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Nitrogen Fertilizer, Cropping Systems, and Iowa Groundwater

Robert DeHaan
Dordt College, robert.dehaan@dordt.edu

Ronald Vos
Dordt College, ronald.vos@dordt.edu

Matt Schuiteman

Matt Van Schouwen

Harlan Kruid

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Abstract

Summary presentation of research conducted over a 5 year period to determine which cropping systems best reduce nitrate leaching. Initial data was collected on nitrate concentration from individual wells in the Sioux Center, Iowa area which led to connections with the Iowa Department of Natural Resources Source Water Protection Program. A community group was then formed comprised of city representatives, Dordt College faculty, local farmers, Source Water Protection Program staff, and others. The group applied for and received a Leopold Center for Sustainable Agriculture grant to fund field experiments to identify cropping systems that retain nitrate and are workable for producers. Five different cropping systems were tested over a five year period. These included continuous corn, continuous grass hay, oat/alfalfa/corn, oat/red clover/corn, and soybean/winter wheat/corn. Results of residual nitrate nitrogen levels for each of the crop rotations is presented along with preliminary economic summaries.

Keywords

nitrogen fertilizer, nitrate leaching, cropping systems, groundwater, Source Water Protection Program, Sioux Center, Iowa Department of Natural Resources

Disciplines

Agriculture

Comments

Accompanying PowerPoint slides are available using the download link.

Recording is also available at https://www.youtube.com/watch?v=j04-diPgVQY

Nitrogen Fertilizer, Cropping Systems, and Iowa Groundwater

Robert De Haan, Ph.D. – Professor of Environmental Studies and Biology at Dordt College

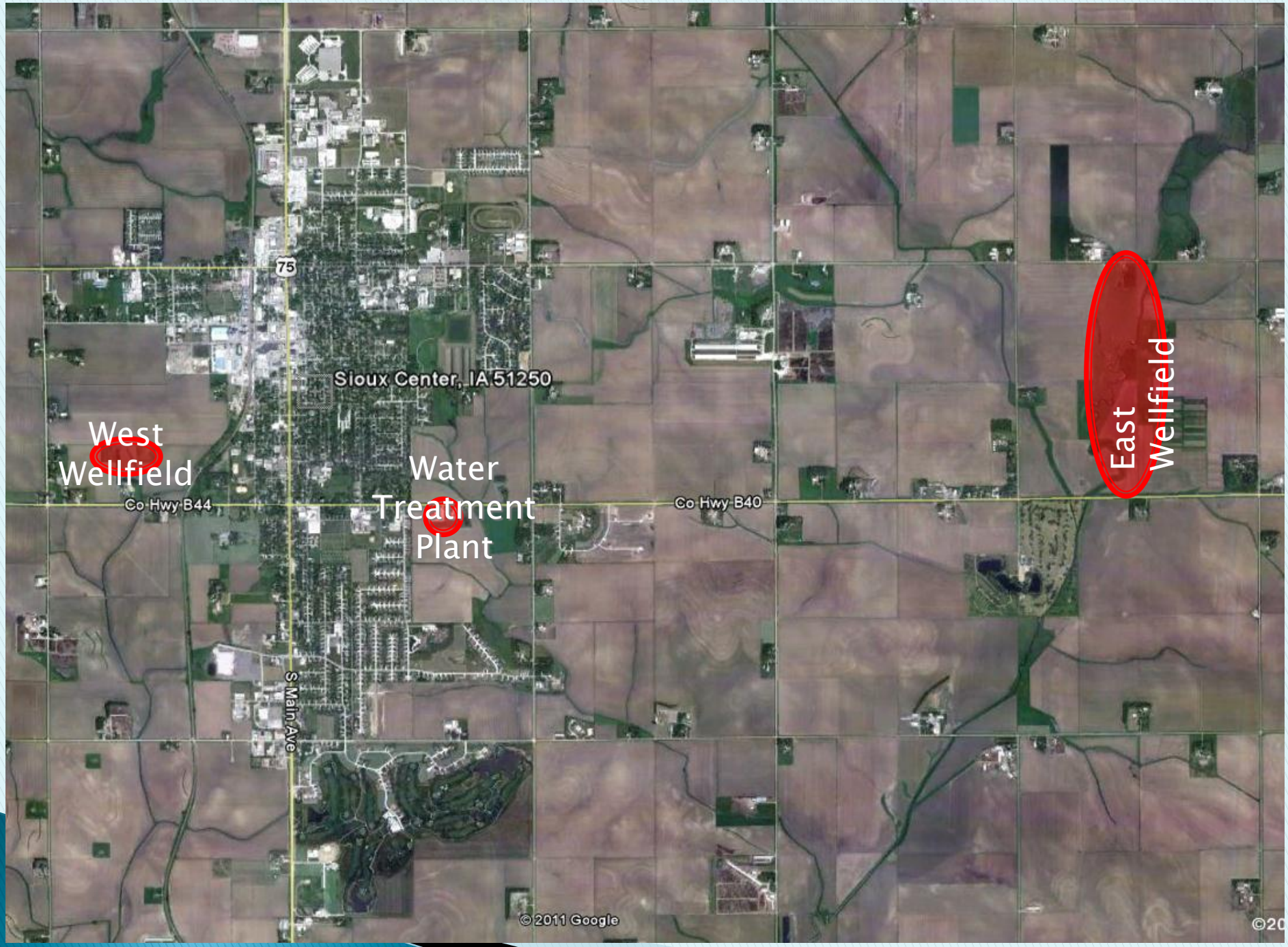
Ronald Vos, Ph.D. – Professor of Environmental Studies and Agriculture at Dordt College

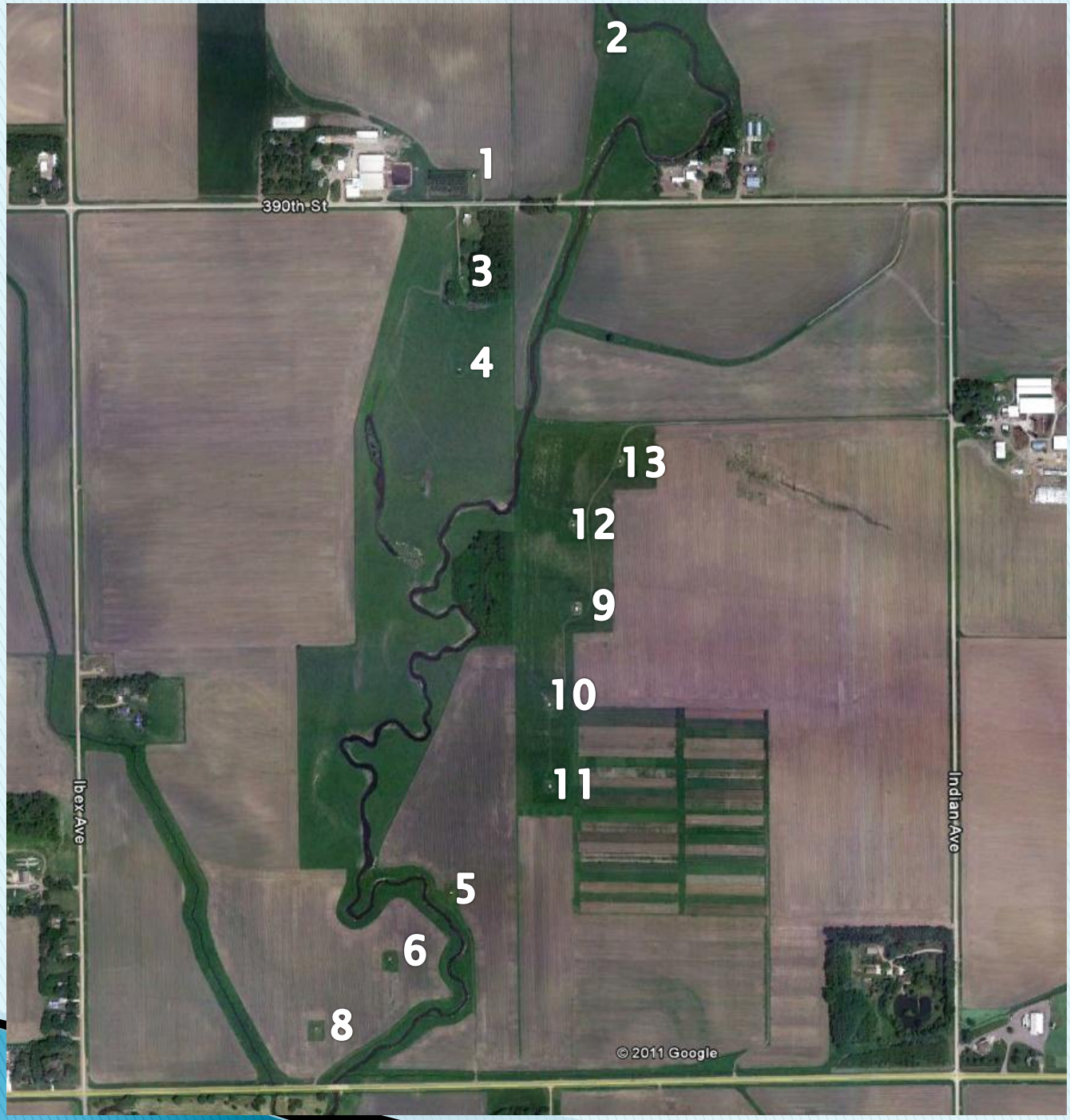
Matt Schuiteman – B.S. in Agronomy from Iowa State – Agricultural Producer and On-farm Researcher

Matt Van Schouwen and Harlan Kruid – City of Sioux Center – City Engineer and Water Plant Manager, respectively

Sioux Center's Water Supply

- East Wellfield
  - 12 shallow wells with an average depth of 40'
  - Flow – 50-150gpm each, 950gpm total
- West Wellfield
  - 3 deep wells with an average depth of 350ft
  - Flow – 250-350gpm each, 900gpm total
- Water Treatment Plant
  - Iron & Manganese Removal
  - Raw water from both well fields is blended & treated


West Wellfield
Water Treatment Plant
East Wellfield
Sioux Center, IA 51250
75
Co Hwy B44
Co Hwy B40
S Main Ave
© 2011 Google


2
1
390th St
3
4
13
12
9
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11
Ibex Ave
Indian Ave
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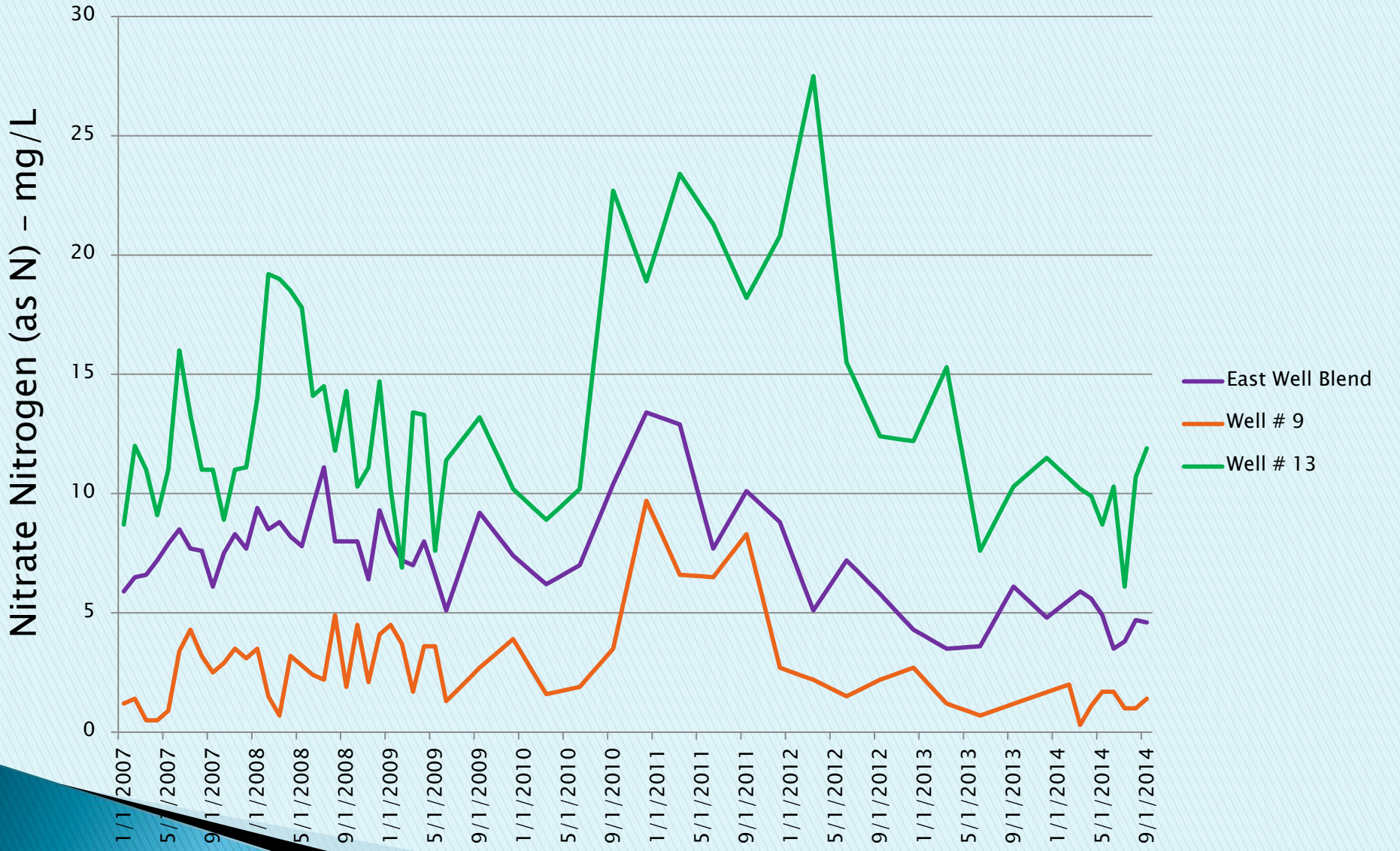
© 2011 Google

Nitrate Test Results



Community Response

- Initial data on nitrate-N concentration from individual wells collected by Dordt College Ag student
- Led to connections with Becky Ohrtman and the IDNR Source Water Protection Program
- Formed Community Group
  - Composition
    - City representatives, DC faculty, Farmers, SWP staff, NRCS personnel, IA DNR staff
  - Actions
    - DC faculty and farmers initiated field experiment
    - IDNR SWP – installed test wells, monitored them, looked at geology and hydrology of the well field
    - Continued well monitoring & operation by city staff
    - Community Field Day – August, 2011

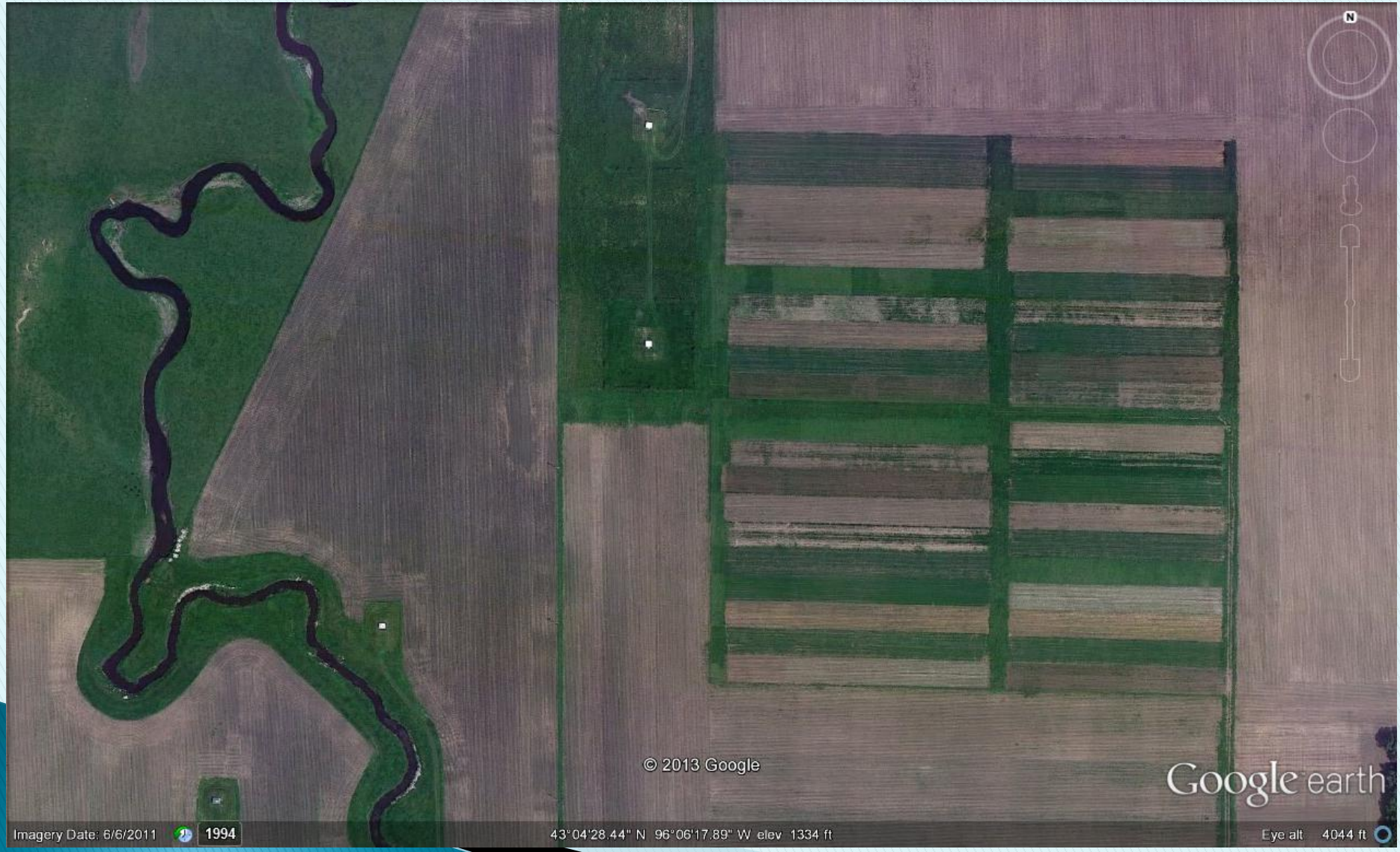
Field Research and Preliminary Results

- Robert De Haan
- Ronald Vos
- Matt Schuiteman

Sioux Center Field Experiment (Funded by a grant from the Leopold Center for Sustainable Agriculture)

- Can we identify cropping systems that retain N and are workable for producers?
- Five different cropping systems, for five years
  - **Continuous corn**
    - With side-dressed N at rate determined by late spring nitrate test, corn followed by winter rye cover crop
  - **Continuous grass hay**
    - No nitrogen application
  - **Oat – Alfalfa – Corn**
    - N for corn from alfalfa only, corn followed by oat cover crop
  - **Oat / red clover – Corn**
    - Red clover cover crop seeded with oat, N side-dressed on corn as needed, corn followed by oat cover crop
  - **Soybean – winter wheat – corn**
    - Winter wheat followed by red clover cover crop, side-dressed N on corn as needed, corn followed by oat cover crop

Experimental Site – 40 plots, each 0.75 acres in size

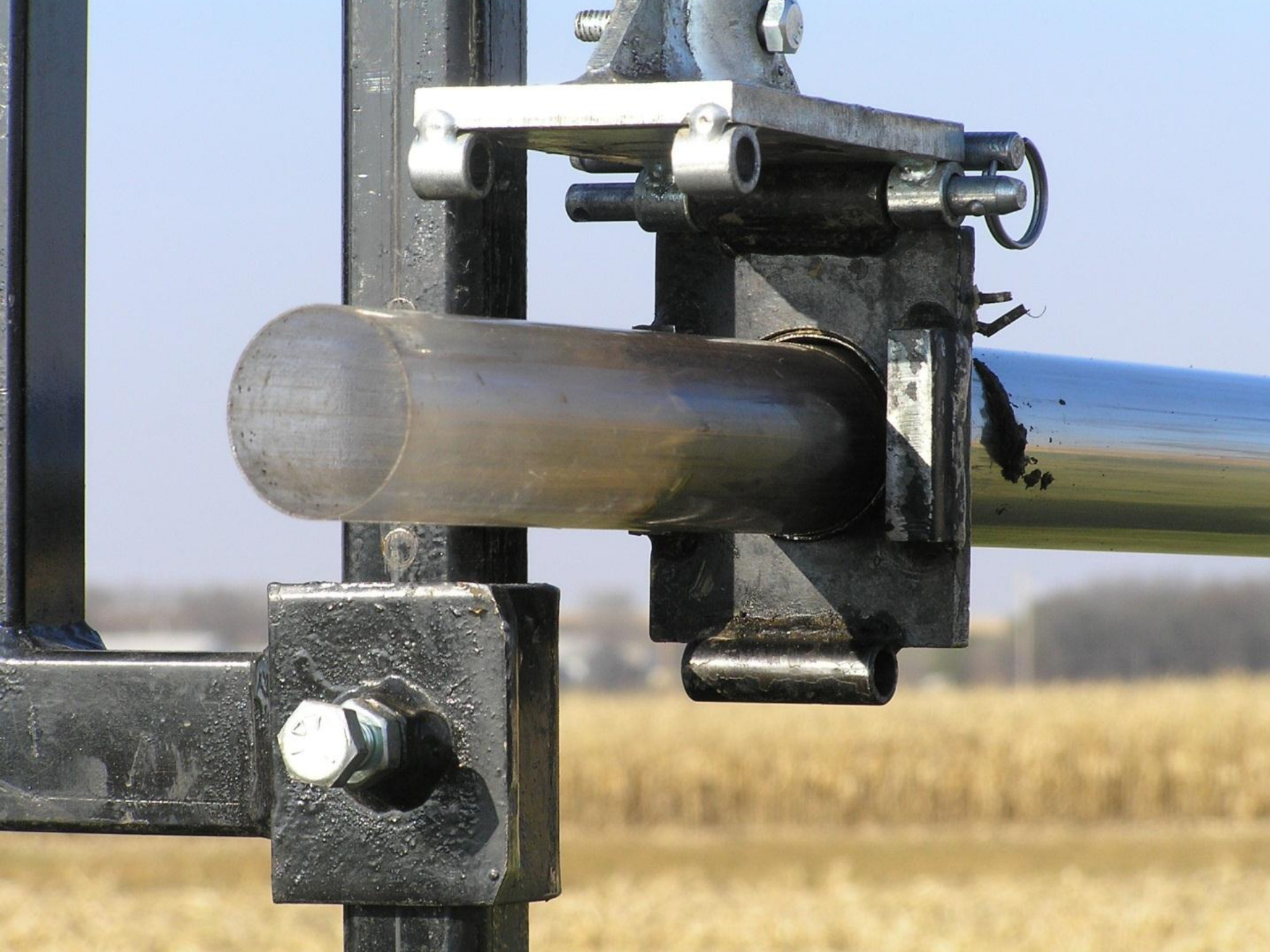


Strip-till system, planting into winter rye cover crop

Plots and Data Collection

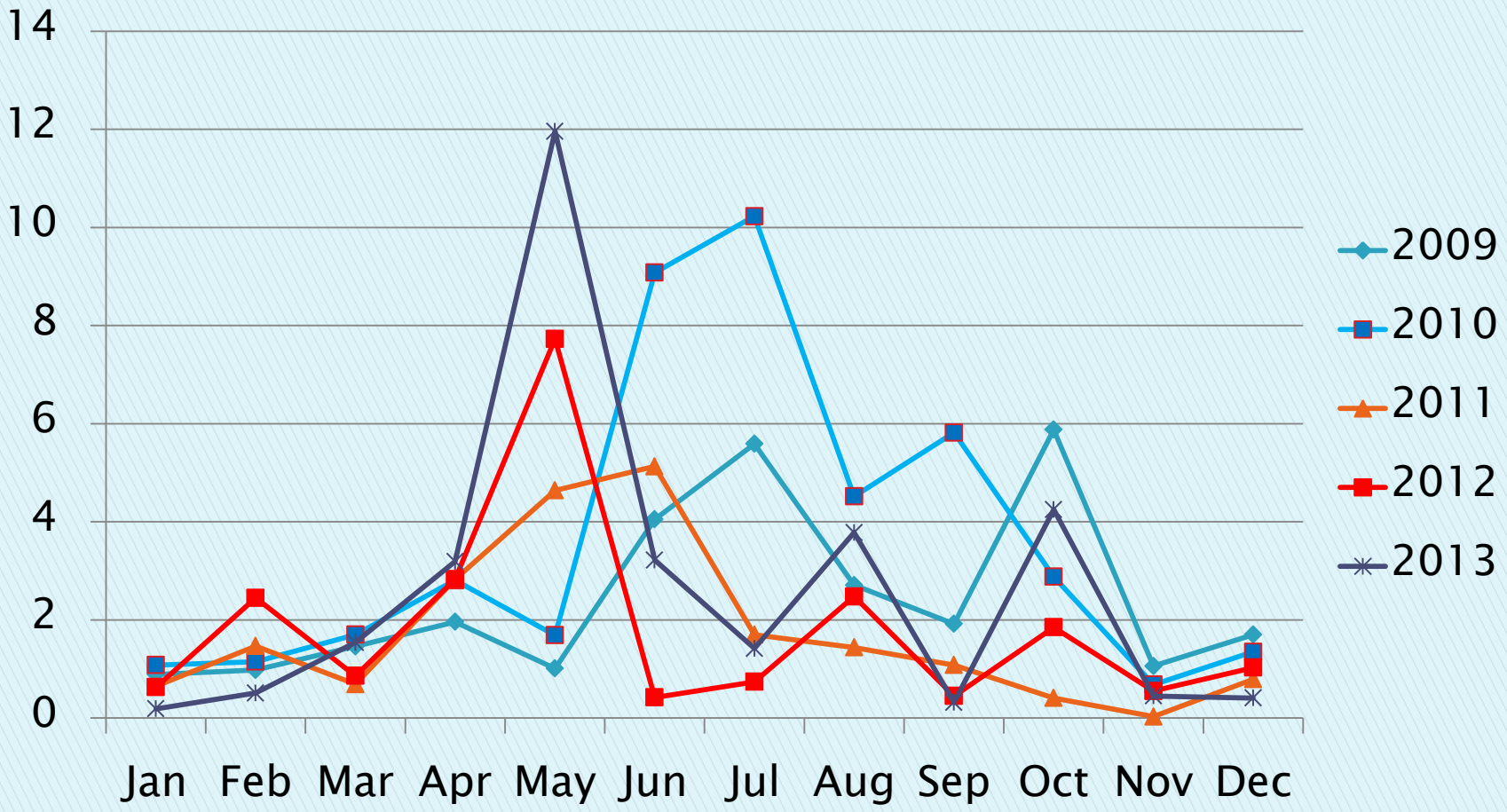
- Plot dimensions – 60’ x 600’
- 4 replications
- Yield and input data recorded for all plots
- 6’ deep soil samples taken annually
  - End of October to mid November
  - Samples divided into 1’ increments
  - Each increment tested for nitrate nitrogen content
- Data shows nitrate nitrogen concentrations throughout the soil profile

Extracting 6’ deep soil samples



Samples ready to be divided into 1’ segments

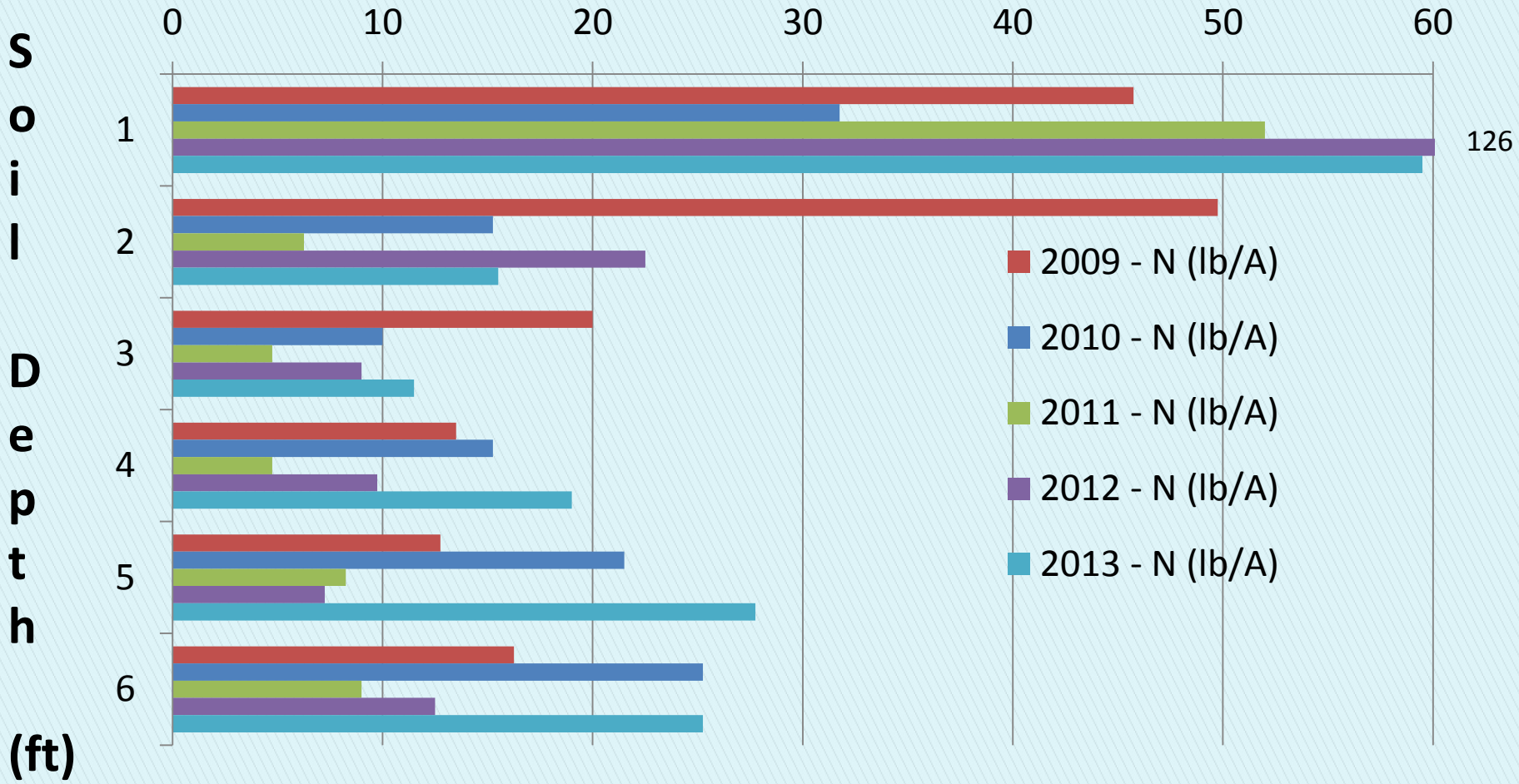
Monthly Precipitation (Inches)



Continuous Corn – June 4, 2011

June 25, 2011

Continuous Corn Plots

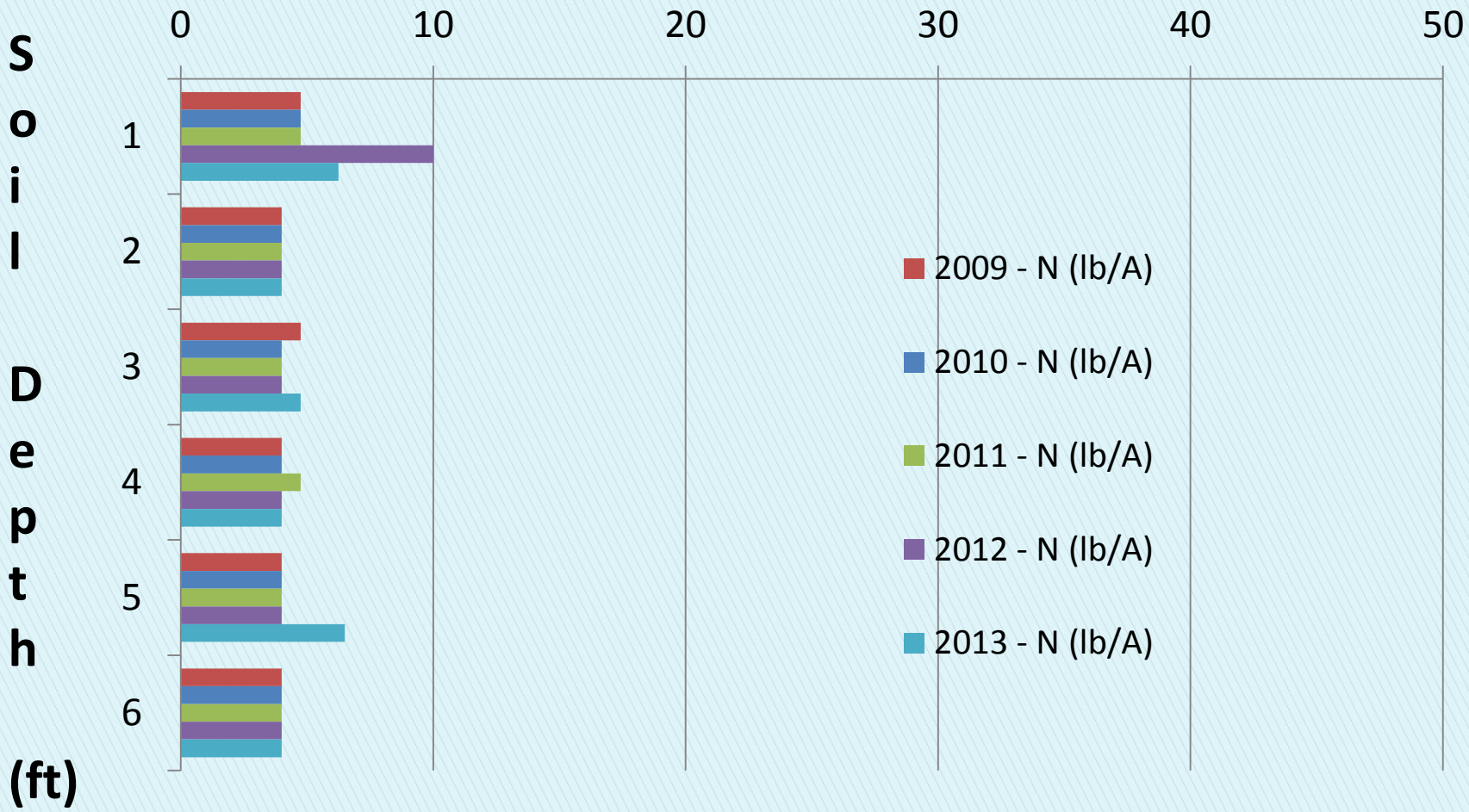


Average N application (2009-2013) – 118.5 lbs/A

Average residual N in top 6’ of soil (2009-2013) – 141.5 lbs/A

Continuous Grass Hay – June 4, 2011

Continuous Grass Hay

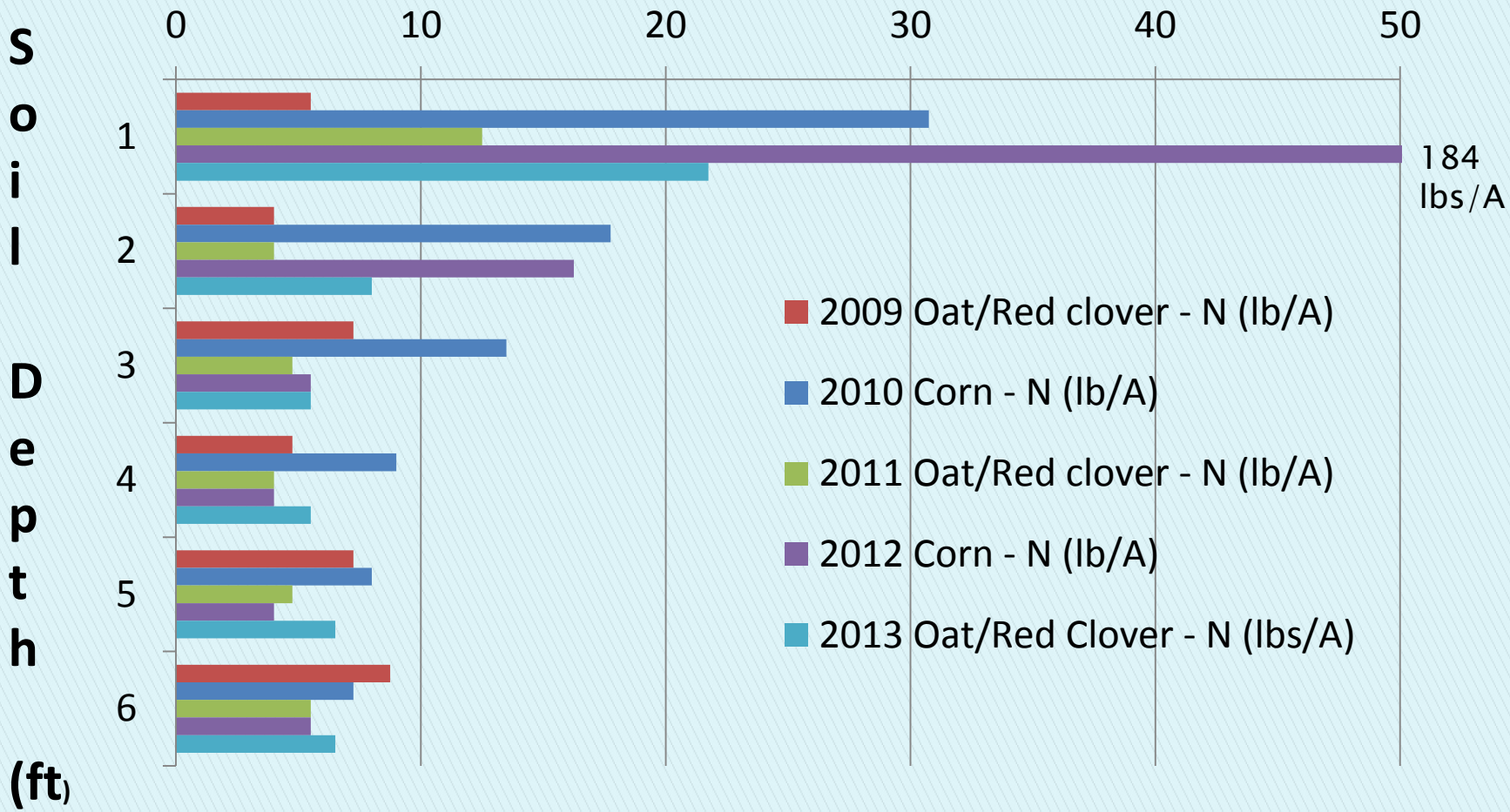


Average N application (2009-2013) – 5.5 lbs/A

Average residual N in top 6’ of soil – (2009-2013) – 27 lbs/A

Oat underseeded with Red Clover

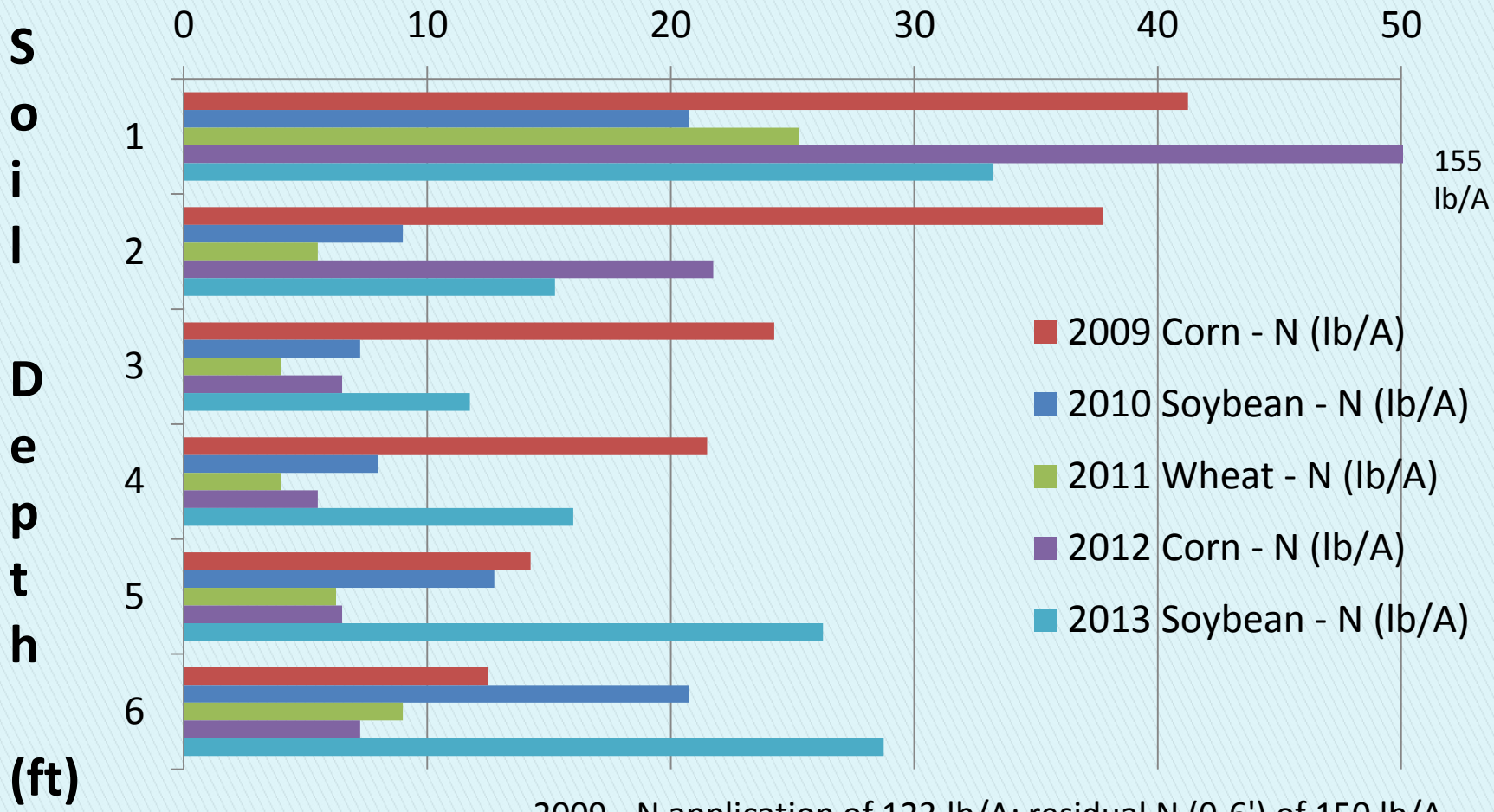
Oat/Red Clover, then Corn



2009 - N application of 0 lb/A; residual N (0-6') of 38 lb/A
2010 - N application of 117 lb/A; residual N (0-6') of 86.25 lb/A
2011 - N application of 14 lb/A; residual N (0-6') of 35.5 lb/A
2012 - N application of 146 lb/A; residual N (0-6') of 218 lb/A
2013 – N application of 0 lb/A; residual N (0-6') of 53.75 lb/A

Soybean following corn and winter rye

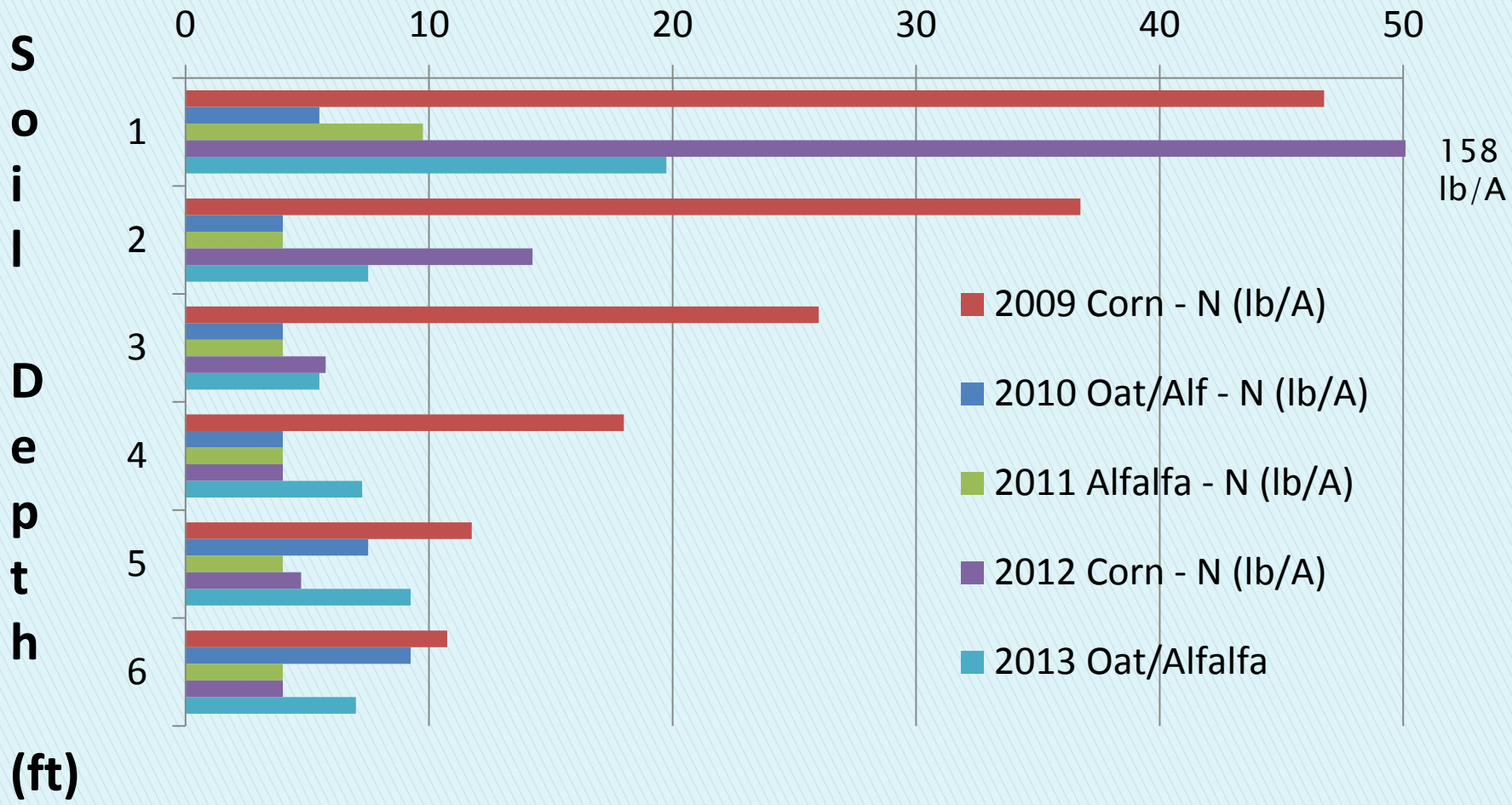
Corn, Soybean, then Wheat



2009 - N application of 123 lb/A; residual N (0-6') of 150 lb/A
2010 - N application of 0 lb/A; residual N (0-6') of 34 lb/A
2011 - N application of 14 lb/A; residual N (0-6') of 54 lb/A
2012 - N application of 116 lb/A; residual N (0-6') of 202 lb/A
2013 - N application of 0 lb/A; residual N (0-6') of 131.25 lb/A

Alfalfa following oats – June 4, 2011

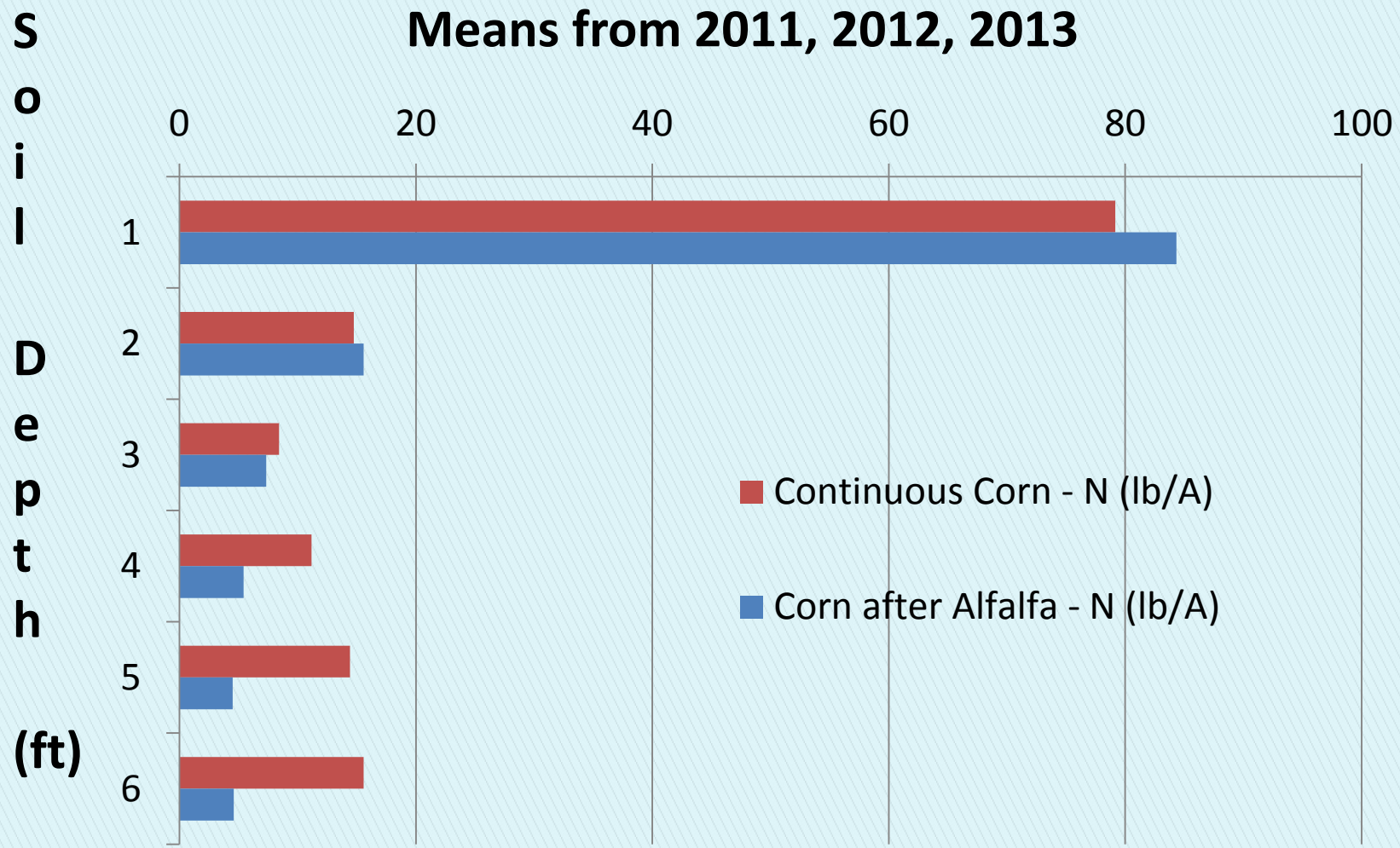
Corn, Oat/Alfalfa, Alfalfa



2009 - N application of 123 lb/A; residual N (0-6') of 150 lb/A
2010 - N application of 0 lb/A; residual N (0-6') of 34 lb/A
2011 - N application of 14 lb/A; residual N (0-6') of 30 lb/A
2012 - N application of 14 lb/A; residual N (0-6') of 190 lb/A
2013 – N application of 0 lb/A; residual N (0-6’) of 56.25 lb/A

Continuous Corn vs. Corn after Alfalfa

Means from 2011, 2012, 2013



Continous Corn - N application of 120 lb/A; residual N (0-6') of 143.5 lb/A
Corn after Alfalfa - N application of 16 lbs/A; residual N (0-6') of 121.75 lb/A

Residual Nitrate Nitrogen in the top 6' of soil in November as Affected by Crop Rotation – 5 yr. ave.

	Continuous Corn	Continuous Grass Hay	Oat/red clover – Corn (2 yr. rot.)	Oat – Alfalfa – Corn (3 yr. rot.)	Soybean – Winter Wheat – Corn
Total Residual N (lbs/A)	142	27	86	67	92

Summary

- Rainfall has a large impact on N in soils
  - N accumulates during dry years
    - John Sawyer data – Integrated Crop Management News, 2-21-2013
  - N is flushed from the system during wet years
- More N remains on the landscape following corn than any other crop
  - Most N is in the top 1-2' and below 4'
  - Longer rotations mean less land in corn in a given year, and therefore reduce the overall risk of N leaching
  - Cover crops, timely N applications are likely to help
  - Tap-rooted perennial plants like alfalfa and red clover can mine deep N and bring it back up to the surface
- Perennial grasses (and other perennial crops) work


NEW HOLLAND
FARMALL
706

Cropping Systems to Reduce Nitrate Leaching

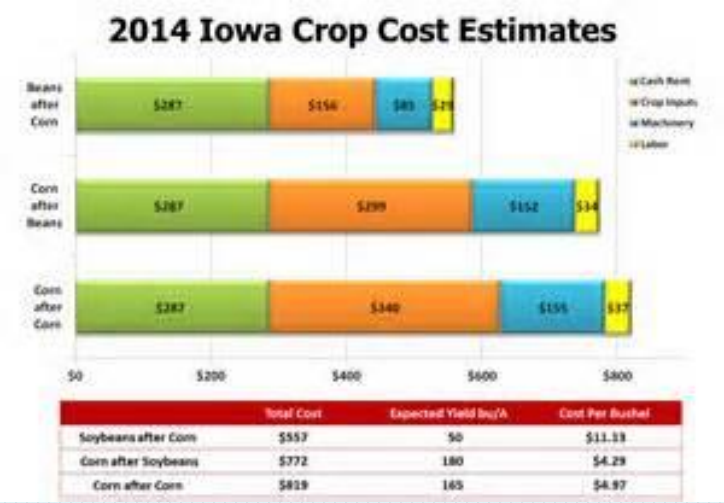
Preliminary Economics Summary 2009-2013

by
Ron Vos Ph.D.
Professor of Agriculture
Dordt College

Methodology

- Enterprise analysis
- ISU annual custom rates
- ISU annual closing inventory prices
- Actual yields (average of 4 reps) for each plot
- Rents charged/A reflected NW Iowa rates
- Economic cost charged for P & K removal
- Cover crop cost included

Iowa State University Extension



Crop Enterprise Analysis

- **Income:** yield x price (ISU closing prices)
- **Operating expenses:** ISU custom rates; opportunity cost for $ tied up: Ave. 6.4%
- **Fixed expenses:** rent (NW Iowa)
  2009: **$187**; 2011: **$ 224**; 2013: **$283**
- **Income** minus **total expenses** = **economic profit**

Enterprise Analysis Example

- **Income** Yield X Price $1000
- **Variable Costs** (examples) $500
  - Seed, herbicide
  - Field Preparation
  - Fertilizer
  - Harvest Cost
- **Fixed Costs** - Rent $300
- **Profit** Income- Costs $200

Continuous Corn

- **Five year average profit**: $208/A
- **Range**: -$(161)/A to $636/A
- **Most profitable year**: 2012
- **Least profitable year**: 2013

Continuous Grass Hay

- **Five year average profit**: $69/A
- **Range**: -$(167)/A to $505/A
- **Most profitable year**: 2013
- **Least profitable year**: 2009

Oat-alfalfa-corn system

- **Average system profit**: $125/A
- **System range**: -$(176) to $678/A
- **Most profitable**: 2010 corn
- **Least profitable**: 2013 oat

Oat/Red Clover-Corn

- **Average system profit**:-$(35) /A
- **System range**: -$(277) to $166/A
- **Most profitable**: 2010 corn
- **Least profitable**: 2013 oat

Soybean-winter wheat-corn

- **Average system profit**: $306/A
- **System range**: $277 to $428/A
- **Most profitable**: 2012 corn
- **Least profitable**: 2013 corn

Observations

- We are interested in high profit systems without high N loses
- SB-WW-Corn had 35% less residual N in top 6 ft of soil than Continuous Corn
- SB-WW-Corn was most profitable
- SB-WW-Corn was least variable
- More complex rotations can reduce the risk of N loss and be profitable

Present situation

- Convenience, farm policy, crop insurance, and rural culture favor Continuous Corn or Corn-Soybean
- Iowa has implemented a Nutrient Reduction Strategy
- More complex rotations may help the state reach the N reduction goals it has set