

Signal Processing Research in Precision Agriculture and Related Areas

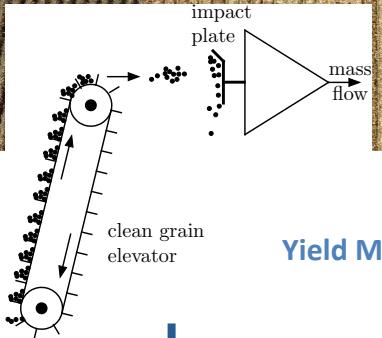
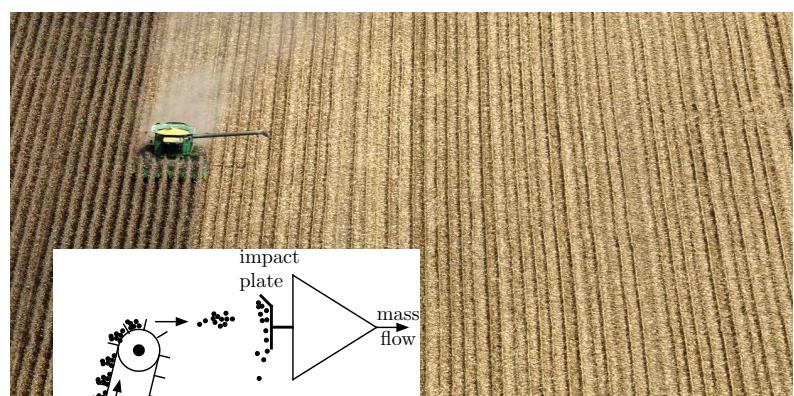
J. V. Krogmeier

The Open Ag Technology and Systems Center
Purdue University

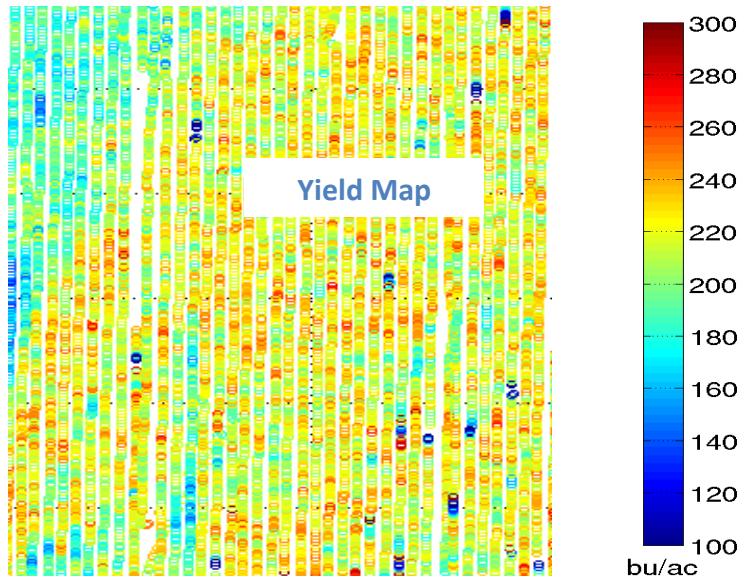
Today's Topics

- Yield maps.

Systems and Signals Examples



Yield Mass Flow Sensor



$$y(x, y)$$

$x \in \mathcal{R}$ (easting)
 $y \in \mathcal{R}$ (northing)

Determine the Management Zones from Multiple Years of Yield Data

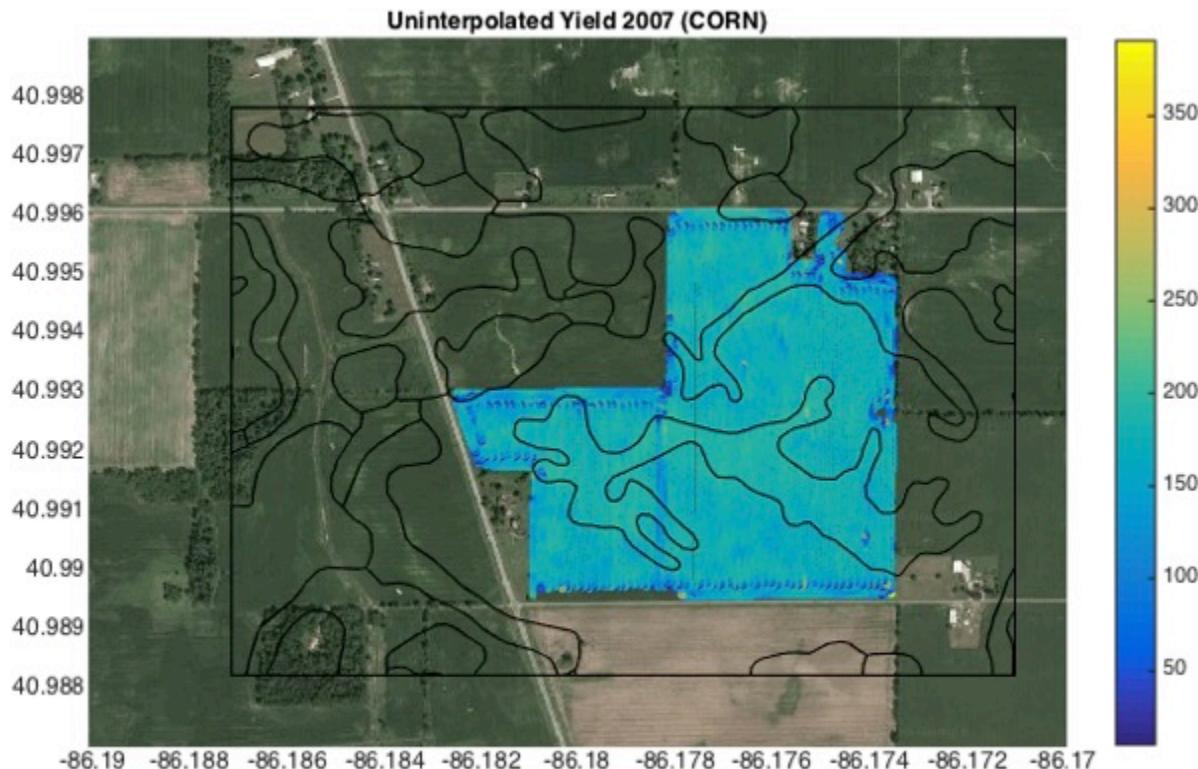
- Our data set:
 - + North central Indiana (Rochester, IN)
 - + About 3,500 acres
 - + 7 to 10 years of calibrated yield data
 - + Corn, soybean rotation
 - + Case IH combines, OEM sensors, monitors
- The state of the art management zone algorithm is called Management Zone Analyst (MZA) – N. R. Kitchen with USDA-ARS Cropping Systems and Water Quality Research Lab, University of Missouri.

Example: Gott East 93

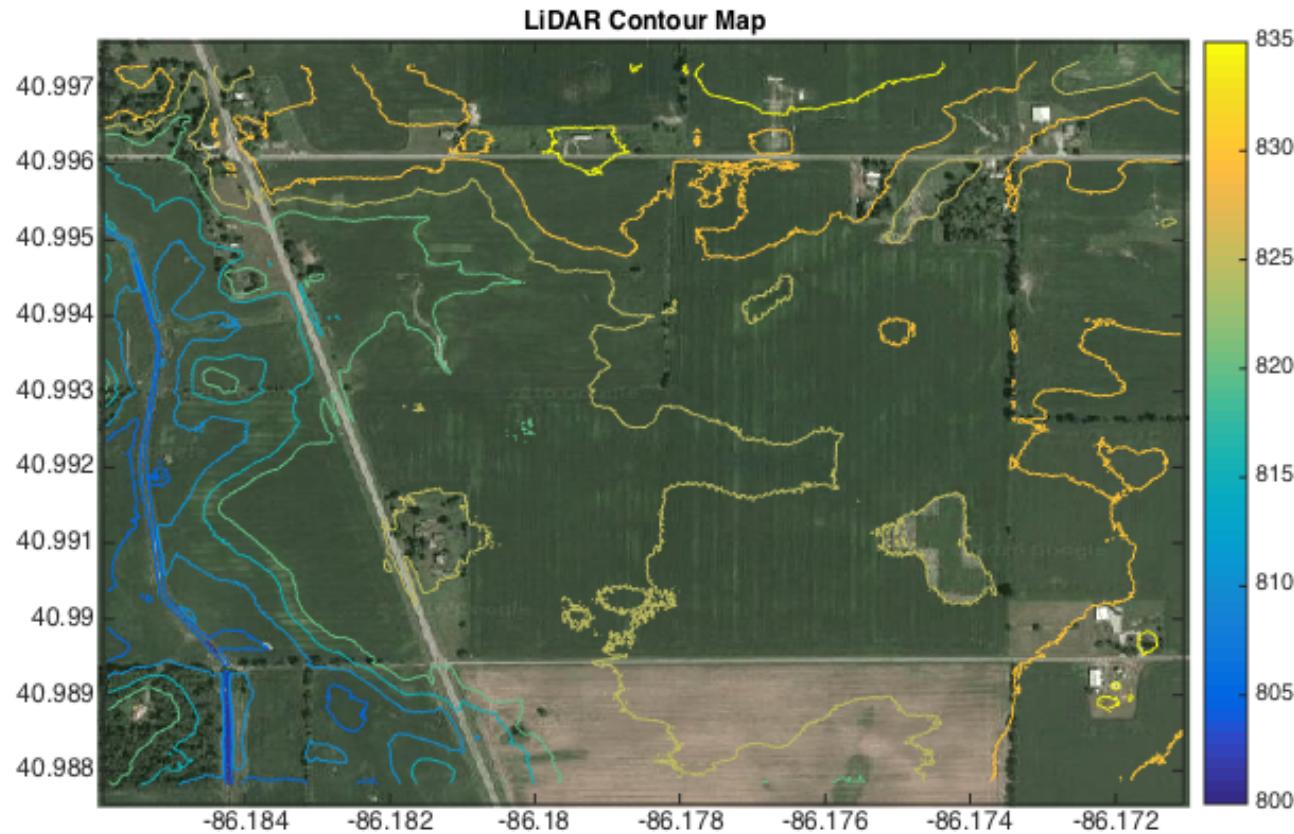
- 7 years of yield data
 - + Corn years: 2007, 09, 11, 13
 - + Soy years: 2010, 12, 14
- Soil series
- Elevation
- Precipitation
- Growing degree days



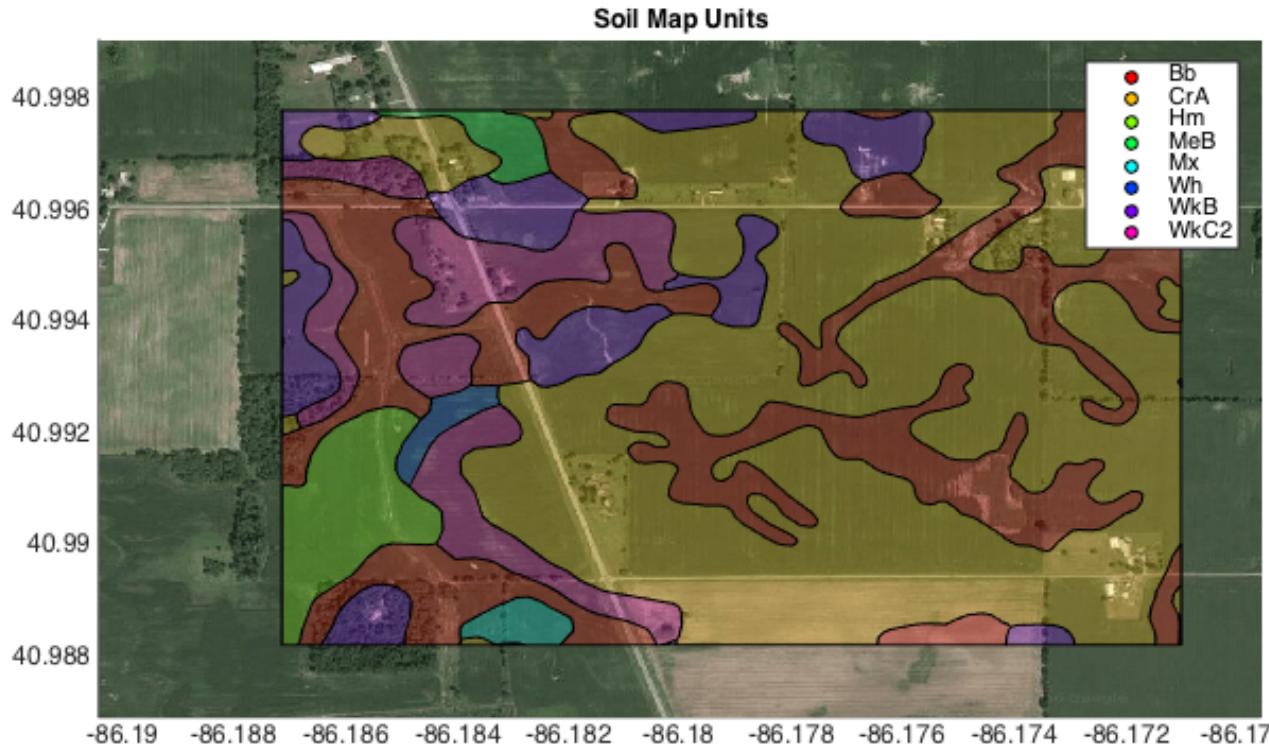
Gott East 93: Yield Map



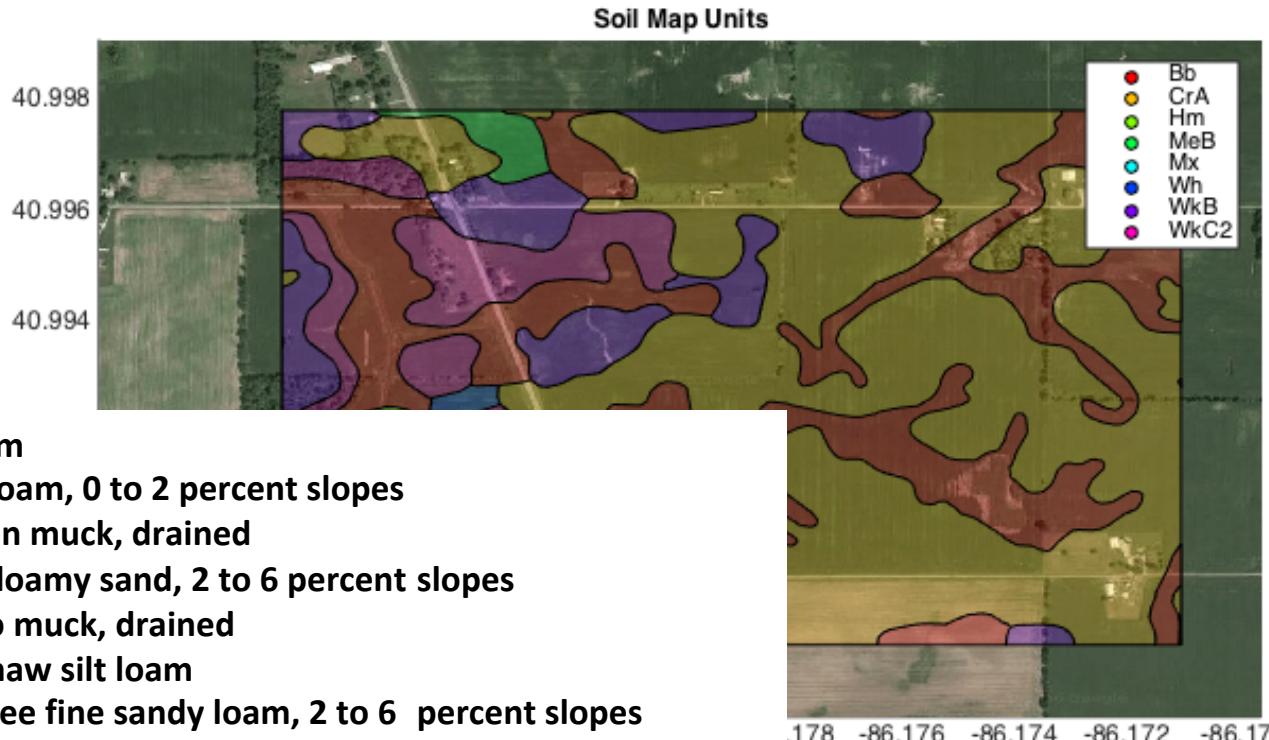
Gott East 93: LiDAR Contour Map



Gott East 93: Soil Series



Gott East 93: Soil Series



"Bb" = Barry loam

"CrA" = Crosier loam, 0 to 2 percent slopes

"Hm" = Houghton muck, drained

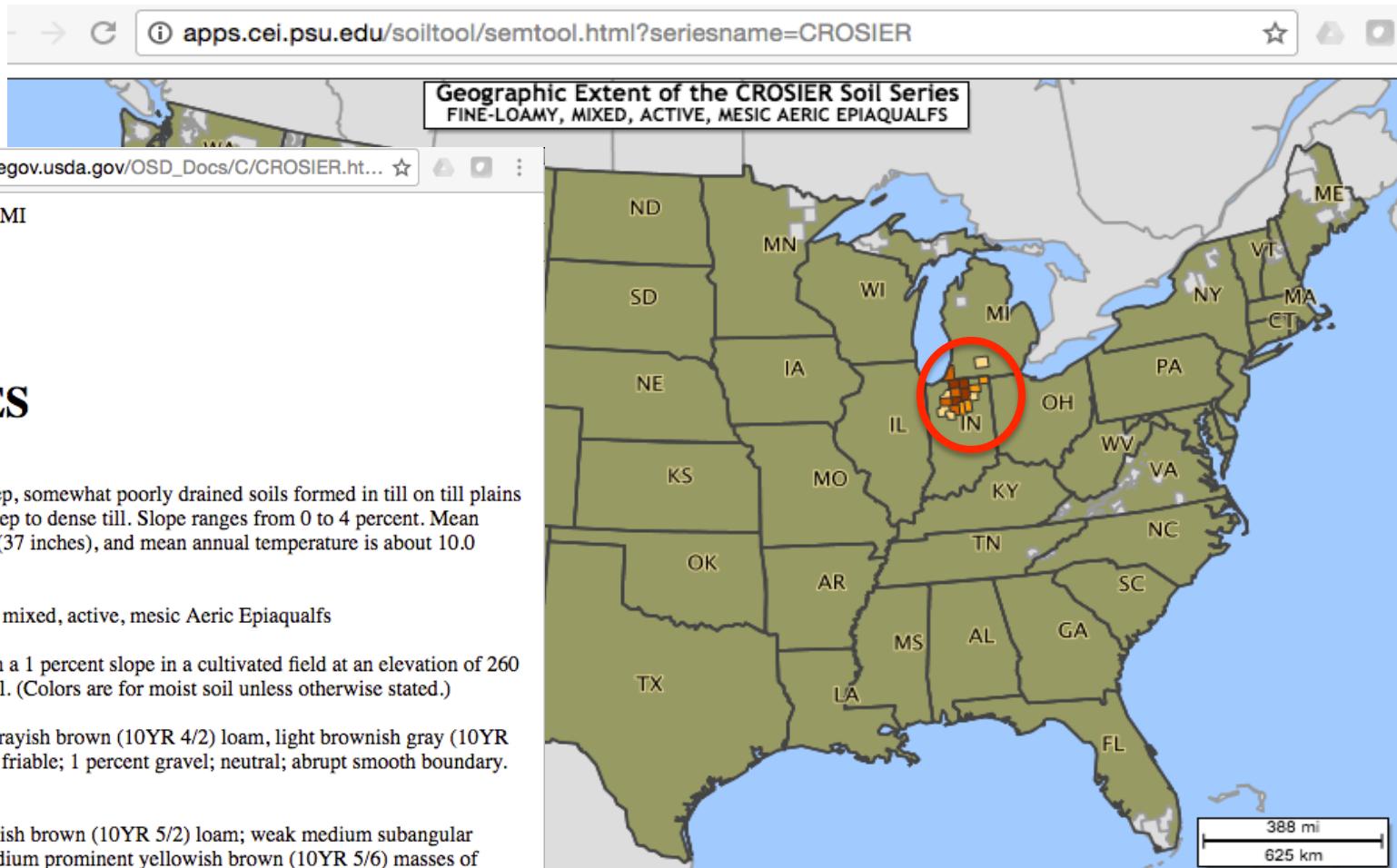
"MeB" = Metea loamy sand, 2 to 6 percent slopes

"Mx" = Muskego muck, drained

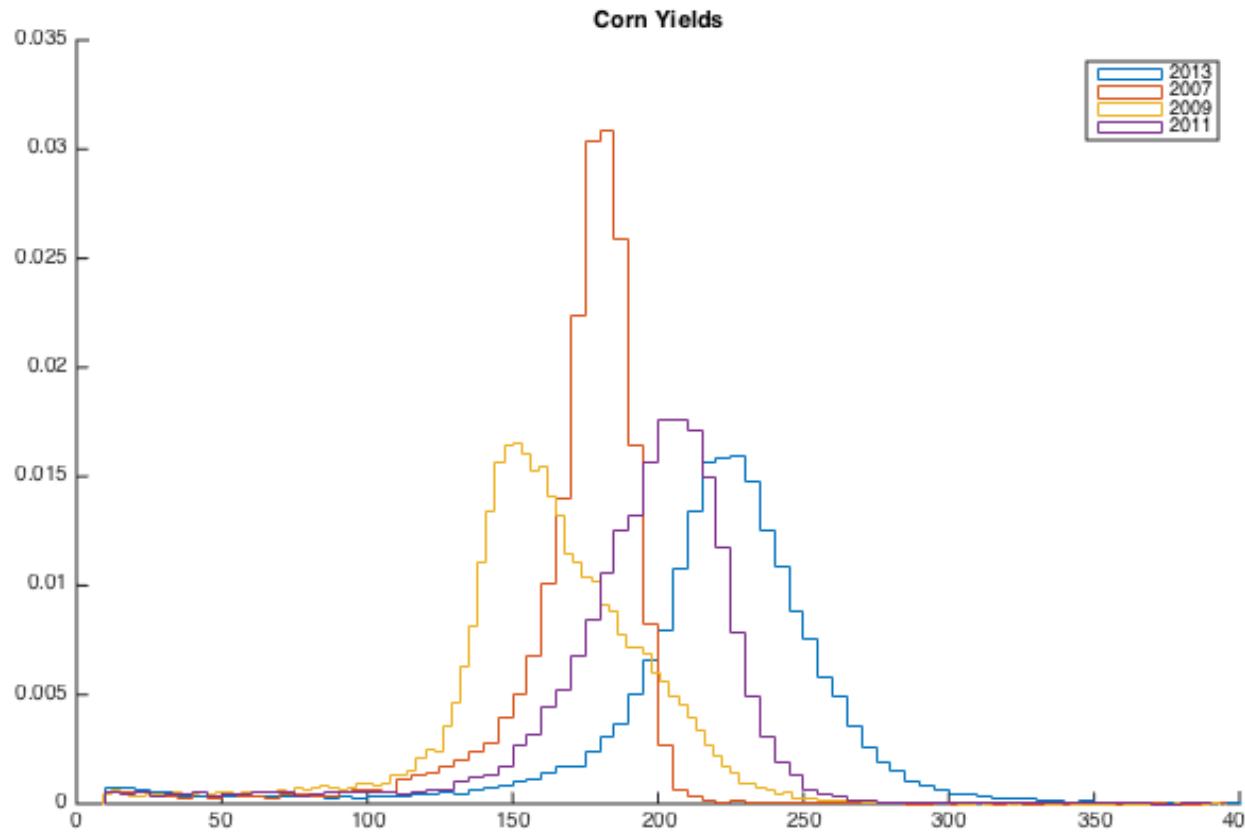
"Wh" = Washtenaw silt loam

"WkB" = Wawasee fine sandy loam, 2 to 6 percent slopes

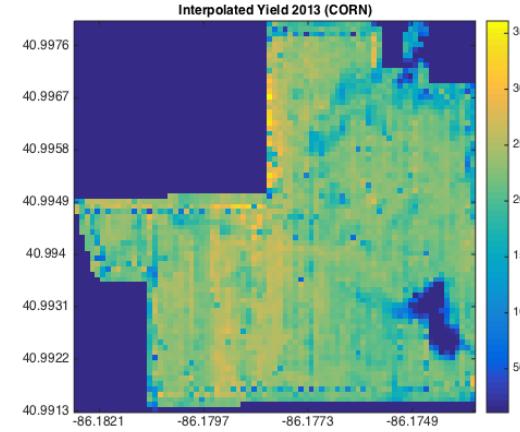
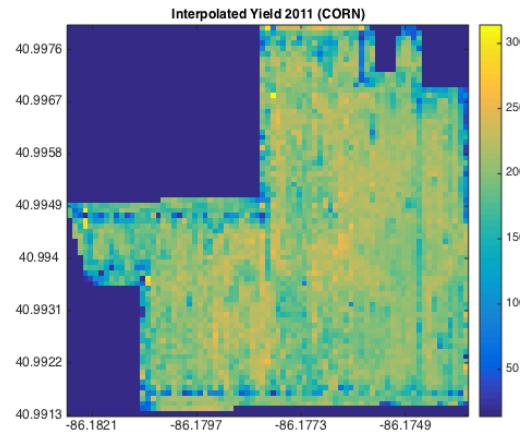
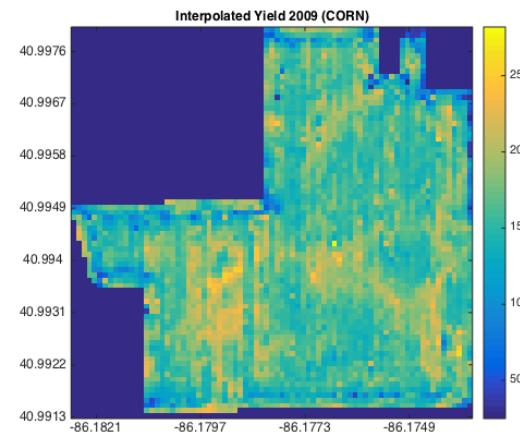
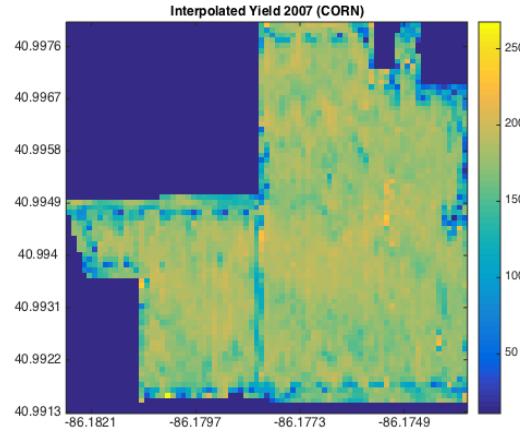
"WkC2" = Wawasee fine sandy loam, 6 to 12 percent slopes,
eroded



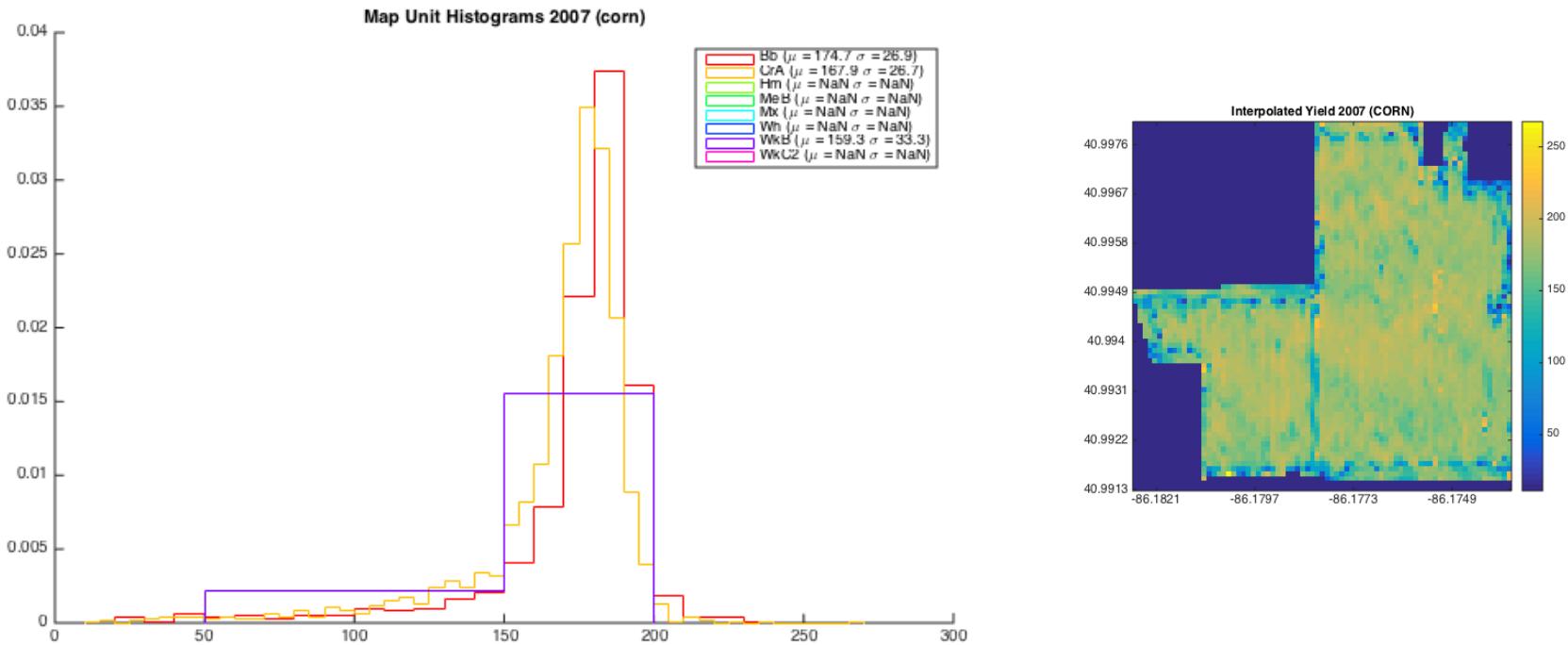
Gott East 93: 4 Years of Corn Yield Histograms



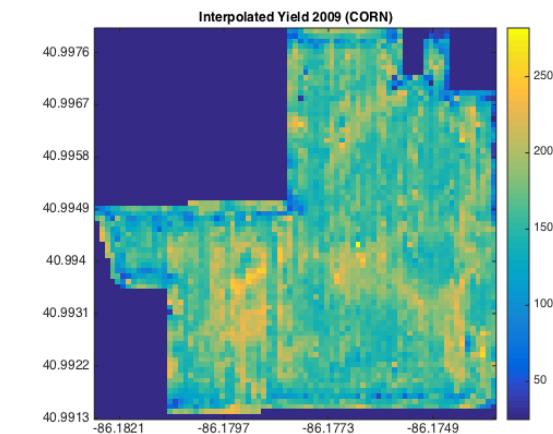
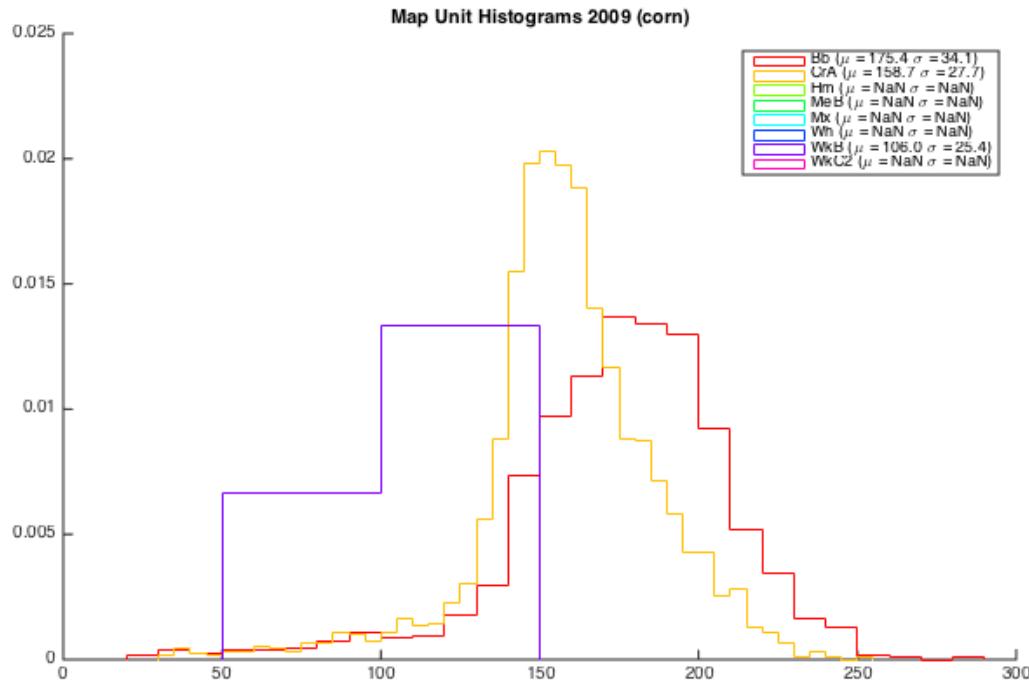
Gott East 93: 4 Years of Yield Maps



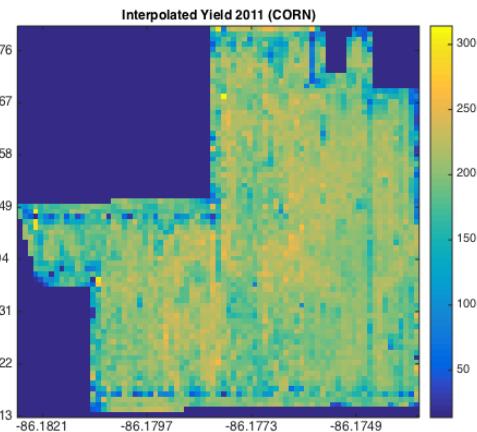
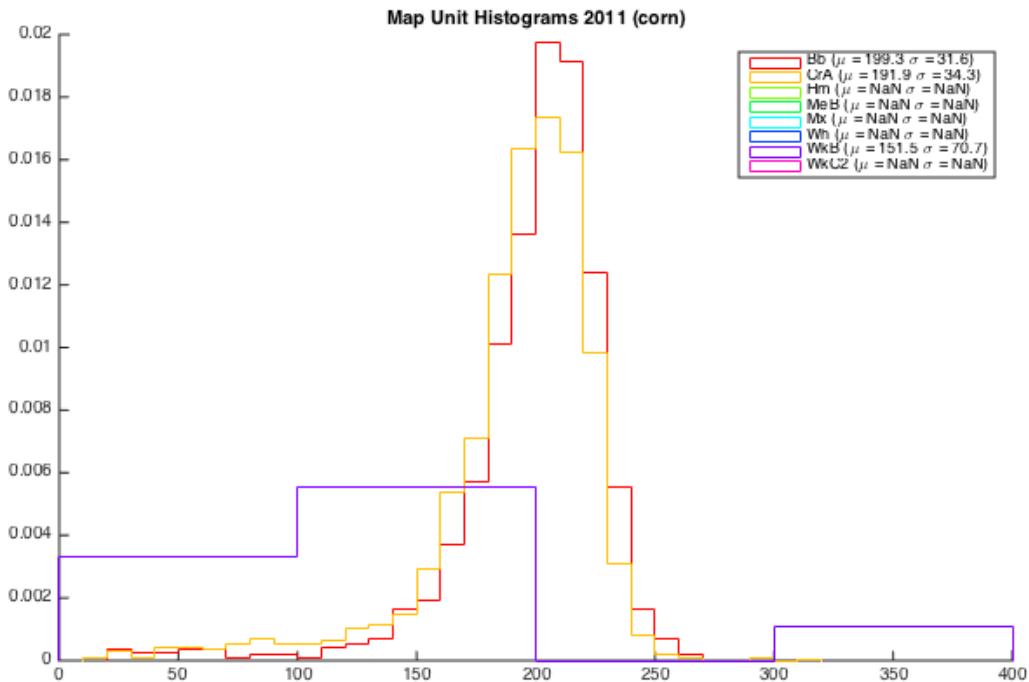
Gott East 93: Yields by Soil Type



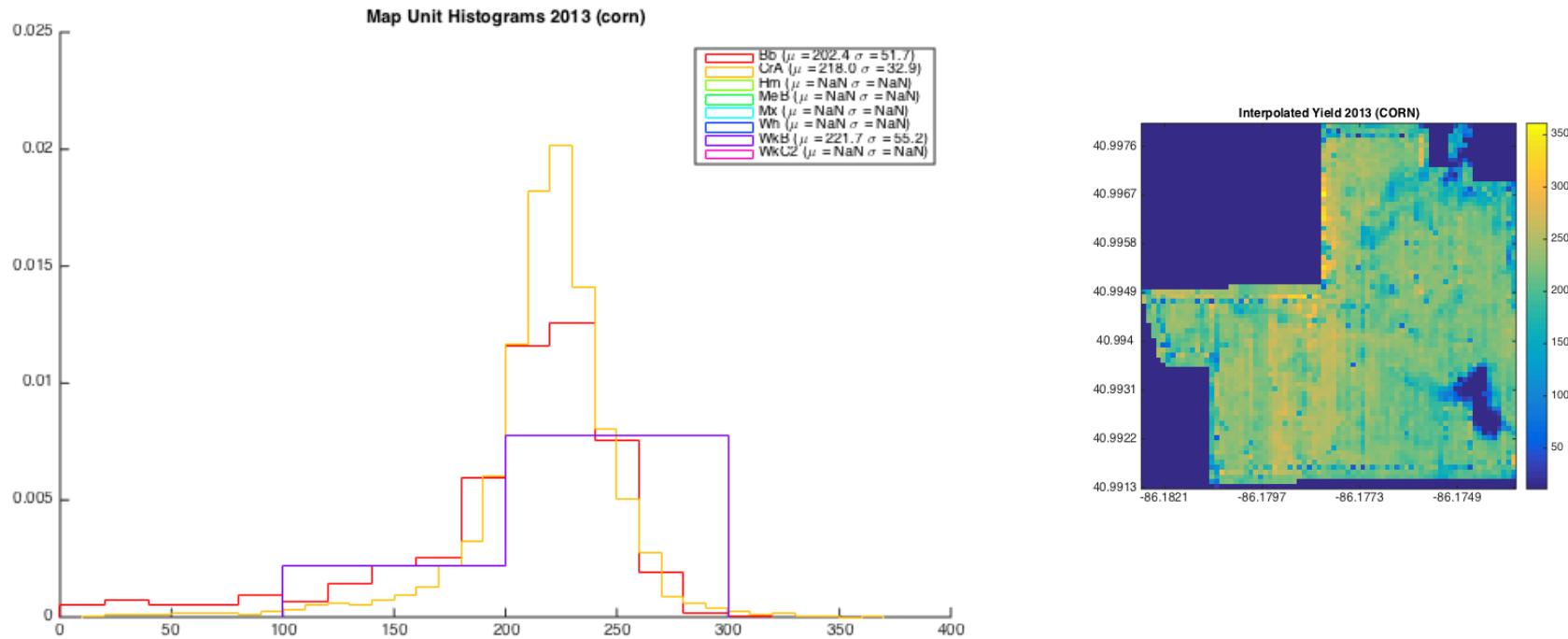
Gott East 93: Yields by Soil Type



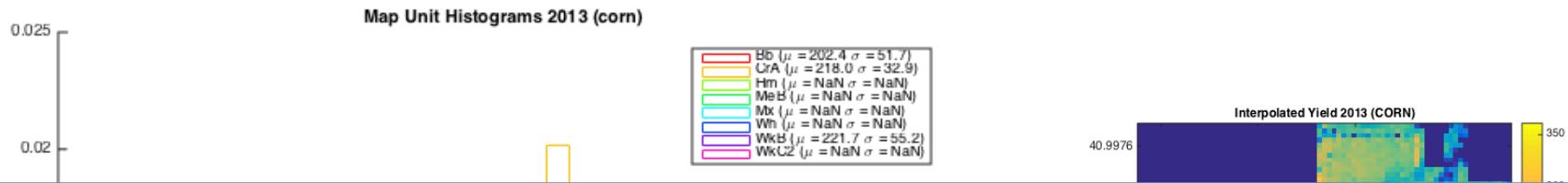
Gott East 93: Yields by Soil Type



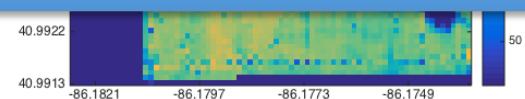
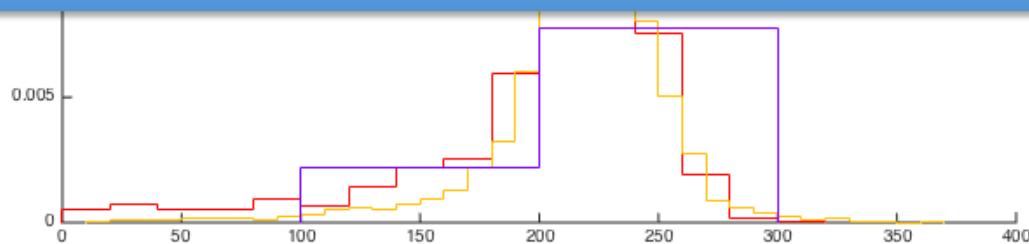
Gott East 93: Yields by Soil Type



Gott East 93: Yields by Soil Type

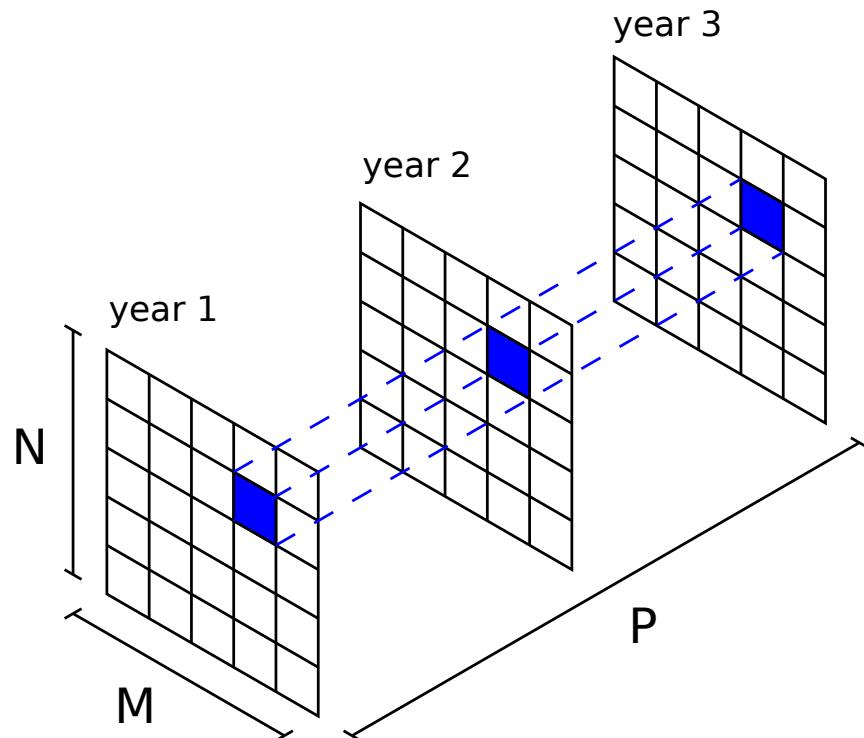


GE 93 (corn): does not appear one should manage by soil type alone



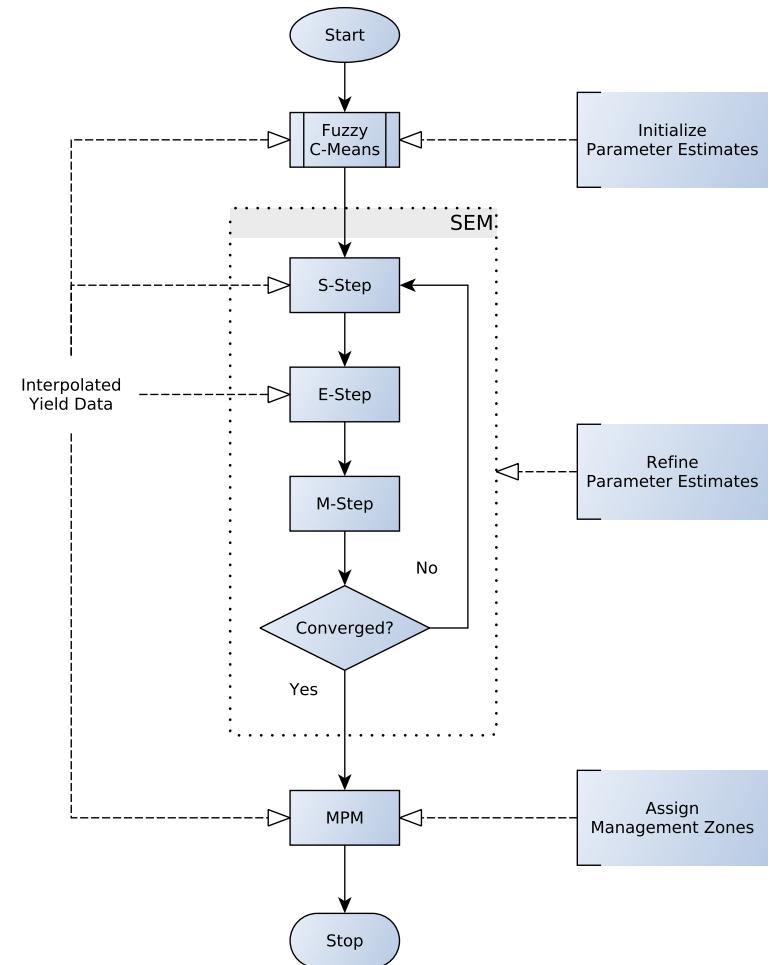
Another Model for Management Zone Estimation

- Management zones modeled as Markov random field
 - + Labels “hidden”
 - + Potts model for spatial relationships
- Multi-year yield vectors modeled as conditionally Gaussian

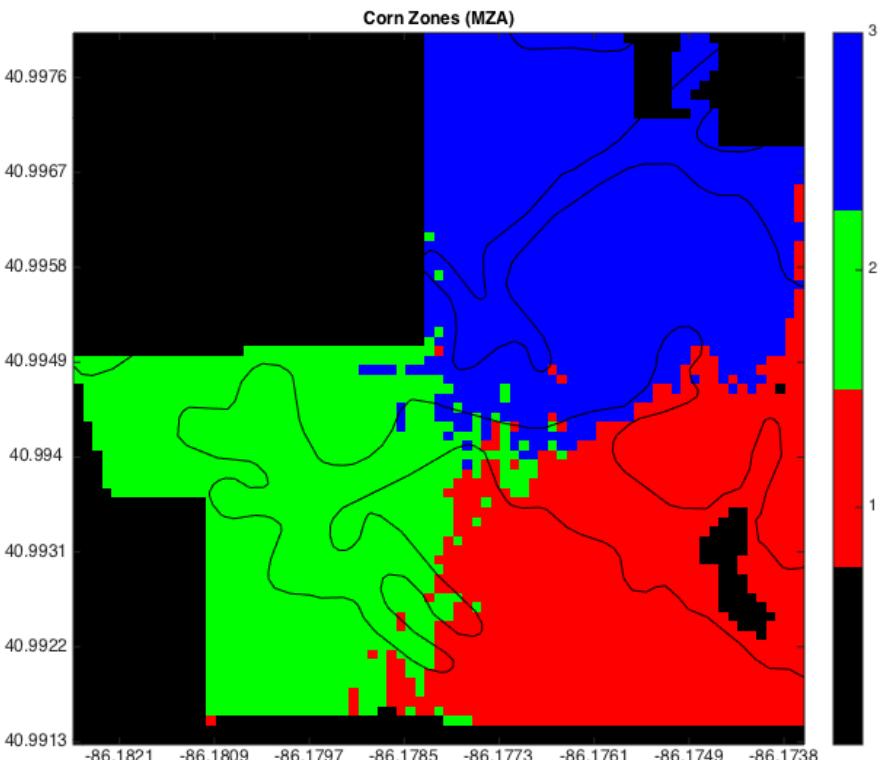
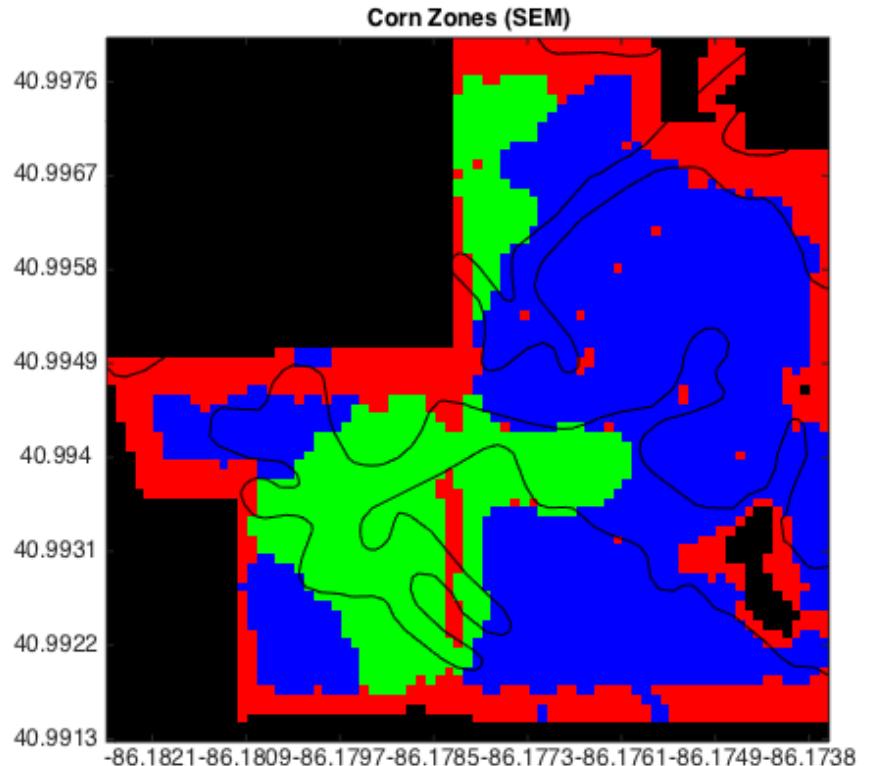


Algorithm: Stochastic Expectation Maximization (SEM)

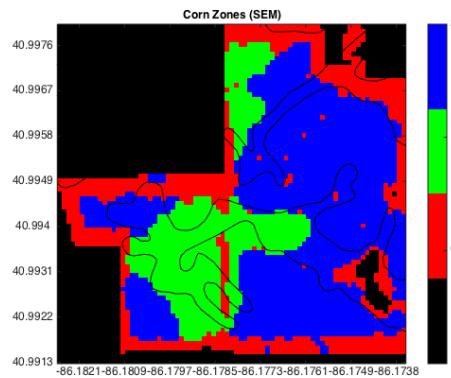
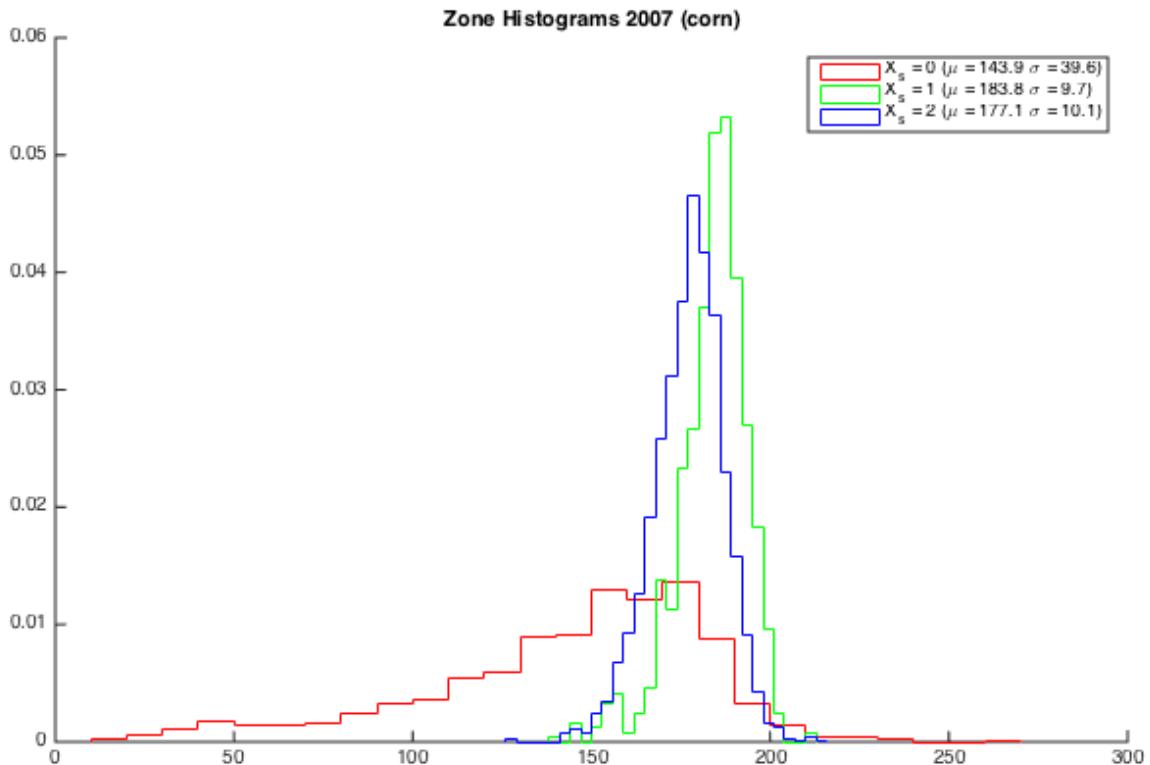
- ❑ Initialize with fuzzy c-means
- ❑ Assume order is known
 - + Used: number of soil types + 1
- ❑ We compare to MZA algorithm



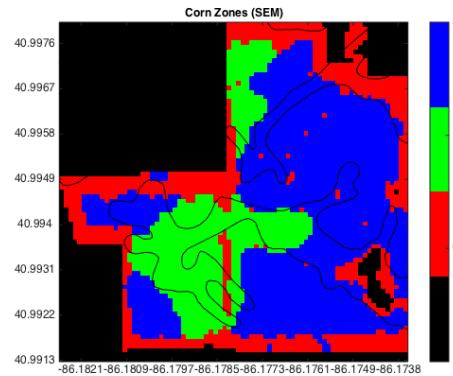
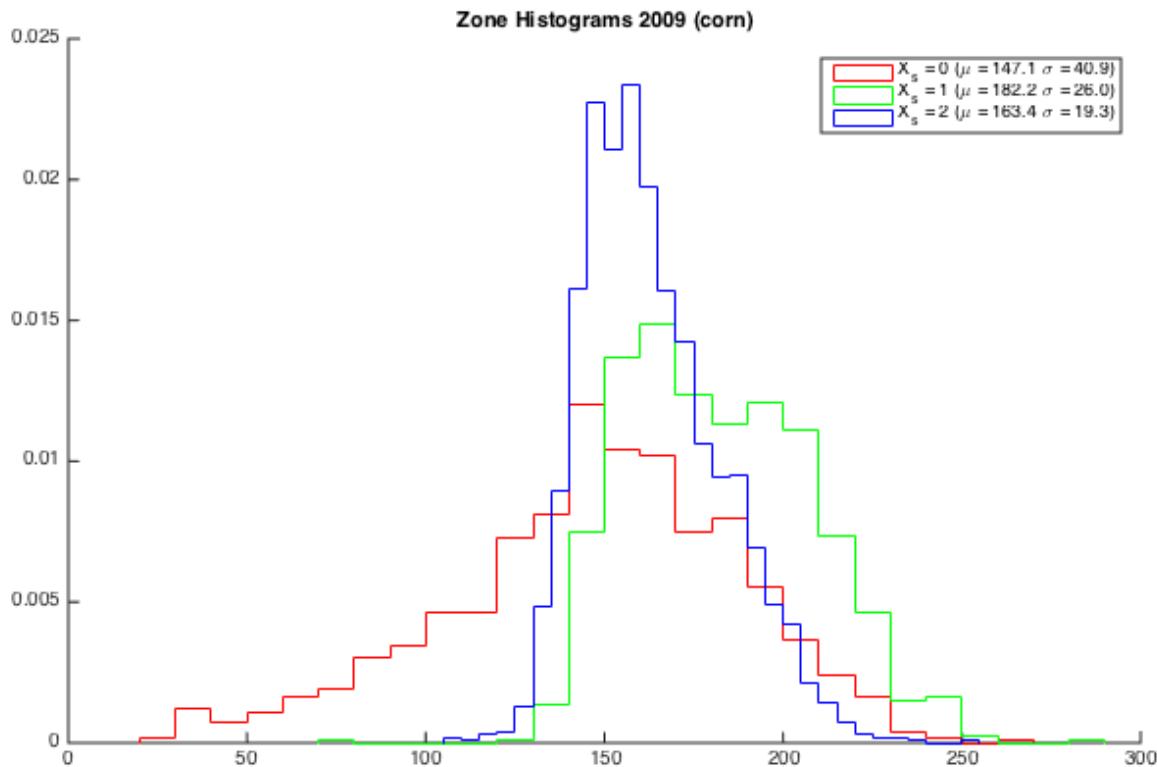
Management Zones: left = SEM, right = MZA (K=3)



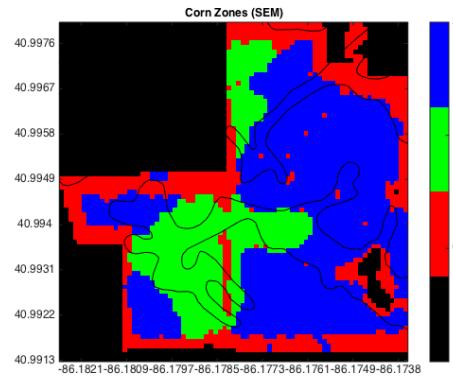
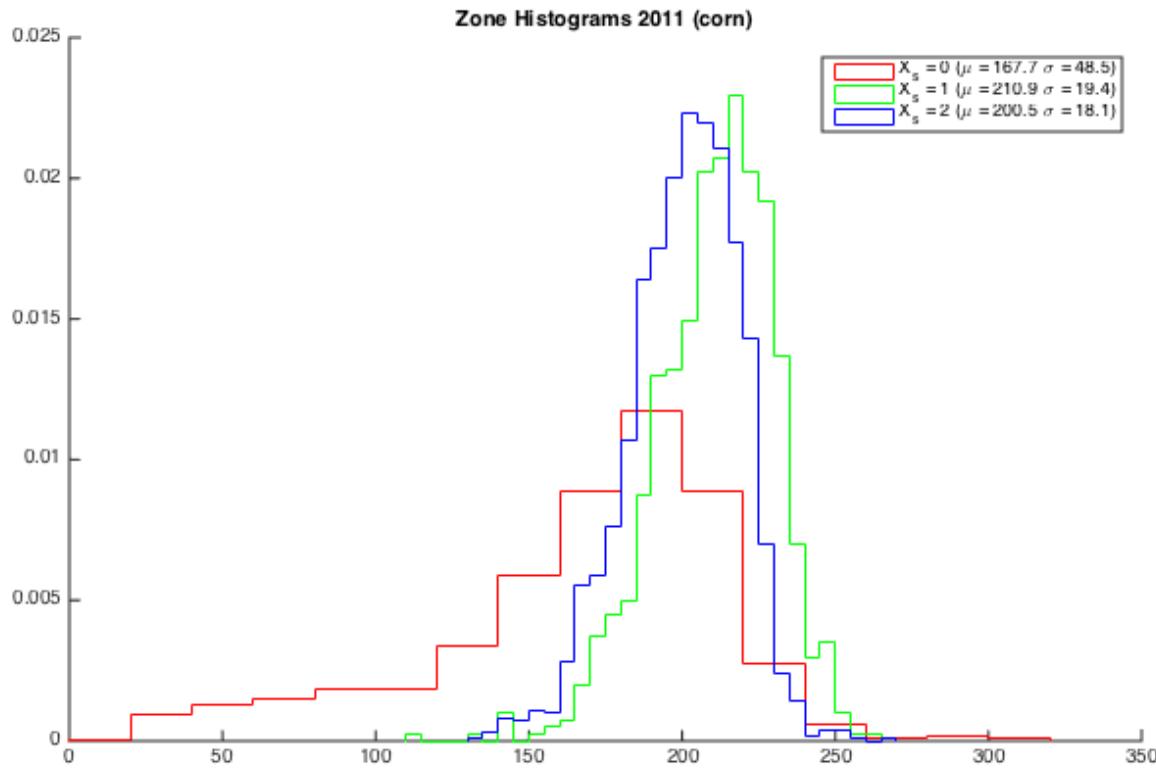
SEM Management Zone Histograms 2007



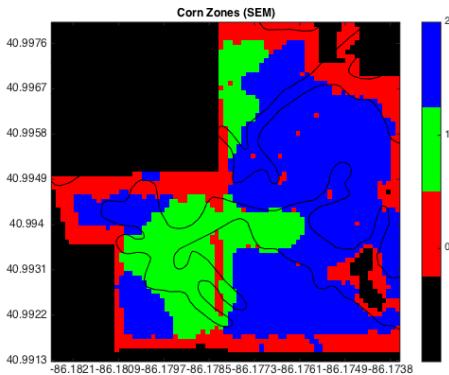
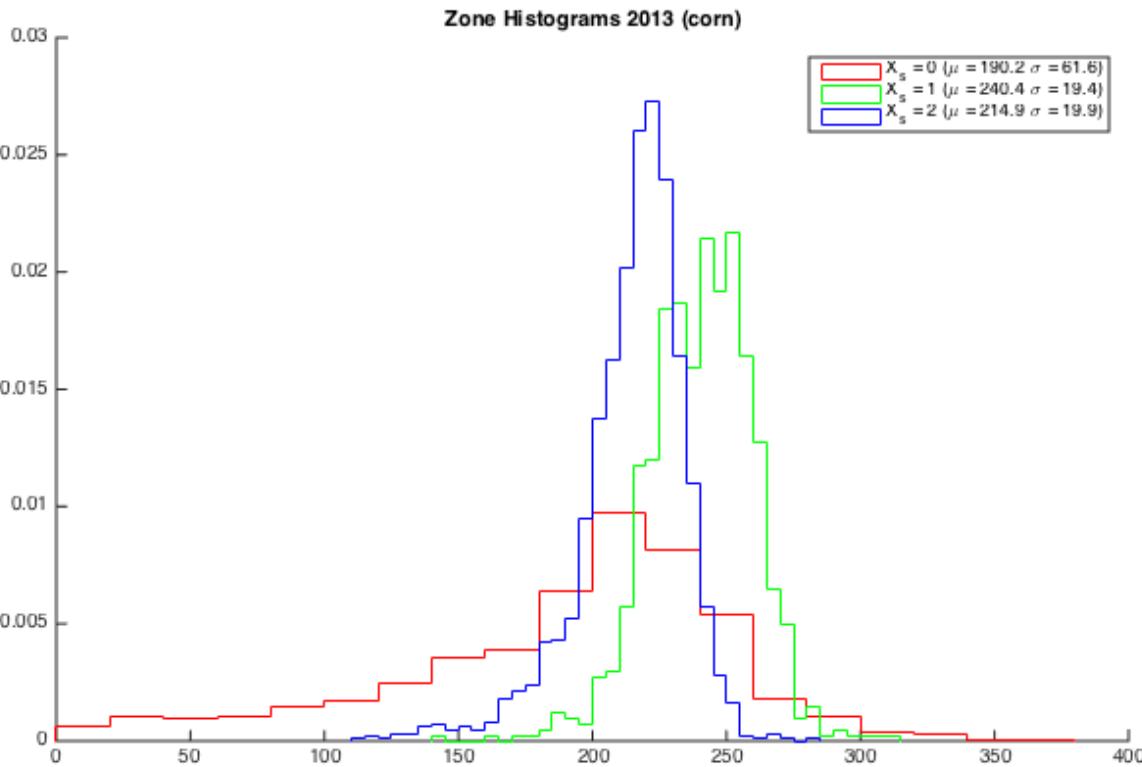
SEM Management Zone Histograms 2009



SEM Management Zone Histograms 2011



SEM Management Zone Histograms 2013



Management Zone Estimation: Preliminary Conclusions

- SEM derived management zones appear to cluster according to corn yield potential
- Not as evident in the MZA derived management zones
- Field boundary clearly needs special attention (compaction, yield map errors?)
- The “resolution” that can be achieved is unclear given this data
- Also (but not shown here):
 - + Soybeans and corn should be treated separately for purposes of management zone estimation (SEM algorithm can combine them)
 - + SEM finds significantly different zones for the two