



# **Soil Effects on Water Quality**

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# According to EPA the #1 pollutant in our waters is

# Soil



# What is soil health?

- It's the ability of the soil to carry out crucial functions
- For farm fields, food (or other crop) production is THE crucial function
  - Ability to produce food is the KEY soil health indicator
- Other functions may be crucial also, but should be specific (NOT 'soil biology')
- Ability to predict function is essential for kits, lab tests, scorecards (look for evidence!)

» From P. Scharf

# Does Soil Quality = Soil Health ??????

In USA, SSSA Ad Hoc Committee on Soil Quality recommended a separation between the two terms, with soil quality being a more analytical and quantitative term (Karlen et al., 1997)

Terms are now used interchangeably in both scientific literature and the media. Soil health generally refers to the condition of a soil as a result of management while soil quality refers to both the condition of the soil and its inherent properties.

# **The Role of Soil in Water Quality**

- **Soil quality needs to be expanded beyond productivity to include a broader concept that encompasses the functions that soils perform in natural and agricultural ecosystems.**
- **Healthy soils:**
  - **Regulate water flow in watersheds**
  - **Reduce emissions of greenhouse gases**
  - **Act as a medium for plant growth**
  - **Are a sink for heat, water and chemicals**
  - **Can be a filter for water**
  - **Are a biological medium to breakdown waste**
  - **Mediate many ecological processes**

# Soil Health and WQ

- A healthy stable soil absorbs and holds water better and leads to better water infiltration and erosion control
- Soil does all this by performing four essential agricultural functions:
  - Regulating water
  - Sustaining plant and animal life
  - Filtering potential pollutants
  - Cycling nutrients

- **What do we find as indicators of healthy soils?**
  - **One-celled bacteria**
  - **Algae, fungi**
  - **Protozoa, nematodes**
  - **Micro-arthropods**
  - **Earthworms**
  - **Insects**
  - **Small vertebrates**
  - **Plants**
  - **Organic matter**
  - **others**

- **What do these components of a healthy soil do for the soil?**
  - **Affect soil structure**
  - **Create more porosity**
  - **Allow for higher water infiltration**
  - **Reduce potential for soil erosion**
  - **Potential increased fertility**
  - **Potential for higher water holding capacity**
  - **Assist with decomposing organic compounds**

# **When we don't have healthy soils**

- Less infiltration of water
- Higher level of runoff
- Poorer plant growth
- Higher potential for pesticide runoff
- Higher potential for nutrient runoff
- Etc.
- The purpose of soil quality improvement is to protect and improve long-term agricultural productivity, water quality, and the habitats of all organisms, including people (K. Clark).

# Soil Erosion

- Destroys stream and lake habitat
- Reduced A horizon leads to less productivity of soil that is remaining
- Carries pollutants into waterways
- Increases organic load in waterways
- Nutrients in soil can increase aquatic plant growth
- Other.

# Why worry about soil, nutrient or pesticide runoff



# **Soil and nutrient runoff into surface waters**

- Excessive nutrient and soil runoff causes:
  - Increased algal growth and other organic materials in fresh water sources
  - Negative effects on recreational use of surface water for boating, whole body contact, fishing, etc.
  - Degrades natural habitats
  - Increases cost of public drinking water to remove organics from the water.



# How can we reduce erosion & save our topsoil?

- Reduce tillage intensity & frequency
  - Leave residue to protect the soil surface
- Grow cover crops to protect the soil surface
- Any change in ground cover or use can affect soil most often in an adverse way.



# **What other concerns for water quality**

- Is soil quality and soil erosion the only thing to look at?
- Probably not but it has the greatest potential for controlling nutrient and pesticide losses.

# **Can we manage for more than one problem at a time**

## **Scenario:**

- North Mo has several small rural water districts that use surface water lakes.
- Most are surrounded by row crop and agriculture production is the main revenue source for the area
- What are the 3 most common things degrading water that are from agriculture?
  - **Sediment, Pesticides and Nutrients**
- What can you do to protect the environment and maximize profits?

# **What can you do to maximize profits while protecting water quality?**

- **Keep records on:**
  - **cost per acre**
  - **Yields for different segments of the field**
- **Understanding farming systems and the effect they have on environment (no-till, minimum till, etc.)**
- **Know the effects caused by fertilizer and herbicides.**
- **Know your watershed and where it drains**
- **Watch the weather.**

- Will one practice reduce the potential for runoff of sediment, nutrients and pesticides into waters of the state?
- What factors work into making that decision?
  - Farming system
  - Cover crops are excellent but may have a narrower window of availability for planting
  - Need to determine what combination of practices can control several different pollutants

- Sediment and nutrient controlled by no-till but not atrazine.
- Atrazine runoff controlled by incorporation but may increase sediment runoff
  - Atrazine binds with the soil to reduce runoff when it is incorporated.
  - Claypan soils have more tendency for runoff than many other soils
- What combination will work?

# Scenario 1

- What is the answer
  - Each person must evaluate what is best for their operation
  - Don't focus on short term economics instead of long-term benefits

# Economic Scenario

- Average dry land corn crop yield in Missouri is 120-125 bu/acre.
- Average cost to produce an acre of corn is \$515 per acre.
- If the farmer has an average year of 120 bu/acre he knows he must sell corn for \$4.30 /bu to break even.

# Economic Scenario

- Farmer Bill averages 120 bu/acre of corn
- At \$6/bu. Farm Bill grosses \$720/acre - \$515 production cost Farmer Bill makes \$205 per acre.
- Generally Farmer Bill applies 1 lb. of N for every bu. he wants to produce
- Weather looks favorable so he thinks this might be a better than average year so he increases N by 10 lbs. per acre.
- At \$0.60 per pound 10 more lbs of N the cost is \$6 and if he produces 10 more bu of corn per acre at \$6.00 per bu. He get \$60 per acre more for the corn
- The \$6 investment in N provides \$60 in corn production

- **What happens if it is a bad year or the soil is marginal and not healthy? Average production may be down to 90 bushel/acre**
  - **To breakeven corn must sell for \$5.70/bu**
- **Can Farmer Bill justify putting marginal soils into crop production?**

# Economic Scenario

- Chris Clayton (DTN Ag Policy Editor) stated average cost to produce a bushel of corn is \$5.15.
- Corn market down to \$4.25
- How many bushel per acre does it take to breakeven? Approximately 121 bu/acre.
- If on marginal soil you won't make the state average.

# Marginal Lands Put into Production

- Lower water holding capacity (decrease the length of time plants have access to available water and nutrients) resulting in a decrease in production
- Plants can't utilize the nutrients so it either leaches into the ground water or runs off
- Provides area for higher weed populations
- Are suburban lawns marginal lands?



- **Short term gain due to high commodity prices do not justify farming poor soils.**
- **Poor soils cause have higher soil erosion rates, less water holding capacity, poorer plant growth, more intense weed populations, higher nutrient runoff, higher pesticide loss, etc.**

# Economic Scenario

- Marginal land may need more fertilizer and nutrients so cost may be \$500/acre
- Marginal land may only produce 90 bu/acre
- At \$6/bu Farmer Bill grosses \$540/acre
- His cost is \$515 so net profit is \$25
- What if corn is \$5/bu
- Can we justify putting marginal land into production for short-term benefits?

# Economic Scenario

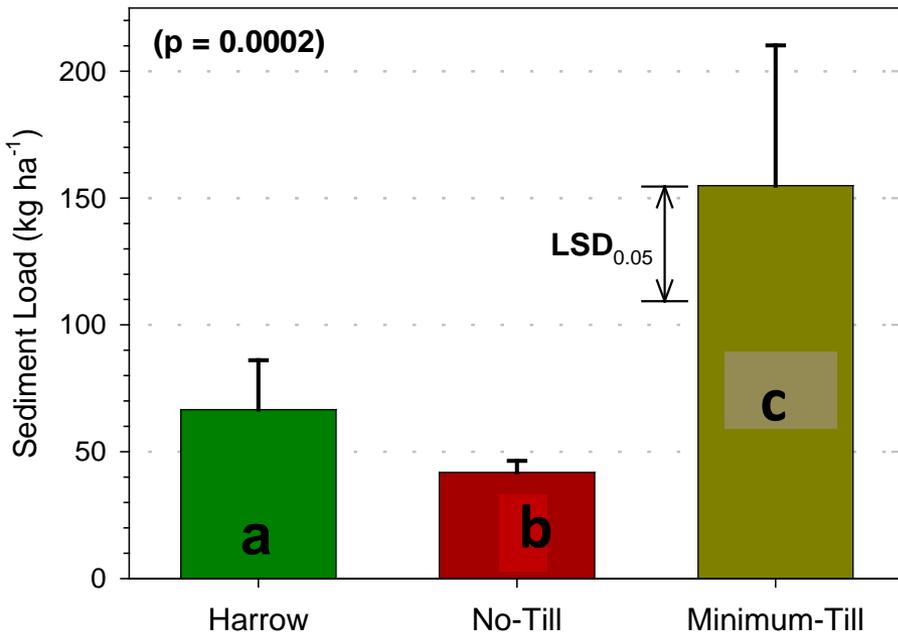
- How important is soil health to the farmer for being productive and for profitability?
- Can marginal soils be improved to increase productivity and environmental protection.
- What would it take to demonstrate to farmers that putting marginal soils in production is not a long-term sustainable practice either environmentally and economically?

# **Runoff Research For Pesticides and Soil**

- **Research Field**
  - Field in no-till for 15 years.
  - Generally a corn/soybean rotation
  - Concerns are runoff water from the field getting into local water sources
  - How do we manage to control sediment, and pesticides?

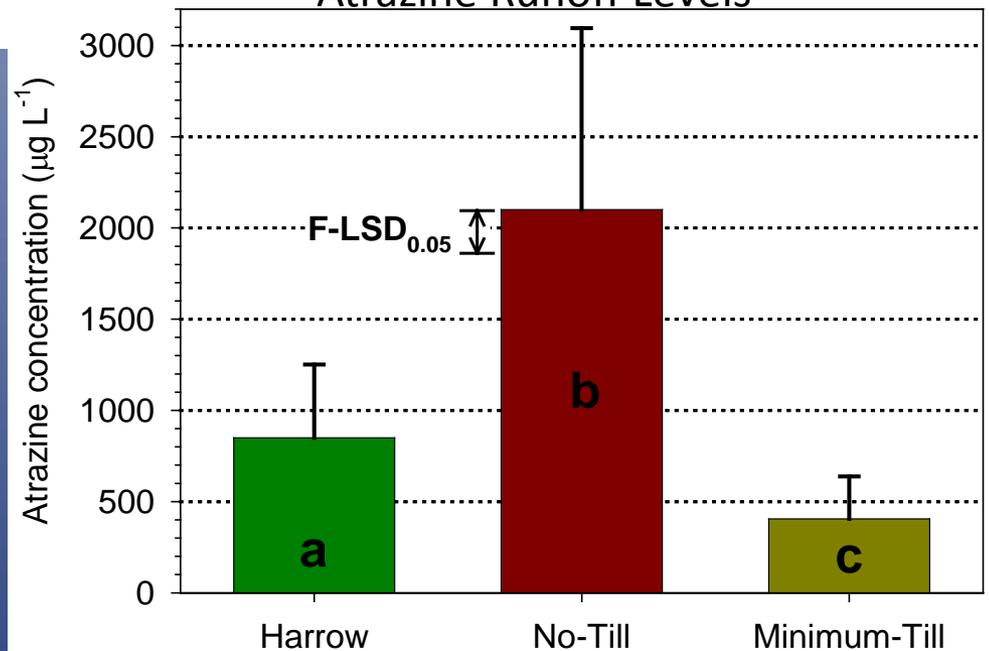
- **Test plots were developed**
  - **Area A was no-till with light disking and then Phillips harrow**
  - **Area B was no-till**
  - **Area C was minimum-till**
- **Same rainfall**
  - **0.9 inches per hour**
- **Same pesticide levels applied**

## Suspended Sediment Load



What combination of practices can be done to protect the environment from sediment, nutrient and pesticide runoff

## Atrazine Runoff Levels



# **What the graphs tell us**

- For controlling soil erosion no-till is most effective method
- For controlling atrazine minimum tillage gets good results (incorporation to 2 inches)
- How do we get the best of both worlds? Try lite tillage on no-till to incorporate less than 1 inch but still retain conservation cover.

- **Why use atrazine at all?**
  - **Effective weed control herbicide**
    - **Used on over 85% of all corn acres**
  - **Economics**
    - **Atrazine cost approximately \$15/acre**
    - **Next best product is approximately \$36/acre**
  - **Easy of use**
    - **Mixes easy**
    - **Works well with many other products**

# Land Management Impacts

Conservation cover with crop residues and cover crops can protect soil from eroding.

Nutrients can be tied up in the crop residue and not be washed away.

Pesticides that bond with the soil have a harder time of running off



# **If the soil was healthier:**

- We would see greater water holding capacity
- May see less need for pesticides
- May see greater utilization on nutrients
- We can combine practices that can improve soil health and still reduce nutrient and pesticide runoff – cover crops and field borders, etc.

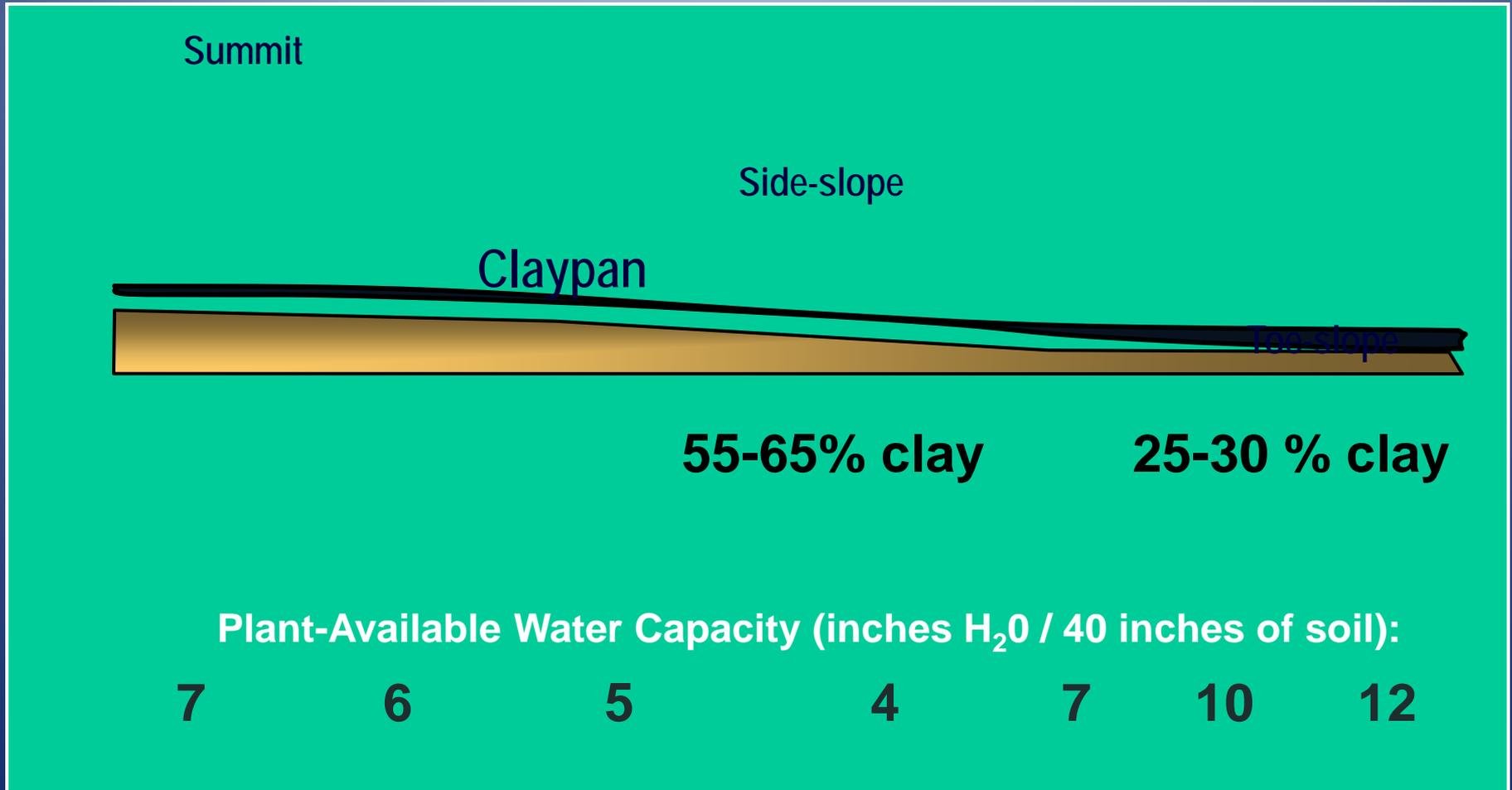
# Tillage and soils

- Can destroy soil structure
- Cause severe soil erosion
- Kills micro-organisms in the soil
- Adversely affect water holding capacity
- Does provide a good seed bed for germination
- Can reduce some weed populations
- Others

# How do erosion and topsoil depth affect yield?

- Small-plot experiments 2009-2011 near Columbia—mostly 1 to 18” of topsoil
  - Newell Kitchen and others (Ag Research Service)
- Corn
  - 4.6 bu/acre per inch of topsoil in 2009
  - 1.1 bu/acre per inch of topsoil in 2010
  - 2.9 bu/acre per inch of topsoil in 2011
- Average 2.9 bu/acre per inch of topsoil
- Similar to 2.2 bu/acre per inch of topsoil measured in another field in 1999 & 2001
  - » From P. Scharf

# Topsoil depth affects water delivery to crops



Stole from Peter Scharf

# From a Drinking Water Perspective

- Excessive nutrient and soil runoff causes:
  - Increased algal growth and other organic materials in fresh water sources
  - Negative effects on recreational use of surface water bodies for boating, whole body contact, fishing, etc.
  - Increased treatment costs for public drinking water resources
    - Removal of excessive organics requires more chlorine to be added. This can result in THMs (trihalomethanes) and DBPs (disinfection by-products), both of which are linked to cancer
    - THMs and DBPs must be removed before the water can be sent out through the distribution system

# **A Combination of Practices to Achieve Our Goals**

- For protecting soil and improving soil quality
  - CRP, no-till, cover crops, etc.
- For protecting environment
  - No-till, CRP, pesticide incorporation, cover crops, buffers, riparian areas, etc.
- For long-term increased productivity
  - Cover crops, no-till, crop rotations, etc.
- For long-term increased profitability
  - You tell me?

# **Will healthier soils reduce the need for nutrients and pesticides?**

- **Healthier soils**
  - Allow for more infiltration
  - Can mitigate some pollutants
  - Can hold nutrients for plant use
  - Provide micro-nutrients for better plant health
  - Have more water holding capacity

# What we are thinking.....

- Cover crops not only increase soil microbial action but improve soil health
- Cover crops can reduce weed populations and potentially cause need for less herbicides
- Cover crops create more water infiltration and water storage capacity in the soil
- Cover crops reduce soil erosion

Are cover crops the answer or just part of the equation?

A wide-angle photograph of a field of tall, golden-brown grasses, likely a prairie or meadow, under a clear blue sky. The grasses are dense and reach towards the top of the frame. In the background, a line of bare trees is visible against the horizon.

**Thank-you!**

**Questions?**