

A History of Grid Sampling/Zone Sampling

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In this room we are all connected with soil and plant analysis and we understand that an important component of soil/plant analysis and its use to predict crop nutrient need and/or soil deficiency or toxicity is the sample that comes to the lab.

In order to map crop nutrient status over an entire field, a sampling method must be used that captures the variability at a cost acceptable to the farmer.

Outline of presentation

- Early grid sampling work**
- Evolution of grid sampling strategies**
- The development of zone sampling**
- The choice of grid or zone methods**



Cyril Hopkins- "Wheat from Stones" about 1910, Illinois Exp Sta Bull.

METHODS OF APPLYING LIME



TRADE BULLETIN NUMBER 186
NATIONAL LIME ASSOCIATION
WASHINGTON, D. C.



TEST YOUR SOIL FOR ACIDITY

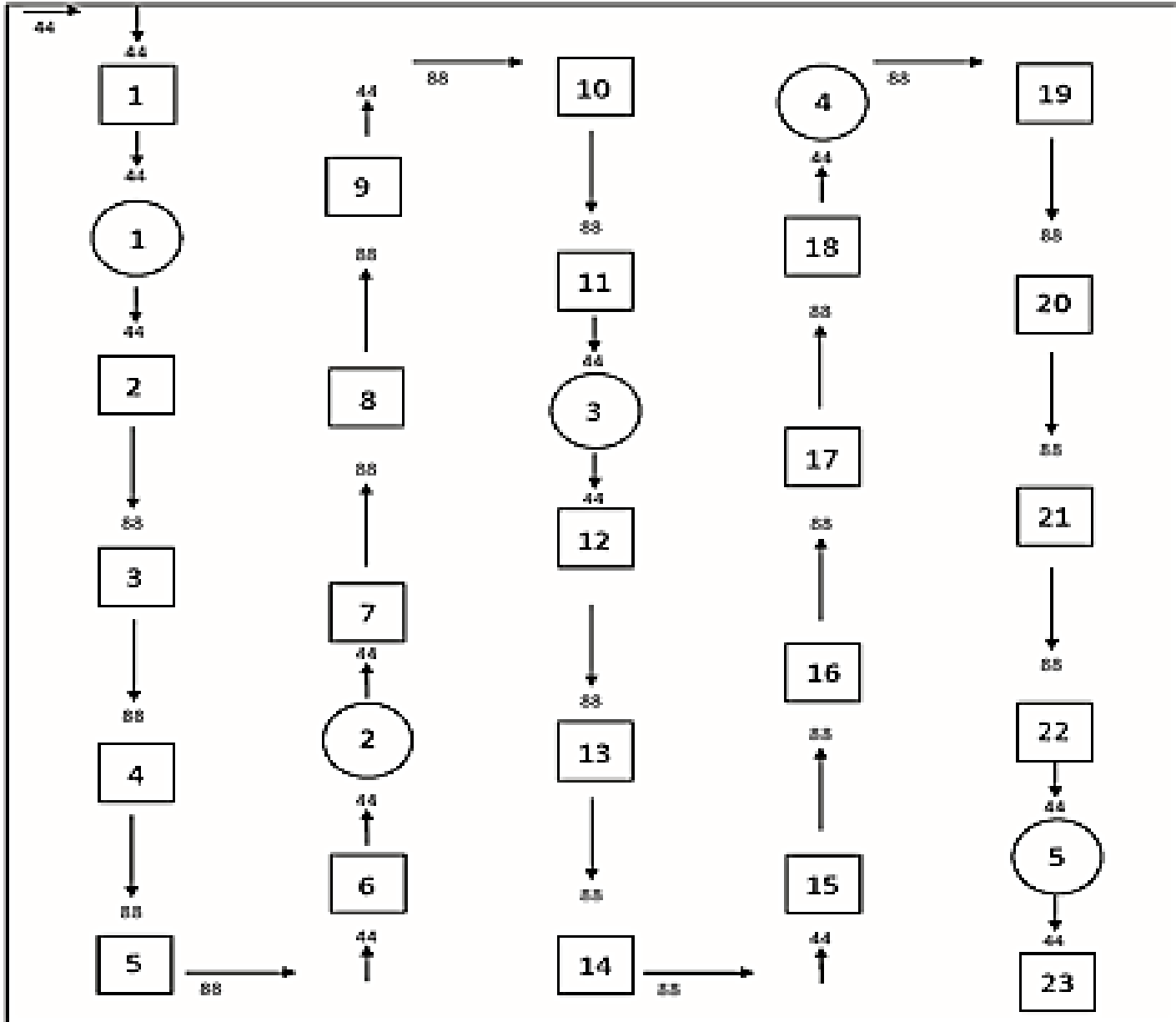
By C. M. LINSLEY AND
F. C. BAUER

THE
NOV 29 1929
UNIVERSITY OF ILLINOIS

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University of Illinois
College of Agriculture and Agricultural Experiment Station
Circular 346



~1 sample per 1.4 acre, 1929 Linsley & Bauer University of Illinois Circular 346

Recommended sampling strategy for a 40 acre square field.

Rectangles are for 0-6 inch cores, and circles denote locations for a deeper, 0-2 foot core.

The '44' or '88' designations are for steps between sampling points, because that was the only reasonably efficient location producer at the time.

In the 1920's-1930's it was probably easier to grid sample and treat only deficient areas than to apply lime to whole fields.

The use of large amounts of N/P/K fertilizer was not used until into the 1950's.

After WWII, machines were efficient enough loading, spreading that it was easier to apply lime to whole fields rather than spend time/effort grid sampling.

Lime application, 1949



With larger machinery, soil sampling consisted of 'composite' sampling to provide one value for each field.



Composite soil sampling strategies varied between regions-

Illinois strategy- 11 soil bags, each consisting of 3-5 cores from a 40-acre field. Analyzed as 11 soil samples.

The mean of the 11 soil sample values was used as the value on which the fertilizer rate was based.

The 11 samples were taken as a grid.

X

X

X

X

X

X

X

X

X

X

X

X	X	X	X
X	X	X	X
X	X	X	X
X	X	X	X

**After ~
1990- Illinois
2.5 acre
grid**

**FOR
COMPOSITE
VALUE**

Many states, including ND obtained 20-30 cores from entire field, mixed in a bucket and took out enough to fill a sample bag.

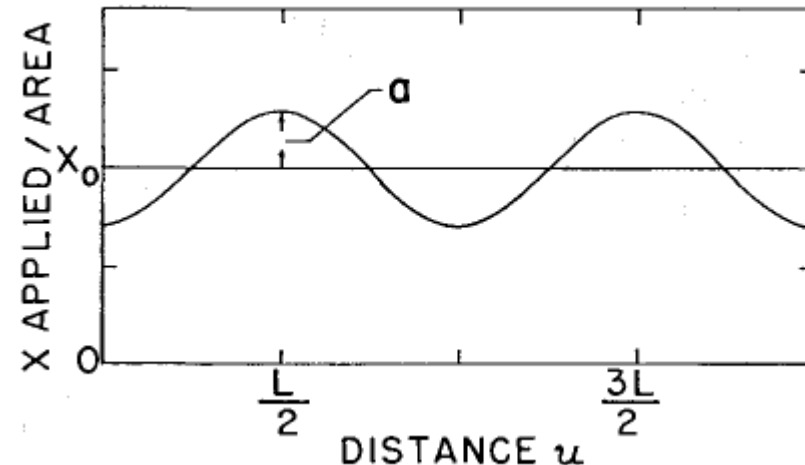
1 soil sample per field.

In the 1960's and 1970's some researchers recognized that within-field variability of crop nutrients may be significant

Some effort should be made to improve fertilizer application methods and sample to capture variability.

Jensen & Pesek, 1962 (rt)

James & Dow, 1972



**The most intensive soil sampling project was conducted by Melsted and Peck, University of Illinois
Sampling began 1961.**



Sig Melsted



Ted R. Peck

Mansfield- soil sampling dates-

**1961, 1976, 1982, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1994,
1999.**

Mansfield corn yield- 1991, 1993, 1999.

Mansfield soybean yield- 1992, 1994.

Thomasboro- soil sampling dates-

**1982, 1986, 1987, 1988, June and October 1989, 1990, 1991,
1992, 1994, 1995, 1999, 2001.**

Thomasboro corn yield- 1992, 1994, 1995, 1999.

Thomasboro soybean yield- 1996.

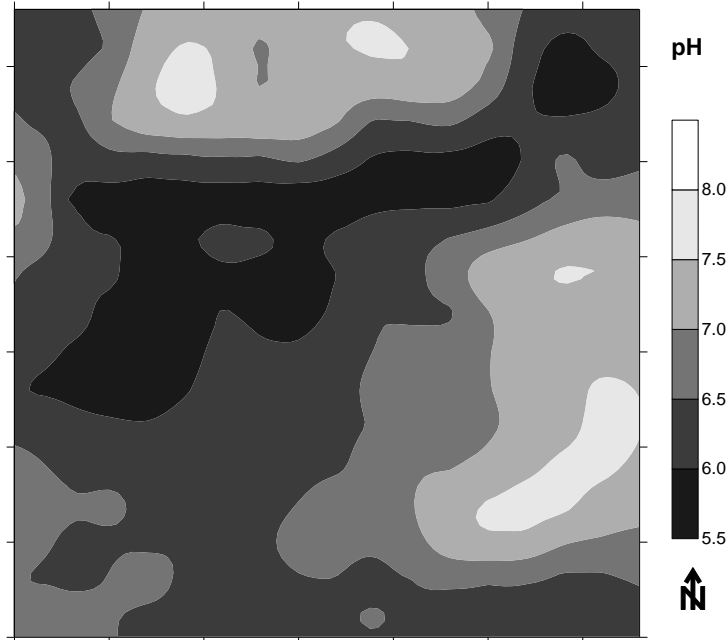
Each field was a square 40 acres.

Each was sampled in an 80 foot (5 rod) grid.

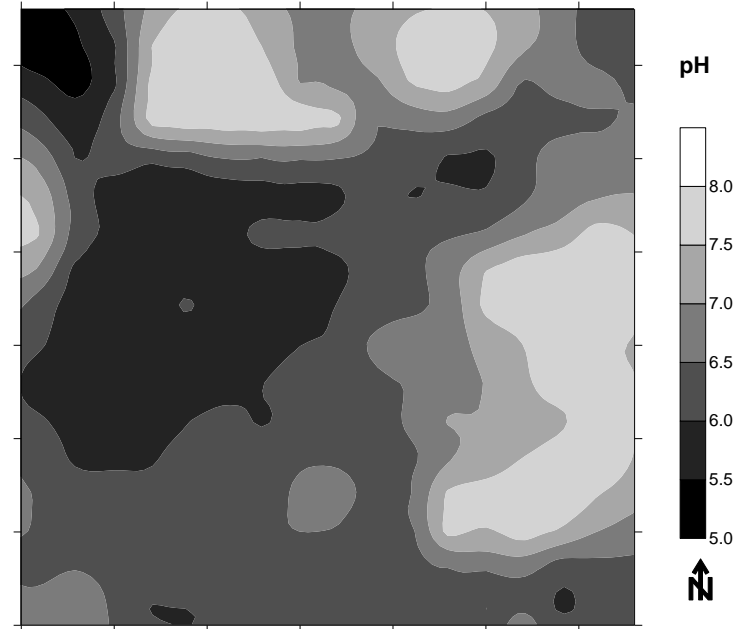
**16 samples X 16 samples 256 sampling locations
(Thomasboro had a building that took up 4 locations)**

Locations were determined using a tape measure

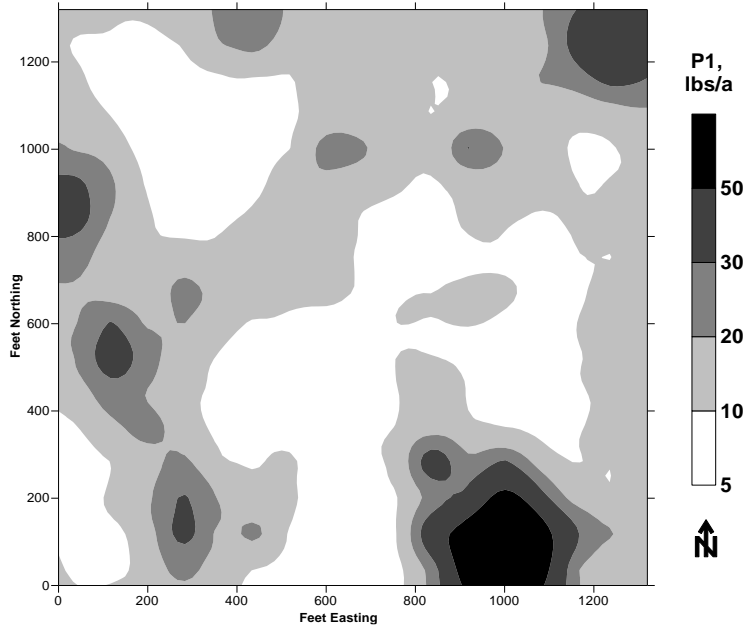
Soil pH, P and K patterns were persistent.



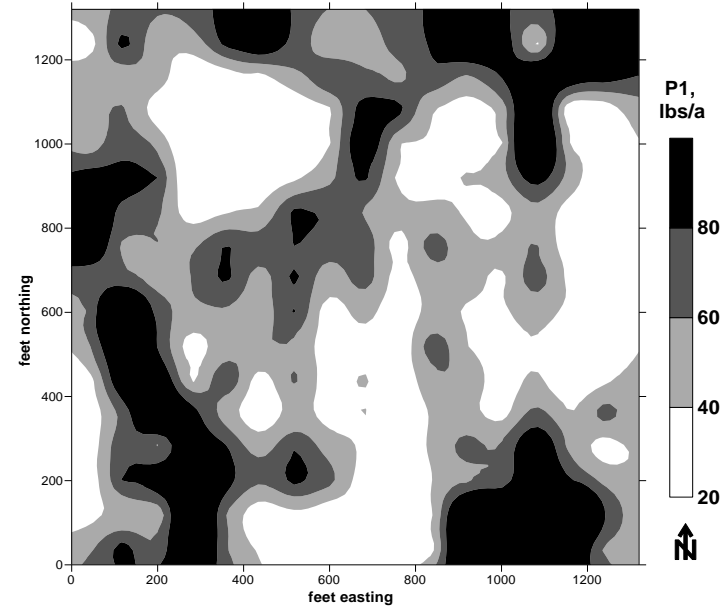
Mansfield, pH, 1961



Mansfield, pH, 1991



Thomasboro, P, 1982



Thomasboro, P, 1991

Buildup P and K applied 1982 to 1988, then no P and K 1989 on

At Mansfield,

5.4 lb/a P_2O_5 added = 1 lb/a increase in P1

7.9 lb P_2O_5 draw-down = decrease P1 test 1 lb/a.

6 lb/a K_2O to increase the K test 1 lb/a,

1.7 lb/a K_2O draw-down = decrease K test 1 lb/a.

At Thomasboro,

5.8 lb P_2O_5 added = 1 lb/a increase in the P1 test.

15 lb/a P_2O_5 draw-down = decrease P1 test 1 lb/a.

7.1 lb/a K_2O to increase the K test 1 lb/a,

3 lb/a K_2O draw-down = decrease the K test 1 lb/a.

Sampling density to reveal soil fertility patterns?

1 sample per acre

Location	Soil test	Sampling grid	
		330 ft	220 ft
			r^2
Mansfield	pH	0.292	0.484
	P	0.025	0.174
	K	0.029	0.166
Thomasboro	pH	0.208	0.261
	P	0.222	0.283
	K	0.166	0.345

In this early 1990's period, others also recommended 1 sample per acre.

Nebraska (Ferguson et al.)

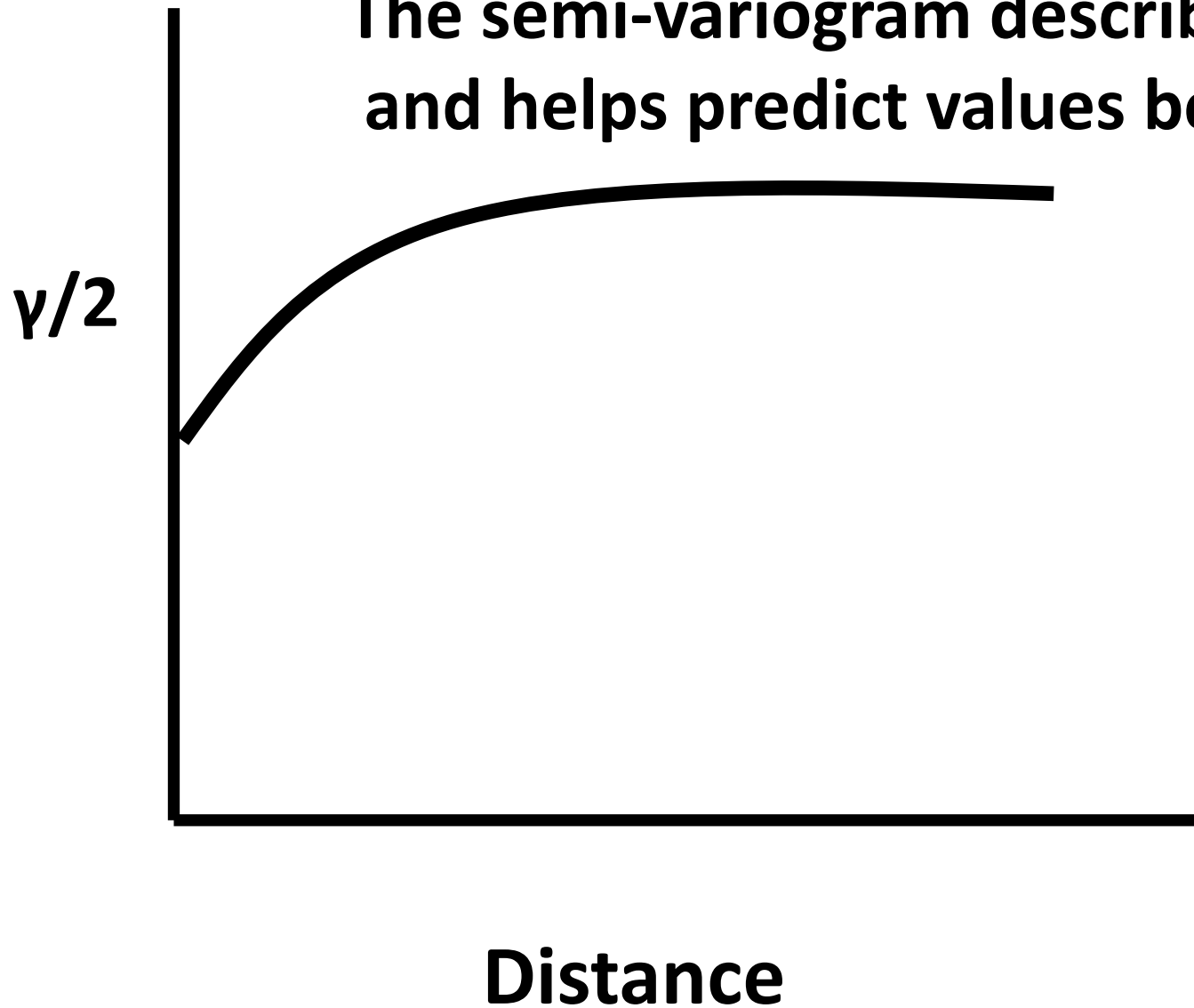
Wisconsin (Wollenhaupt et al.)

Sampling and mapping-

Needs to enough data to enable the application of kriging (30 samples per field at least)

Samples should be taken in a manner so that systematic errors are not woven into the map (like fertilizer overlap-underlap).

**The semi-variogram describes this relationship
and helps predict values between sampled locations.**



Systematic unaligned grid (Wollenhaupt)

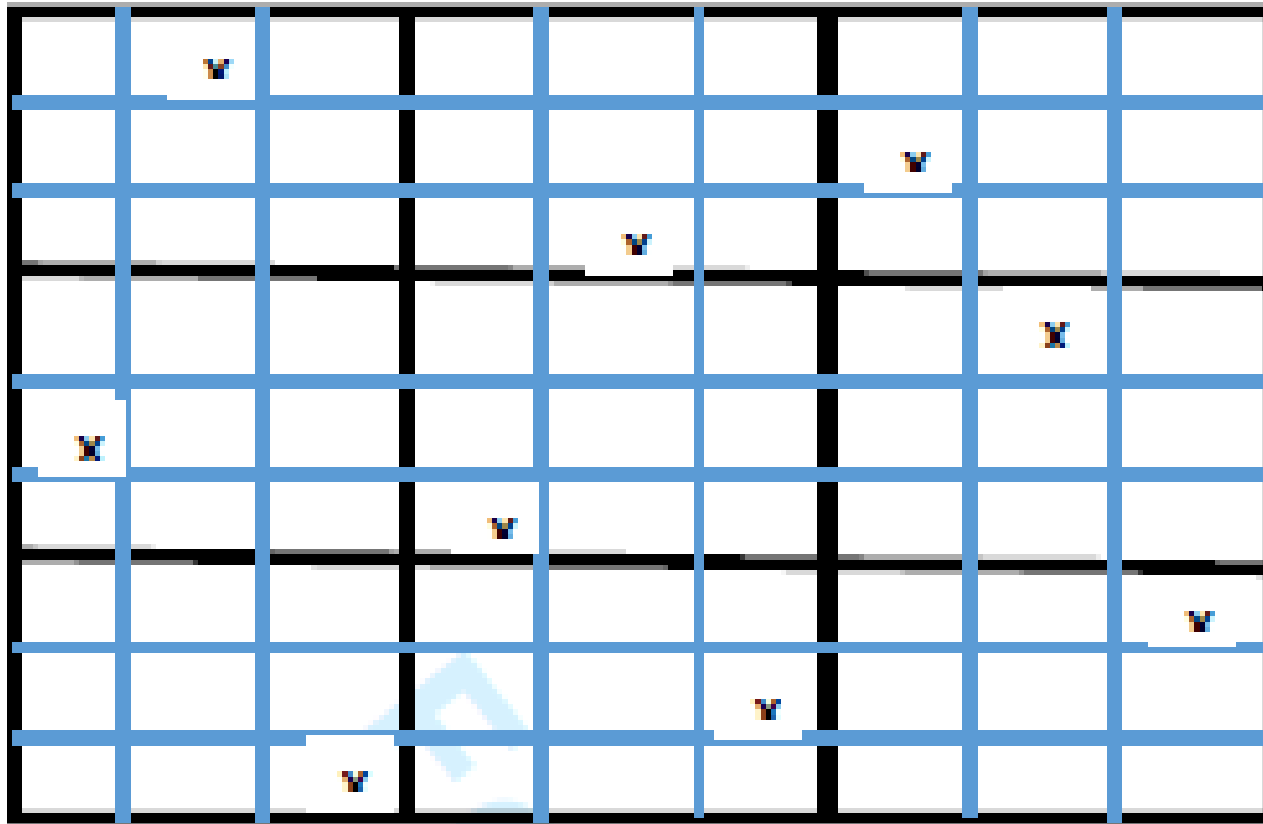


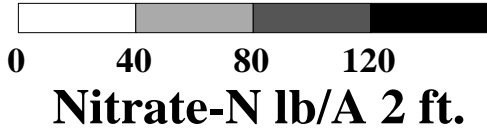
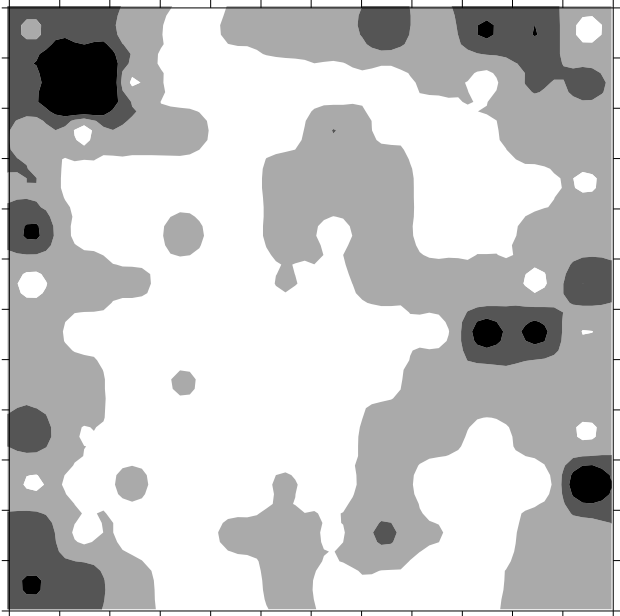
Figure 5. Systematic unaligned grid sampling example.

Minimizes systematic errors

Results in many value vs distance intervals for increased kriging equation predictions.

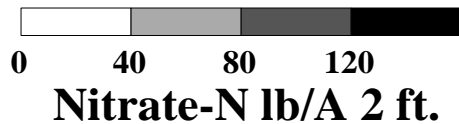
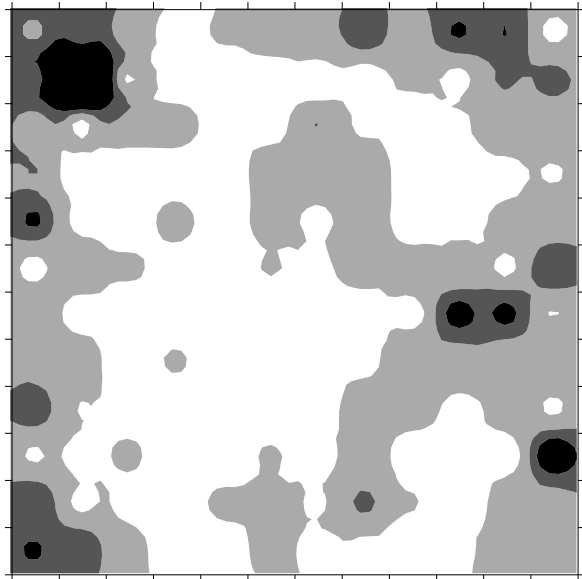
**In North Dakota, sampled fields at 110 foot grid-
144 samples per 40 acres- to 4 feet in depth**

1994

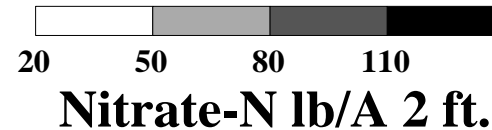
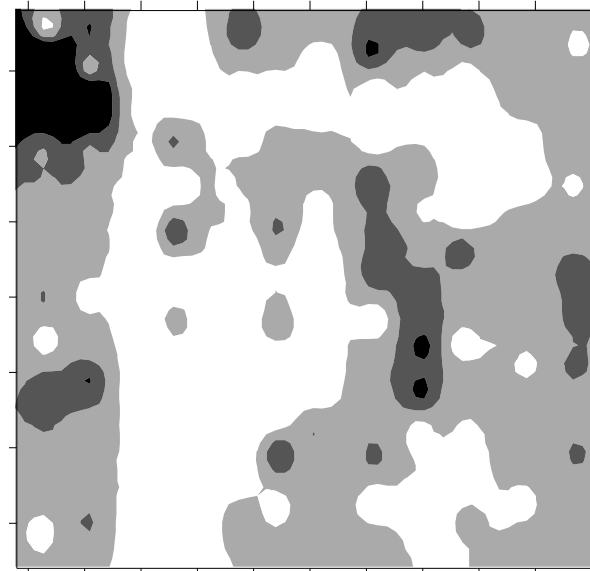


The second year, patterns of residual nitrate were similar to those of year 1.

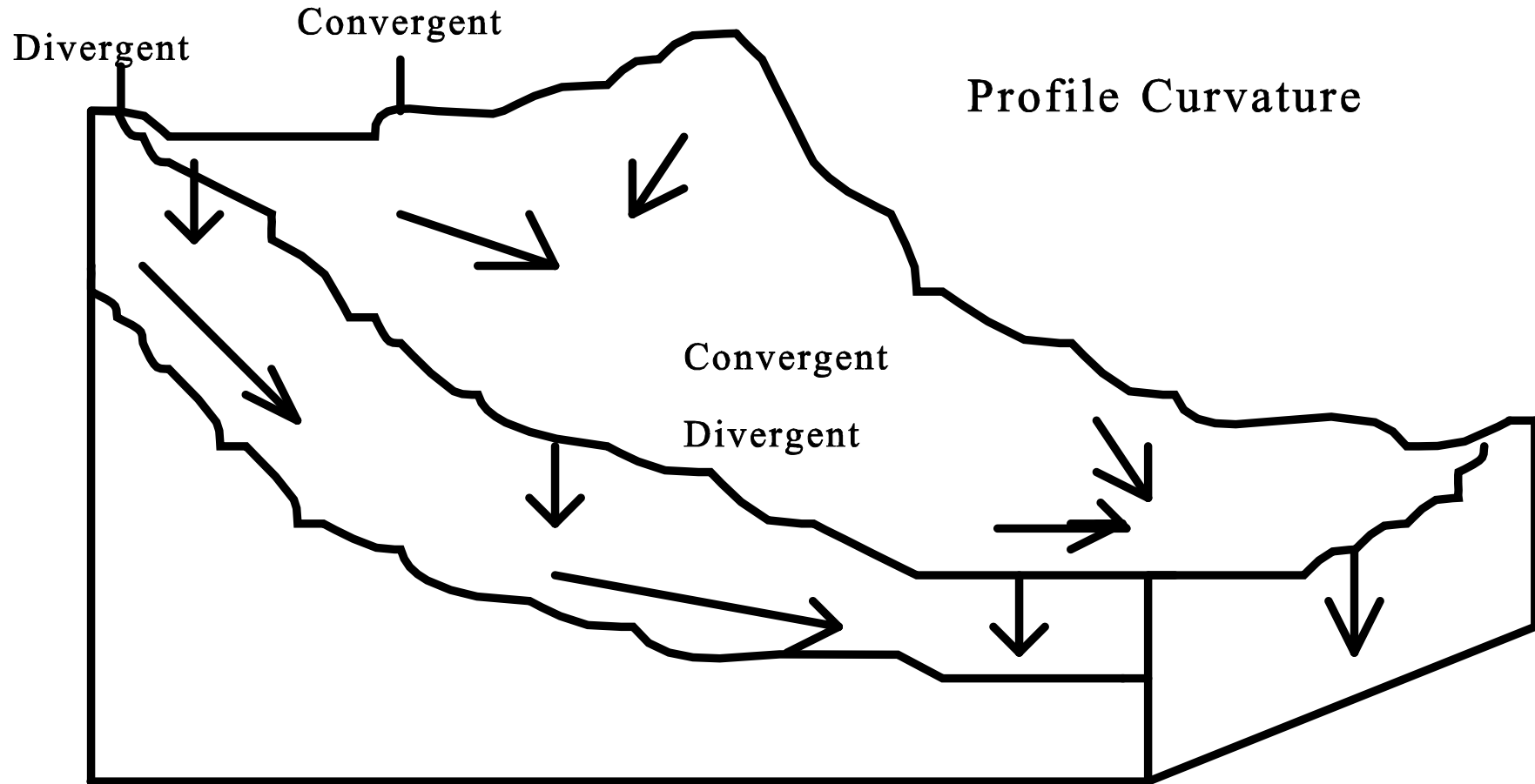
1994



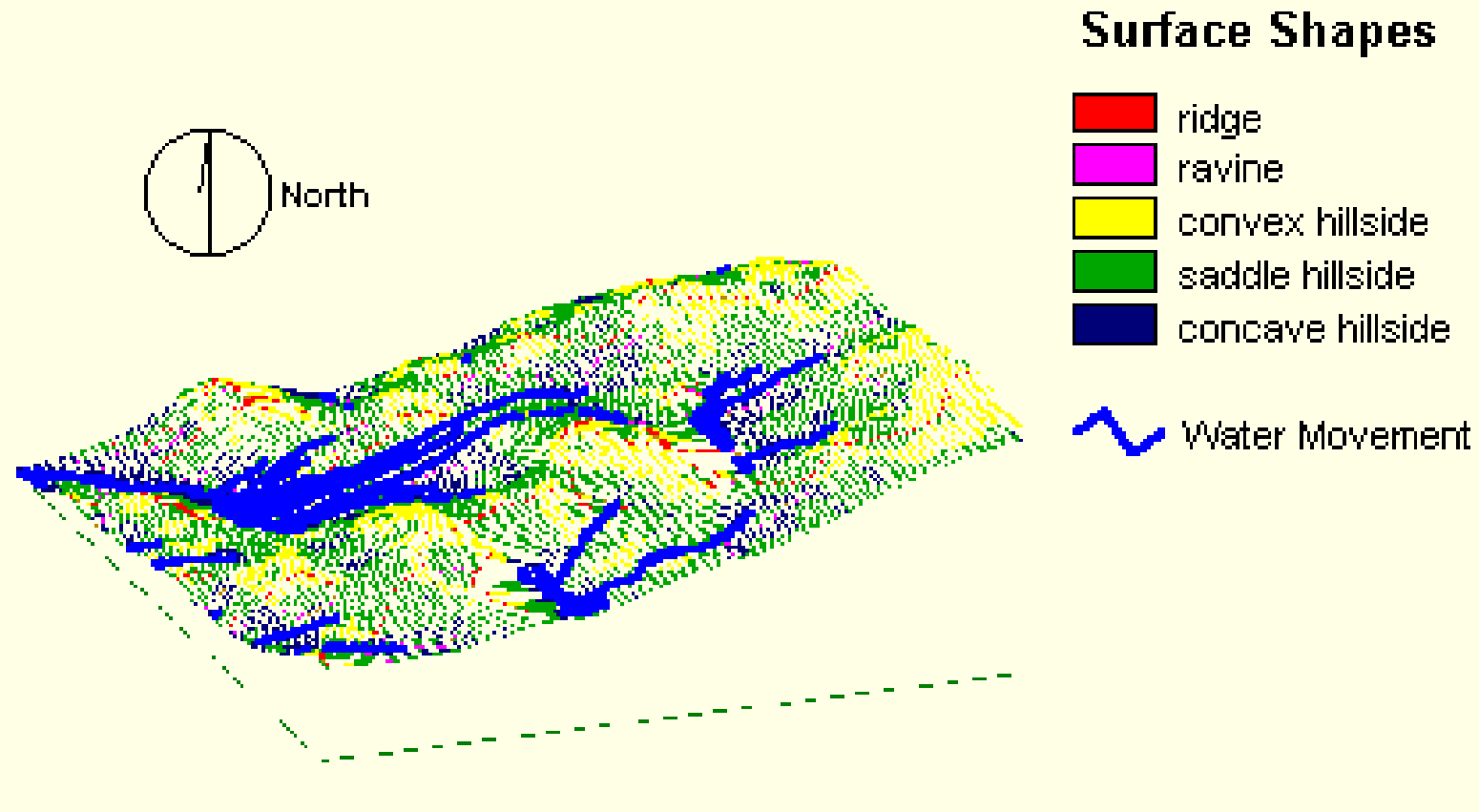
1995



TOPOGRAPHY



Terrain Shape and Water Movement



Similar idea to Pennock et al.
in Canadian papers.

Landform Classification and Soil Distribution in Hummocky Terrain, Saskatchewan, Canada

D.J. PENNOCK^{*1}, B.J. ZEBARTH and E. DE JONG

Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, Sask. (Canada)

Electrical conductivity



Electrical conductivity, EM-38



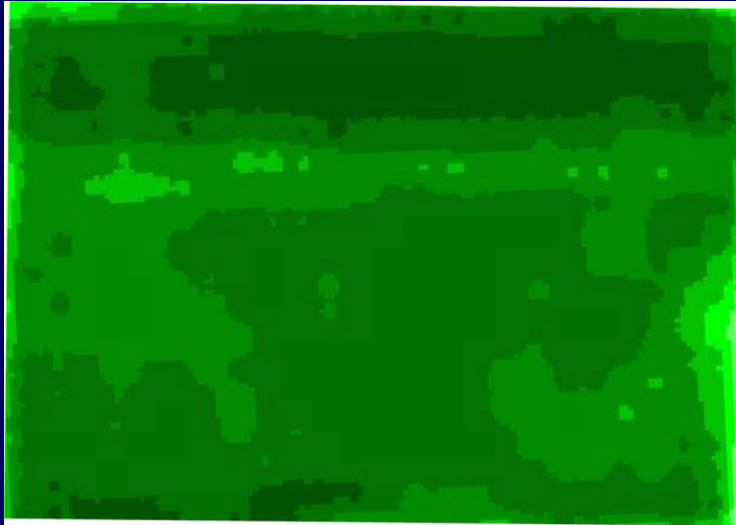
Geonics, Inc., Mississauga, ON

Remotely Sensed Images (RSI)

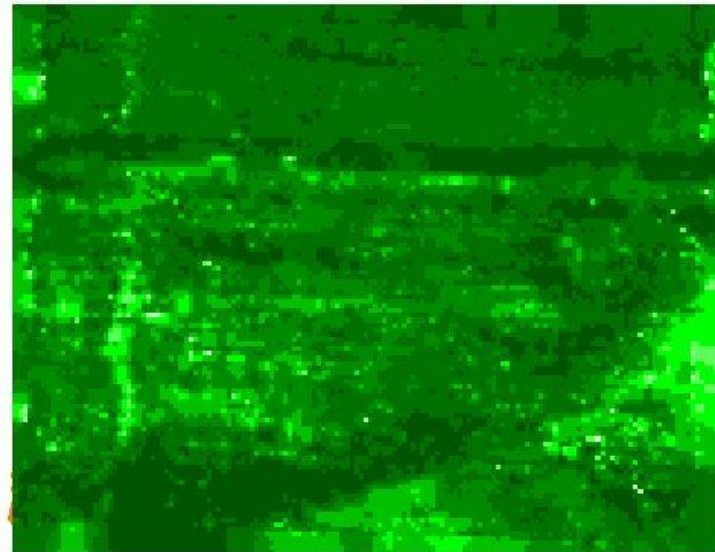
- Landsat 7 satellite pictures
- Aerial photos: Ektochrome color film.



Satellite

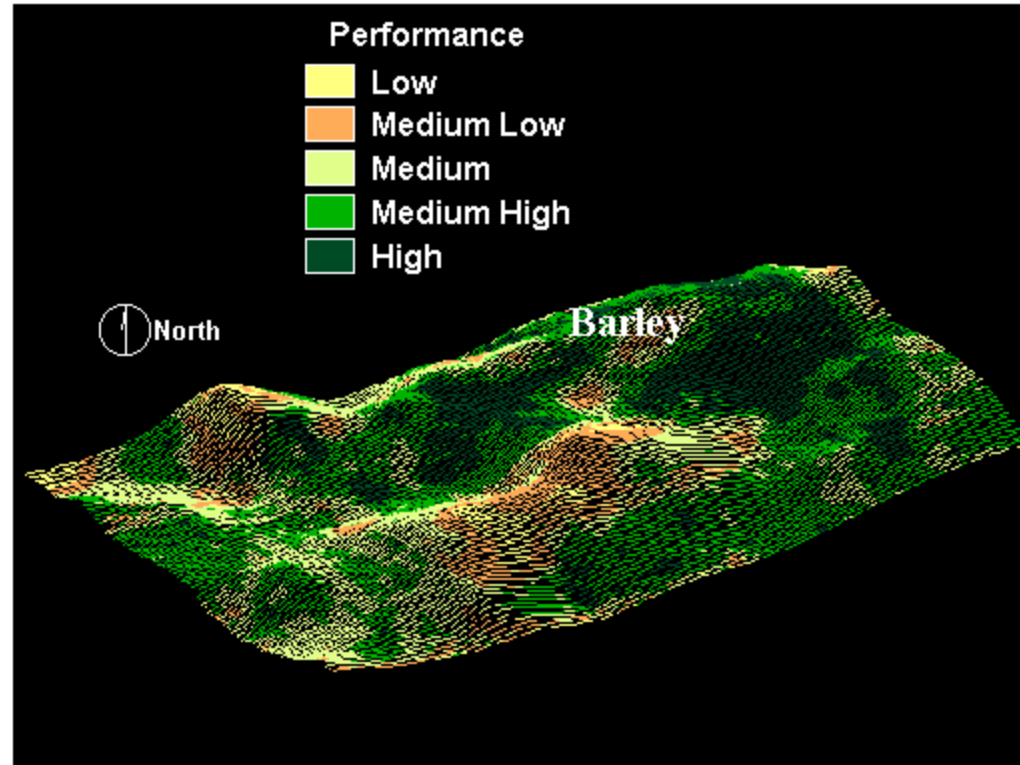


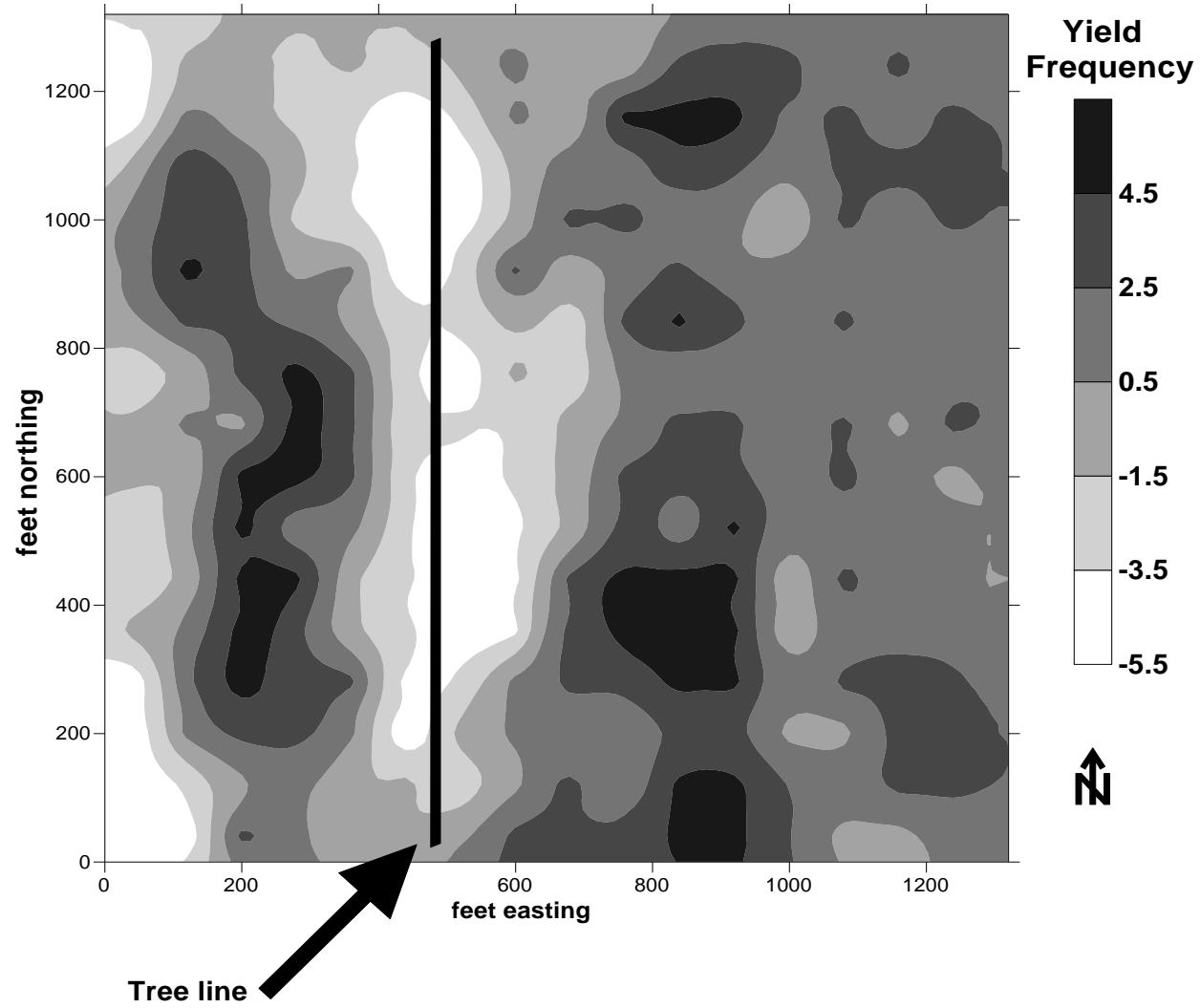
Greenseeker sensor



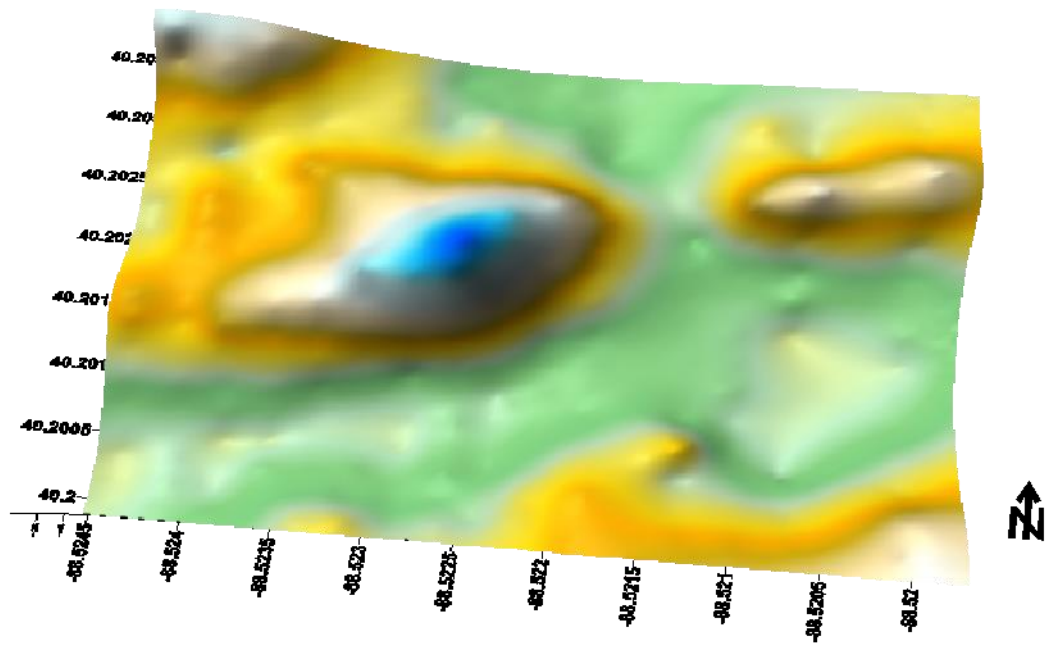
Yield

Valley City - Zones for Barley Yield (2001)





Yield frequency map, Thomasboro.



Layered and clustered EM and elevation data, Mansfield.

Zone sampling is a method of investigating patterns of nutrients and other soil factors within a field based on some logical, easy to measure effect, either natural or manmade.

Fields from Havre, MT to Renville, MN were sampled in a study using common protocol.

¼ acre grid sampling

EC with Veris (shallow/deep)

Multi-year yield mapping

Satellite imagery of growing crop

Topography

Zone sampling was superior to 2.5 grid in soil nitrate across the region.

EC was most helpful in the drier environments

Topography was helpful in all

Zone or grid in Iowa? (Mallarino & Wittry)

**Using a base sampling of ½ acre grids, compared
3-5 acre grid with zone approach for pH, OM, P and K.**

Grid method was superior for P.

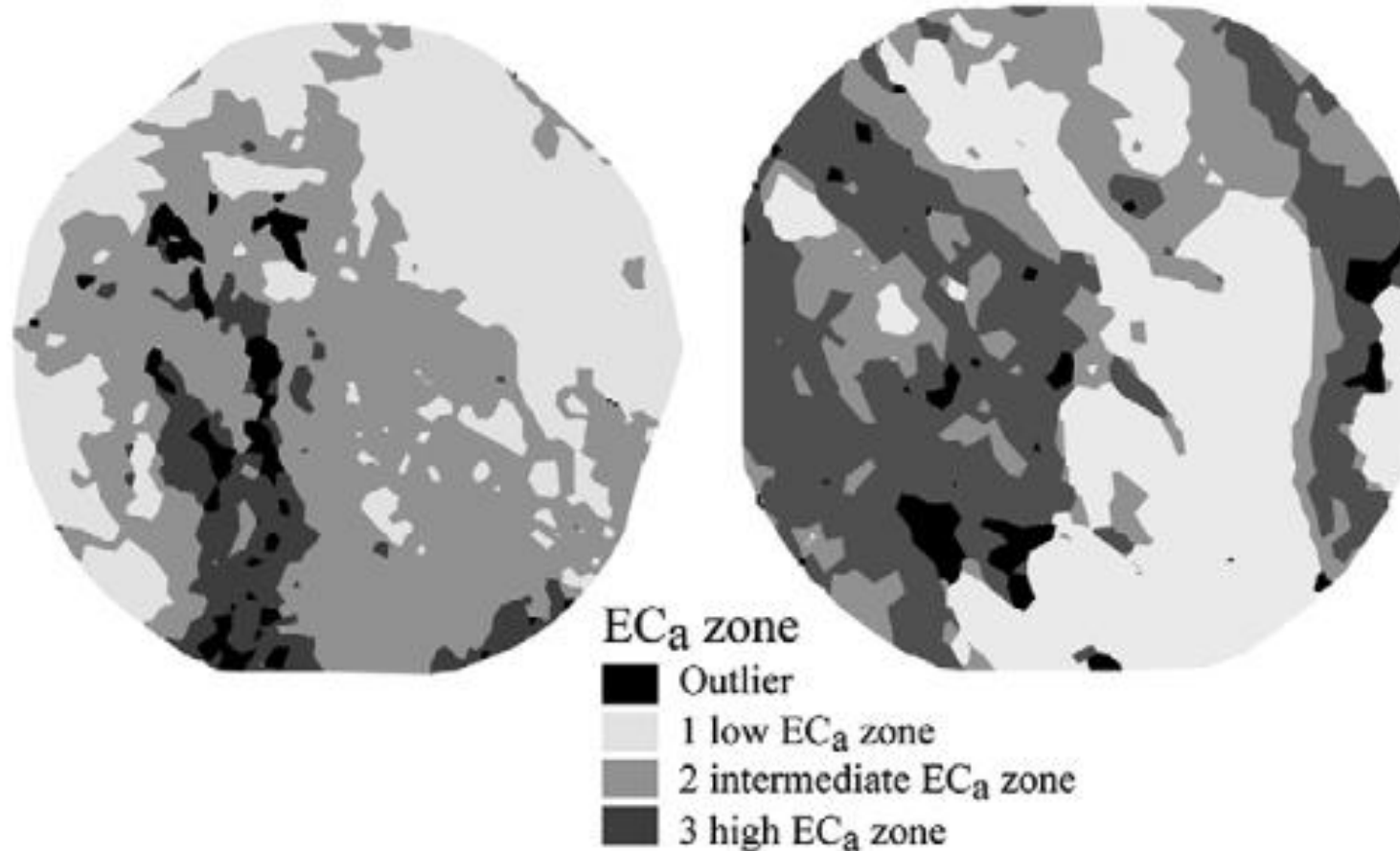
Zone method was similar to Grid for pH and K.

Zone method was superior for OM.

Khosla et al. studies in Colorado irrigated corn

Used EC (Veris), bare soil imagery, farmer input.

EC_a zones based on ECs and ECd patterns



What now?

In ND region, zone sampling continues to grow.

In 'I' states, grid sampling (2.5 acre) is dominant.

Knowledge of individual fields is a good guide to determine the best method to sample.

Thinking back on my days as agronomist for farmers in a 20 mile radius region, soil sampling every four years, there were several fields that would have benefited from a zone approach, and more in which the 2 ½ acre grid would have worked fine.

Degree of soil test buildup with fertilizer rates and natural 'lay of the land' would heavily influence any decision.

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