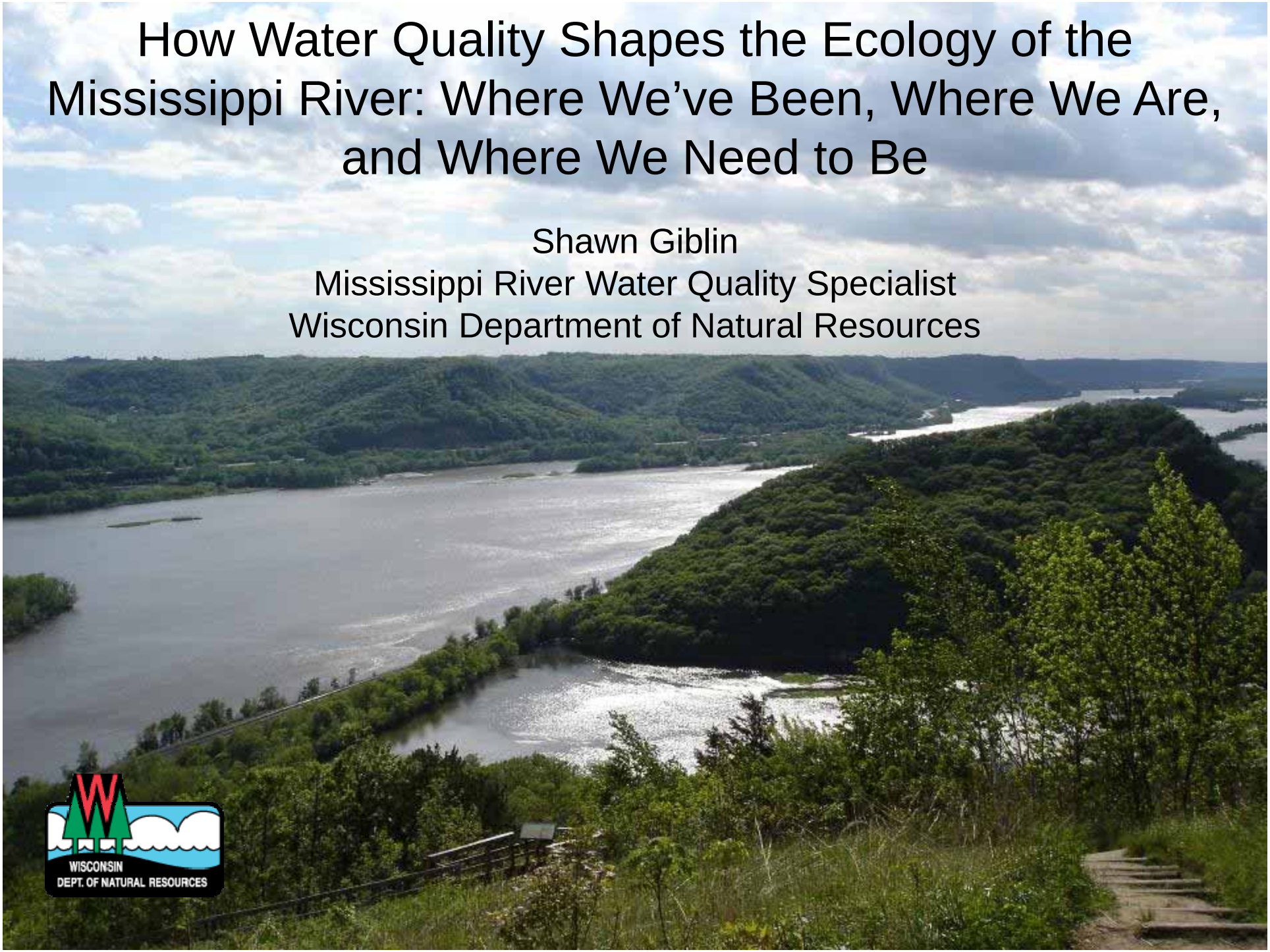
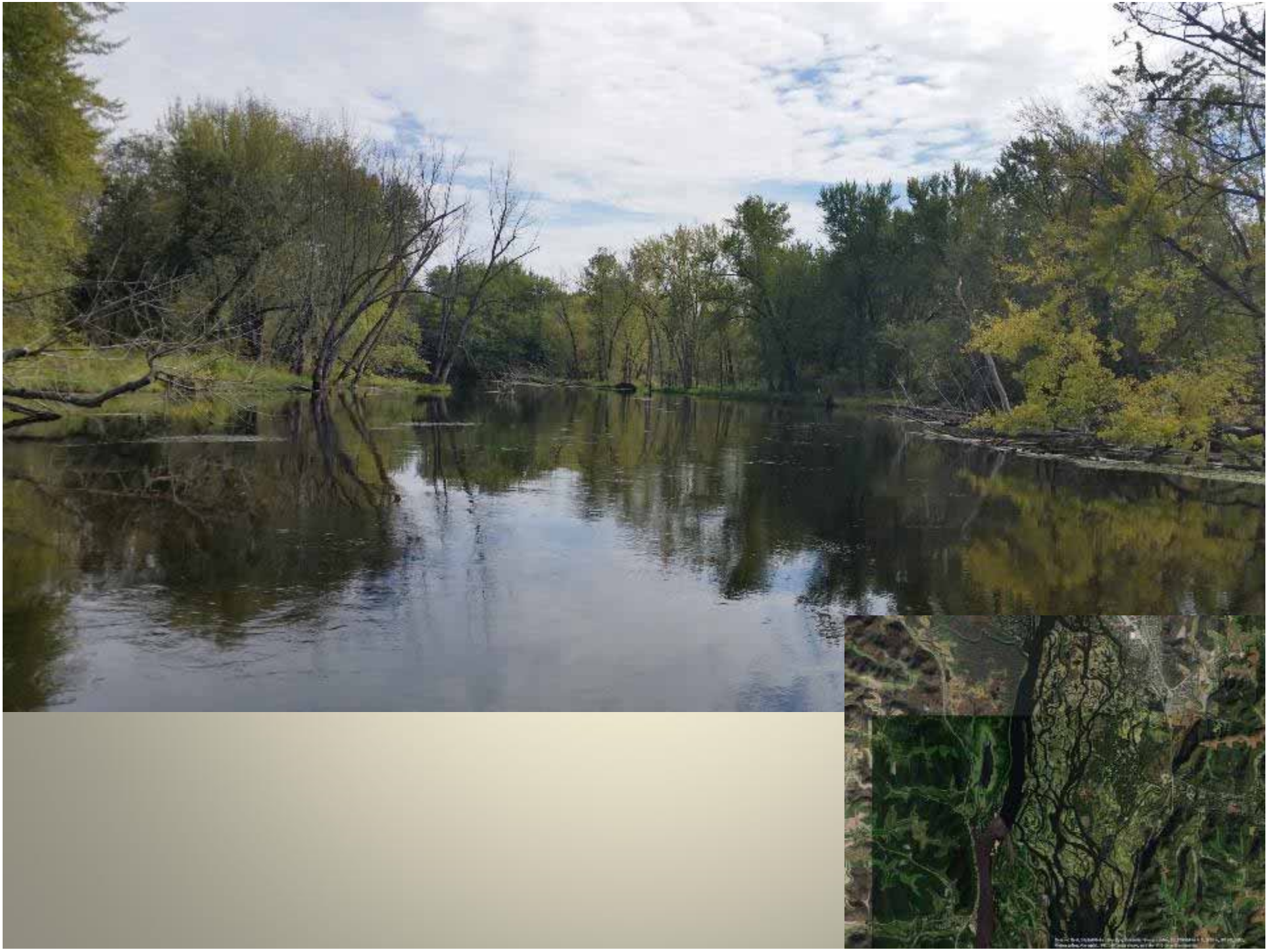
How Water Quality Shapes the Ecology of the Mississippi River: Where We've Been, Where We Are, and Where We Need to Be

Shawn Giblin
Mississippi River Water Quality Specialist
Wisconsin Department of Natural Resources




Ruth Nissen


Brenda Kelly

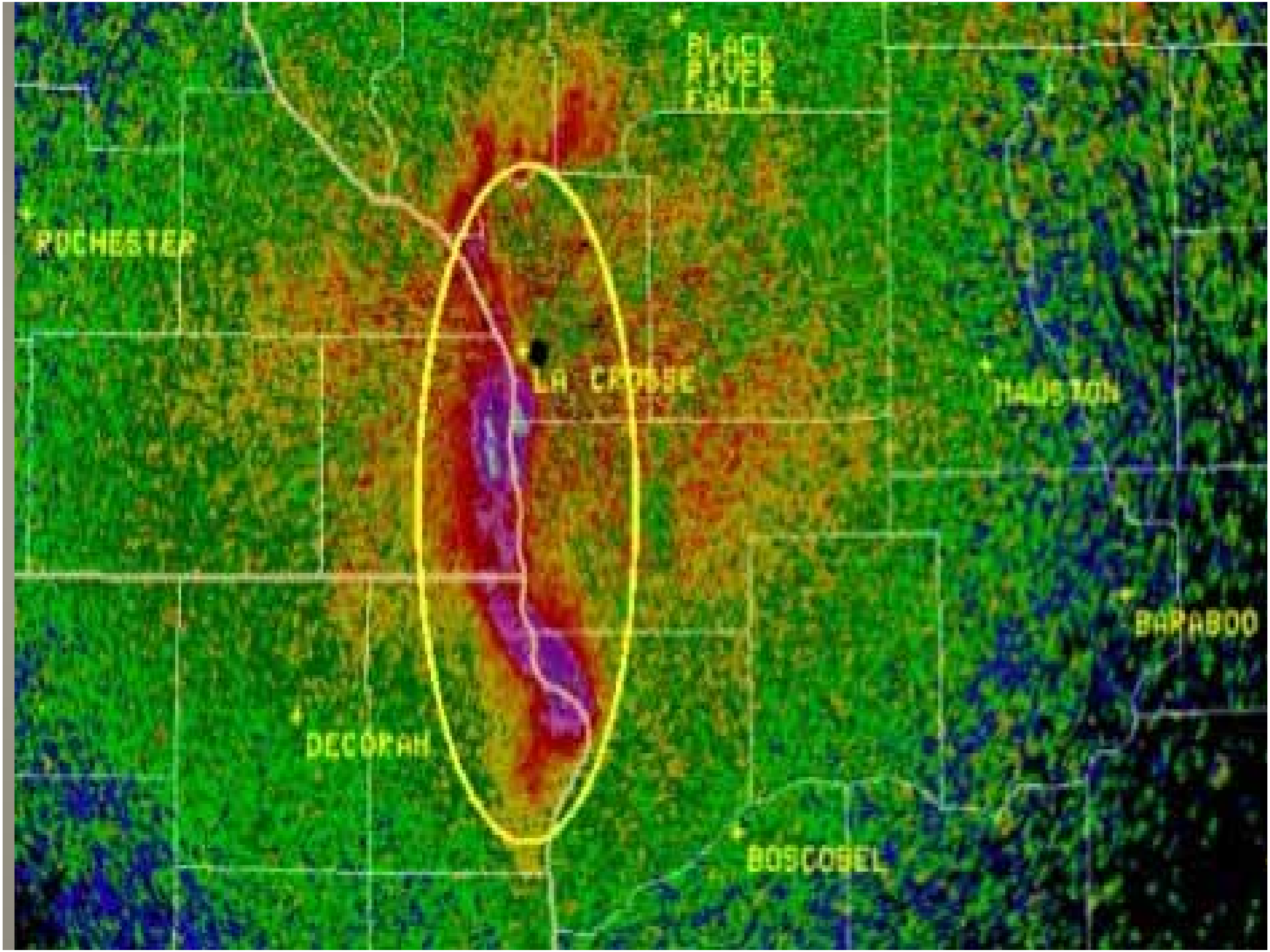



AIR RANGER


LD3- Near Diamond Bluff, WI

Trempealeau, WI- July 2014

This is something biologists like to see. This hatch means the river is healthy!


ROCHESTER
LA CROSSE
DECORAH
BOSCOBEL
BARABOO

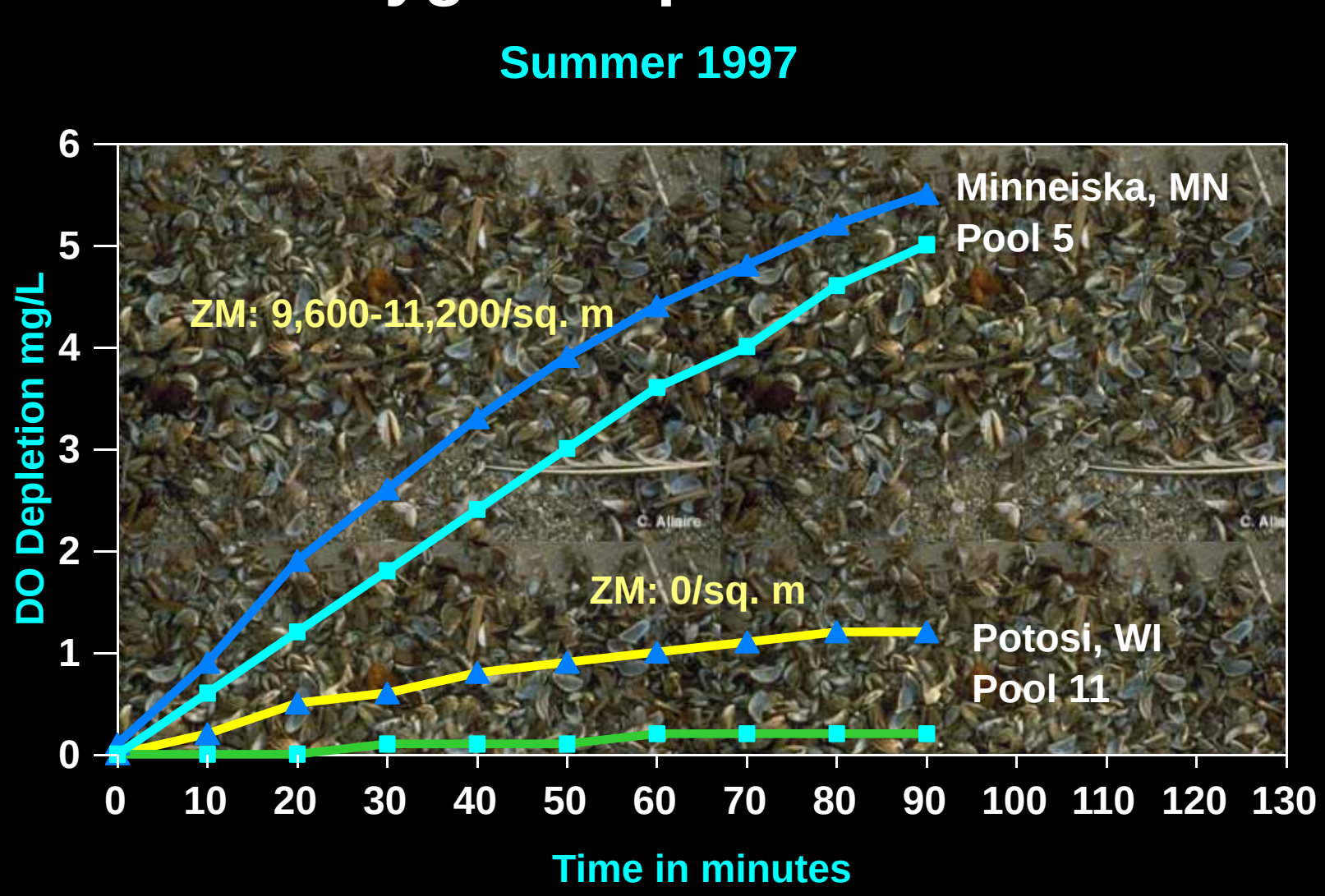
The Mississippi River is home to the highest number of freshwater mussels species any place in the world….but they are in trouble.

Factories on the Mississippi River in Muscatine, IA manufactured over 1.5 billion buttons a year in 1905.

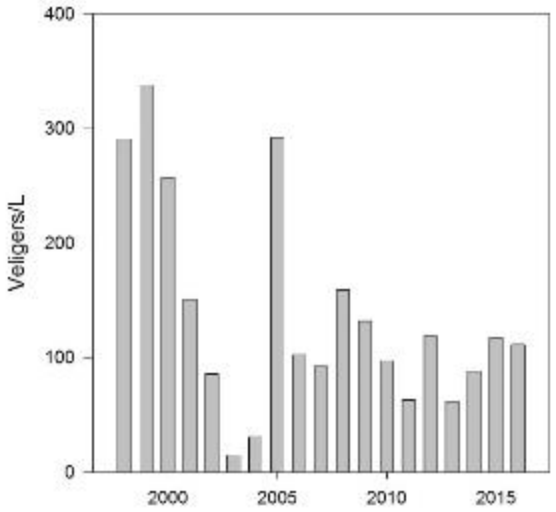
Zebra mussels introduced from Europe. Exotic species.


Introduced mid-1990s. By 1997 densities >10,000/m^2

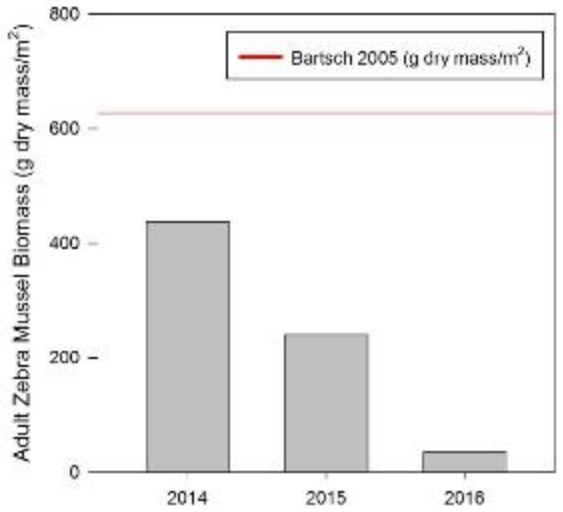
Miss. River Oxygen Depletion Measurements



Average Zebra Mussel Veliger Concentration at Lock and Dam 7
1998-2016



Adult Zebra Mussel Biomass at Lock and Dam 7 and 8
2014-2015



American white pelicans at Lock and Dam 11 near Potosi, WI.

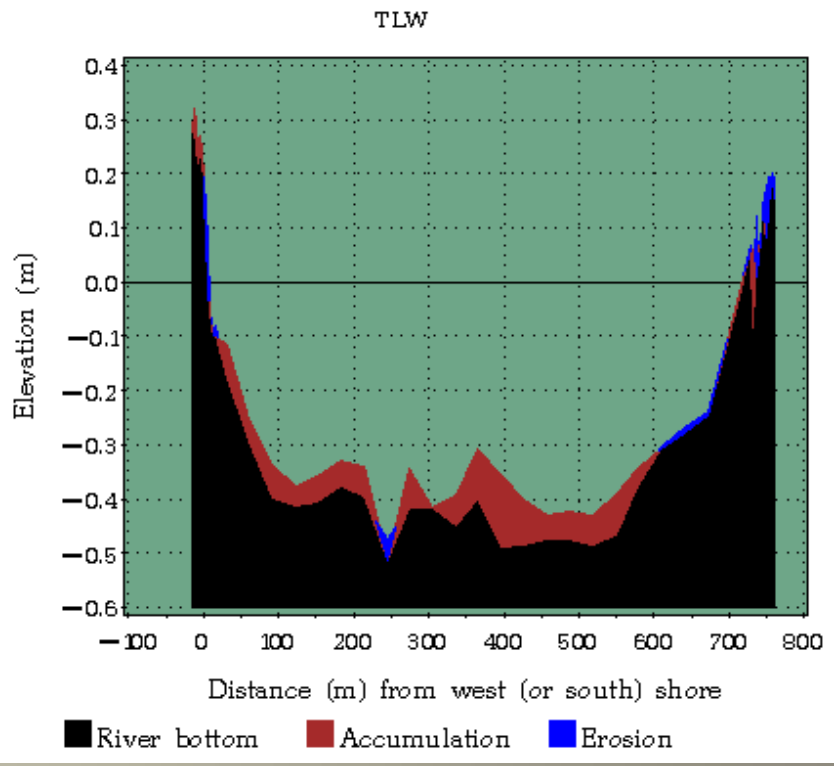
Brownsville Overlook, MN (November)
Tundra Swans

Smallmouth bass- 15 minutes of shocking

Backwater lake in fall- 15 minutes of shocking

Backwater lakes are critical for ecosystem health- overwintering habitat for bass, bluegill, and crappie.

…And we are losing them to sedimentation at about 0.5 cm/year.



Water Quality: The biological, chemical and physical conditions of a waterbody; a measure of the ability of a waterbody to support beneficial uses for humans and biota (all plants and animals).

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Two Forms of Pollution

Point

A lot of progress has been made

Non-Point

More work needs to be done

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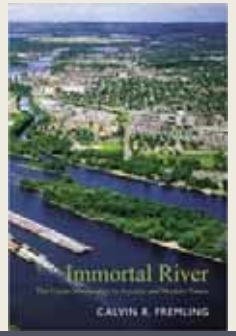
Sewage Mats on the Mississippi: June 1933

Sewage Mats on the Mississippi: May 1933

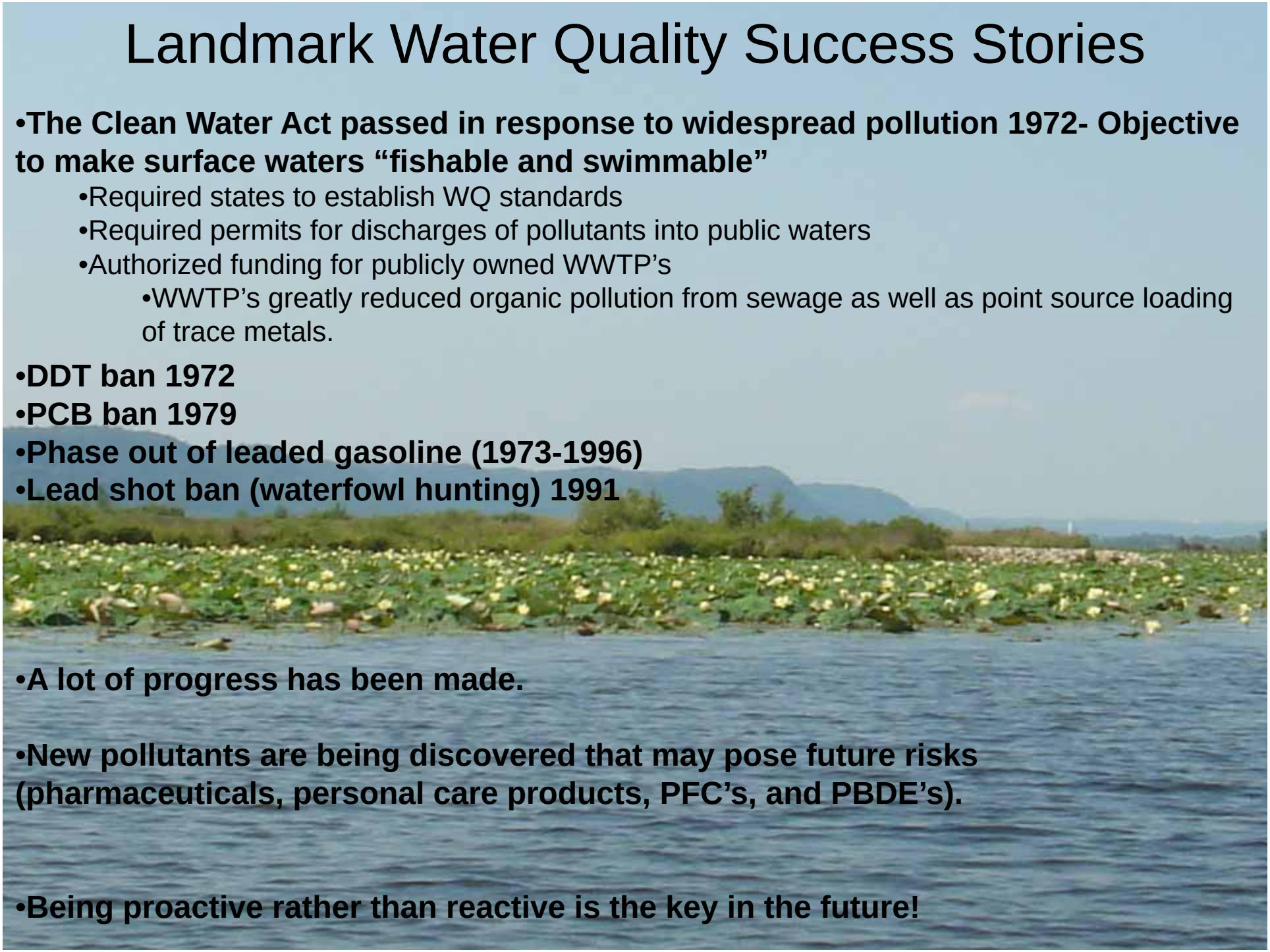
“The fetid, festering accumulation of raw sewage led the U.S. Bureau of Fisheries to report that during August of 1927, forty-five miles of the river below St. Paul lacked sufficient oxygen to sustain fish life of any kind.”

Cal Fremling, *Immortal River*



Cuyahoga River Fire 1952

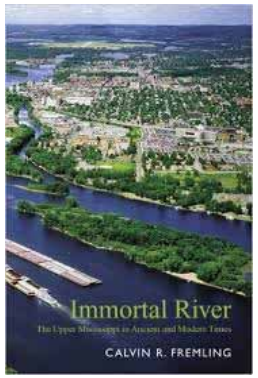
Landmark Water Quality Success Stories



- **The Clean Water Act passed in response to widespread pollution 1972- Objective to make surface waters "fishable and swimmable"**
  - Required states to establish WQ standards
  - Required permits for discharges of pollutants into public waters
  - Authorized funding for publicly owned WWTP's
    - WWTP's greatly reduced organic pollution from sewage as well as point source loading of trace metals.
- **DDT ban 1972**
- **PCB ban 1979**
- **Phase out of leaded gasoline (1973-1996)**
- **Lead shot ban (waterfowl hunting) 1991**
- **A lot of progress has been made.**
- **New pollutants are being discovered that may pose future risks (pharmaceuticals, personal care products, PFC's, and PBDE's).**
- **Being proactive rather than reactive is the key in the future!**

“Several river cities have erected eagle watch facilities that attract hundreds of eagle watchers. Shoppers strolling down the main street of Alma, WI have grown accustomed to seeing eagles flying at treetop height.”

Cal Fremling, *Immortal River*



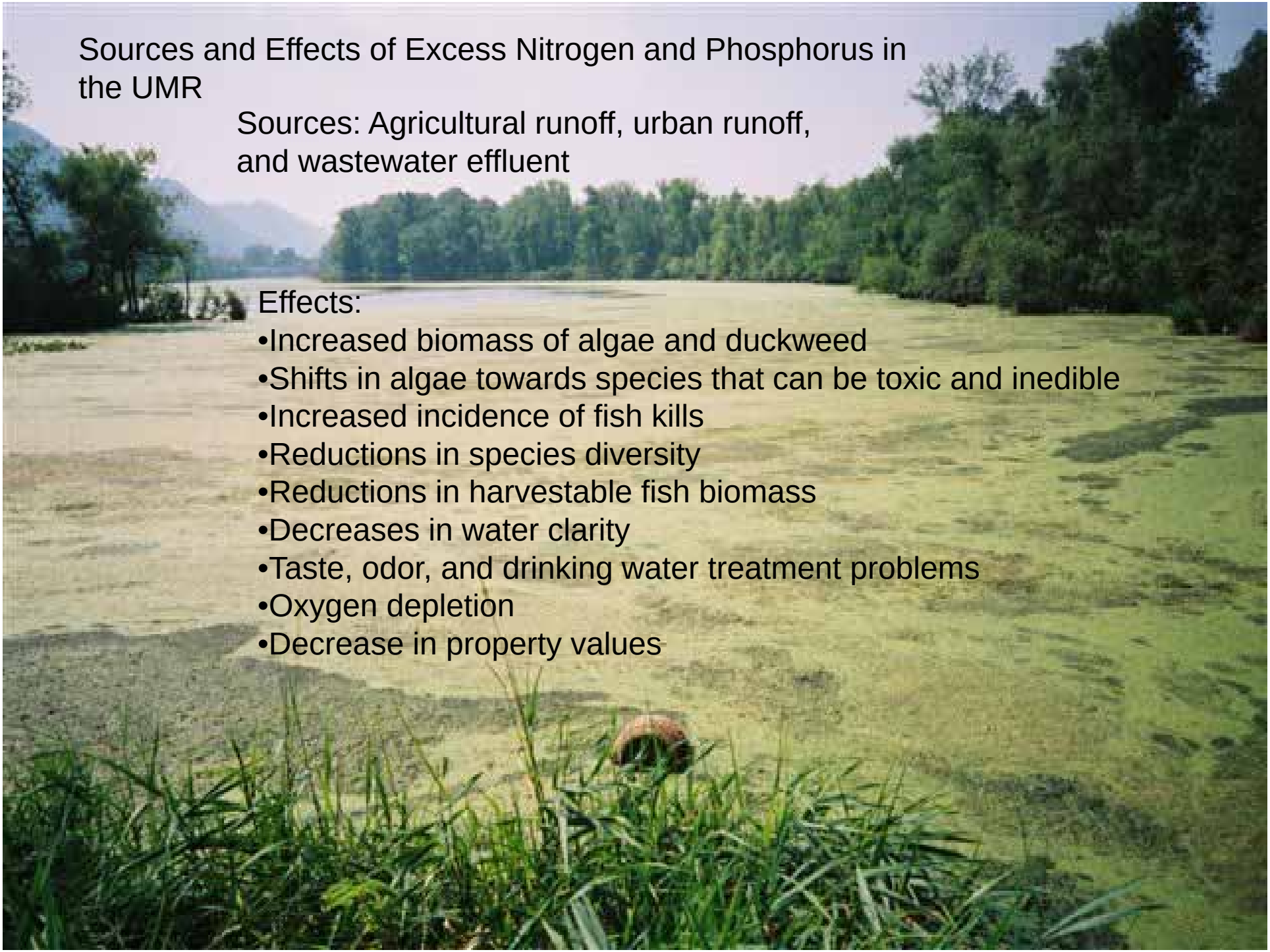
Non-Point Source Pollution Challenges

The current regulatory framework provided by the Clean Water Act does not adequately address non-point pollution.

“The landscape is leaking sediment, nitrogen and phosphorus”

We need to build on our successes dealing with point source pollution and deal with pollution flowing off the landscape.

When you come to a fork in the road, take it. - Yogi Berra
Yogism #1

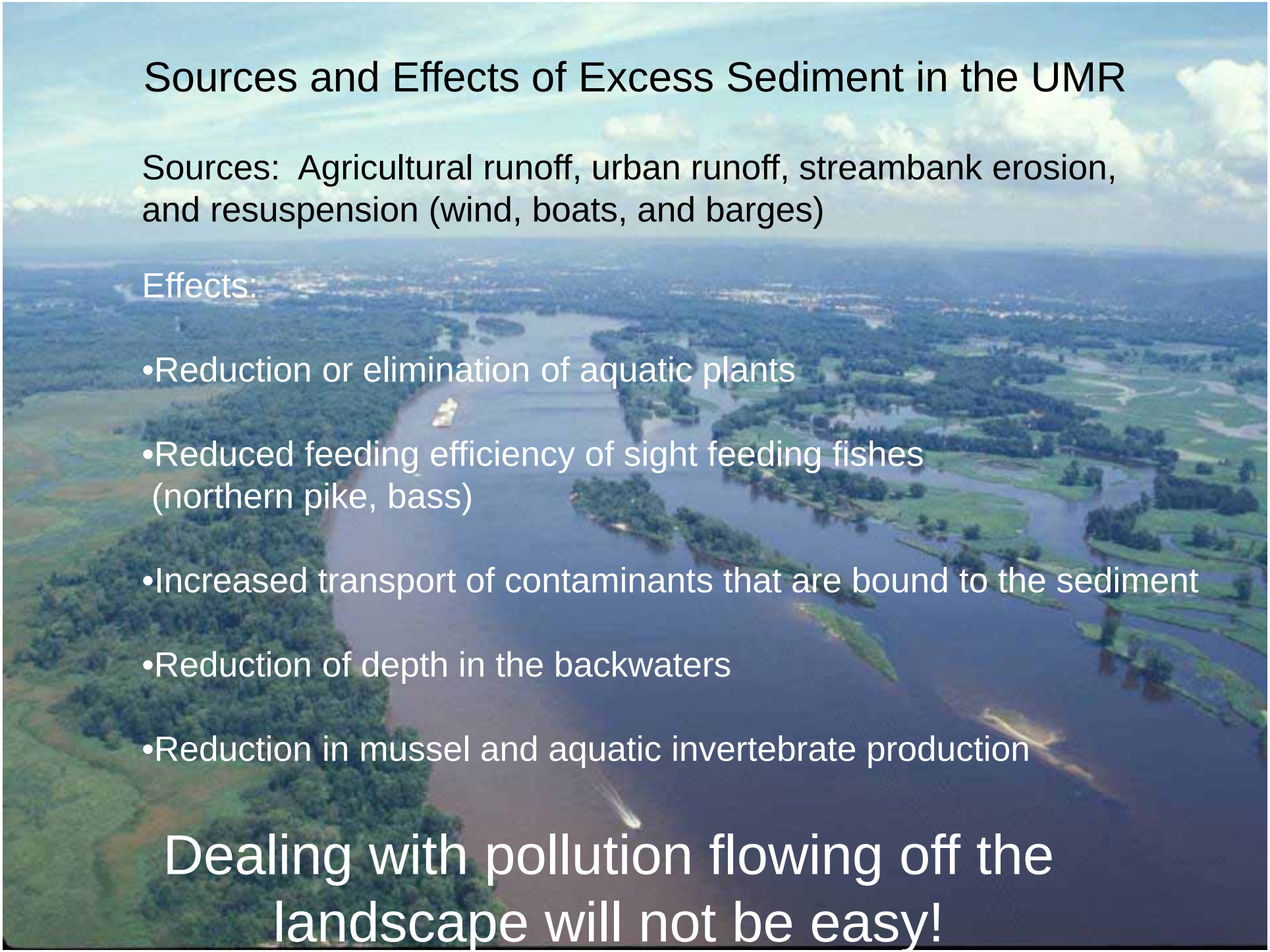


Sources and Effects of Excess Nitrogen and Phosphorus in the UMR

Sources: Agricultural runoff, urban runoff, and wastewater effluent

Effects:

- Increased biomass of algae and duckweed
- Shifts in algae towards species that can be toxic and inedible
- Increased incidence of fish kills
- Reductions in species diversity
- Reductions in harvestable fish biomass
- Decreases in water clarity
- Taste, odor, and drinking water treatment problems
- Oxygen depletion
- Decrease in property values



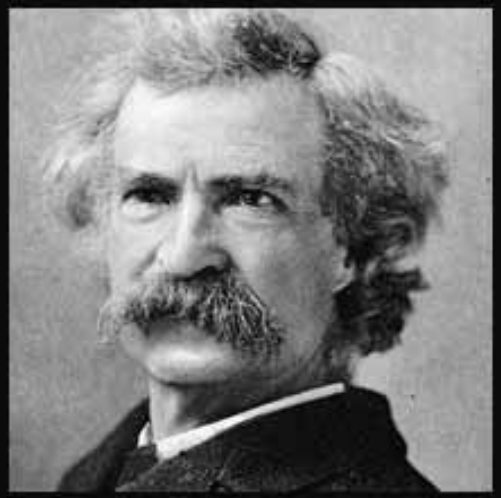
Sources and Effects of Excess Sediment in the UMR

Sources: Agricultural runoff, urban runoff, streambank erosion, and resuspension (wind, boats, and barges)

Effects:

- Reduction or elimination of aquatic plants
- Reduced feeding efficiency of sight feeding fishes (northern pike, bass)
- Increased transport of contaminants that are bound to the sediment
- Reduction of depth in the backwaters
- Reduction in mussel and aquatic invertebrate production

Dealing with pollution flowing off the landscape will not be easy!

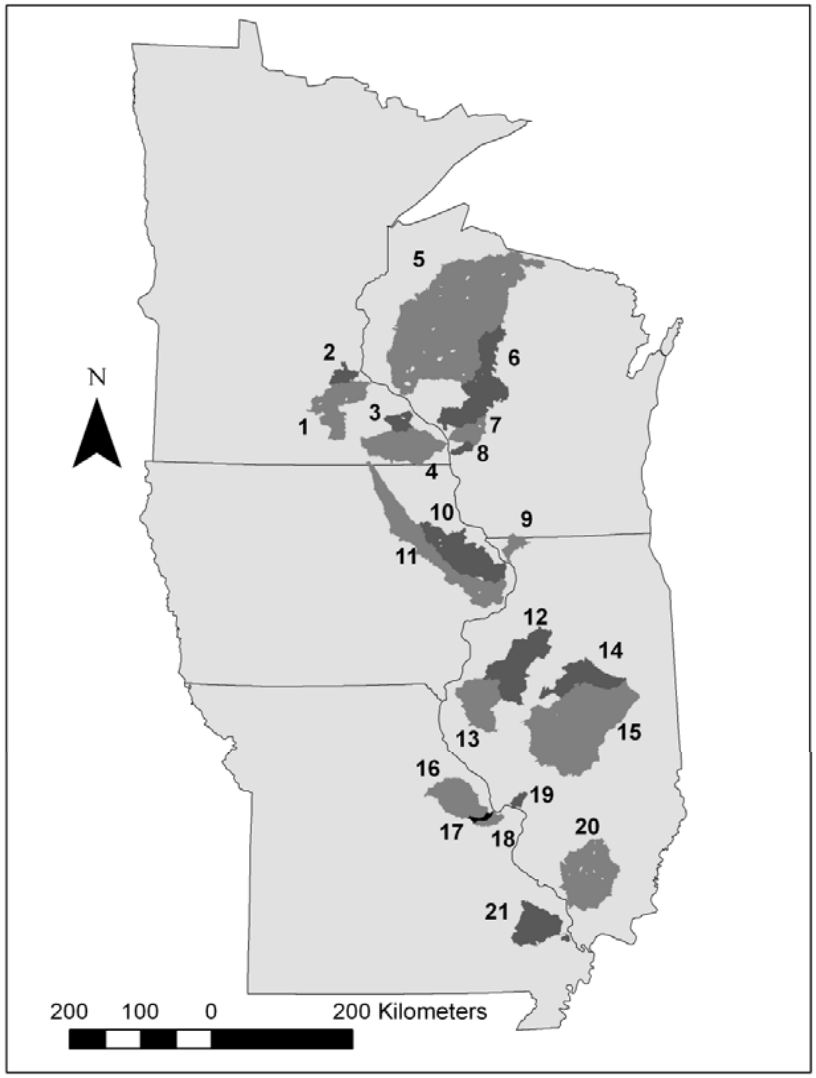


Whiskey is for drinking; water is for fighting over.

~ Mark Twain

AZ QUOTES

LTRM Tributary Watershed Data



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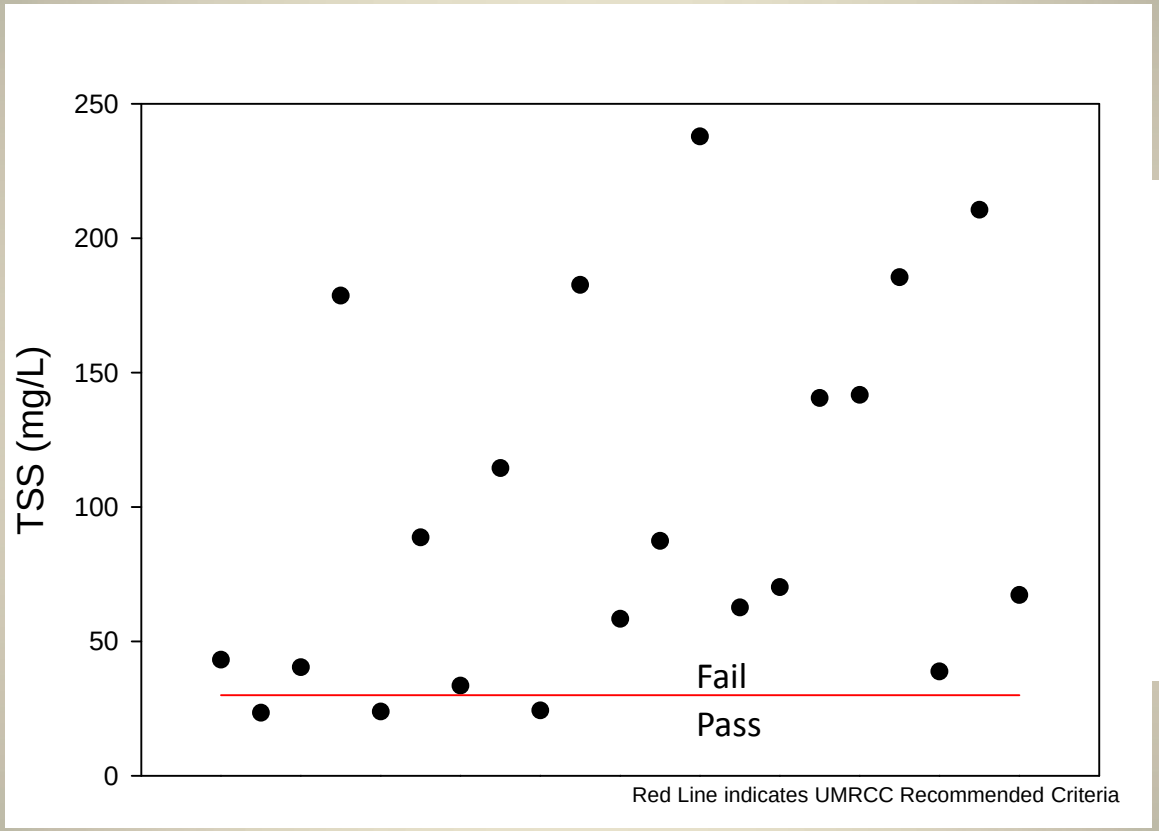
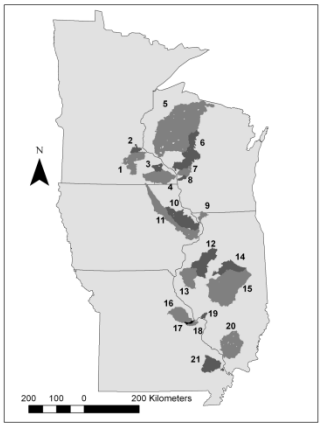
Upper Midwest Environmental Sciences Center

Mean Total Suspended Solids (sediment)





18 of 21 tributary watersheds fail to meet the recommended criteria for TSS

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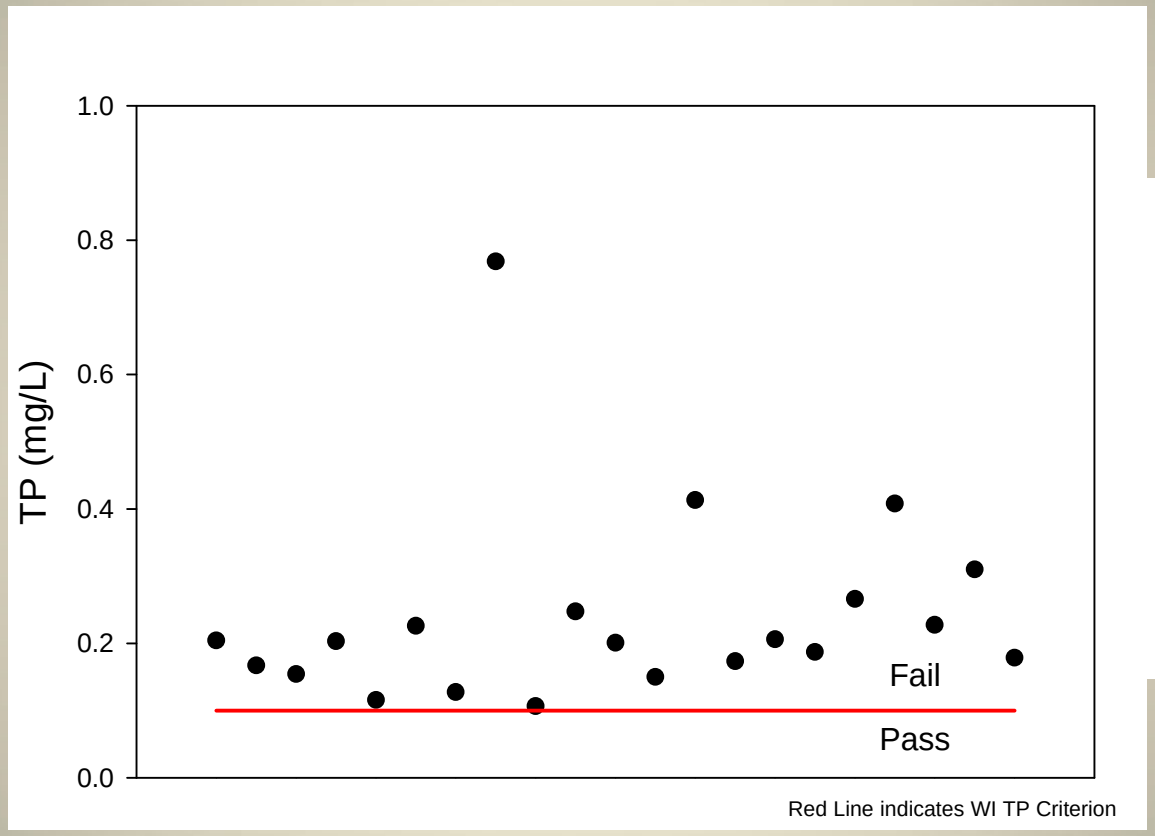
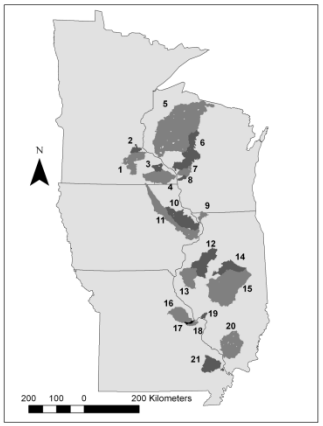
Mean Total Phosphorus





All 21 tributary watersheds fail to meet the recommended criteria for Total Phosphorus

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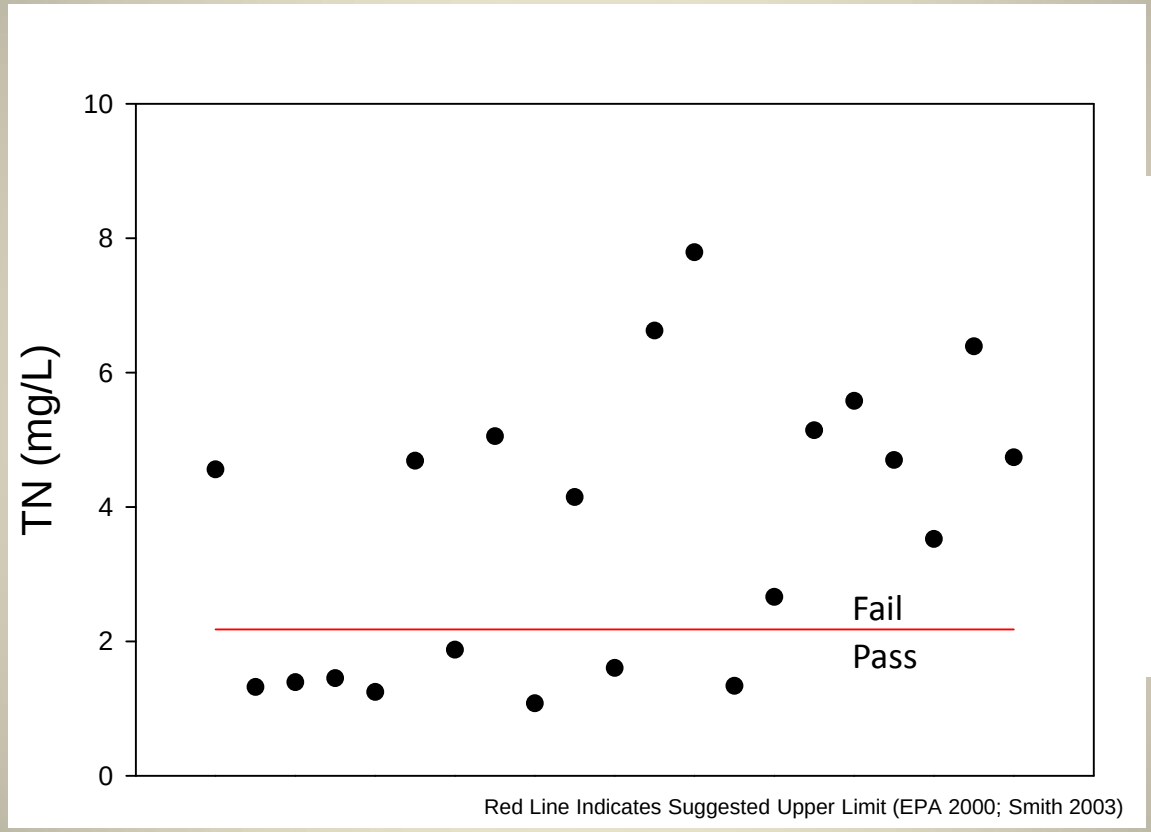
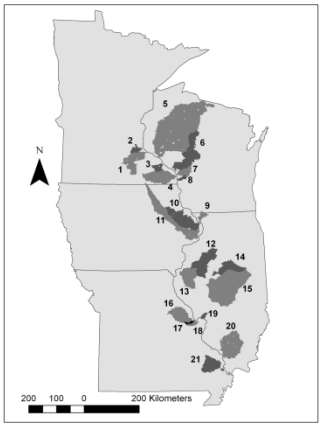
Mean Total Nitrogen



Red Line Indicates Suggested Upper Limit (EPA 2000; Smith 2003)



13 of 21 tributary watersheds fail to meet the recommended criteria for Total Nitrogen

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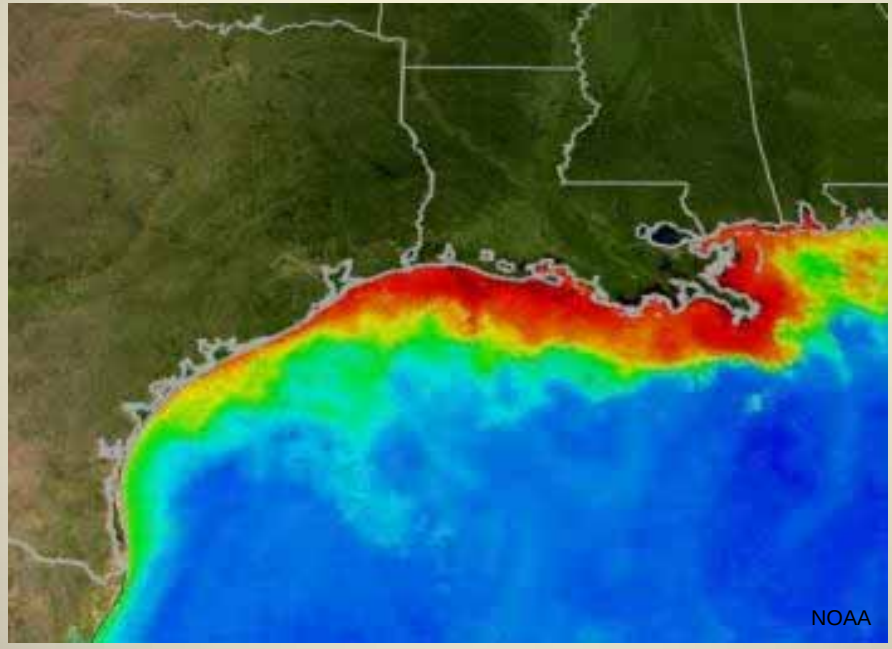
Dead Zone in the Gulf of Mexico

•Nitrate-N has increased by a factor of 10 over the past 100 years in the Lower Mississippi River

•Up to 8,000 sq. miles unsuitable for life- Roughly the size of New Jersey



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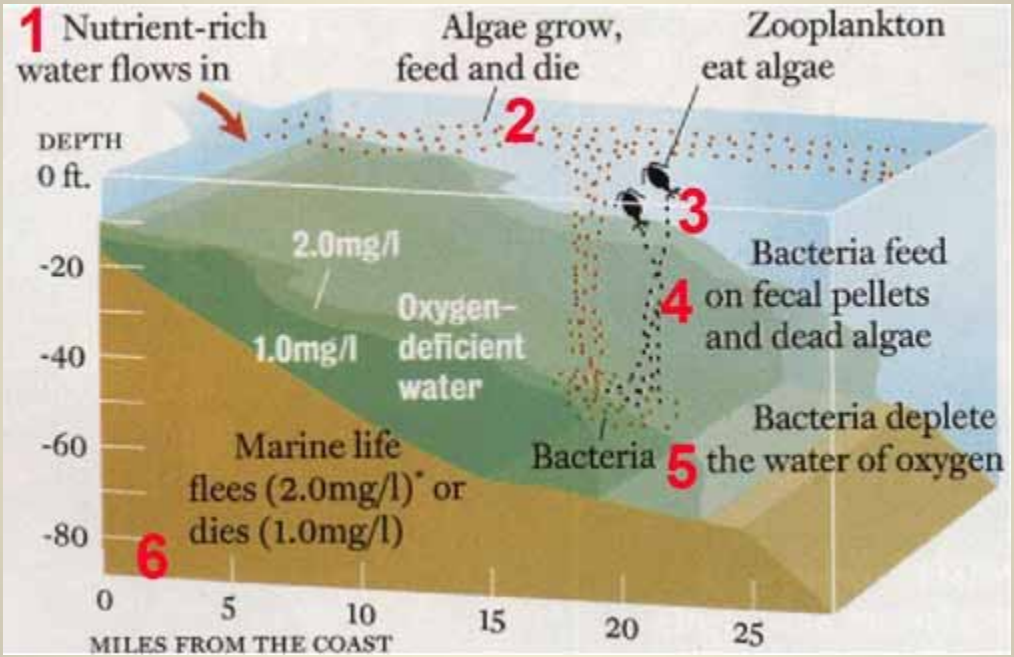

LUMCON

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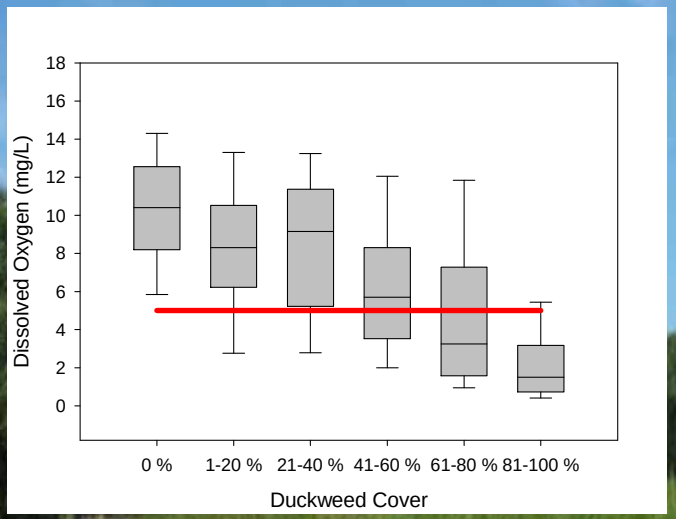
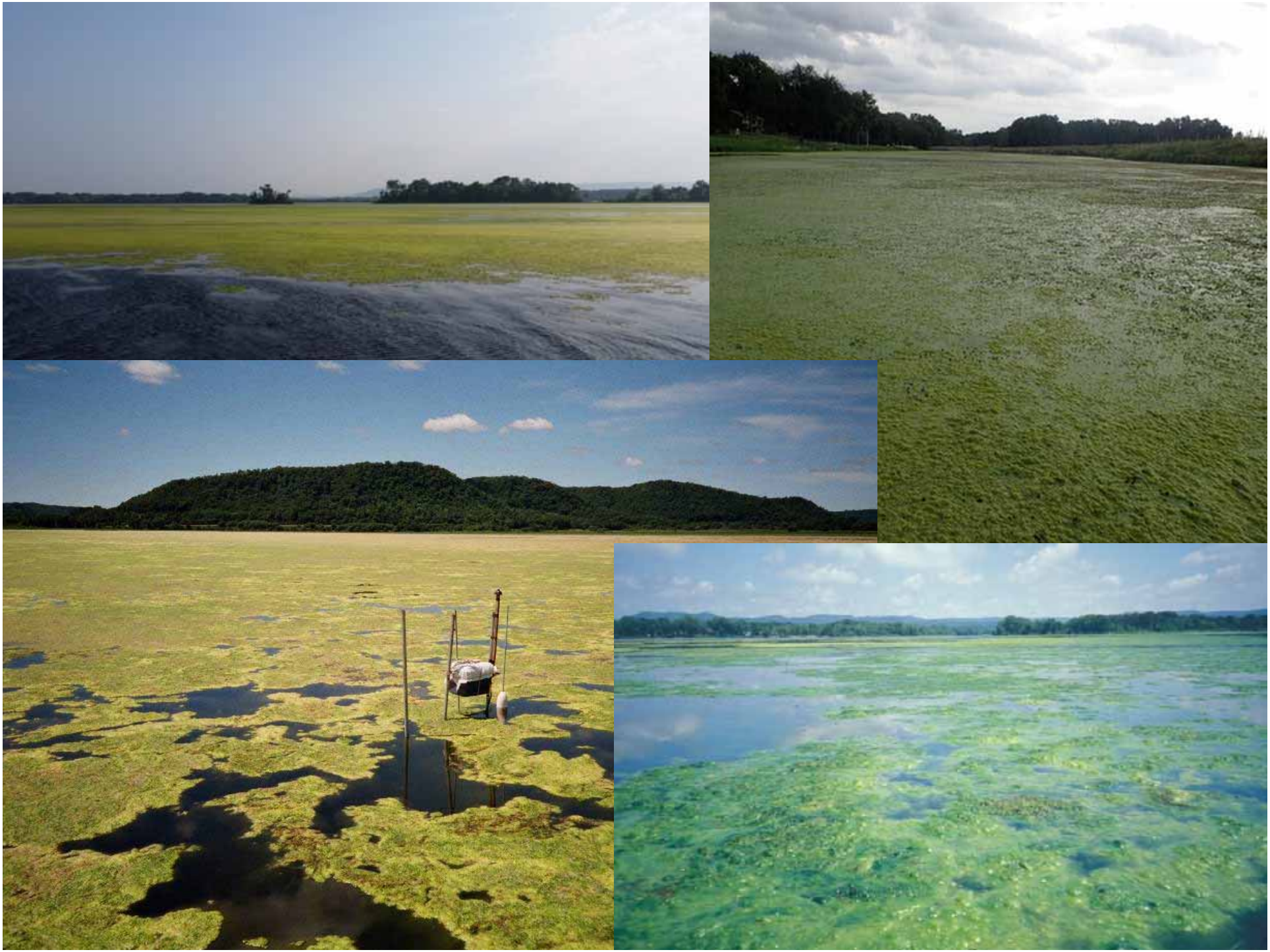
Local Effects of Excess Nitrogen and Phosphorus



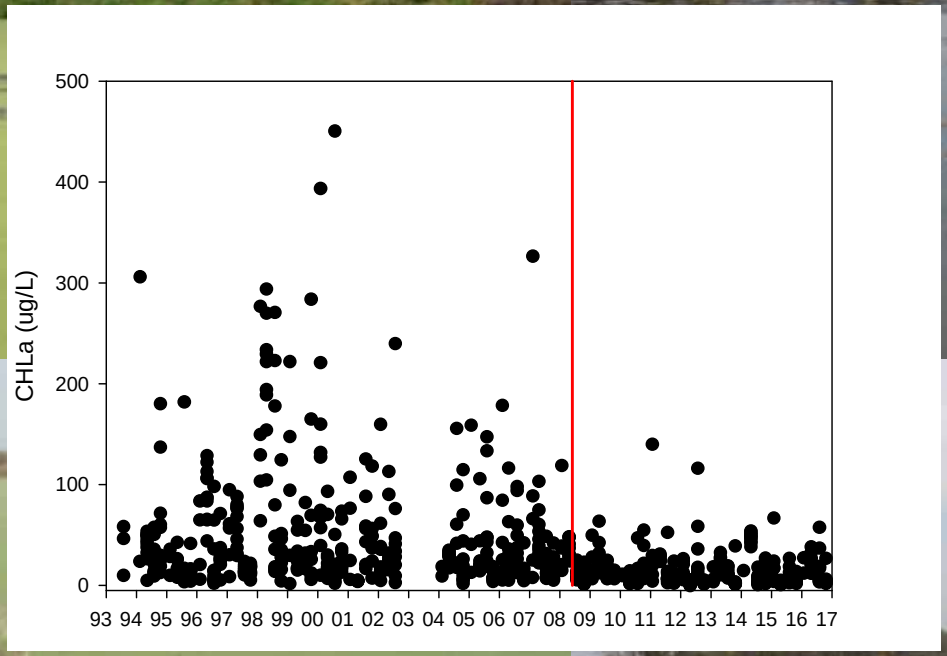
Mini Dead Zones



You can observe a lot just by watching - Yogism #2

Fall 2004

Fall 2010



Wabasha County
Herald August 4, 2010

That's not green carpet behind the group gathered at Bonnie Koopman's residence on Bridge Avenue and Grant Blvd. last week. That's apparently "Duckweed" that has grown out of control in the Slough here, as it has in many other locations in the area. The residents of the backwaters areas met with DNR officials to discuss what to do about this "growing" problem.

—Photo by Michael Smith

Shoreline residents seeing too much 'green'

by Michael Smith

In these tight economic times, few people around here, you could say, are seeing an over-abundance of "green"; meaning the George Washington or Abe Lincoln money-type green.

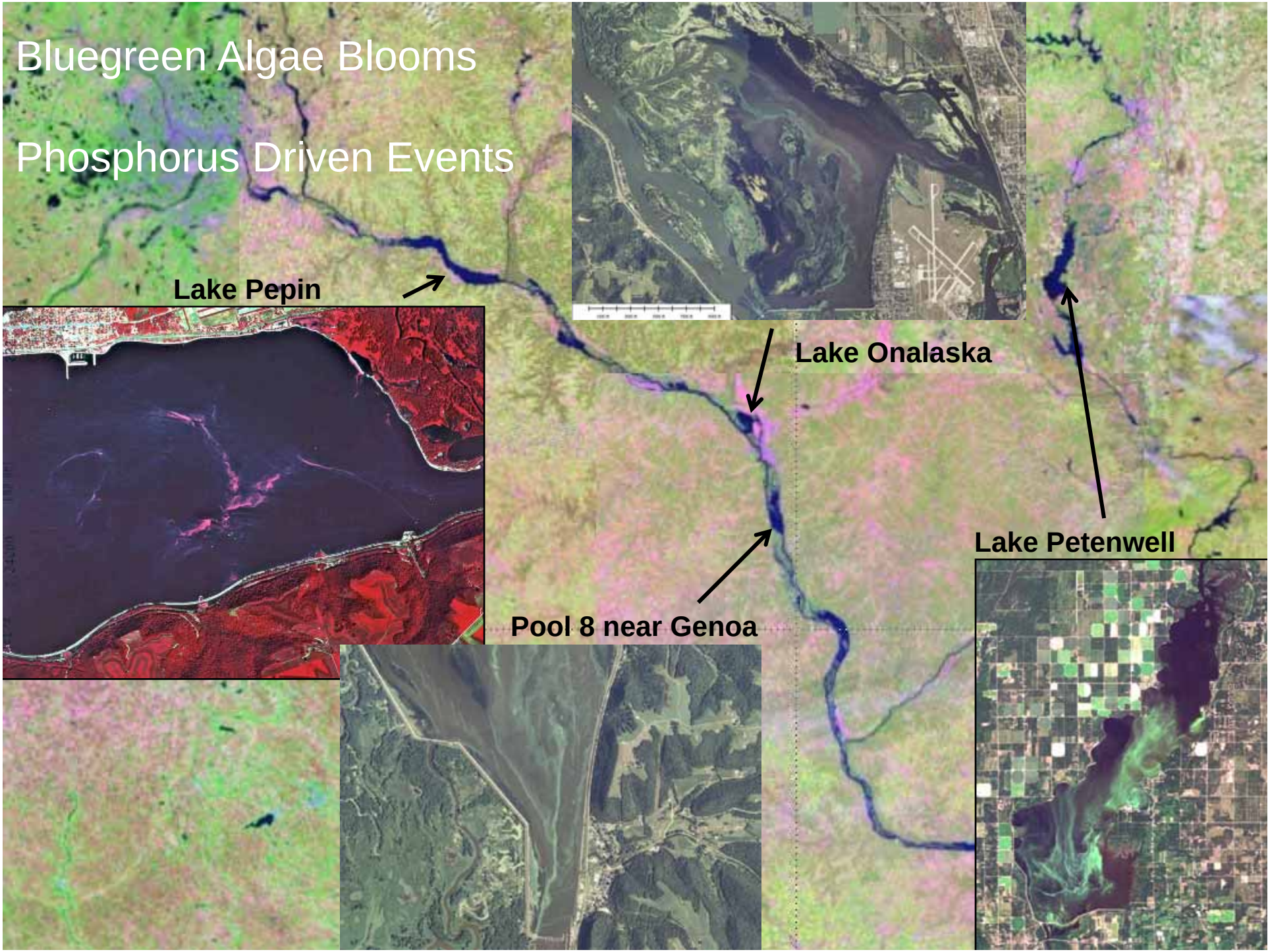
Residents along the slough—the old Zumbro River bed—in Wabasha, and along Robinson and Peterson Lakes or by other area coves and backwaters, are definitely seeing too much "green" these days, however: the kind that forms on the surface of the water and which most will agree is "pretty ugly"...to say nothing of inconvenient, troublesome and potentially very costly.

Many of those residents met with Minnesota DNR officials on July 26th to discuss a "growing" problem in the waters outside their doors. That problem is in the form of "Duckweed" and "Coontail"—two native plant species that have infested the backwaters and turned the open water into green carpet and gotten so thick it tangles up in boat props. But the so-called "pond scum" (to put it candidly) is not as welcome as lush green carpet would be to these residents.

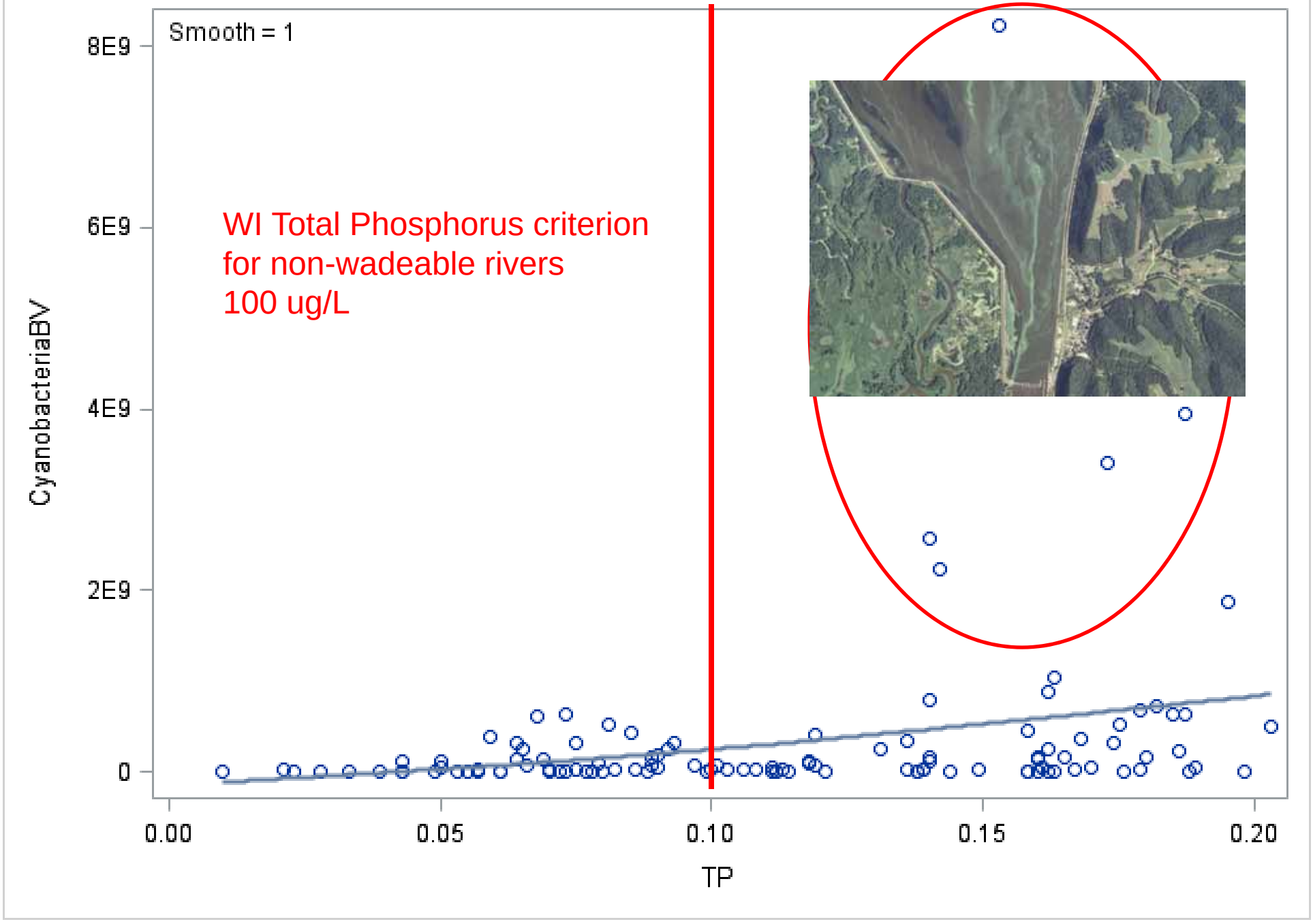
According to one of the DNR officials present that day, Aquatic Plant Management Specialist Sean Sisler, (the other was Area Fisheries Supervi-

Turn to SHORELINE page 3

Caption: "That's not green carpet behind the group… That's "Duckweed" that has grown out of control… The residents of backwater areas met with DNR officials to discuss what to do about this "growing" problem. "


Bluegreen Algae Blooms
Phosphorus Driven Events
Lake Pepin
Lake Onalaska
Lake Petenwell
Pool 8 near Genoa

Bluegreen Algae Biovolume vs. Total Phosphorus



Emerging Threat
Algal Toxins

Microcystin 69.8 ug/L- August 2013- Crater Lake near La Crosse- *Microcystis Aeruginosa* bloom

Draft EPA Guidance (Swimming Advisory)
Microcystin 4 ug/L

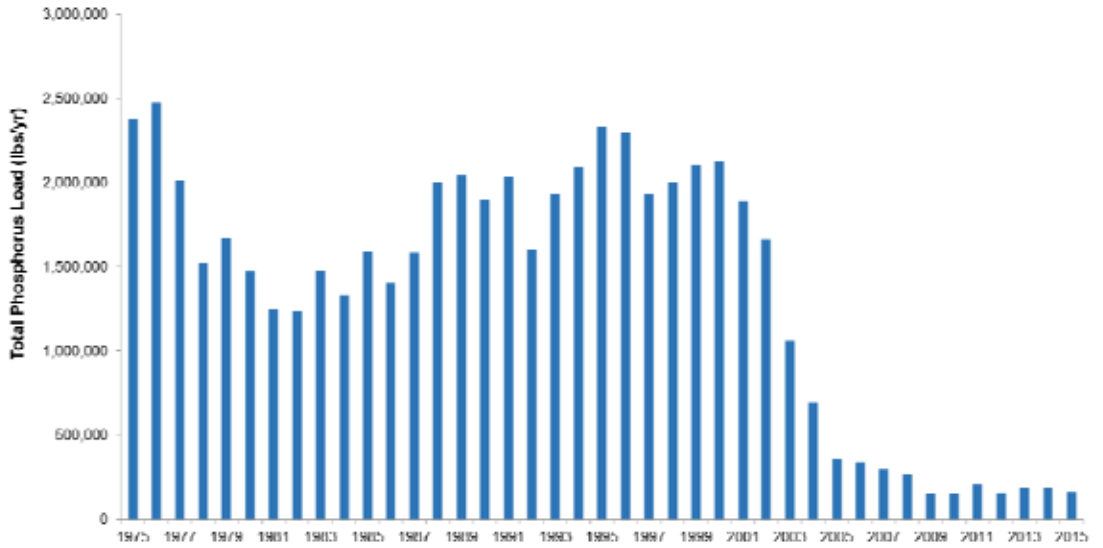
Lake Pepin Fish Kill
Maiden Rock, WI
July 12, 1988

Dissolved Oxygen 0.4 mg/L
Ammonia N 5.1 mg/L
Chlorophyll *a* 780 ug/L

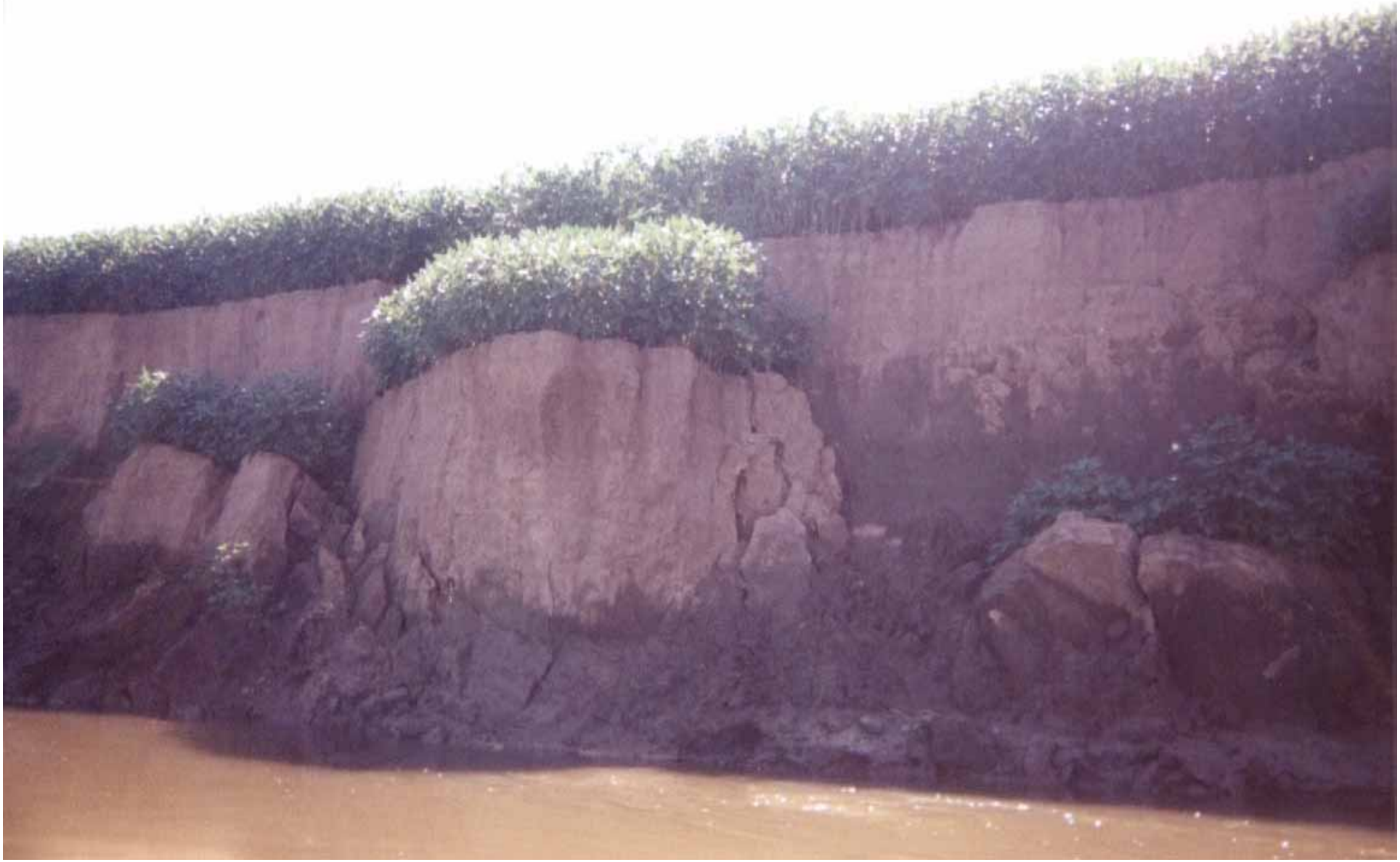
Probable Cause= High Phosphorus

Since this time Twin Cities WWTP began phosphorus removal
>90% reduction.

Still high phosphorus and sediment load from landscape.



Sediment Issues



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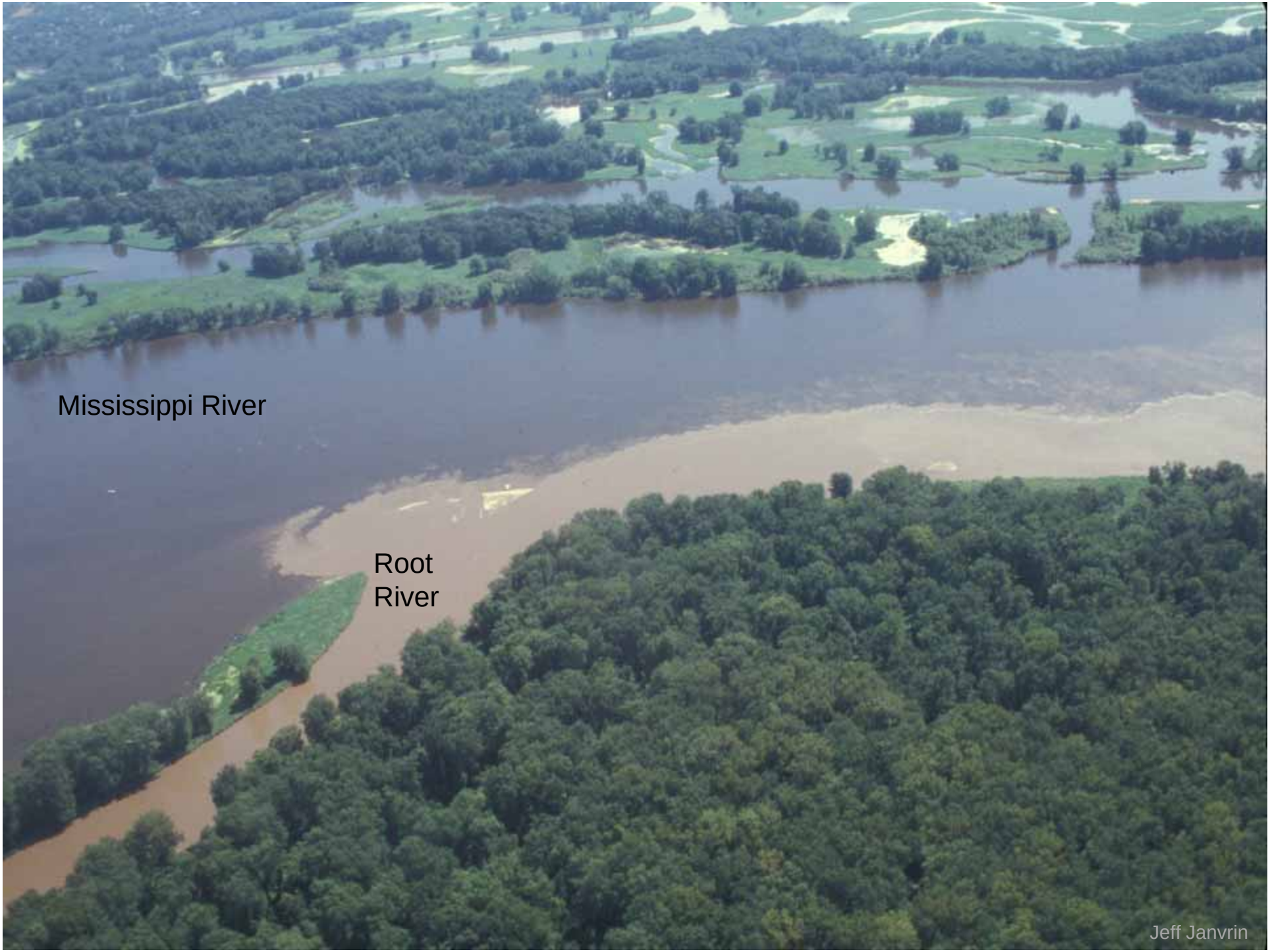
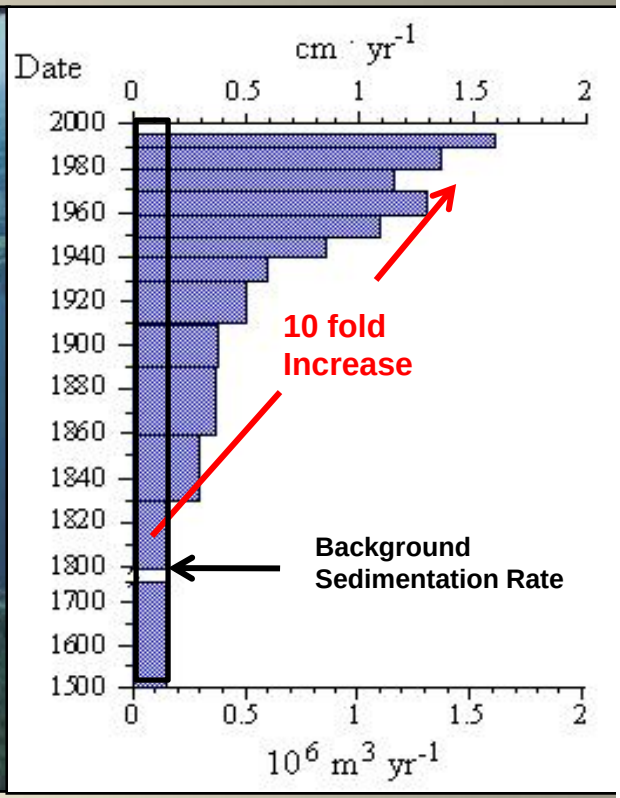

Mississippi River
Root
River
Jeff Janvrin

You can observe a lot just by watching - Yogism #2

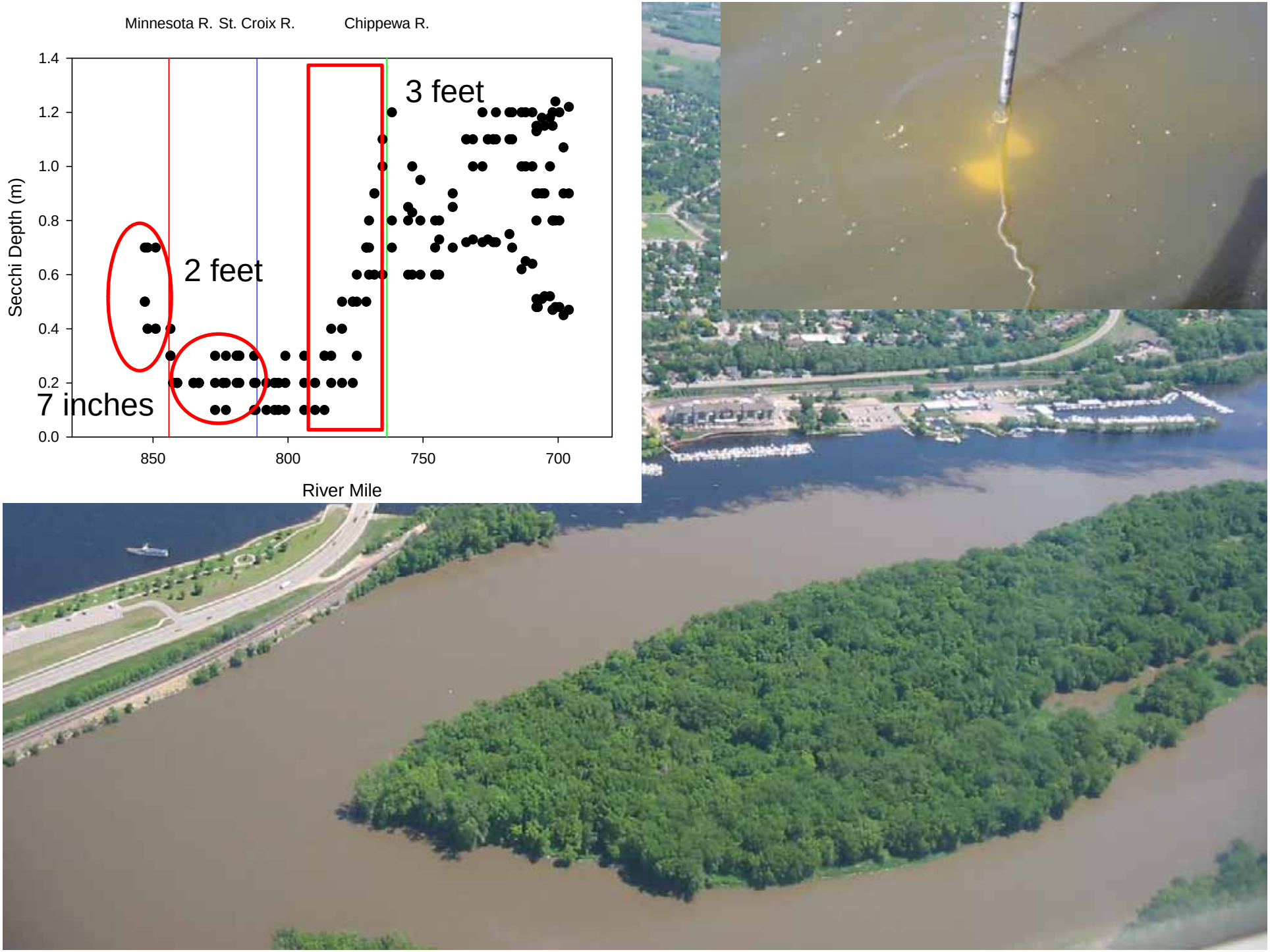

St. Croix River
Mississippi River
Jeff Janvrin

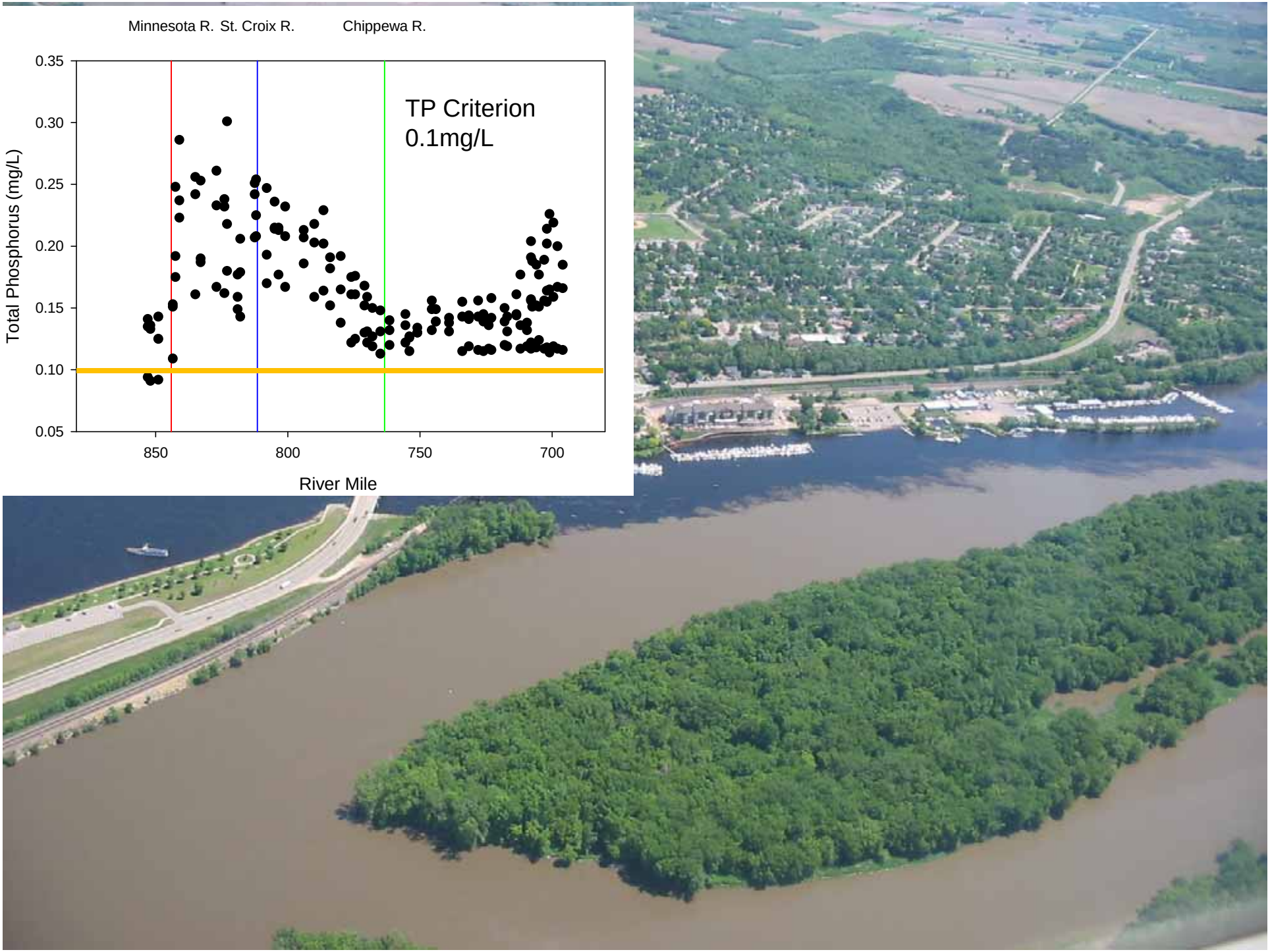
Lake Pepin Sedimentation Rates

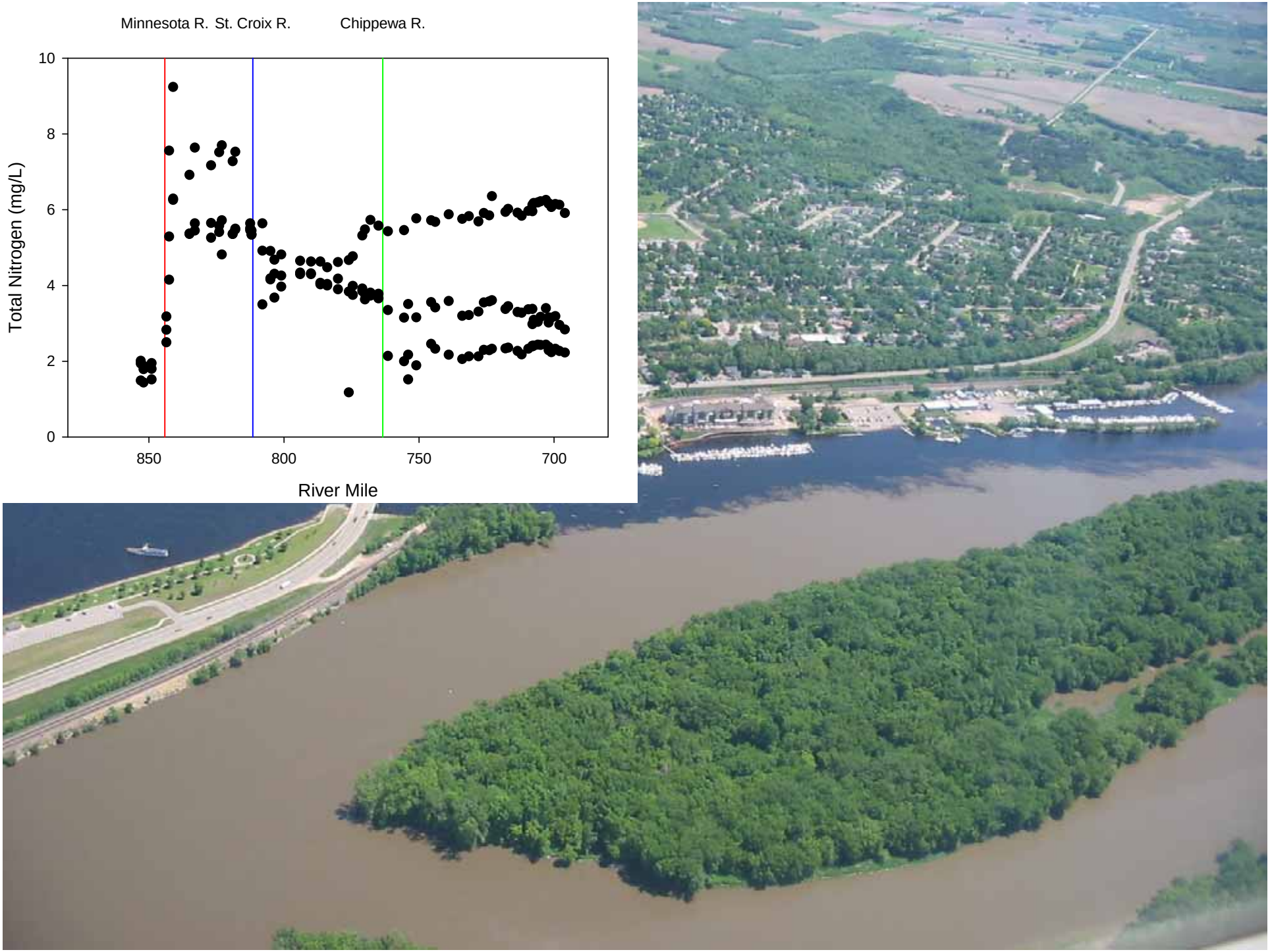


Engstrom et. al. 2000

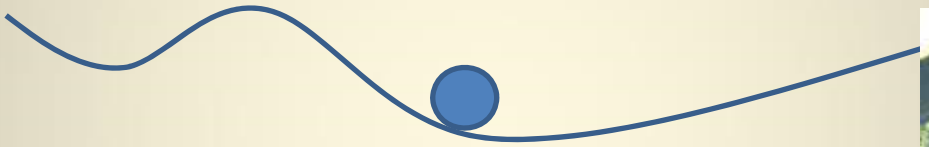
- Lake Pepin is projected to be filled in 340 years.
- Under natural sediment loading rates this process would take thousands of years.
- Not just Lake Pepin, many productive backwaters will be marsh within 50-100 years.


Minnesota R.
St. Croix R.
Chippewa R.
Secchi Depth (m)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
850
800
750
700
River Mile
3 feet
2 feet
7 inches


Minnesota R.
St. Croix R.
Chippewa R.
0.35
0.30
0.25
0.20
0.15
0.10
0.05
Total Phosphorus (mg/L)
TP Criterion
0.1mg/L
850
800
750
700
River Mile

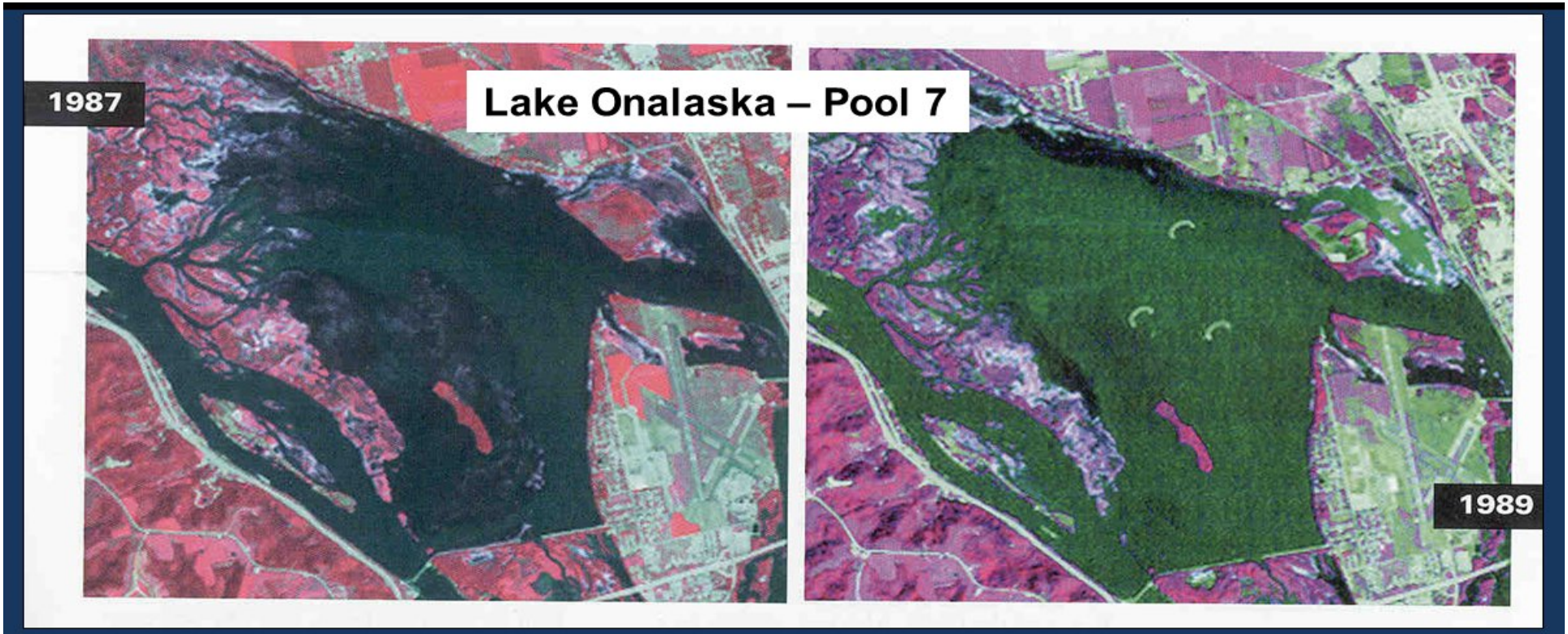

Minnesota R.
St. Croix R.
Chippewa R.
Total Nitrogen (mg/L)
0
2
4
6
8
10
850
800
750
700
River Mile

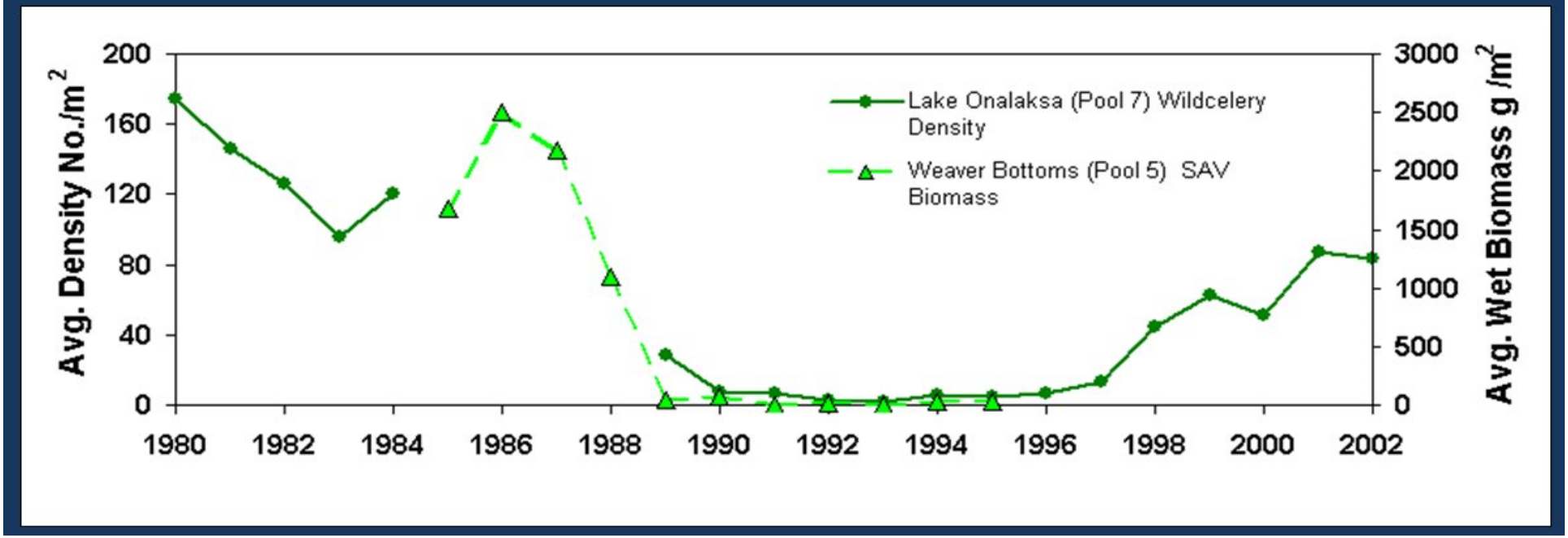
Mississippi River Downstream of Lake Pepin
Last 30 years



Turbid/Unvegetated

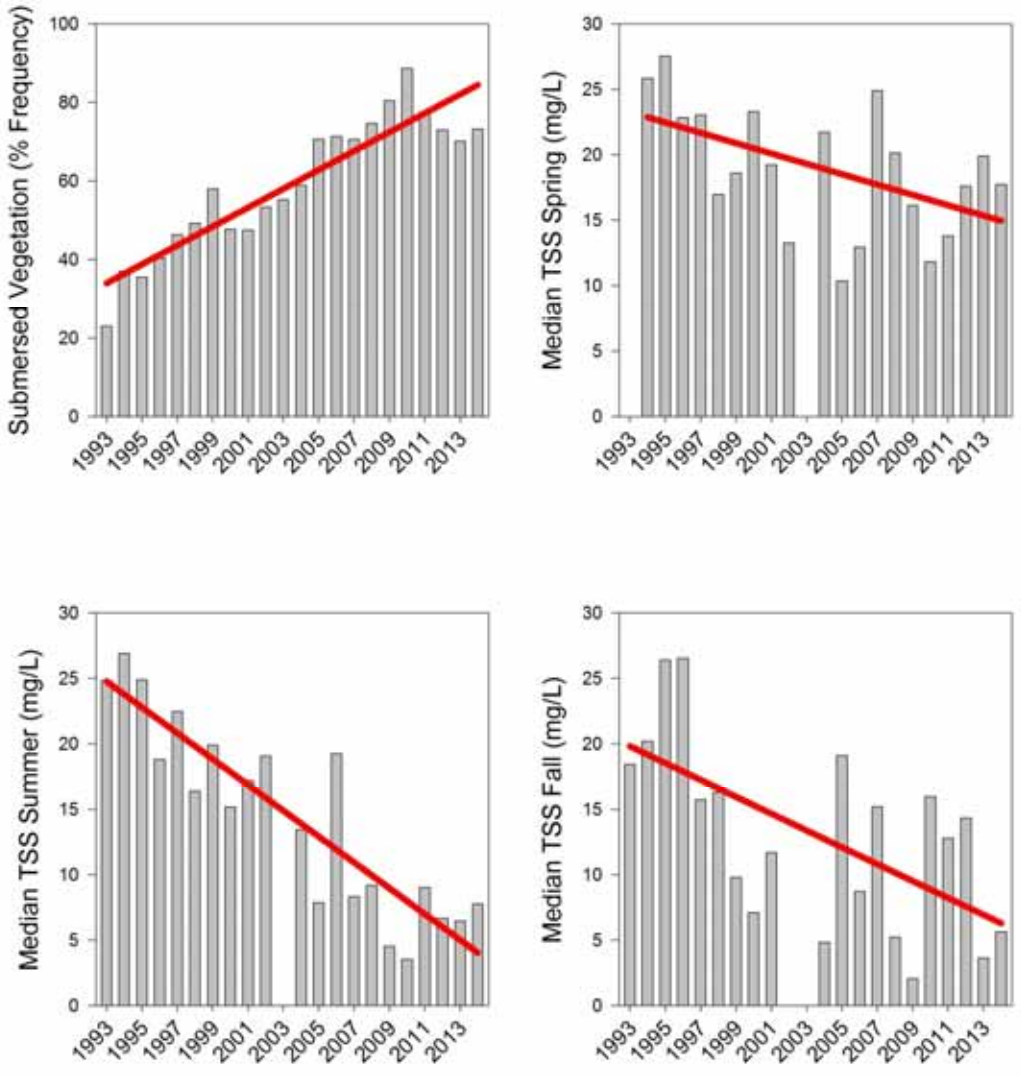
Clear/Vegetated


1987
Lake Onalaska – Pool 7
1989


Avg. Density No./m2
Avg. Wet Biomass g /m2
Lake Onalaksa (Pool 7) Wildcelery Density
Weaver Bottoms (Pool 5) SAV Biomass
0
40
80
120
160
200
0
500
1000
1500
2000
2500
3000
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

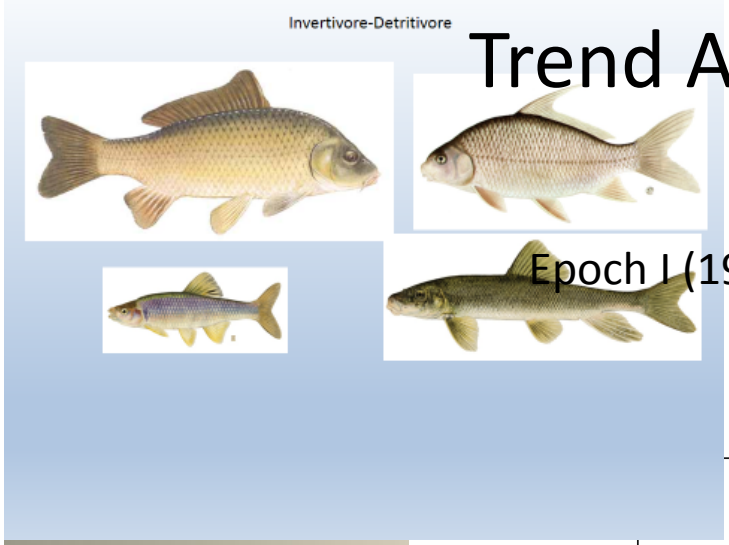
Pool 7 (UMR)
Brice Prairie, WI
June, 1988

Long Term Resource Monitoring Data
Pool 8- near La Crosse, WI
1993-2014

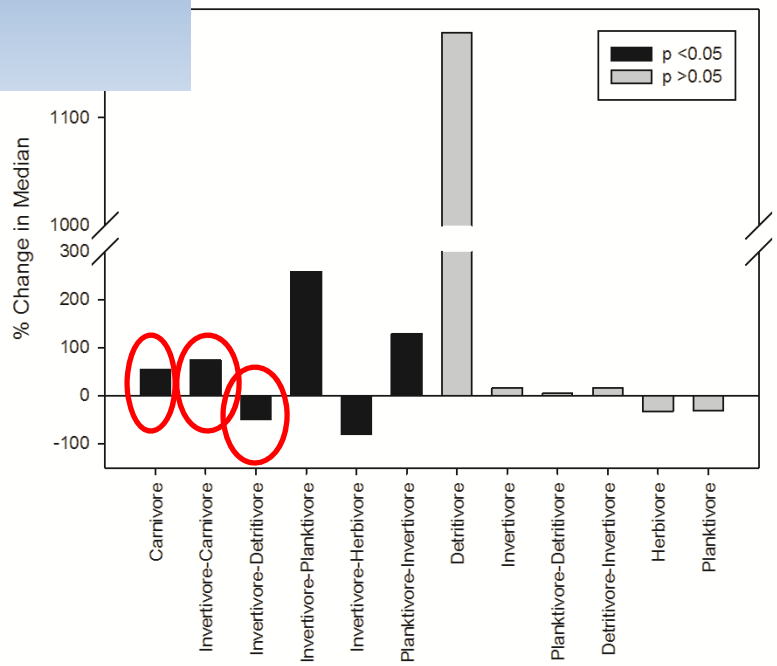


Past ~20 years- rooted aquatic vegetation and water clarity have increased significantly.

Trend Analysis- Fish Feeding Groups

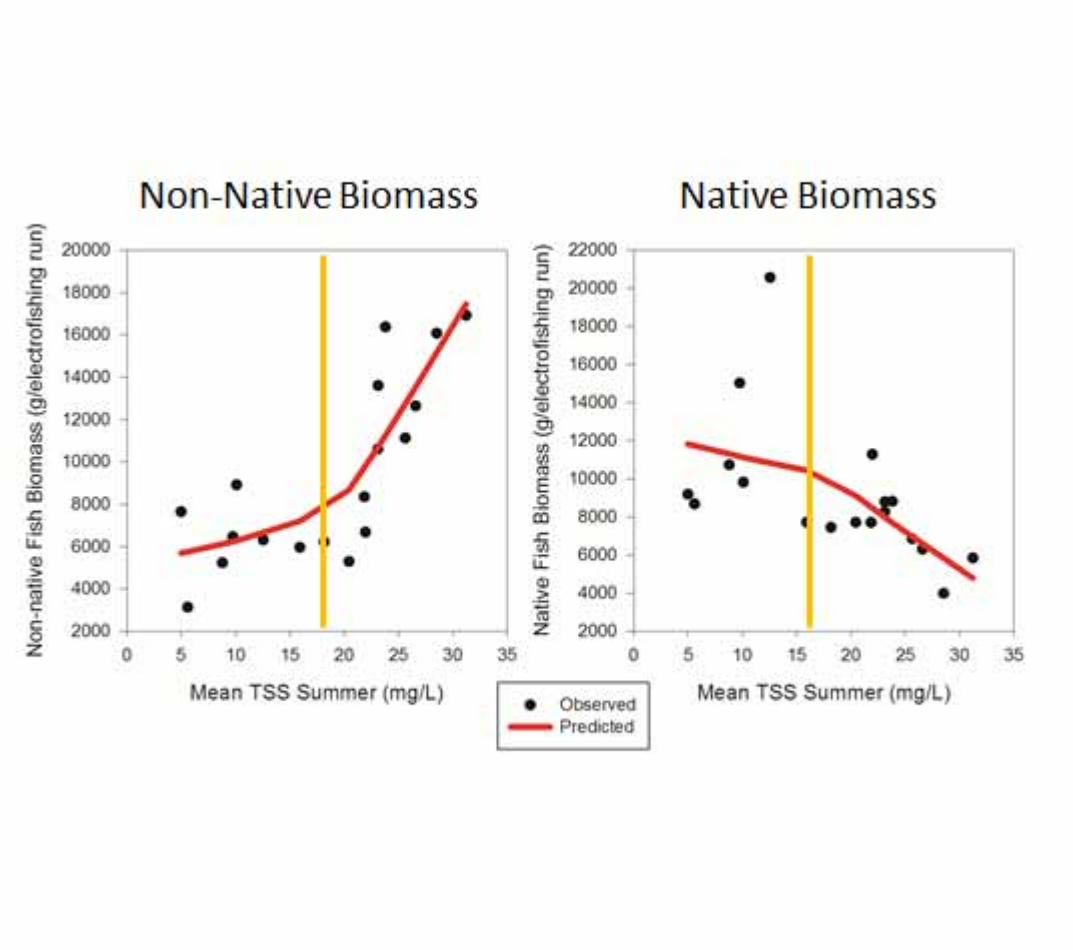


Epoch I (1993-2001) vs. Epoch II (2002-2011)



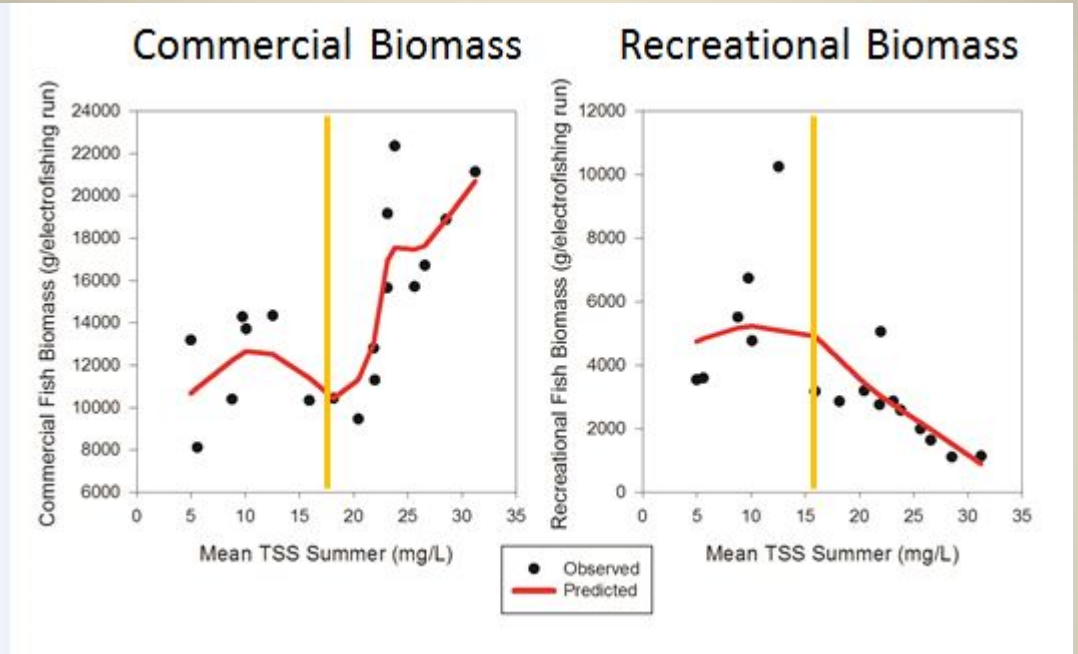
We now have a river with more top predators and less common carp

Threshold Analysis for Key Environmental Variables



Better Water Clarity = More Native Fish, Less Non-Native Fish

Threshold Analysis for Key Environmental Variables

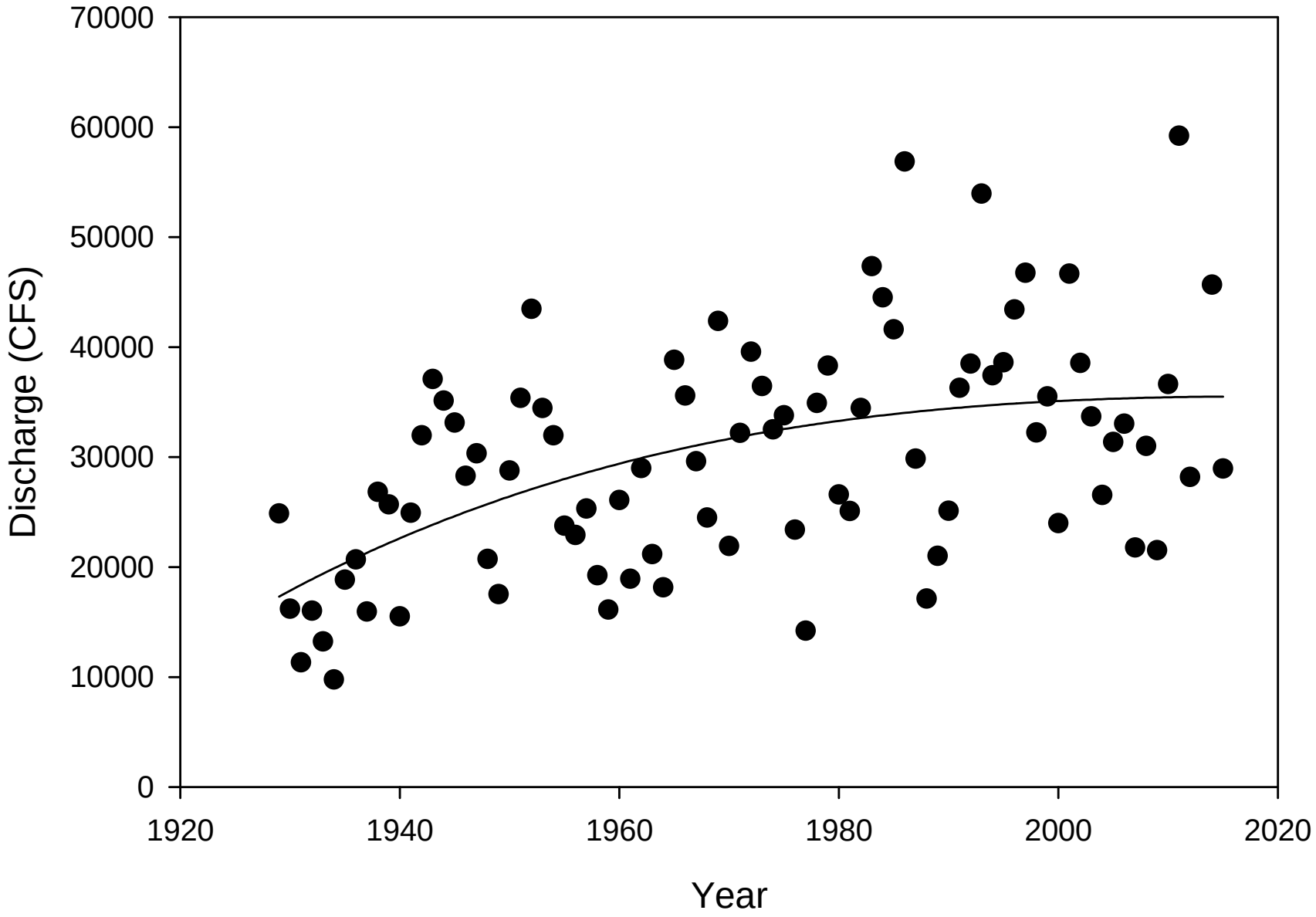


Better Water Clarity = More Fish We Like to Catch

Economic impact of improved water quality
(national bass tournaments, increased tourism…)

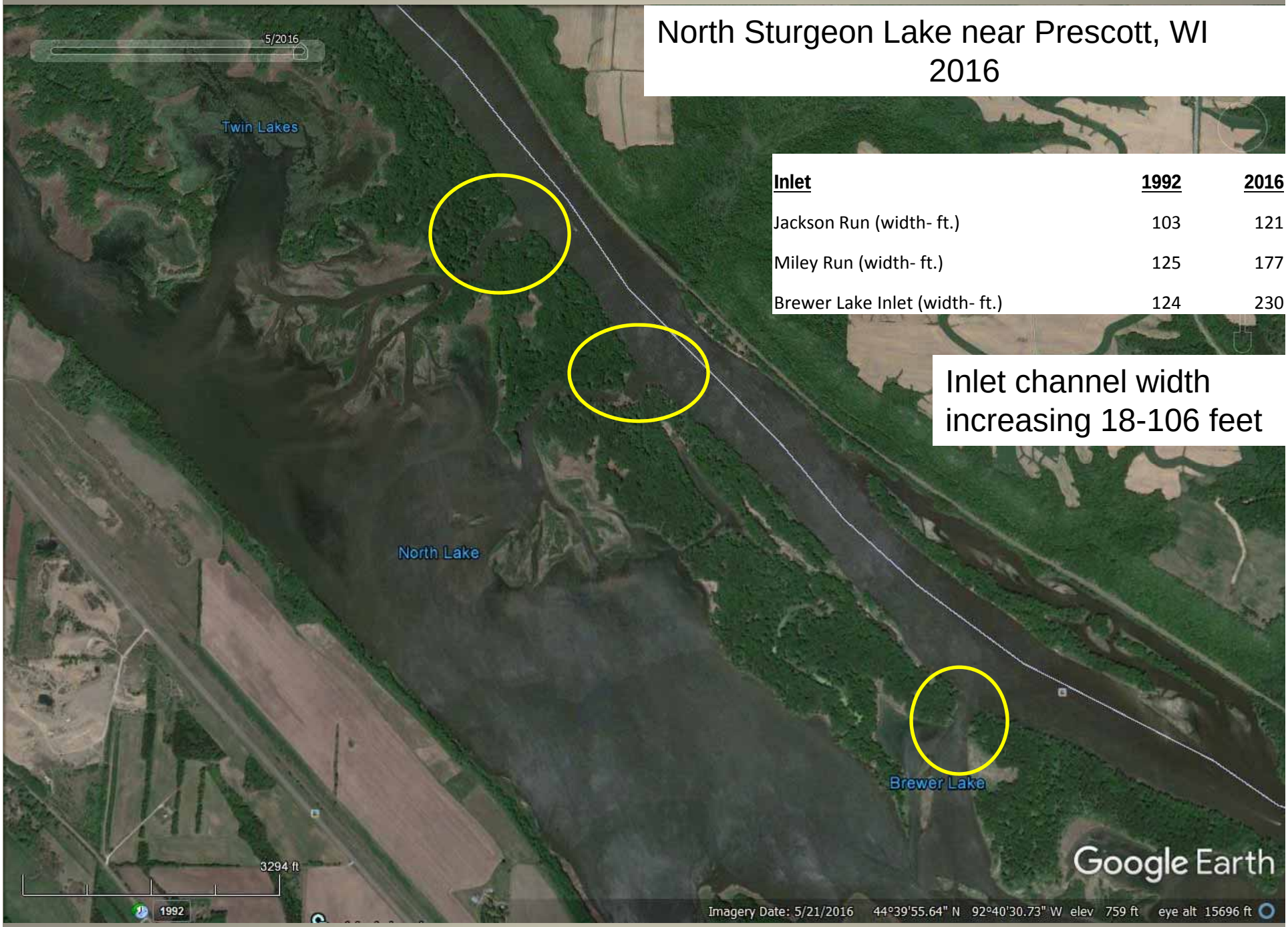
Mean Annual Discharge Mississippi River at Winona, MN 1928-2015

Water Quantity



North Sturgeon Lake near Prescott, WI
1992

North Sturgeon Lake near Prescott, WI 2016

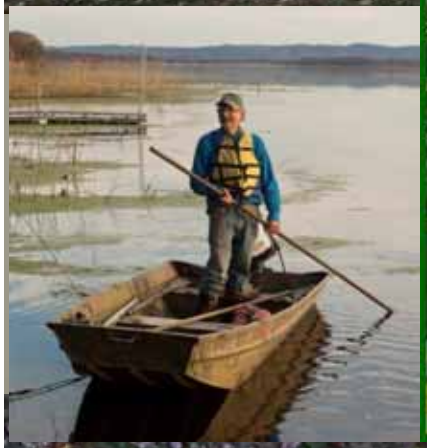


Inlet	1992	2016
Jackson Run (width- ft.)	103	121
Miley Run (width- ft.)	125	177
Brewer Lake Inlet (width- ft.)	124	230

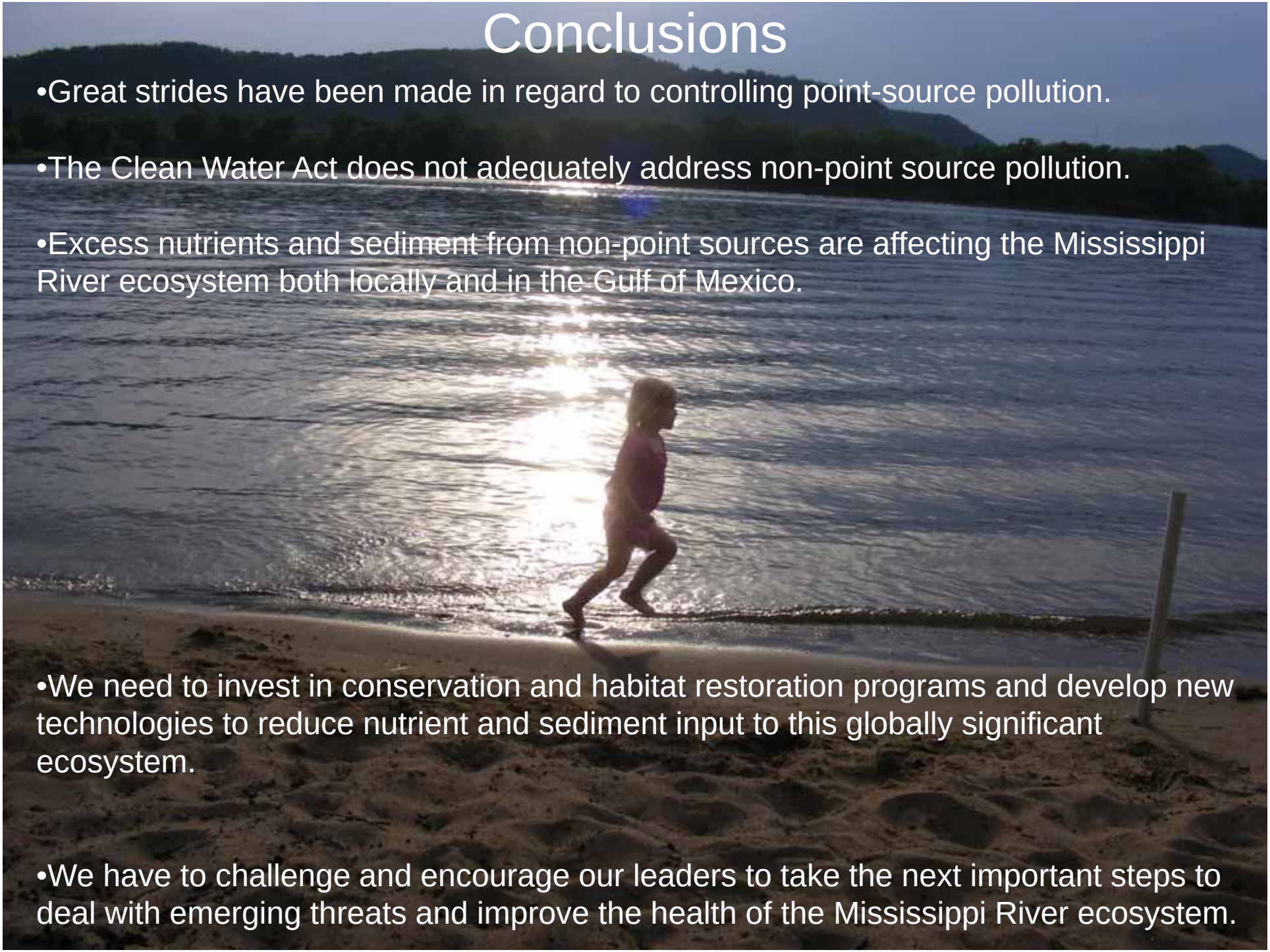
Inlet channel width increasing 18-106 feet

Lake Onalaska Water Lettuce/ Water Hyacinth Invasion October 2015


Water lettuce found on Lake Onalaska; volunteers sought for Sunday harvest



Conclusions



•Great strides have been made in regard to controlling point-source pollution.

•The Clean Water Act does not adequately address non-point source pollution.

•Excess nutrients and sediment from non-point sources are affecting the Mississippi River ecosystem both locally and in the Gulf of Mexico.

•We need to invest in conservation and habitat restoration programs and develop new technologies to reduce nutrient and sediment input to this globally significant ecosystem.

•We have to challenge and encourage our leaders to take the next important steps to deal with emerging threats and improve the health of the Mississippi River ecosystem.

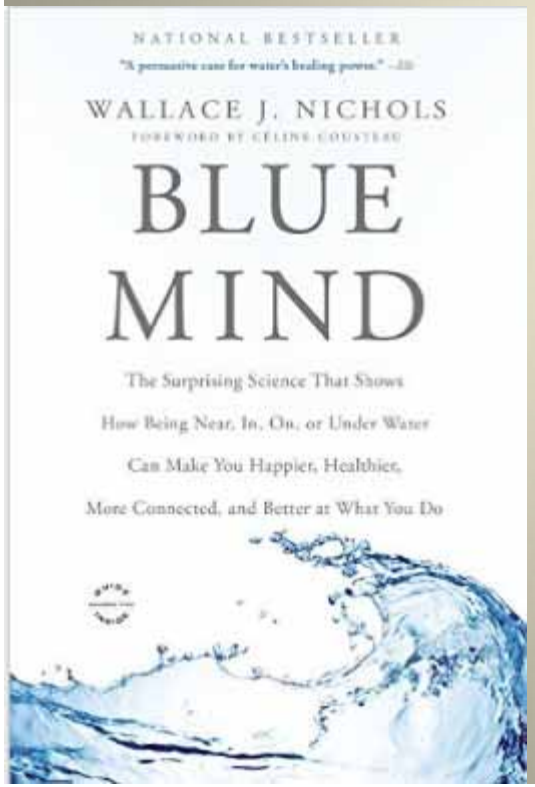
“We would accomplish many more things if we didn’t think of them as impossible.” - Vince Lombardi

Enjoying the Mississippi River

Wallace J. Nichols
closing of Blue Mind

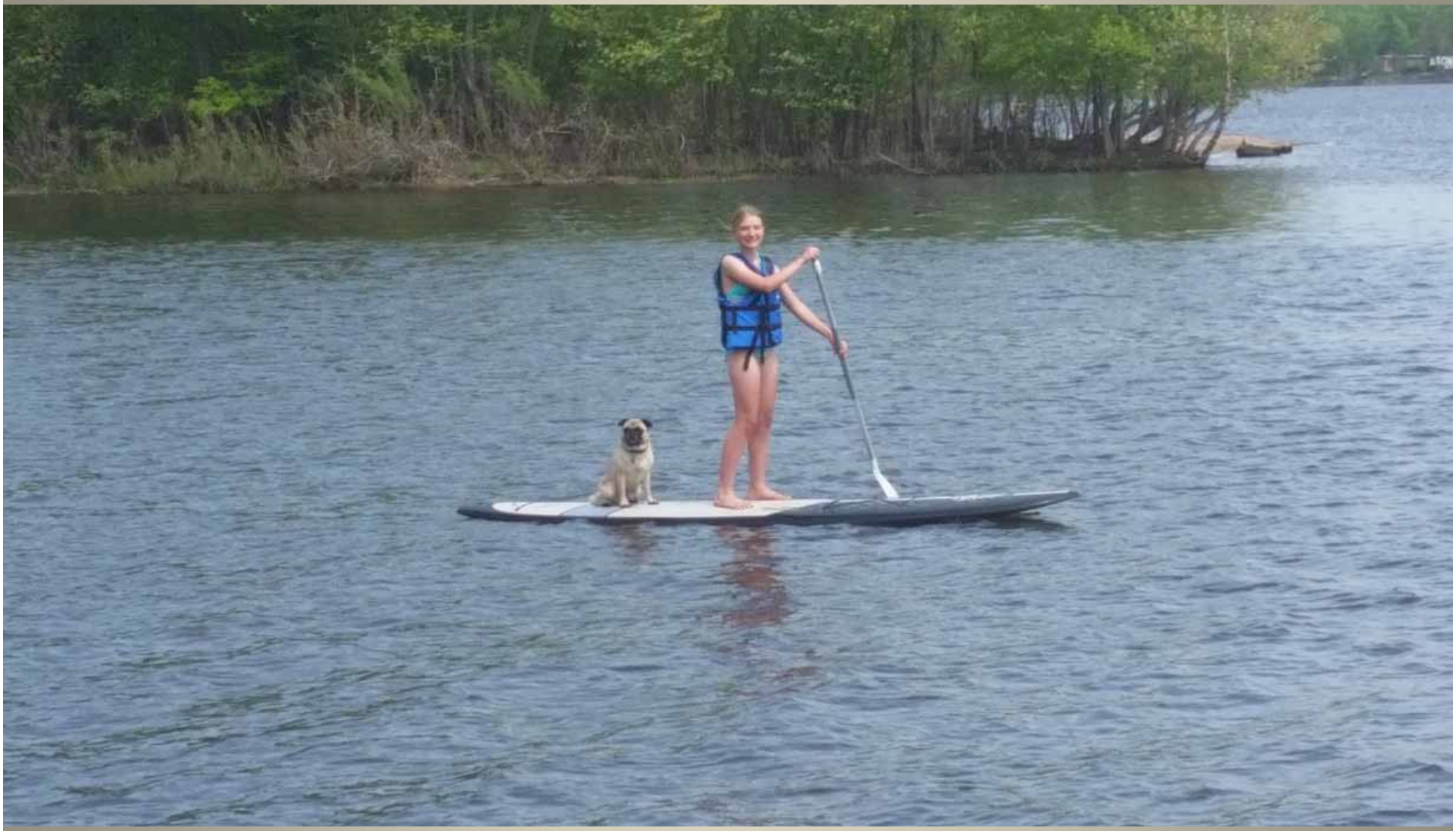
All I really want to say is this:

Get in the water.



Walk along the water.

Move across its surface.



Get under it. Sit in it.

Leap into it. Touch the water. Close your eyes and drink a big glass.

Fall more deeply in love with water in all its shapes, colors, and forms.

Let it heal you and make you a better,
stronger version of yourself.

You need water.

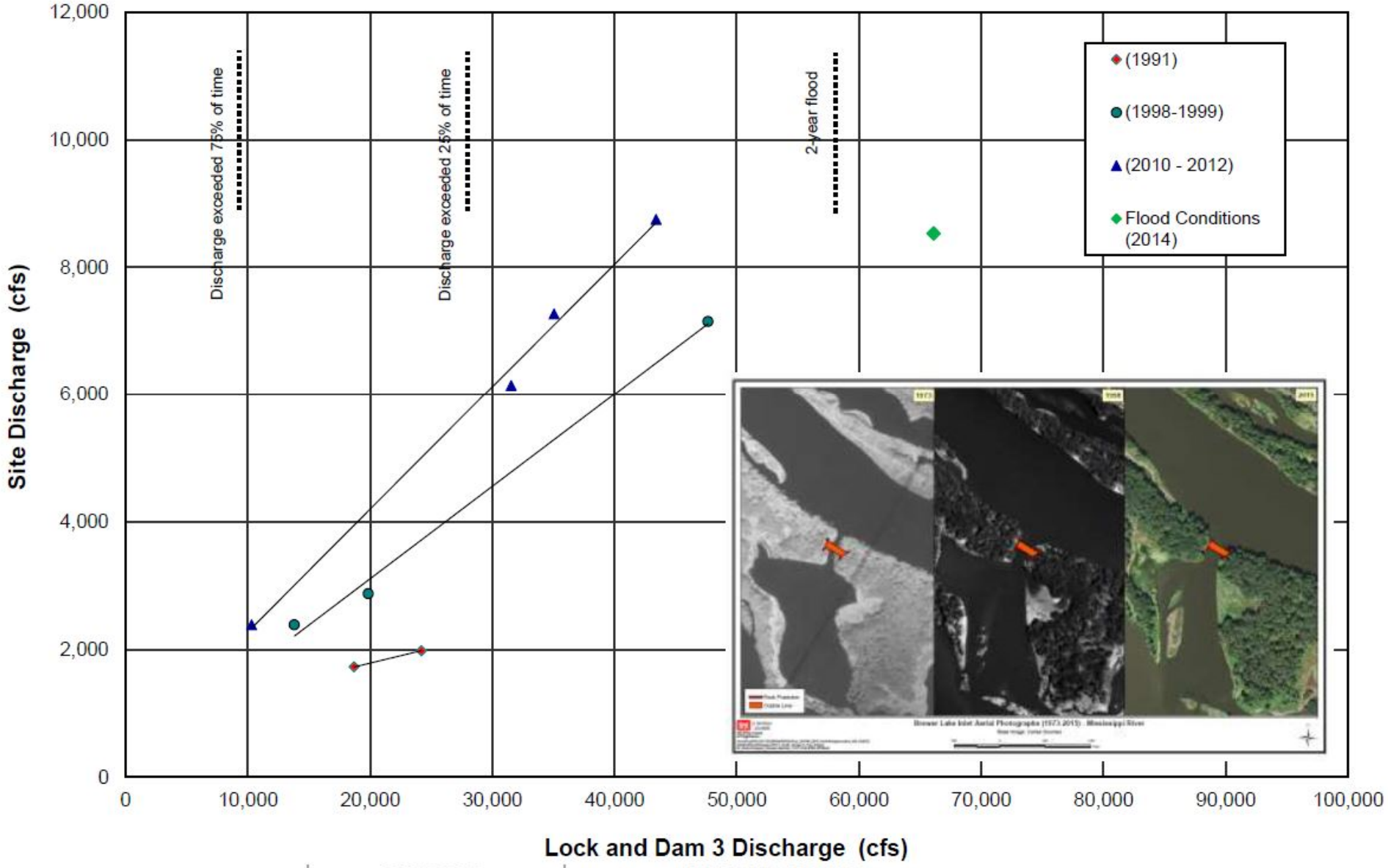
And water needs you now.

I wish you water.

Wallace J. Nichols
closing of Blue Mind


Questions?

Mississippi River - Pool 3
RM 801.70 SW (800') - Brewer Lake Inlet



John Hendrickson- USACE

Final Yogism- It gets late early out here.

Questions?

Here is your country. Cherish these natural wonders, cherish the natural resources, cherish the history and romance as a sacred heritage, for your children and your children's children. Do not let selfish men or greedy interests skin your country of its beauty, its riches or its romance.

— Theodore Roosevelt —

AZ QUOTES

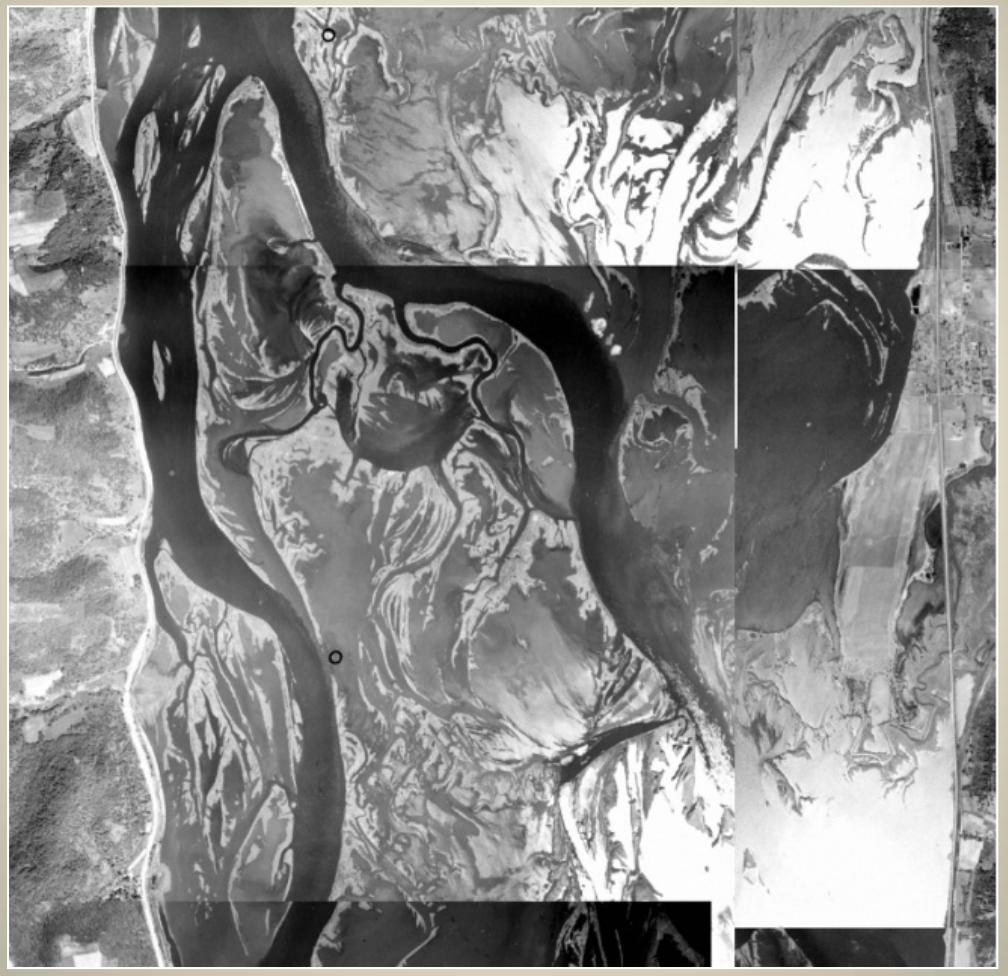
Prediction is hard, especially about the future. - Yogi Berra
Final Yogism

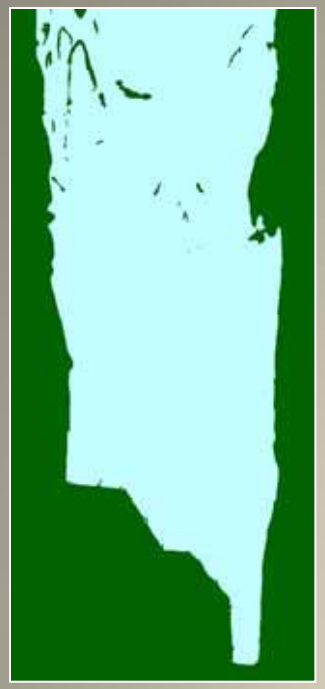
Habitat Loss in Lower Pool 8

1930

Habitat Loss in Lower Pool 8

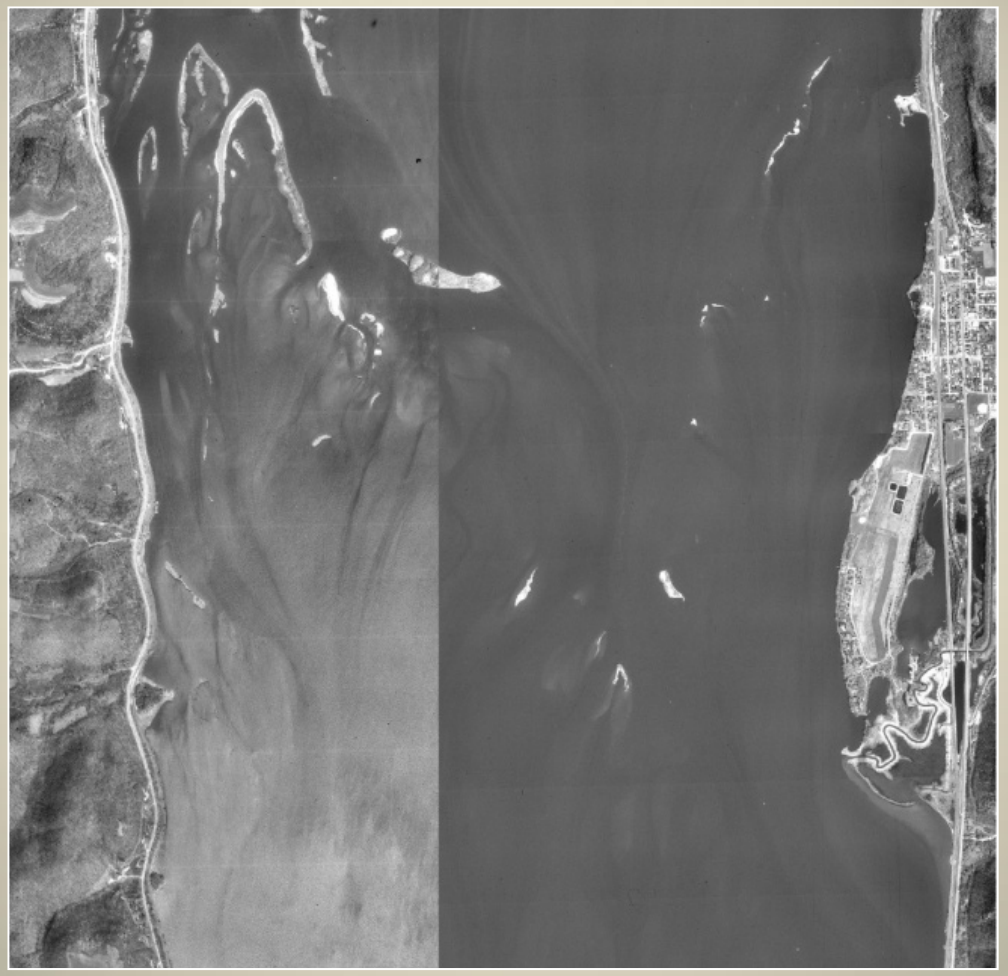
1938

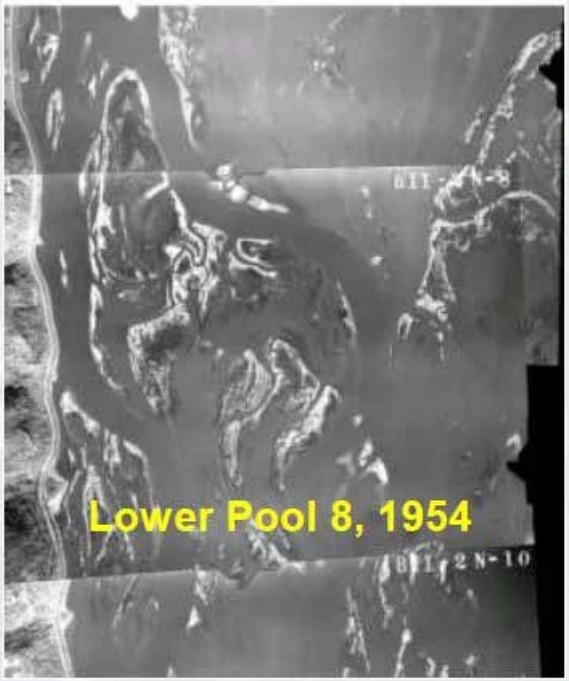


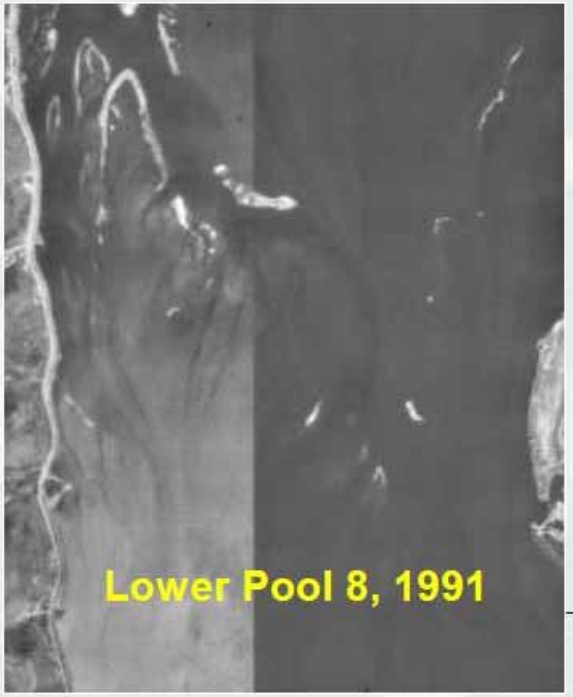


Habitat Loss in Lower Pool 8

1991

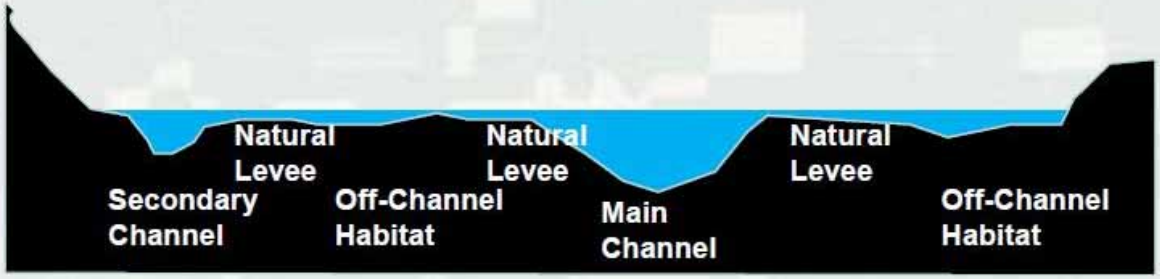






Geomorphic Response

The backwaters became a very efficient flow path resulting in secondary channel erosion

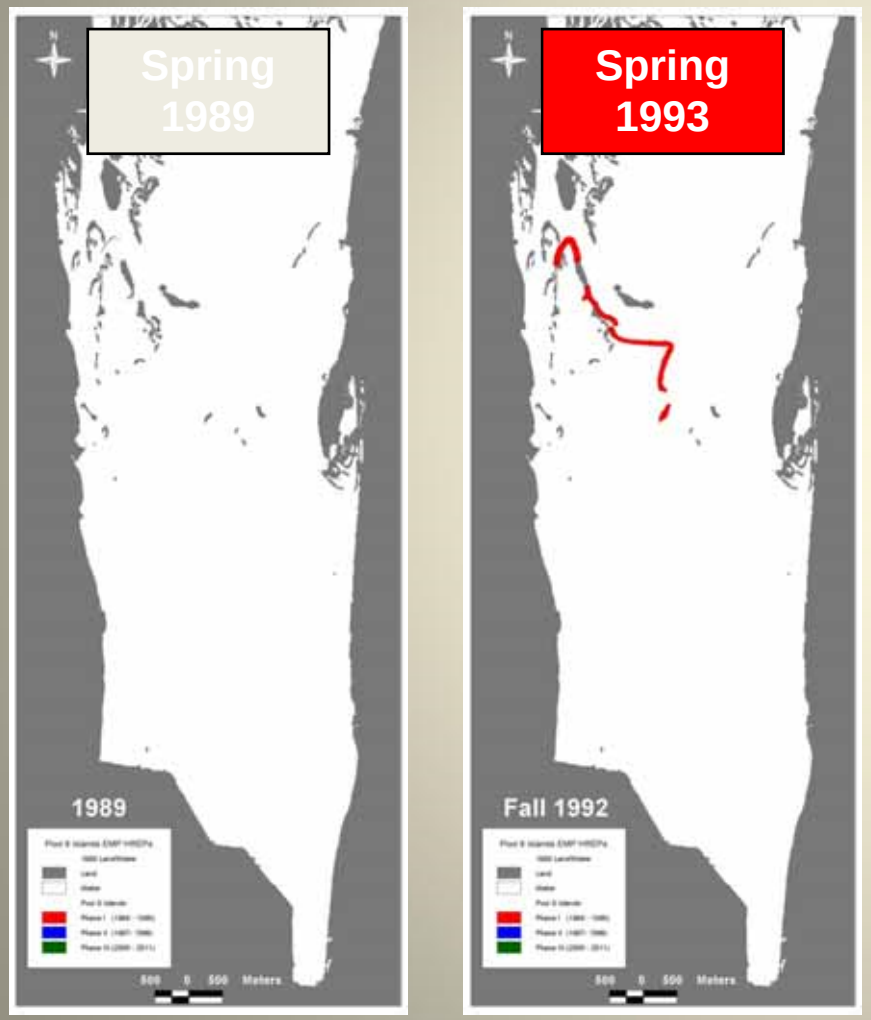


BUILDING STRONG®

John Hendrickson- USACE

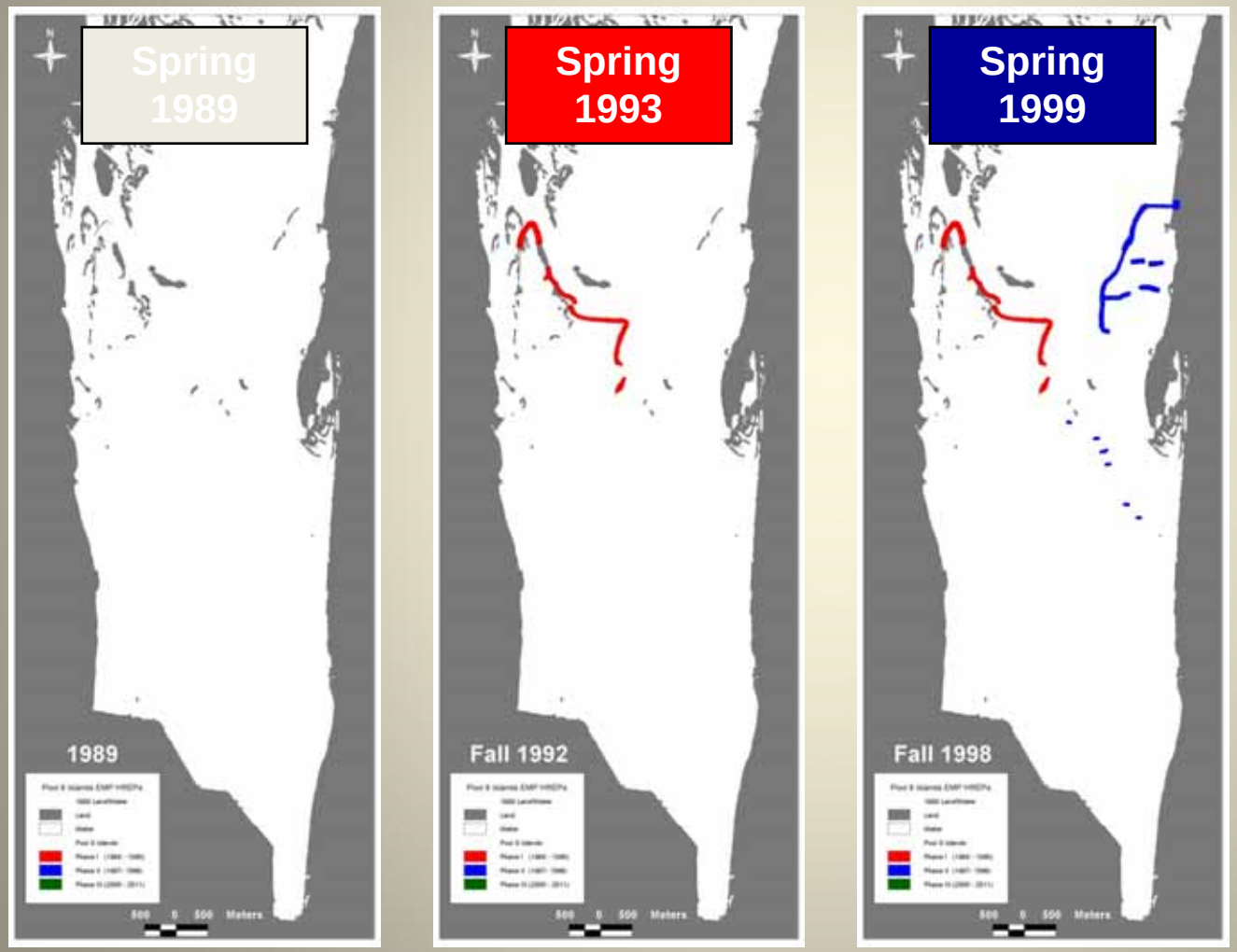
Island Restoration
Upper Mississippi River - Lower Pool 8

Pre Project **Phase I**



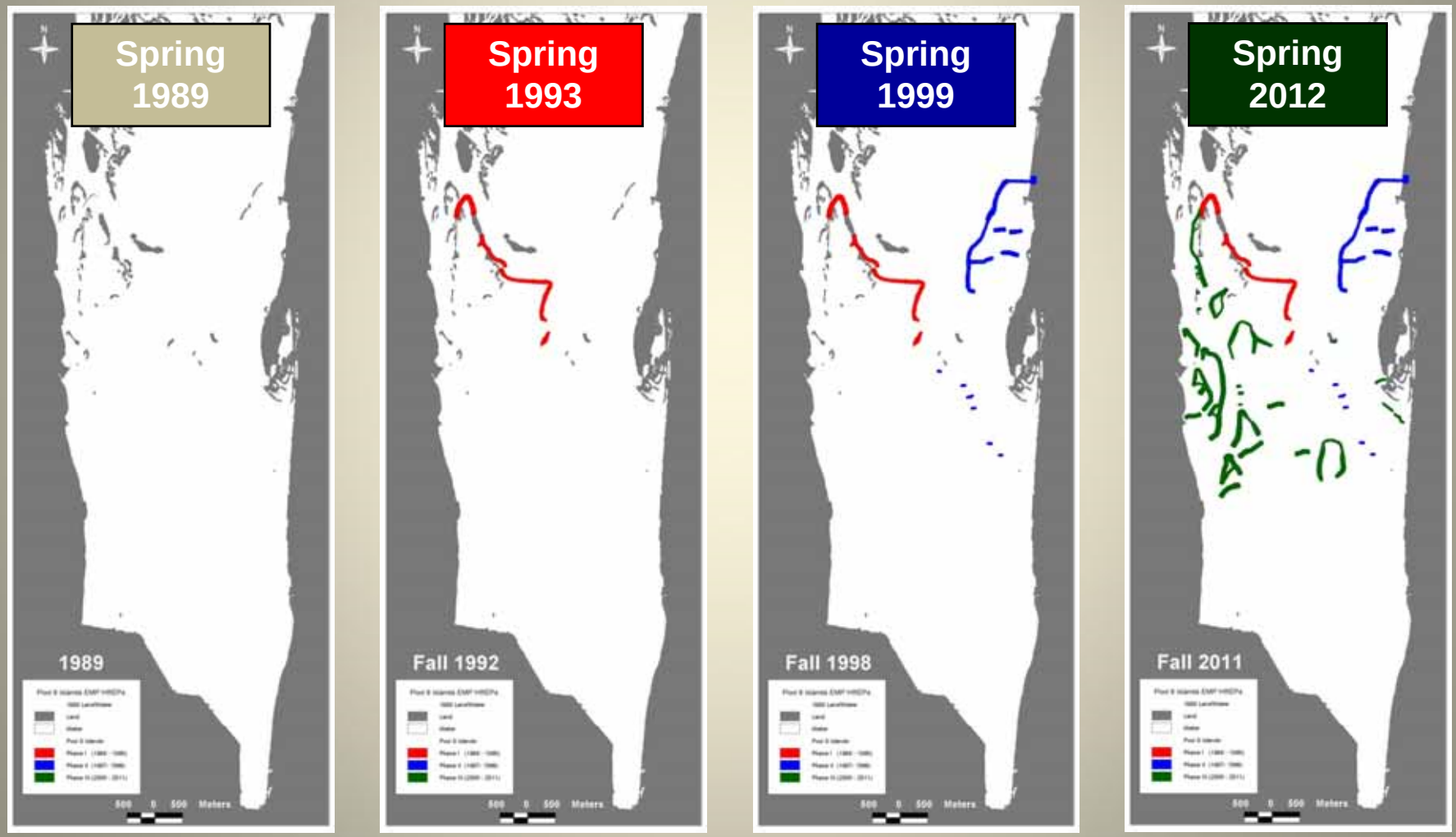
Island Restoration
Upper Mississippi River - Lower Pool 8

Pre Project | **Phase I** | **Phase II**



Island Restoration
Upper Mississippi River - Lower Pool 8

Pre Project | Phase I | Phase II | Phase III



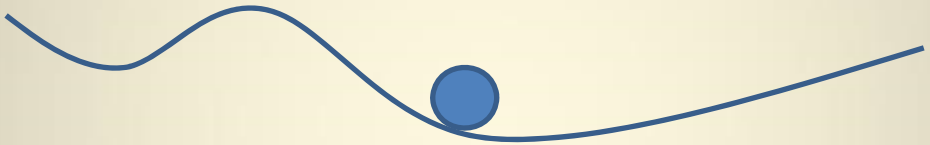
Emerging Threats
Pool 11- near Potosi, WI (February 2015)

Alma, WI
November 2015

Pool 8- near La Crosse, WI
January 27, 2016

Pool 9- near Ferryville, WI
September 2016

The Concept of Alternative Stable States



Turbid/Unvegetated

Increased wind resuspension

Increased algal abundance

Decreased refuge for zooplankton

Increase in benthivorous fish (e.g. common carp)

Reduction in visual feeding top predators (e.g. northern pike)

Clear/Vegetated

Decreased wind resuspension

Decresed algae (allelopathy + sinking in plant beds)

Increased refuge for zooplankton

Decrease in benthivorous fish

Increase in top predators (trophic cascade)

Increase in denitrification within plant beds

Examples of Alternative Stable States

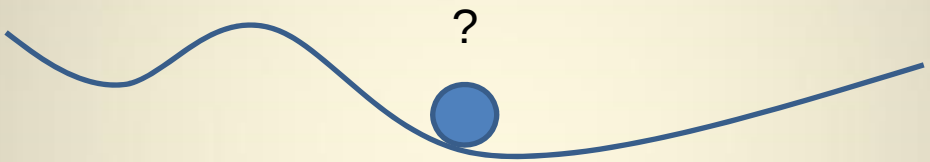
Lakes

- Lake Apopka (FL, USA)
- Lake Tämnaren (Sweden)
- Rice Lake (WI, USA)
- Lake Ellesmere (New Zealand)
- Linford Lakes (England)

Rivers

- River Krutynia (Poland)
- Illinois River (IL, USA)
- River Spree (Germany)
- Flathead River (MT, USA)
- Upper Mississippi River (USA)

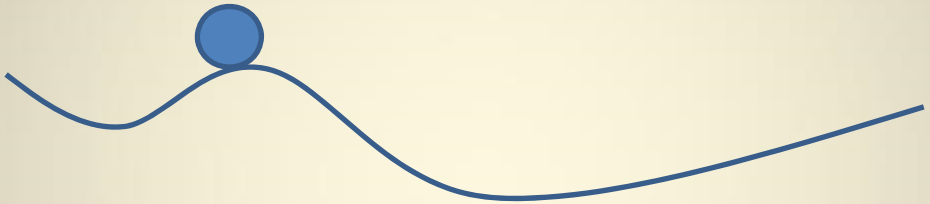
1988 – No plant data collected through LTRM Program



Turbid/Unvegetated Clear/Vegetated

1989 – Five transects across the entire pool

at river miles: M682.5 (1%), M685.5 (18%), M691.1 (33%), M693.7 (30%), and M701.1 (10%)*

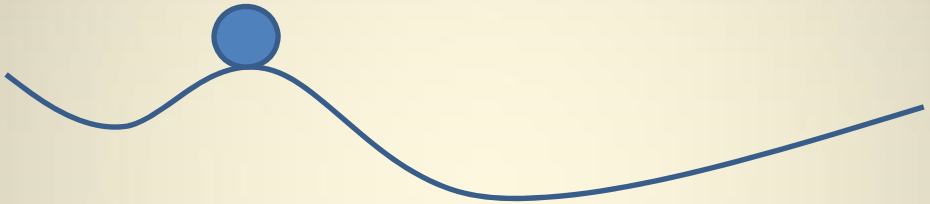


Turbid/Unvegetated Clear/Vegetated

*Percent of submersed aquatics estimated from figure in report “A qualitative analysis of five vegetation belt transects
Collected a peak biomass, 7 August to 11 August, 1989, for the Upper Mississippi River Pool 8” by G. Benjamin.

1990 – Five spring transects across the entire pool

at river miles: M682.5 (n=2)*, M685.5 (57%; n=7), M691.1 (33%; n=21), M693.7 (40%; n=15), and M701.1 (0%; n=7)



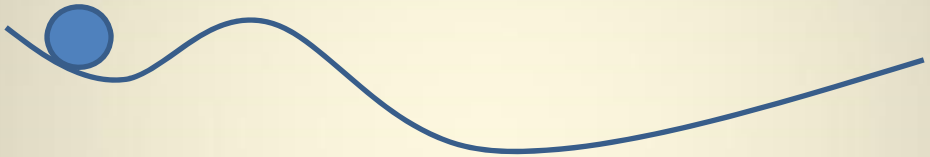
Turbid/Unvegetated Clear/Vegetated

*Transect data collected in May 1990; M682.5 – observers described aquatic veg between Minnesota shore and raft channel, the rest of the transect had no aquatic plants

1991 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years

19 beds



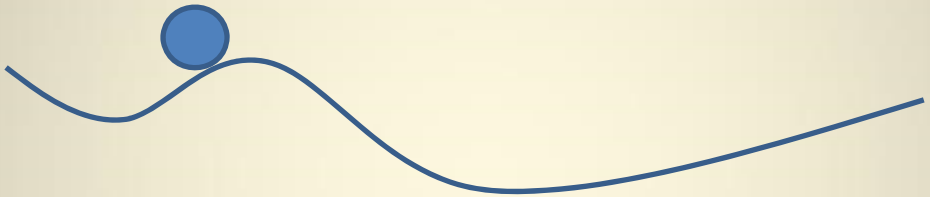
Turbid/Unvegetated

Clear/Vegetated

1992 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years

58 beds



Turbid/Unvegetated

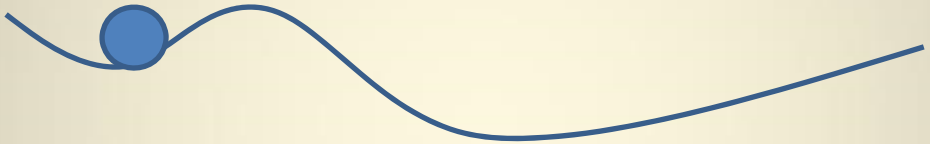
Clear/Vegetated

1993 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years

Summer flood

31 beds



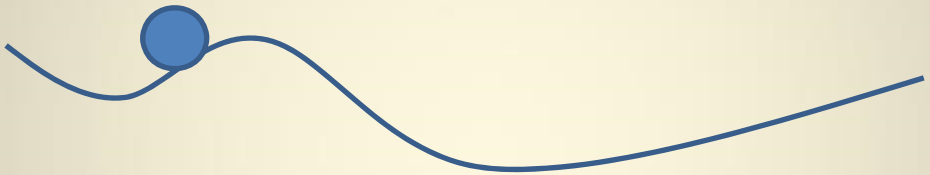
Turbid/Unvegetated

Clear/Vegetated

1994 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years

46 beds

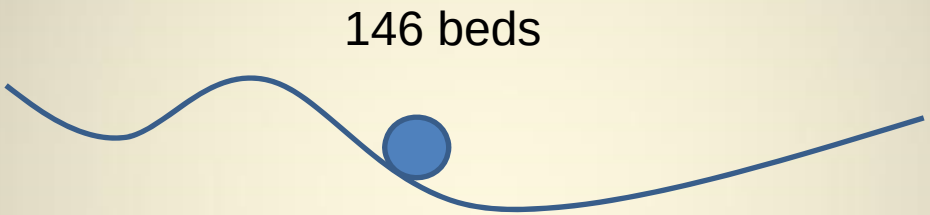


Turbid/Unvegetated

Clear/Vegetated

1995 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years



Turbid/Unvegetated

Clear/Vegetated

1996 – LTRM Informal Vegetation Survey of Pool 8

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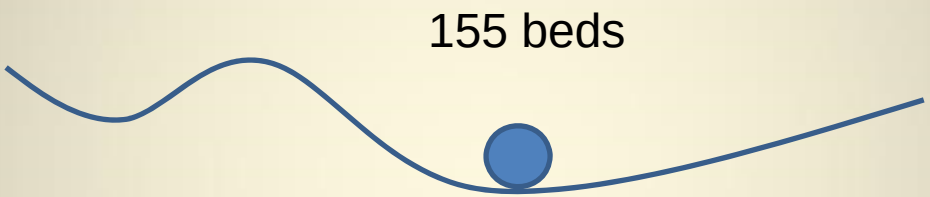
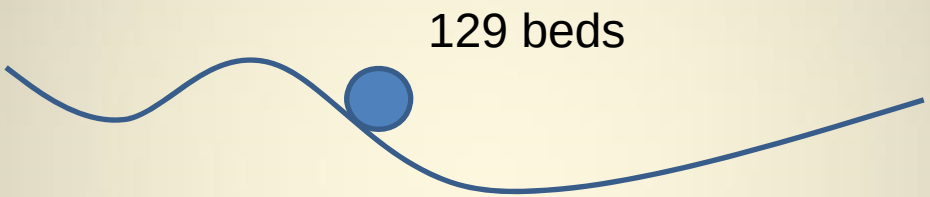


Turbid/Unvegetated

Clear/Vegetated

1997 – LTRM Informal Vegetation Survey of Pool 8

Only included beds at least 10 meters long or wide – same observer in all years

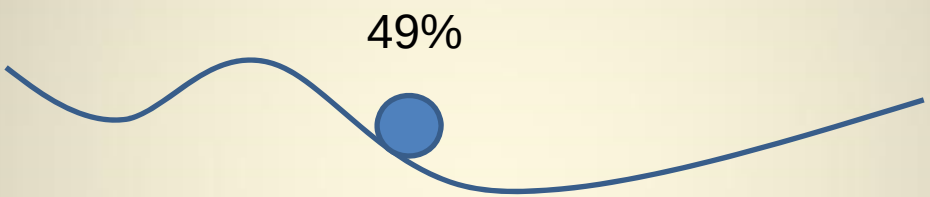


Turbid/Unvegetated

Clear/Vegetated

1998 – LTRM SRS Vegetation Survey of Pool 8

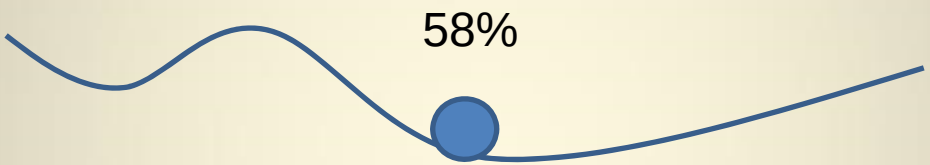
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

1999 – LTRM SRS Vegetation Survey of Pool 8

Percent frequency of submersed vegetation from graphical browser

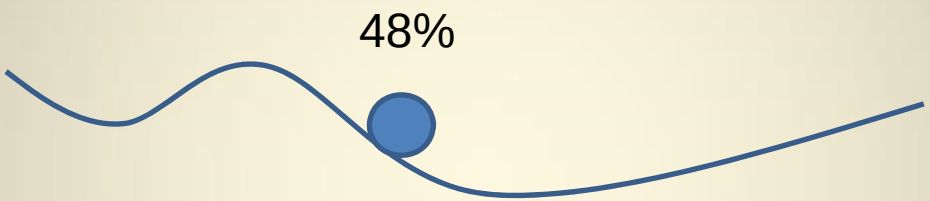


Turbid/Unvegetated

Clear/Vegetated

2000 – LTRM SRS Vegetation Survey of Pool 8

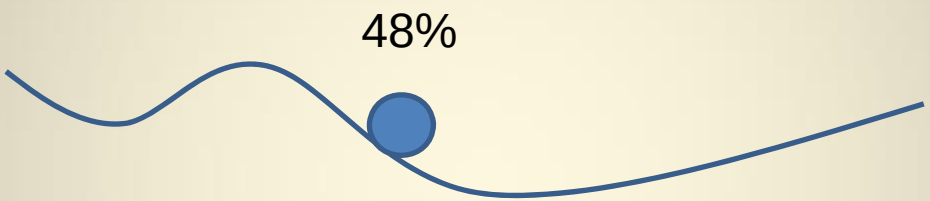
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2001 – LTRM SRS Vegetation Survey of Pool 8

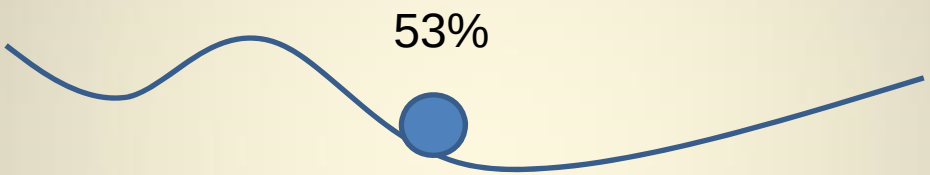
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2002 – LTRM SRS Vegetation Survey of Pool 8

Percent frequency of submersed vegetation from graphical browser

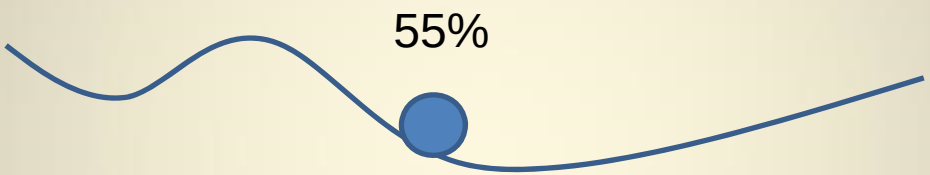


Turbid/Unvegetated

Clear/Vegetated

2003 – LTRM SRS Vegetation Survey of Pool 8

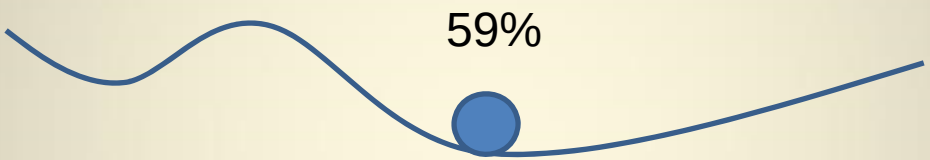
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2004 – LTRM SRS Vegetation Survey of Pool 8

Percent frequency of submersed vegetation from graphical browser

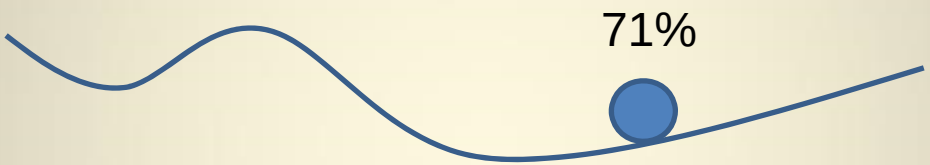


Turbid/Unvegetated

Clear/Vegetated

2005 – LTRM SRS Vegetation Survey of Pool 8

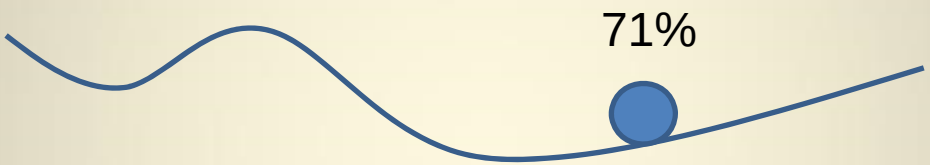
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2006 – LTRM SRS Vegetation Survey of Pool 8

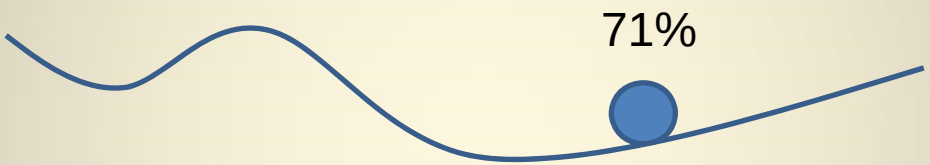
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2007 – LTRM SRS Vegetation Survey of Pool 8

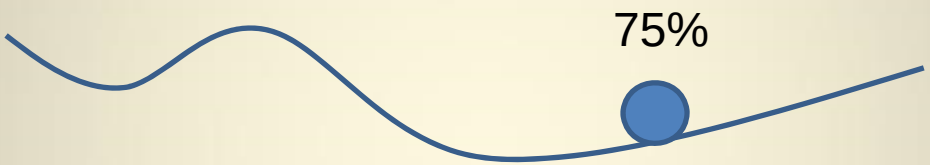
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2008 – LTRM SRS Vegetation Survey of Pool 8

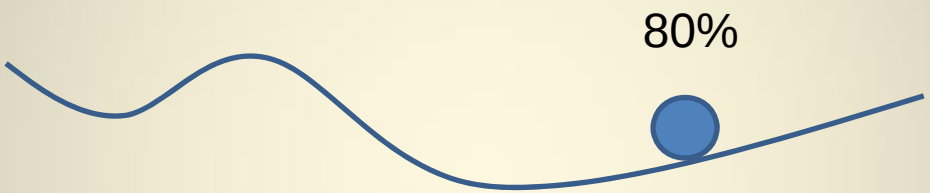
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2009 – LTRM SRS Vegetation Survey of Pool 8

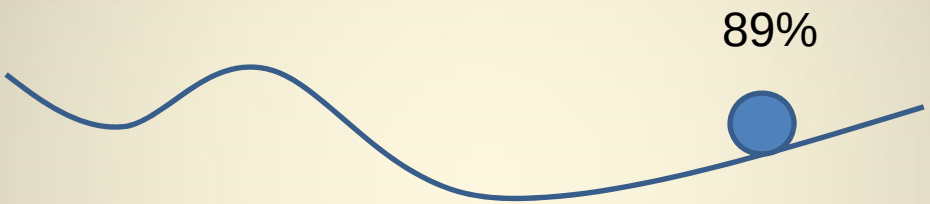
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2010 – LTRM SRS Vegetation Survey of Pool 8

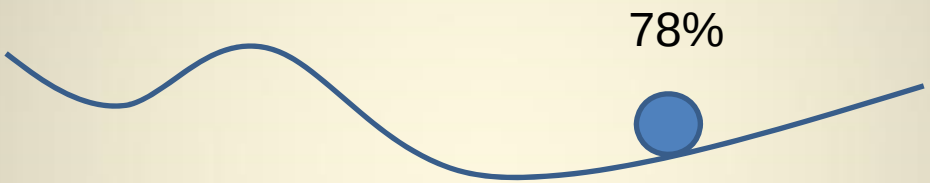
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2011 – LTRM SRS Vegetation Survey of Pool 8

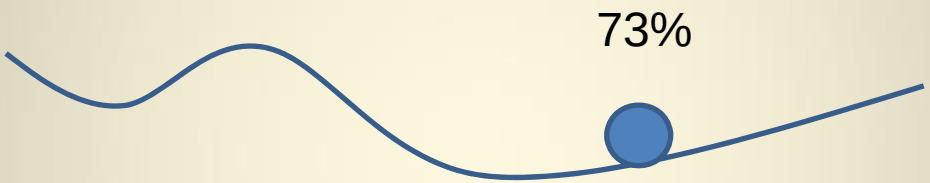
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2012 – LTRM SRS Vegetation Survey of Pool 8

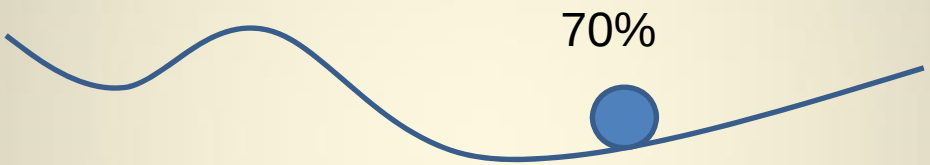
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2013 – LTRM SRS Vegetation Survey of Pool 8

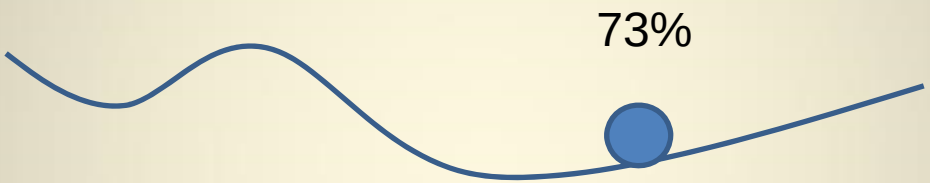
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2014 – LTRM SRS Vegetation Survey of Pool 8

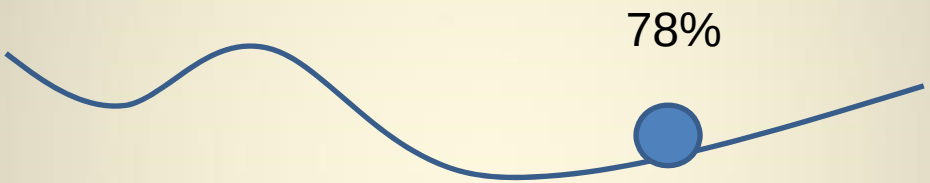
Percent frequency of submersed vegetation from graphical browser



Turbid/Unvegetated Clear/Vegetated

2015 – LTRM SRS Vegetation Survey of Pool 8

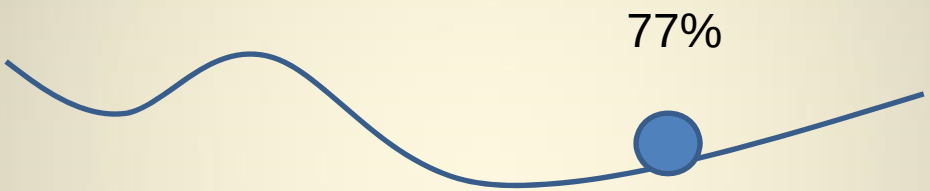
Percent frequency of submersed vegetation from graphical browser



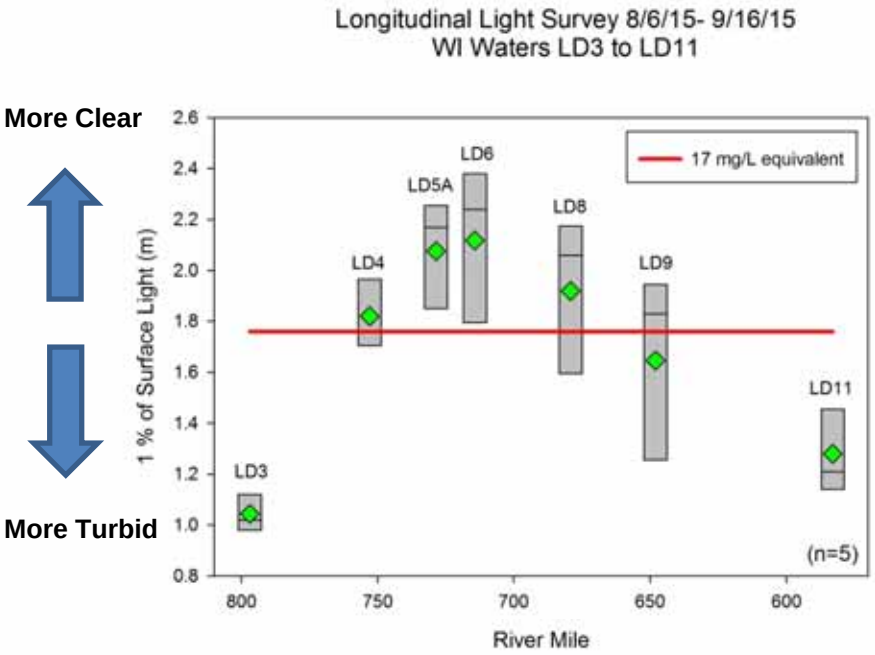
Turbid/Unvegetated Clear/Vegetated

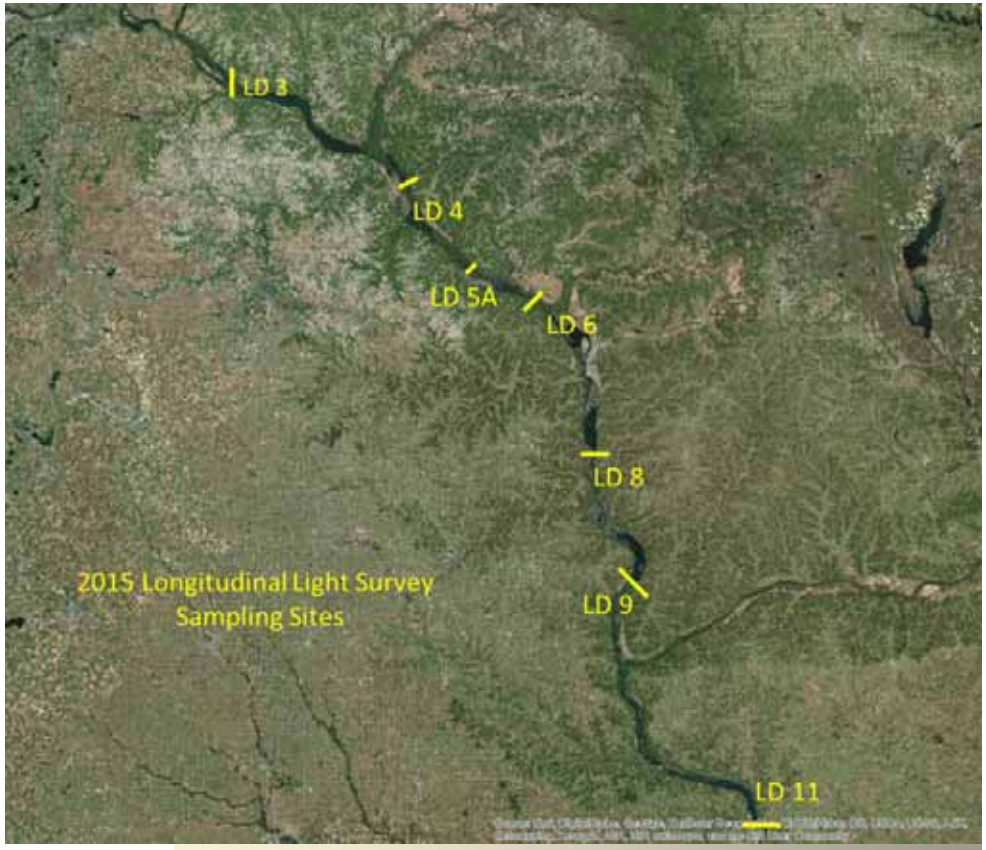
2016 – LTRM SRS Vegetation Survey of Pool 8

Percent frequency of submersed vegetation from graphical browser



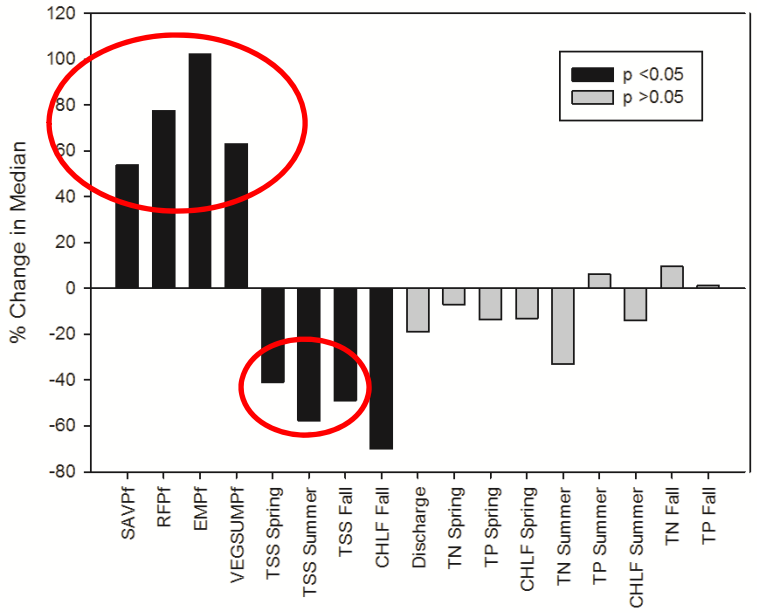
Turbid/Unvegetated Clear/Vegetated


Longitudinal Light Survey 8/6/15- 9/16/15
WI Waters LD3 to LD11
More Clear
More Turbid
1 % of Surface Light (m)
River Mile
17 mg/L equivalent
LD3
LD4
LD5A
LD6
LD8
LD9
LD11
(n=5)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
800
750
700
650
600

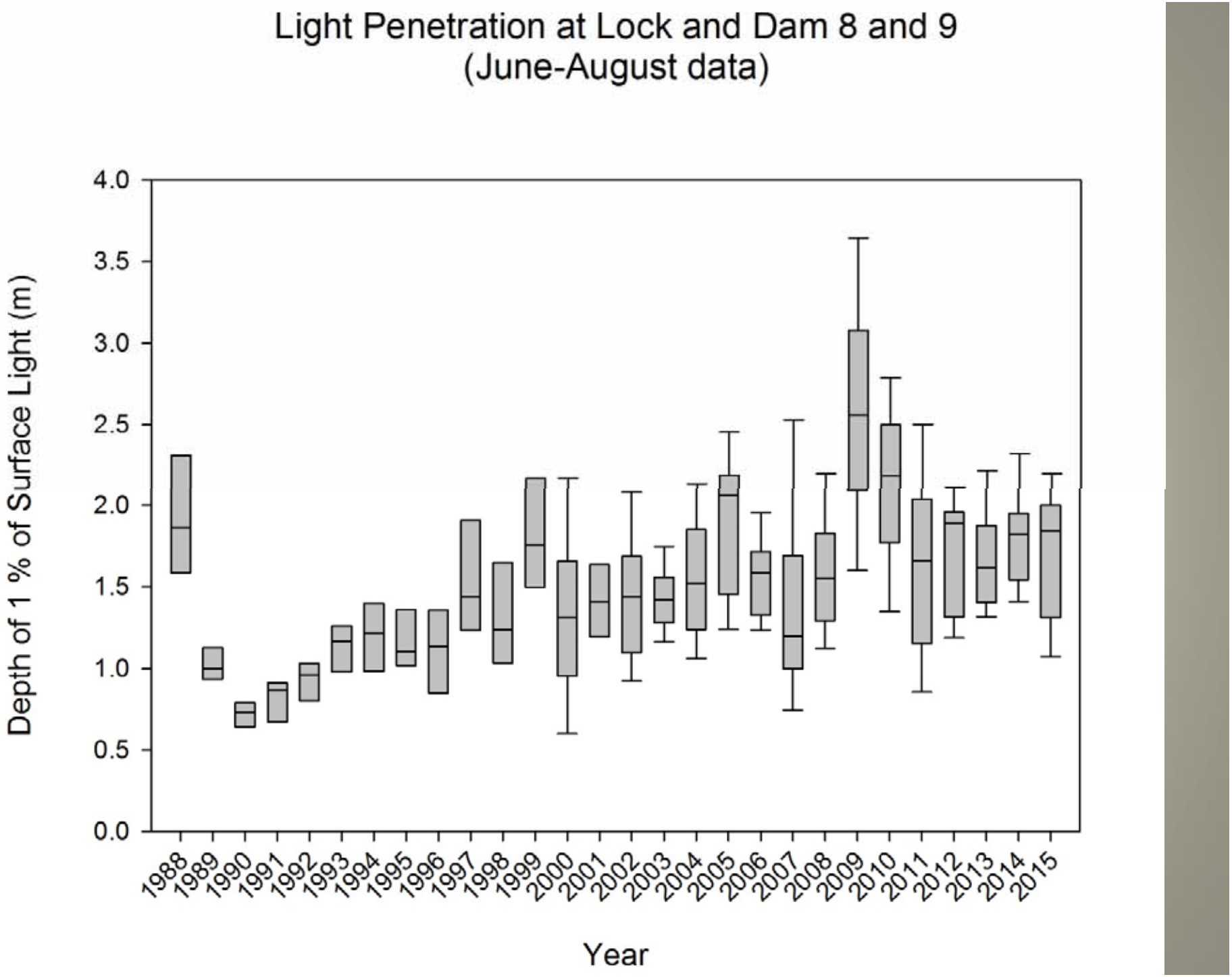

LD 3
LD 4
LD 5A
LD 6
LD 8
LD 9
LD 11
2015 Longitudinal Light Survey
Sampling Sites

Trend Analysis- Total Suspended Solids and Aquatic Vegetation

Epoch I (1993-2001) vs. Epoch II (2002-2011)



Past ~20 years- rooted aquatic vegetation and water clarity have increased significantly.

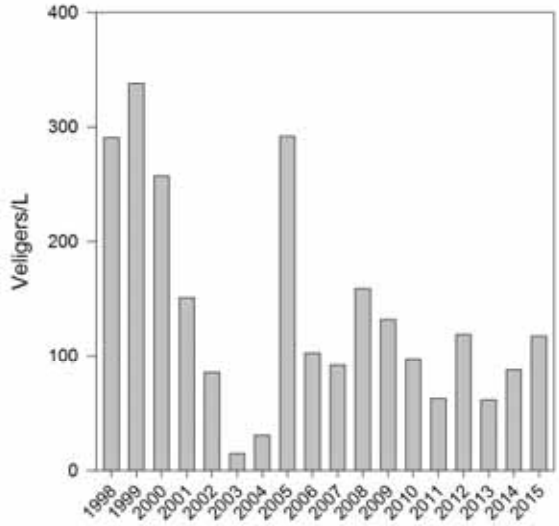

Light Penetration at Lock and Dam 8 and 9
(June-August data)
Depth of 1 % of Surface Light (m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

Nutrient Enrichment Issues

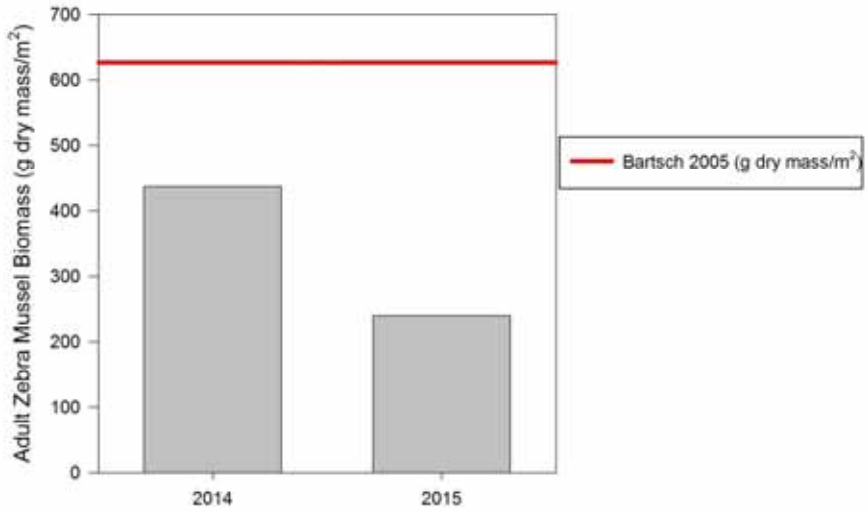
Excess Nitrogen and Phosphorus = Algae Blooms

Very high for cyanobacteria cell density. High for microcystin conc.

Average Zebra Mussel Veliger Concentration at Lock and Dam 7
1988-2015

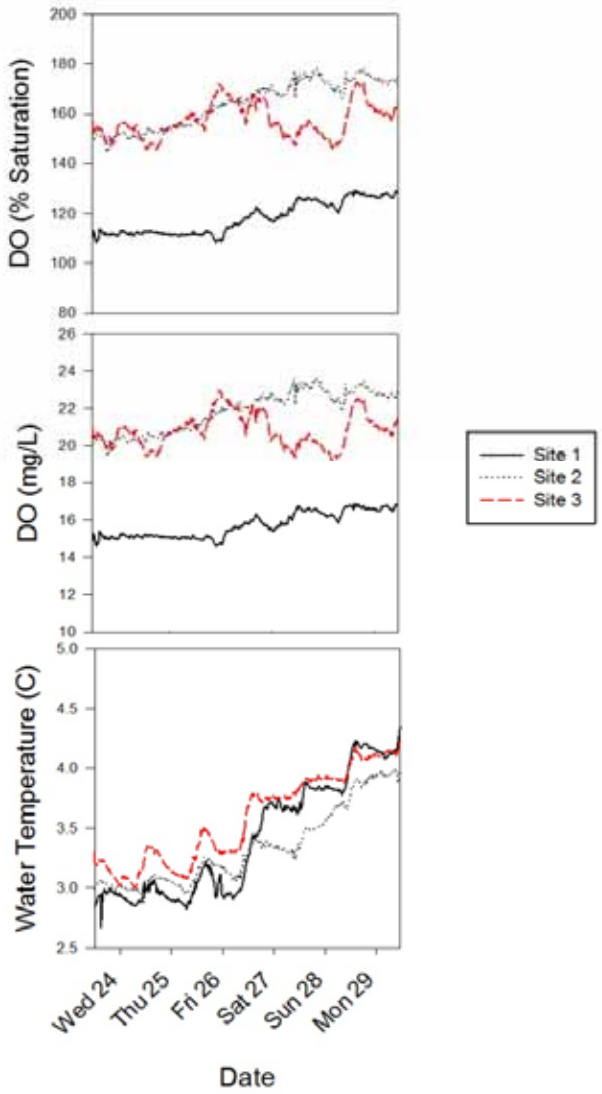


Adult Zebra Mussel Biomass at Lock and Dam 7 and 8
2014-2015



Curlyleaf Pondweed


Ruth Nissen


DO (% Saturation)
200
180
160
140
120
100
80
DO (mg/L)
26
24
22
20
18
16
14
12
10
Water Temperature (C)
5.0
4.5
4.0
3.5
3.0
2.5
Wed 24
Thu 25
Fri 26
Sat 27
Sun 28
Mon 29
Date
Site 1
Site 2
Site 3

Six Things Can We Do To Improve Water Quality?

Install Stream Buffers

Buffers:

- Our best water quality is linked to streams with the best stream buffers
- Stabilize streambanks
- Provide recreational opportunities
- Provide corridors for improved wildlife habitat and movement
- Prevent devastating losses due to flooding

Six Things Can We Do To Improve Water Quality?

Implement Nutrient Management Plan and Improve Soil Health

A Nutrient Management Plan will:

- Improve soil health
  - Enhance soil structure
  - Incr. nutrient retention
  - Incr. water holding capacity
- Improve water quality
  - Reduce nutrient delivery to surface waters
- Save money by reducing the need for purchased fertilizer

Six Things Can We Do To Improve Water Quality?

Improve Open Feedlots

Improving Feedlots:

- Eliminates excess water through the lot
- Contain solids
- Reduce nutrient delivery to streams
- Reduce the chance of fish kills

Six Things Can We Do To Improve Water Quality?

Protect and Create Wetlands

Wetlands:

- Reduce nitrates from the landscape
- Serve as a sink for phosphorus, sediment and pesticides
- Reduce flood risk
- Provide valuable wildlife habitat

Six Things Can We Do To Improve Water Quality?

Stop Soil Erosion

Examples of permanent soil conservation practices are:

- Contour farming
- Terraces

- Grassed waterways

- **Protect the soil and WQ while providing valuable wildlife habitat**

Six Things Can We Do To Improve Water Quality?

Invest in Conservation and Habitat Restoration Programs

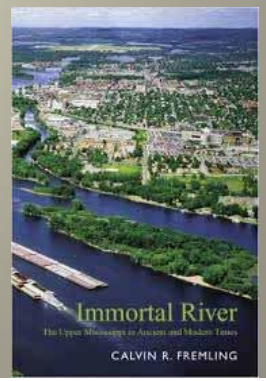
Investing in programs such as CRP and UMRR will:

- Improve water quality by reducing sediment and nutrient delivery to the UMR
- Benefit fish and wildlife populations
- Improve soil quality


“The wildlife are getting tired of winning!”
“I made the Mississippi River great again!”

“Several river cities have erected eagle watch facilities that attract hundreds of eagle watchers. Shoppers strolling down the main street of Alma, WI have grown accustomed to seeing eagles flying at treetop height.”

Cal Fremling, *Immortal River*



Here is your country. Cherish these natural wonders, cherish the natural resources, cherish the history and romance as a sacred heritage, for your children and your children's children. Do not let selfish men or greedy interests skin your country of its beauty, its riches or its romance.

— Theodore Roosevelt —

AZ QUOTES