

# The Impact of Karst on Agriculture

Conduits, Karst, and Contamination –  
Addressing Ground Water Challenges

2012 MGWA Spring Conference



presented by

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# Outline

- Introduction
- Karst's impact on modern cropping practices
- Karst's impact on water resources
  - Water Quantity
  - Water Quality
- Karst's impact on soil
- Conclusions

# Introduction

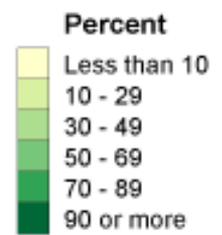
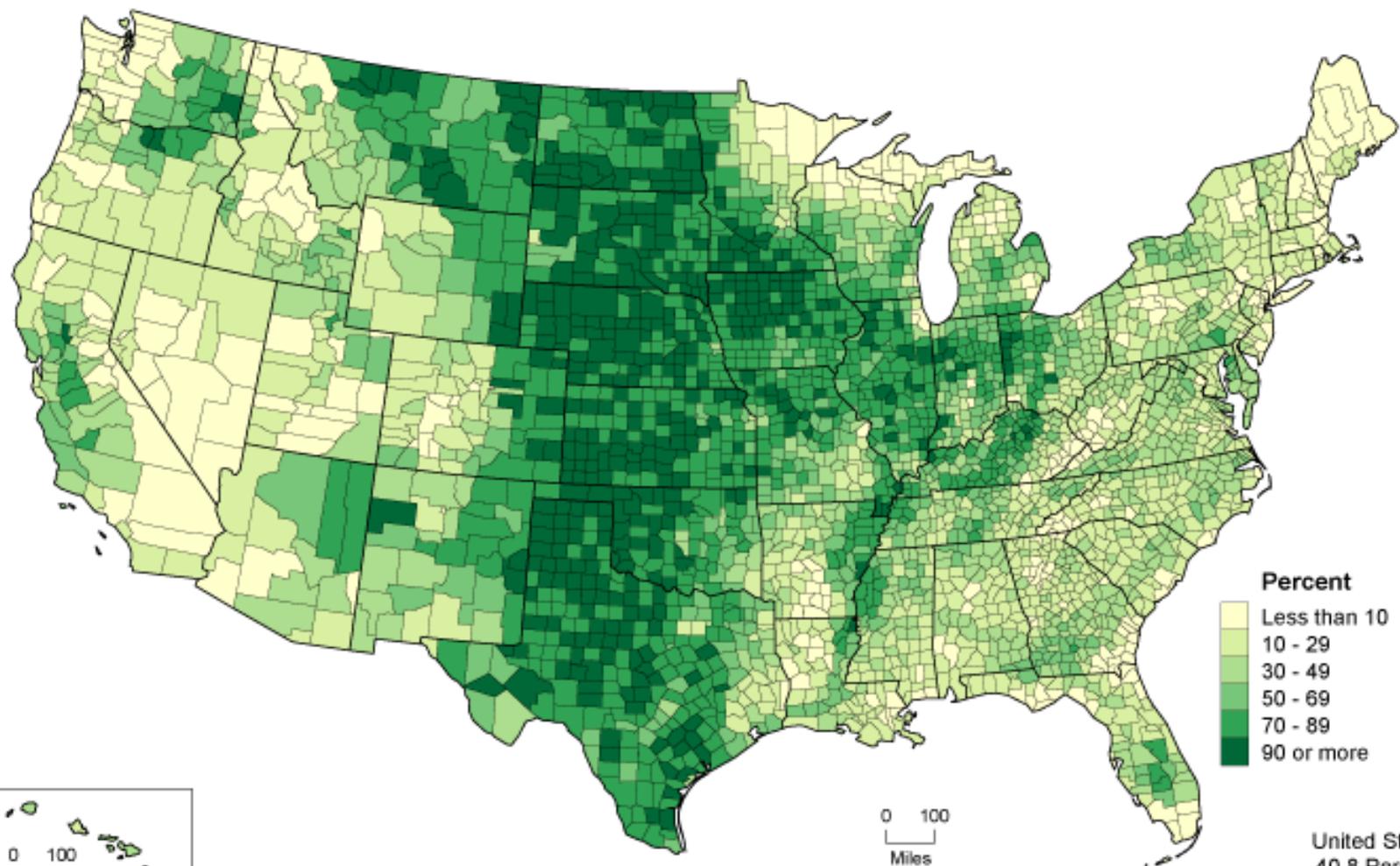
## Agriculture



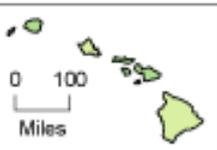
Farmers are basically in the business of harvesting solar energy.

In the Minnesota they use devices  
(corn and soy bean plants)  
that only work about four months of the year.

# Acres of Land in Farms as Percent of Land Area in Acres: 2007



United States  
40.8 Percent



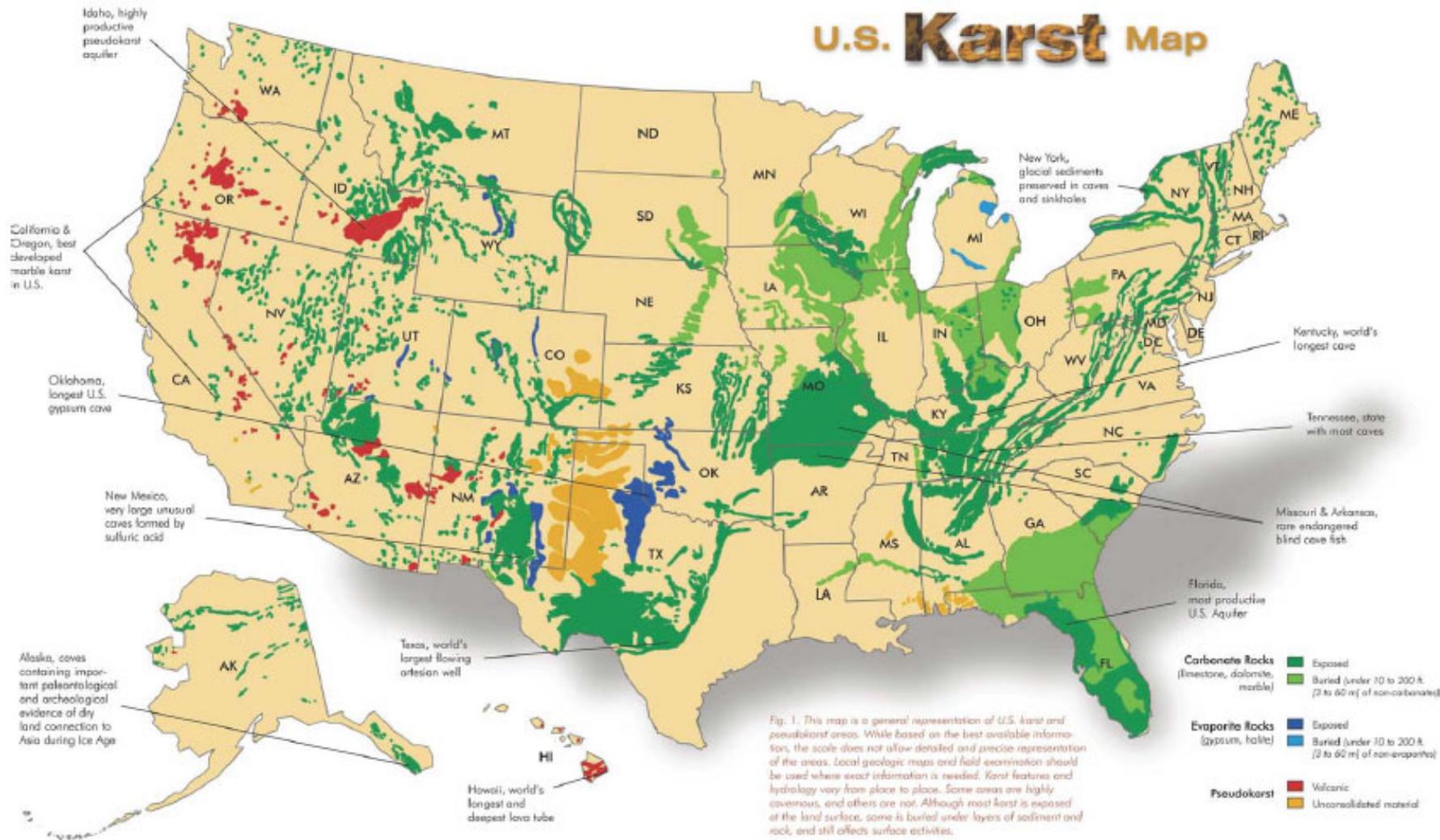
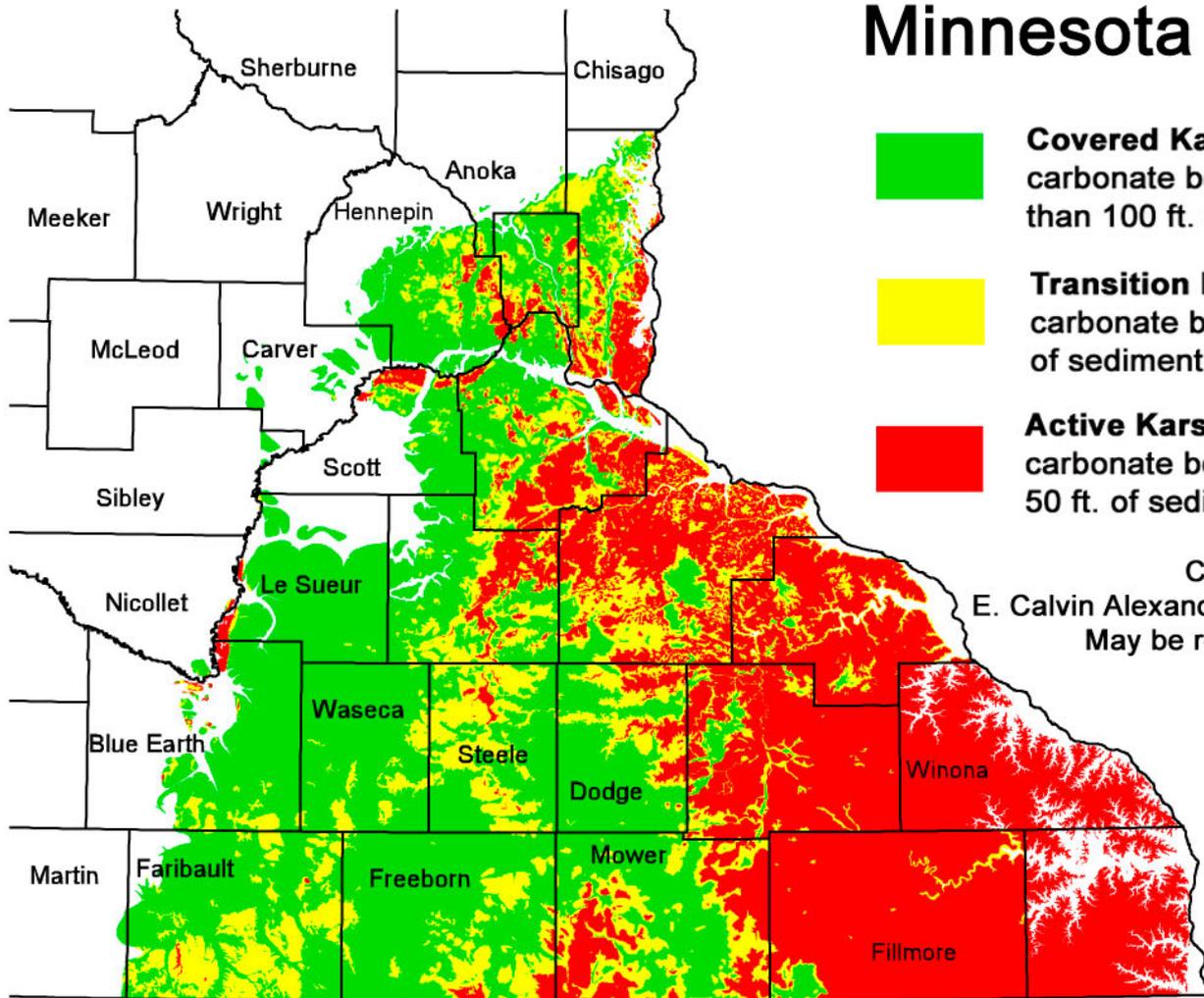


Figure 3: Karst map of the US published by AGI (Veni *et al.* 2001).

# Minnesota Karst Lands



**Covered Karst.** Areas underlain by carbonate bedrock but with more than 100 ft. of sediment cover.



**Transition Karst.** Areas underlain by carbonate bedrock with 50 - 100 ft. of sediment cover.



**Active Karst.** Areas underlain by carbonate bedrock with less than 50 ft. of sediment cover.

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50 0 50 100 150 Kilometers

50 0 50 100 Miles



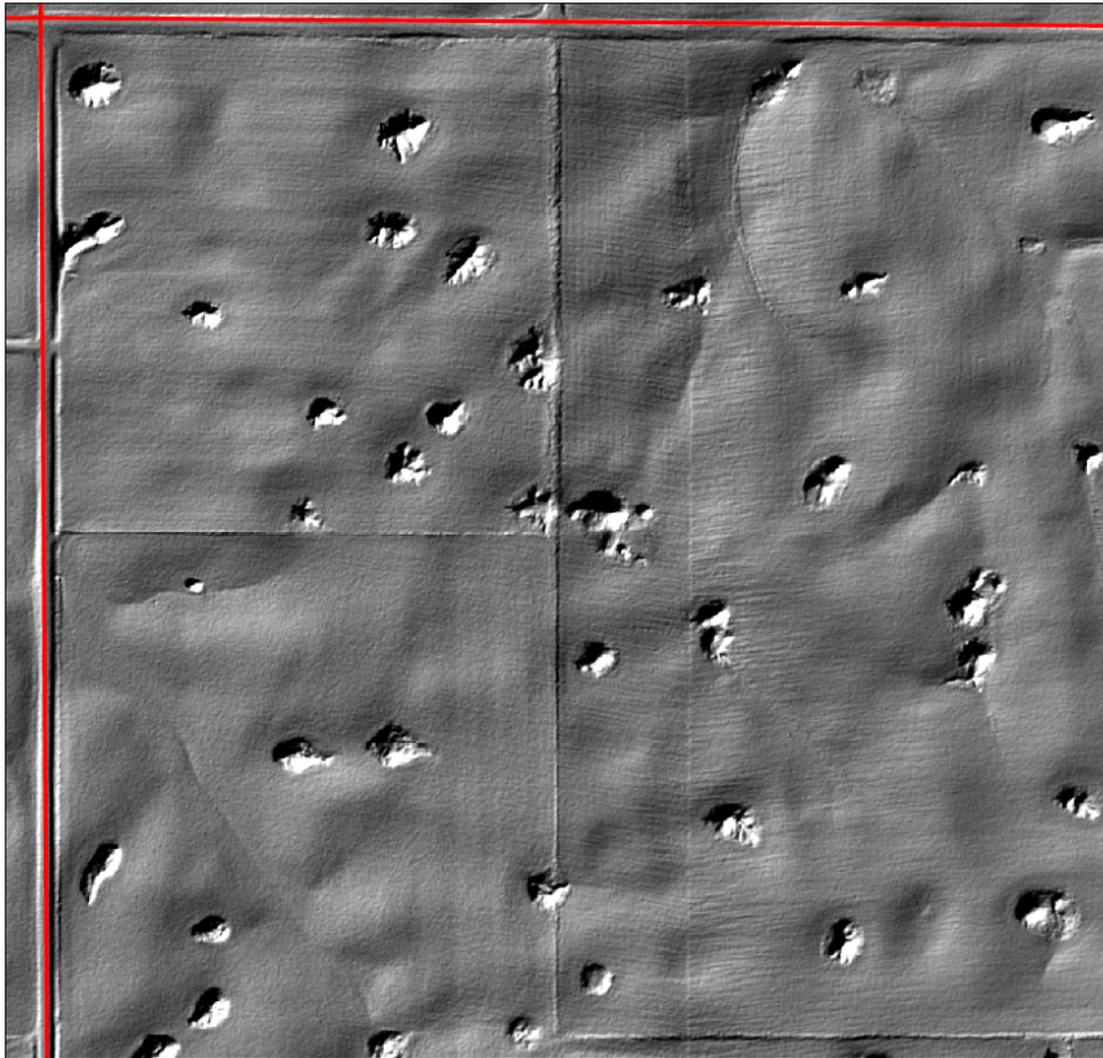
What does karst do to this equation?

In the American mode, I am using an irrational mixture of SI and English units. For the rational members of the audience I offer the following area conversions:

1 mile<sup>2</sup> = 1 section = 640 acres  $\approx$  256 hectares

$\frac{1}{4}$  mile<sup>2</sup> = 40 acres  $\approx$  16 hectares

NW sec. 1, T 103 N, R 11 W, Fillmore County, MN



0 50 100 200 300 400 Meters

# LiDAR

Flown Oct. 2008

7 Counties in  
SE Minn.

1 meter pixels  
~ 25 cm vertical

Shaded relief  
DEMs

Sun angle  $45^\circ$   
Sun azimuth  $315^\circ$

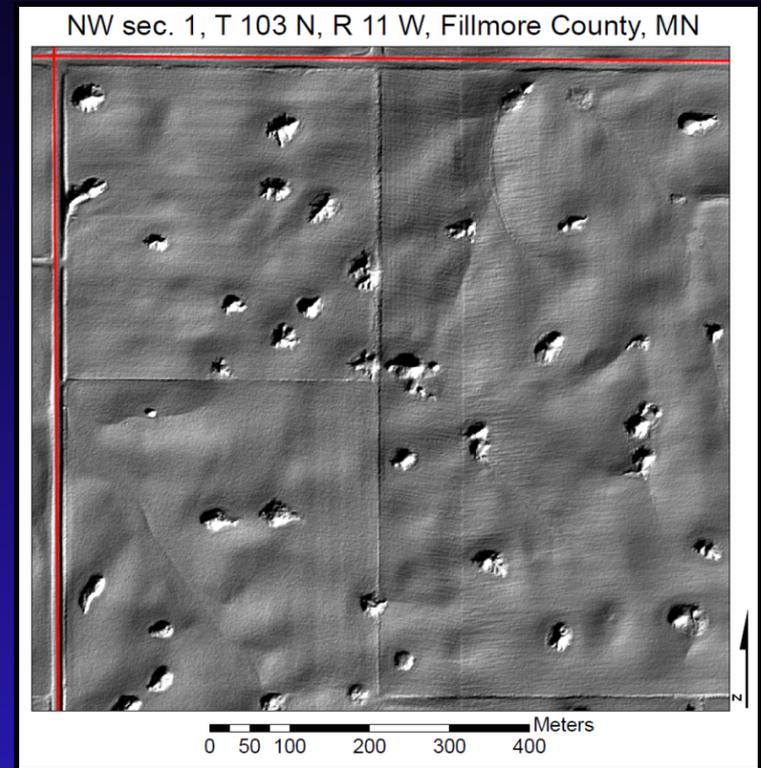
# Karst's Impact on Modern Farming I.a

- Modern intensive agriculture is optimized to farm broad expanses of relatively flat land.
  - Hundreds of meters to kilometers of flat land.



# Karst's Impact on Modern Farming I.b

- Modern intensive agriculture is optimized to farm broad expanses of relatively flat land.
- Karst topography is often spectacularly “not flat”.



# Karst's Impact on Modern Farming I.c

- Karst land surfaces are dynamic.
- Dynamic landscapes complicate farming



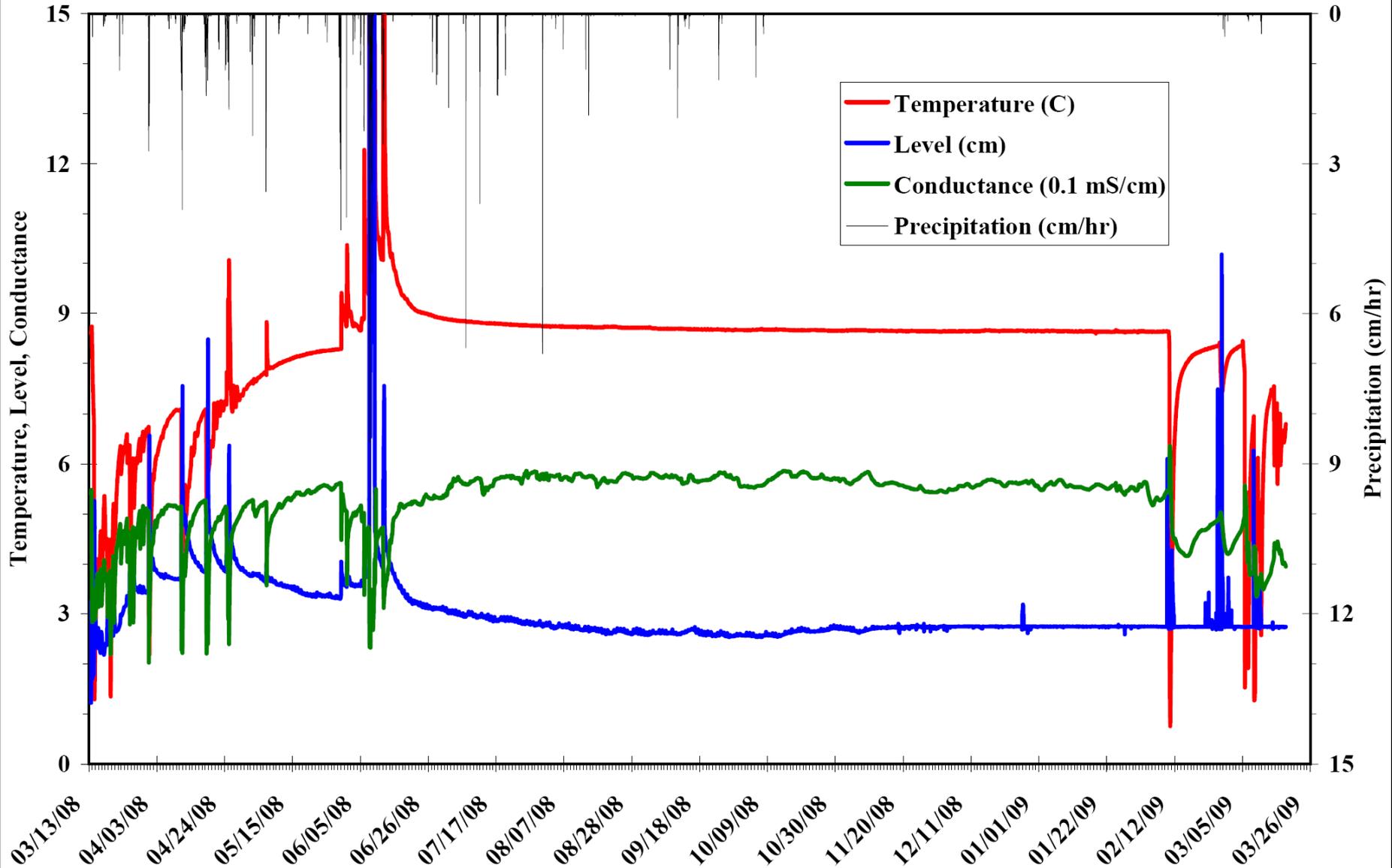
- Karst adds another risk factor to agriculture.

# Karst's Impact on Water Resources II.a

- The rapid interconnections between surface and ground waters in karst exacerbate water resources management – particularly in areas with strongly seasonal precipitation.
- In wet periods karst systems are very prone to flooding.
  - Sometimes from below.
- In dry periods surface water may be essentially absent for months at a time.

# Shallow Water Table Aquifers in Karst are Flashy

Goliath's Cave at David's Entrance



7 June 2008 Rain, Bristol Twp, MN

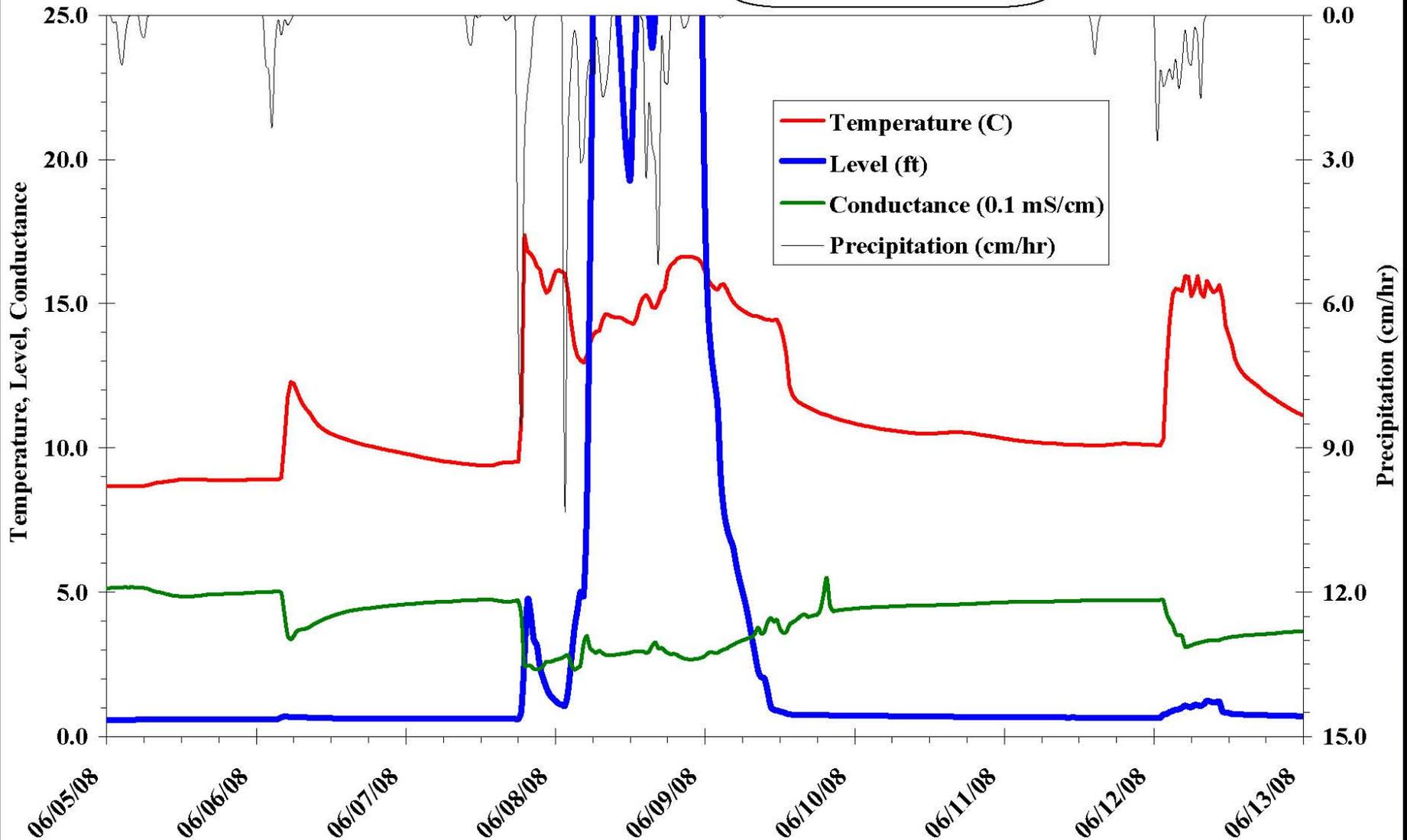


and then it REALLY rained overnight 7-8 June 2008

# 8 June 2008 Storm

## Goliath's Cave at David's Entrance

Peak water level 37.6 feet



# Societal Logic Error

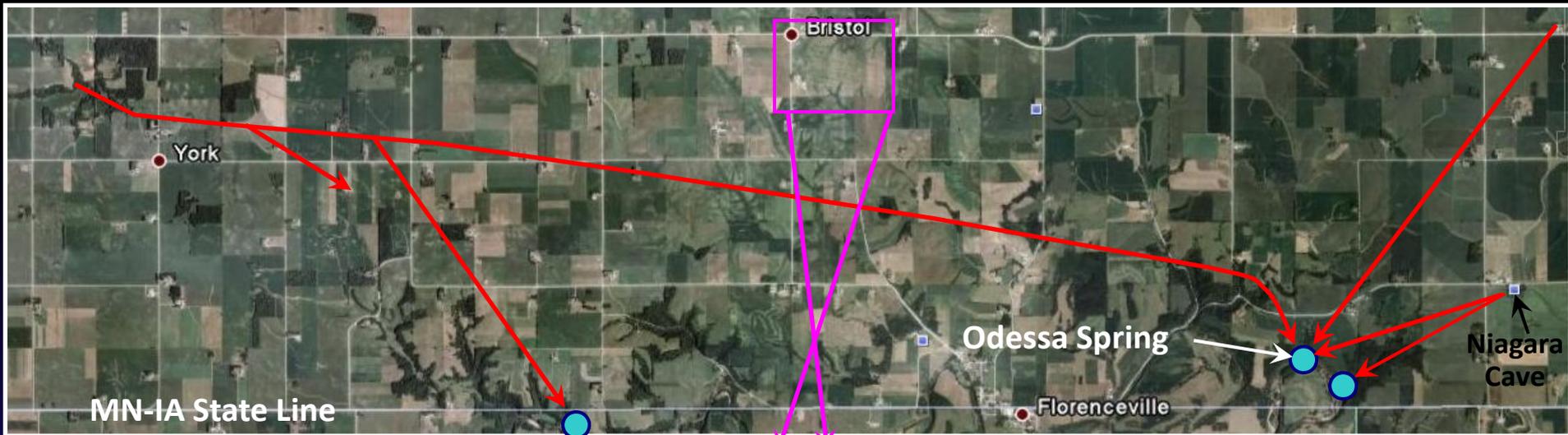
Karst sinkholes (dolines) are sufficient evidence that a karst aquifer is present –

But sinkholes are not necessary evidence that a karst aquifer is present.

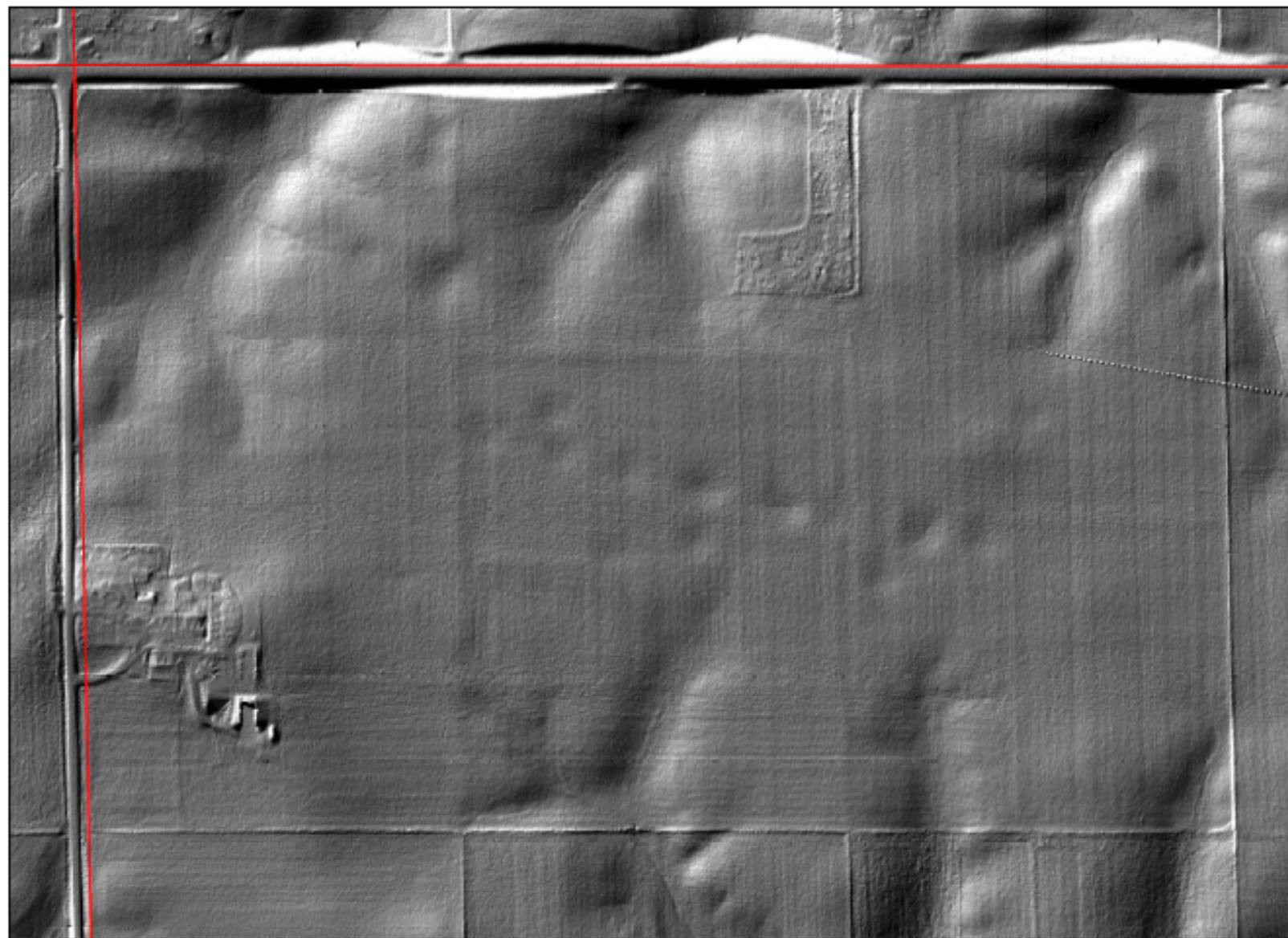
The absence of sinkhole  
on a specific piece of property  
is not evidence – much less proof –  
of the absence of a karst aquifer.

- Large sinkholes are end members of a continuum that extends down to mm macropores.
- New sinkholes routinely form.
- Old sinkholes are closed in various ways.
- In Minnesota these processes include natural processes: glacial activity, wind and running water,
  - and bulldozers, front end loaders and dump trucks.

# York Blind Valley – Odessa Spring



N ½ sec. 21, T 101 N, R 11 W, Fillmore County, MN



0 0.125 0.25 0.5 0.75 1 Kilometers

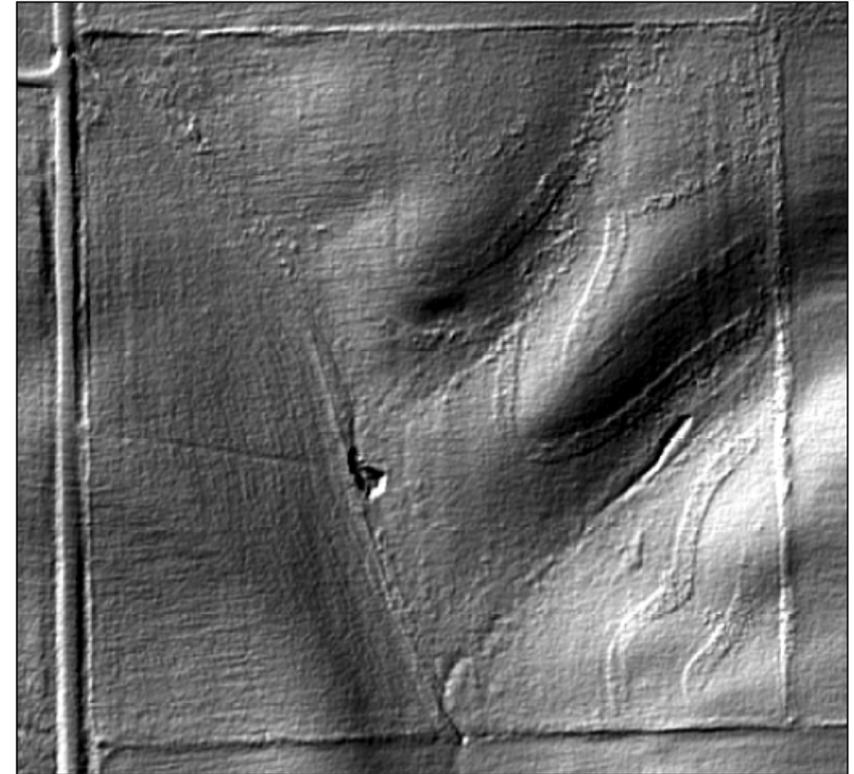
# Holly Grail Cave



# Sinkhole MN23:D5061, Holy Grail Cave



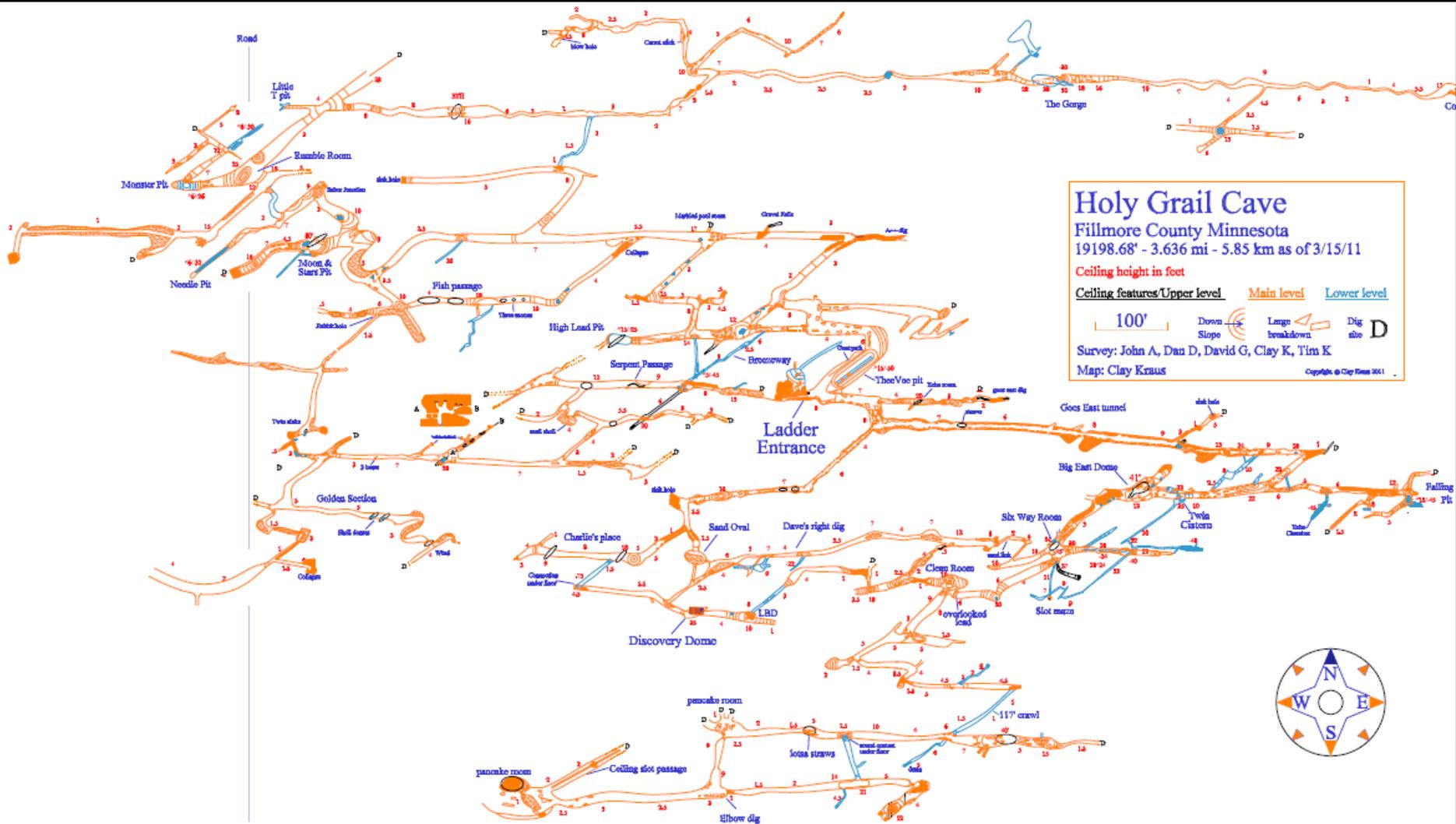
NW ¼ of SE ¼ of sec. 19, T 101 N, R 11 W, Fillmore County, MN



0 50 100 200 300 400 Meters

- Sinkhole length = 27 m at  $330^\circ N_{mag}$ .
- Sinkhole width = 14 m at  $45^\circ N_{mag}$ .
- Sinkhole depth =  $\sim 6$  m to bedrock.
- “A horizon” top soil, over imbricated limestone colluvium, over colluvium with Ostrander polished pebbles and iron ore fragments.

# Holy Grail Cave



# Holy Grail Cave



# Holy Grail Cave

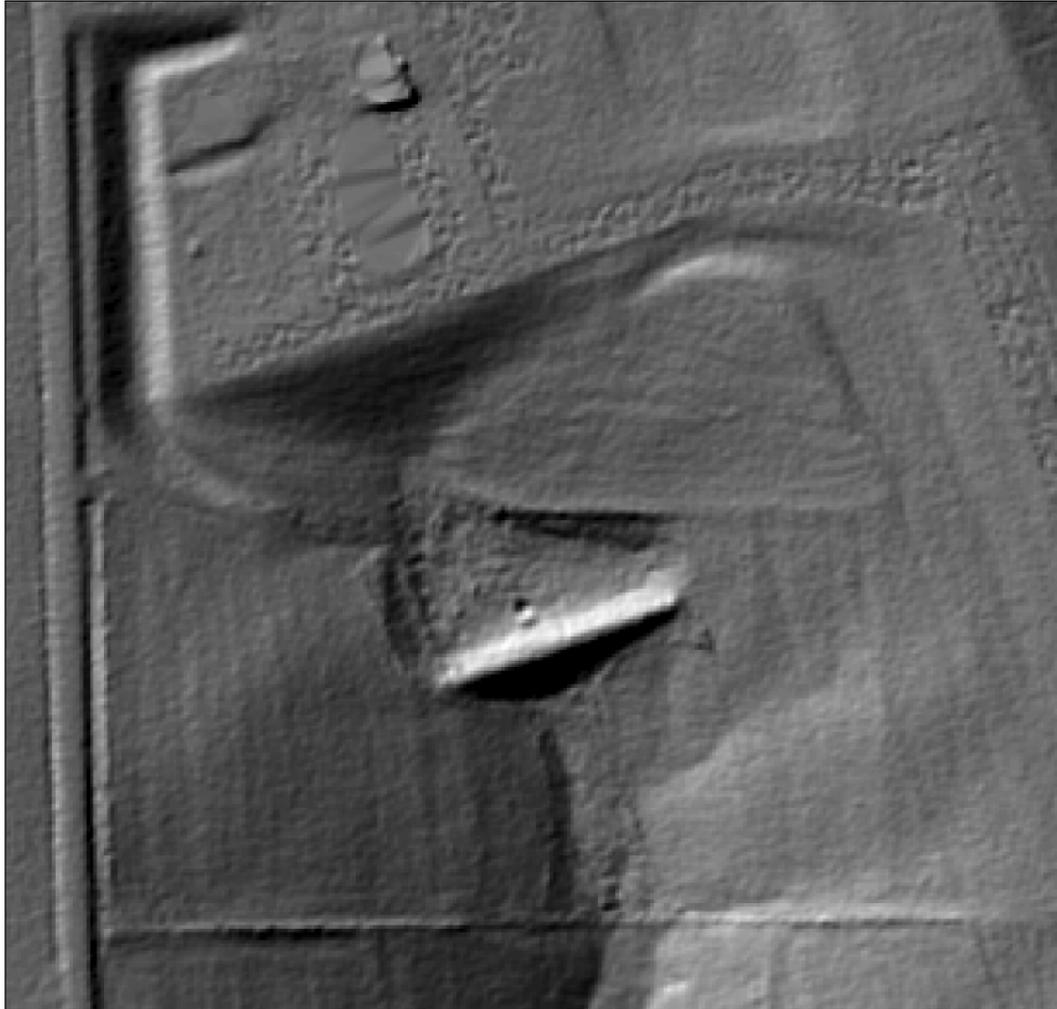


# Viewing a Sinkhole from the Bottom



# Karst's Impact on Water Resources II.b

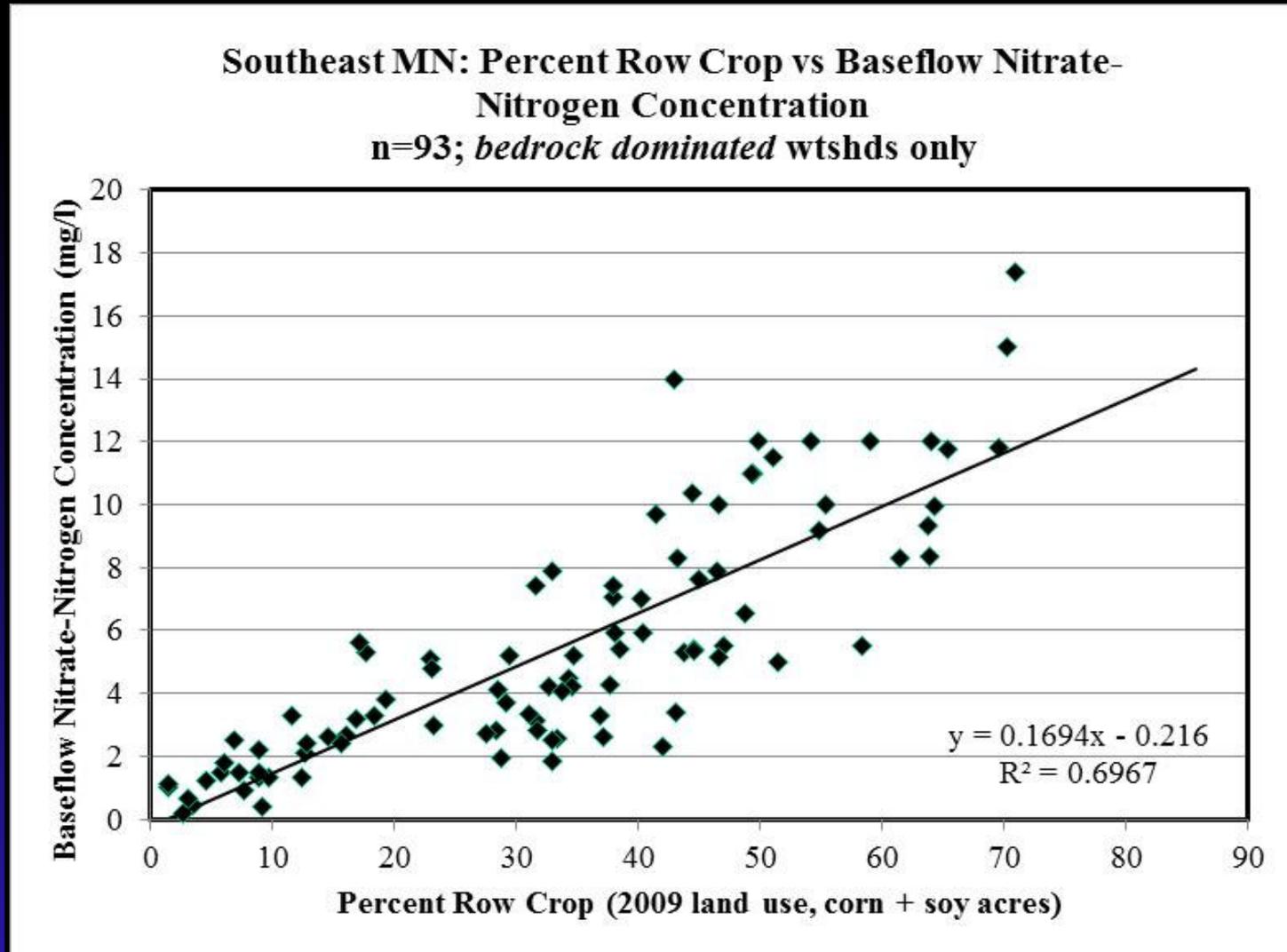
SE of SE sec. 7, T 104 N, R 8 W, Fillmore County, MN



Water storage dams (of all scales) built in karst have a prohibitively high rate of failure.

# Karst's Impact on Water Resources II.c

## Loss of Nutrients and Water Quality Degradation



Justin Watkins, Rochester MPCA , private communications (2011)

# Karst's Impact on Water Resources II.d

- No “Goldilocks” zone!
- Karst goes from too much water on the surface to too little water on the surface in time scales that can be as short as hours.
- Very little time is spent with a “just right” amount of water on the surface.

# Karst's Impact on Water Resources II.e

All of the above notwithstanding:

- Karst aquifers are some of the most productive aquifers on Earth and supply a major fraction of humanity's fresh water supply.
- Karst springs have provided critical water sources for humanity for hundreds of thousands of years.

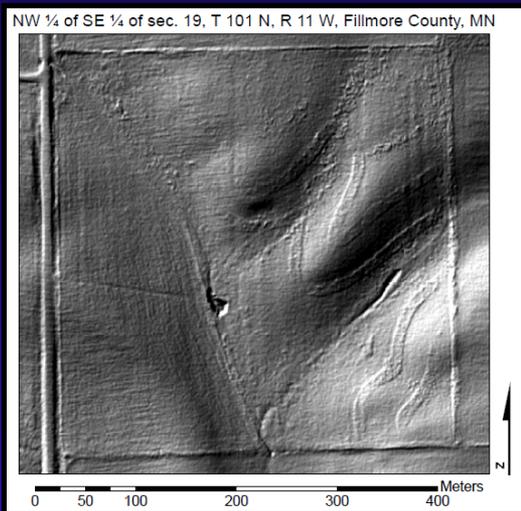
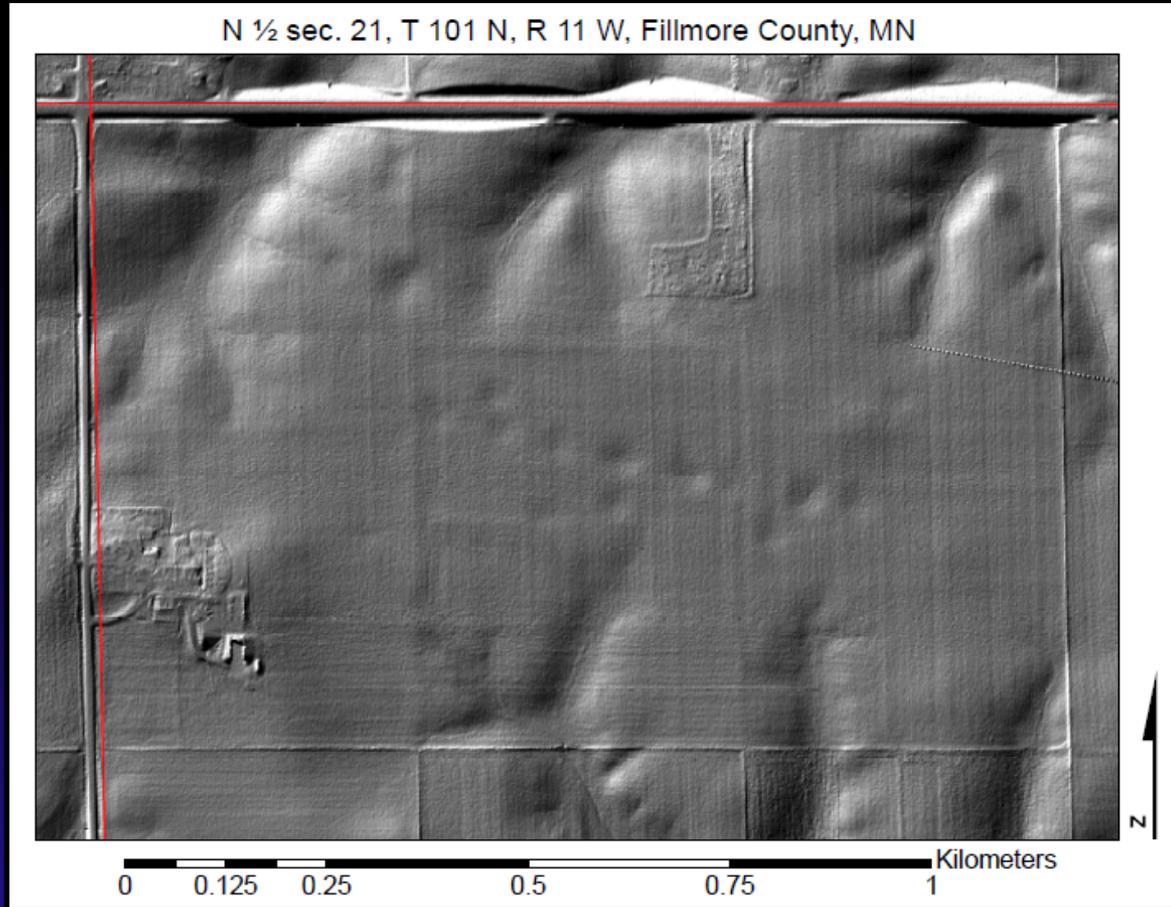
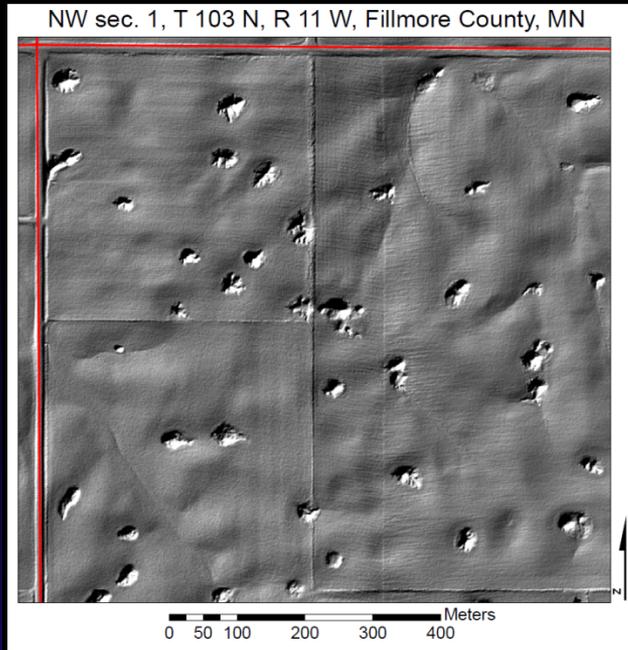
# Karst's Impact on Agricultural Soils III.a

- Karst carbonates typically have little residual solids when weathered and their weathering produces little soil.
- Soils on karst landscapes are typically thin, patchy and extremely fragile.
  - Barren limestone hills in Europe and Asia that were verdant forests before the advent of agriculture.
  - In Minnesota Karst Lands soils are mostly material transported from other areas by glacial processes.

# Bosnian Karst



# Karst's Impact on Agricultural Soil III.b



Why are the fence rows visible in the LiDAR images in MN?

# Karst's Impact on Agricultural Soils III.c

- The highly productive soils in the Minnesota's karst lands are derived from loess, glacial till, and outwash recently deposited on the carbonates.
- Since European settlers converted the land from prairie/savannah to farm land in between 1850 and ~1880, a meter or more of topsoil has been lost to erosion in much of the area.

# Karst rocky desertification in southwestern China



# Agriculture



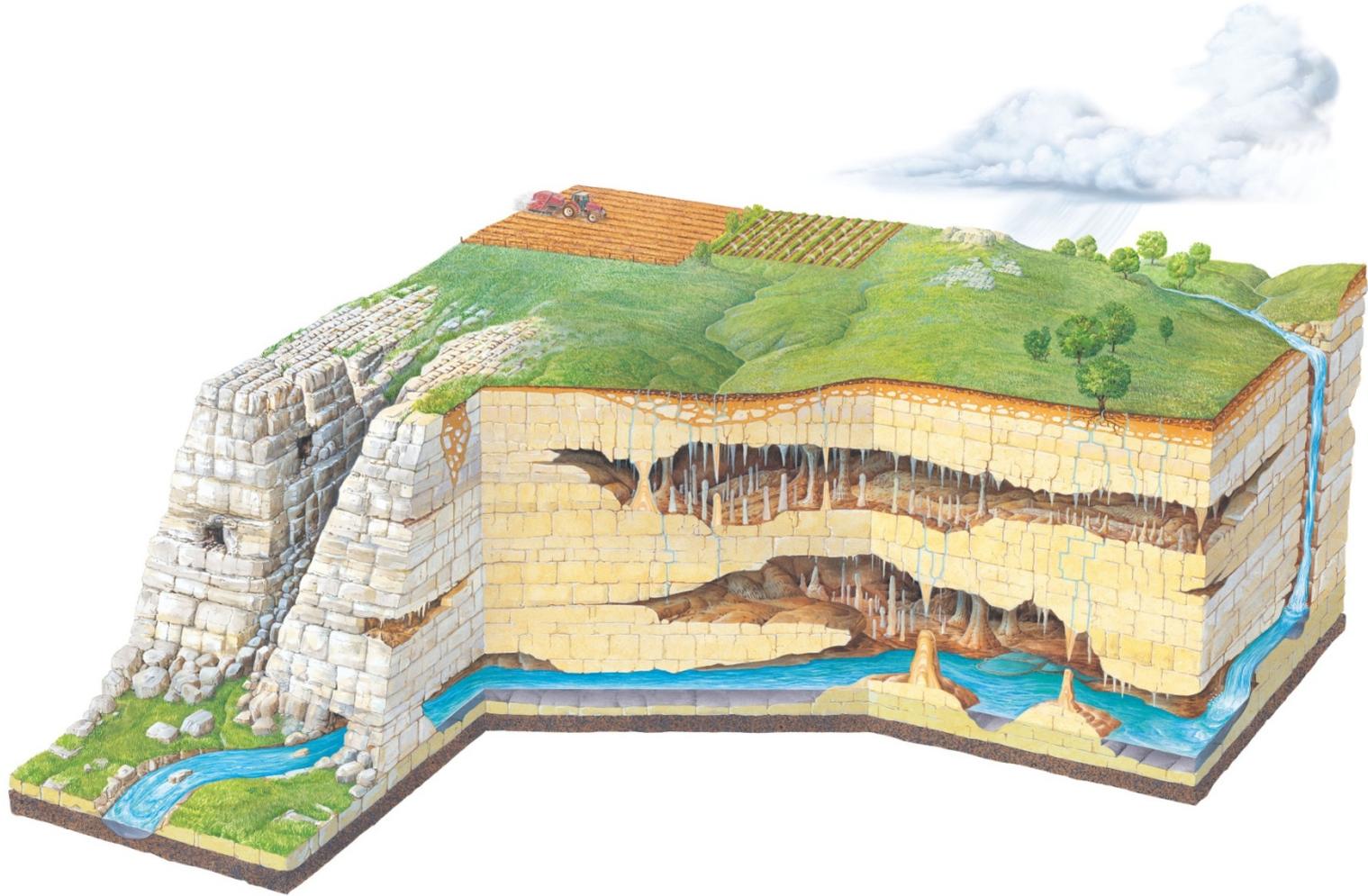
## Karst has major impacts

- Topography:
  - Highly irregular at field scale.
  - Dynamic.
- Water:
  - Karst exacerbates both flood and drought conditions – particularly in monsoonal precipitation environments.
- Soil:
  - Karst produces thin, patchy, fragile soils.
  - Agriculture in karst can lead to extremely rapid soil loss.

# Conclusions

- Agriculture in karst is possible but unless conducted very carefully is unsustainable.
- Large scale, input and machine intensive, modern agriculture in karst can quickly destroy the soil resources of a karst area.
- *"Whether we and our politicians know it or not, Nature is party to all our deals and decisions, and she has more votes, a longer memory, and a sterner sense of justice than we do."*  
— Wendell Berry

Thank you. Questions or Comments?



Feinberg and Lascu (2011) private communication