

AGRO 896/ MSYM 898 Understanding and Managing Variability in Soils

Lecture 2: Sources and scales of variability

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Objectives:

1. Define spatial and temporal variability.
2. Understand the major natural and management-induced factors that cause spatial and temporal variability of soil and their properties at different scales.
3. Understand the key characteristics of spatial variability of soil properties in agricultural productions.

Content:

1. *What is variability?*

- Values can change because of changes in one or more underlying factors
- In space: spatial variability
 - i. Lateral: from place to place, across different scales
 - ii. Vertical: across depth
- In time: temporal variability
- In space and time: spatio-temporal variability
- Values can also change randomly because of error in the measurement

2. *What causes spatial and temporal variability of soil properties?*

- Natural factors related to soil formation (Jenny, 1941):
Soil = f (c, o, r, p, t)
c: climate
o: organisms (plants, microbes, insects, animals)
r: relief (topography)
p: parent material
t: time
- Management-induced variability (humans):
Land use (cropping systems, field boundaries)
Old roads, farmsteads, etc.
Earth movement (land leveling, terraces)
Tillage & traffic
Planting patterns (e.g., in row crops)
Fertilizer application, other amendments (lime, manure)
Irrigation & salinity
Crop nutrient removal (yield and crop residue management)
- Examples

Soil carbon content in the continental USA
Soil forming factors and soil distribution in Nebraska
Causes of field-scale variability: spatial and temporal variability of soil properties and crop growth

3. What are key characteristics of spatial variation of soil properties within a field?

- Systematic variation: structured changes in soil properties as a function of known causes (soil-forming factors and management). Can be modeled quantitatively and stochastically.
- Random variation: unstructured short-distance or microvariability which cannot be resolved with the sampling method chosen or for which we cannot establish clear causes. Includes sampling and analytical error. Can only be modeled stochastically.
- Spatial variation is **attribute-specific**: Soils must be described in terms of measurable morphological, chemical, physical, or biological attributes. Each of these features may exhibit another type of spatial variation in the same field, depending on the predominant factors that cause the variability. Relatively stable (static) soil properties tend to have different spatial structure than more dynamic soil properties..
- Spatial variation is **scale-specific**: soils vary continuously from megascopic to microscopic levels of resolution, and there is no homogeneity at all. Even seemingly random variation has its causes. The spatial variability revealed depends on the particular scale and sampling scheme chosen.
- Spatial variation is **site-specific**: soil forming factors and management impacts are highly diverse and site-specific. Information obtained from one area cannot be transferred to presumably ‘similar’ areas without thorough verification.
- Spatial variation is **method-specific**: variations in sample processing and laboratory methods affect how much variability is revealed.
- Spatial variation is **time-specific**: some soil properties change quickly over time, others changes slowly. Spatial patterns at one time might be different from spatial patterns at another time, for example when management changes.

4. Summary: implications for sampling and management

- Soils and their properties vary in space in time due to natural processes and management.
- Climate, land use/vegetation, topography, parent material, and time are the major determinants of regional soil variation.
- At the field scale, naturally occurring (systematic) soil variation is modified by short- and long-term effects of soil and crop management. This causes much short-distance or microvariability (both ‘systematic’ and seemingly ‘random’).
- Spatial variability is attribute-, scale-, site-, method-, and time-specific. Results obtained for one field cannot be easily transferred to another field.
- To assess spatial variability for site-specific management, soils must be sampled at the appropriate time, depth, and spatial density. Sampling schemes must provide a good compromise for all soil properties of interest.

Advanced reading materials

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