PURDUE
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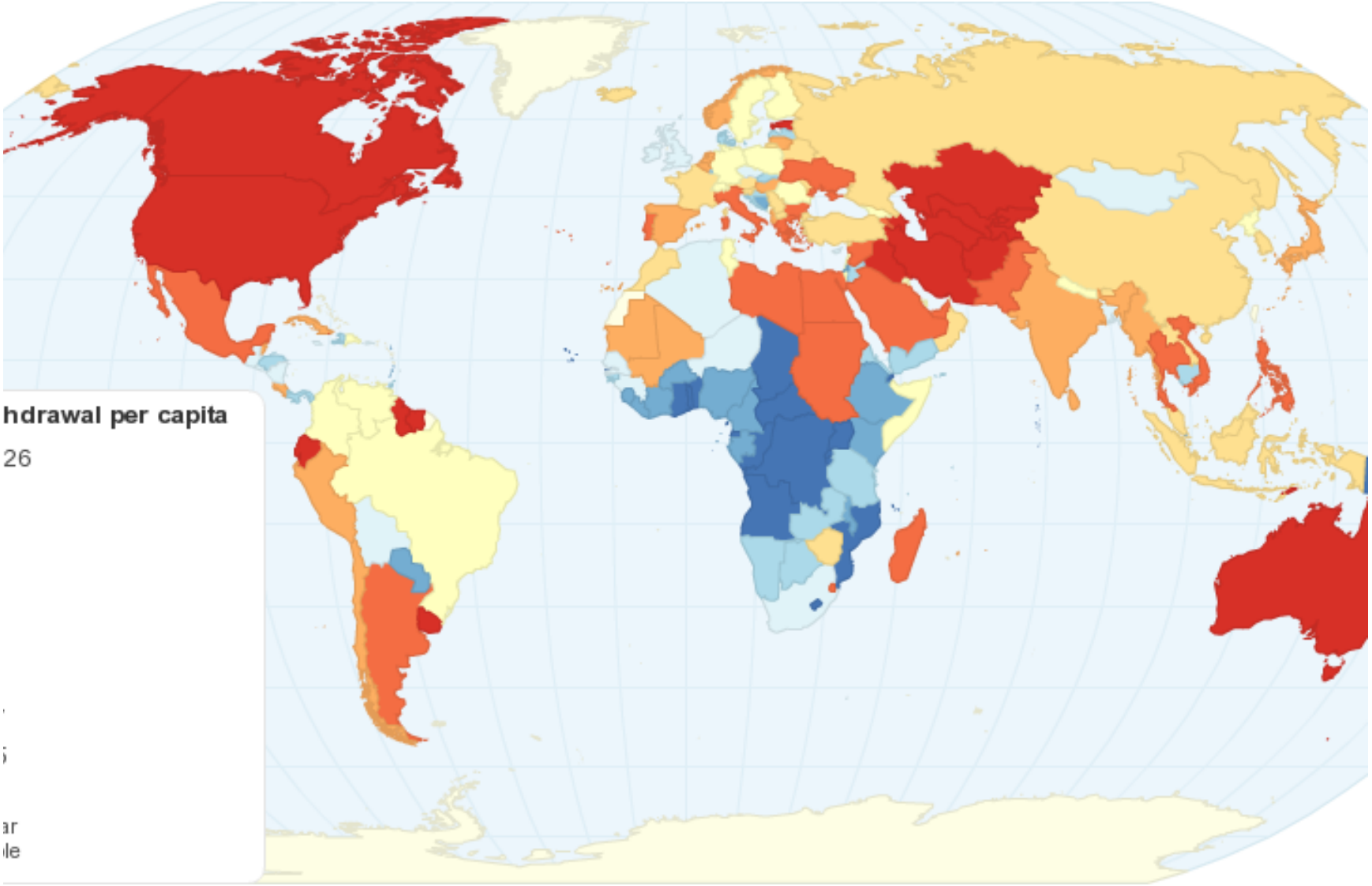
Challenges & Opportunities in Environmental and Natural Resources Engineering

Sara McMillan
Agricultural and Biological Engineering, Purdue University
ABE 290 Seminar, October 20, 2015

Total Global Water Use



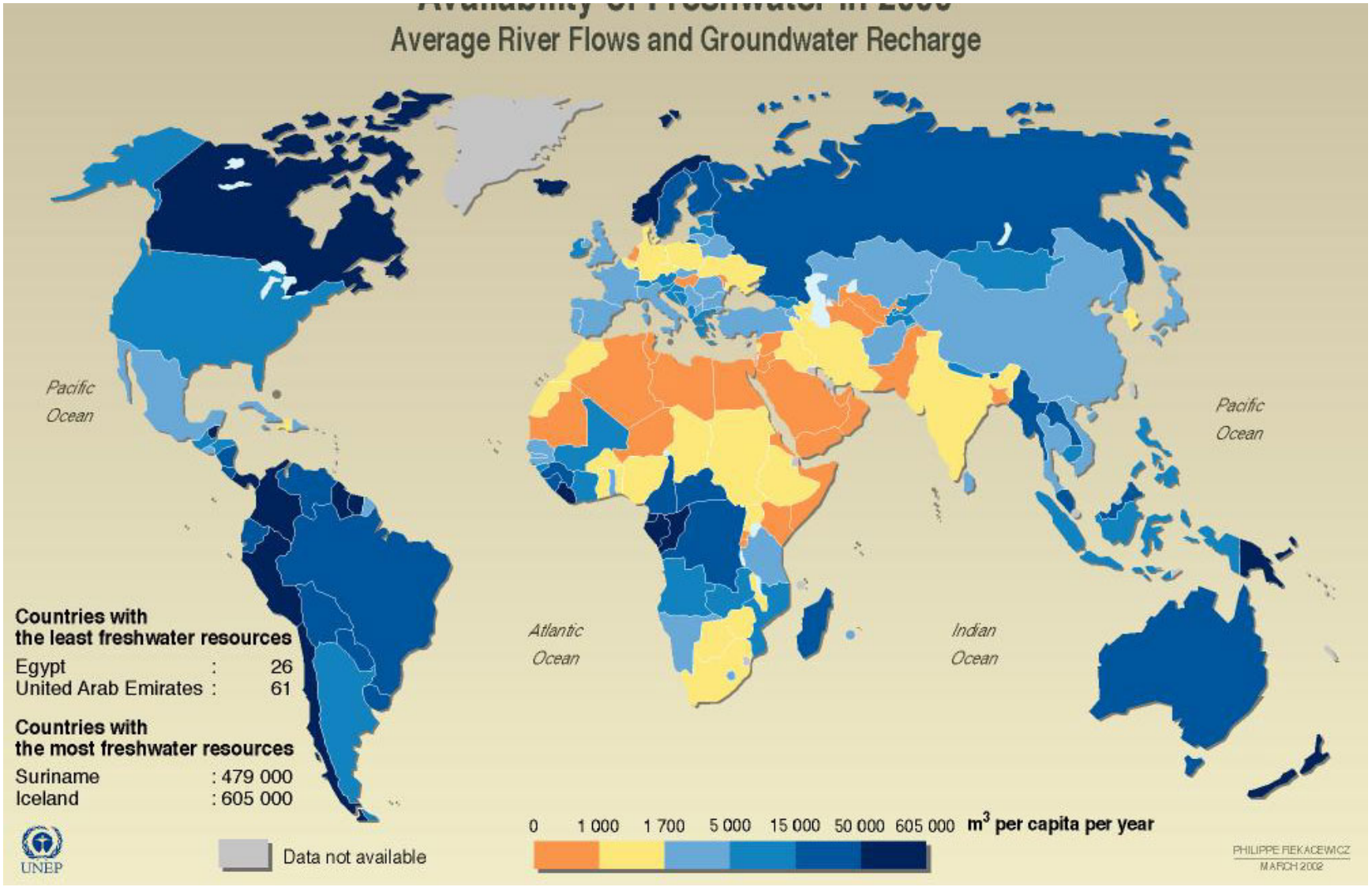
Source: http://chartsbin.com/view/1455

Global Water Usage Statistics

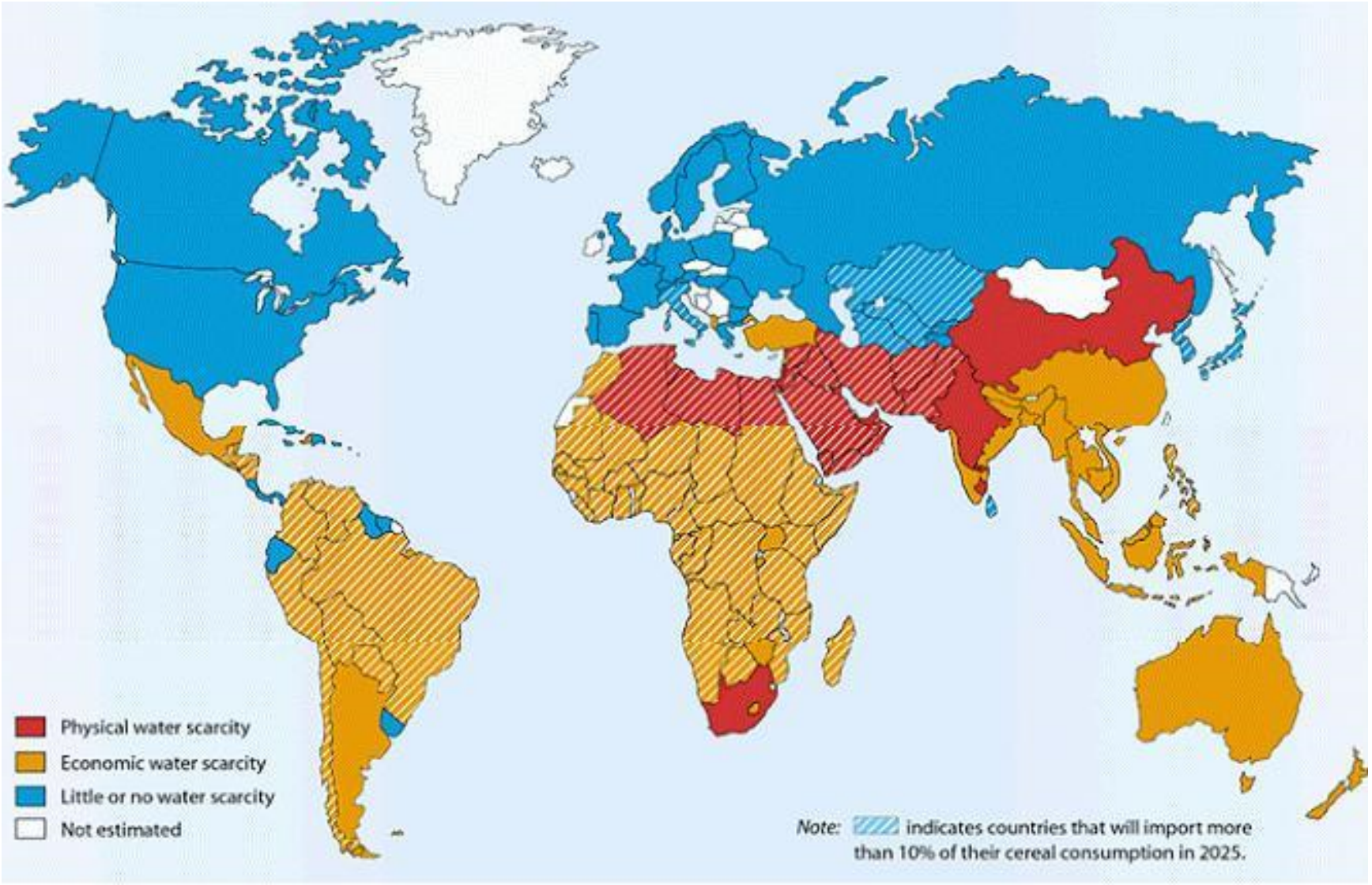
- 1.1 billion people live without clean drinking water
- 2.6 billion people lack adequate sanitation (2002, UNICEF/ WHO 2004)
- 1.8 million people die every year from diarrheal diseases.
- 3,900 children die every day from water borne diseases (WHO 2004)

Source: www.worldwatercouncil.org

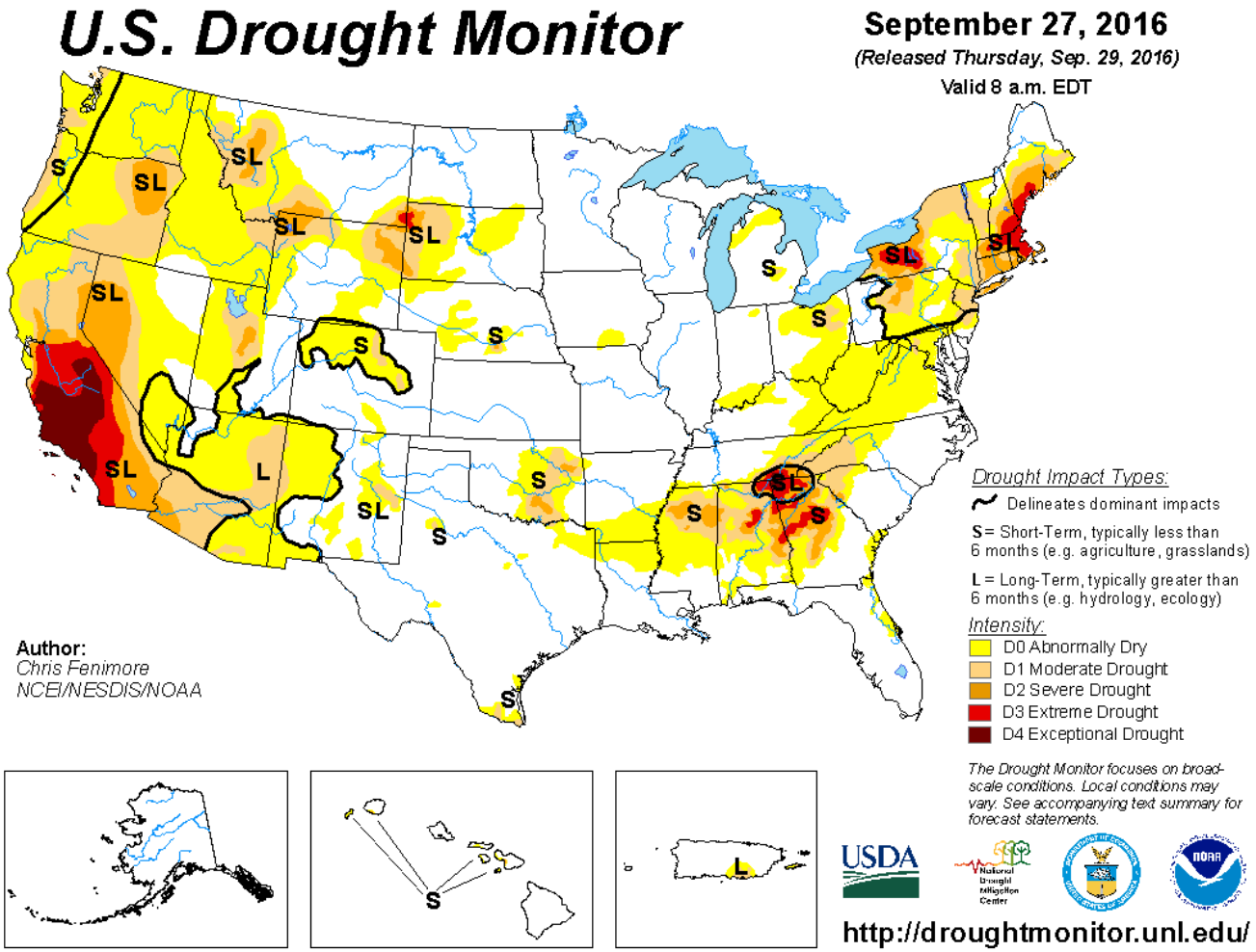
Global Water Distribution



Global Water Scarcity



Timing has much to do with scarcity!



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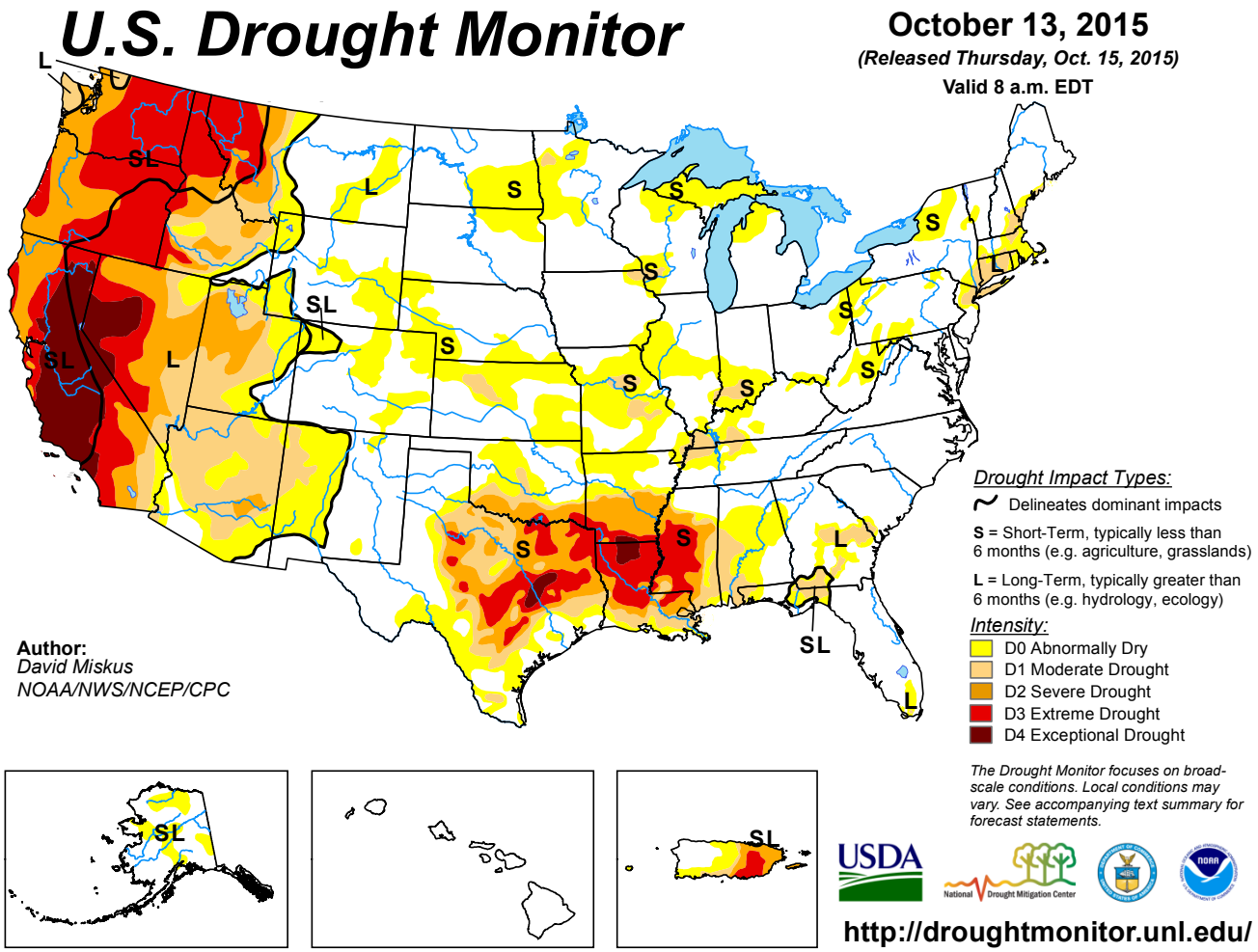
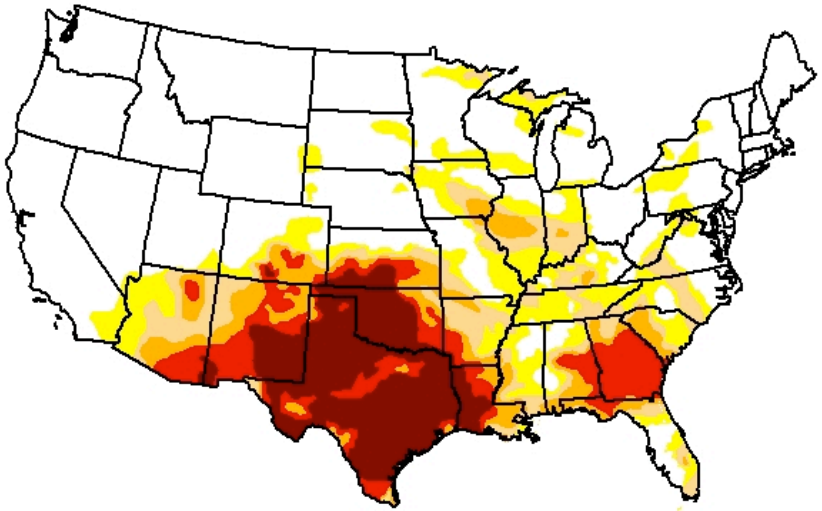


Timing has much to do with scarcity!

U.S. Drought Monitor
CONUS



August 30, 2011
(Released Thursday, Sep. 1, 2011)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	54.07	45.93	32.83	24.75	18.27	11.21
Last Week 8/23/2011	54.81	45.19	30.95	23.43	17.24	11.14
3 Months Ago 5/31/2011	68.95	31.05	25.56	20.69	14.68	6.25
Start of Calendar Year 1/4/2011	60.50	39.50	21.74	8.50	2.60	0.00
Start of Water Year 9/28/2010	60.05	39.95	13.16	3.09	0.30	0.00
One Year Ago 8/31/2010	68.42	31.58	9.55	1.49	0.14	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Eric Luebehusen
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/

Timing has much to do with scarcity!

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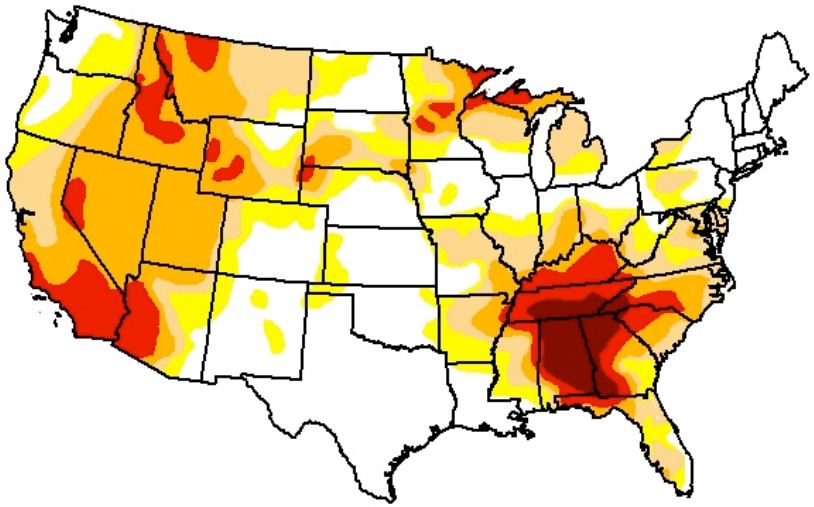

August 21, 2007
(Released Thursday, Aug. 23, 2007)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	35.36	64.64	48.75	33.29	12.50	2.86
Last Week 8/14/2007	34.79	65.21	48.17	32.85	10.01	2.34
3 Months Ago 5/22/2007	50.97	49.03	33.80	17.38	6.65	0.00
Start of Calendar Year 1/2/2007	50.01	49.99	25.63	12.62	5.93	0.33
Start of Water Year 9/26/2006	45.13	54.87	32.93	16.30	6.61	0.14
One Year Ago 8/22/2006	35.50	64.50	47.98	29.16	11.04	2.00

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Author(s):
Richard Heim
NCDC/NOAA

USDA National Drought Mitigation Center

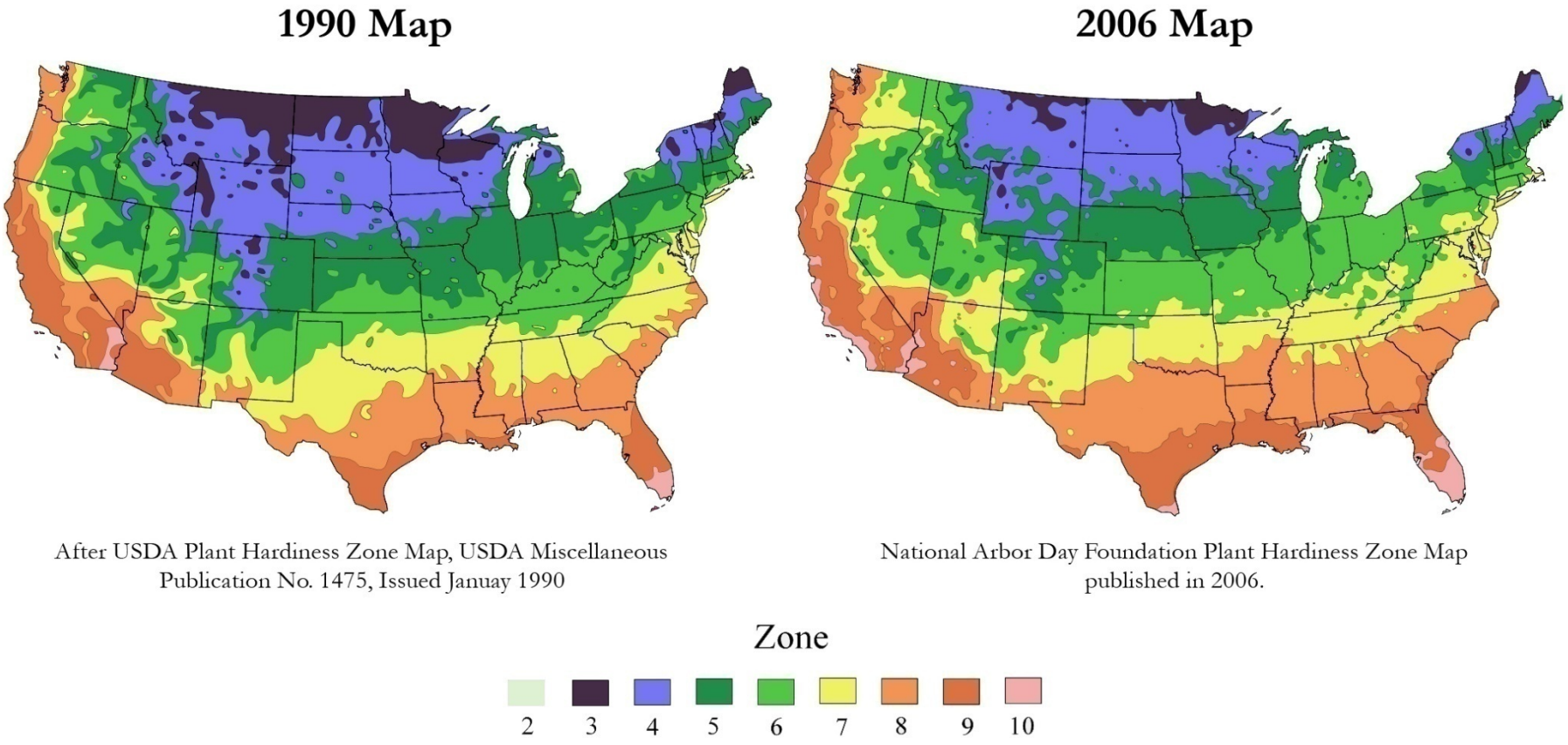
http://droughtmonitor.unl.edu/

Is Climate Changing?

- IPCC Fourth Assessment Report (AR4) - 2007
- The Physical Science Basis
  - "Warming of the climate system is unequivocal"
  - "Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* (> 90%) due to the observed increase in anthropogenic greenhouse gas concentrations."

Evidence for Climate Change

National temperature from 1990 to 2006



After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued Januay 1990

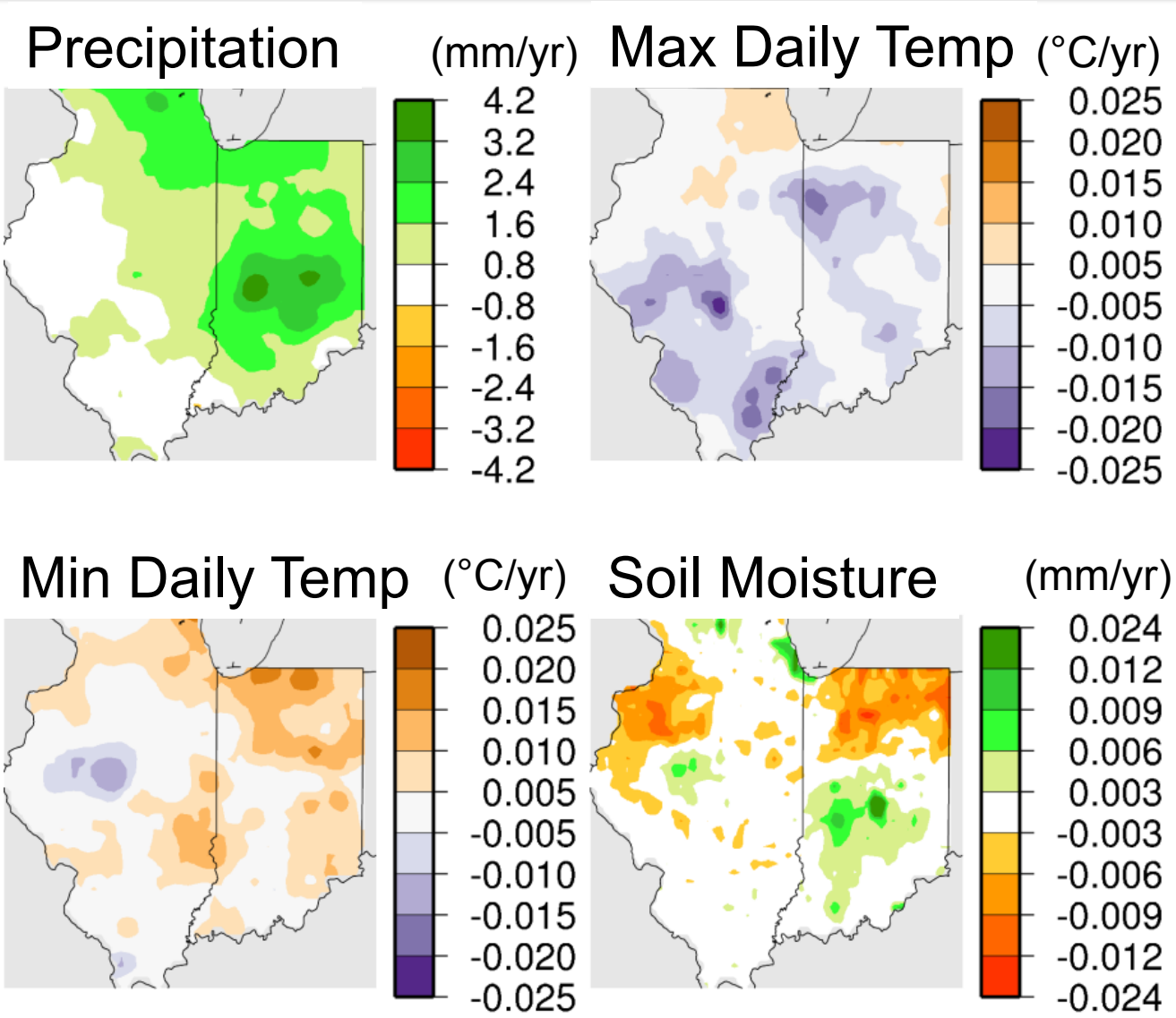
National Arbor Day Foundation Plant Hardiness Zone Map published in 2006.

The plant hardiness zone for Indiana has *already* shifted to what Kentucky was like just 20 years ago.

Local Evidence for Climate Change… Here in Indiana

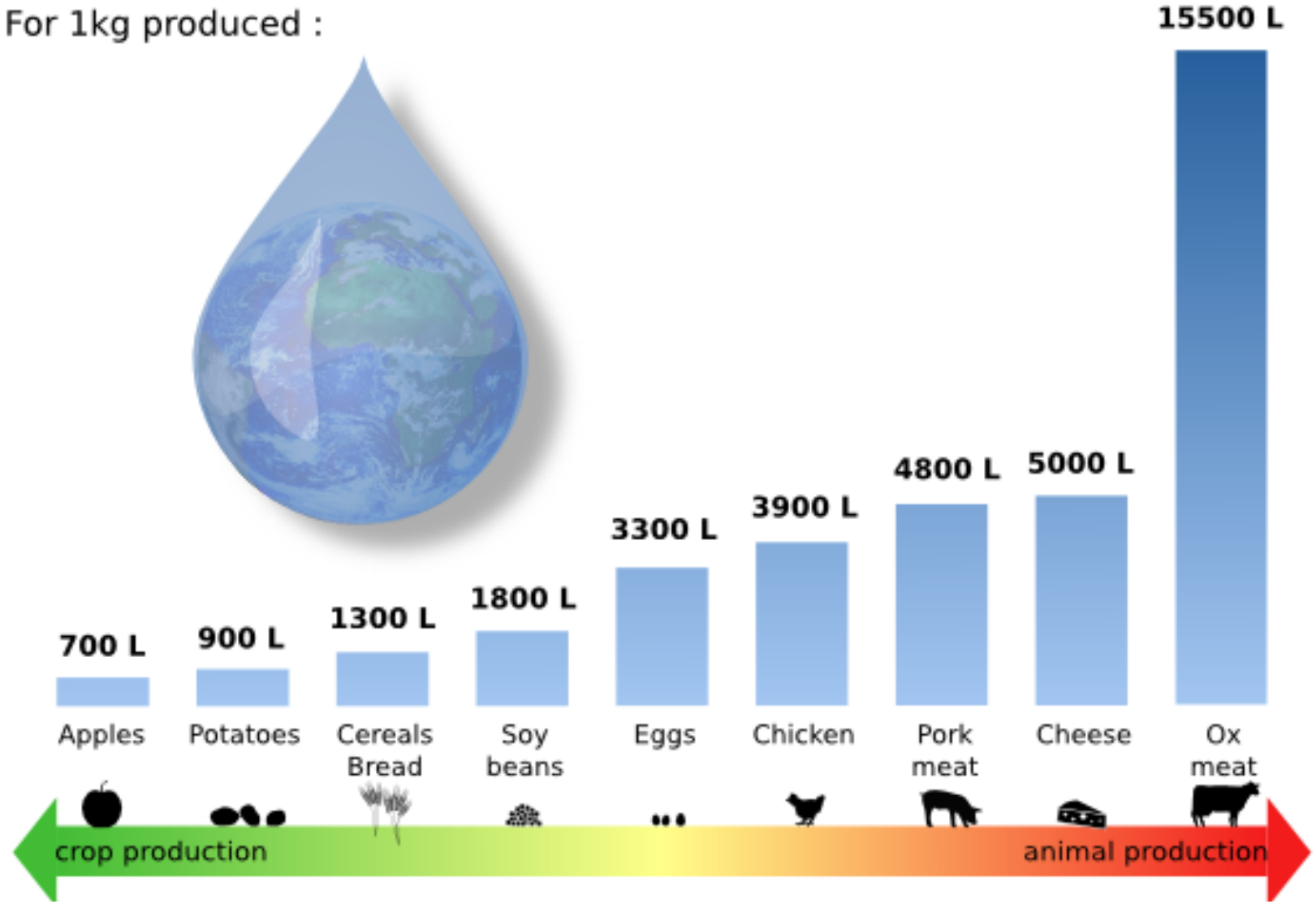
- Temperatures are rising, especially in winter
- Extreme rainfall events (24-hr and 7-day) are becoming more frequent
- Winters have become shorter
- Spring is coming earlier
- Shorter duration of ice cover, especially on smaller lakes

Observed Trends 1916-2007



Mishra and Cherkauer, 2010

Water Used for Food Production



What can you do?

- Designs should take changing climate into consideration
- Climate impacts may be overwhelmed or compensated for locally by land use management and change
- Design with the environment in mind
  - Changing hydrologic regimes
  - Climate change is in part a result of human activities – pollution
  - Design to minimize waste and pollution

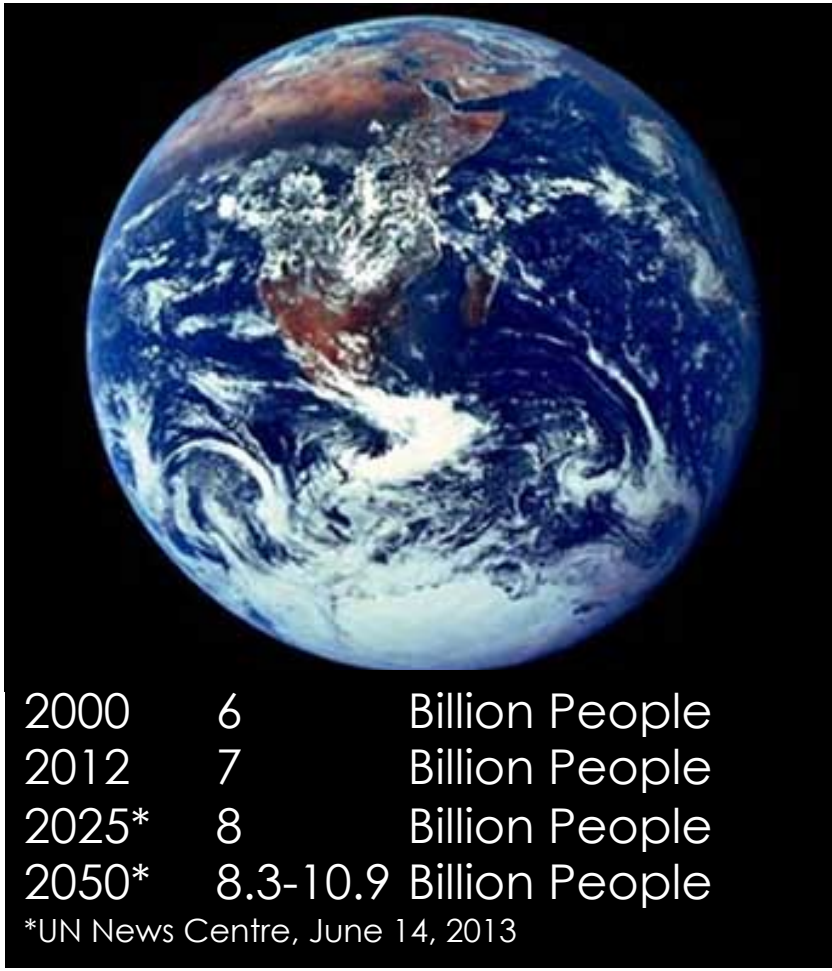
Agricultural and Biological Engineering to address environmental concerns

- **Agricultural:** We address environmental issues and problems faced by communities in rural areas but also in developing nations, urban areas and natural landscapes
- **Biological:** We use biological principles to develop solutions
- **Engineering:** We analyze problems, review options, and design site-specific solutions.



National Academy of Engineering Grand Challenges

1. Advance personalized learning
2. Make solar energy economical
3. Enhance virtual reality
4. Reverse-engineer the brain
5. Engineer better medicines
6. Advance health informatics
7. Restore and improve urban infrastructure
8. Secure cyberspace
9. Provide access to clean water
10. Provide energy from fusion
11. Prevent nuclear terror
12. Manage the nitrogen cycle
13. Develop carbon sequestration methods
14. Engineer the tools of scientific discovery



2000	6	Billion People
2012	7	Billion People
2025*	8	Billion People
2050*	8.3-10.9	Billion People

*UN News Centre, June 14, 2013

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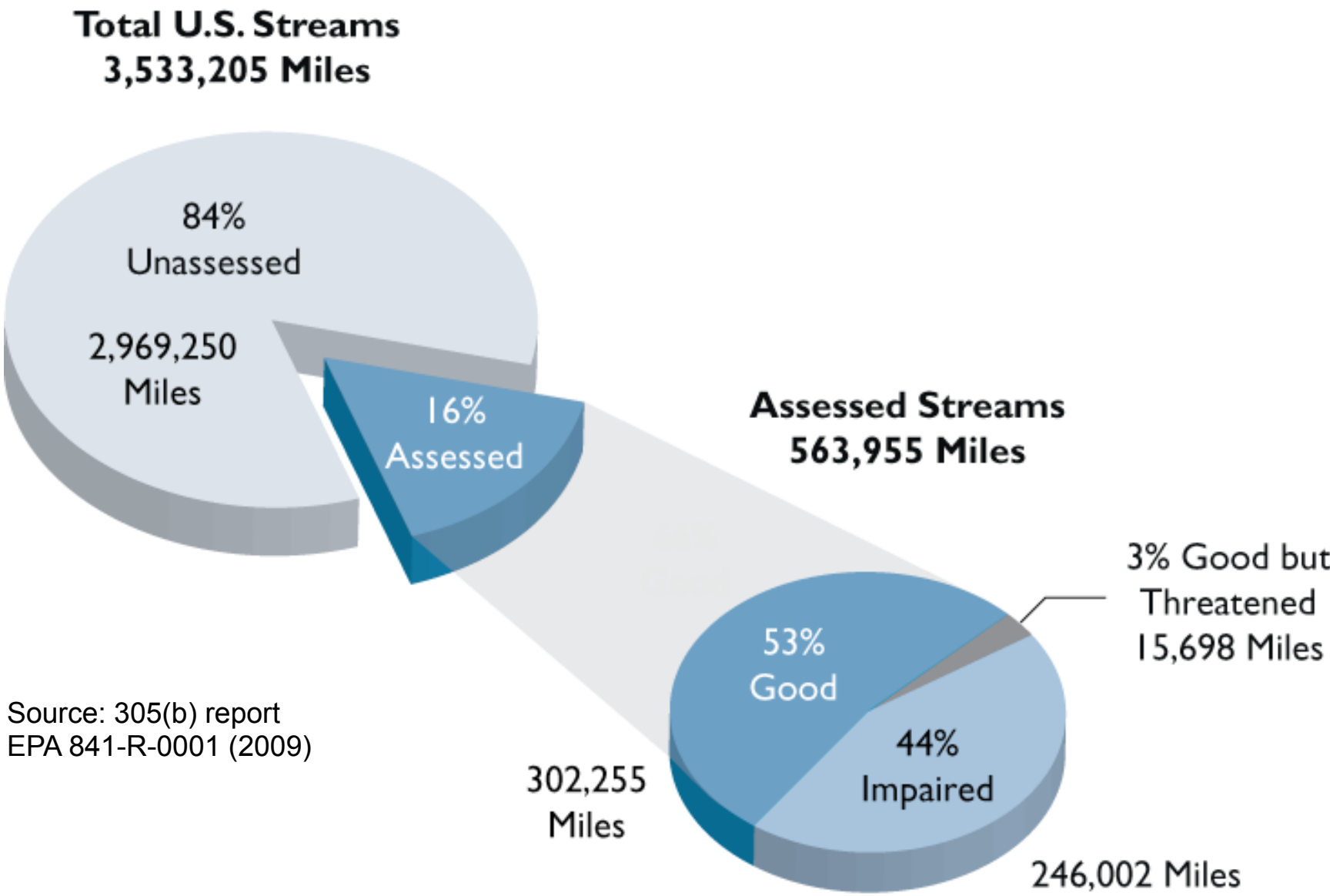
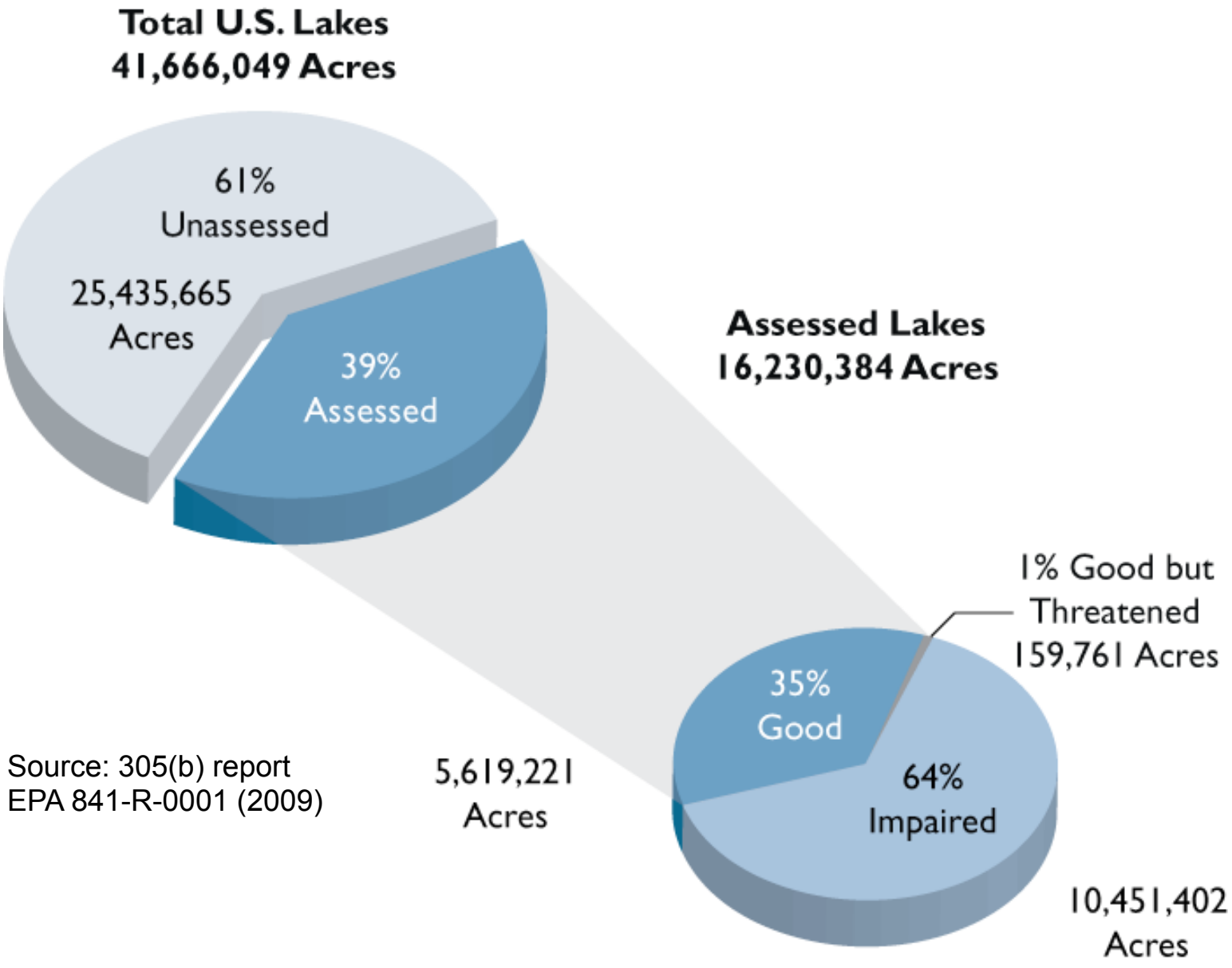
Stream Water Quality in USA



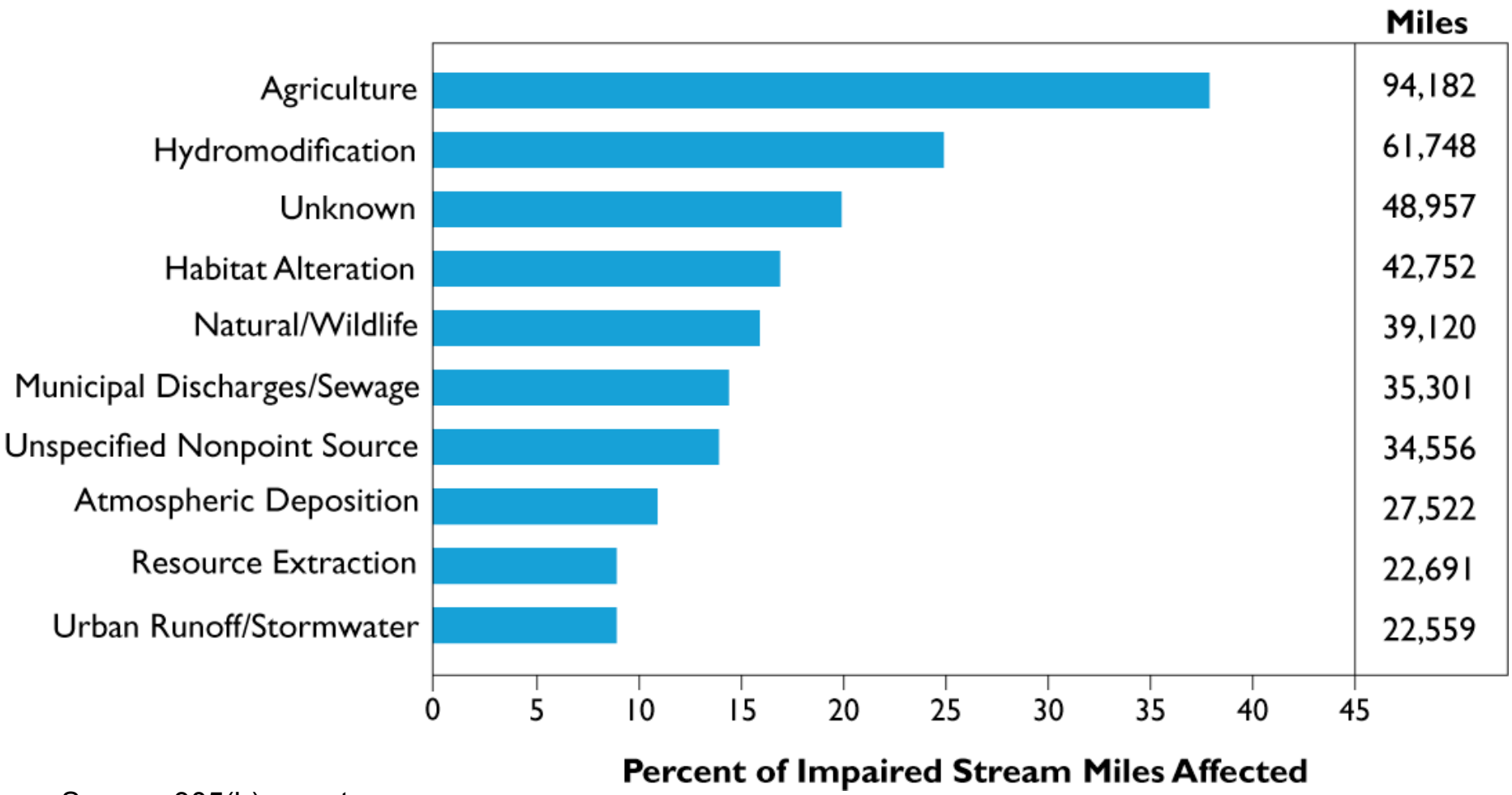
Source: 305(b) report
EPA 841-R-0001 (2009)

Lake Water Quality in USA



Source: 305(b) report
EPA 841-R-0001 (2009)

Top 10 Source of Stream Impairments



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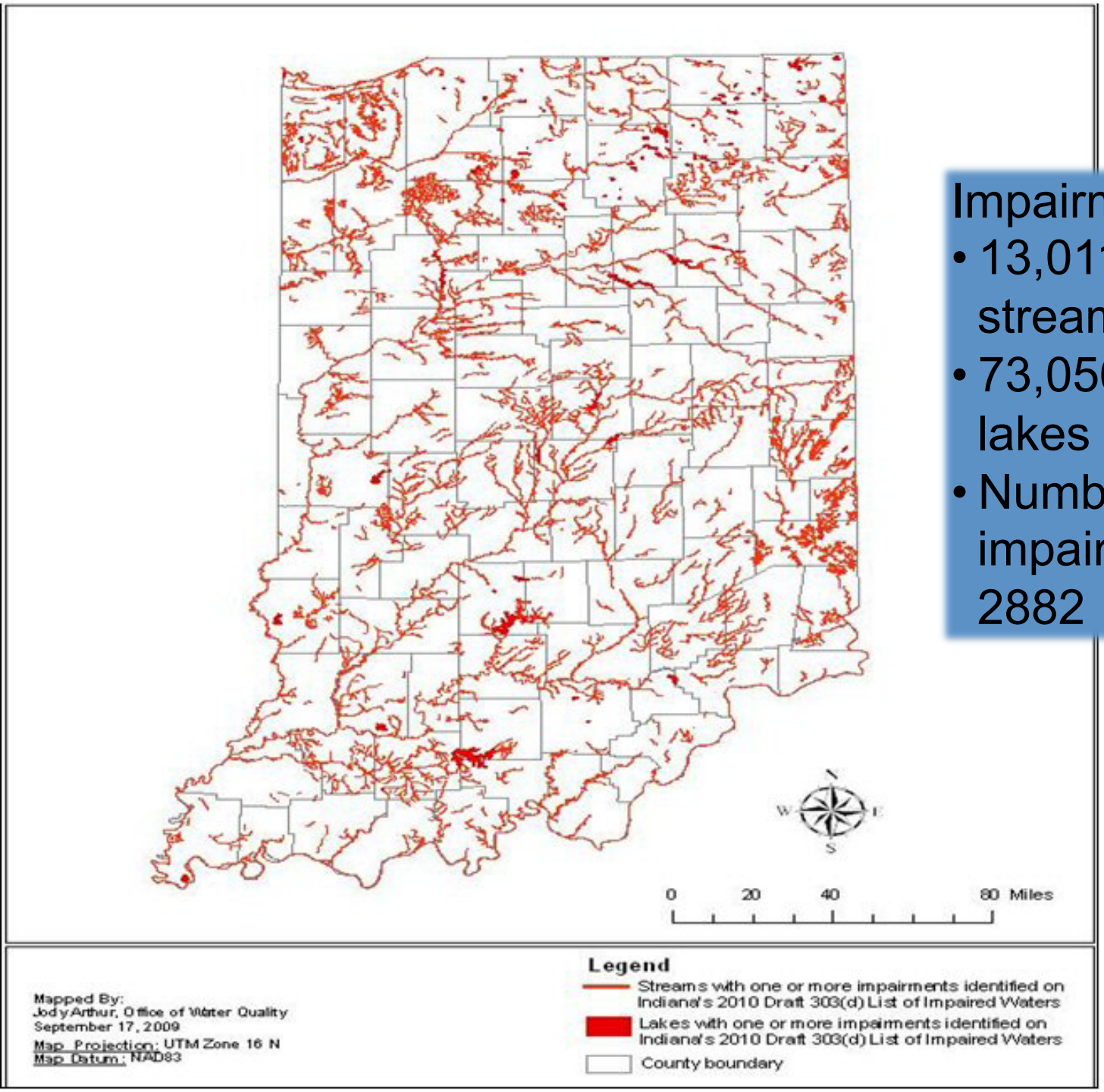


Impairment

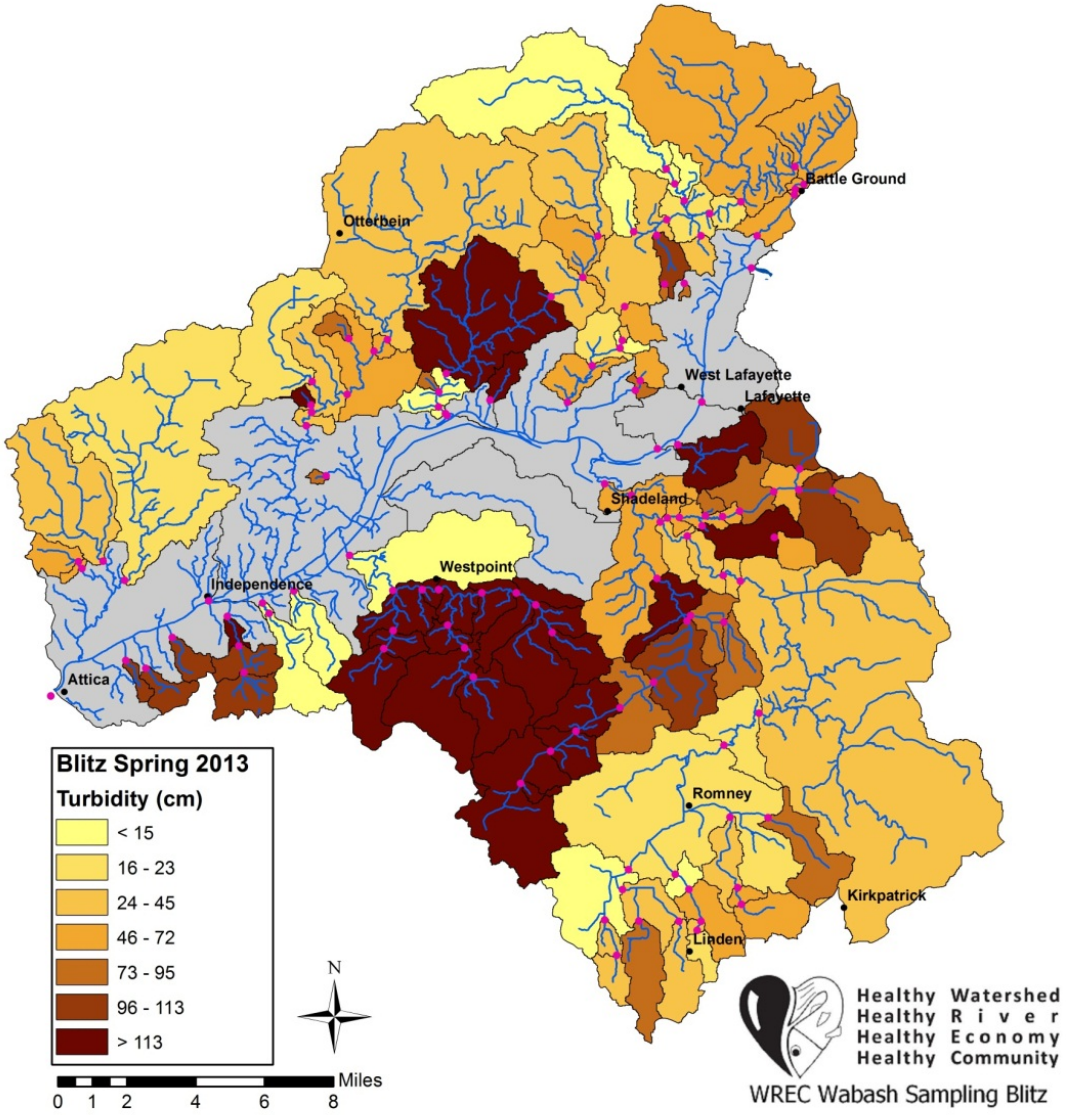
- 13,011 miles of streams
- 73,056 acres of lakes
- Number of impairments = 2882

Environmental & Natural Resources Engineering

- Understand basic principles related to water, water, plant, atmosphere interactions
- Use knowledge of math, science and engineering to quantify extent of the problem
- Design components and tools to evaluate impacts on soil, water, air
- Design to mitigate and adapt to problems

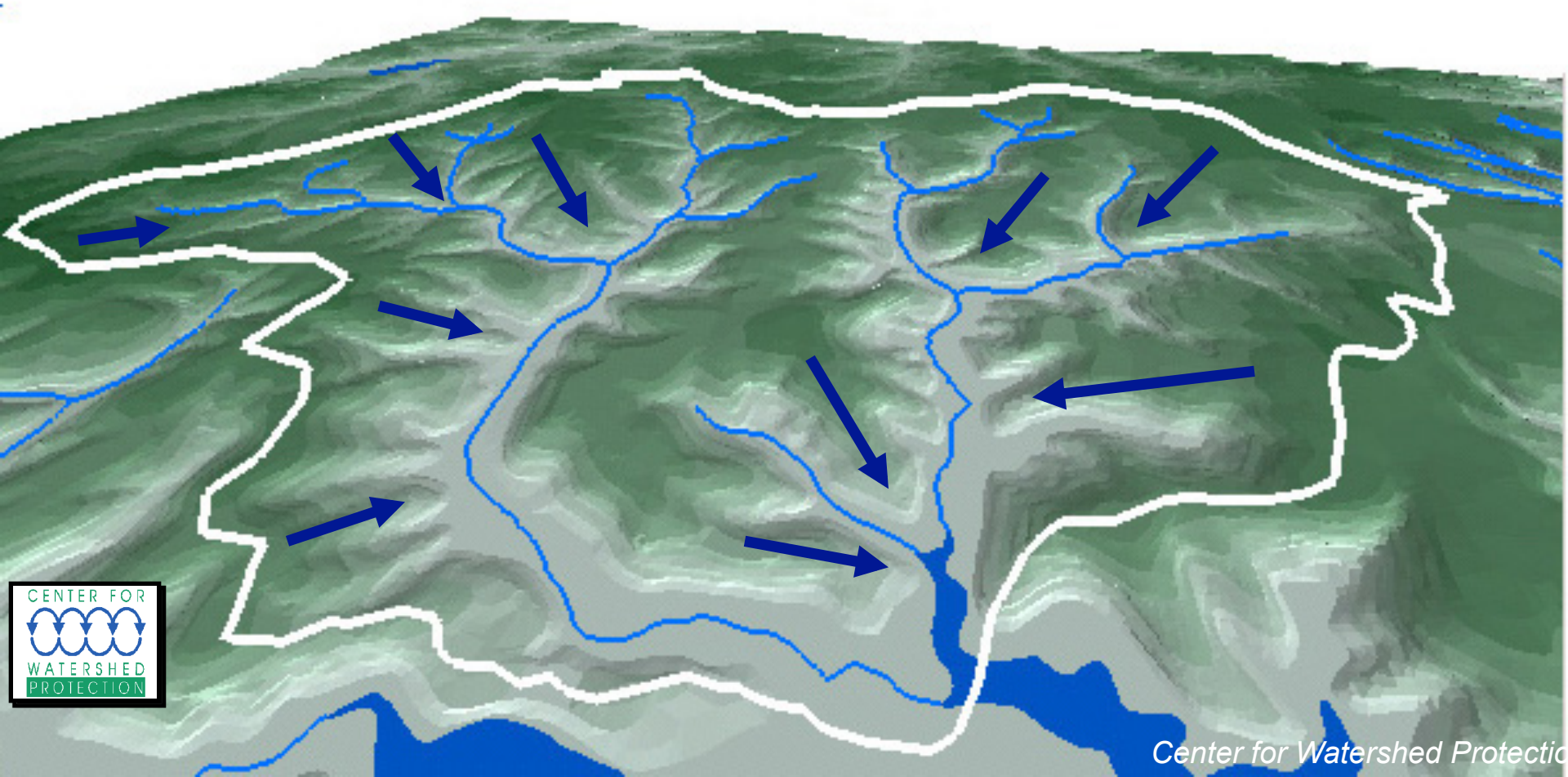
Environmental & Natural Resources Engineering

- We all live in a watershed that is very likely experiencing water quality problems



What is a watershed?

A watershed is the area of land that drains to a particular point along a stream



EVERYONE lives in a watershed

Water quality issues affect everyone.

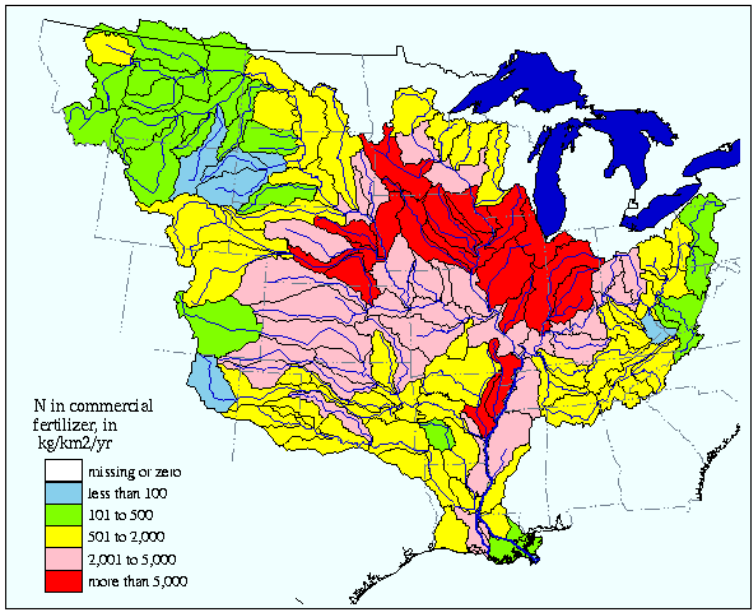
What issues concern you?

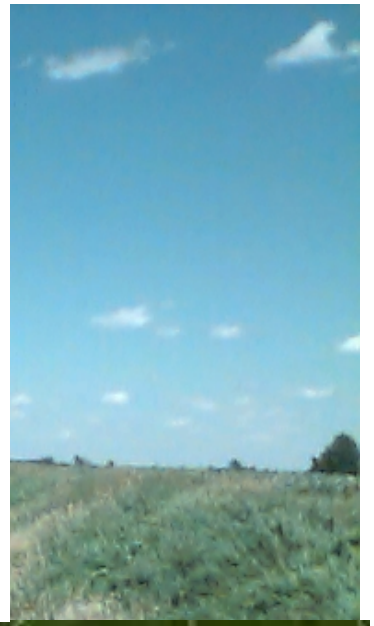
Runoff from parking lots & streets (salt, sediment, oil)

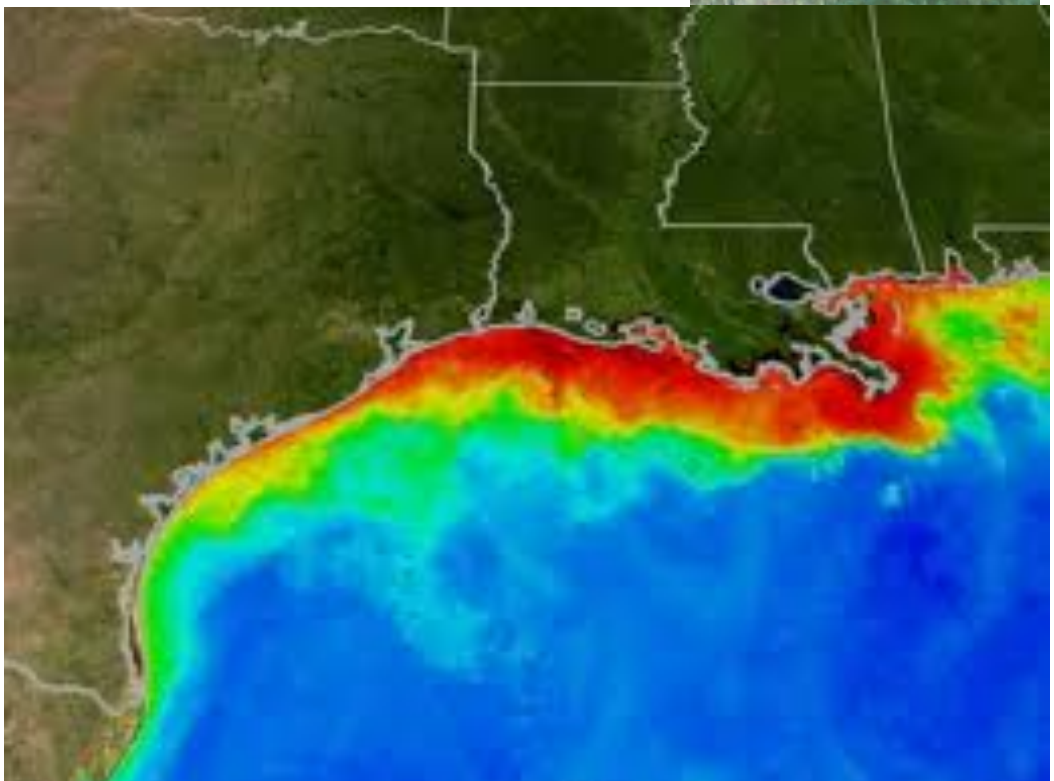
Runoff from agriculture (fertilizer, pesticides, manure)

Examples of Indiana issues

Artificial drainage has greatly changed the landscape

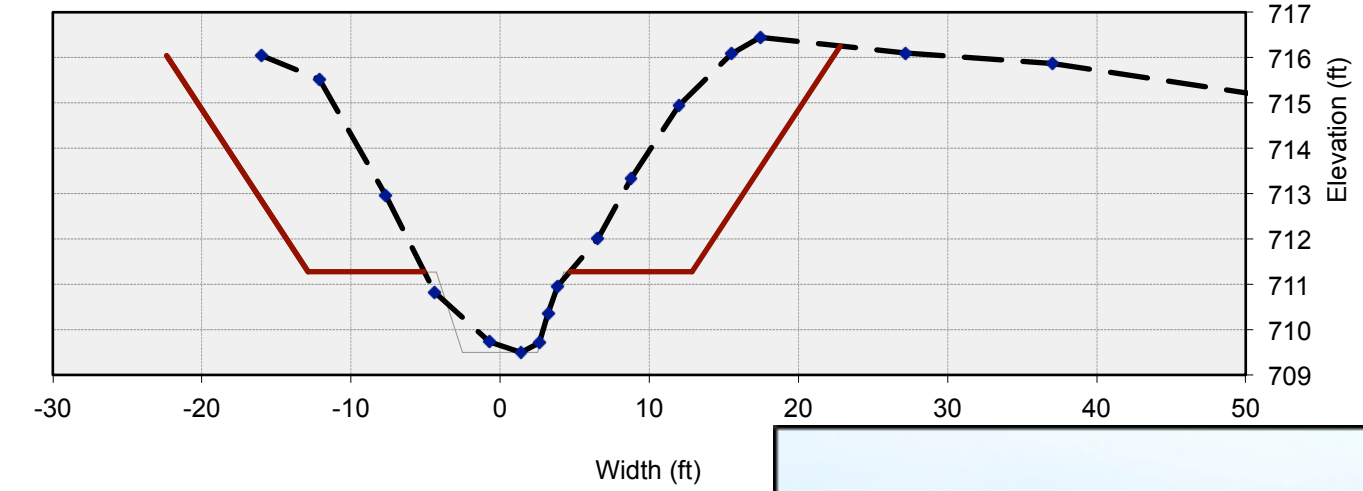


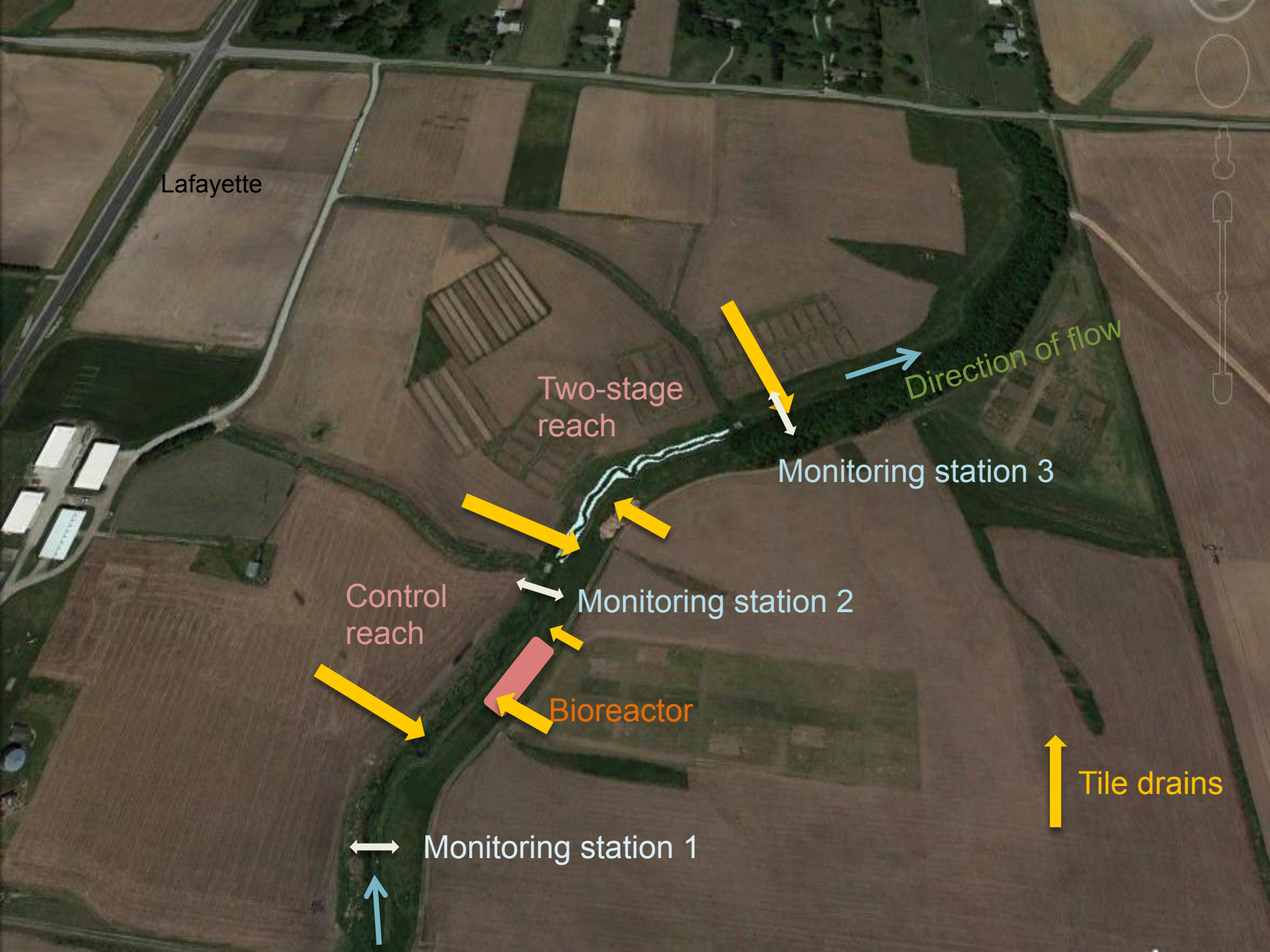




Cross Section 1: Downstream of existing weir
Bench Elevation: 711.3 ft

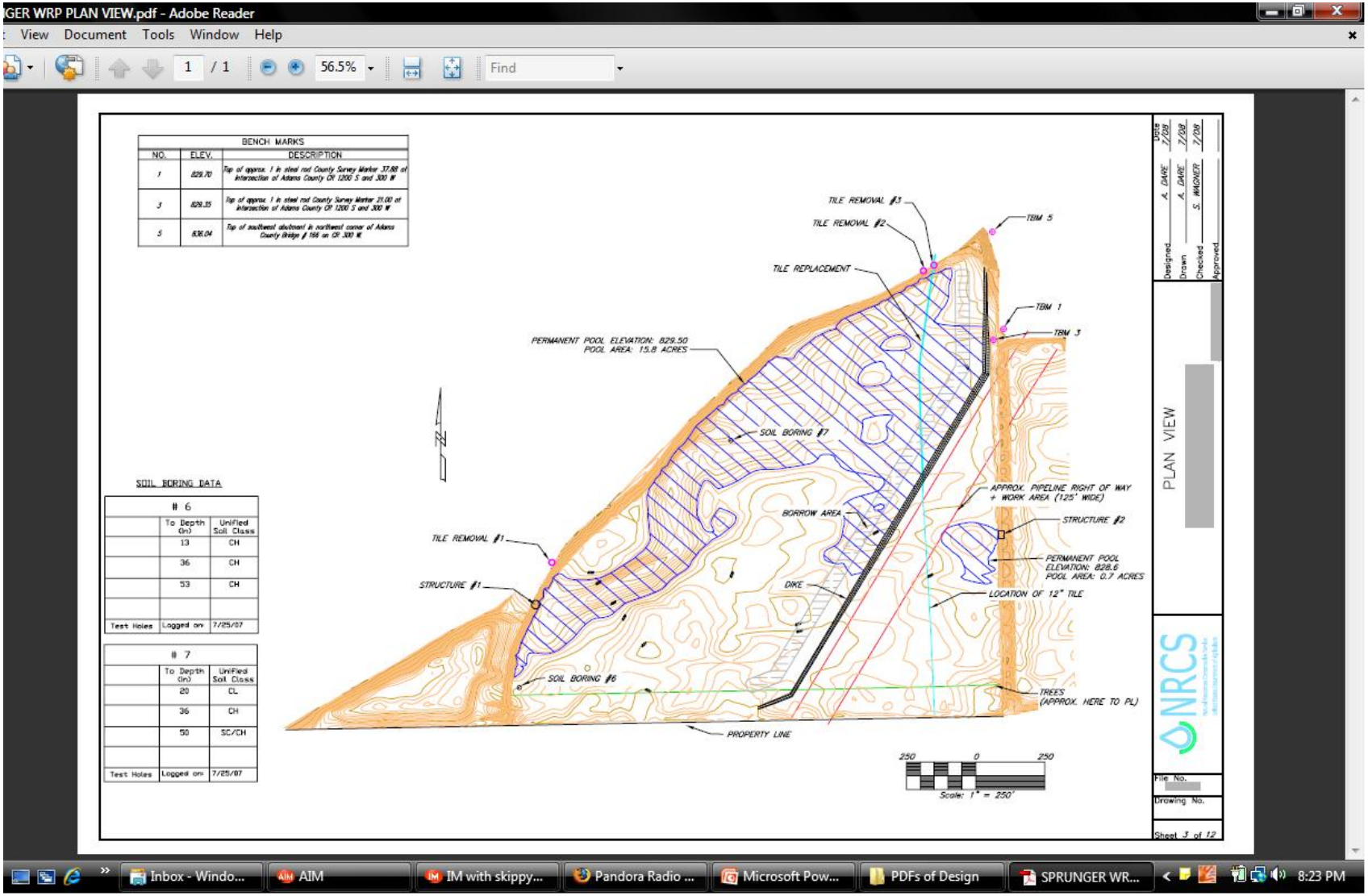
Earthwork Balance: cut 81 sq.ft.
Stream elevation 709.43



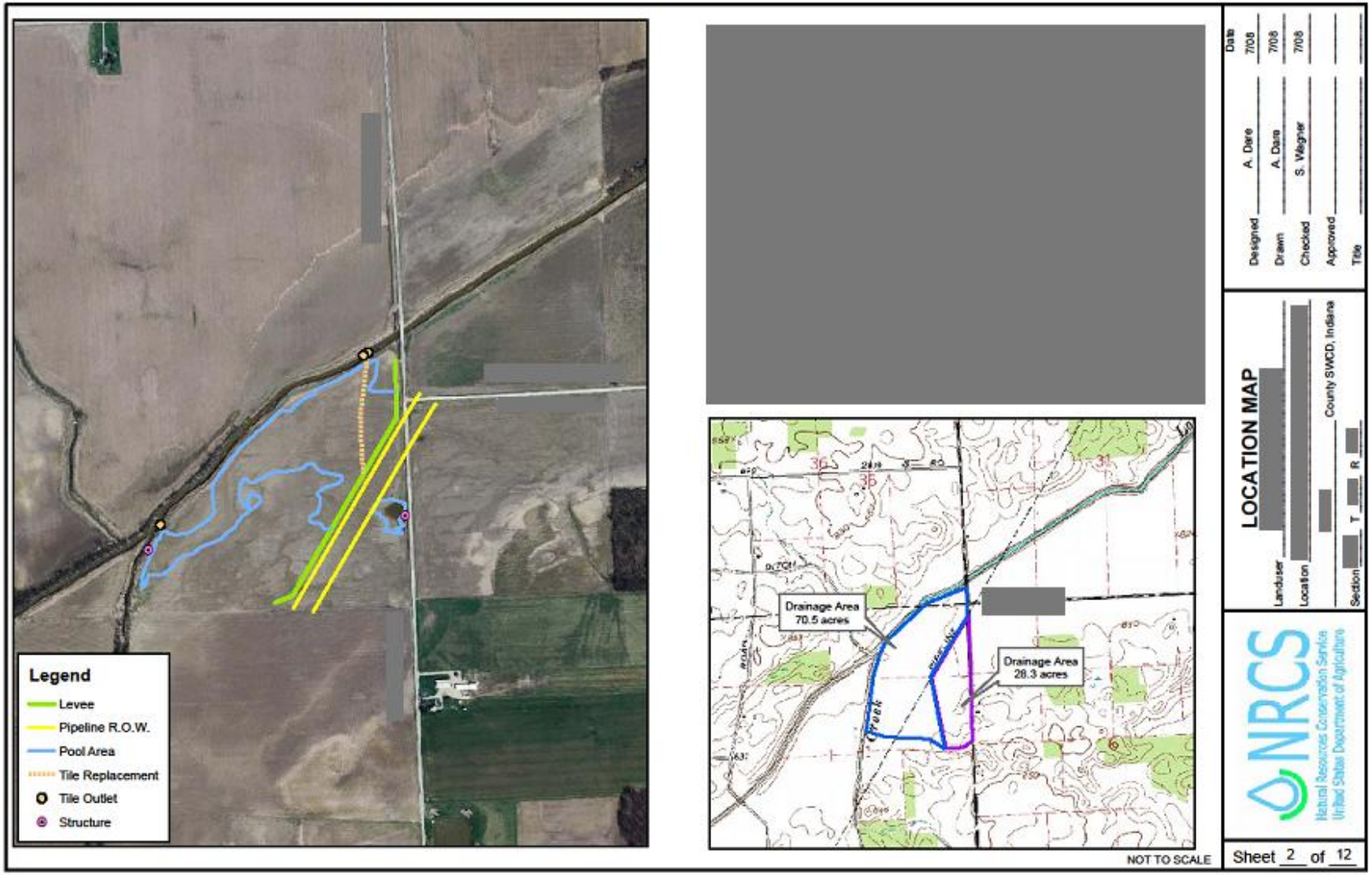

Lafayette
Two-stage reach
Direction of flow
Monitoring station 3
Control reach
Monitoring station 2
Bioreactor
Tile drains
Monitoring station 1

Design example – Wetland Restoration

Wetland Restoration – USDA NRCS



Wetland Restoration – USDA NRCS



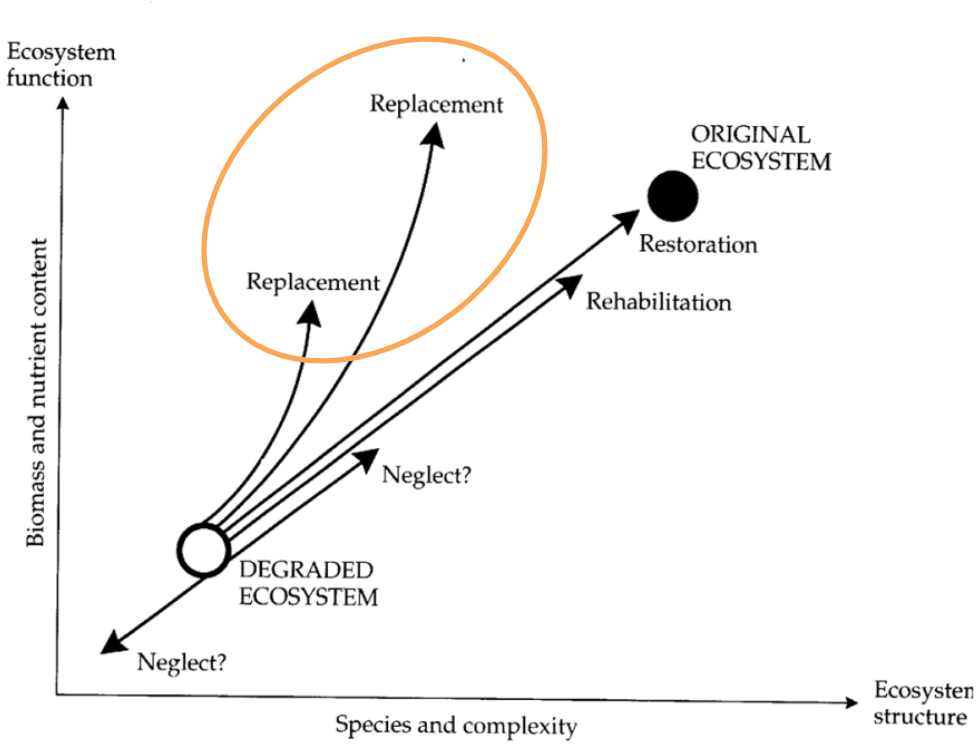
Installation of Water Control Structure
Wetland Restoration – USDA NRCS

Expected benefits of restoration

- Improved habitat for fish and microinvertebrates
- Local and downstream water quality improvements
- Reduced sediment transported downstream
- Less streambrank erosion because energy is dissipated during high flow events

What is the goal of restoration?

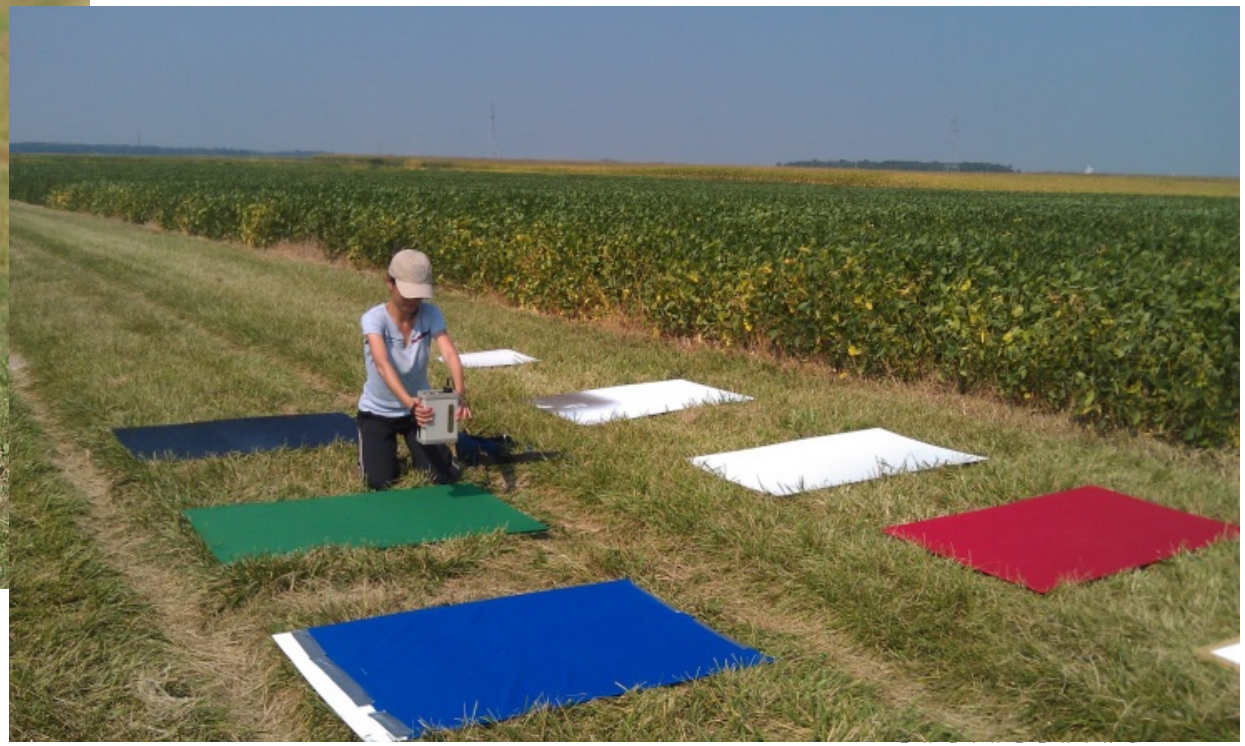
Restoring lost function? Stabilization?
Returning to pre-disturbed condition?



From Judy Meyer, Univ. Georgia

Unmanned Aerial Vehicles (UAVs)

One of many new sensor systems that have great potential for helping to manage and monitor the environment!



Undergraduate Research

Soil, air, & water quality

Ecological engineering

Global water & food security

Climate change

Any Questions?