Water Quality and Water Quantity

Are they significant issues in the bioeconomy?

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Water Quantity

- How much is used per gallon of ethanol produced?
- How much ethanol will be produced in Iowa in a mature industry?
- How does water use (for ethanol) compare to recharge to aquifer under the present climate? Under future climate?

Water Quantity

- How does water use (for ethanol) compare to water usage by existing major users?
  - Industry
  - Cities
- Is the stability of water supply sufficient that processing plants can be insured sufficient water to run unimpeded by episodic changes in water supplies?

Water Quantity

- Average precipitation of 30 inches/year
- Assume ~ 10% of annual precipitation goes to recharge groundwater
- Assume 4 billion gallons ethanol production annually in Iowa in mature industry
- Assume 4 gallons of water use per gallon of ethanol

Water Quantity

- Use 0.55% of recharge
  - Ethanol water use/(Area of Iowa X 10% of precipitation)
- Equals about17% of public water withdrawal[1] from groundwater
- e.g., Ames used 10 million gallons per day for several days in June – Lincolnway Energy use about 548,000 g/day, assuming 4 gal H_2O/gal ethanol

[1]Estimated Use of Water in the United States in 1995. U.S. Geological Survey Circular 1200, 1998

Water Quantity

While we think of water as being relatively abundant in Iowa, the distribution of groundwater availability and sustainability is far from uniform; and neither is the distribution of demand.

Robert D. Libra, State Geologist, Iowa Geological Survey, and Michael K. Anderson, Senior Engineer, Water Allocation Program, Iowa Department of Natural Resources. August 21, 2006.

Future Concerns

- Recharge would decrease under drier climate conditions
  - Competition for water between cities and industry under more arid conditions
  - Stream flow may decrease, causing cities like Des Moines to use more groundwater
- Ethanol plant construction in areas of known groundwater scarcity – do plants require “drinking water” quality or could deeper aquifers be used?
- Need for a risk analysis?

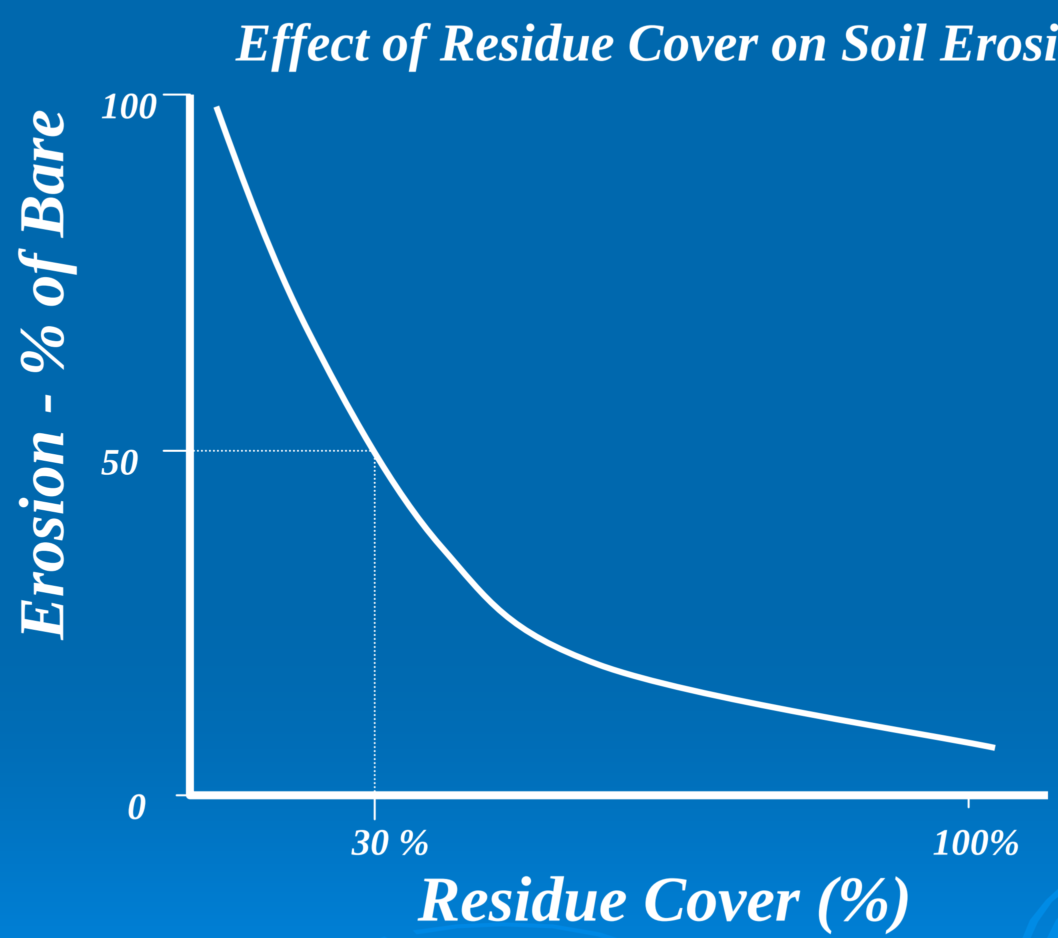
Factors Affecting Water Quality

- Point Sources
  - Water quality entering the plant
  - Dilution potential of water leaving the plant

Factors Affecting Water Quality

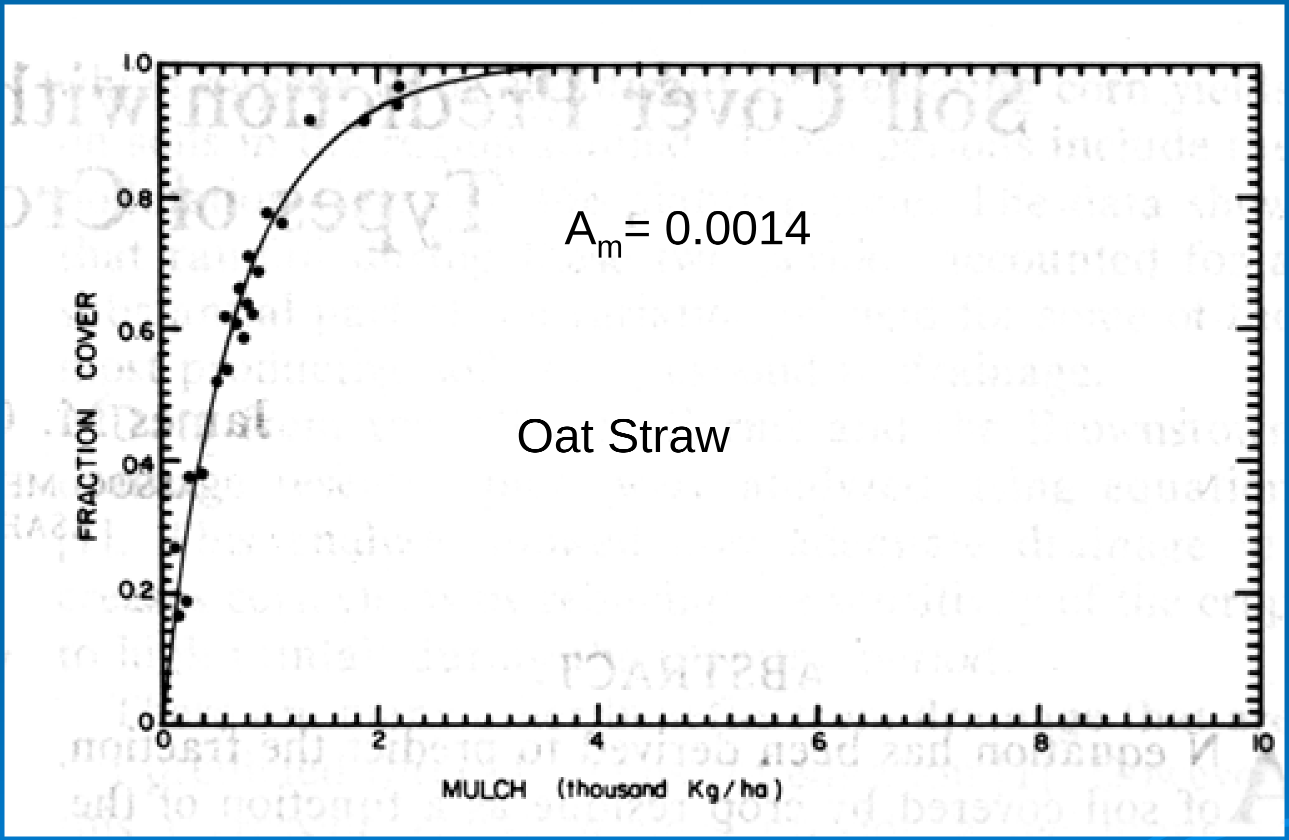
- Nonpoint Source & Lignocellulosic Conversion
  - Sediment
  - Nutrients

Residue Impacts on Erosion



Laflen, J. M., and T. S. Colvin. Effect of crop residue on soil loss from continuous row cropping. Trans. Am. Soc. Agric. Eng. 24(3):605-609. 1981.

Residue Impacts on Erosion



Sloneker, L.L. and W.C. Moldenhauer. 1977. Measuring the amounts of residues remaining after tillage. J. Soil and Water Conserv. 32:231-236.

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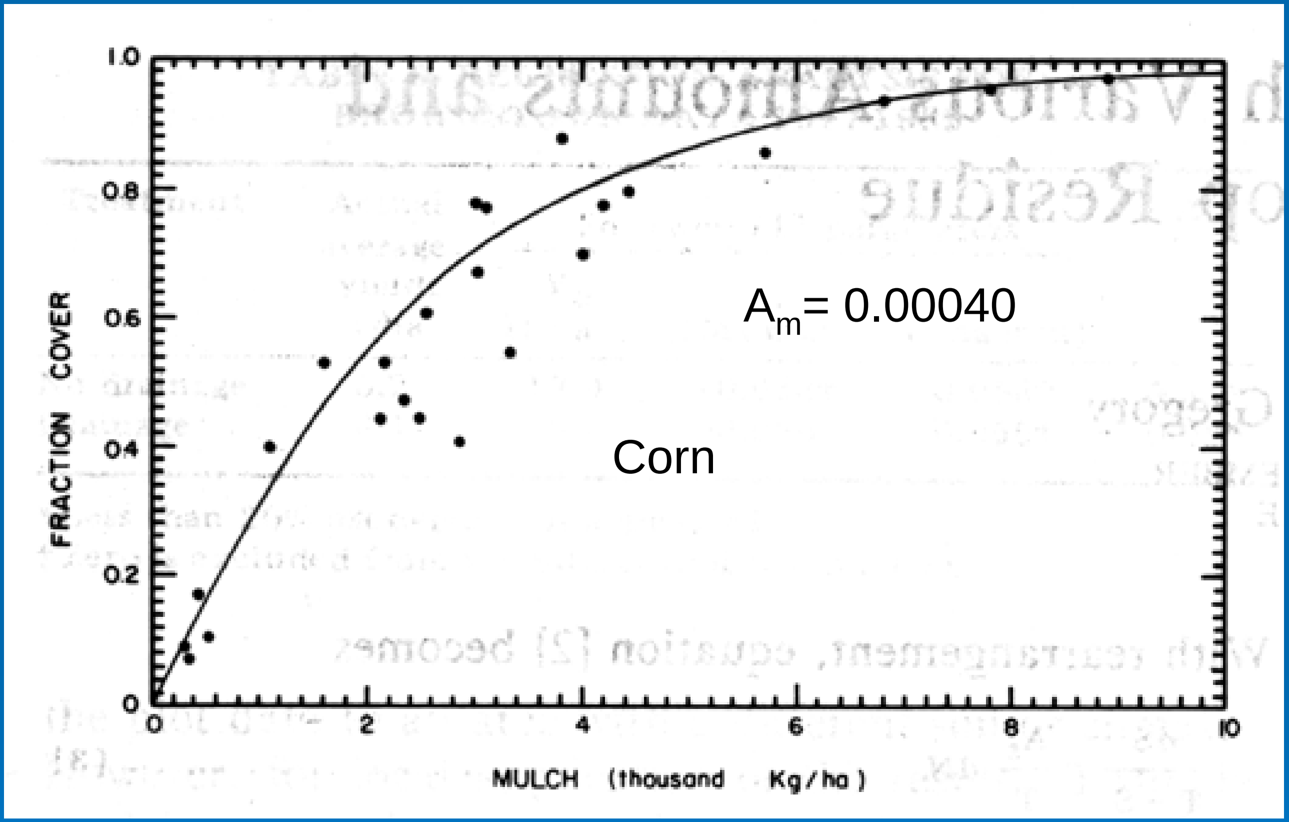

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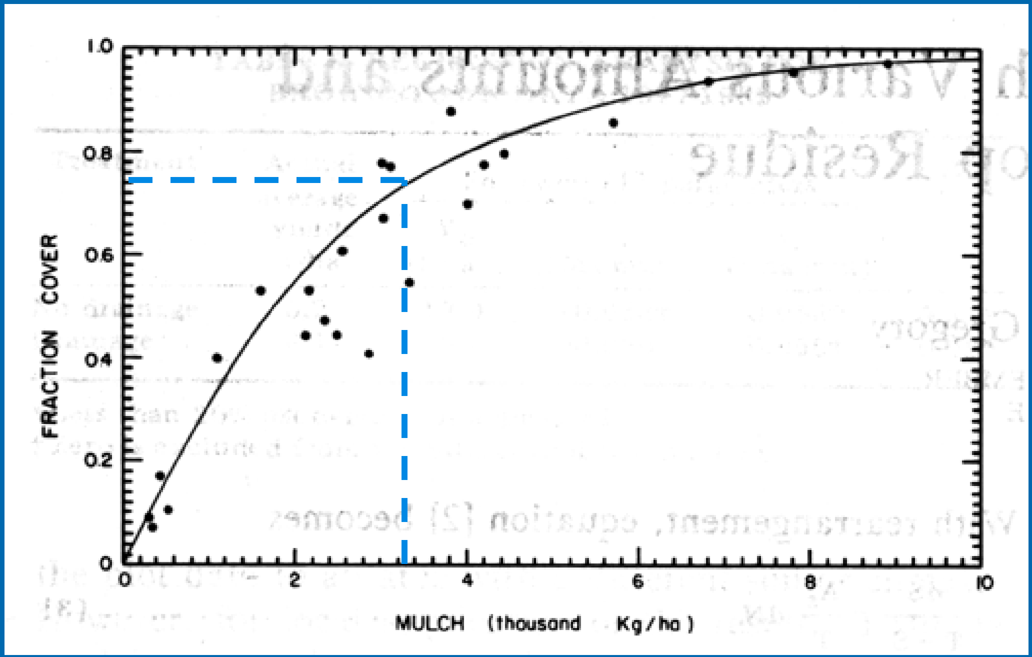
Residue Impacts on Erosion

Residue Impacts on Erosion

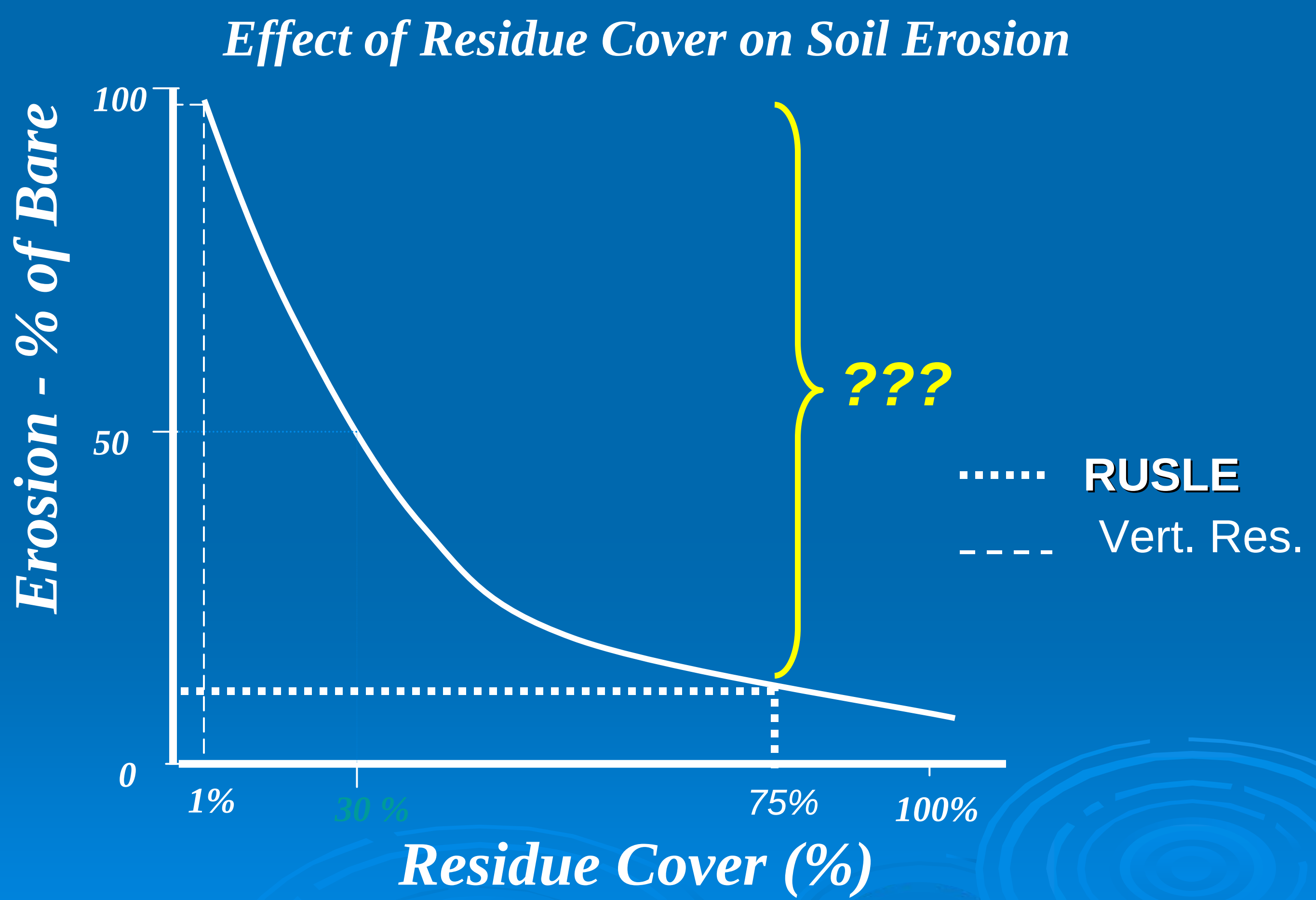
- Residue cover calculation & assumptions
  - Stalk density = 0.5 g/cm^3
  - Stalk cut height = 8 inches
  - Stalk diameter = 1 inch
  - Plant density = 30,000 plants/acre
- Residue mass remaining in field = 1.6 tons/A

Residue Impacts on Erosion



- Gregory formula calculates residue cover > 75%
- Assuming stalks stand vertical - cover < 1%

Residue Impacts on Erosion



Management Options

- Stalk chopping/shredding
- Cover crops
- Narrow row corn
- ???

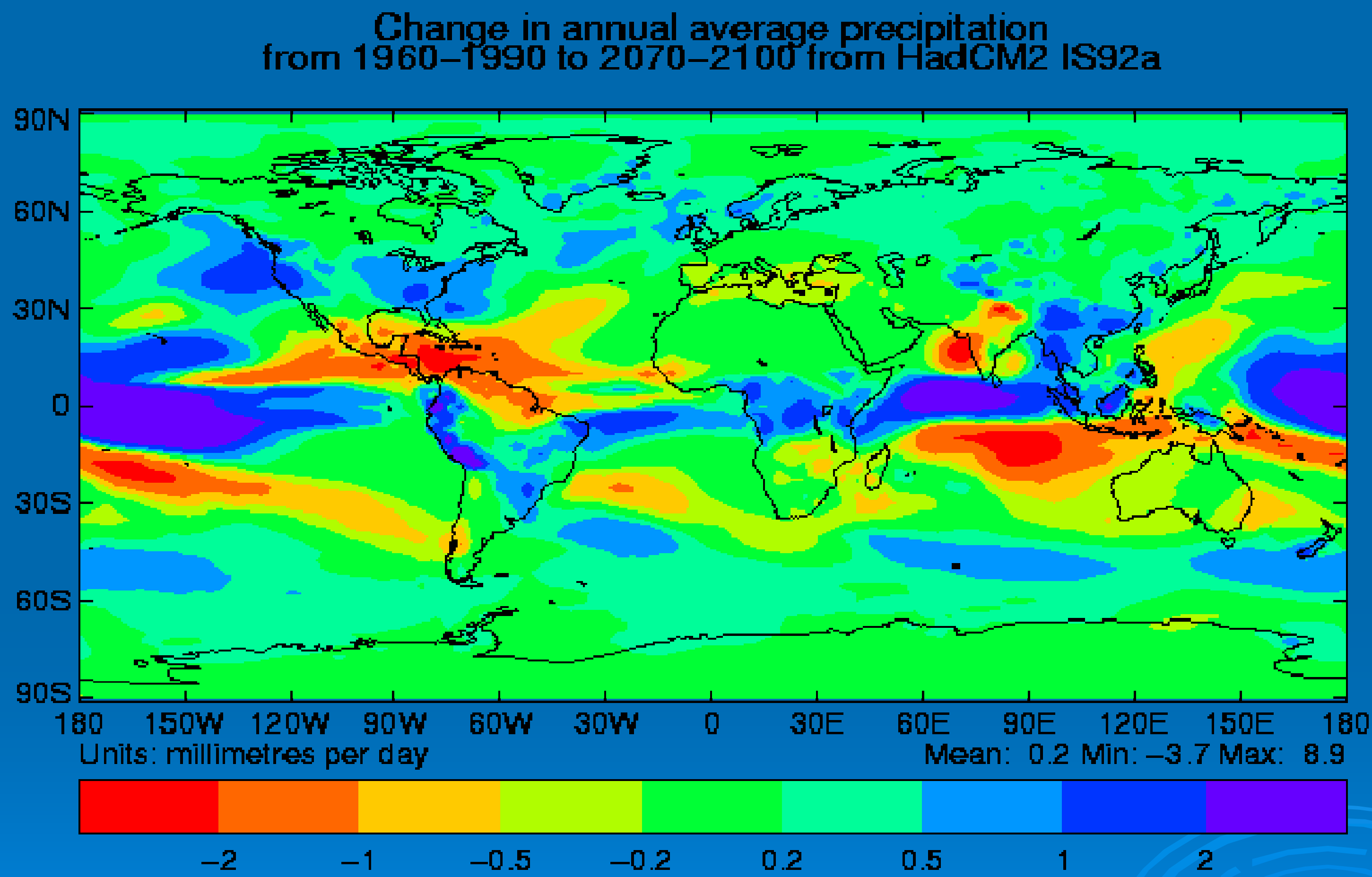
Climate Change & Soil Erosion

- 20% precipitation ↑ leads to 37% erosion ↑ (Lee et al. 1996)
- Runoff ↑ 10% - 310% for different Midwest regions (O'Neal et al. 2005)
- Soil loss ↑ 33% - 274% for different Midwest regions (O'Neal et al. 2005)

Lee, J.L., D.L. Phillips, and R.F. Dodson. 1996. Sensitivity of the US Corn Belt to climate change and elevated CO2:II. Soil erosion and organic carbon. Agric. Systems 52: 503–521.

Monte R. O'Neal, M.A. Nearing, Roel C. Vining, Jane Southworth, and Rebecca A. Pfeifer. 2005.Climate change impacts on soil erosion in Midwest United States with changes in crop management. Catena 61:165-184.

Trends in Precipitation



Hadley Centre for Climate Prediction and Research, The Met. Office

Trends in Precipitation

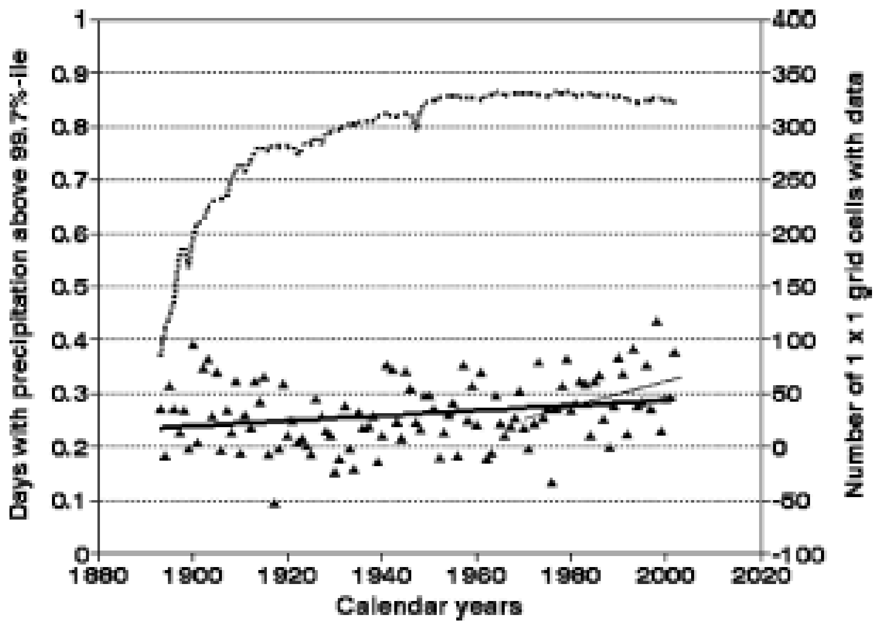
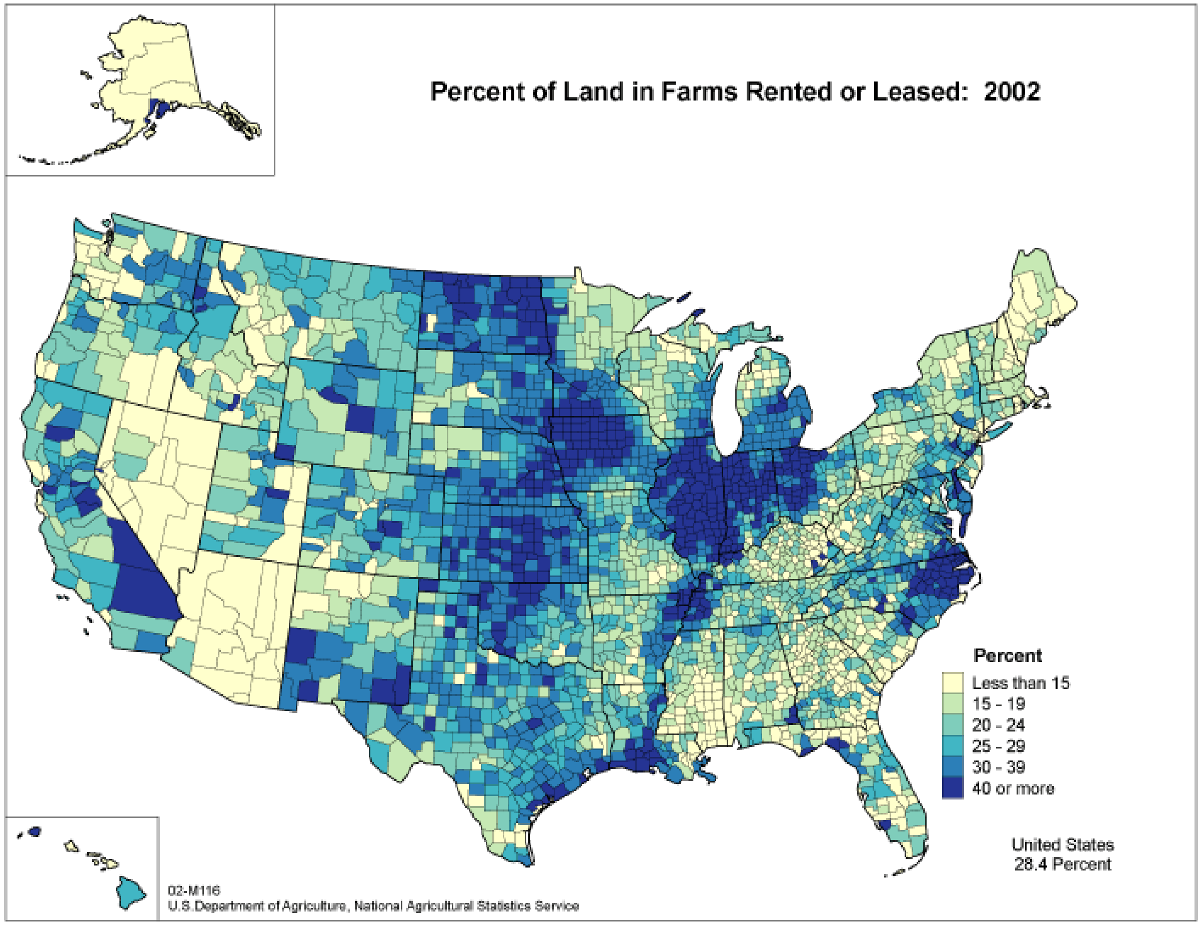


FIG. 9. Very heavy precipitation (upper 0.3% of daily rain events with return period of 4 yr) over regions of the central United States (hatched in Fig. 1) and their linear trends. Linear trends for the 1893–2002 and 1970–2002 periods (solid lines) are equal to 20% (110 yr)$^{-1}$ and 26% (30 yr)$^{-1}$, respectively, and are statistically significant at the 0.05 level or higher. Note that there was not any change in very heavy precipitation prior to 1970. The numbers of 1° × 1° grid cells with valid station data are shown by dotted line.

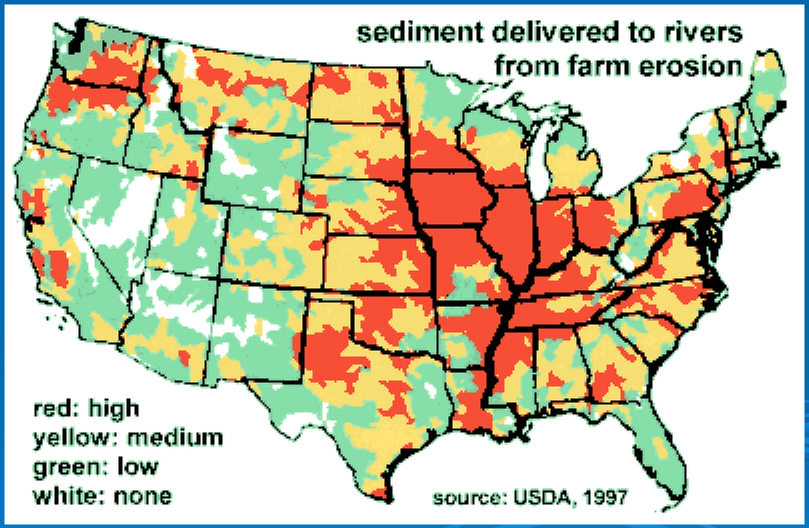
Groisman, Pavel Ya., Richard W. Knight, David R. Easterling, Thomas R. Karl, Gabriele C. Hegerl, and Vyacheslav N. Razuvaev. 2005. Trends in intense precipitation in the climate record. J. of Climate. 18:1326-1350.

Farmland Ownership



Farmland Ownership – Major Obstacle

- HARVESTED FARMLAND - % Rented[1]
  - Iowa – 65%
  - Minnesota – 74%
  - Illinois – 84%
  - Indiana – 86%
- Harvested land
  - Biomass source
  - Best land



[1] http://www.nass.usda.gov/census/census02/volume1/us/st99_2_040_040.pdf

Why Is Land Ownership Important?

- Effective Soil and Water management benefits from
  - Temporal management
  - Spatial management
  - Incentives for long term profitability linked to sustainability – Water quality and soil conservation issues

Why Is Land Ownership Important?

- Market for most important soil and water conservation tool – crop residue
- Renter competition increases rent bids, increases need for increased gross return – residue sales
- Industrial and investor expectations may increase demand for feedstocks
- Soil and water conservation tools limited with rented land
  - Renters vs. owners strategic plans
- “Nothing accelerates faster, stops quicker, or corners harder than a rented car”

Natural Resource Concern

- Crop residue effects on soil erosion/water quality
- Land rentals and short-term profit motive
- Intensifying precipitation patterns
- Soil erosion impacts on feedstock supplies

Soil & Water Opportunities

- Common market for wide range of crops
- Multiple purpose, multiple function
- Temporal & spatial management

Greatest opportunity since native prairie!

Conclusions

- Bioenergy vision offers significant challenges to soil and water resources
- Bioenergy industry offers soil and water resource opportunities not recently experienced
- Opportunities will require paradigm shift in land management education/application
- Production WITH protection is possible, but is major challenge with current farming/industrial structure and climate change projections.