



Columbia Environmental  
Research Center

## *River Corridor Habitat Dynamics*

# Flow, Form, and Fish Responses in An Intensively Engineered River System: The Lower Missouri River

Robert B. Jacobson  
Duane C. Chapman  
Aaron J. Delonay  
Harold E. Johnson, III

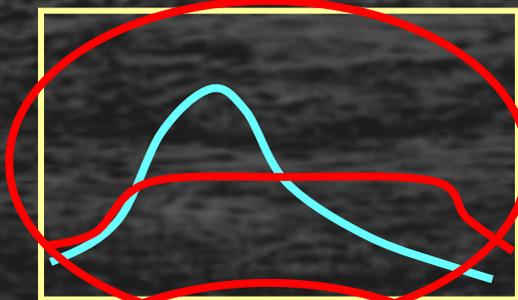
U.S. Geological Survey  
Columbia, Missouri

U.S. Department of Interior  
U.S. Geological Survey

[rjacobson@usgs.gov](mailto:rjacobson@usgs.gov)

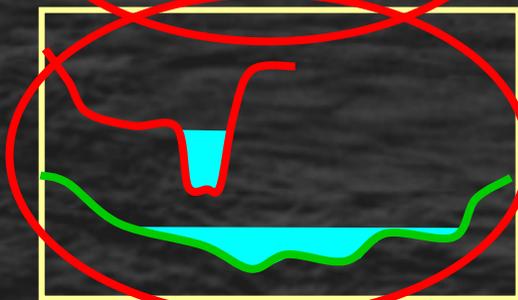
**INDEPENDENT AND  
MANAGEABLE VARIABLES**

**FLOW REGIME**



**HYDROLOGIC ANALYSIS,  
IHA, ETC.**

**CHANNEL FORM**



**INSTREAM HYDRAULICS**

**TEMPORAL &  
SPATIAL  
DISTRIBUTION  
PHYSICAL  
HABITAT**

**ECOSYSTEM  
STRUCTURE  
&  
FUNCTION**

**BIOTA OF  
INTEREST**

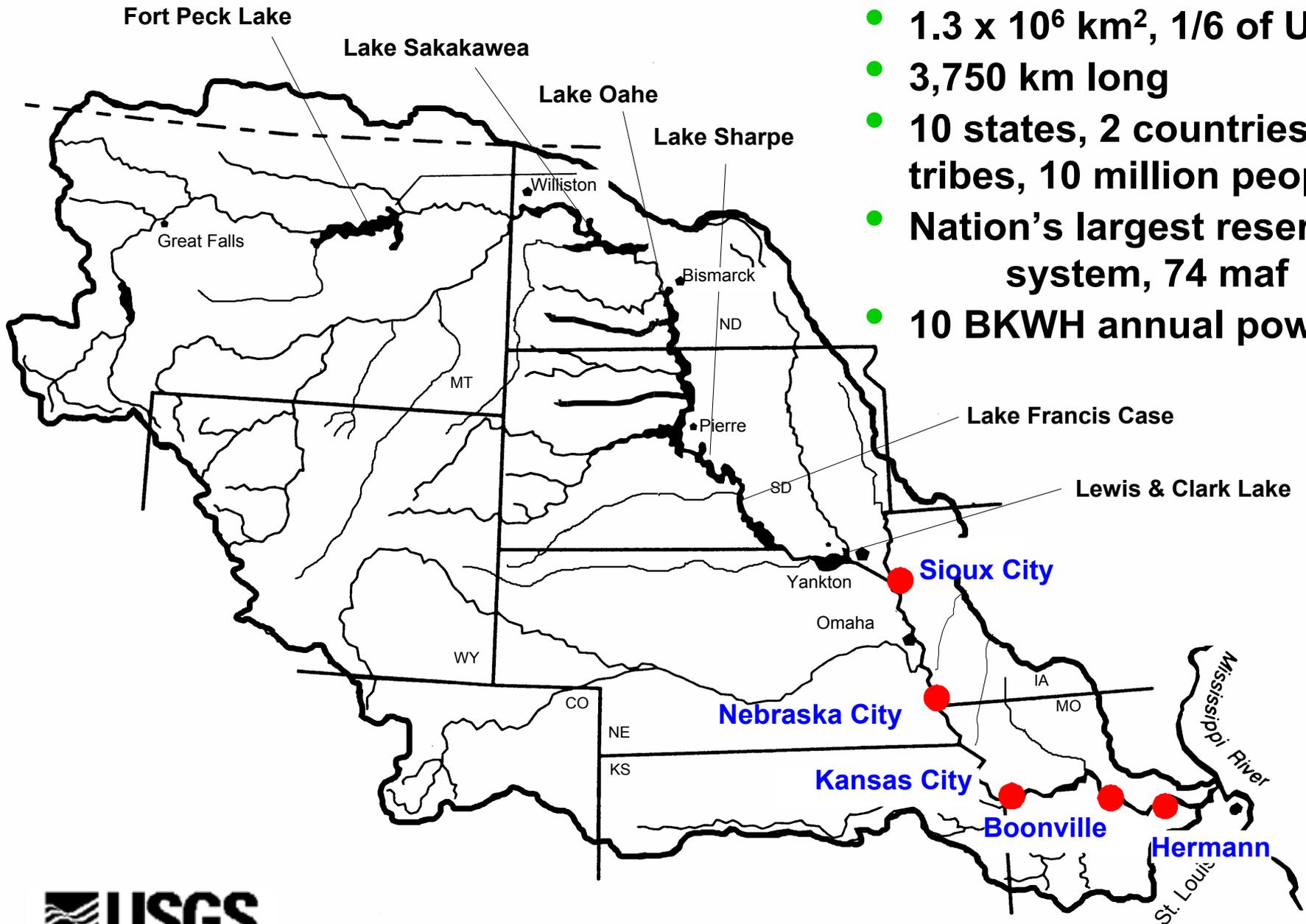
**GEOMORPHIC ANALYSIS**

## *Large, intensively engineered rivers:*

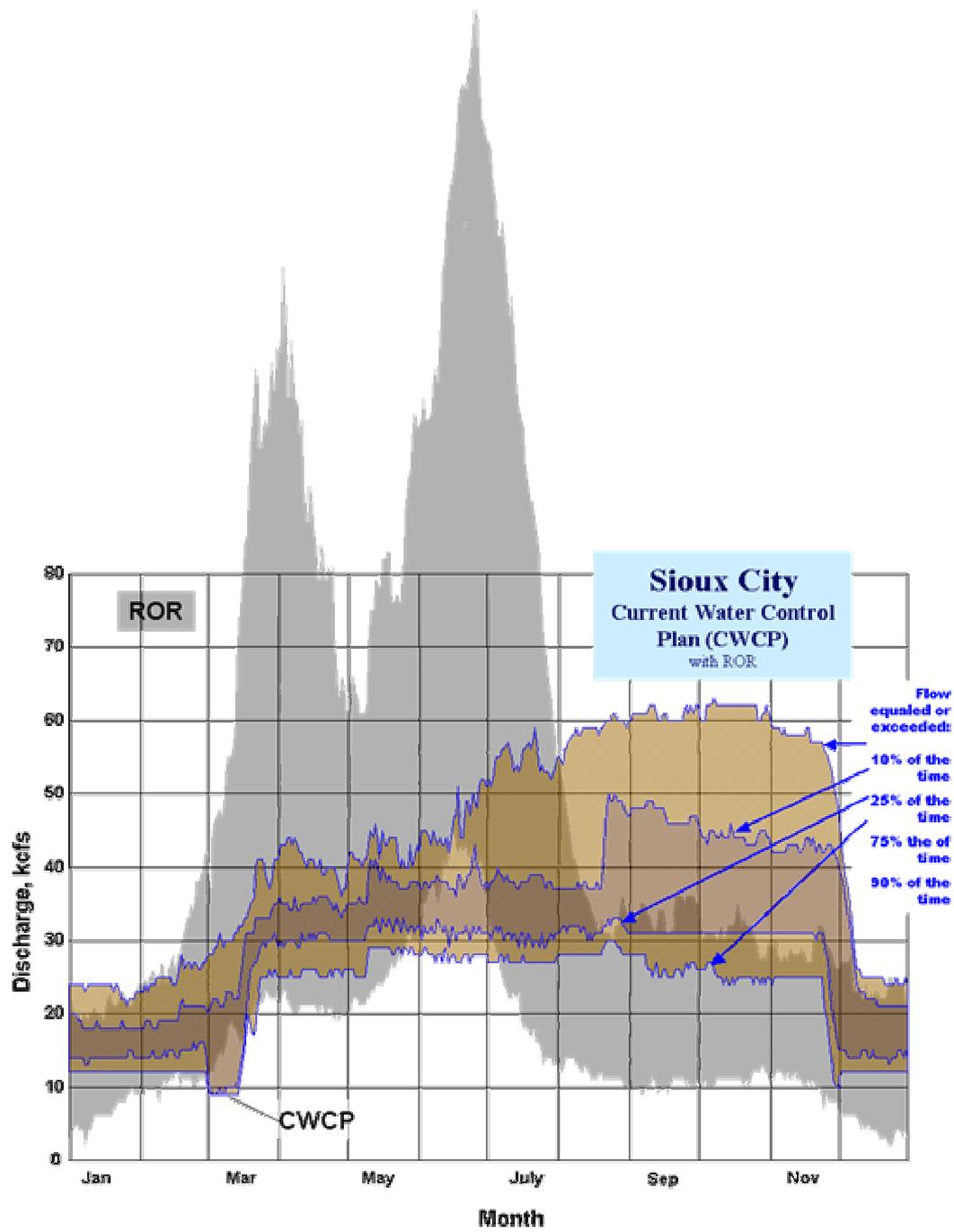
*Physical habitat template is controlled by two (mostly) independent variables:*

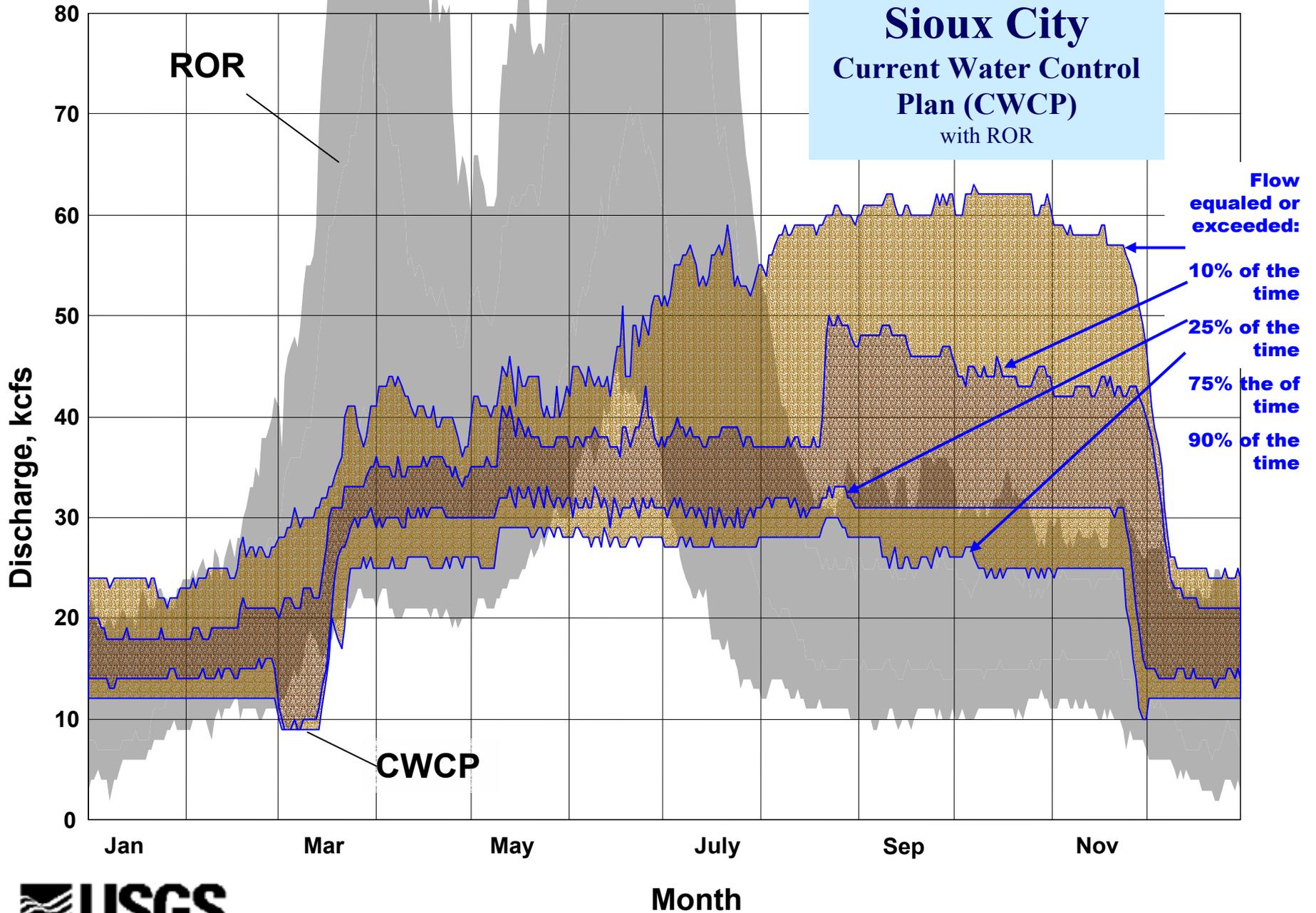
- Flow Regime – quantity of water in river corridor, timing, seasonality
- Geomorphic Form – how water is distributed to achieve attributes of depth, velocity, substrate





- 1.3 x 10<sup>6</sup> km<sup>2</sup>, 1/6 of US
- 3,750 km long
- 10 states, 2 countries, 28 tribes, 10 million people
- Nation's largest reservoir system, 74 maf
- 10 BKWH annual power





# Geomorphic Alteration

## Lower Missouri River

### Indian Cave Bend, Nebraska

Photos: U.S. Army Corps of  
Engineers



1934



1935



1977

# Wing Dikes: A Major Habitat Feature of the Lower Missouri River





**Pallid Sturgeon**

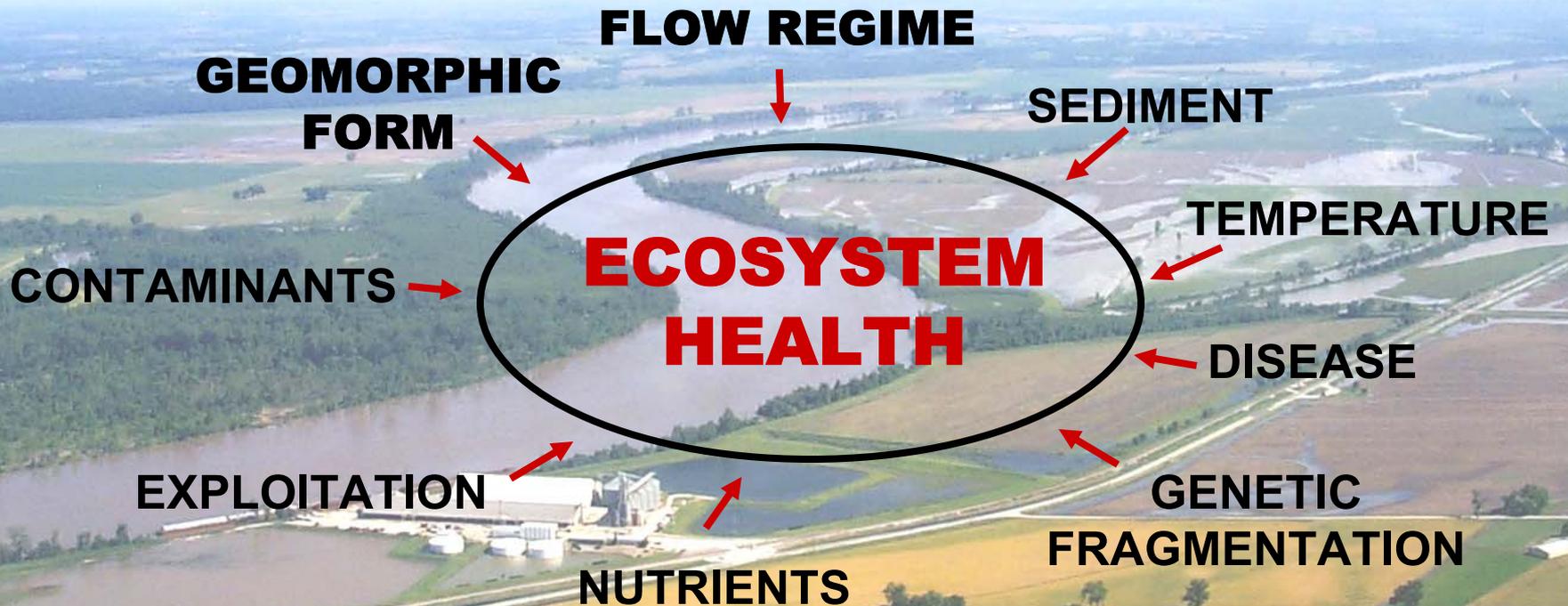


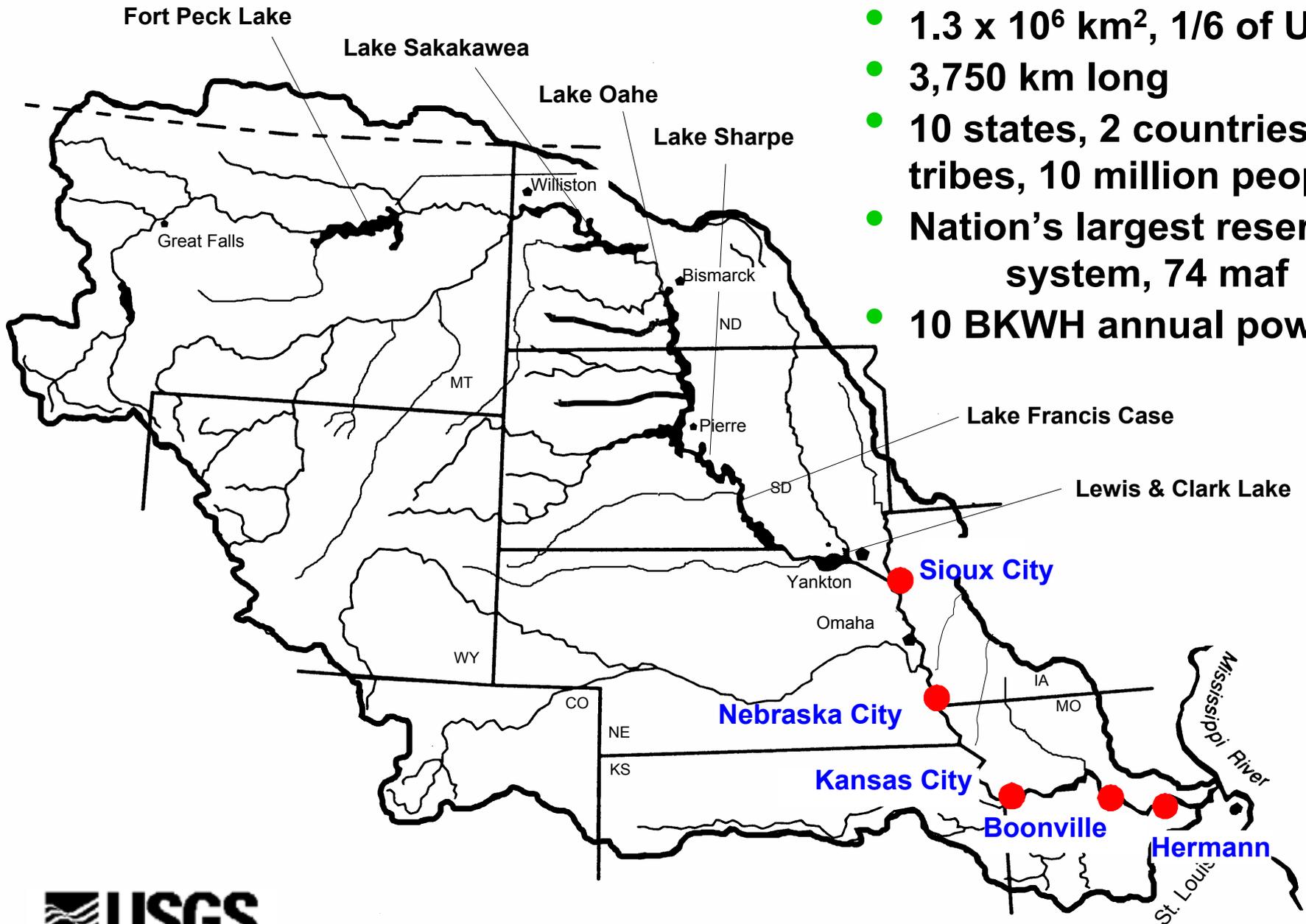
**Interior Least Tern**



**Piping Plover  
(threatened)**

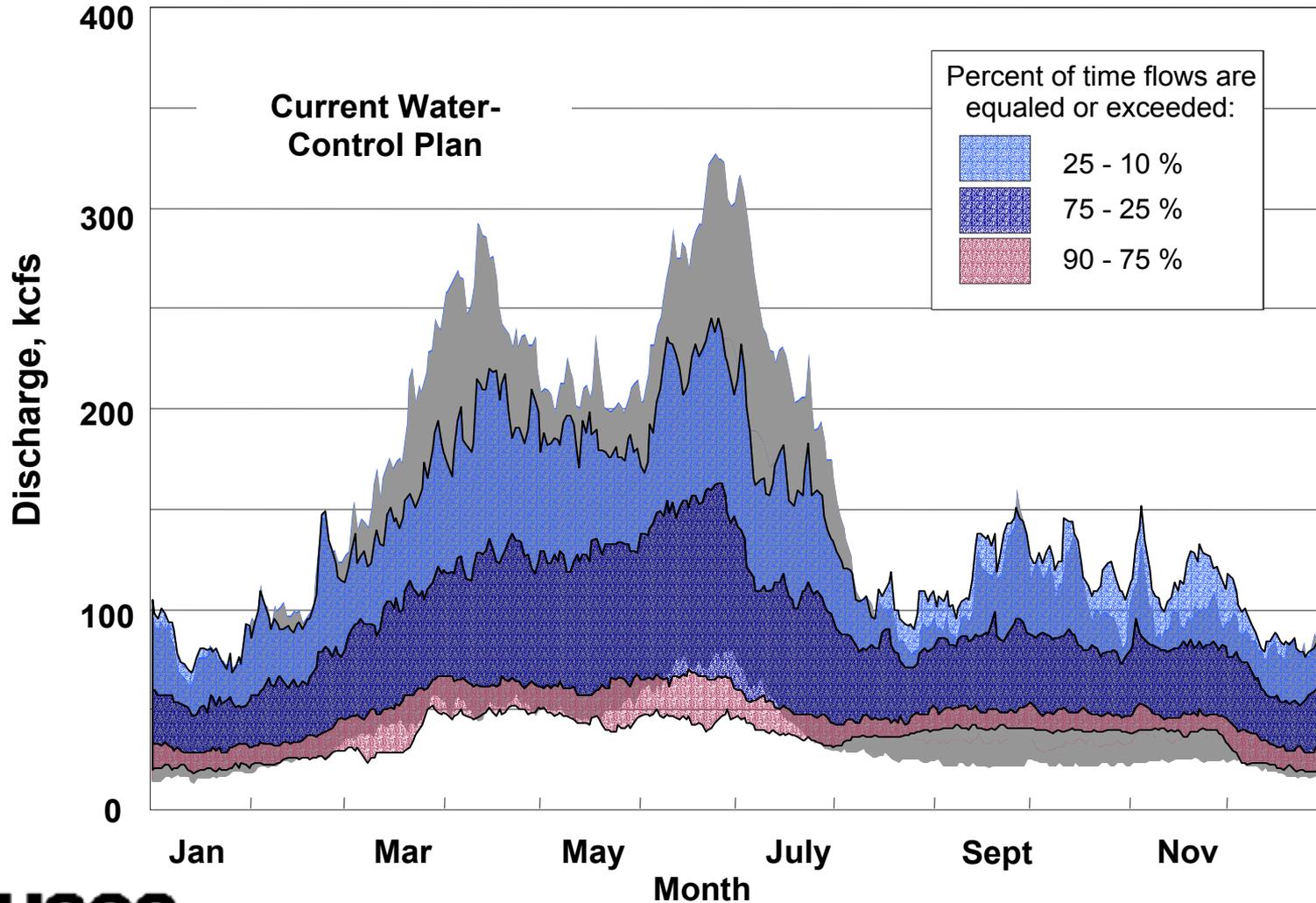
# Stresses on Lower Missouri River Ecosystem





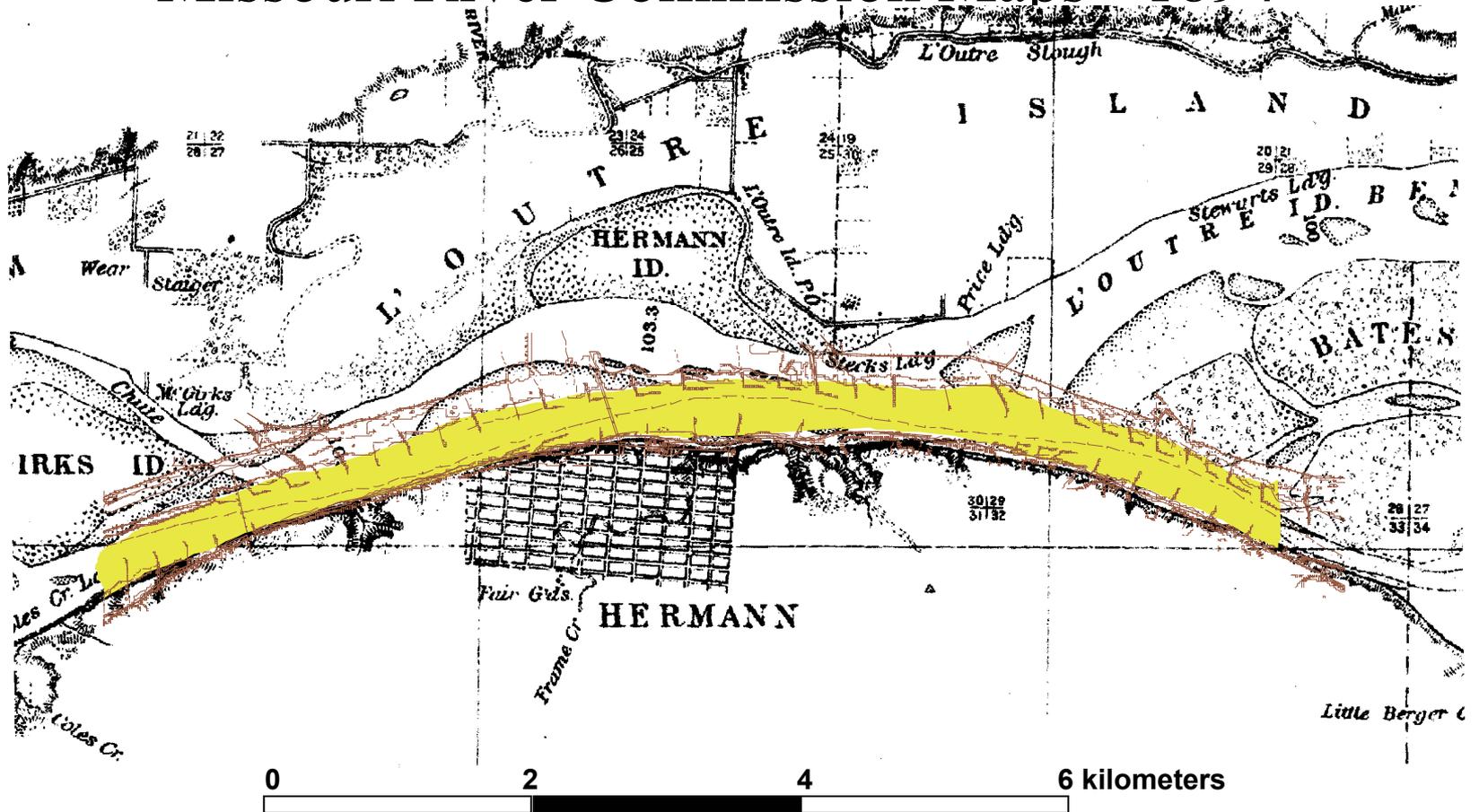
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# Hydrologic Alteration, Hermann, Missouri

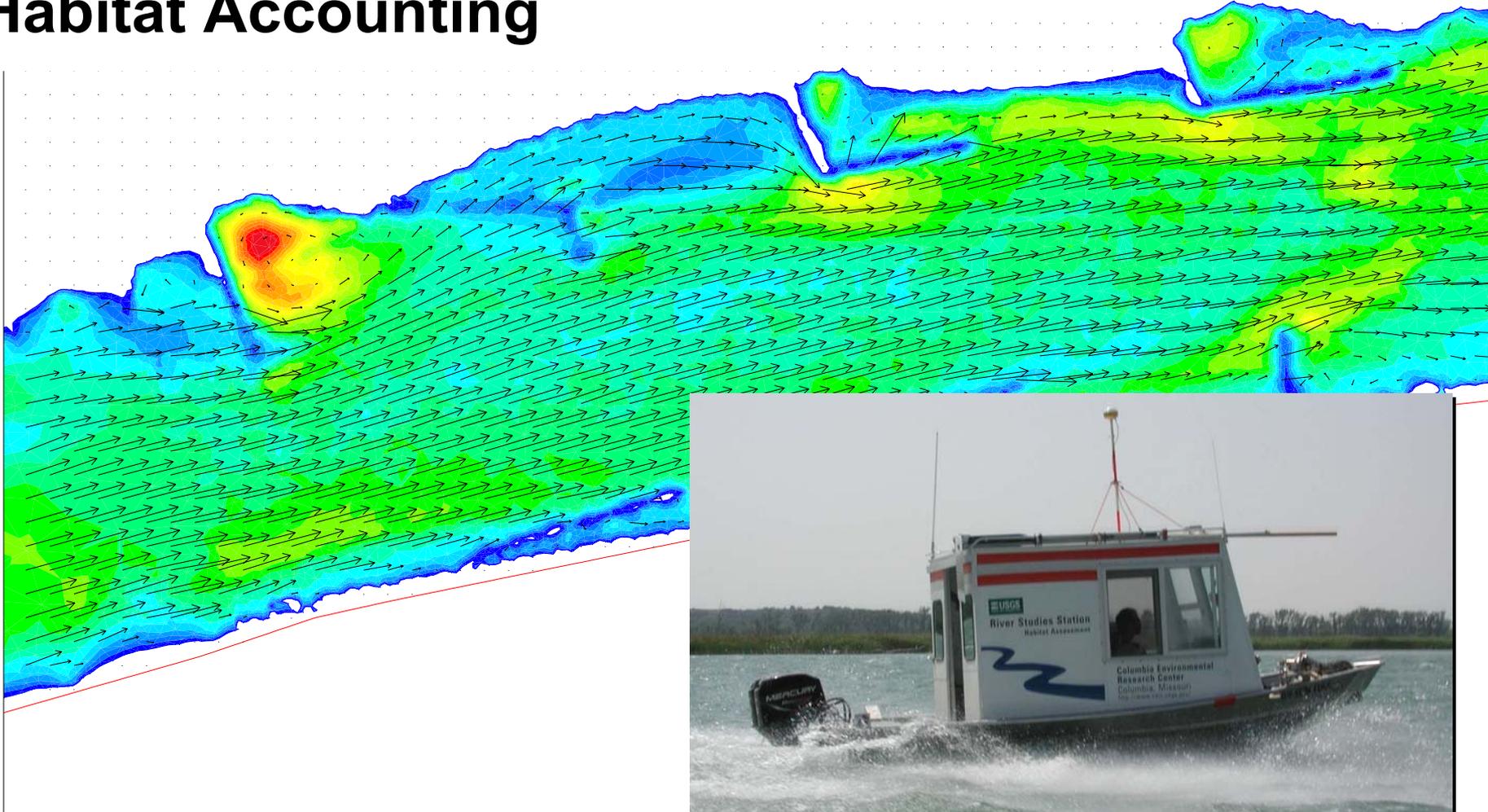


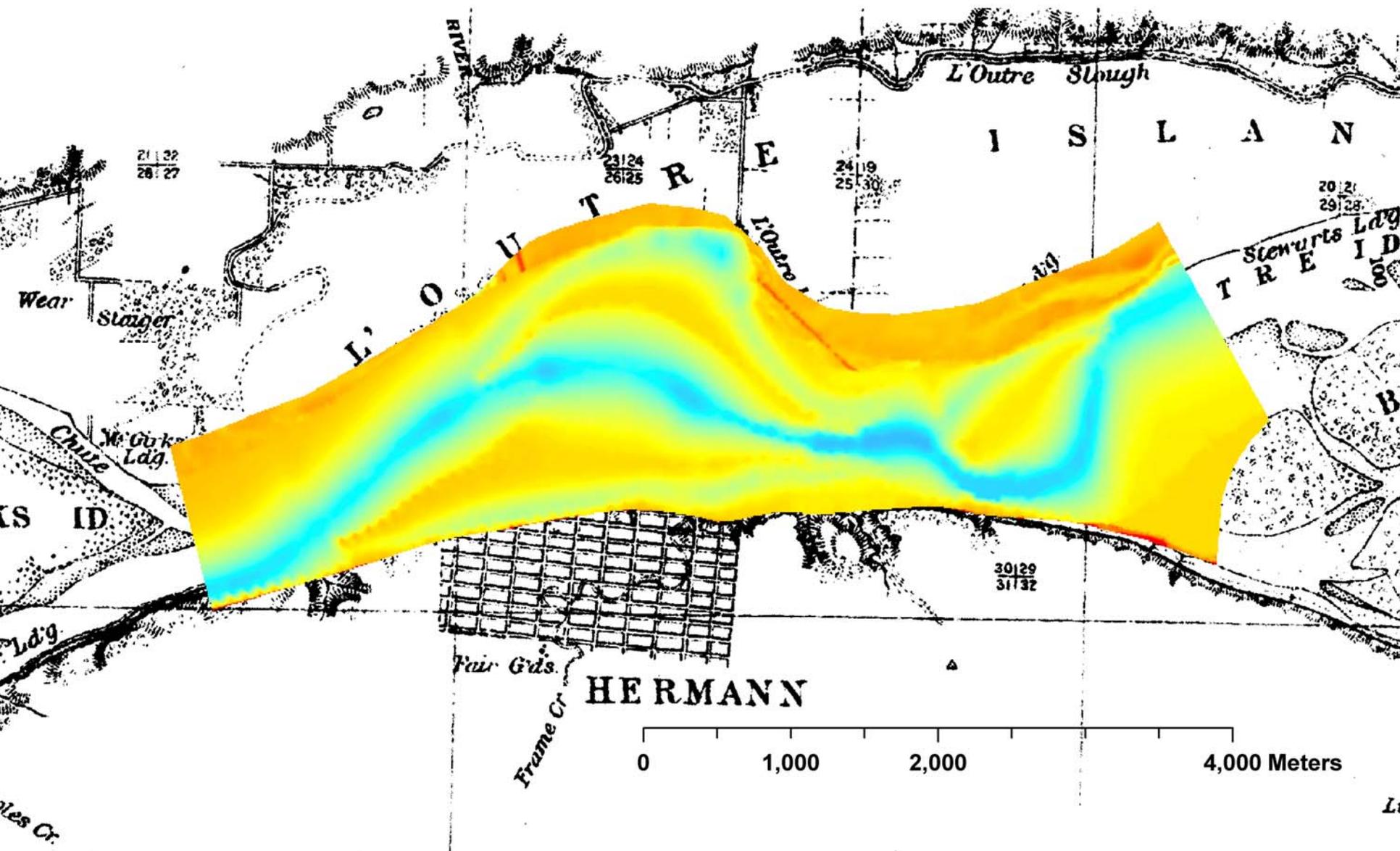
# Lower Missouri River at Hermann, Missouri

## Missouri River Commission Maps - 1894

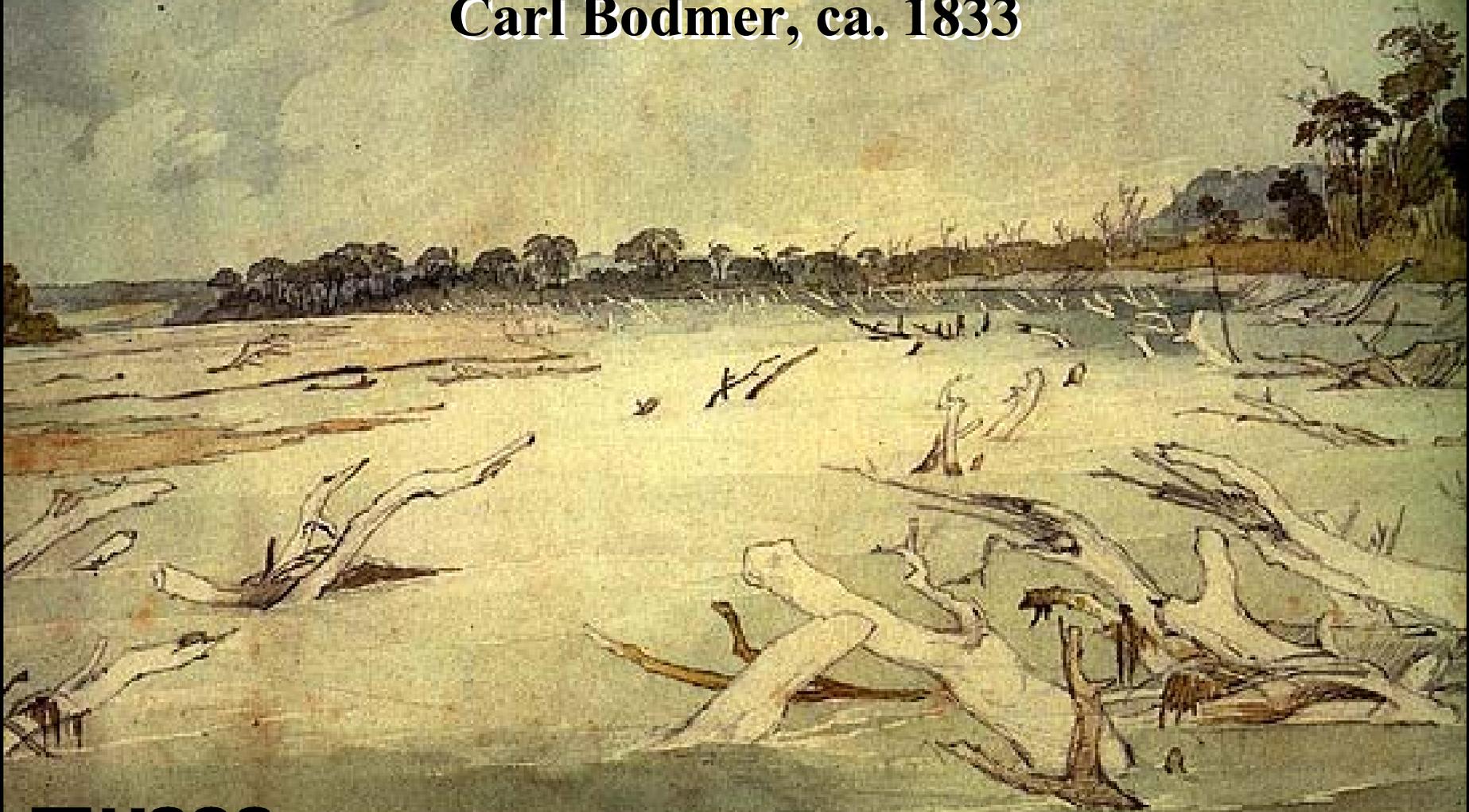


# Conventional 2-D Models for Habitat Accounting

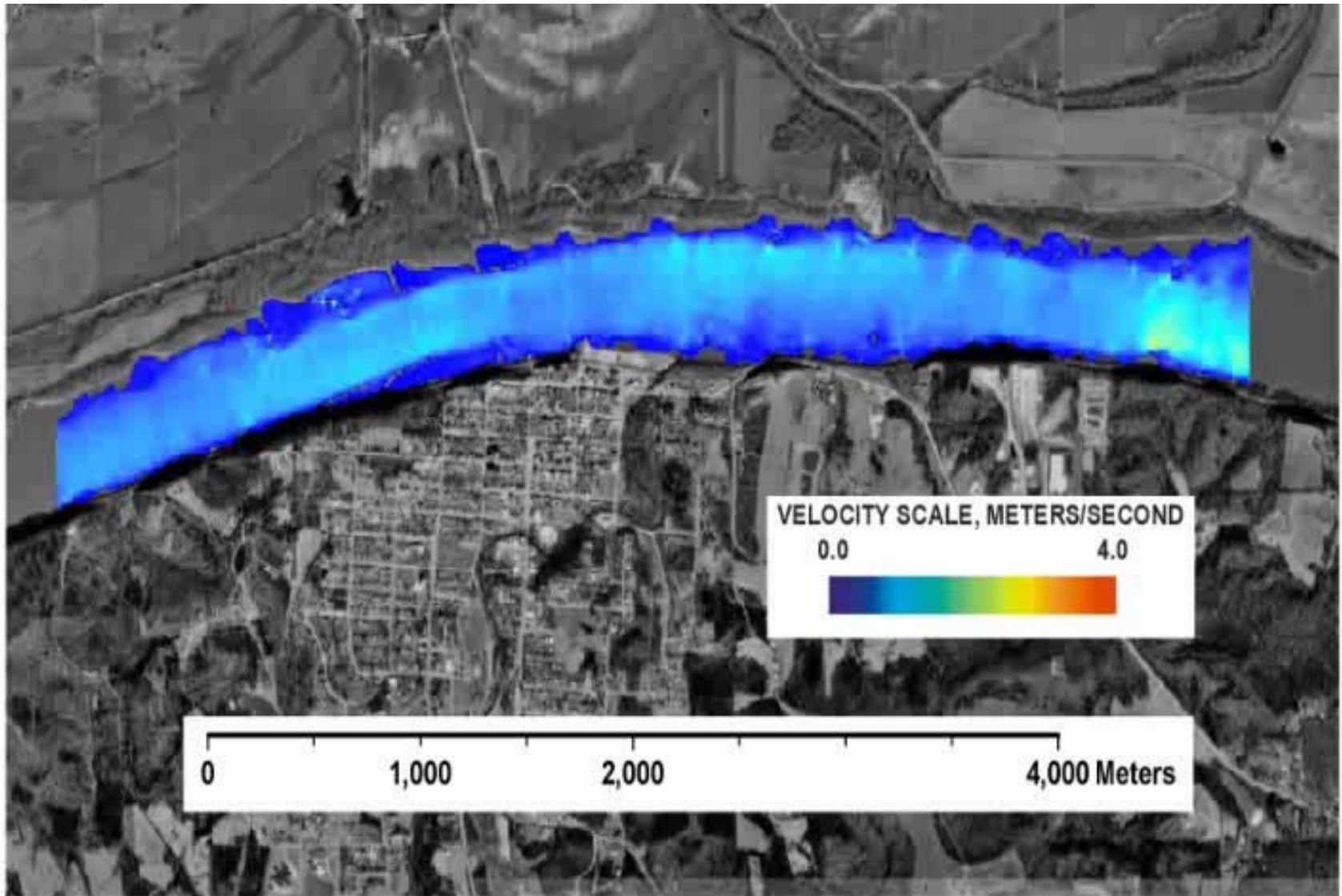




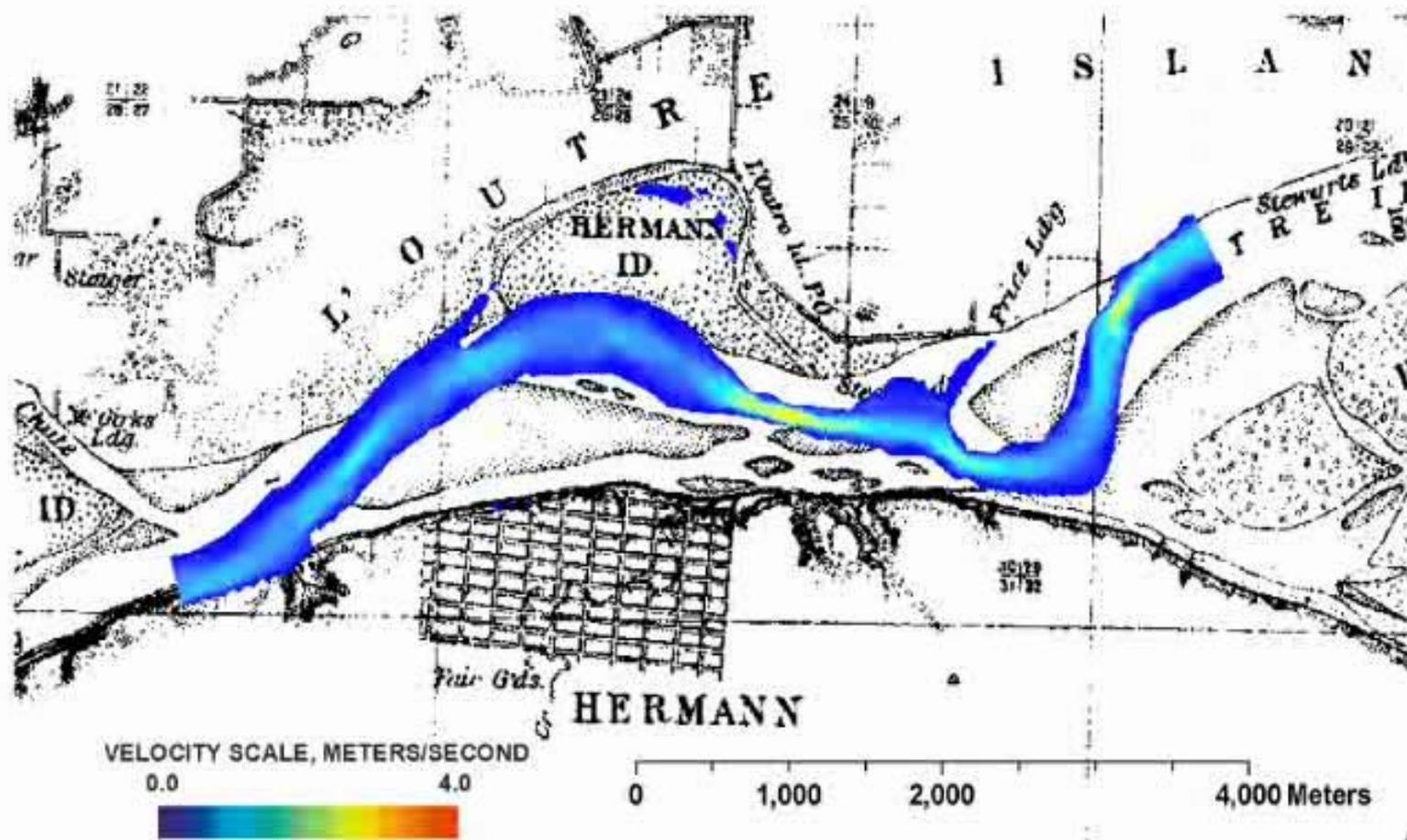
**Large Woody Debris, Missouri River,  
Carl Bodmer, ca. 1833**



# Hermann, Missouri, 2000: 30 – 250 kcfs



# Hermann, Missouri, 1894: 30 – 250 kcfs

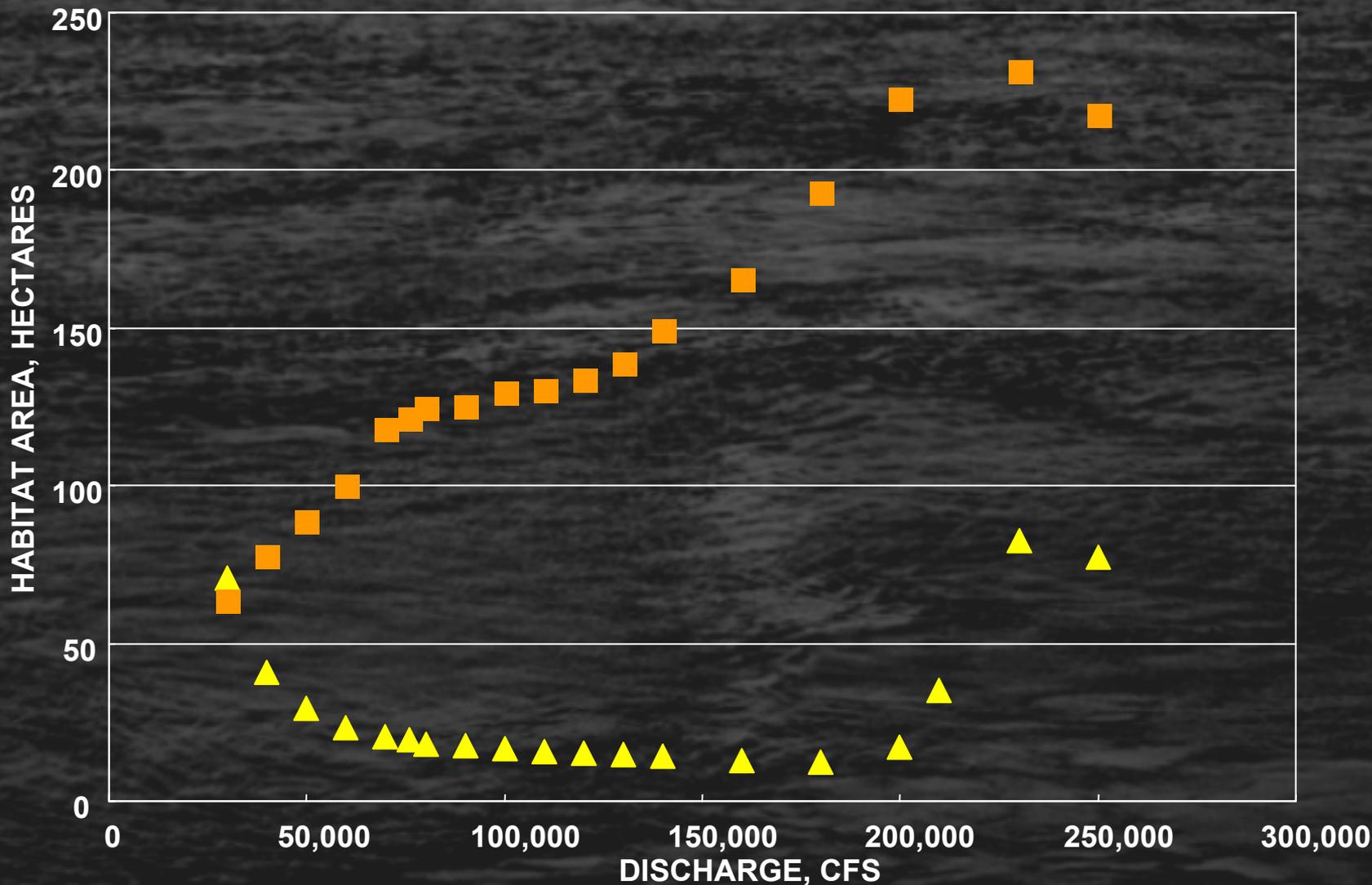


# Physical Habitat Simplification

Classes of physical habitat negotiated in management debate, assumed to be limiting:

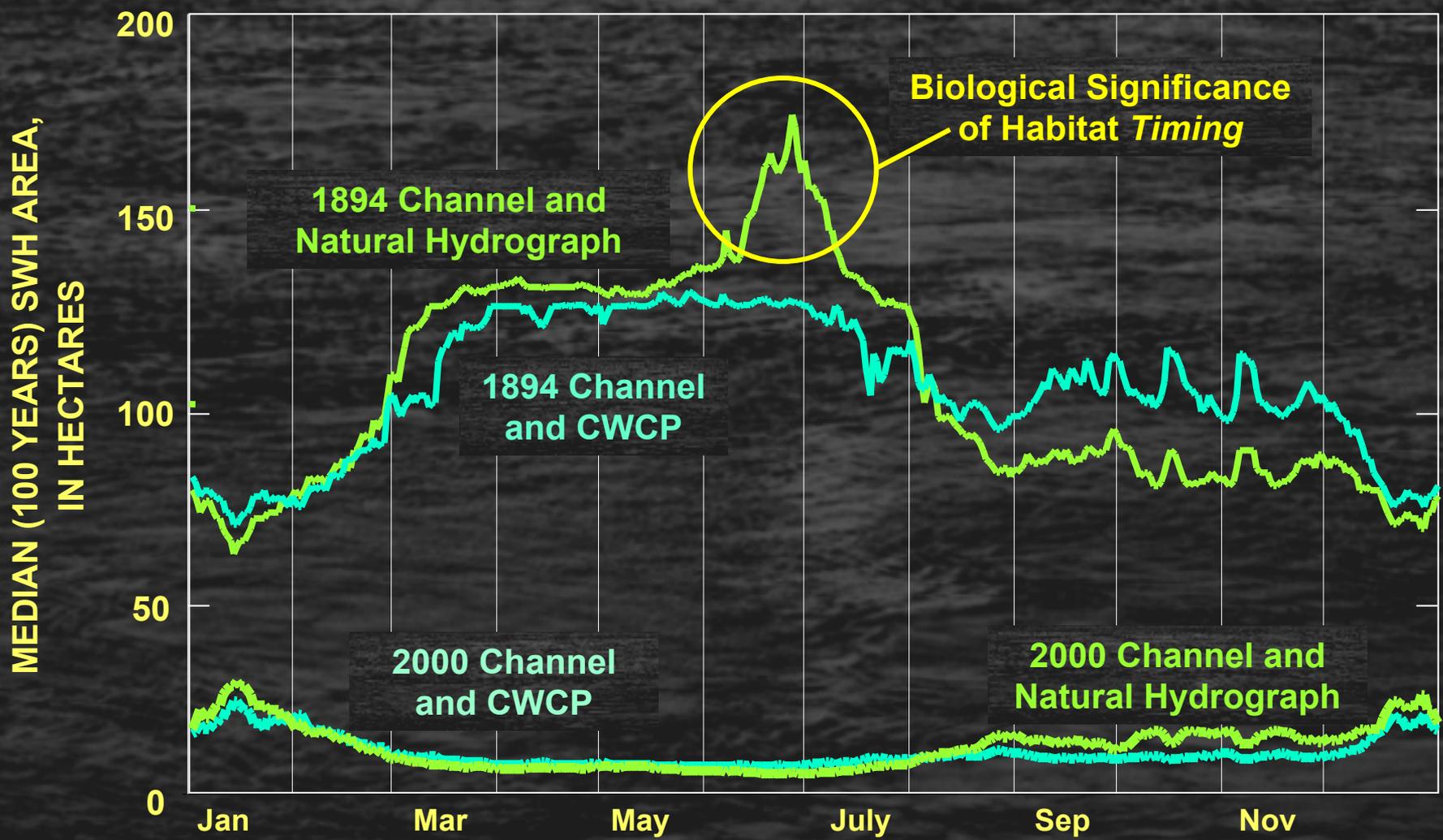
- **Terns and Plovers:** Emergent Sandbar Habitat (ESH): bare sandbars, tern and plover nesting habitat
- **Pallid Sturgeon:** Shallow Water Habitat (SWH): 0-5' deep and 0-2 ft/second current velocity, juvenile and larval habitat

# Discharge – Shallow Water Habitat Relations



# Habitat Availability in Space and Time

## Integrating Flow and Form



# LMOR: Fish of Interest

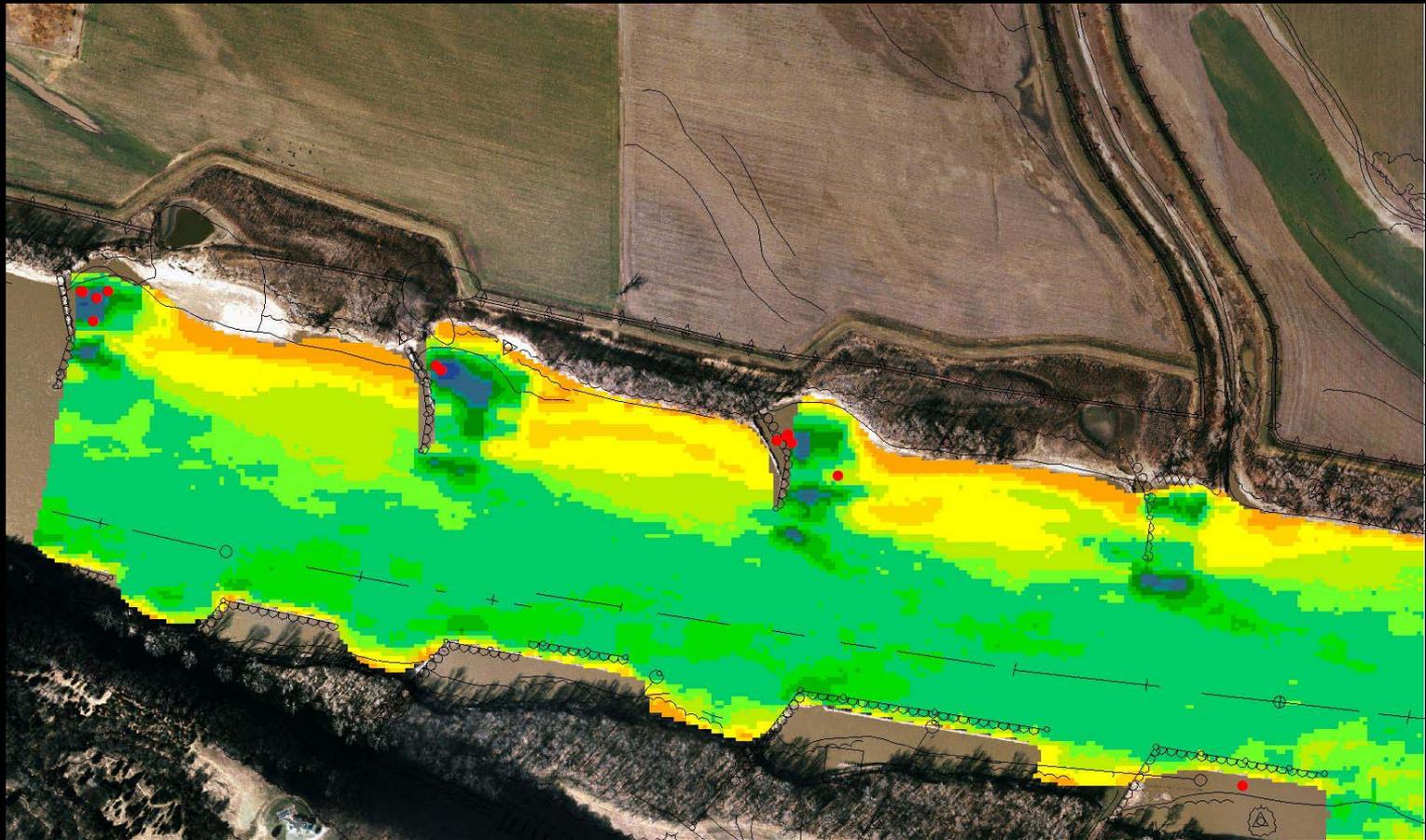


**Pallid Sturgeon**



**Asian carp**

# LMOR Mainstem Carp Habitat



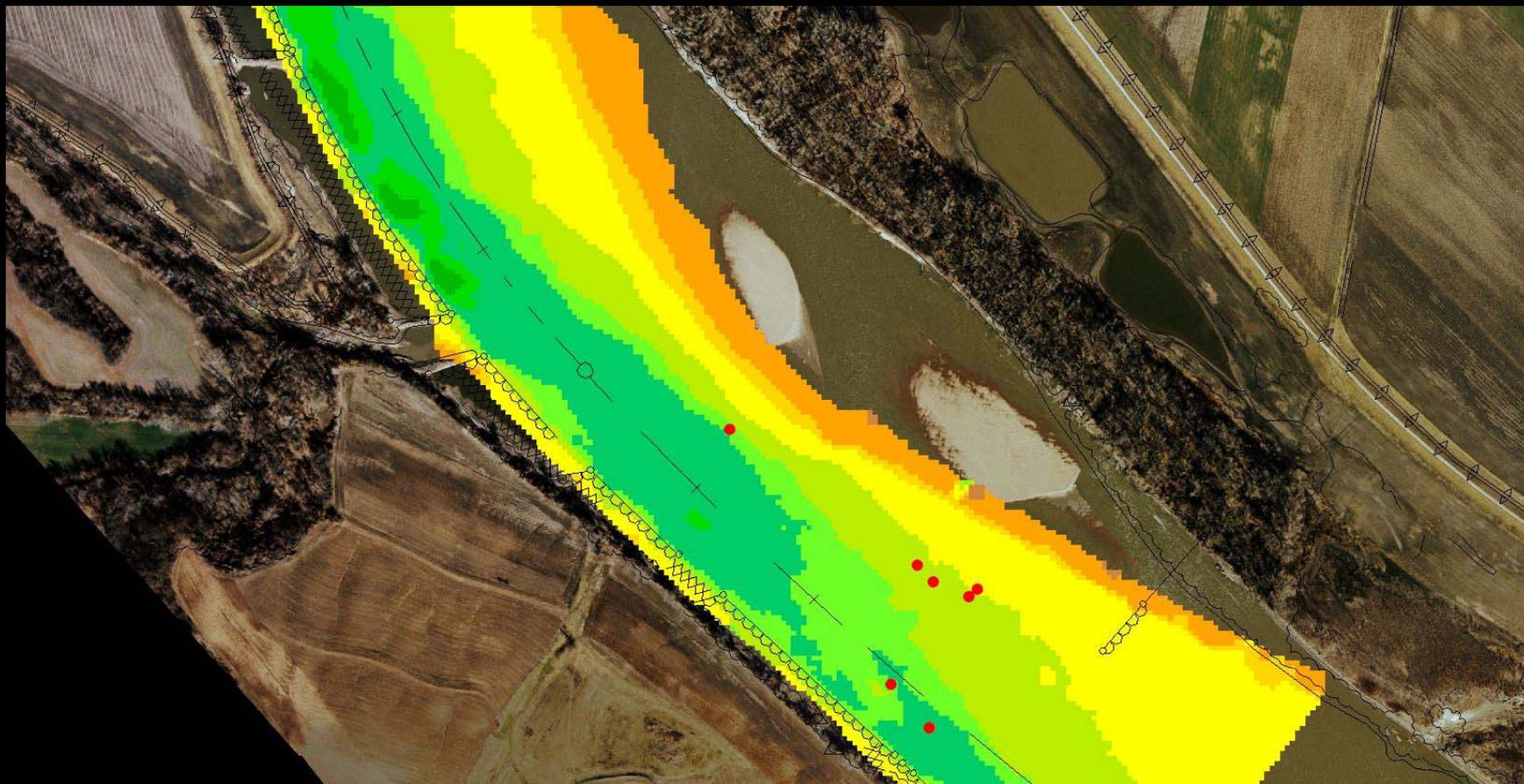
0 1 2 Km

DEPTH SCALE

0 2 4 6 8 10 15 20 m



# LMOR Mainstem Sturgeon Habitat

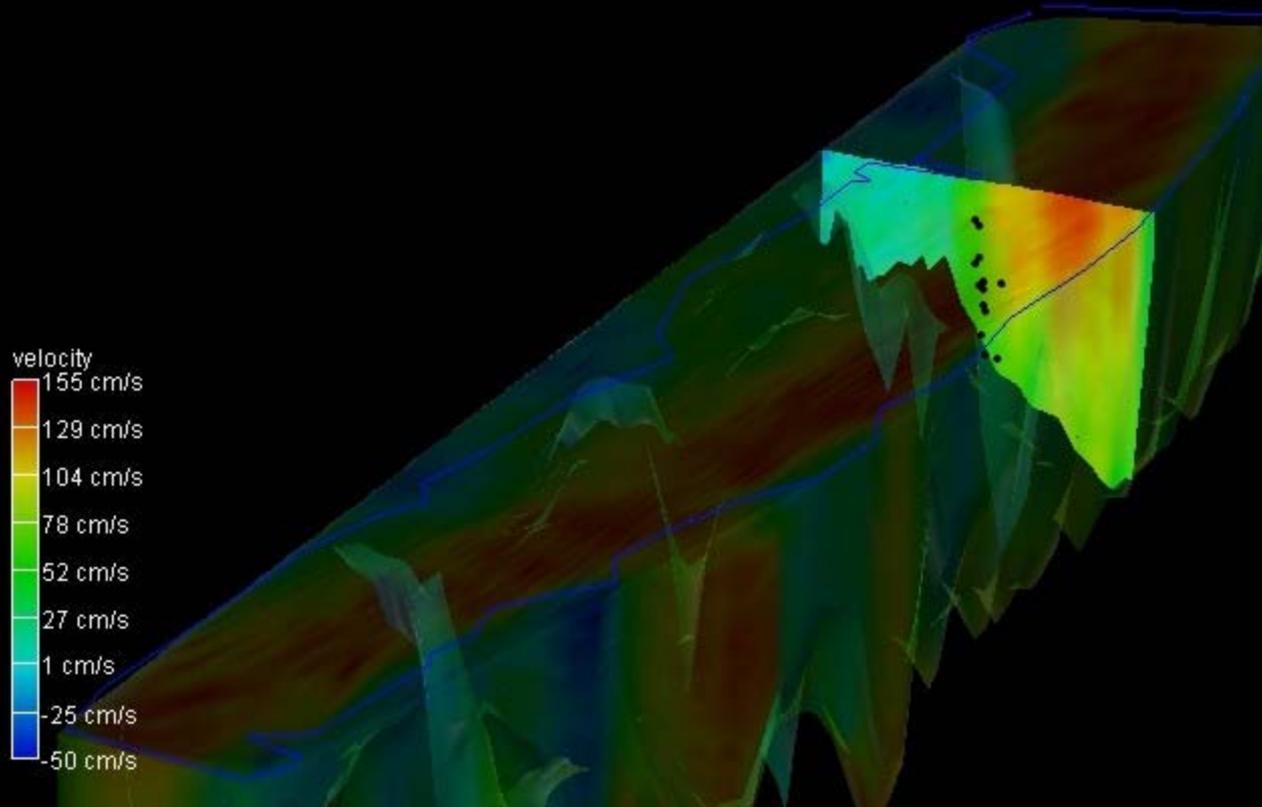


DEPTH SCALE

0 2 4 6 8 10 15 20 m



# LMOR Mainstem Sturgeon Habitat



# Habitat Definitions/Hypotheses

- **Carp: Deep and slow. Use Froude # < 0.09.**

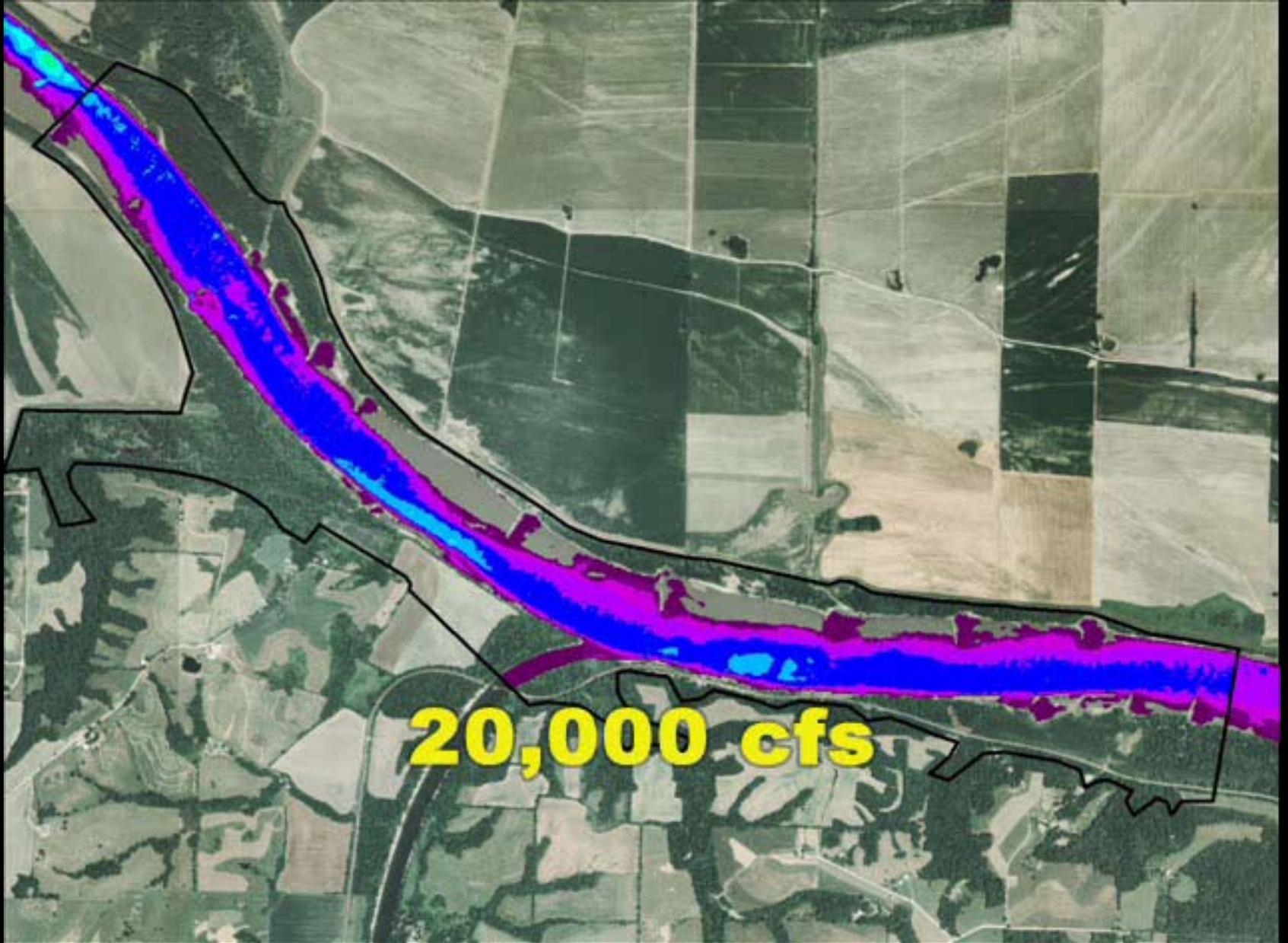
$$Fr = \frac{v}{(g*d)^{1/2}}$$

- **Pallids: Edge dwellers. Pick joint occurrence of moderate spatial velocity and depth gradients within 30 m radius: wake areas (eddy fences) downstream of dikes and bars.**
- **SWH: for comparison.**

# Habitat Use

15-m radius

	<u>Velocity,</u>		<u>Depth, m</u>		<u>Froude</u>	
	<u>m*s<sup>-1</sup></u>					
	Mean	Std	Mean	Std	Mean	Std
Sturgeon (22)	111.9	8.6	4.7	0.5	0.176	0.016
Carp (28)	41.2	6.8	7.1	1.0	0.053	0.010



VELOCITY SCALE





DEPTH SCALE

0 2 4 6 8 10 15 20 m



0 1 2 Km



CARP FROUDE # CRITERION





STURGEON WAKE CRITERION:



0

1

2 Km





**20,000 cfs**



SWH CRITERION:



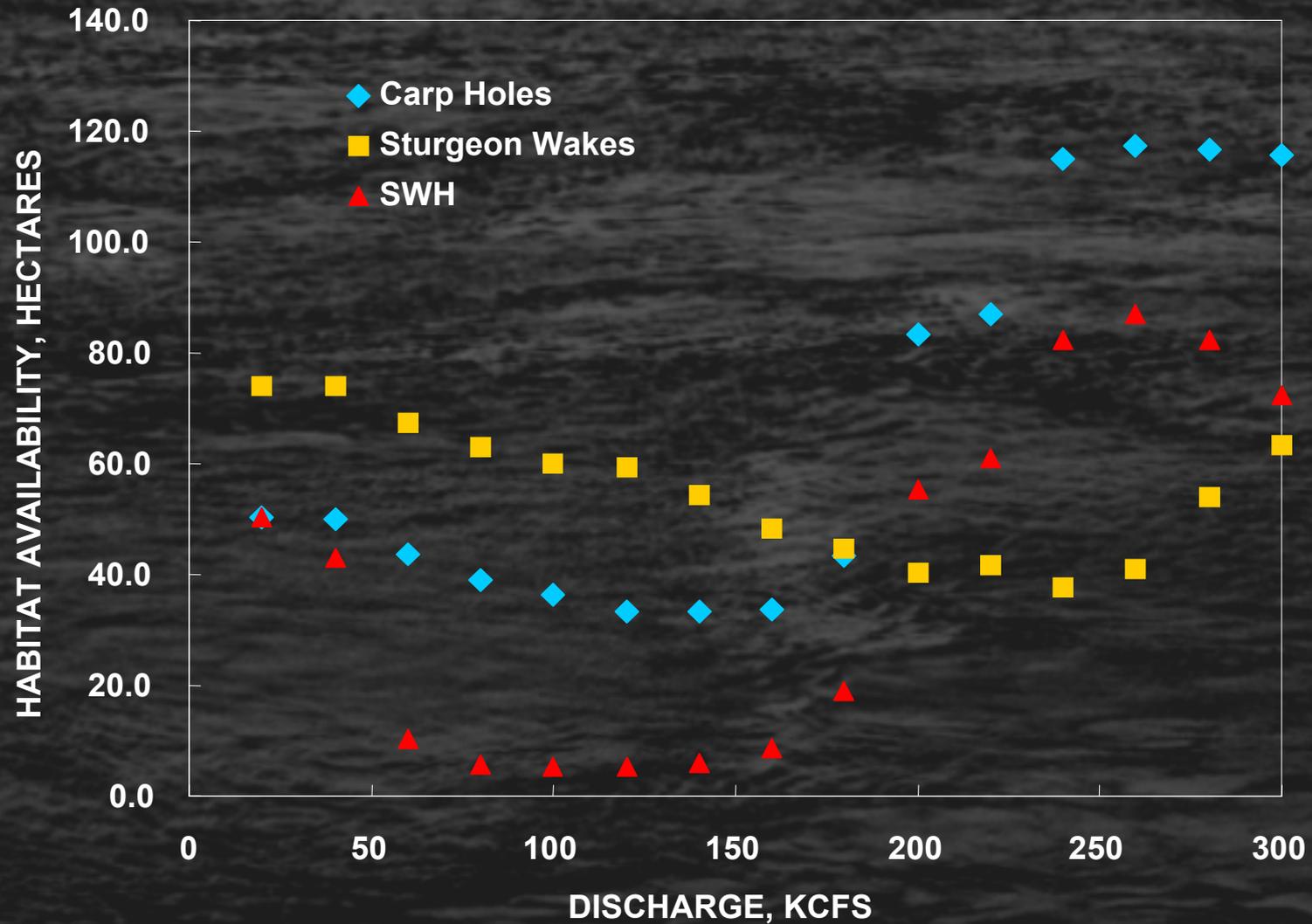
0

1

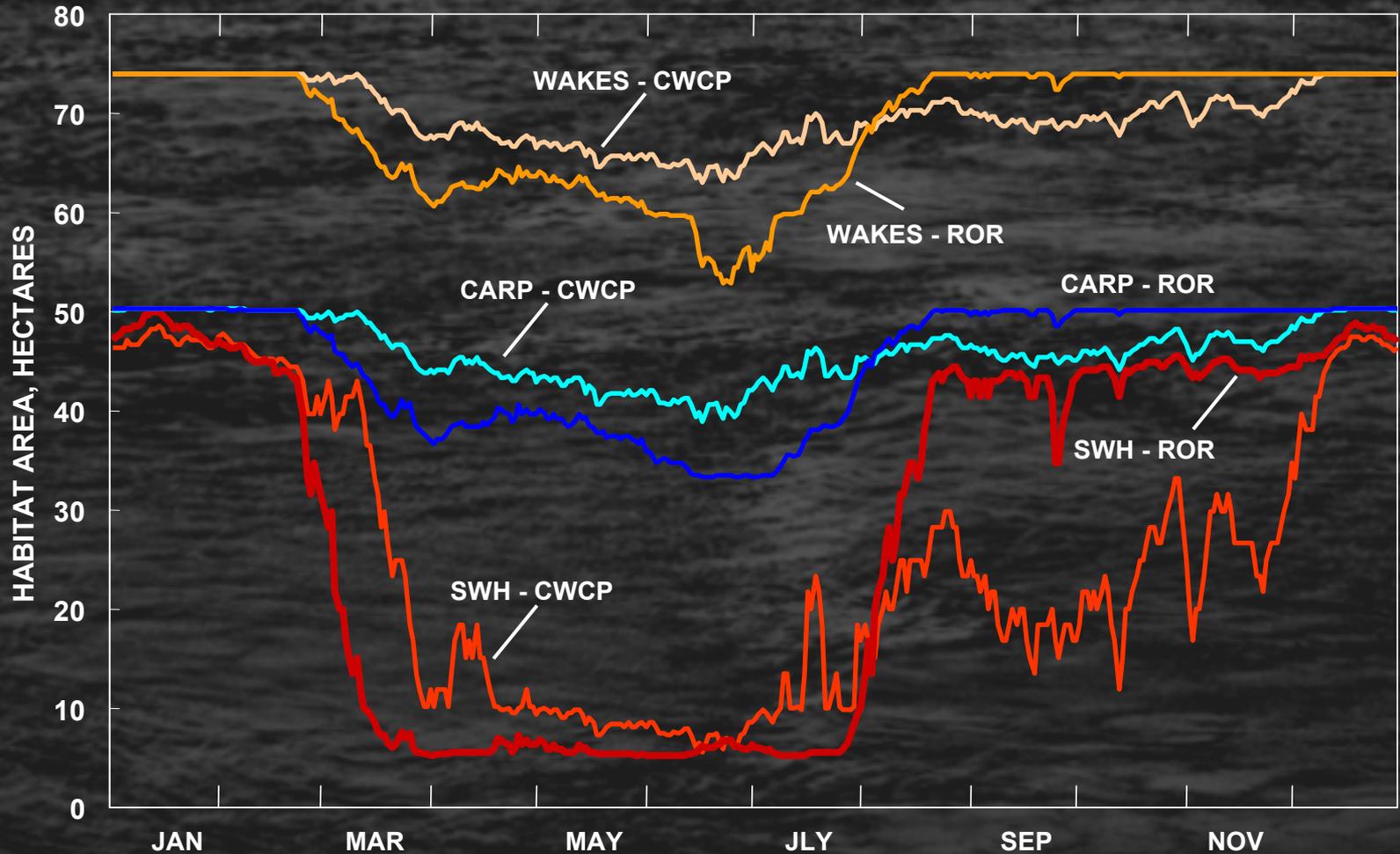
2 Km



# Habitat – Discharge Relations



# Habitat Availability - Hydrology Relations



# Flow, Form, and Fish Responses, LMOR

- Flow and form are practically independent on intensively engineered rivers. Can be separately manipulated for management and recovery.
- Channel form has strong leverage on habitat availability in rivers like LMOR. Management of timing, however, requires the hydrograph.
- Linkage to biota is persistent challenge in designing recovery.
  - Detailed definitions needed as engineering becomes more precise.
  - Is habitat limiting?
  - Detailed mapping of habitat use T&E and invasives shows promise.
  - 2-d hydraulic modeling allows exploration of spatial characteristics like gradients, edges.
  - With present channel, some habitat types are sensitive to flow, esp. late summer flows