Understanding Risk in Agriculture

WHAT IS CAUSING RISK?
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Crop Insurance Claims

Top 2 insurance claims since 1989
- Excessive moisture
- Drought
Is it soil or climate?
Our Changing Climate
Illinois Precipitation: 1901-2010
Spring and Summer Rainfall - Illinois

July-August Precipitation (inches)

May-June Precipitation (inches)

Dry Spring
Wet Summer

Wet Spring
Wet Summer

Dry Spring
Dry Summer

Dry Spring
Dry Summer

1895-1980
1981-2013
Extreme Precipitation

Contiguous U.S. Extremes in 1-Day Precipitation (Step 4*)
Annual (January-December) 1910-2016

Upper Midwest Extremes in 1-Day Precipitation (Step 4*)
Annual (January-December) 1910-2016

Percent (%)
Climate trends

Increasing precipitation

Shift in seasonality with more spring and more variable summer precipitation

Minimum temperatures are increasing more than maximum

Temperatures are increasing more in the winter than the summer
Rain into the soil

Assuming an average rate of crop water use during the grain-filling period for corn

Hudson, 1994
What are we doing to our soil?
Soil Degradation Spiral

- Poor Land Management
- Aggregation Degradation
  - Compaction & crusting
- Water & Wind Erosion
- Plant Growth
- Soil Biology
- Yield
- Reduced Soil Productivity
Soil Organic Matter Changes

Decrease in OM quantity & changes in OM quality

Paustian et al., 1997
Stable Soil Systems

**Low Biological Activity**

- Low stability
- Slow infiltration, fast time to runoff
- Unstable microclimate

**High Biological Activity**

- High stability
- High infiltration, delays runoff
- Stable microclimate

Entrained material
Variation of Water Holding Capacity within production fields
Soybean Production Field

Yield variability in a field comes from soils inability to supply water during grain-filling.
Crop Yield Variation
Good Soils = Good Yields

Soybean yields across Iowa, Kentucky, and Nebraska

Climate resilience is derived from good soils in rainfed agricultural systems
Maize County Yields

Y = 436.096 + 478.149X, r² = 0.58***
Variation in NCCPI across the Midwest
Yield Gaps

We have found that 20% of the yield loss occur 80% of the time due to short term stresses, e.g., we needed an 2 inches but only received 1 inch of rainfall for the week so the plant is under a moderate stress and not fulling its yield potential.
Role of residue on the soil surface
Stable Microclimate

Temperature profiles in the soil

Extremes in temperature limit the biological activity in the soil, induced by a dry soil

85-90 F

120-130 F
Benefits of Using Cover Crops

- Reduced erosion
- Reduced nitrate leaching
- Reduced phosphorus losses
- Increased soil organic matter
- Improved weed control
- Support and maintain soil organisms
- Improve soil structure – especially no-till
- Grazing and forage potential
- Recycling manure nutrients
The “living soil”, a biological system.

Mammals - gophers, moles, mice, groundhogs
Earthworms - night crawlers, garden worms
Insects and mollusks - ants, beetles, centipedes, snails, slugs
Microfauna - nematodes, protozoa, rotifers≈
Microflora - fungi, yeast, molds, mychorhiza
Actinomycetes - smaller than fungi, act like bacteria
Bacteria - autotrophs, heterotrophs, rhizobia, nitrobacter
Algae - green, blue-green

Earthworms, insects and rodents are “nature’s plow” and the most visible components of the “living soil” team. They work in tandem with other soil fauna, soil microorganisms and fungi to contribute to aeration and nutrient cycling as part of a “soil factory” team effort.
## Carbon Balance in Corn-Soybean Fields 2000-2016

<table>
<thead>
<tr>
<th>Rates (Mg C ha(^{-1}) yr(^{-1}))</th>
<th>Field</th>
<th>Footprint</th>
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</thead>
<tbody>
<tr>
<td>ΔTC</td>
<td>-1.52 ± 0.78</td>
<td>-1.54 ± 0.76</td>
</tr>
<tr>
<td>C budget</td>
<td>-1.70 ± 0.01</td>
<td>-1.72 ± 0.02</td>
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</tbody>
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Current state of our soils

Continually lose carbon
Decrease the soil quality and infiltration rate
Increasing the potential for yield variation within fields
Increasing the risk of weather impacts on production
Soil Experiment – Laboratory

Evaluation of cover crop mixtures on changes in soil properties and gas exchange (CO$_2$ and O$_2$)
Risk

We can reduce the risk due to weather and climate changes by increasing the capacity of or soils to cycle water and nutrients.
What do we know

Our weather is becoming more variable

Efficient crop production is dependent upon good weather and a good soil

We can manage the soil to increase climate resilience by increasing water availability and nutrient cycling

Enhancement is soil is only possible by enhancing and maintaining the soil biological system
Overcoming Variability for Maximum Yield