DEPARTMENT OF NATURAL RESOURCES

# Pelican Rapids Dam

## Environmental Issues and Restoration Options

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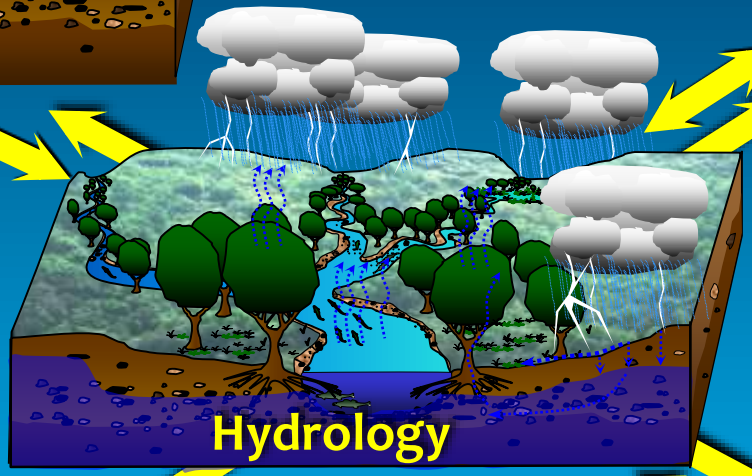
*Department of Natural Resources*

- Related river functions and ecosystem health
- Dam related issues, problems, and implications
- Solutions and case examples
- Possibilities at Pelican Rapids

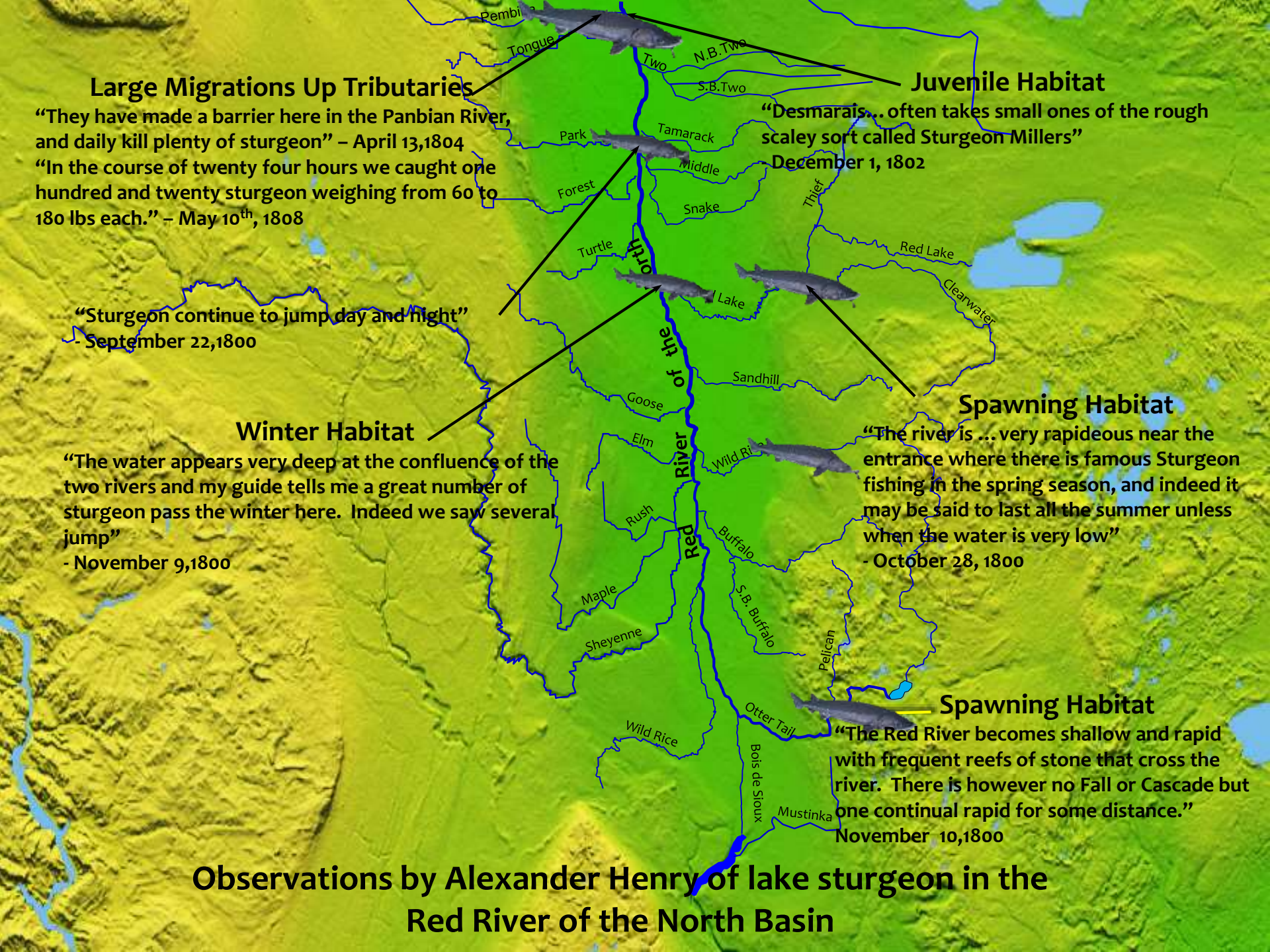
# Components of Watershed Health




Geomorphology (habitat)

# Rivers- Arteries of Life

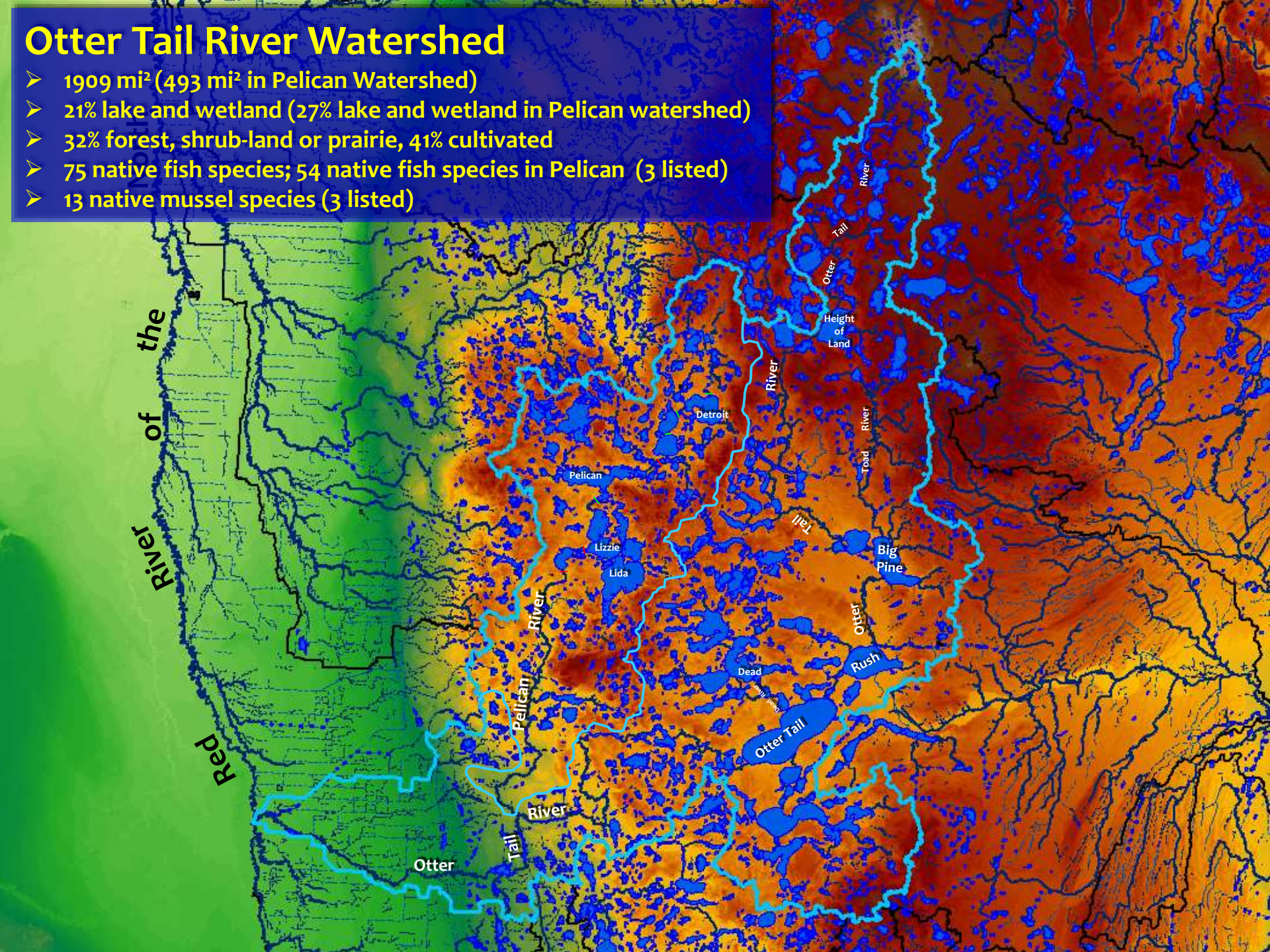
## Minnesota would be fishless if it weren't for river connections




# Observations by Alexander Henry of lake sturgeon in the Red River of the North Basin

# Otter Tail River Watershed

- 1909 mi² (493 mi² in Pelican Watershed)
- 21% lake and wetland (27% lake and wetland in Pelican watershed)
- 32% forest, shrub-land or prairie, 41% cultivated
- 75 native fish species; 54 native fish species in Pelican (3 listed)
- 13 native mussel species (3 listed)



# The Otter Tail River

Kakaweuapa (the "River of the Falls") Dakota
Nequiquano ("Otter Tail") to Grand Forks - Ojibwa
Red – Nicollet 1836 map, also in 1923 plat book
from Alfred C. Seltz, J. 1999

*"The Red River becomes shallow and rapid with frequent reefs of stone that cross the river."* Alexander Henry November 10, 1800

*"We unexpectedly came upon turbulent rapids, the water foaming among a multitude of boulders."* Major David Owen 1848

# Fishes that spawn in falls, rapids, glides, and riffles

**Dead Man's Rapids on Little Fork River**

Tagged sturgeon traveled 135 miles from Lake of the Woods to these rapids

# Documented Migration Distances of Minnesota Fish Species

Walleye
164 miles

Channel catfish
454 miles miles

Lake sturgeon
682 miles

White bass
800 miles

Sauger
217 miles

Bigmouth Buffalo
318 miles

Paddlefish
1900 miles

American Eel
3440 miles

Blue Sucker
108 miles

References: Stancille et al. 2002, Mosindy and Rusak 1991, Bellgraph 2006, Ron Bruch, news release, Mike Larson, personal communications, Jaeger 2004, Nick Schloesser, personal communication, Altena 2003, Neely et al. 2009, Finke 1966)

# Why do fish need to migrate?

Spawning walleye
85% of harvested walleyes are from natural reproduction

Spawning lake sturgeon

Spawning Coho salmon

## Reproduction

Spawning migrations can be hundreds or even thousands of miles

Overwintering Flathead catfish

## Seasonal changes in habitat needs.

Winter often initiates downstream migration to deep, low velocity habitat while spring initiates upstream migrations. Video courtesy of Chris Domeier.

Channel catfish fry
Invertivores

Channel catfish adult
piscivore

## Changing forage and habitat needs.

As fish grow larger they optimize feeding by migrating to habitats with abundant suitable forage

Drought, Minnesota River, Minnesota

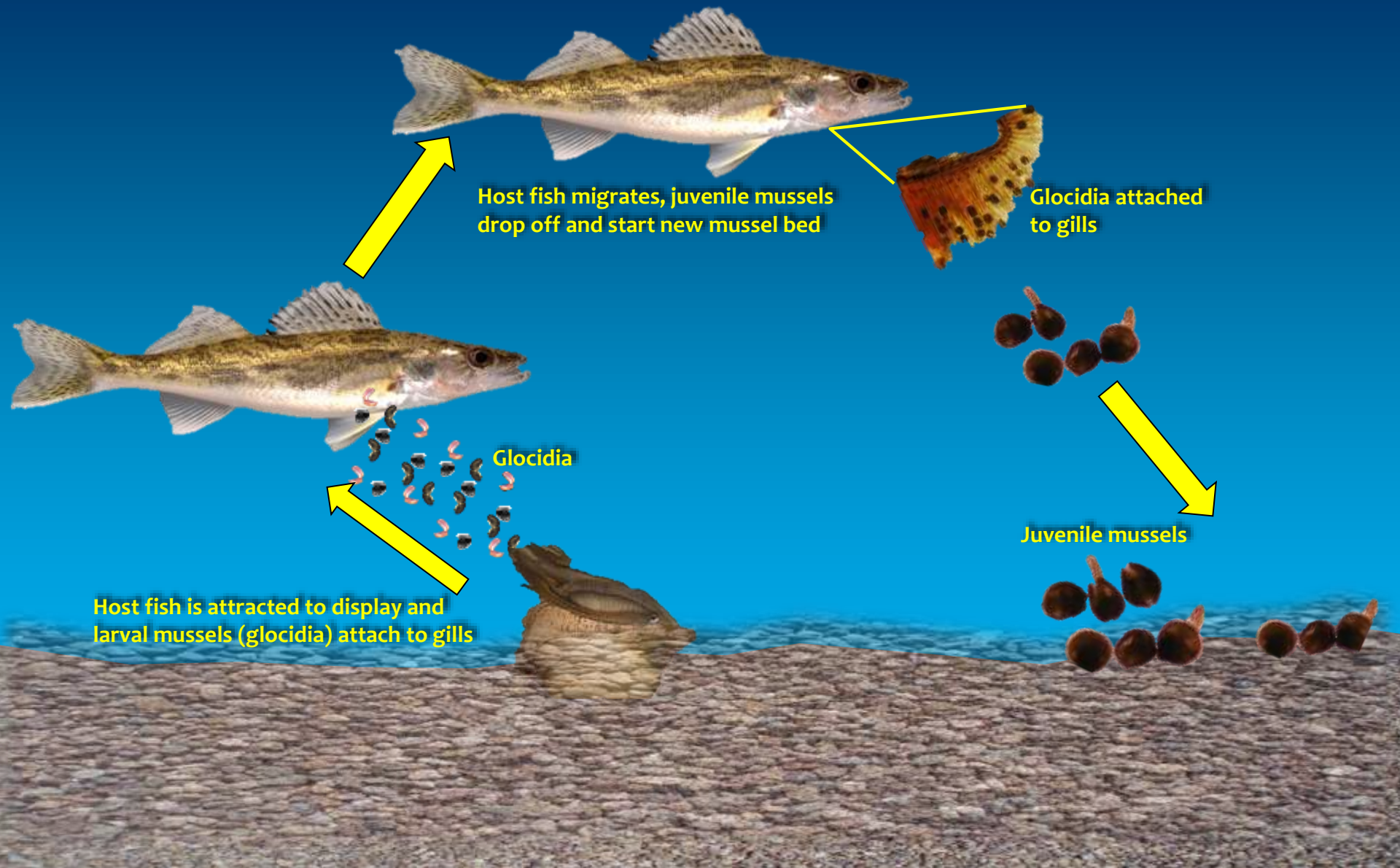
Fish Kill, Indian River, Florida 2012

## Re-colonization

Drought, low dissolved oxygen, winter stress, chemical spills, and catastrophic events can cause complete or extensive mortality. Many rivers periodically stop flowing during drought.

# Native Mussel Life History

## Some mussel species been aged at over 280 years



Pocket book mussel
Hosts: sauger, white crappie
(Found in Otter Tail River)

# Otter Tail Watershed Mussel Species

Mapleleaf

Black Sandshell
(Special Concern)

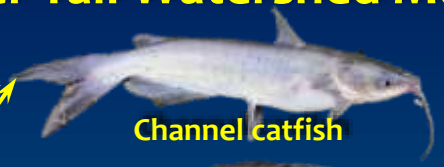
Fluted shell
(Threatened)

Threeridge

Wabash Pigtoe

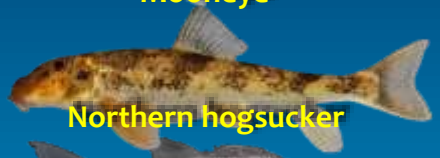
Cylindrical papershell

Pink Papershell


Channel catfish

Bowfin

Mooneye


Northern hogsucker

White bass

Sauger

Black crappie

Spotfin shiner

Freshwater drum

White Heelsplitter

Creek Heelsplitter
(Special Concern)

Giant Floater

Creeper

Plain Pocketbook

Fat Mucket

X Live in Pelican upstream of Elizabeth
X Dead in Pelican upstream of Elizabeth
X Live downstream of Elizabeth Dam

# Important Functions of Mussels

(Some mussels can live to over 200 years)

## Filter Water

Mussels of the Upper Mississippi River filter 53.1 million $m^3$ of water per day or 76 times the Minneapolis-St. Paul Metropolitan Wastewater Treatment Plant, one of the largest in the USA (Newton et al. 2011).

## Stabilize Stream Beds

Increased steam bed shear strength by 24% (Zimmerman and Szalay 2007).

## Increase Benthic Invertebrate Abundance and Diversity.

Mussels increase the biodiversity and abundance of benthic invertebrates by increasing interstitial space in the stream bed, creating attachment surfaces, and deposition of pseudofaeces (Spooner and Vaughn 2006; Vaughn and Hakenkamp 2001; Gutierrez et al. 2003).

## Reduce prevalence of cyanobacteria

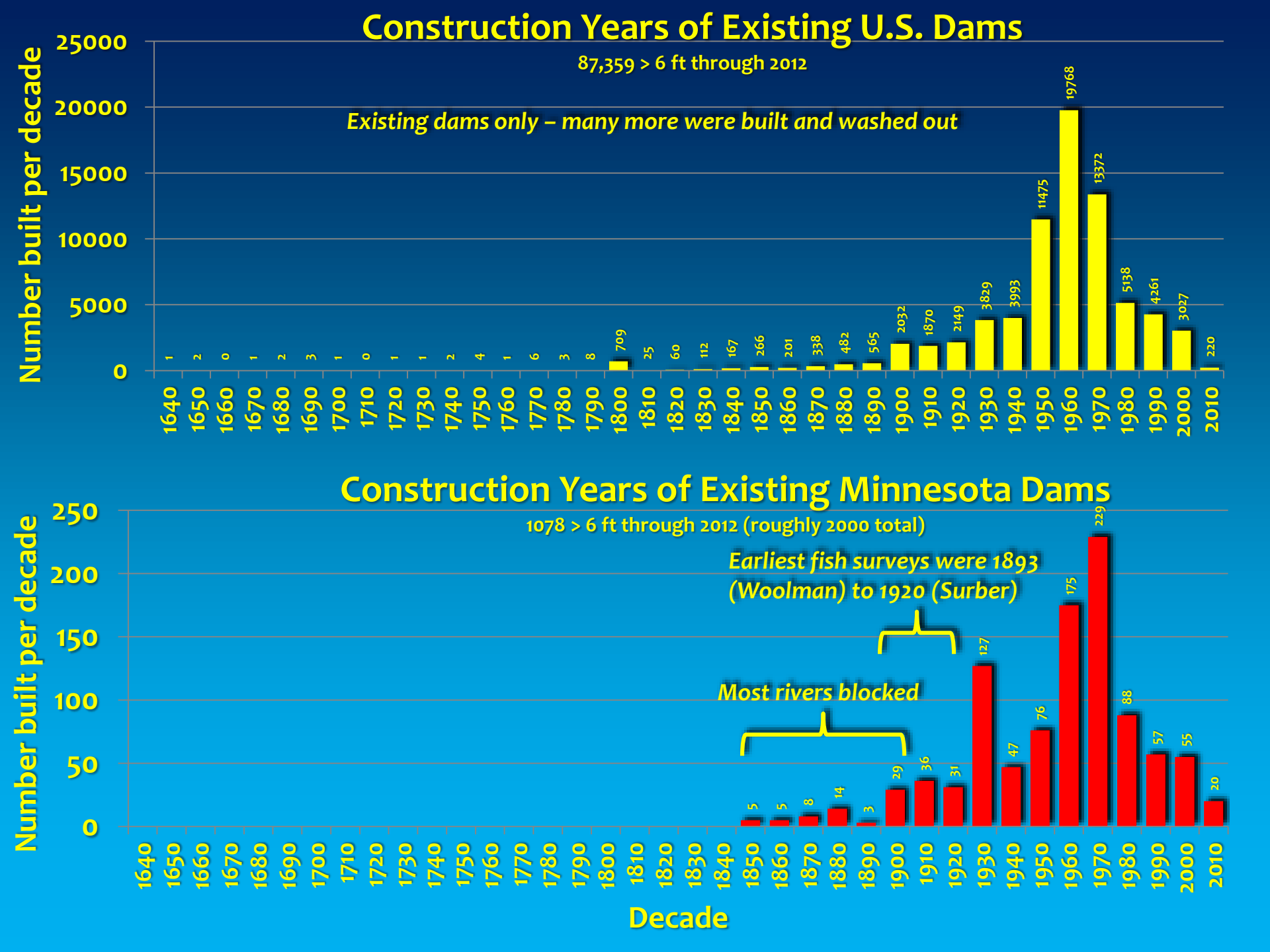
Regulate N:P ratios and alleviate N limitation shifting phytoplankton from cyanobacteria to diatons (Atkinson et al. 2013).

## Remove CECs (Contaminants of Emerging Concern)

Removed 80% of some CECs within 72 hours (Ismail et. al. 2014).

## Remove harmful bacteria

Removed 98% of E-coli within 24 hours regardless of e-coli densities (Ismail et. al.2015)


Construction Years of Existing U.S. Dams
87,359 > 6 ft through 2012
Existing dams only – many more were built and washed out
Number built per decade
25000
20000
15000
10000
5000
0
1 2 0 1 2 3 1 0 1 1 2 4 1 6 3 8 709 25 60 112 167 266 201 338 482 565 2032 1870 2149 3829 3993 11475 19768 13372 5138 4261 3027 220
1640 1650 1660 1670 1680 1690 1700 1710 1720 1730 1740 1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Construction Years of Existing Minnesota Dams
1078 > 6 ft through 2012 (roughly 2000 total)
Earliest fish surveys were 1893
(Woolman) to 1920 (Surber)
Most rivers blocked
Number built per decade
250
200
150
100
50
0
5 5 8 14 3 29 36 31 127 47 76 175 229 88 57 55 20
1640 1650 1660 1670 1680 1690 1700 1710 1720 1730 1740 1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Decade

# Aging Dams

- The average age of the 90,580 dams in the U.S. is 56 years. At least 2170 of the 15,500 high hazard dams in the U.S. are deficient and repairing them would cost nearly $45 billion (ASCE 2017).
- The American Society of Civil Engineers gave the U.S. a "D" grade for dams.
- There are roughly 40 dam failures per year in the U.S (NRCS 2000).
- Dams can fail even when well maintained.

Pelican Rapids is a high hazard dam in poor condition

Silver Lake Dam Failure 2003
(shortly after PMF upgrade)
$102 million damages

# Some Recent Dam Failures in Minnesota

## Breckenridge Dam Failure - 1997

Otter Tail River

200-y flood , also failed in 1989, 2001, 2006, and 2007

## Willow River Dam Failure - 2016

Willow River

5 to 8 inch Rain event

## Thomson Forebay Failure -2012

St. Louis River

No major deficiencies

500-y flood (50,000 cfs)

$90 million (forebay) + $21.3 million (hwy 210) + ??

## Heiberg Dam Failure – 2002

Wild Rice River

No major dam deficiencies

500-y Flood (June 9)

2000-y flood (June 24)

## High Island Carp Dam Failure - 2014

High Island Creek

25-yr flood, no major dam deficiencies

## S. Mound Creek Dam Failure - 2014

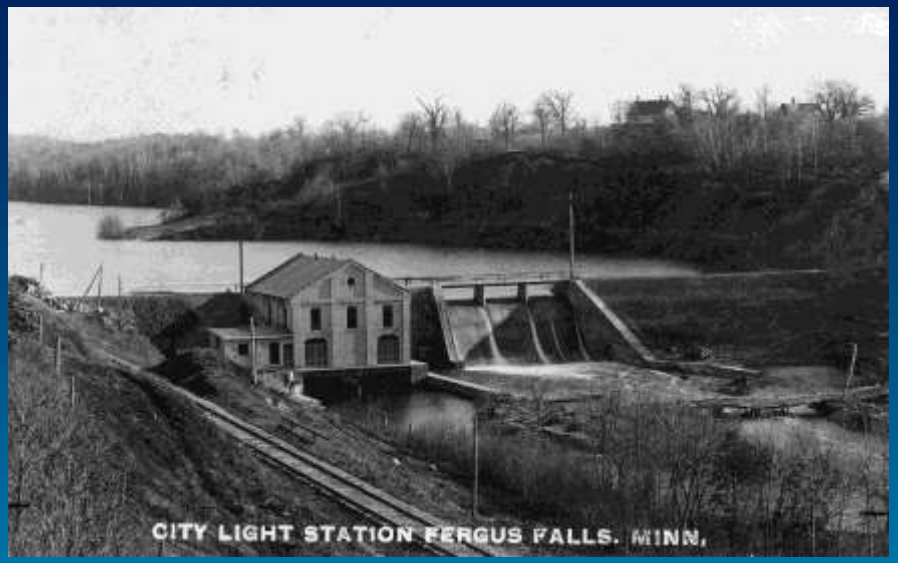
7 inch rain, No major dam deficiencies

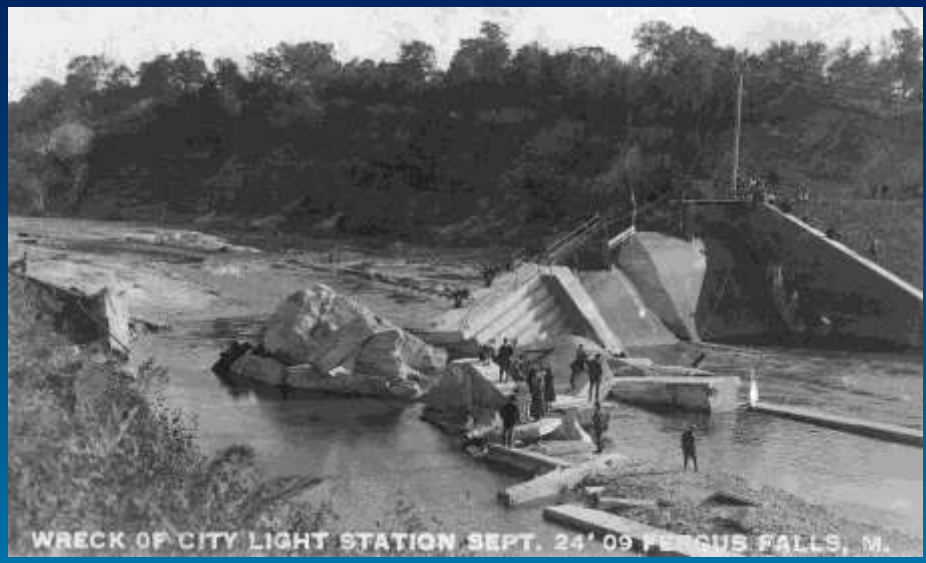
## Appleton Dam Failure – 1997
## Pomme de Terre River

500-yr Flood

## Lake Shady Dam Failure – 2010
## Zumbro River

500-yr Flood, no major dam deficiencies



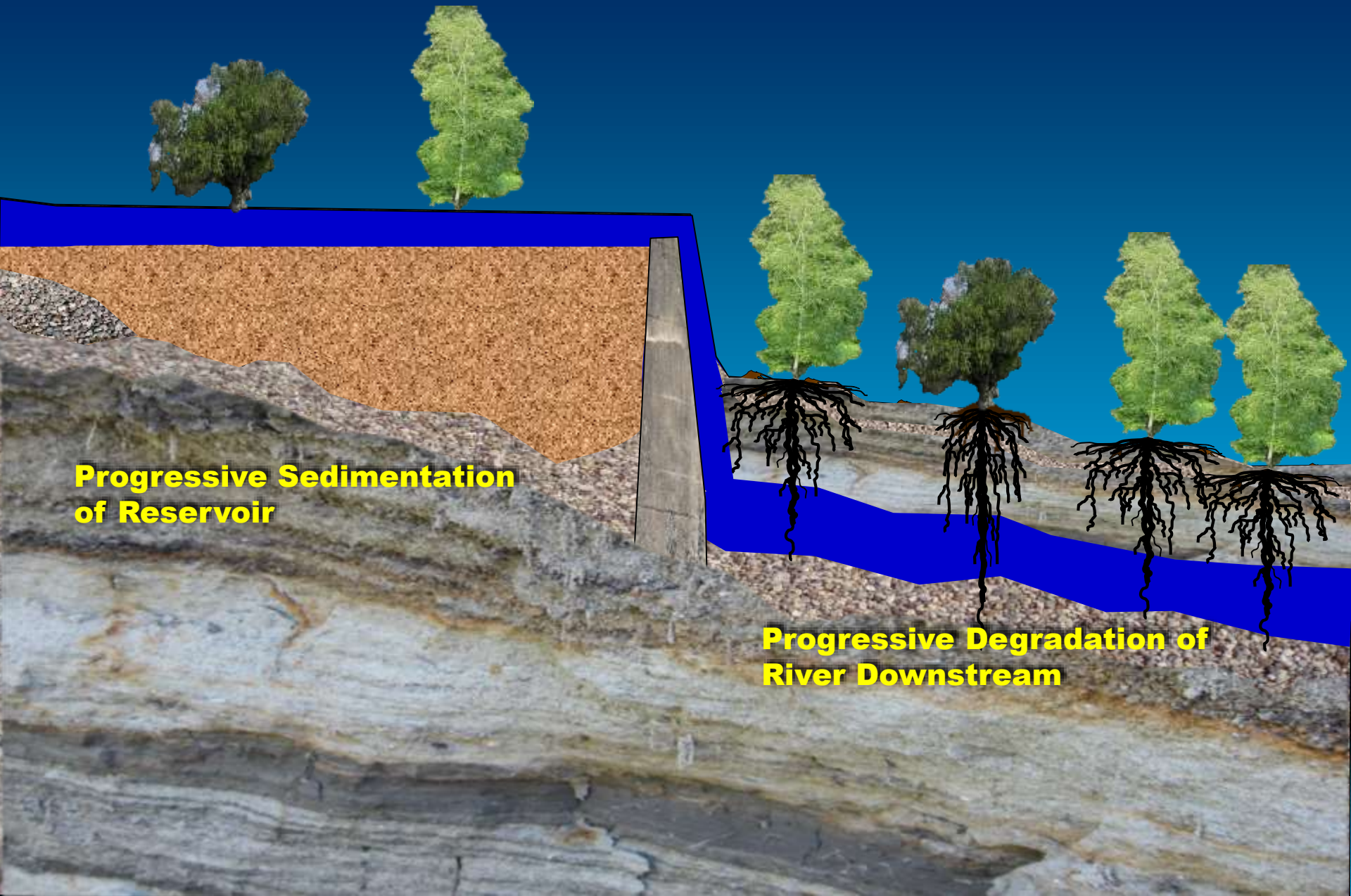




**Fergus Falls during the failure of the City Light Dam in September, 1909.**

**The resulting flood surge washed out 5 additional dams including the Kirk Dam, Woolen Mill Dam, and Central Dam (September, 1909). The Otter Tail River was not flooding prior to the failure, flowing at 580 cfs (USGS gage data).**

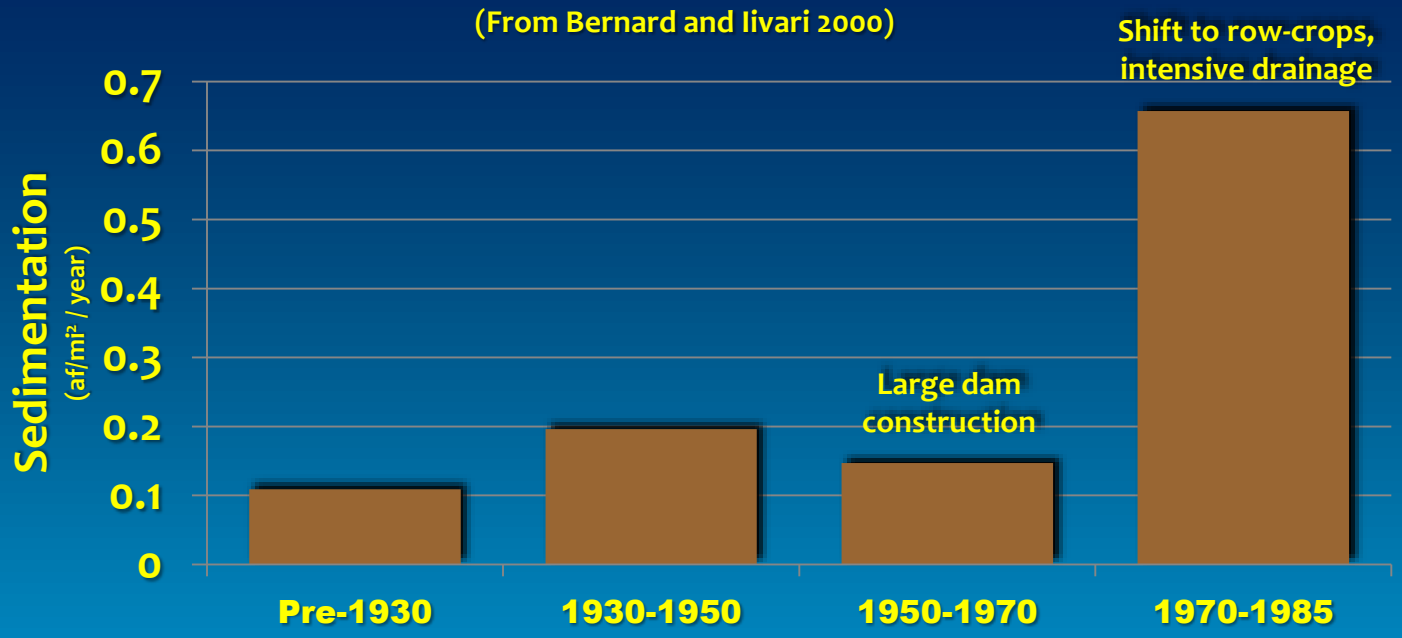
Over 300 pelicans killed by hydraulic undertow at Marsh Lake Dam

# Grade Effects of Dams



# Sedimentation Rate in U.S. Reservoirs

(From Bernard and Iivari 2000)




## Rapidan Dam

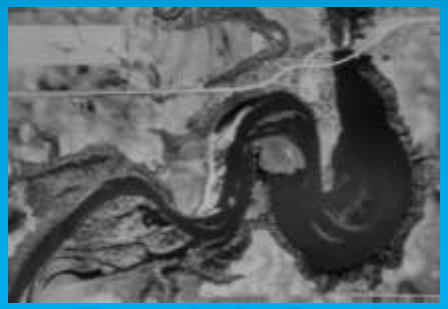
Built in 1910

**1939**

Reservoir 60 feet deep

**1950**

**1991**



12 million yards of sediment in 1991. Over $105 million if dredged plus $2 million/ yr maintenance

**2015**

Sediment 60 feet deep

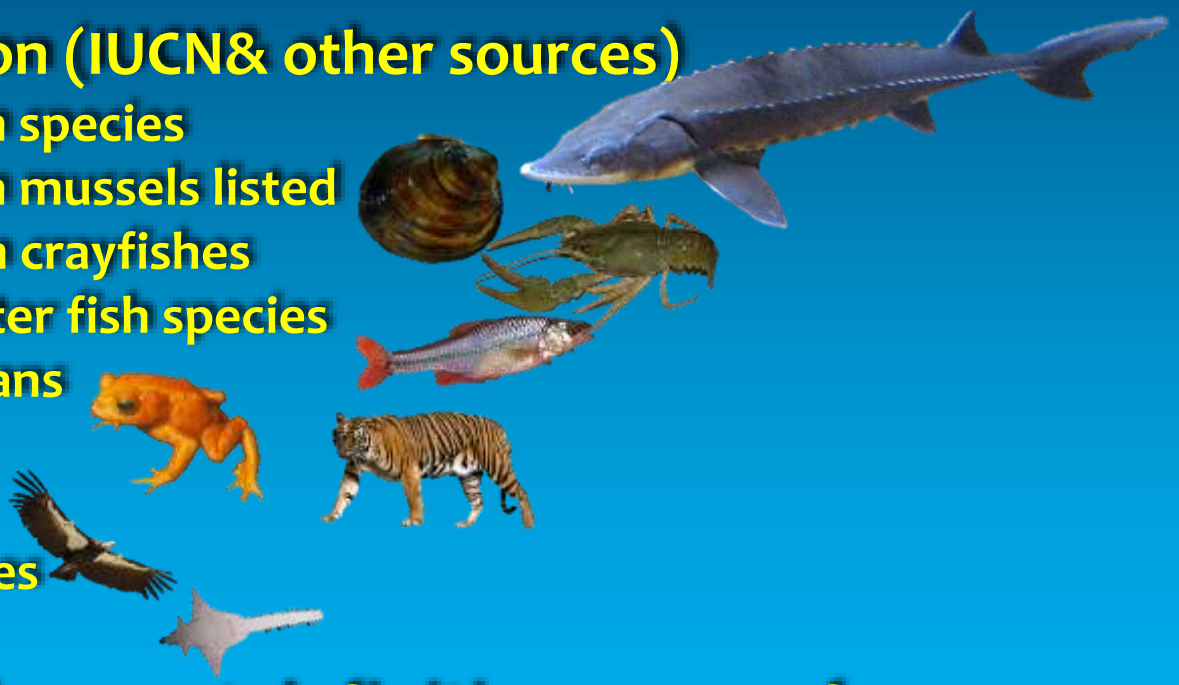
# Loss of Biodiversity

Considered the most severe environmental decline facing humanity (Rockstrom et al. 2009)

Freshwater extinction rates are about 5 times that of terrestrial rates and comparable to loss of tropical rainforest. (Ricciardi and Rasmussen 1999)

Threatened with extinction (IUCN& other sources)

- 85% of global sturgeon species
- 72% of North American mussels listed
- 48% of U.S. & Canadian crayfishes
- 36% of global freshwater fish species
- 30% of global amphibians
- 21% global mammals
- 12% global birds
- 10% global marine fishes



**Dam construction is the most definitive cause of extirpation and extinction of freshwater species**

# High Island Creek Carp Dam

| Species | Present in Watershed | Upstream of Dam | Upstream of Failed Dam (as of 2017) | Tolerance |
|---|---|---|---|---|
| Common carp | 1 | 1 | 1 | tolerant |
| Brassy minnow | 1 | 1 | 1 | tolerant |
| Creek chub | 1 | 1 | 1 | tolerant |
| White sucker | 1 | 1 | 1 | tolerant |
| Black bullhead | 1 | 1 | 1 | tolerant |
| Brook stickleback | 1 | 1 | 1 | tolerant |
| Green sunfish | 1 | 1 | 1 | tolerant |
| Pumpkinseed | 1 | 1 | 1 | stocked |
| Orangespotted sunfish | 1 | 1 | 1 | tolerant |
| Bluegill | 1 | 1 | 1 | tolerant |
| Largemouth bass | 1 | 1 | 1 | stocked |
| White crappie | 1 | 1 | 1 | stocked |
| Black crappie | 1 | 1 | 1 | stocked |
| Yellow perch | 1 | 1 | 1 | stocked |
| Walleye | 1 | 1 | 1 | stocked |
| Shortnose gar | 1 | | 1 | |
| Bowfin | 1 | | | |
| Gizzard shad | 1 | | 1 | |
| Central stoneroller | 1 | | | tolerant |
| Spotfin shiner | 1 | | 1 | |
| Common shiner | 1 | | 1 | |
| Hornyhead chub | 1 | | 1 | intolerant |
| Emerald shiner | 1 | | 1 | |
| Bigmouth shiner | 1 | | 1 | tolerant |
| Sand shiner | 1 | | 1 | tolerant |
| Mimic shiner | 1 | | | intolerant |
| Northern redbelly dace | 1 | | | |
| Bullhead minnow | 1 | | 1 | |
| Bluntnose minnow | 1 | | 1 | |
| Fathead minnow | 1 | | 1 | tolerant |
| Blacknose dace | 1 | | 1 | tolerant |
| Quillback | 1 | | | |
| Northern hogsucker | 1 | | | intolerant |
| Smallmouth buffalo | 1 | | | |
| Bigmouth buffalo | 1 | | | |
| Silver redhorse | 1 | | | |
| Golden redhorse | 1 | | | |
| Shorthead redhorse | 1 | | | |
| Yellow bullhead | 1 | | 1 | |
| Channel catfish | 1 | | | intolerant |
| Stonecat | 1 | | 1 | |
| Tadpole madtom | 1 | | | |
| Northern pike | 1 | | | stocked |
| Central mudminnow | 1 | | | tolerant |
| Iowa darter | 1 | | | |
| Johnny darter | 1 | | 1 | |
| Log perch | 1 | | 1 | |
| Blackside darter | 1 | | 1 | |
| Slenderhead darter | 1 | | 1 | intolerant |
| Freshwater drum | 1 | | | |
| Total | 49 | 18 | 34 | |
| Percent absent | | 65% | 30% | |

**241 mi² Watershed**

**86% of watershed is upstream of dam**

High Island Carp Dam at High Flow

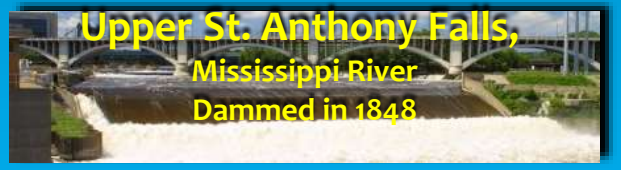
High Island Carp Dam at Low Flow

High Island Carp Dam failure in 2014

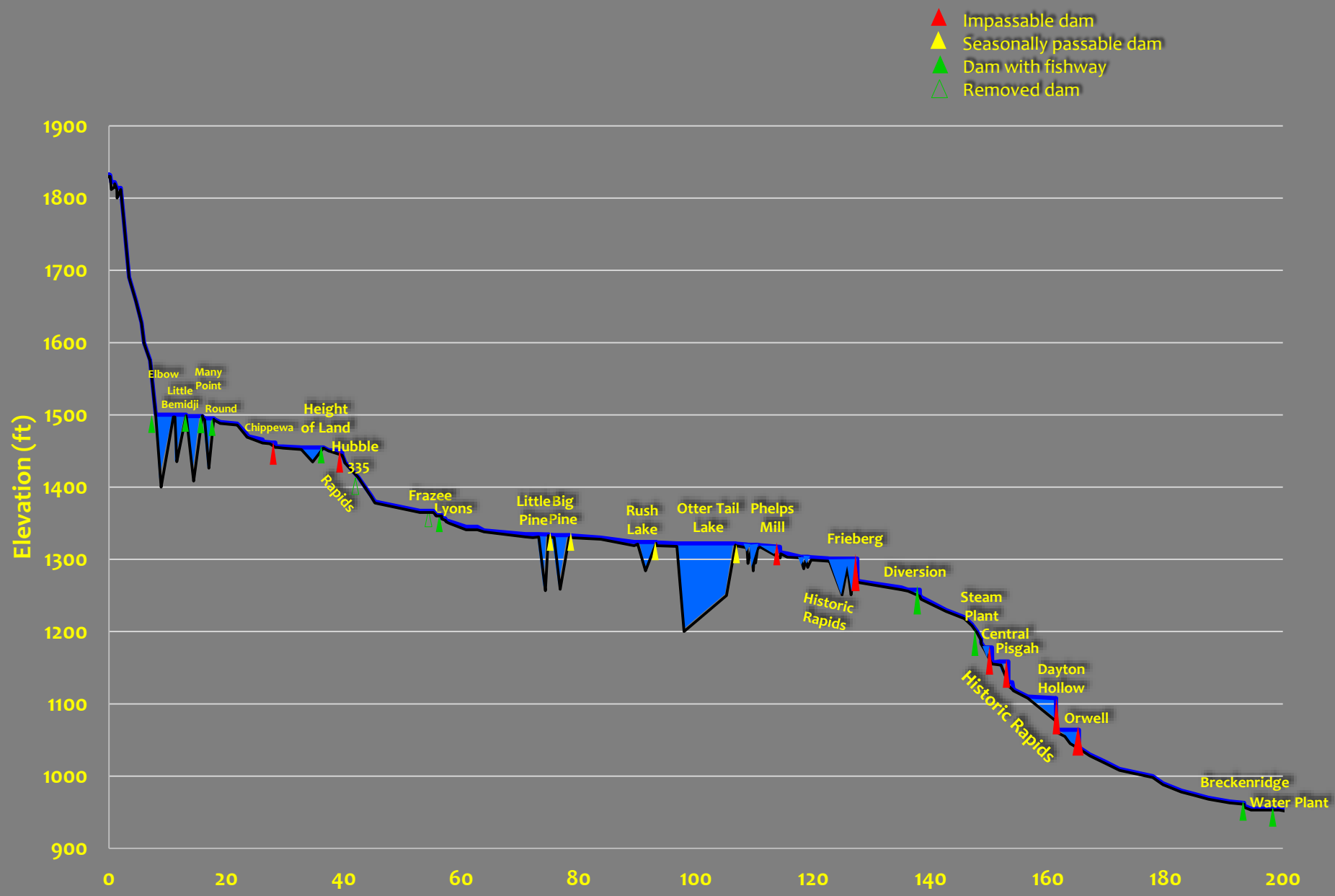
**Dam was removed in 2015**

**From Lore 2011 and other sources**

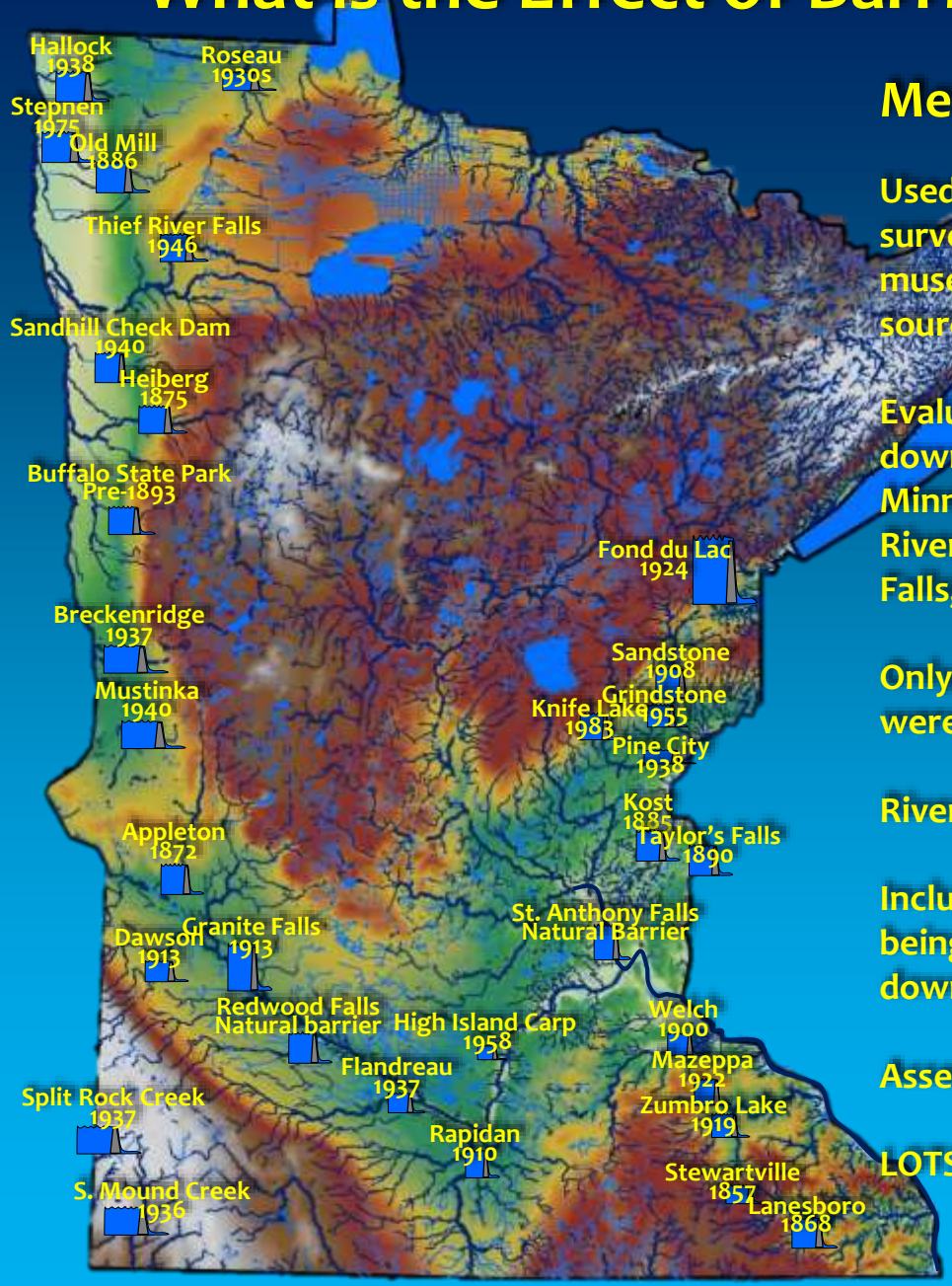
# Where are the Rapids and Falls??



# Otter Tail River Profile and Dams



# What is the Effect of Barriers on Native Species?




## Methods

Used FISHMAPPER and additional geo-referenced fish surveys from DNR-Fisheries, DNR-EWR, PCA, the Bell museum, university collections, and other reliable sources.

Evaluated species diversity above and below 32 downstream-most barriers on tributaries of the Minnesota, Red, Mississippi, Rock, Big Sioux, and St. Croix Rivers, and mainstem barriers at St. Anthony Falls, Taylors Falls, and Minnesota Falls.

Only species absent from entire upstream watershed were considered "absent"

River watersheds ranged from to 17 to 19,100 $mi^2$

Included only species documented from the tributary being evaluated. Didn't include species in the downstream river mainstem for tributary barriers.

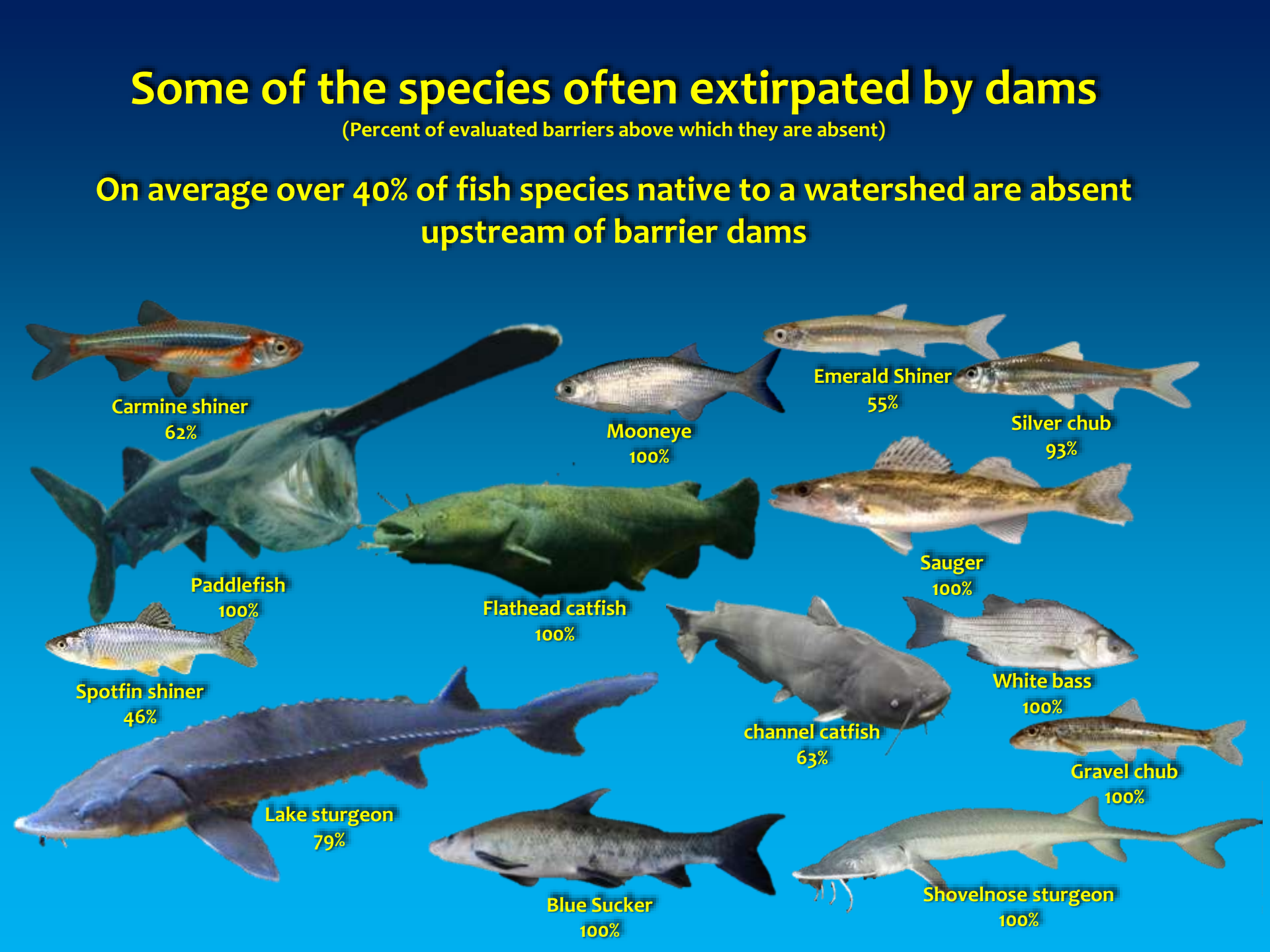
Assessment included 150 species of fish; 134 native

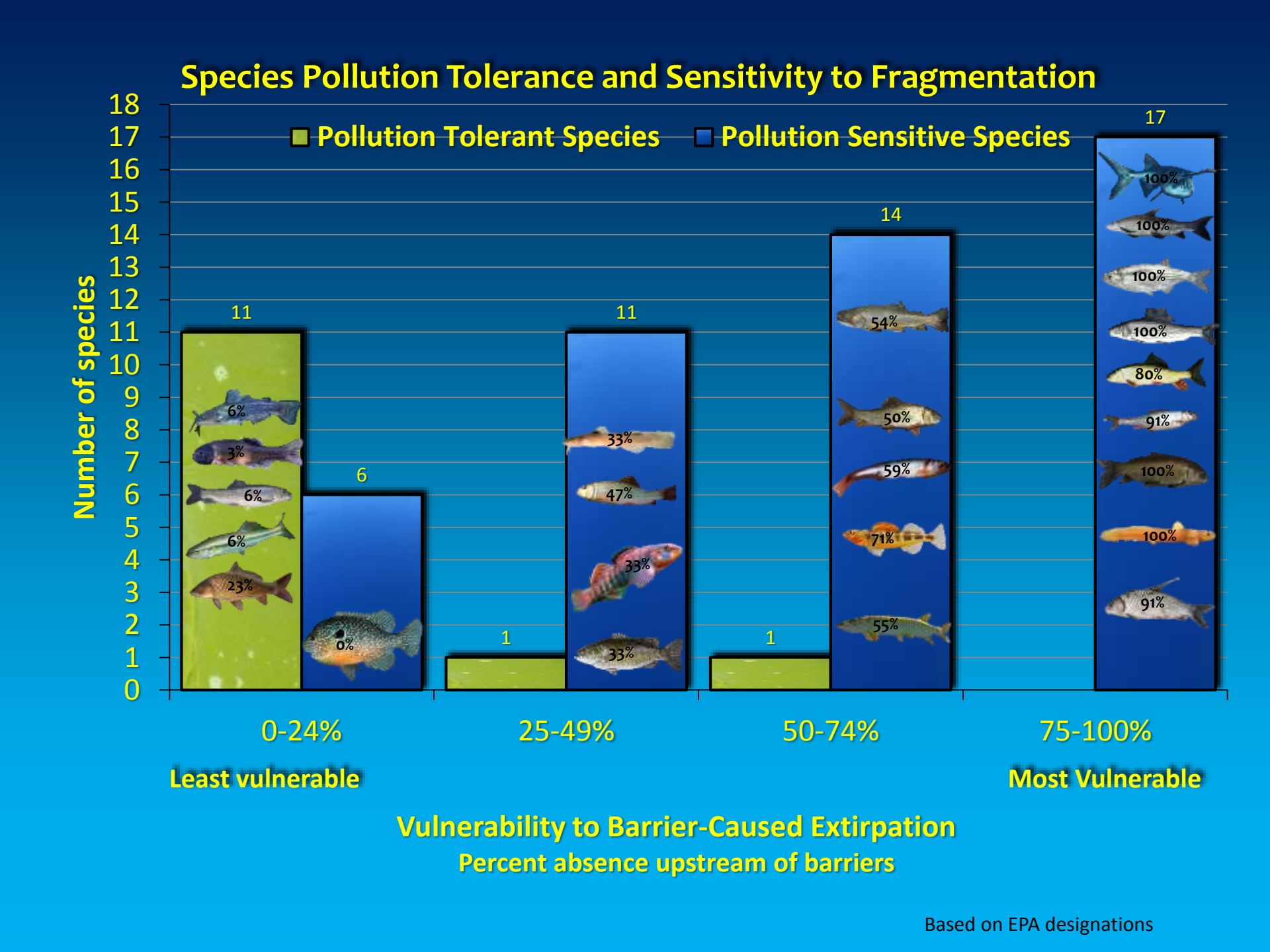
LOTS OF HELP FROM AREA FISHERIES STAFF!!!

# Some of the species often extirpated by dams

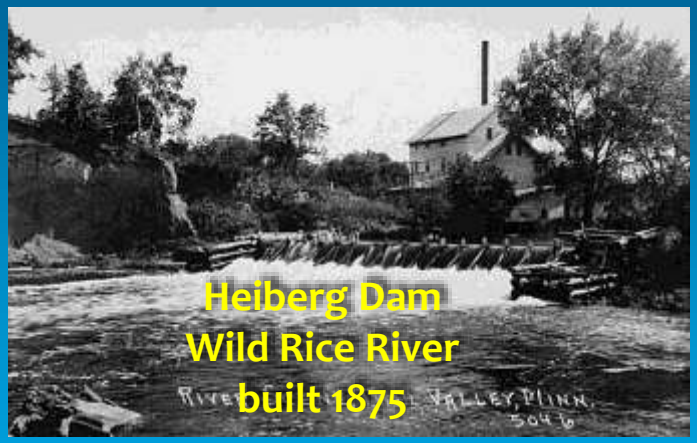
(Percent of evaluated barriers above which they are absent)

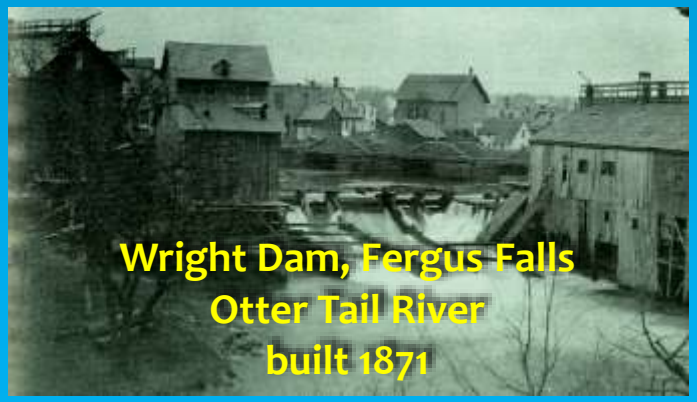
## On average over 40% of fish species native to a watershed are absent upstream of barrier dams




Species Pollution Tolerance and Sensitivity to Fragmentation
Pollution Tolerant Species
Pollution Sensitive Species
Number of species
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
11
6
1
11
1
14
17
6%
3%
6%
6%
23%
0%
33%
47%
33%
33%
54%
50%
59%
71%
55%
100%
100%
100%
100%
80%
91%
100%
100%
91%
0-24%
25-49%
50-74%
75-100%
Least vulnerable
Most Vulnerable
Vulnerability to Barrier-Caused Extirpation
Percent absence upstream of barriers
Based on EPA designations

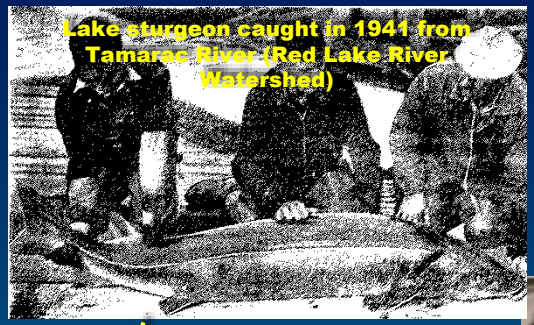
# Dams Inundating or Blocking Access to Spawning Habitat





405 pound lake sturgeon from the Roseau River, October, 1903

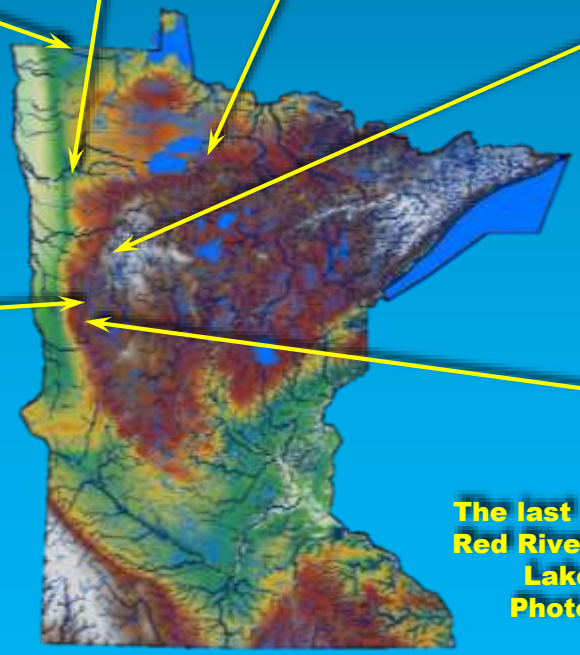
Lake sturgeon from Red Lake River (unknown size and date)



Lake sturgeon caught in 1941 from Tamarac River (Red Lake River Watershed)

176 pound lake sturgeon from White Earth Lake, Wild Rice Watershed May, 1926

105 pound lake sturgeon from Detroit Lake (Otter Tail Watershed), October, 1890



The last lake sturgeon (102 lbs.) recorded from the Red River of the North Basin was caught in 1947 in Lake Lida, Otter Tail (Pelican) Watershed
Photo courtesy of the Pelican Rapids Press

# Strategies for Reconnecting Rivers

**Dam Removal** **Nature-like Fish Passage**

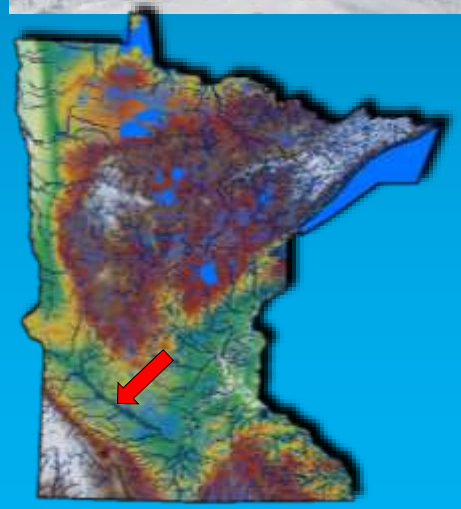
**Rock Arch Rapids** **By-pass Fishway**

| Problem Corrected/Restored | Dam Removal | Rock Arch Rapids | By-pass Fishway |
|---|---|---|---|
| Stream Habitat | ★★★ | ★½ | ★* |
| Safety – Dam Failure Risk | ★★★ | ★ | |
| Safety – hydraulic undertows | ★★★ | ★★½ | |
| Maintenance costs | ★★★ | ★★½ | ★★ |
| Fish & Wildlife Passage | ★★★ | ★★½ | ★★* |
| Canoe passage, recreational boating | ★★★ | ★★ | ★* |
| Geomorphic and ecological processes (sedimentation, incision, nutrient processes, etc.) | ★★★ | | |

*Size dependent

# Minnesota Falls Dam – Minnesota River

- Built in 1871 & 1905, Hydropower retired in 1958
- 17 feet high
- Upstream limit of 32 species of fish
- Inundated Minnesota Falls
- Worker drowned in 2011 during maintenance
- High hazard dam with significant structural deficiencies
- Repairs estimated at 5 to 7 Million dollars



**Dam Removed in January, 2013 for $942,000**

# Minnesota Falls

## Native species that have returned since dam removal

American Eel
Special Concern
Over 6000 km from Sargasso Sea

Sauger

Paddlefish - Threatened

Flathead Catfish

Lake Sturgeon – Special Concern

River Carpsucker

Gizzard Shad

Shovenose Sturgeon

Highfin Carpsucker

Mooneye

Blue Sucker – Special Concern

Shortnose Gar

SILVER LAMPREY

Black Buffalo - Threatened

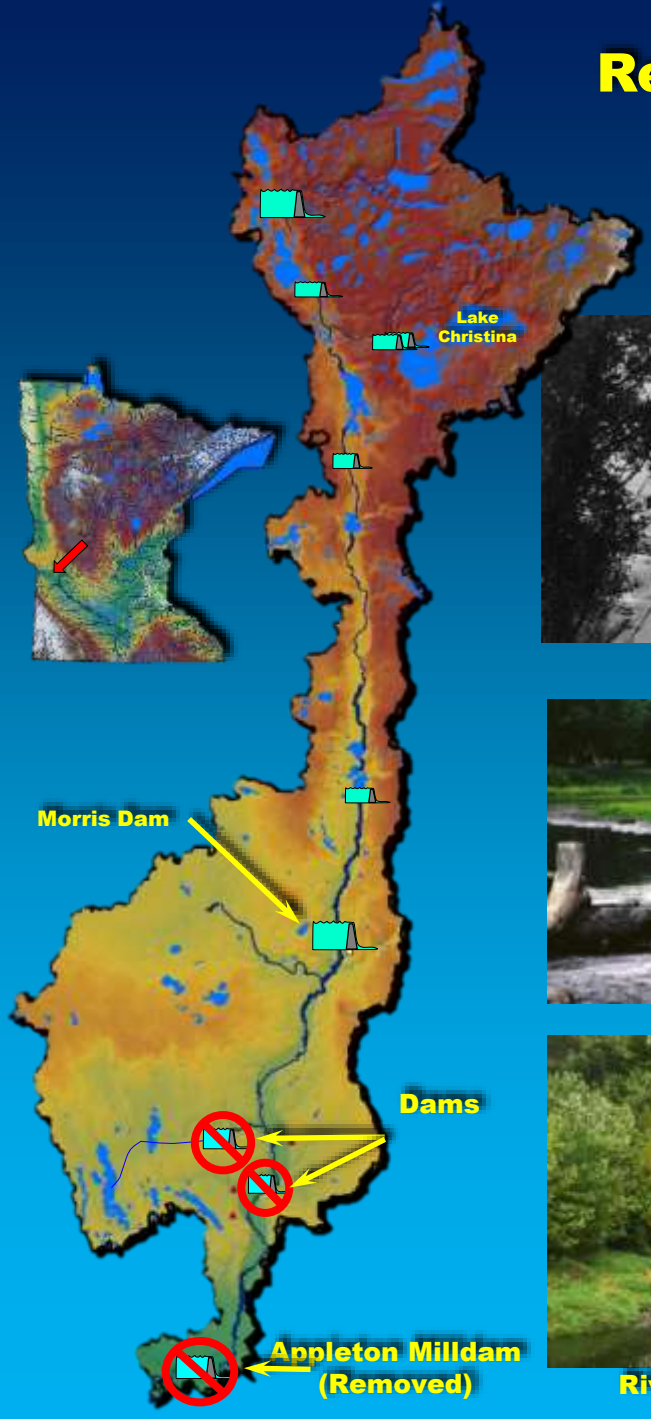
Longnose Gar

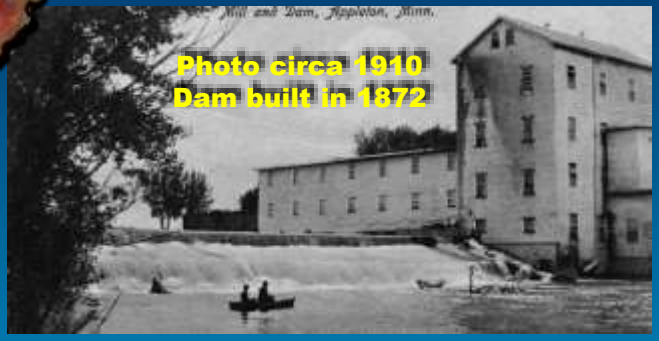
# Healthier River = New Recreational Opportunities

**City of Granite Falls is assessing:**
**Further development of paddling opportunities**
**Options for fish passage through the Granite Falls Dam**

# Removal of the Appleton Milldam
# Pomme De Terre River

**$117,000 for dam removal**
**$250,000 for river restoration**



Reservoir sediments up to 15 feet deep

River cutting through sediments

River restoration 1999 - 2001

Restored Pomme De Terre River Channel
Sediments stabilized in place

Quillback
Returned
Silver Redhorse
Returned
Greater Redhorse
Returned
Banded Darter
Returned
Channel Catfish
Returned
Freshwater Drum
Returned
Lake Sturgeon
(blocked by downstream dams but being reintroduced to Bigstone Lake)
Northern Hogsucker
Smallmouth Buffalo
(blocked by downstream dams)
Emerald Shiner
Returned
White Bass
Returned
Carmine Shiner
Returned
Central Stoneroller
Pomme de Terre River Species absent upstream of Appleton Dam to Morris Dam
77% (10/13) returned after removal

# Appleton Milldam Removal

**Mussels found only as dead shells prior to removal (1990 survey) that recolonized upstream to the Morris Dam following removal (2007 survey).**

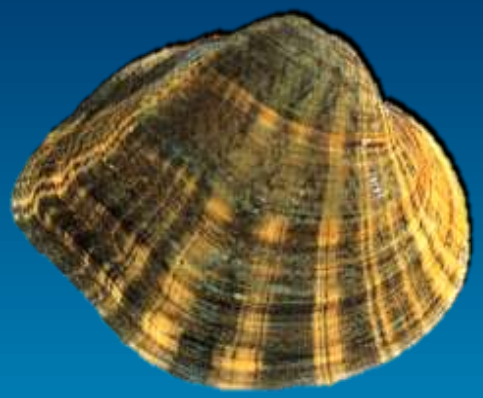
**Video courtesy of Bernard Sietman**

**Elktoe Mussel**
***Alasmidonta marginata***

**Hosts:**
**Rock bass NI**
**Shorthead redhorse NI**
**White sucker NI**
**Northern hogsucker * NI**
**Silver redhorse**?**
**Greater redhorse**?**

**Pocketbook Mussel**
***Lampsilis cardium***

**Hosts:**
**Walleye LT**
**Sauger* NI**
**Bluegill LT**
**Largemouth bass LT**
**Smallmouth bass LT**
**White crappie NI, LT**
**Green sunfish LT**
**Tiger salamander LT**



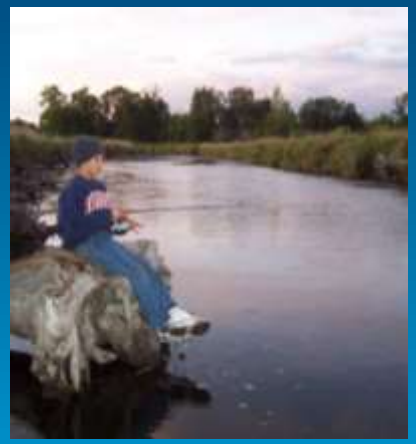
**Deertoe Mussel**
***Truncilla truncata***

**Host:**
**Freshwater drum** NI**

* Species absent upstream of dam
** Species returned after removal
NI Natural infestation
LT Laboratory transformation

Four other extirpated mussel species (round pigtoe, creek heelsplitter, mucket, and black sandshell) have not yet been found upstream of the former dam site

# New Recreational Opportunities after Dam Removal and River Restoration



Knutson Dam at Cass Lake on the Mississippi River
Owned by the U.S. Forest Service

# Dunton Locks, Pelican River

**Maintained water level for Muskrat and Big Detroit Lake**
**Historic Dam built in 1889**

**Dam removed and replaced with rock arch rapids**

# Breckenridge Dam, Otter Tail River

built in 1936

# Sedimentation of Breckenridge Reservoir

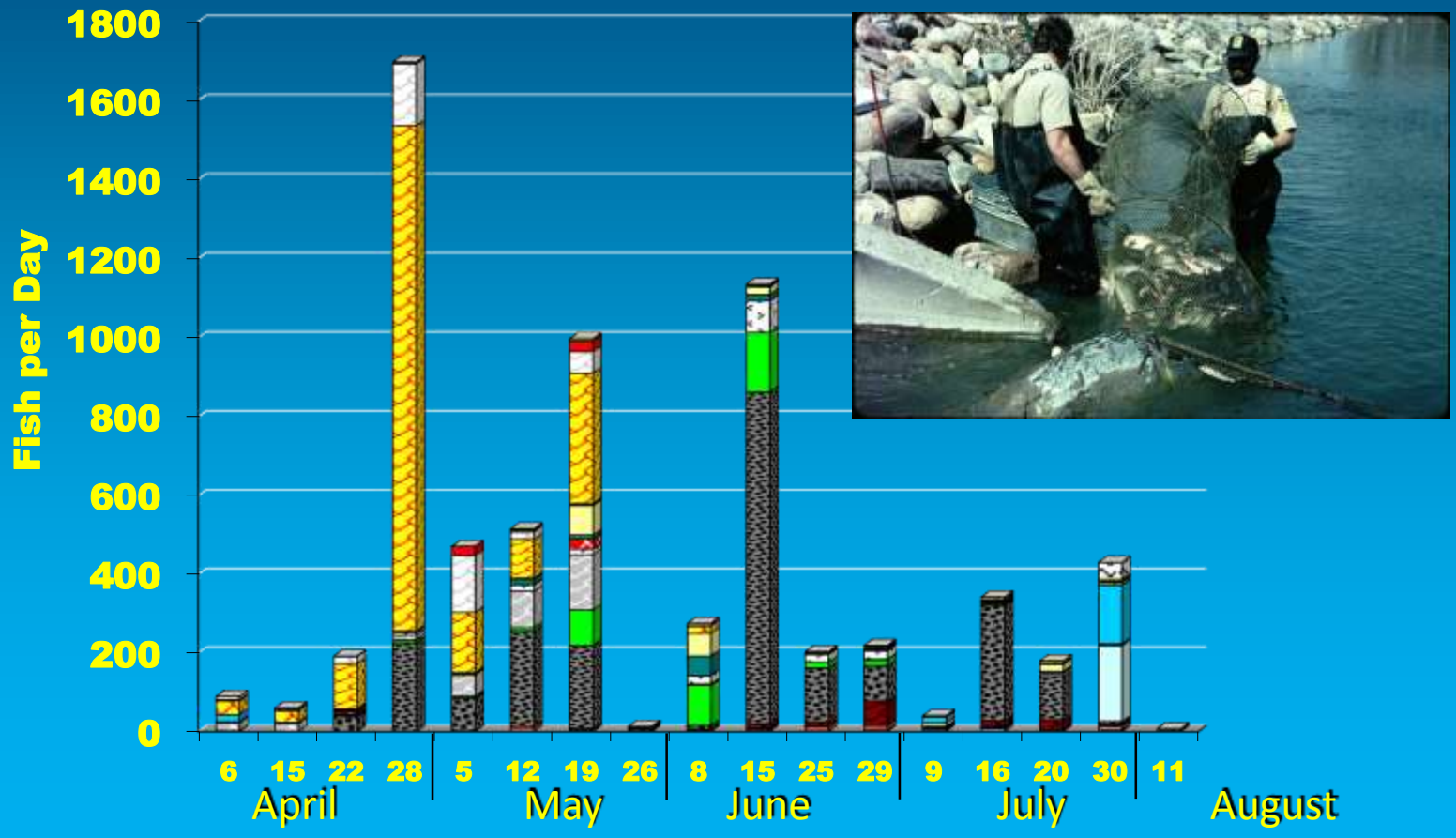
Otter Tail River

Built in 1936

# Breckenridge Dam Fishway

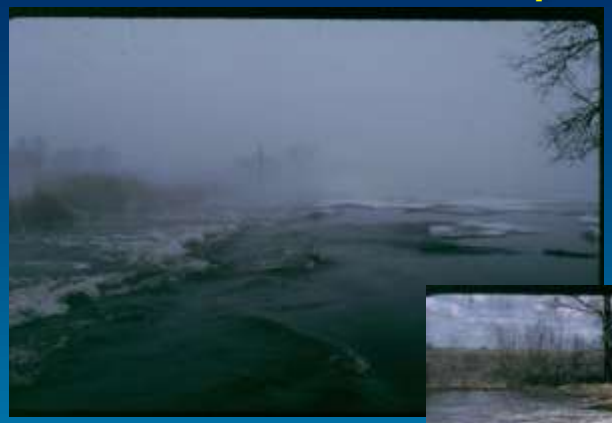
Built in 1996 for $20,000

# BRECKENRIDGE FISHWAY 2004



# Breckenridge Dam Failures

## Repaired with Federal Disaster Declaration Funds



# Breckenridge Dam

Removed in 2007 for $100,000
Rapids built for grade control
County Park established, bike trails connect site to the city
Record 2009 flood caused no damages at site

# Native fish species absent from the Otter Tail Watershed upstream of Breckenridge Dam that returned after fish passage and dam removal

14 additional native species that had not been caught in the reach between Breckenridge and Orwell dams prior to the removal were caught in that reach after fishway construction.

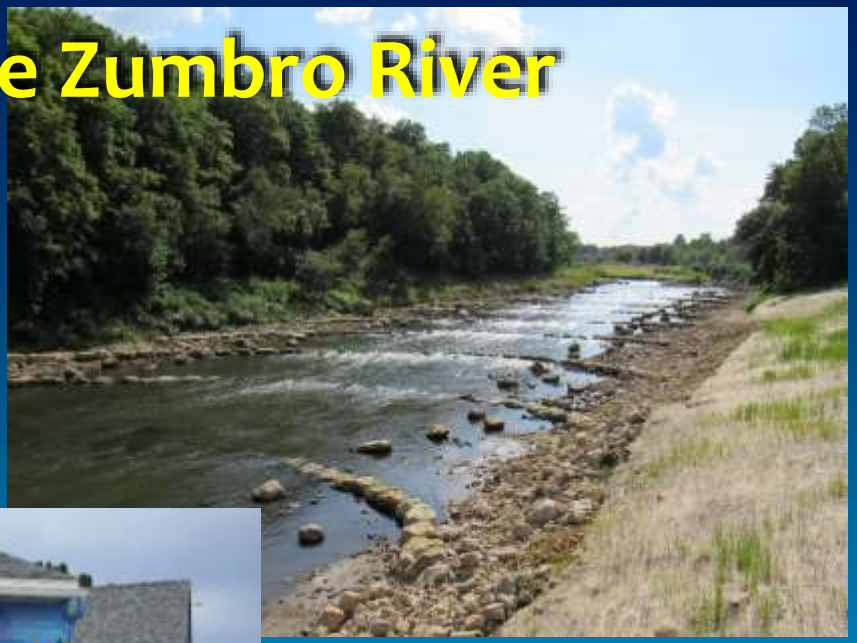
# Lake Shady Dam

No major structural problems
Reservoir largely filled with sediment
County considered removal

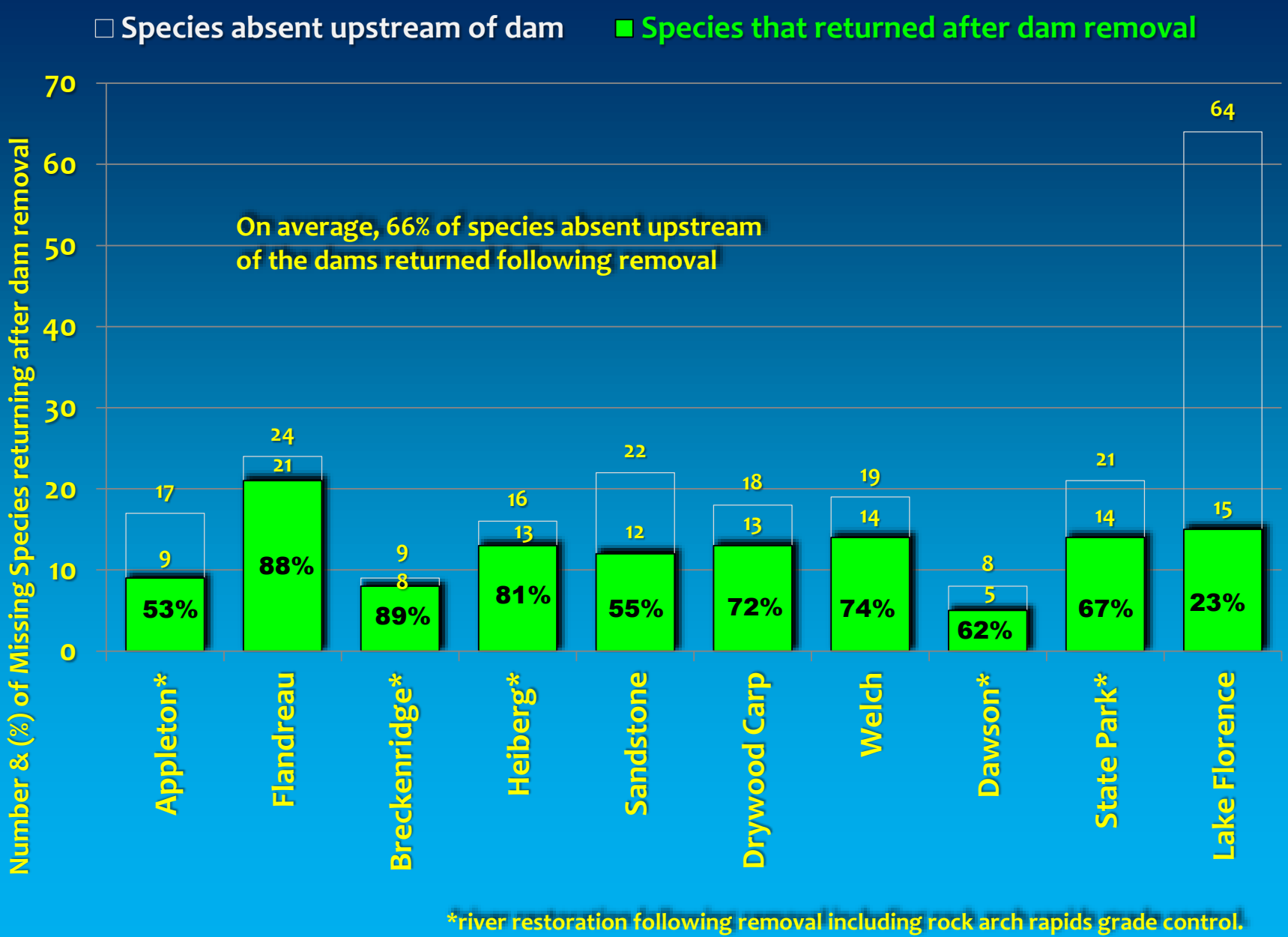
# Lake Shady Dam

**Dam failed in 2010 flood**

# Restoration of the Zumbro River



# Barrier Removal Effects on Species Richness




*river restoration following removal including rock arch rapids grade control.

# Reconnecting the Red River of the North Basin

# Sturgeon Reintroduction

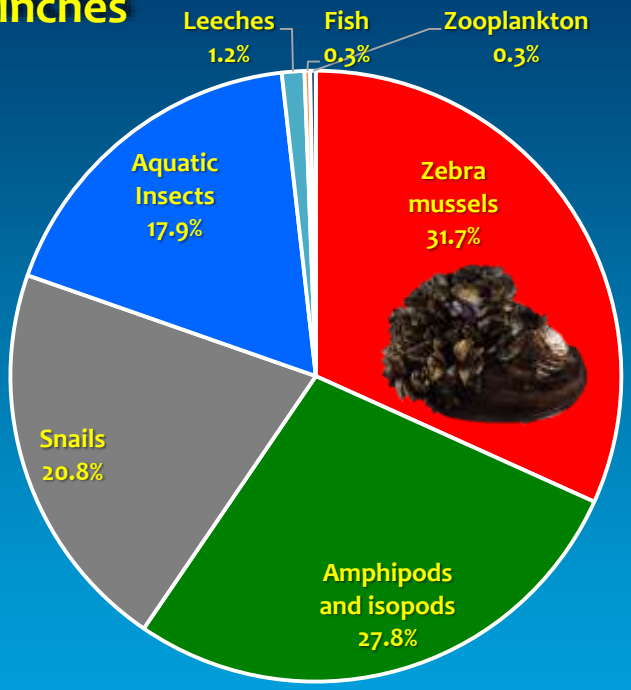
## Starting in 1998

**Eggs purchased from Rainy River First Nation**
**Fry hatched at the Detroit Lakes Hatchery**
**Fingerlings raised by USFWS at La Crosse, WI**

## Sturgeon in Dunton Locks Rapids

## Sturgeon in Diversion Fishway

**Lake Oneida lake sturgeon grow faster than anywhere in North America; zebra mussels are the dominant forage for fish over 35 inches**




Data from Cornell research station

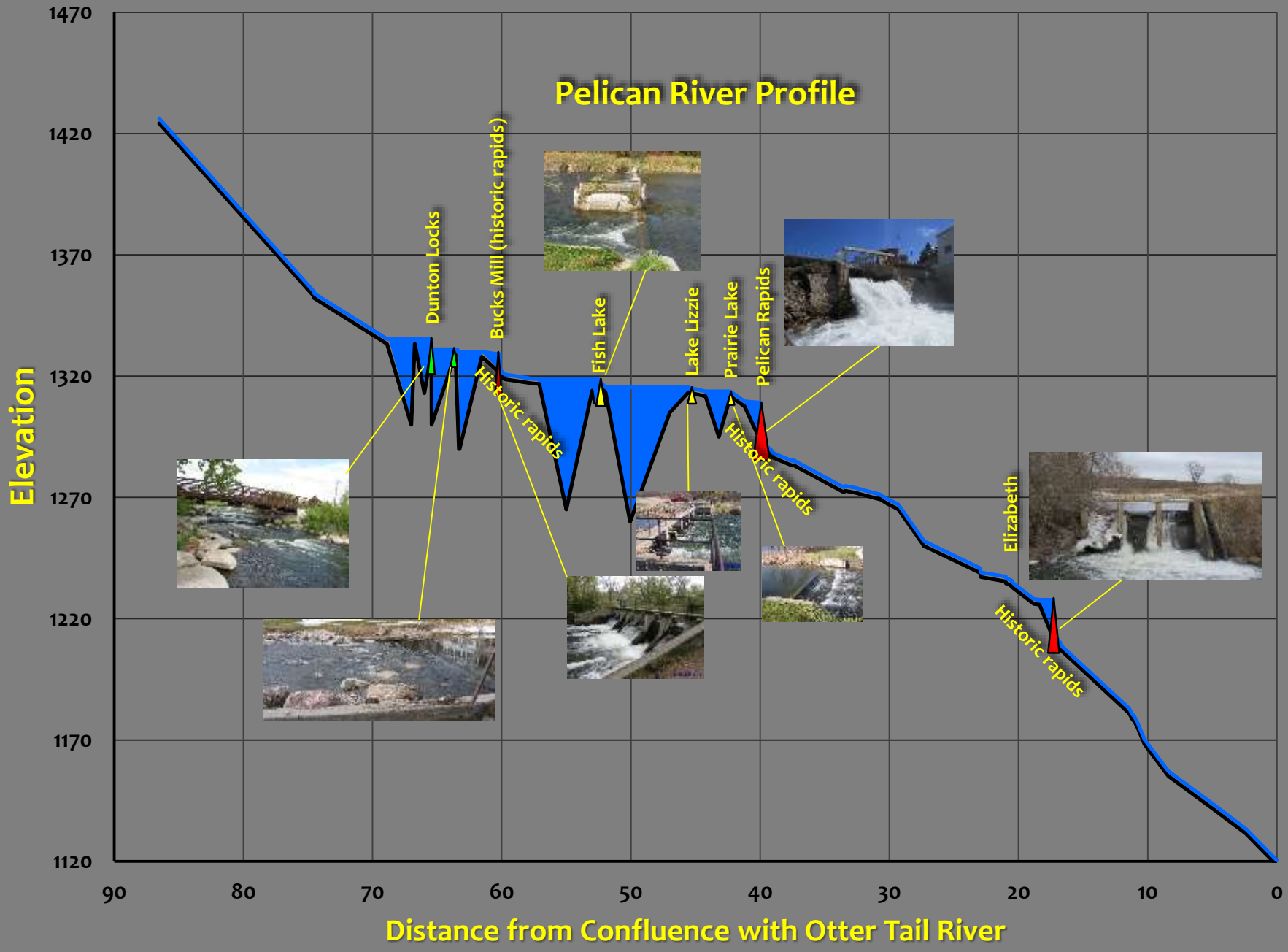
**Zebra mussels taken from the stomachs of sturgeon speared in Lake Winnebago**

***We have videos of sturgeon swimming over rocks carpeted with zebra mussels; and a few seconds later the rocks are clean,"***
***Michigan fisheries biologist Dr. Ed Baker***

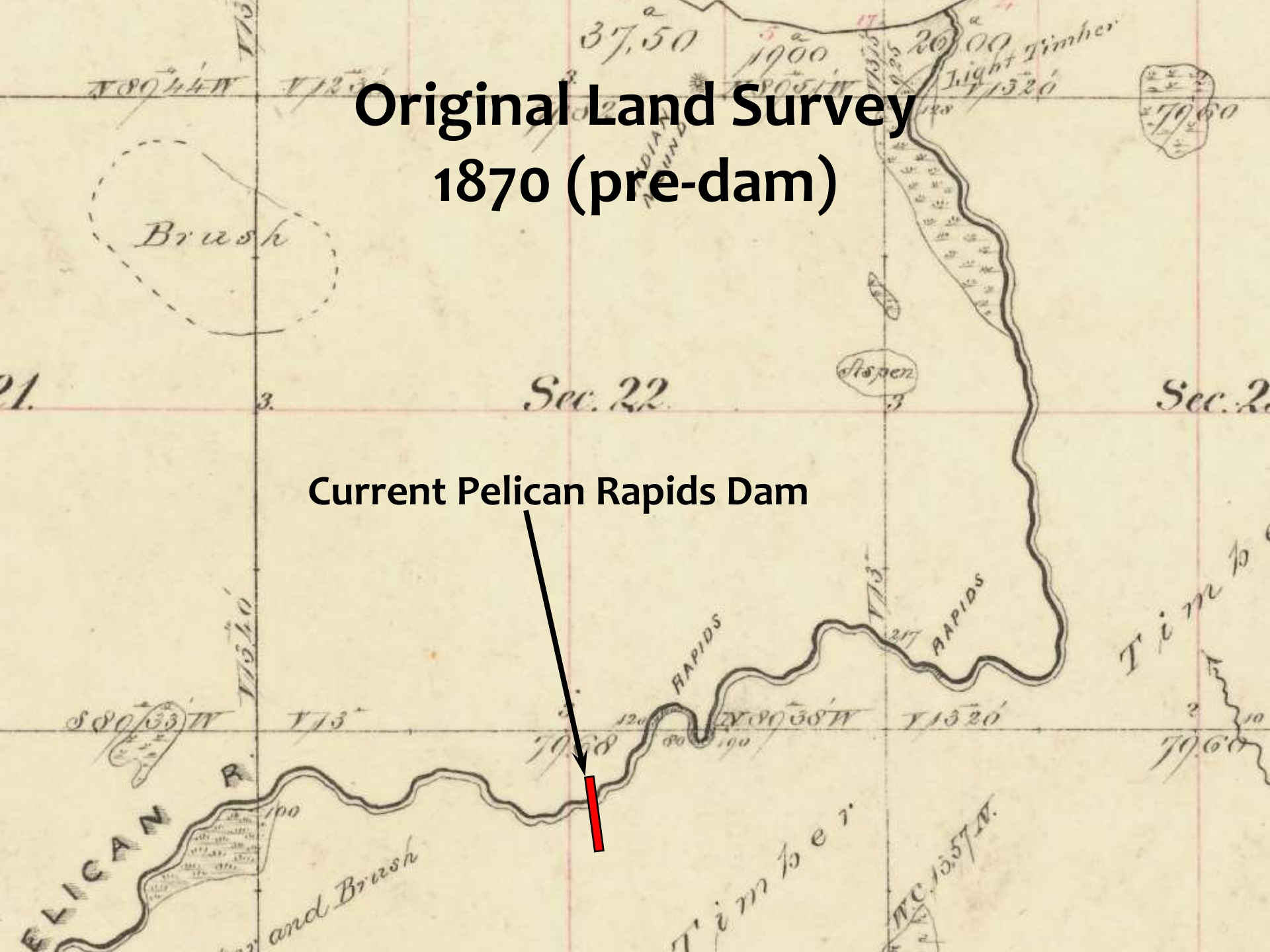
# Pelican Rapids Dam

## Built in 1870
## 14 feet high

- 11 fish species found in the Pelican river are absent from surveys upstream of Pelican Rapids and Elizabeth Dams.
- 35 fish species found in the Otter Tail watershed are absent upstream of Pelican Rapids Dam.
- The Pelican River upstream of Elizabeth got failing IBI scores in PCA surveys
- The highest IBI score in the Red River Basin was downstream of Orwell Dam

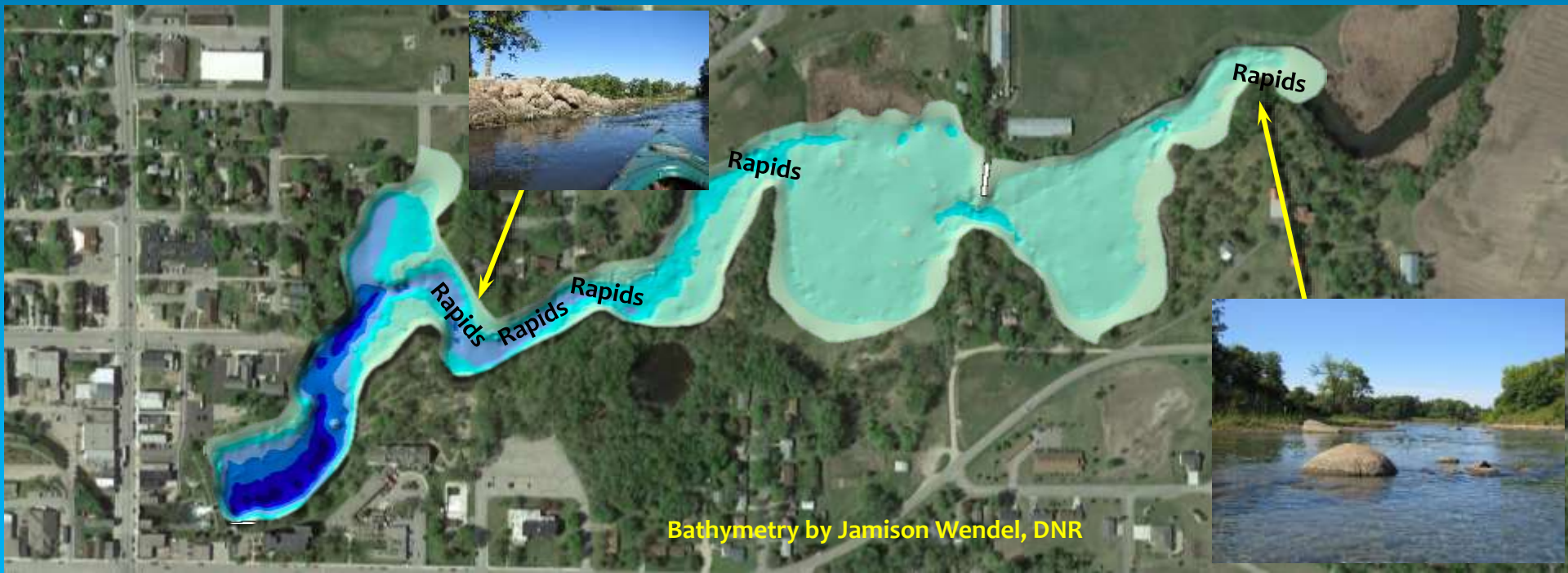

Pelican River Profile
Elevation
1470
1420
1370
1320
1270
1220
1170
1120
90
80
70
60
50
40
30
20
10
0
Distance from Confluence with Otter Tail River
Dunton Locks
Bucks Mill (historic rapids)
Historic rapids
Fish Lake
Lake Lizzie
Prairie Lake
Pelican Rapids
Historic rapids
Elizabeth
Historic rapids

# Original Land Survey
# 1870 (pre-dam)



Historic Pelican Rapids
1st St NE
1st Ave NE
E Mill St
108
59

Drone image by Houston Engineering




Bathymetry by Jamison Wendel, DNR

*"Humankind has not woven the web of life. We are but one thread within it. Whatever we do to the web, we do to ourselves. All things are bound together. All things connect."*
*~ Chief Seattle*