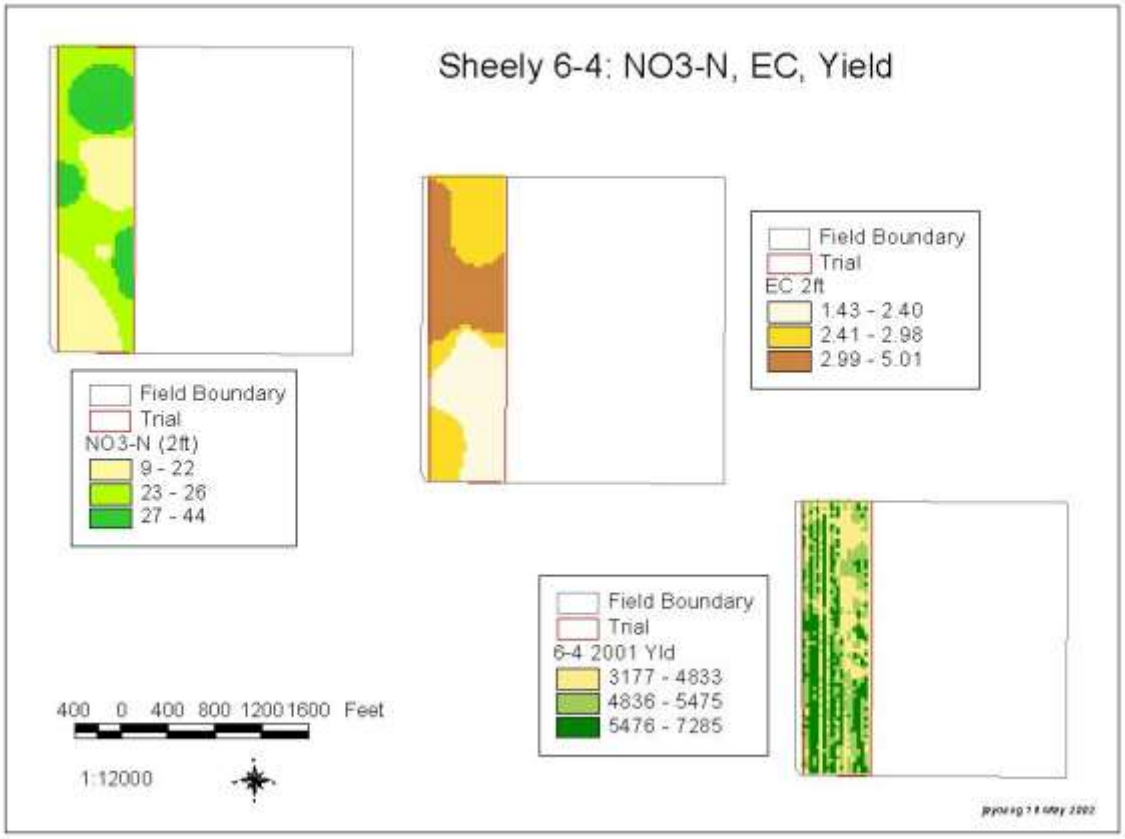
Example: 2002 trial based on 2001 yield map



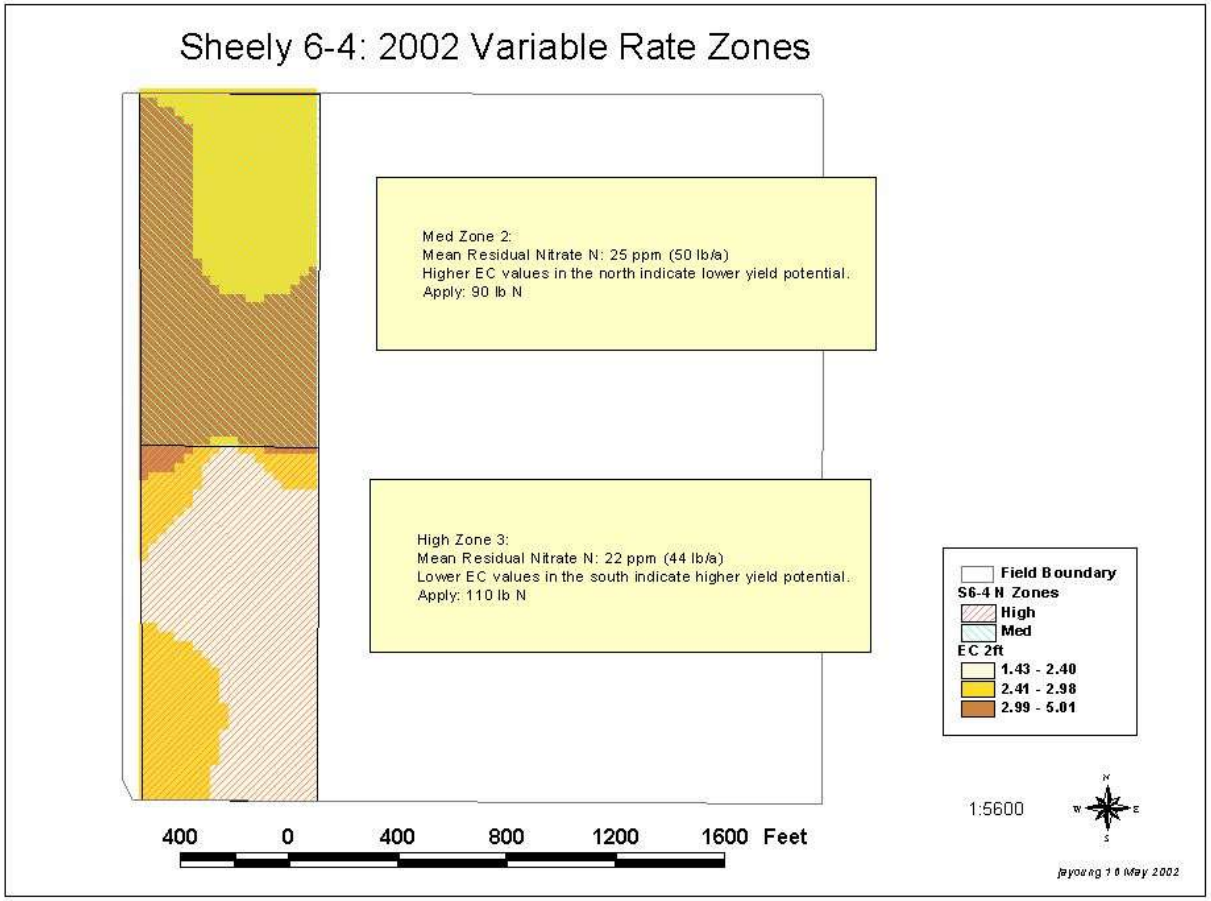
Soil N


Sheely 6-4: 2002 Nitrate Nitrogen
0 to 1ft
1 to 2 ft
2 to 3 ft
Trial
S6-4: N 1ft (ppm)
3 - 13
14
15 - 30
Field Boundary
Trial
S6-4: N 2ft (ppm)
9 - 20
21 - 28
29 - 43
Field Boundary
Trial
S6-4: N 3ft (ppm)
14 - 24
25 - 28
29 - 36
Field Boundary
400 0 400 800 1200 1600 Feet
1:12000

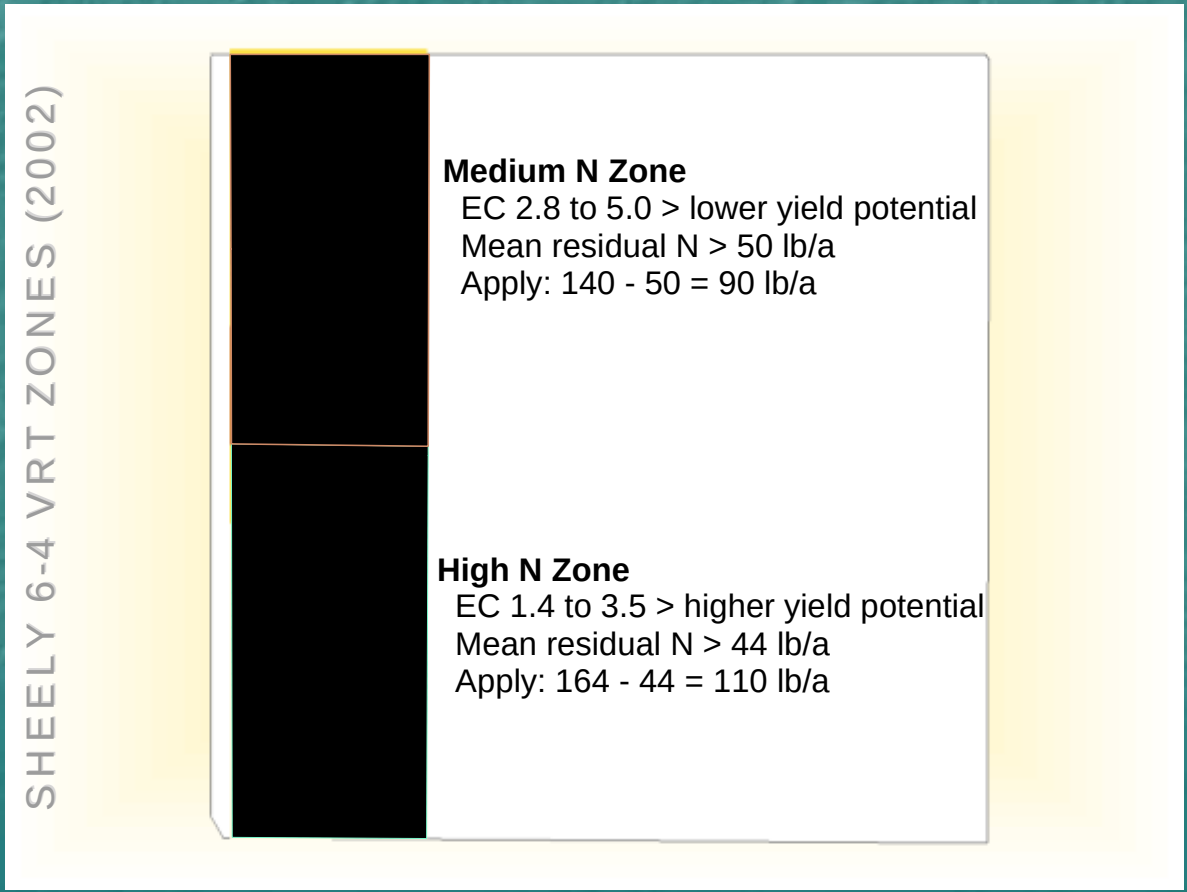
All major components



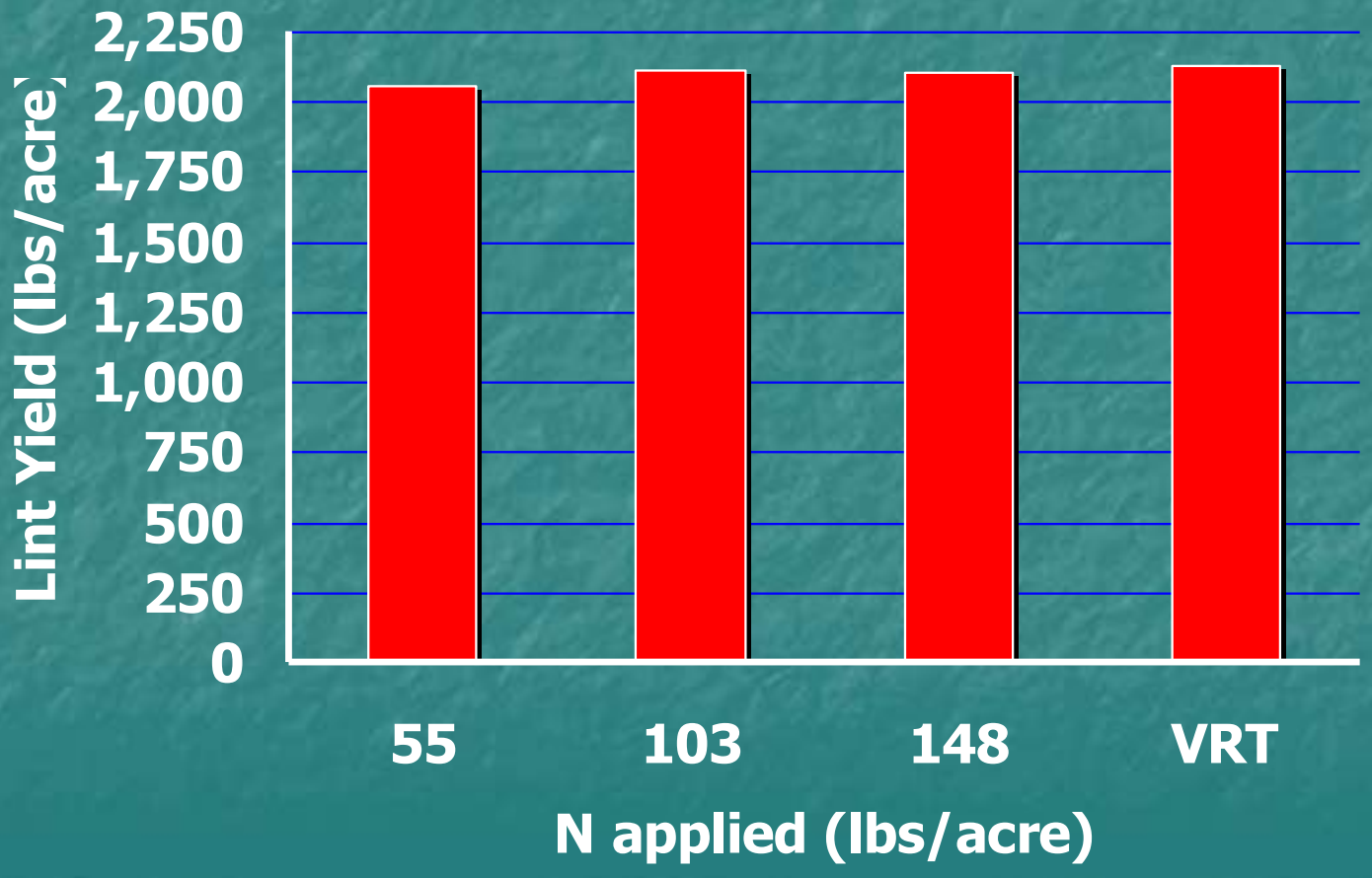
Management zones



Resulting application map



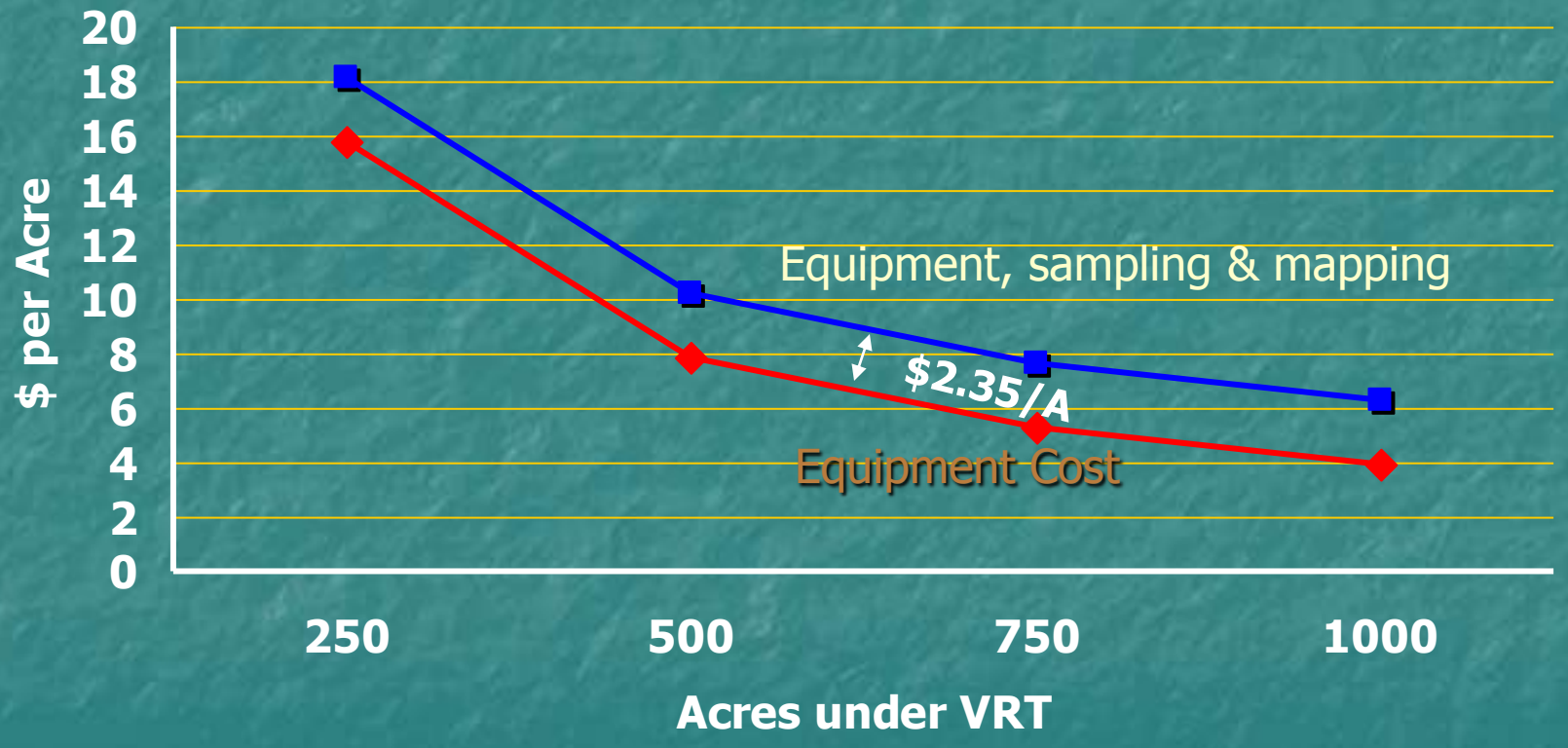
Yields from 2002 Sheely Trial



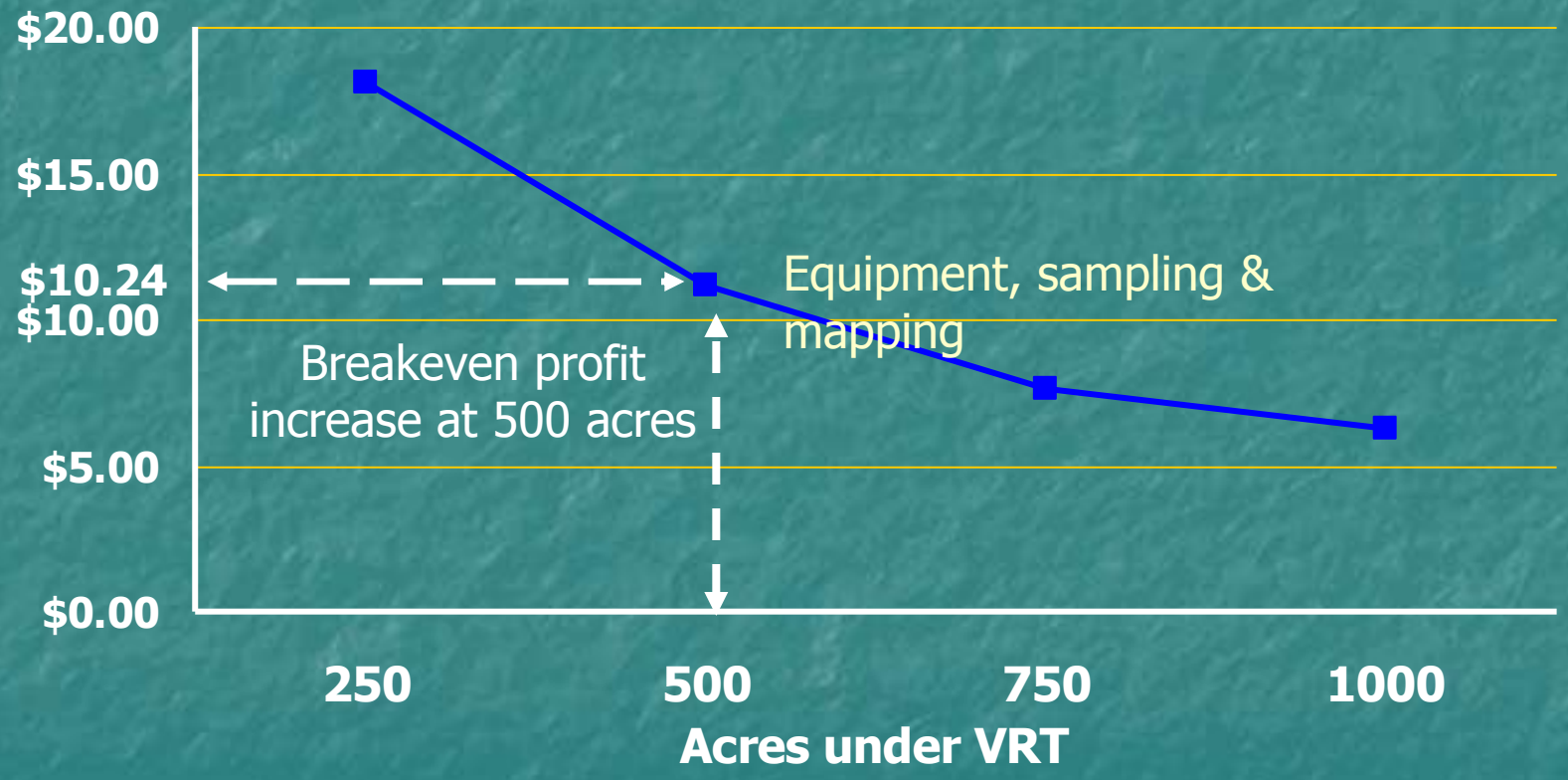
Economic analysis

- Overall question: Does variable rate N application reduce costs sufficiently to overcome the increased cost of implementing the VRT program?
- Partial budgets computed for each of the test sites

VRT Cost per Acre



VRT Breakeven profit increase ($/A)



Conclusions

- Substantial savings in fertilizer even with conservative VRT N management
- For all 3 sites profit increased primarily from decrease in N use and not from increasing N use
- Breakeven fertilizer savings decreases with acreage increase
- Breakeven acreage decreases with increases in fertilizer, labor, or fuel costs

Conclusions, contd.

- Profit margin can be increased by using the equipment for other purposes or for other crops.
- Some recommended potential uses:
  - Variable rate soil amendment application.
  - Variable rate Pix on cotton
  - Variable rate seeding