Numeric Assessment of Soil Mapping Value (Error Evaluation)

Viacheslav Adamchuk
Biological Systems Engineering

David Marx
Biometry

University of Nebraska-Lincoln

Mark Morgan
Agricultural and Biological Engineering
Purdue University

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"The sensing of soil variability is probably the most important step in site-specific management. Without accurate maps, varying application rates are no more appropriate than an average, uniform rate. Obtaining this descriptive information about a field is expensive using today's techniques."

(Schueller et al., 1993)

How accurate are soil maps?
What crops?
What soil properties?
What mapping technique?
What fields?

Soil Mapping Concepts

- Manual soil sampling with laboratory analysis (grid sampling)
  - FME is a single grid cell
- Adaptive soil sampling with laboratory analysis
  - FME is an area of the field (zone)
- Automated on-the-go mapping
  - FME is a fixed area determined by at least one measurement

FME – Finite Management Element

Automated Soil Mapping Systems

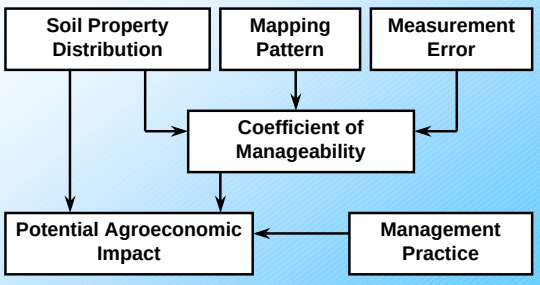
Soil pH Mapping

Mechanical Soil Resistance Mapping

Value of Soil Map

- The value of soil maps can be defined as the difference between an estimate of economic performance when the optimum management strategy is applied to the same conditions using soil maps and using the alternative conventional estimate (field average)
- Misrepresentation of the true soil conditions results in a penalty

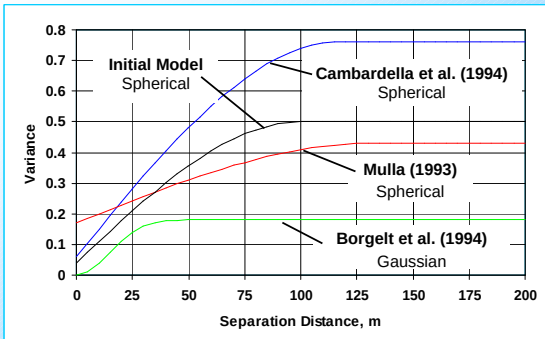
Comprehensive Numeric Model



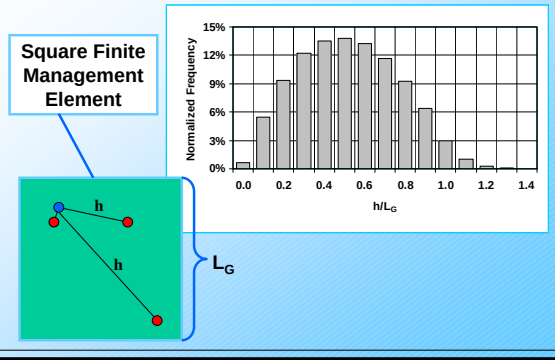
Objectives

- Develop a methodology for estimating the amount of soil variability that is manageable
- Apply these methods to compare different strategies of soil pH mapping
- Use obtained estimate in the comprehensive numerical model (agroeconomic analysis)

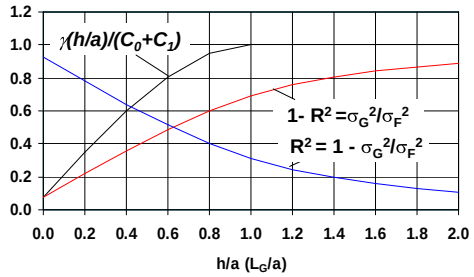
Semivariogram



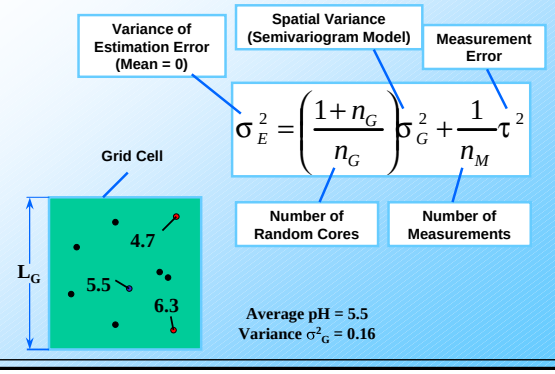
Point-to-point Separation Distances



Variance within a Square FME



Estimation Error



$$\sigma_E^2 = \left(\frac{1+n_G}{n_G}\right)\sigma_G^2 + \frac{1}{n_M}\tau^2$$

Coefficient of Manageability

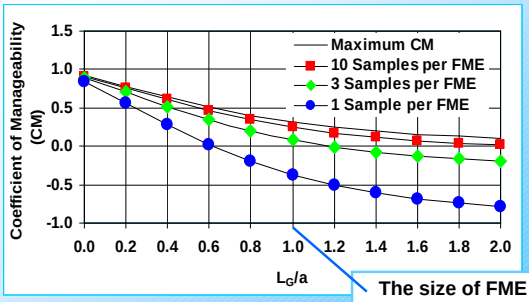
$$CM = 1 - \frac{\sigma_E^2}{\sigma_F^2}$$

Estimation Error Variance

Field Variance

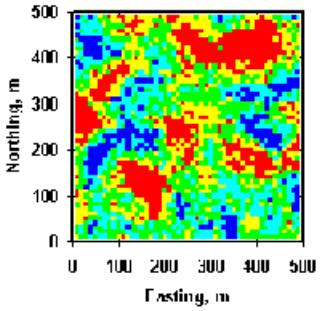
CM = 1	when the true value of a soil property is known at each point (impossible case)
CM = -1	a single random sample from the entire field is analyzed without measurement error (worst case)

Coefficient of Manageability



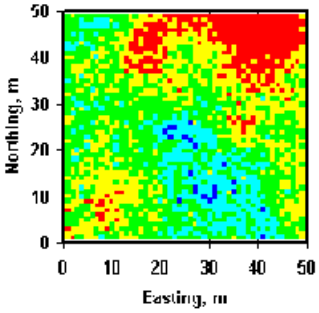
The size of FME equal to the range

Simulated 25 ha Field



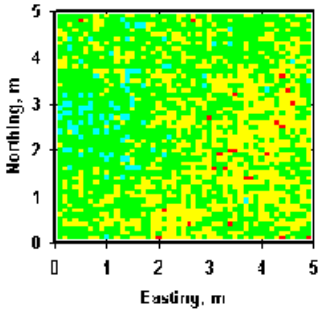
$\mu_F = 6.1$
$\sigma_F^2 = 0.50$
$CV = 12\%$

Simulated 0.25 ha Field



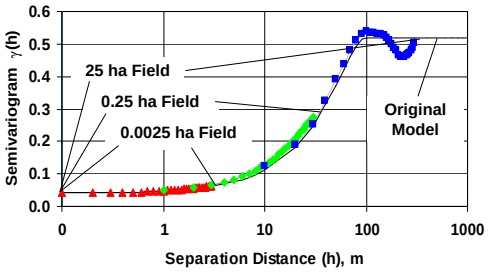
$\mu_F = 6.0$
$\sigma_F^2 = 0.23$
$CV = 8\%$

Simulated 0.0025 ha Field

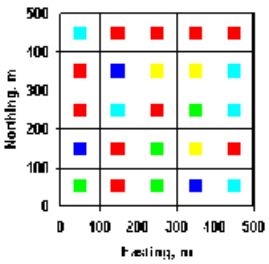


$\mu_F = 6.1$
$\sigma_F^2 = 0.06$
$CV = 4\%$

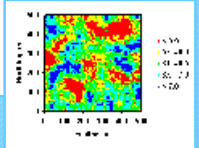
Semivariogram of the Simulated Fields



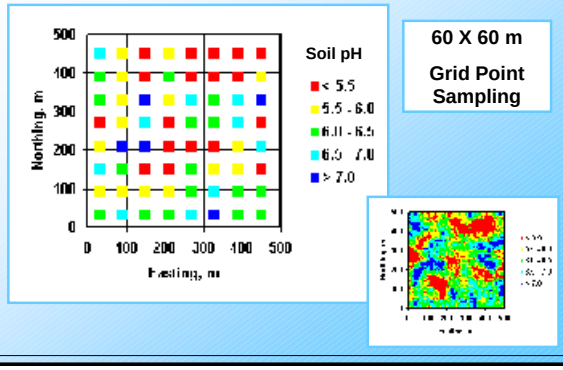
Simulated 25 ha Field



100 X 100 m
Grid Point Sampling



Simulated 25 ha Field



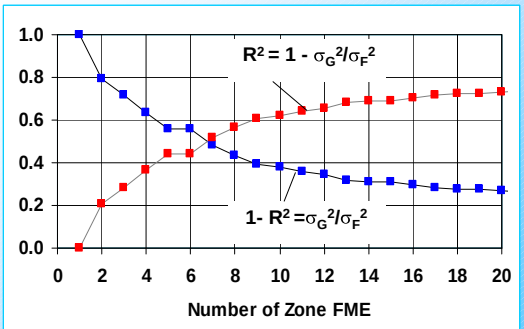
60 X 60 m

Grid Point Sampling

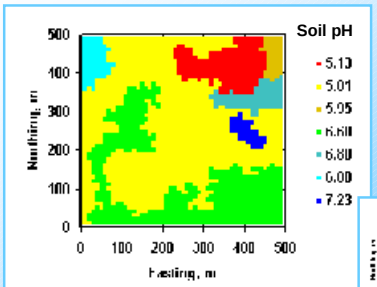
Defining Zone FMEs

1. Assign each data point to a separate FME
2. Define easting and northing neighbor for each point (if possible)
3. Calculate the sum of squared errors (SSE) as the squared difference between each point and the average of corresponding FME
4. Accept the merge resulting in the smallest SSE
5. Compute R^2 after combining two FMEs
6. Repeat steps 3-5
7. Define the appropriate number of zone FMEs (minimum acceptable R^2)

Zone FME Classification



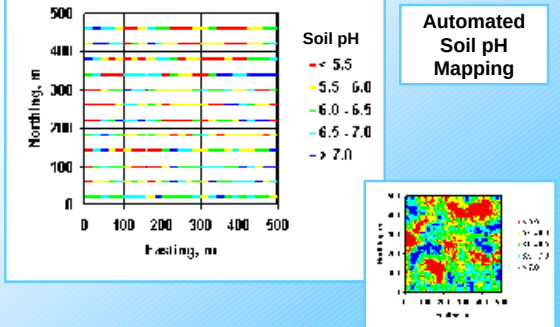
Simulated 25 ha Field



7 Zone FMEs

R^2 = 0.51

Simulated 25 ha Field



Automated Soil pH Mapping

Comparison between Different Mapping Practices

Mapping Practice	Calculated		Simulation Study	
	σ_E^2	CM	σ_E^2	CM
100x100 m (1 ha) manual grid	0.76	-0.45	0.57	-0.10
60x60 m (0.36 ha) manual grid	0.55	-0.05	0.37	0.28
7 zone FMEs (3.4 ha on average)	0.38	0.28	0.43	0.17
40x40 m (0.16 ha) automated grid	0.33	0.37	0.23	0.57
Whole field (25 ha)	0.69	-0.33	0.65	-0.26

Conclusions

- The presented analysis technique provides a method for using geostatistical field parameters to determine the manageability of a soil property
- The derived coefficient of manageability will be one of the key components for future numeric analysis of the potential agroeconomic impact
- Alternatives to manual grid soil sampling, such as automated mapping or zone finite management elements, are expected to achieve significantly lower mapping errors

Main Questions

- What soil mapping method is the most appropriate for a particular site?
- What site conditions would actually justify “the most appropriate soil mapping method”?
- The comprehensive numeric model will give the answer (if asked correctly).

http://bse.unl.edu/adamchuk
E:mail: vadamchuk2@unl.edu