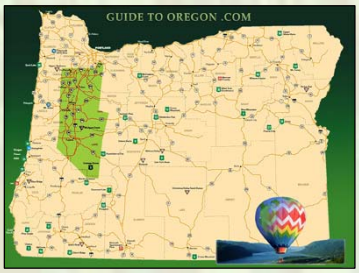
The Use of GIS in Precision Agriculture for Grass Seed Production

Presented by

Dan Coyne & Beth Robinson

Importance of Grass Seed

- Oregon is the number one producer of cool-grass seed in the United States.
- 470,000 acres of seed grown in Willamette Valley



What is Precision Agriculture?

- An attempt to manage for spatial variability within a field by dividing a field into different zones where different rates of input are applied as appropriate (Hedstrom, K. 2005.)

Precision Agriculture Assumptions

- Yield within a field is limited by some factor.
- Different limiting factors control yields within different fields.
- Crop yields vary spatially across a field.

Research Questions

- How do nutrients (P, K, Mg) and buffer pH, considered important for grass seed production, correlate with yield?
- Can multivariate regression predict yield variability based on soil nutrient levels?

Yield Monitor

- A yield monitor (GPS unit) attached to combine
- Reads location, amount of seed coming into combine, elevation

Error Contributions

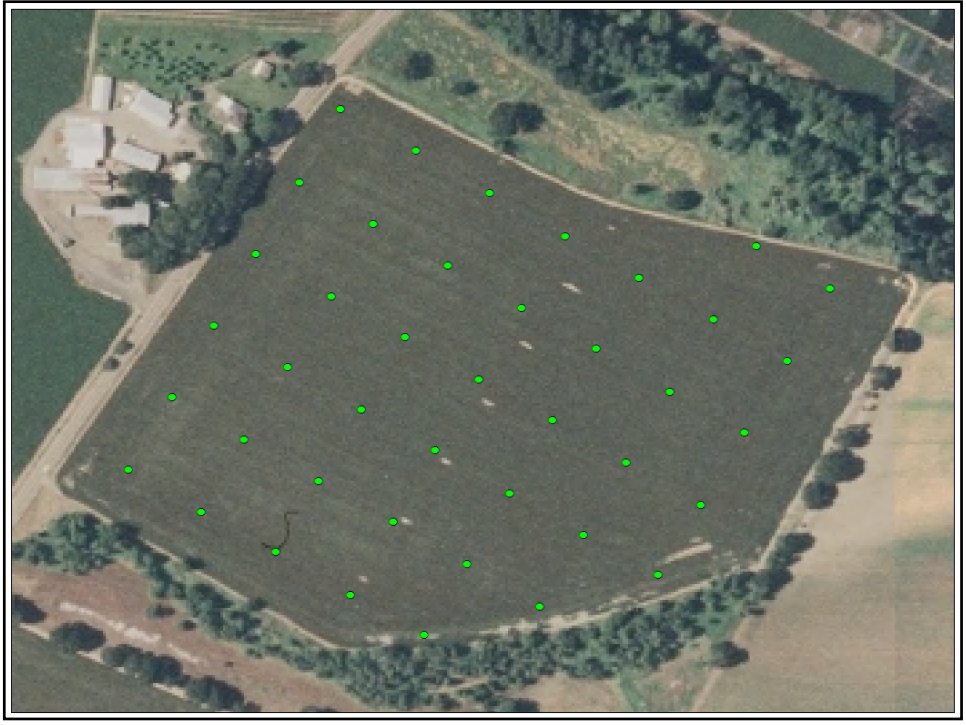
- GPS loss of signal
- Operator error
- Flux of combine speeds
- Time lag of grain through the machine
- Lack of correct sensor calibration
- Combine turning corners reads seeds it has previously collected

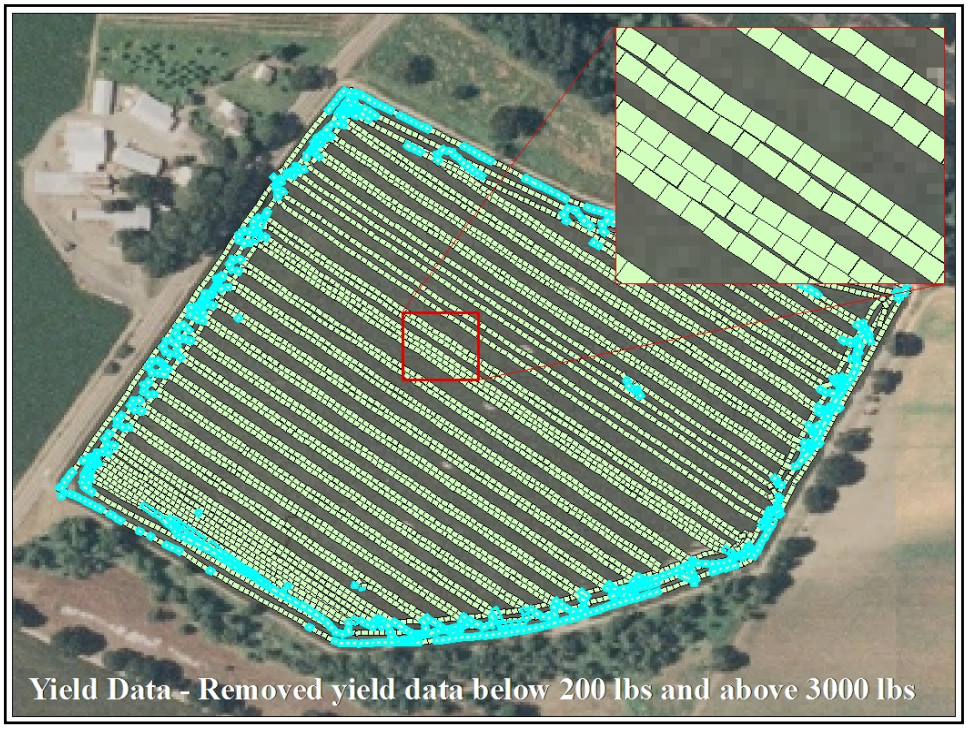
Clean up

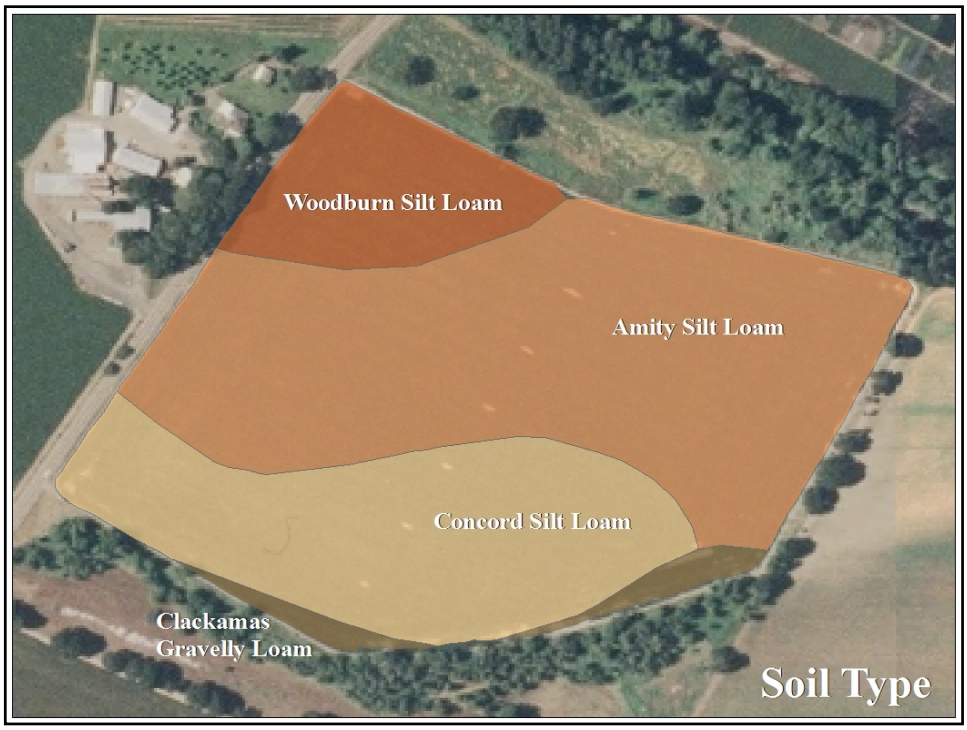
- Yield data can contain errors and missing data
- Manually remove incorrect data points
- Select yield based on specific parameters
- Industry improvements

DATA

- Harvest Geographics, Canby, OR
  - Yield
    - Combine Yield Monitor
  - Soil Nutrition
    - Macro & Micronutrients
- NRCS
  - Soil Type & Characteristics (spatial data)
  - 2006 Imagery




Yield Data - Removed yield data below 200 lbs and above 3000 lbs


Woodburn Silt Loam
Amity Silt Loam
Concord Silt Loam
Clackamas
Gravelly Loam
Soil Type

Analysis

- *Statistical Analysis*
  - ANOVA, *SPSS 12.0.2*
  - Multiple Regression, *SPSS 12.0.2*
- Overlay Analysis
  - Spatial Interpolation – Kriging
  - Reclassification
  - Yield & Nutrient Map Combination

Multiple Regression Formula

$$y_i = b_0 + b_1 x_{i1} + \ldots + b_p x_{ip} + e_i$$

where

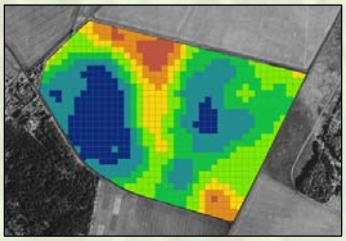
y_i is the value of the i^{th} case of the dependent scale variable

p is the number of predictors

b_j is the value of the j^{th} coefficient, $j = 0, \ldots, p$

x_{ij} is the value of the i^{th} case of the j^{th} predictor

e_i is the error in the observed value for the i^{th} case



Statistical Analysis


60 ft. Bufer

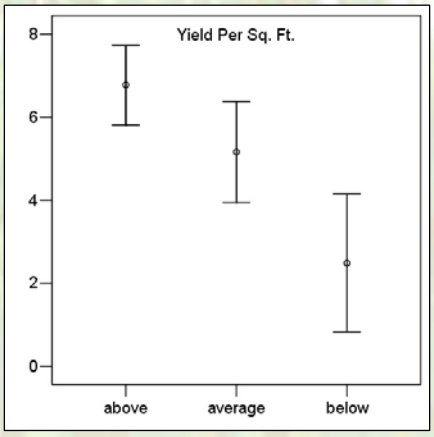

Select By Location

ANOVA ANALYSIS

- ANOVA
  - Determines if variation within groups is greater than between groups
- Individual Yield
  - Exported yield data to Excel
    - Converted data to yield per sq. ft.
  - Rated data to below, average and above average
    - average = +,- one standard deviation of the mean

ANOVA ANALYSIS

- Mean value and standard error
- ANOVA assumes equality of variance across groups



ANOVA ANALYIS

- The Levene statistic rejects the null hypothesis that the group variances are equal.
  - You do not want this test to be significant

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
32.497	2	1143	0.000

Multiple Regression

- Multiple Regression
  - Studies the relationship between a dependent variable and a set of independent explanatory variables.
- Data
  - Used Spatial Join to calculate average yield per soil sample buffer area.
  - Used join-to-many to join soil type to each soil sample point.
  - Used soil sample identifier to join soil type to soil buffer area containing yield data.

Multiple Regression

- Data
  - Nutrient Correlation
    - Removed one nutrient from each correlated group.
  - Dummy Variable
    - Soil type defined as Capability Class 2 & 3 by the NRCS
    - Converted class 2 into a dummy variable

MULTIPLE REGRESSION

- Dependent variable – Average yield per sq. ft.
- Independent variables
  - Macronutrients
    - Phosphorous, Potassium, Magnesium, Calcium, Sulfur
  - Micronutrients
    - Boron, Iron, Manganese, Zinc
  - Buffer pH
  - Soil Type
    - Presence or absence of Capability Class 2

MULTIPLE REGRESSION

- All independent variables used
  - Method 'Enter' – all variables are entered into the equation as a group

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	**0.786**	**0.617**	0.472	0.617

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.82	11.00	1.62	**4.25**	**0.00**
	Residual	11.06	29.00	0.38		
	Total	28.88	40.00			

MULTIPLE REGRESSION

- Continued…

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.930	5.286		2.068	0.048
	P	0.003	0.008	0.049	0.324	0.748
	K	0.003	0.007	0.069	0.425	0.674
	Mg	-0.003	0.005	-0.154	-0.581	0.566
	Buff pH	-1.120	0.845	-0.204	-1.325	0.195
	Ca	-0.001	0.002	-0.131	-0.542	0.592
	S	0.147	0.125	0.225	1.174	0.250
	B	4.582	4.495	0.216	1.019	0.316
	Fe	**0.020**	**0.007**	**0.984**	**3.045**	**0.005**
	Mn	**-0.231**	**0.045**	**-0.908**	**-5.140**	**0.000**
	Zn	0.300	1.377	0.056	0.218	0.829
	Cap2	0.149	0.352	0.084	0.422	0.676

MULTIPLE REGRESSION

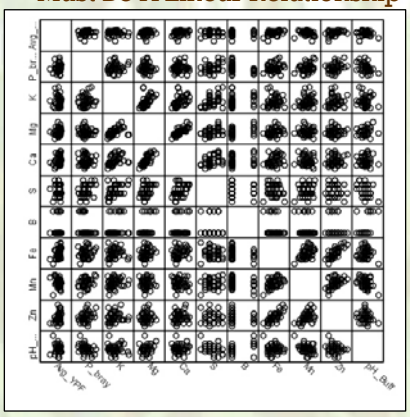
- Continued…

Coefficients(a)

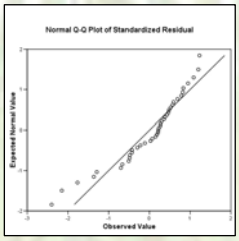
Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	13.397	4.002		3.347	0.002
	Fe	0.016	0.003	0.784	6.144	**0.000**
	Mn	-0.189	0.035	-0.745	-5.409	**0.000**
	Buffer pH	-1.397	0.661	-0.254	-2.114	**0.041**

ASSUMPTIONS

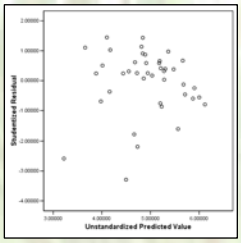
Must Be A Linear Relationship



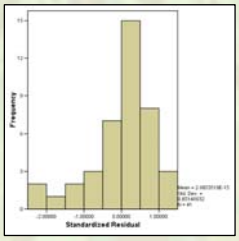
Normal Distribution



Equal Variance



Independent Residuals

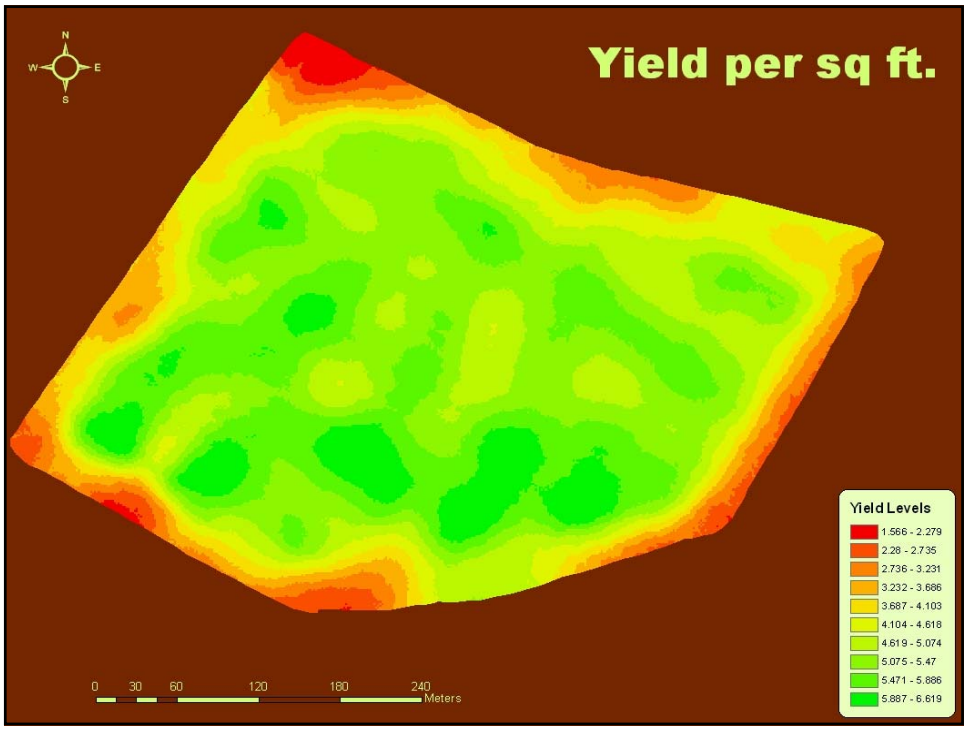


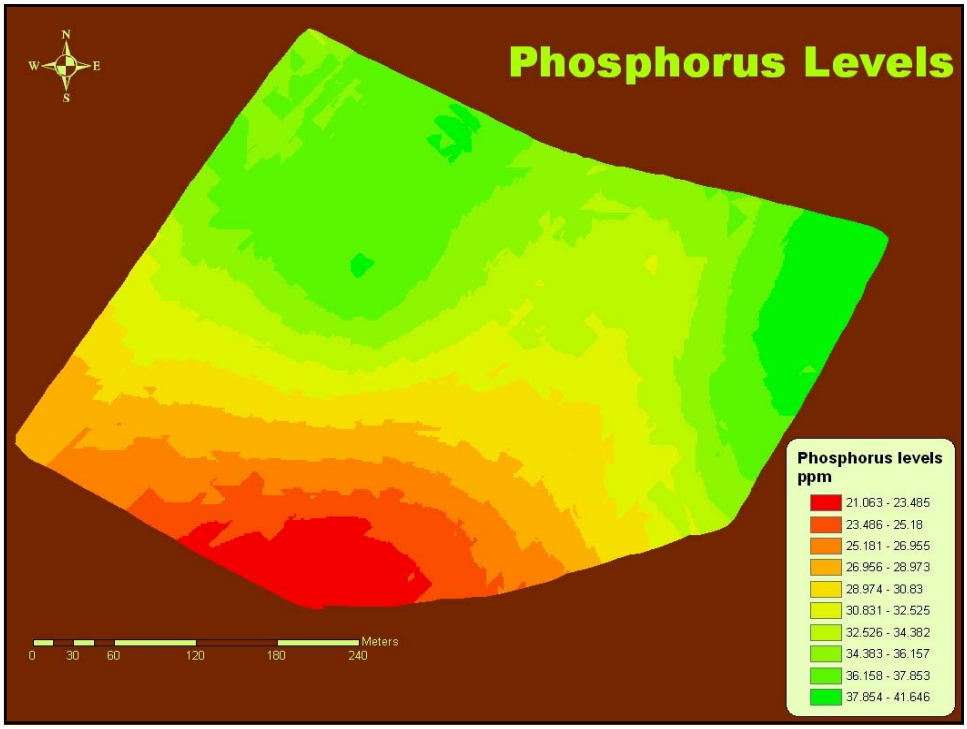
No Multicollinearity

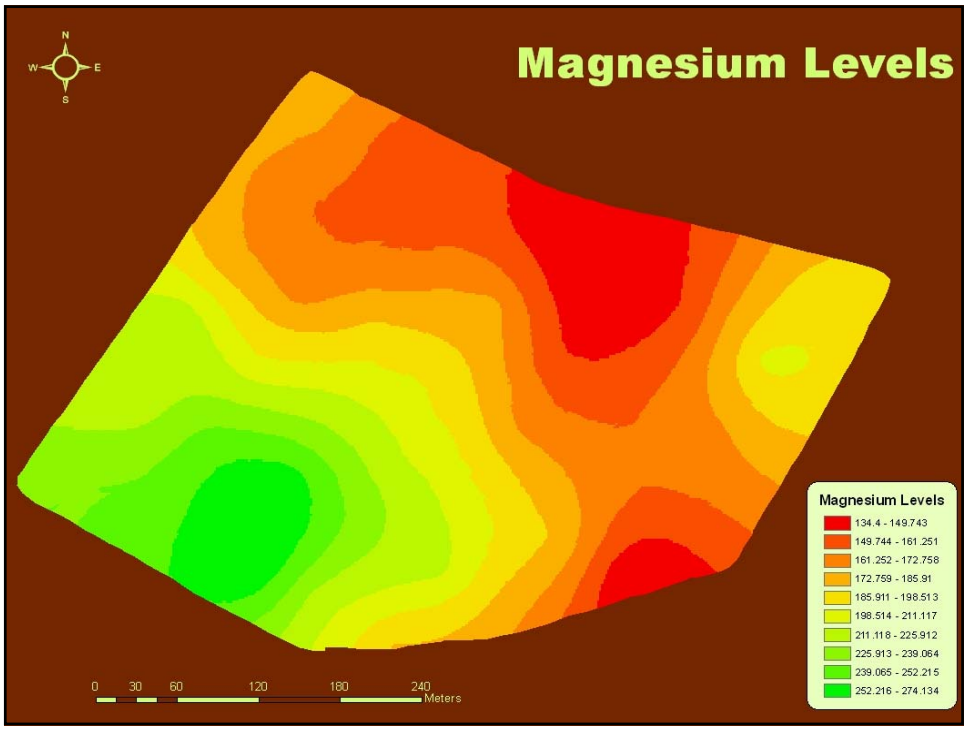
	Collinearity Statistics	
	Tolerance	VIF
(Constant)		
P_bray	0.584	1.714
K	0.500	2.000
Mg	0.187	5.358
pH_Buff	0.557	1.794
Ca	0.227	4.404
S	0.358	2.789
B	0.293	3.413
Fe	0.126	7.921
Mn	0.423	2.367
Zn	0.197	5.070
Cap2	0.333	3.001

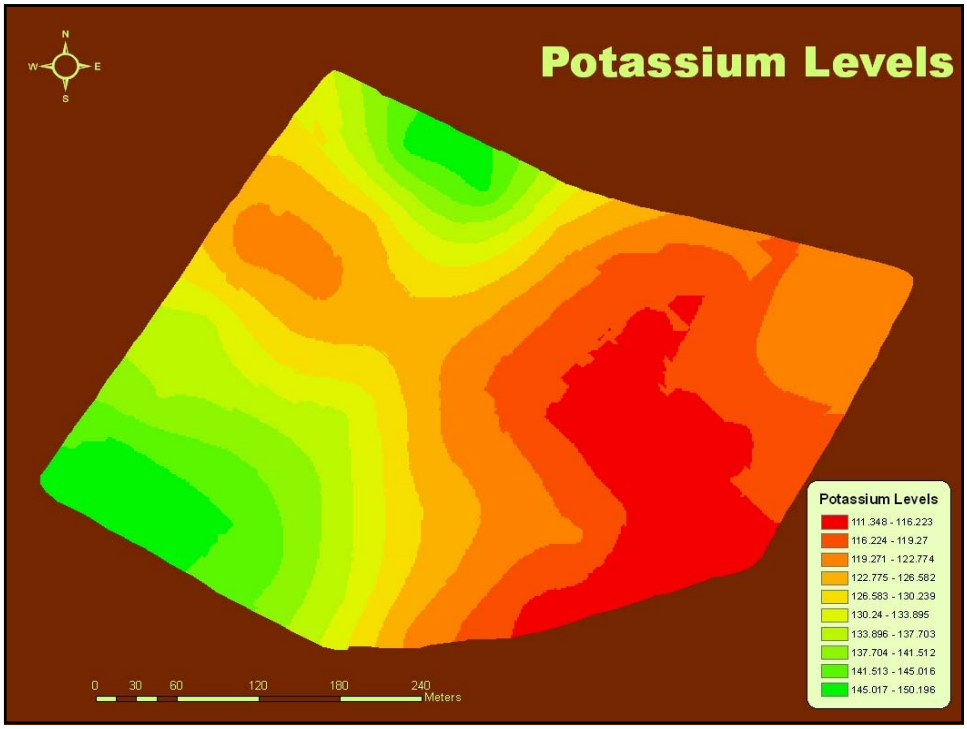
Overlay Analysis

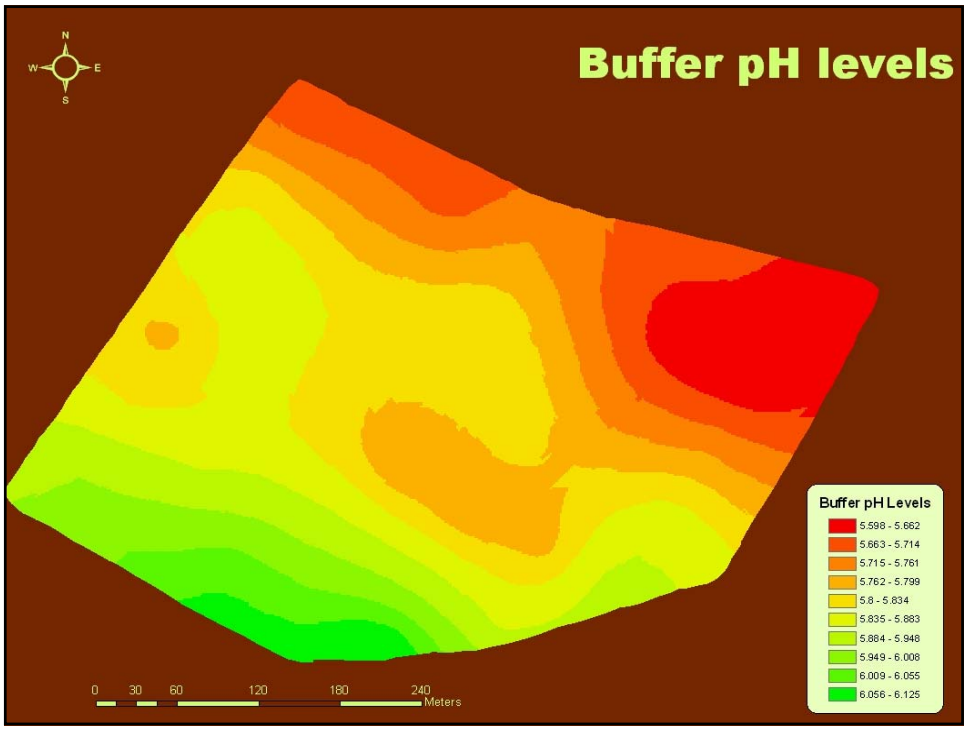
Kriging Interpolation → Reclassification → Binary Grid Overlay

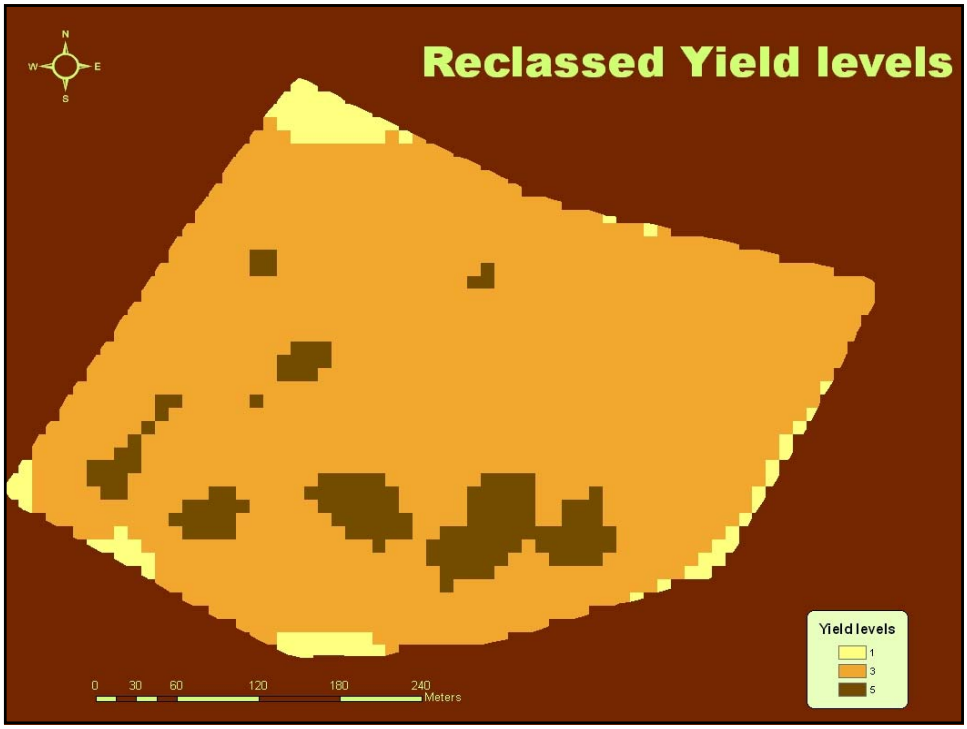



Phosphorus Levels
N
W
E
S
Meters
0 30 60 120 180 240
Phosphorus levels ppm
21.063 - 23.485
23.486 - 25.18
25.181 - 26.955
26.956 - 28.973
28.974 - 30.83
30.831 - 32.525
32.526 - 34.382
34.383 - 36.157
36.158 - 37.853
37.854 - 41.646

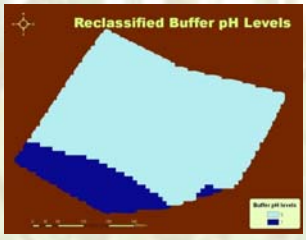

Magnesium Levels
N
W
E
S
0 30 60 120 180 240
Meters
Magnesium Levels
134.4 - 149.743
149.744 - 161.251
161.252 - 172.758
172.759 - 185.91
185.911 - 198.513
198.514 - 211.117
211.118 - 225.912
225.913 - 239.064
239.065 - 252.215
252.216 - 274.134

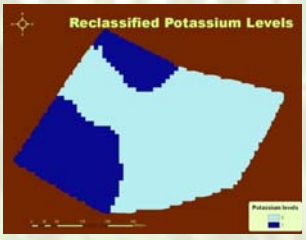

Potassium Levels
N
W
E
S
0 30 60 120 180 240
Meters
Potassium Levels
111.348 - 116.223
116.224 - 119.27
119.271 - 122.774
122.775 - 126.582
126.583 - 130.239
130.24 - 133.895
133.896 - 137.703
137.704 - 141.512
141.513 - 145.016
145.017 - 150.196

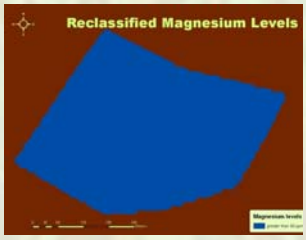

Buffer pH levels
N
W
E
S
0 30 60 120 180 240
Meters
Buffer pH Levels
5.598 - 5.662
5.663 - 5.714
5.715 - 5.761
5.762 - 5.799
5.8 - 5.834
5.835 - 5.883
5.884 - 5.948
5.949 - 6.008
6.009 - 6.055
6.056 - 6.125

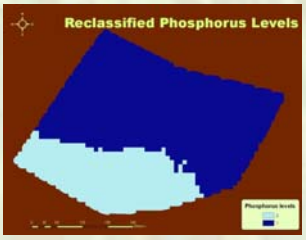


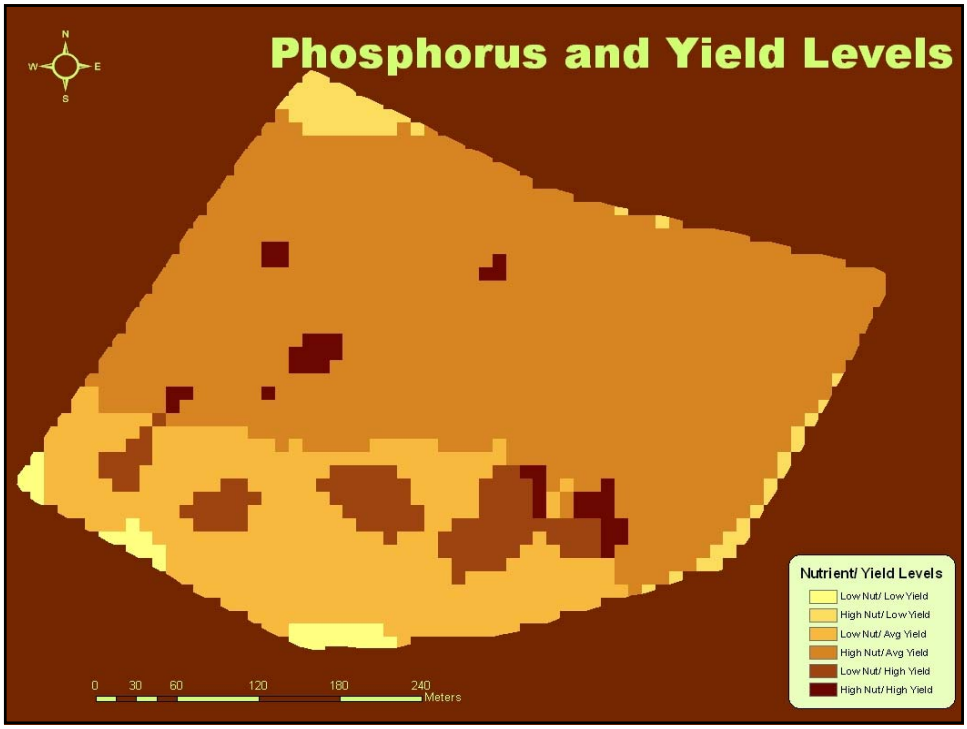
Reclassified Nutrient Levels

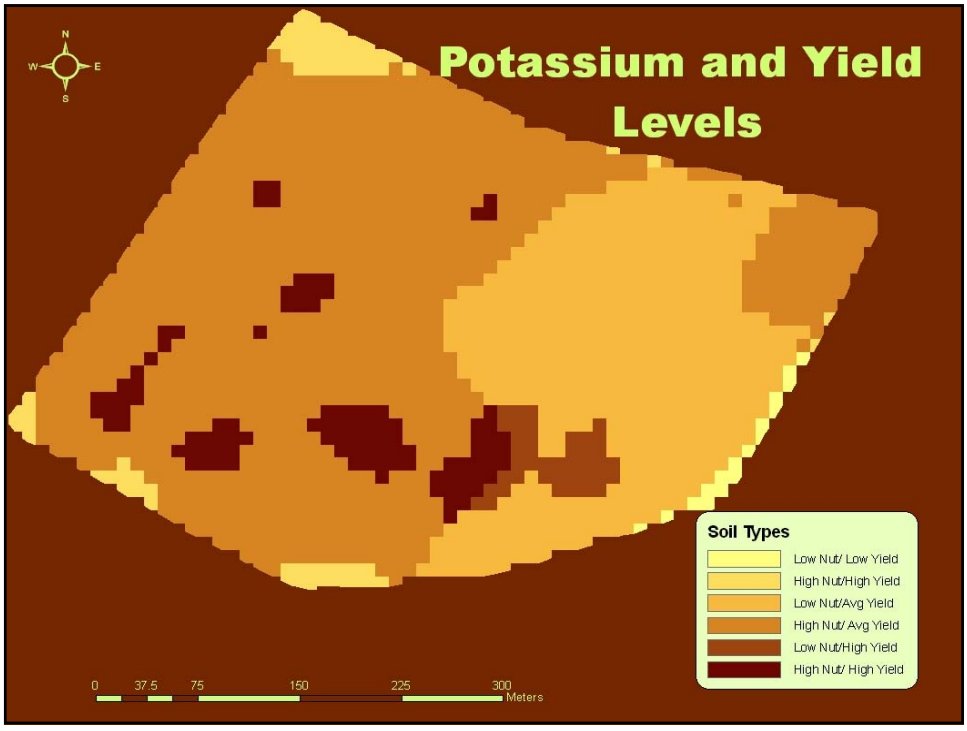


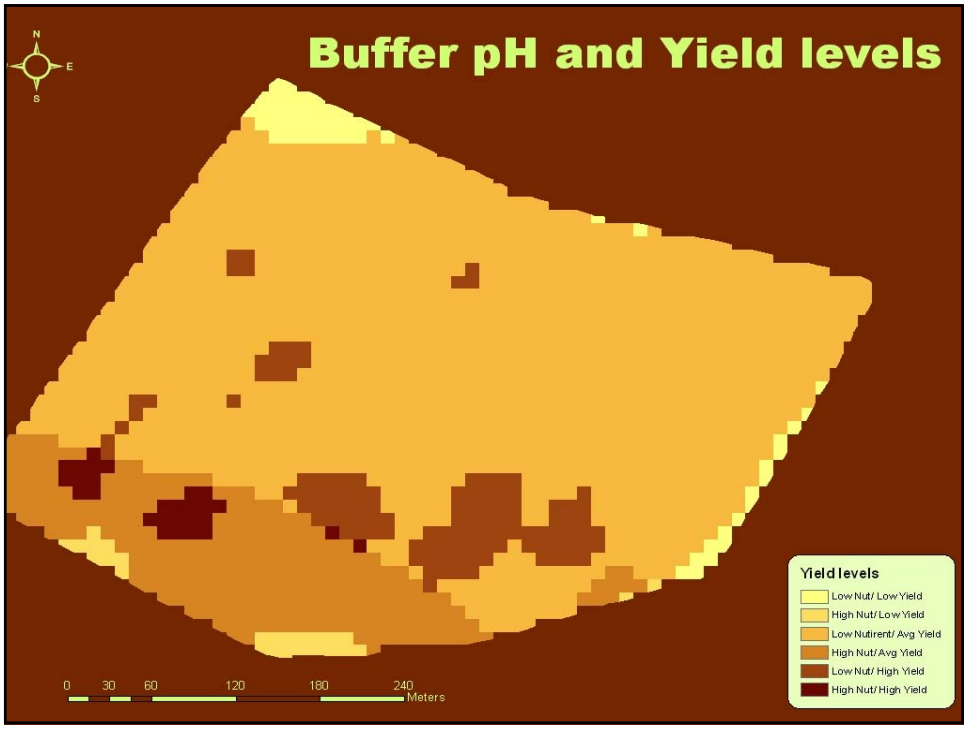


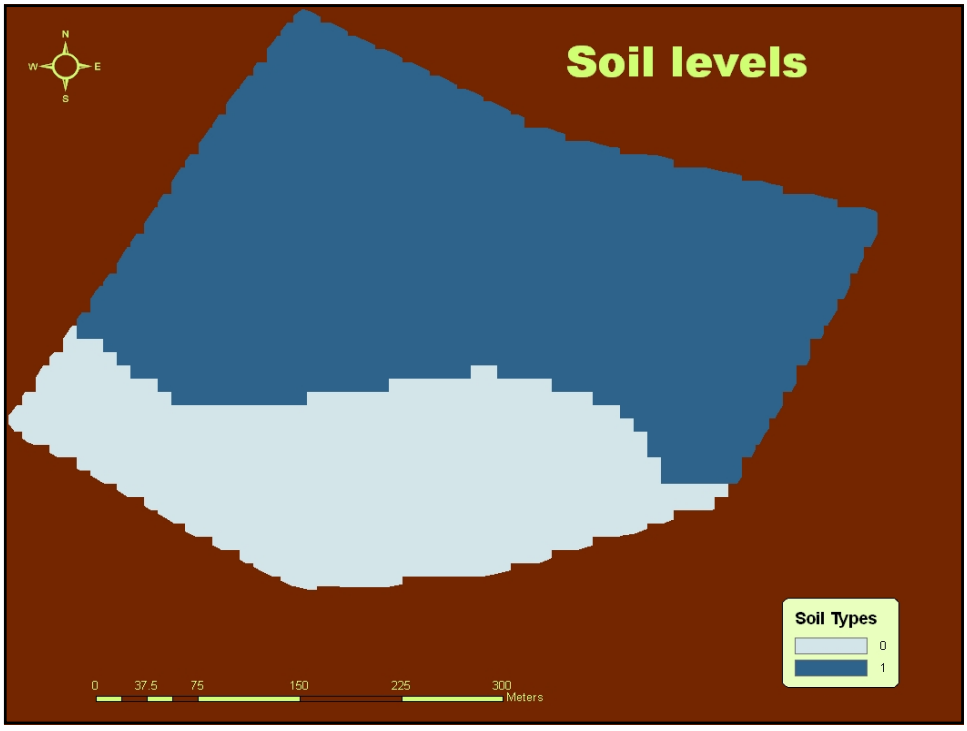


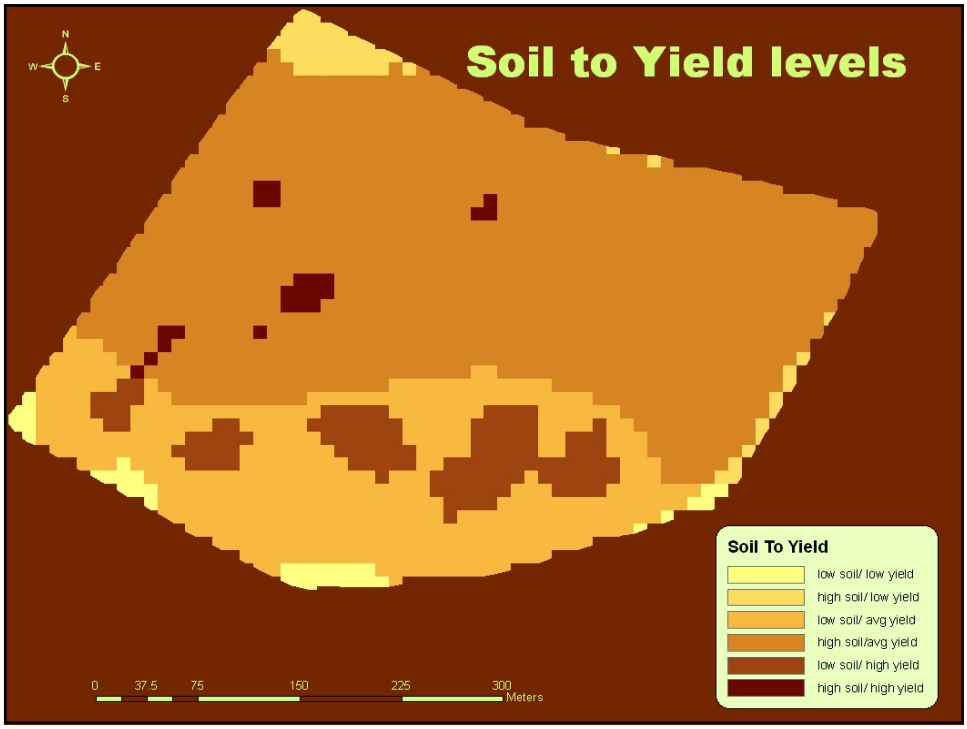


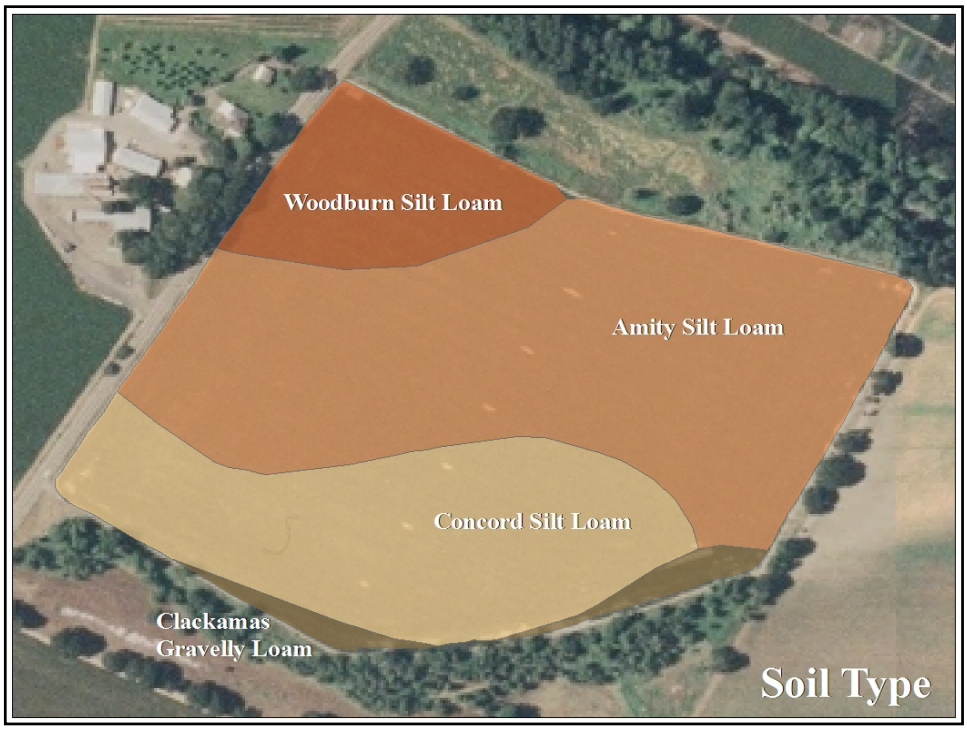

Phosphorus and Yield Levels
N
W
E
S
Nutrient/ Yield Levels
Low Nut/ Low Yield
High Nut/ Low Yield
Low Nut/ Avg Yield
High Nut/ Avg Yield
Low Nut/ High Yield
High Nut/ High Yield
0 30 60 120 180 240
Meters


Potassium and Yield Levels
N
W
E
S
Soil Types
Low Nut/ Low Yield
High Nut/High Yield
Low Nut/Avg Yield
High Nut/ Avg Yield
Low Nut/High Yield
High Nut/ High Yield
0 37.5 75 150 225 300
Meters


Buffer pH and Yield levels
N
E
S
Yield levels
Low Nut/ Low Yield
High Nut/ Low Yield
Low Nutirent/ Avg Yield
High Nut/ Avg Yield
Low Nut/ High Yield
High Nut/ High Yield
0 30 60 120 180 240
Meters


Soil levels
N
W
E
S
Soil Types
0
1
0 37.5 75 150 225 300
Meters


Soil to Yield levels
N
W
E
S
Soil To Yield
low soil/ low yield
high soil/ low yield
low soil/ avg yield
high soil/avg yield
low soil/ high yield
high soil/ high yield
0
37.5
75
150
225
300
Meters


Woodburn Silt Loam
Amity Silt Loam
Concord Silt Loam
Clackamas
Gravelly Loam
Soil Type

LIMITATIONS

- The grower applied a variable rate application of fertilizer to the field after soil analysis and prior to harvest.
- An additional combine was used in the field, which did not contain a yield monitor.
- There was no correlation between nutrient levels and yield distribution.

CONCLUSIONS

- Nutrient levels may not be directly related to yield.
  - Management practices & pest activity also affect yield.
- Understanding relationship between yield and nutrient levels in your field, may decrease nutrient inputs.

RESOURCES

- Hedstrom K.E. 2005. Introducing Geographic Information Systems to Grass Seed Growers in the Willamette Valley of Oregon. Master's thesis, Oregon State University.
- NRCS. 2006. Marion County Soil Survey: Irrigated and Non-irrigated Yields by Map Unit Component. USDA: NRCS.
- Hart, J.M, Mellbye, M.E., Horneck, D.A., Gingrich, G.A., Young III, W.C., Silberstein, T.B. 2005. Western Oregon Fertilizer Guide: Perennial Ryegrass Grown for Seed. Oregon State University Extension Service.
- NRCS Web Soil Survey http://websoilsurvey.nrcs.usda.gov/app/

Thank You