Ecological Considerations for Designing Stream Crossings

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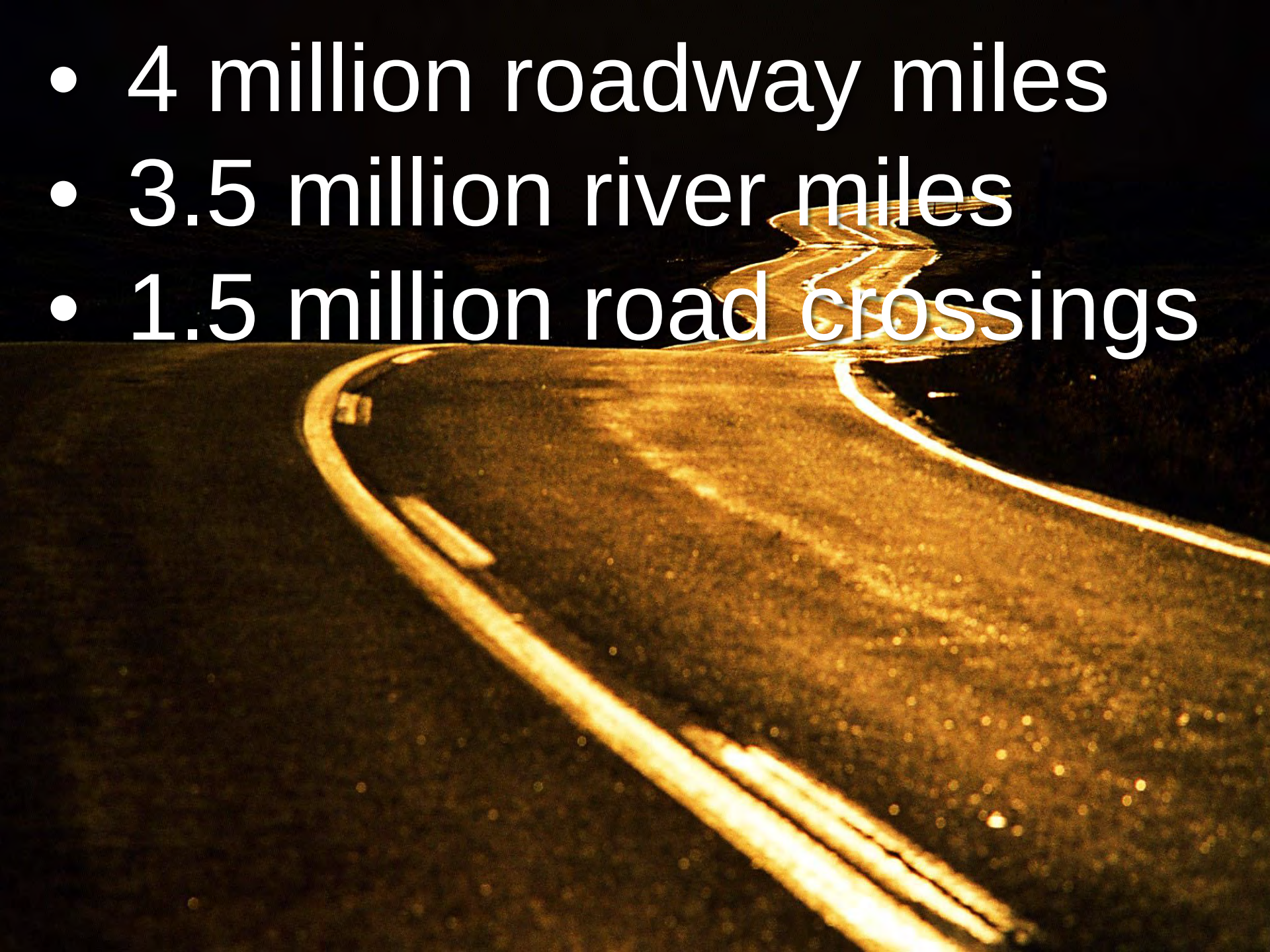
or,
Why did the fish
cross the road?



- 4 million roadway miles
- 3.5 million river miles
- 1.5 million road crossings

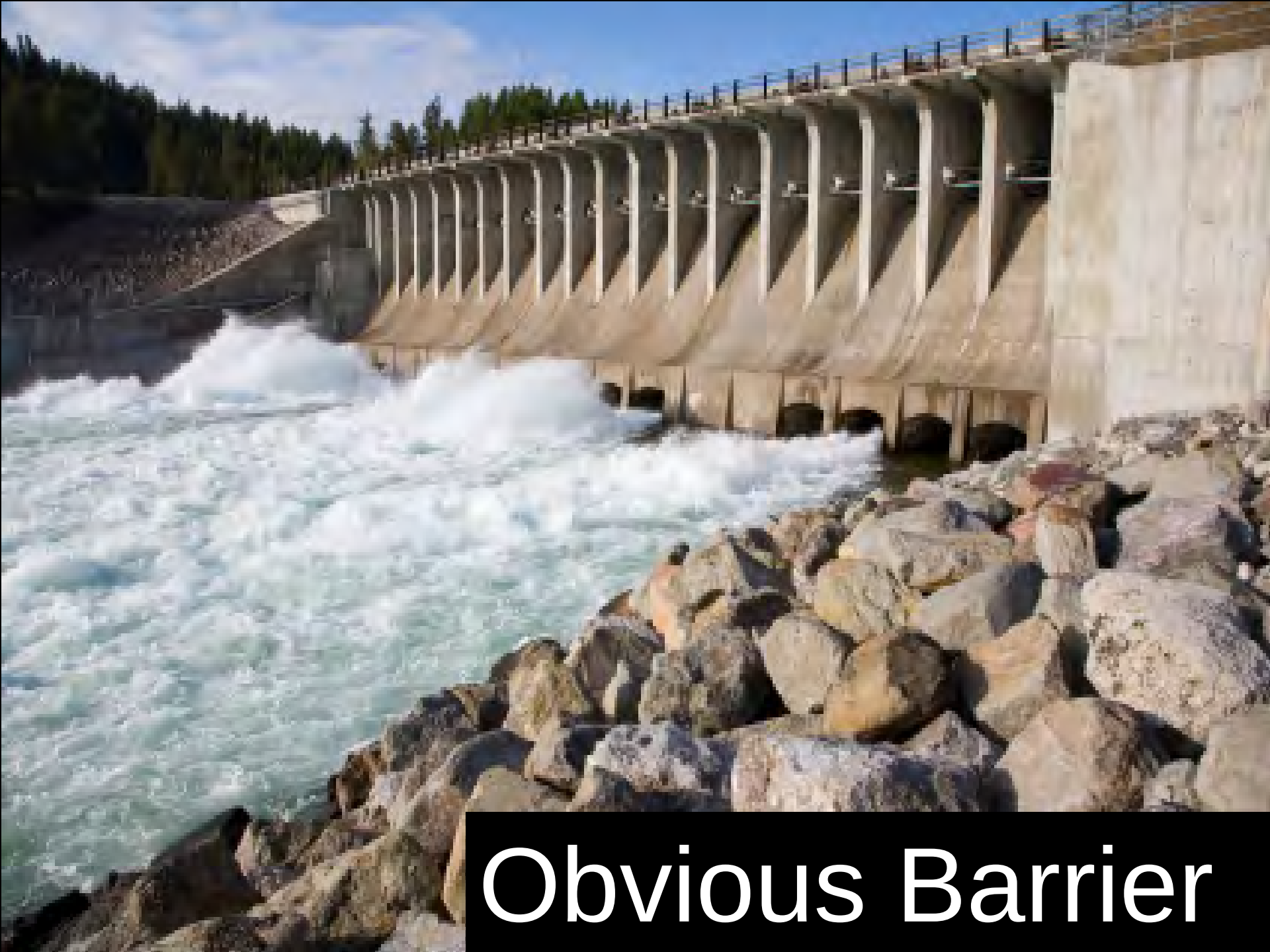
Overview:

1. Importance of continuity
2. How streams get fragmented
3. Estimates of the threat

1. Ecological Importance of Stream Continuity

To function, both roads and rivers need to be connected.

What ecologic functions are lost?


Obvious Barrier

Less obvious barriers

Primary design consideration:

move water

Less obvious barrier
(is this stream continuous?)

Blandings Turtle

- Semi-terrestrial
- 1.5 mi. home range
- 17 yrs. to maturity
- Reproduce for decades

Go Badgers!
Stream corridors increasingly important wildlife pathways

River Continuum Concept:

- From headwaters to mouth, streams change:
  - Size
  - Temperature
  - Habitats
  - Energy Sources

- Each section is dependent upon the entire stream.

Fish Migration

Numerous species migrate, most will disperse

Upstream spawning migrations of trout

Clean, well-oxygenated gravel for egg incubation

Nursery habitats for young

Downstream movements to overwintering habitats:

- Trout
- Catfish
- Smallmouth bass
- Turtles

Fragmentation impacts to trout

Reduced:

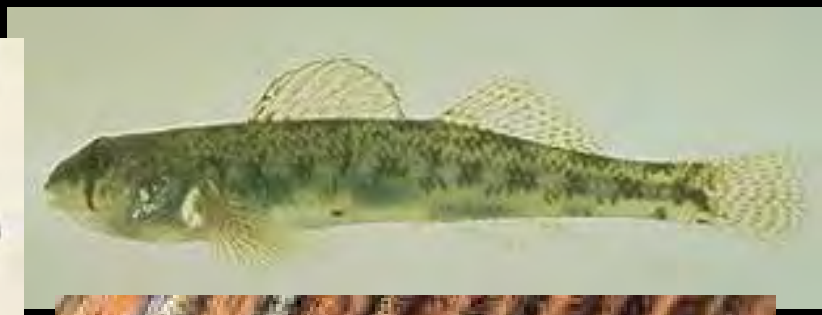
- Stream productivity
- Stream carrying capacity / shift towards younger fish
- Genetic vigor / shift towards smaller adults

March of the Mayflies

Significant (100s of m) upstream movement of mayflies, amphipods, snails.

Turtles too!

Fragmentation influences animal interdependancies



The occurrence of some species are dependant on the presence of others

Whether turtle or trout, the environment is often a patchy place. Habitats, food, mates, are <u>not</u> always found in one place.

2. How Streams Get Fragmented

Raised “perched” outlets make ponds out of streams

- Impounds water
- Raises water level
- Widens channel
- Slows flow, deposits silt
- Warms water

Perched Outlets

One – way biological check valves

Animals differ in their ability to move against stream currents

Culverts often create a single (high) velocity environment

Culvert length

- **Behavioral barrier**:

  Dark, ***Scary*** place; avoidance by wildlife

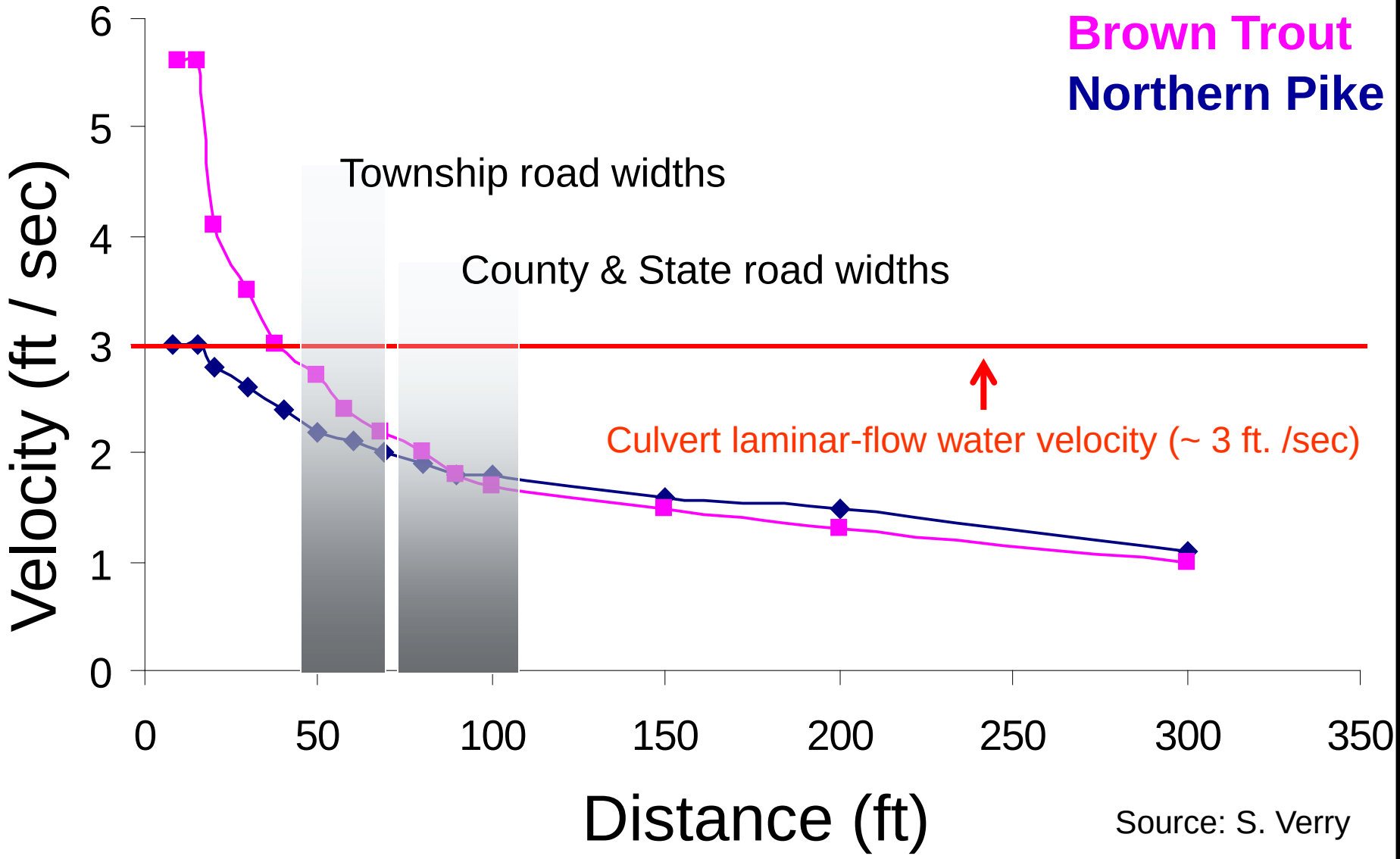
- **Physical barrier**:

  Fish or amphibians may tire before reaching upstream end of culvert

Fish sustained swimming speeds

Fish Species	**Size** (inches)	**Speed** (ft/sec)
Brook Trout	4	1.0
Northern Pike	24	1.4
Brook Trout	8	1.5
B. Stickleback	2	1.5
White Sucker	8	1.6
Walleye	16	2.5
Redhorse Sucker	8	4.0
Brown Trout	8	5.0

Fish swim distance Vs. water velocity



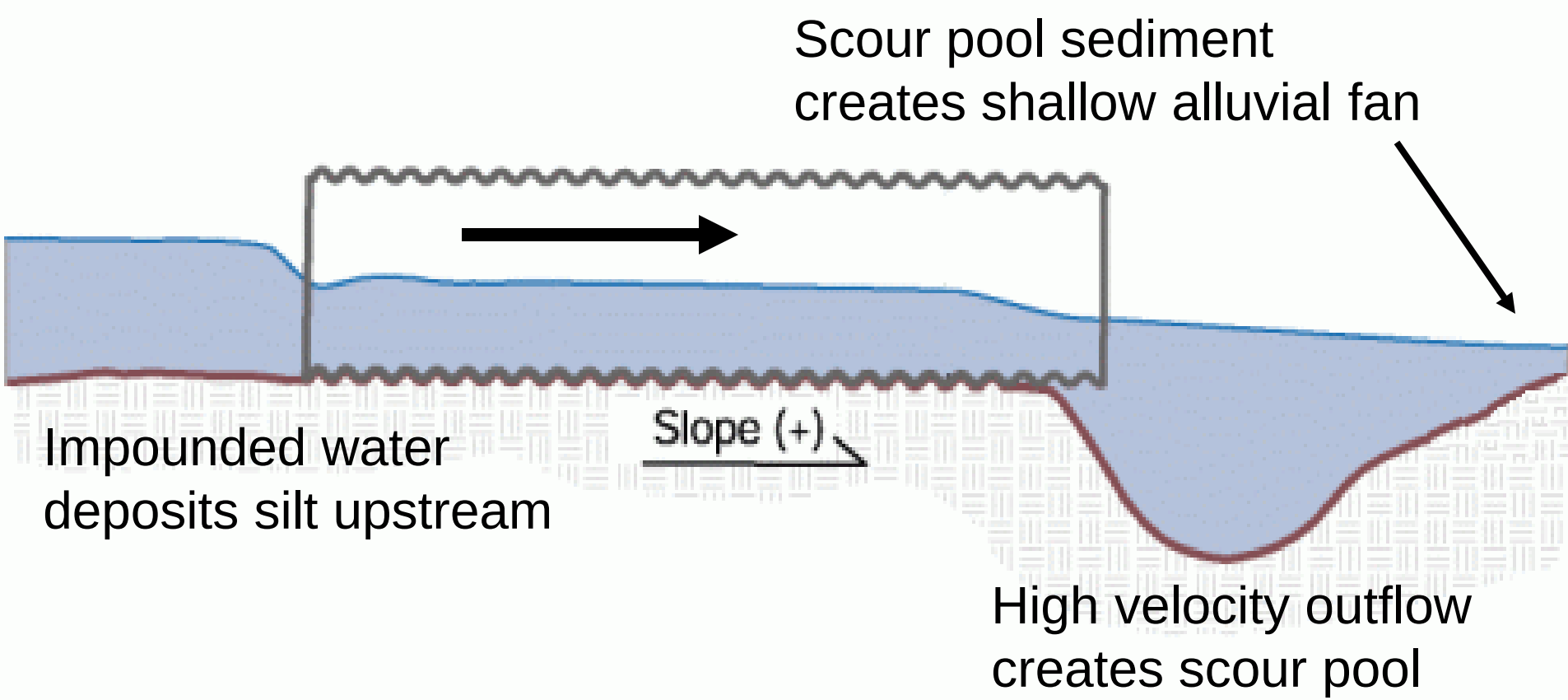
Source: S. Verry

Water depth

Shallow water =

- Avoidance by fish
- Inefficient swimming
- Reduced passage potential

Streambed alterations



Effects of undersized or improperly set culvert

Debris

- Blockage
- Constrictions increase water velocity

Rip – rap can become
pits-traps for young,
or attract nesting animals
to dangerous environments

3. Estimates of the threat in Wisconsin and elsewhere

Is fish passage an issue?

- Manitowish River Headwaters, WI (2009)
  77% of crossings were barriers
- Pine and Popple Rivers, WI (2007)
  20% of crossings were barriers
- Etowah R. Basin, GA (2006)
  34% of crossings…
- Upper Cheat R., WV (2005) **69%** of culverts…
- Jefferson Co., WA (2000) **50%** of culverts...
- Humboldt Co., CA (2000) **37%** of culverts…

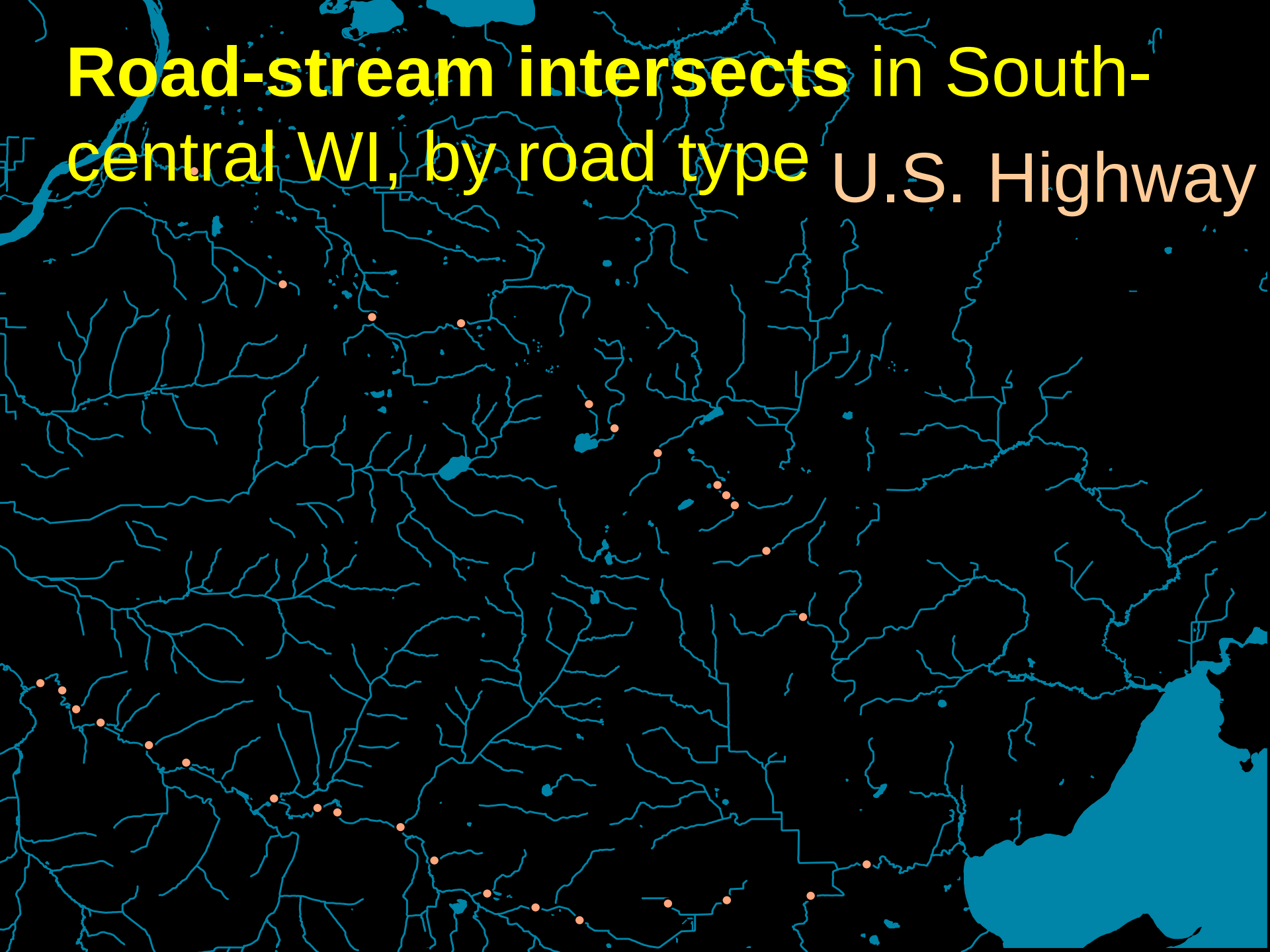
Estimated number of crossings in Wisconsin

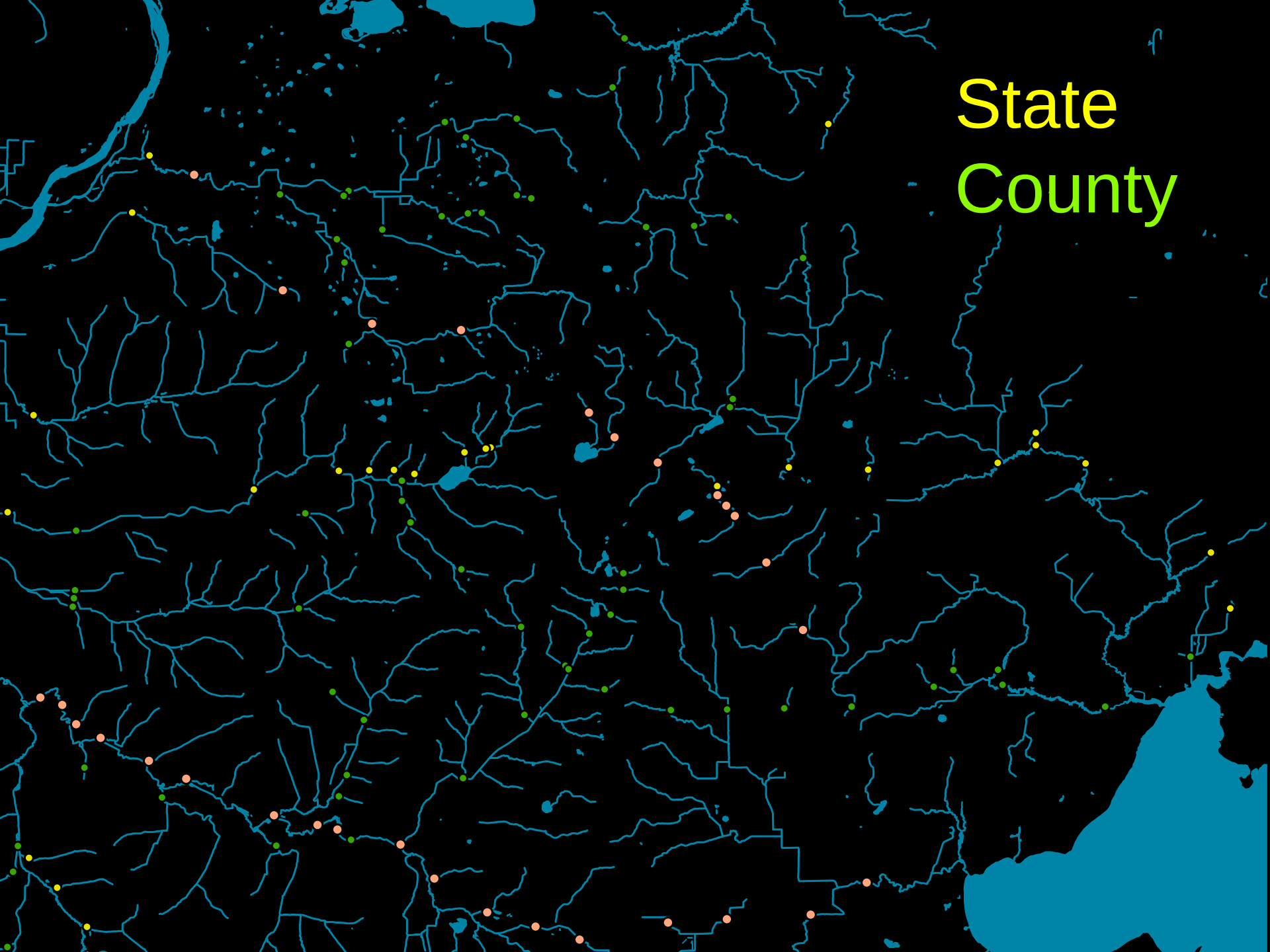
By road type:

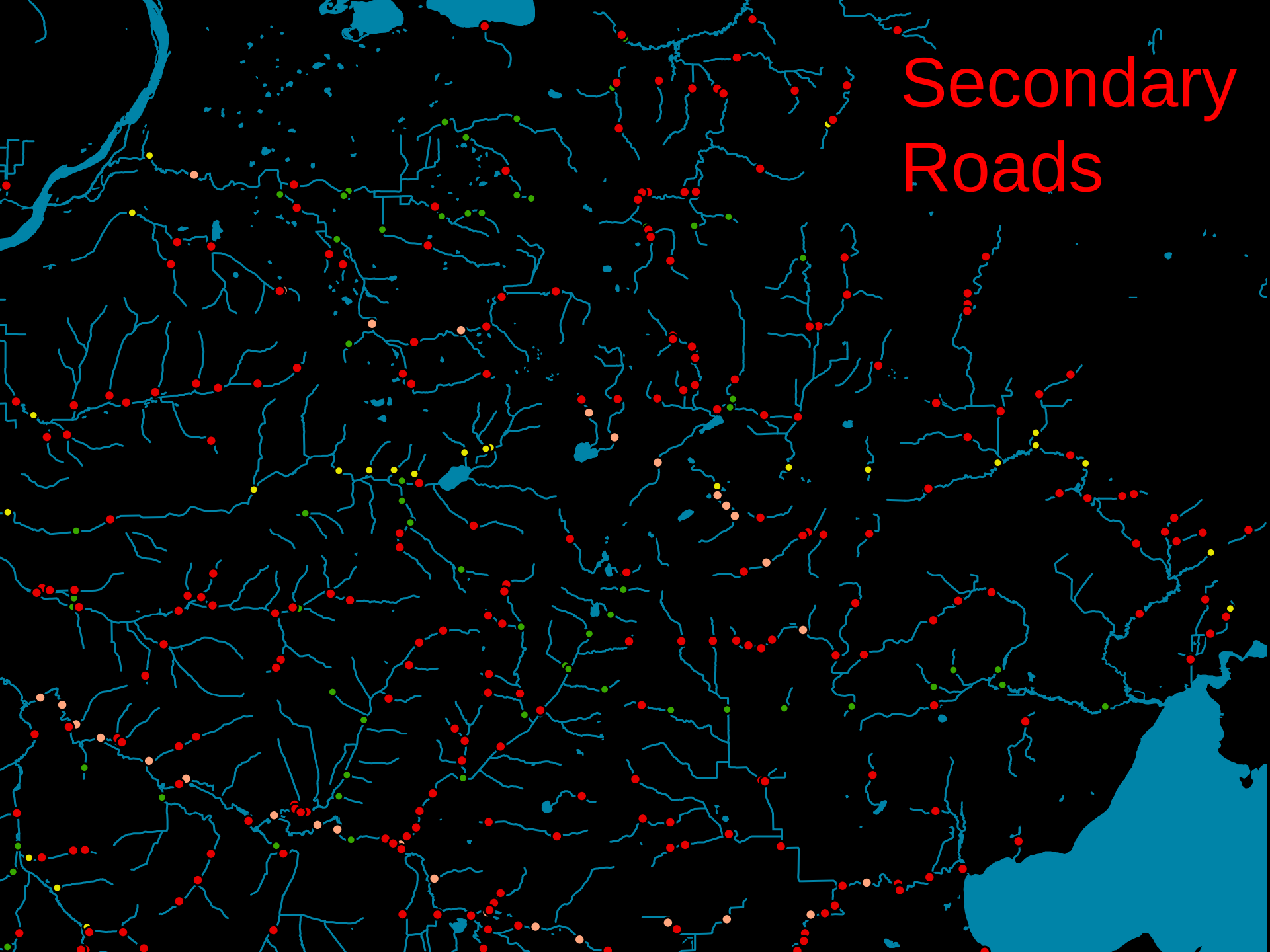
- Interstate Highway: 817
- U.S. Highway: 1,982
- State Highway: 5,341
- County Highway: 12,776
- Secondary Road: 41,055

N = ~ 62,000 road-stream crossings

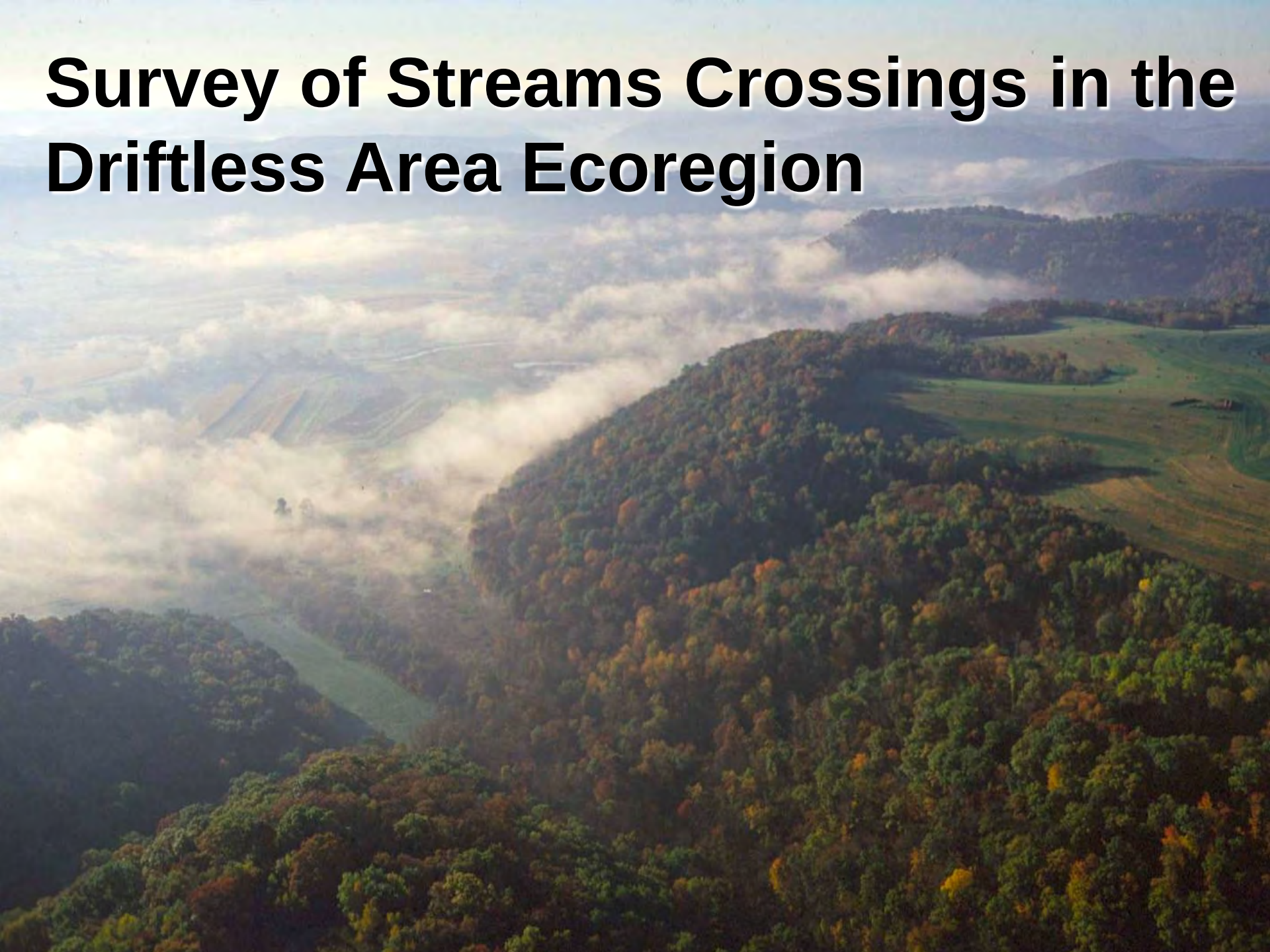
Road-stream intersects in South-central WI, by road type



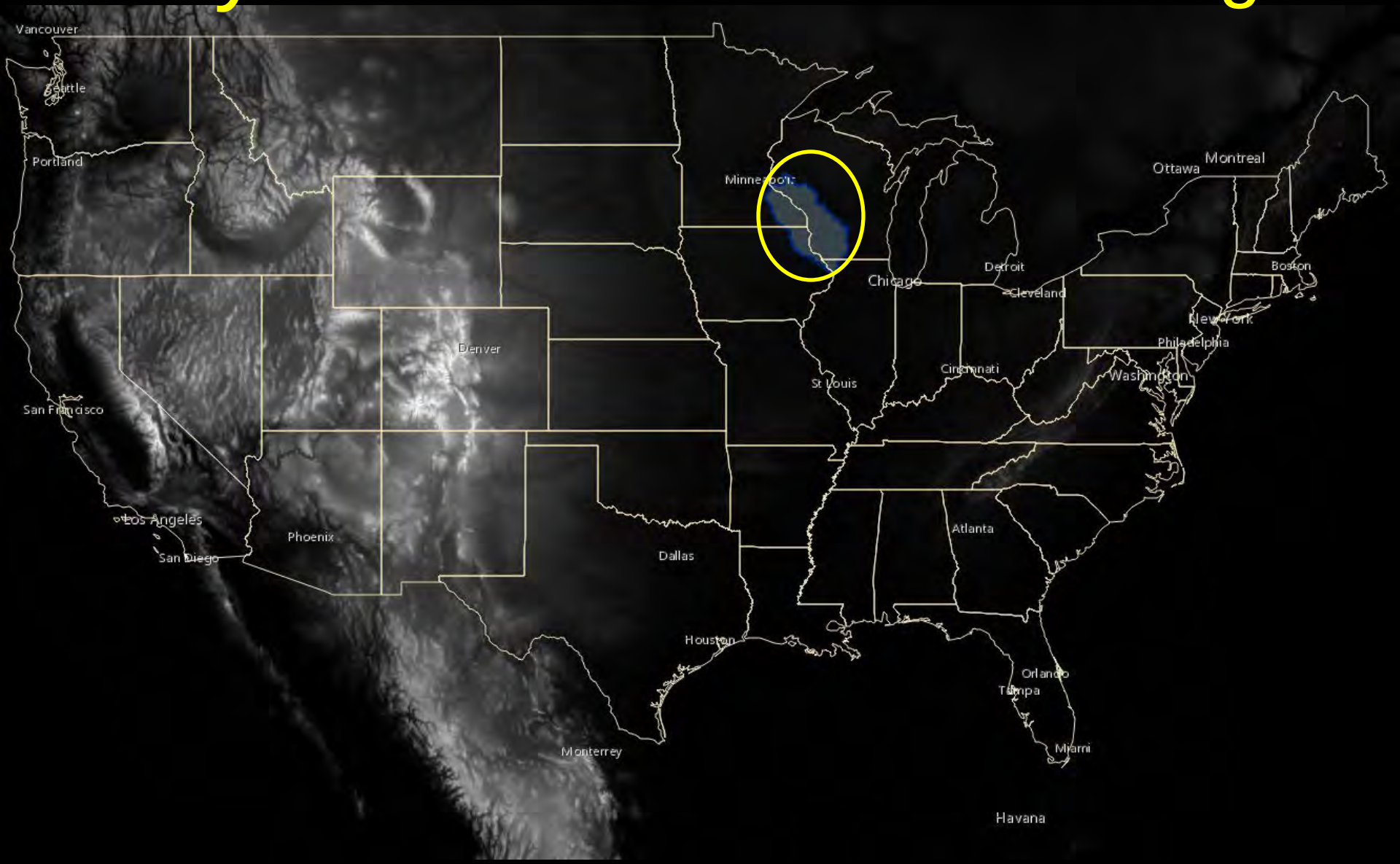

State
County

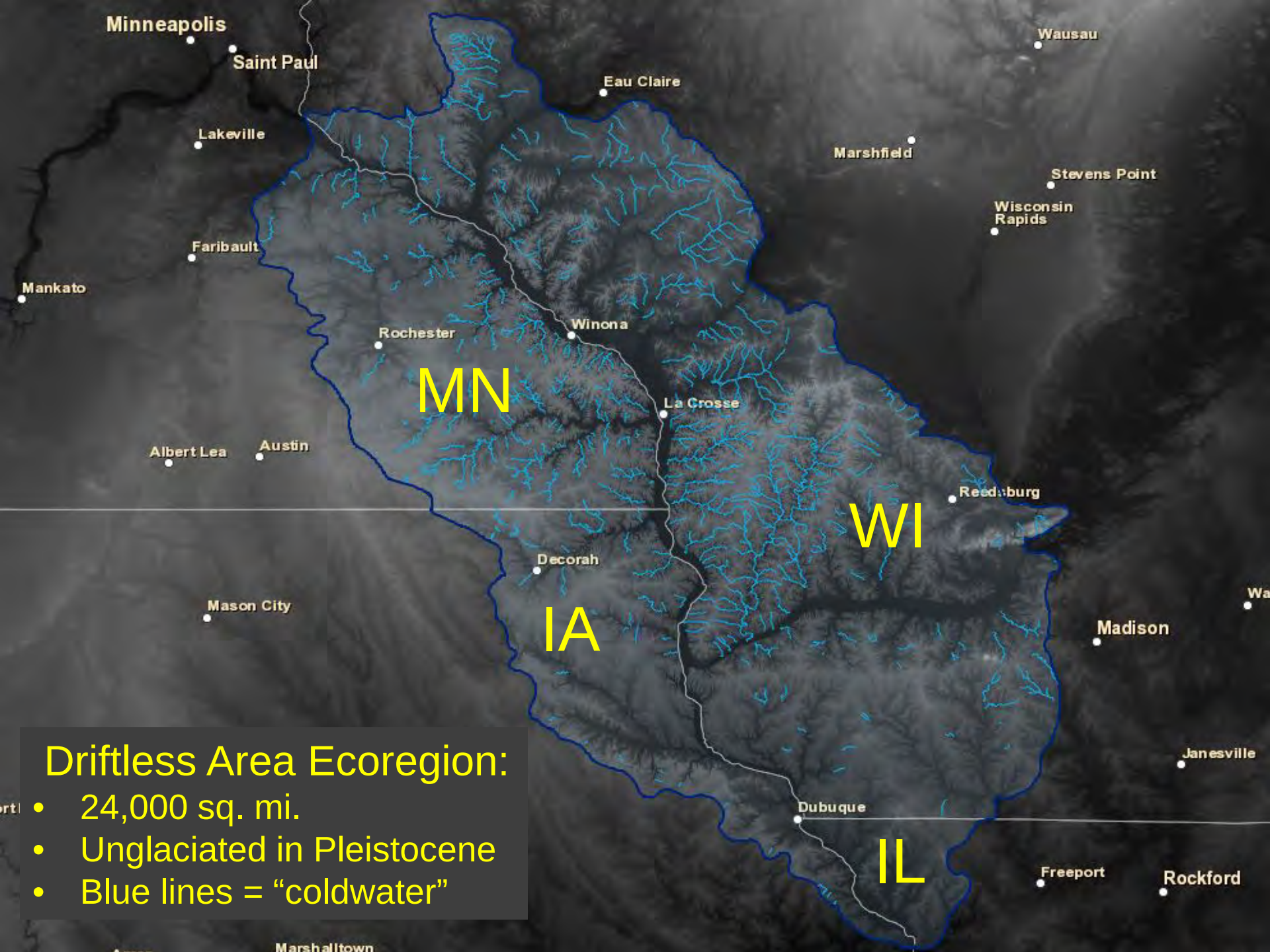

Secondary
Roads

Survey of Streams Crossings in the Driftless Area Ecoregion



Study Area: Driftless Area Ecoregion





Driftless Area Ecoregion:

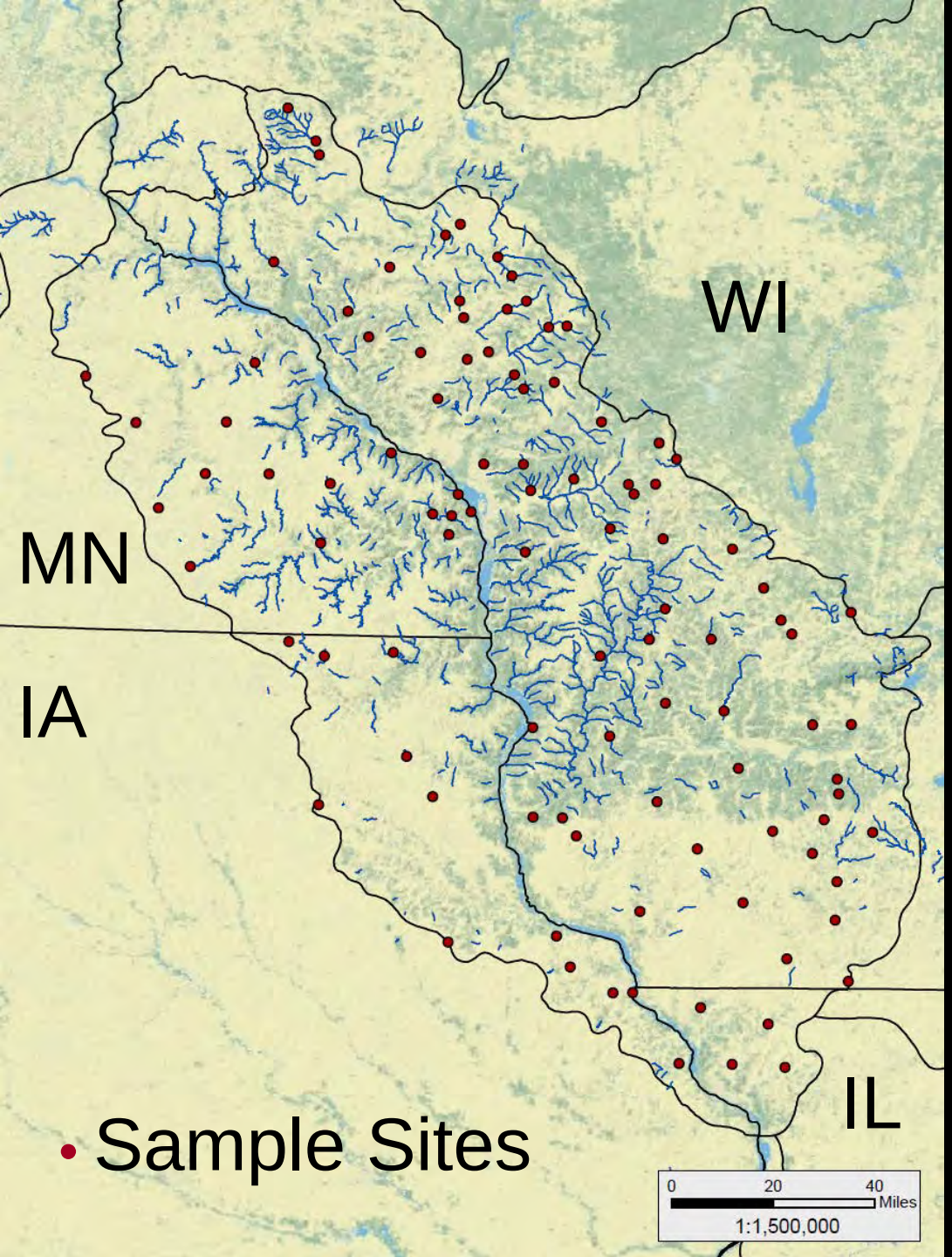
- 24,000 sq. mi.
- Unglaciated in Pleistocene
- Blue lines = “coldwater”

Groundwater recharge, discharge
Cold, stable, baseflow
3,600 miles “trout” streams

$600 million in direct spending on trout angling in Driftless Area each year*

* **Source**: North Star Economics Inc.

Study Design



Sampling Design:

- NHD & TIGER data
- 8,660 intersects IDed
- n = 100
- Probabilistic

Barrier Classes:

Complete barrier:

- Perched structure
- Structure water velocity > 3 fps
- Structure / stream water depth ratio < 0.1

Barrier for some species or flows:

- Structure water depth (< 0.2’)
- Structure water velocity 2 – 3 fps
- Structure length (> 30’) w/o substrate

Temporary, high – flow barrier:

- Constriction ratio (< 0.5)
- Scour pool present

Not a barrier to fish passage

Results and Implications

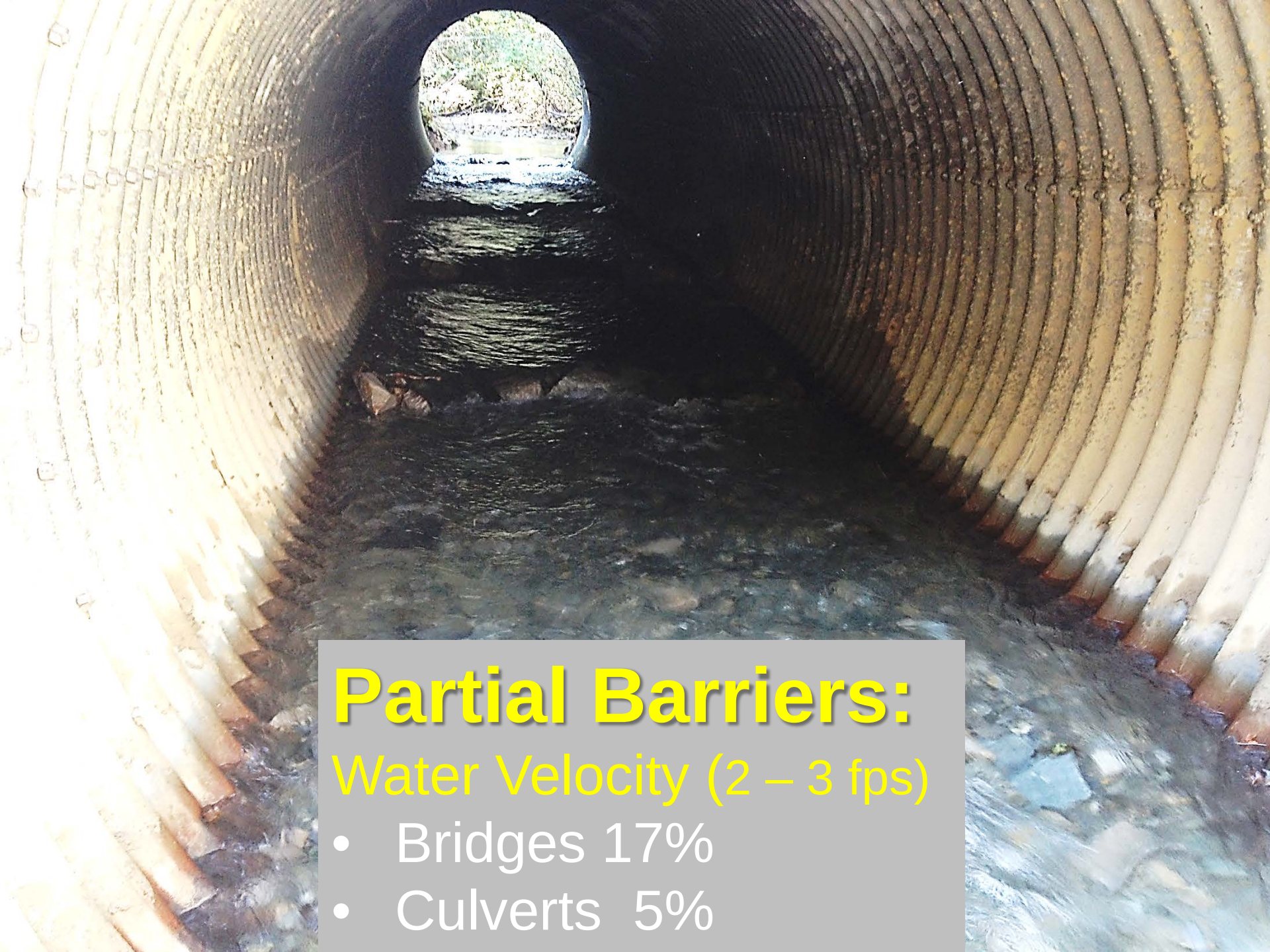
Complete Barriers:

- 10% of culvert sample
- 2% of bridge sample

Partial Barriers:

Structure > 30’ long
w/o substrate

- 49% of culvert sample
- 2% of bridge sample



Partial Barriers:

Water Velocity (2 – 3 fps)

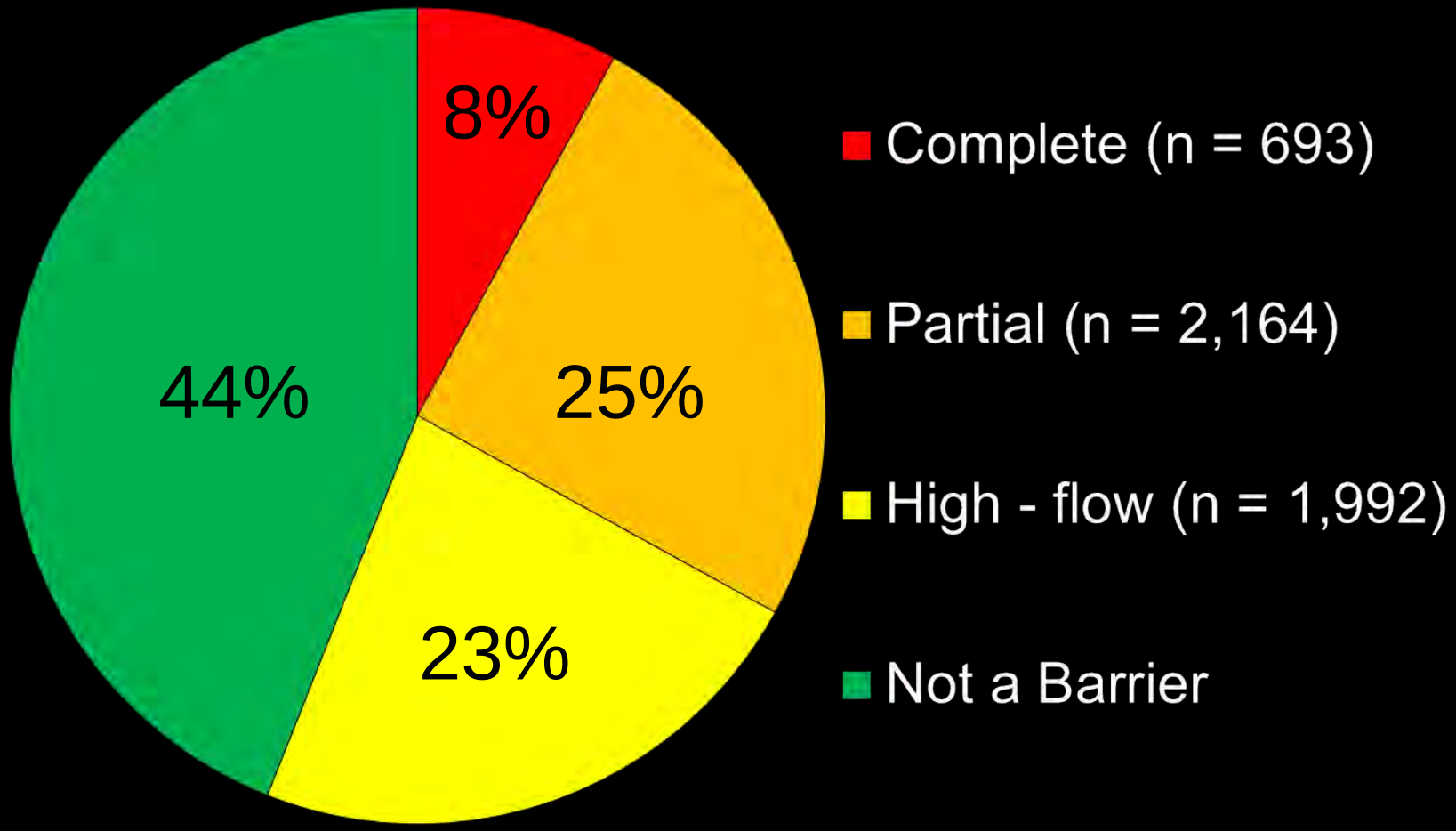
- Bridges 17%
- Culverts 5%

Temporary (High Flow) Barriers:

- Culverts: 33% of sample
- Bridges: 24% of sample

Roadway Barrier Proportions and Total Number Estimates

(crossing N = 8,660)



Summary:

What was learned?

- Significant proportion of crossings are barriers; types IDed

What difference does it make?

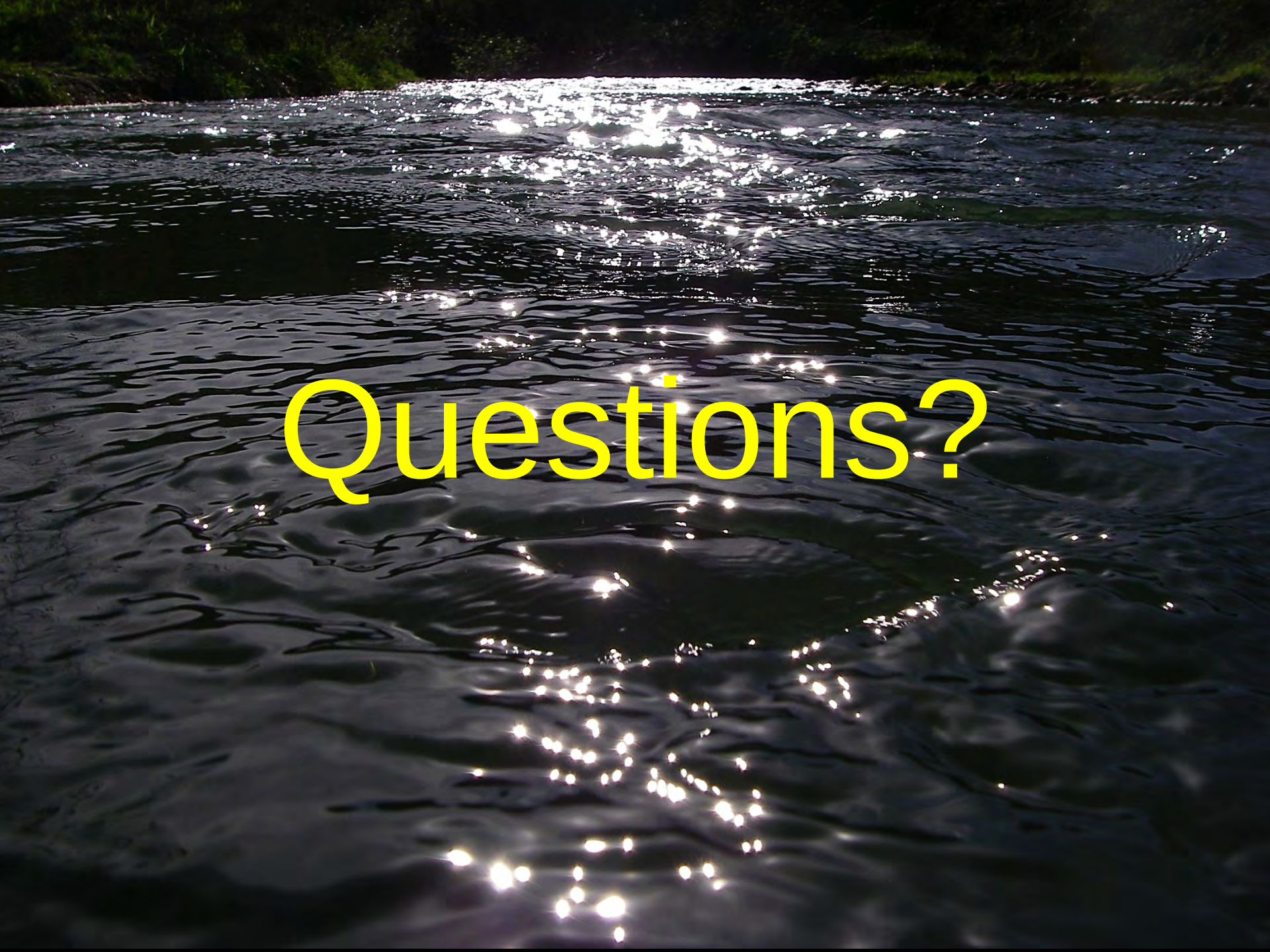
- Information to improve crossing constructions and retrofits

What is the benefit to the public?

- ID problems, spur actions to improve stream continuity

What does it mean for this audience?

- Raise your awareness and understanding of the problem


Questions?