Applications of Precision Agriculture in Rural Communities

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Pre-mechanization

- Farming operations done by hand or with small-scale equipment
- Differing performance of different pieces of ground was an incentive to diversify treatment
- Essentially precision farming
Post-mechanization

- Higher efficiencies of labor and time than in non-mechanized systems
- “Industrial scale” operations
- Equipment and management treat large areas uniformly
- Farming by averages
Grain Harvest - East Boender - Low Moist Corn

Grower: Donald Dean
Farm: Boender Farm
Field: East Boender
Operation: Grain Harvest
Crop/Product: Low Moist Corn
Op. Instance: Harvest - 1
Area: 86 ac
Avg. Yield: 205 bu/ac
Avg. Moisture: 16%

Estimated Volume (Dry) (bu/ac)
- Above 228 (15 ac)
- 215 - 228 (17 ac)
- 204 - 215 (18 ac)
- 190 - 204 (18 ac)
- 0 - 190 (18 ac)

Histogram of Estimated Volume (Dry) (bu/ac):
Examples of crop development variability in central Iowa US, during 2012 drought.
Phosphate concentration (Serrano et al. 2011)

Soil nitrate concentration (Franzen et al. 2011)

Cation exchange capacity (Terron et al. 2011)

Topography
Is there variability?

Of course there is.

Determine the cause(s) and effects of the variability

Determine the most appropriate response to the variability

Optimize the production system – consider productivity, profitability, and environmental impact
What will it take?

• Be able to sense and monitor more data
• Know which data is most important under which circumstances
• Know what management will be the most appropriate response
• Have the technology to vary the management accordingly
Sense and monitor

Robust, inexpensive, smart sensors, both remote and in situ

Observations:
- Soil water content and temperature
- Soil chemistry (esp. nutrients and salts)
- Soil texture
- Plant biomass
- Plant health
- Crop growth stage
- Equipment performance

Different spatial and temporal resolutions needed for different observations
Communicate data

Communication networks

• From sensor(s) point of decision
• From point of decision to point of response
• To logger when necessary
Frontier 2: Knowledge to Information

Internet of (Agricultural) Things

- Cataloging and tracking
- Historical maps for recurring trends;
- On-the-go maps for instantaneous conditions
- Separating the stationary from the non-stationary
- Determination of management zones

Credit: Forbes magazine & Kraay family farm
Frontier 2: Knowledge to Information

Knowledge is half the battle. Knowing what to do with it is the other half.

- Finding relationships and making predictions in nonlinear systems
  - Machine learning;
  - Data fusion
  - Data assimilation
- Data → Action

Kumhalova et al. 2011
Frontier 3: Nimble Decision & Response Systems

• Control systems
• Decision systems that can account for uncertainty
• Adaptable to new circumstances

Fig. 7. Cumulative exponential probability of unused N in grid cell #4 for N rates of 80–320 kg ha\(^{-1}\). Thorp, et al. (2006)
Frontier 3: Nimble Decision & Response Systems

Smaller, more flexible equipment
Opportunities in the developing world

• Leapfrogging over uniform mechanized management
• Applications for smaller fields
• Capitalizing on local knowledge
• Adaptation to low-technology environment

Arago Galindo et al. 2012