

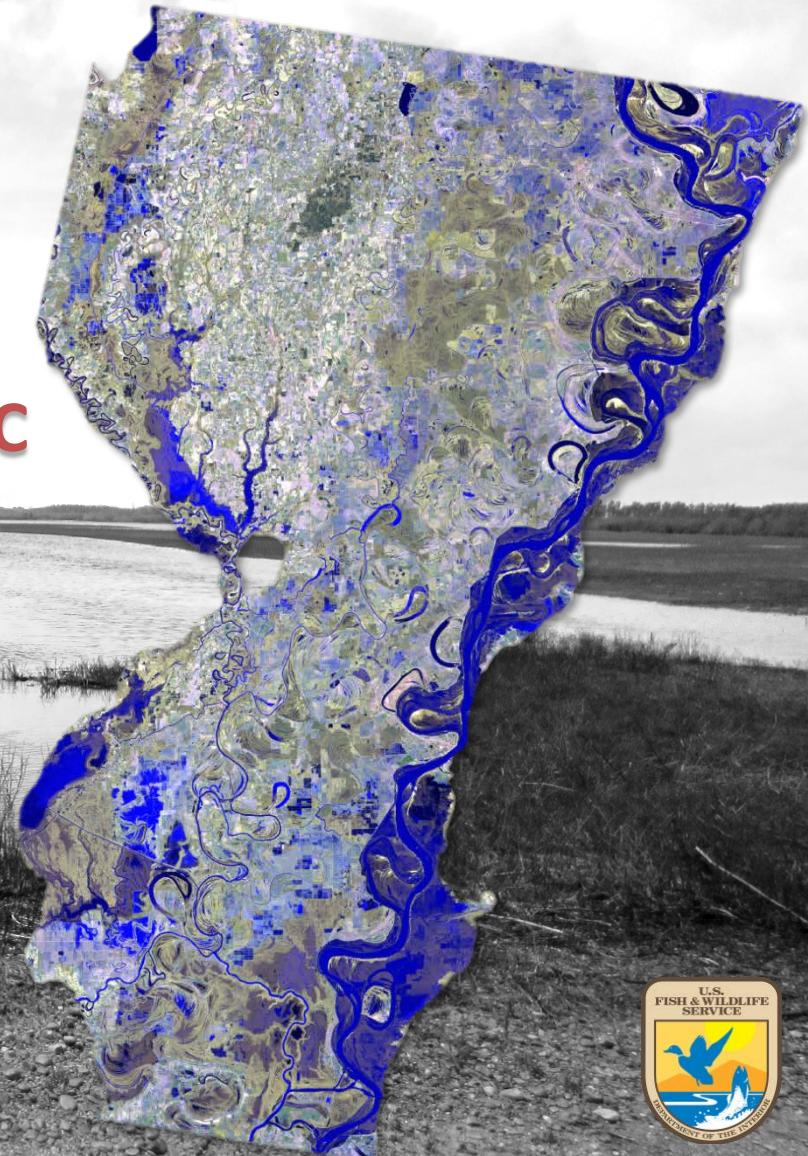
# Development and Application of Landscape Scale Floodplain Inundation Frequency Using Landsat Imagery

**Yvonne Allen**

**Aquatic Habitat Analyst**

**Gulf Coastal Plains and Ozarks LCC**

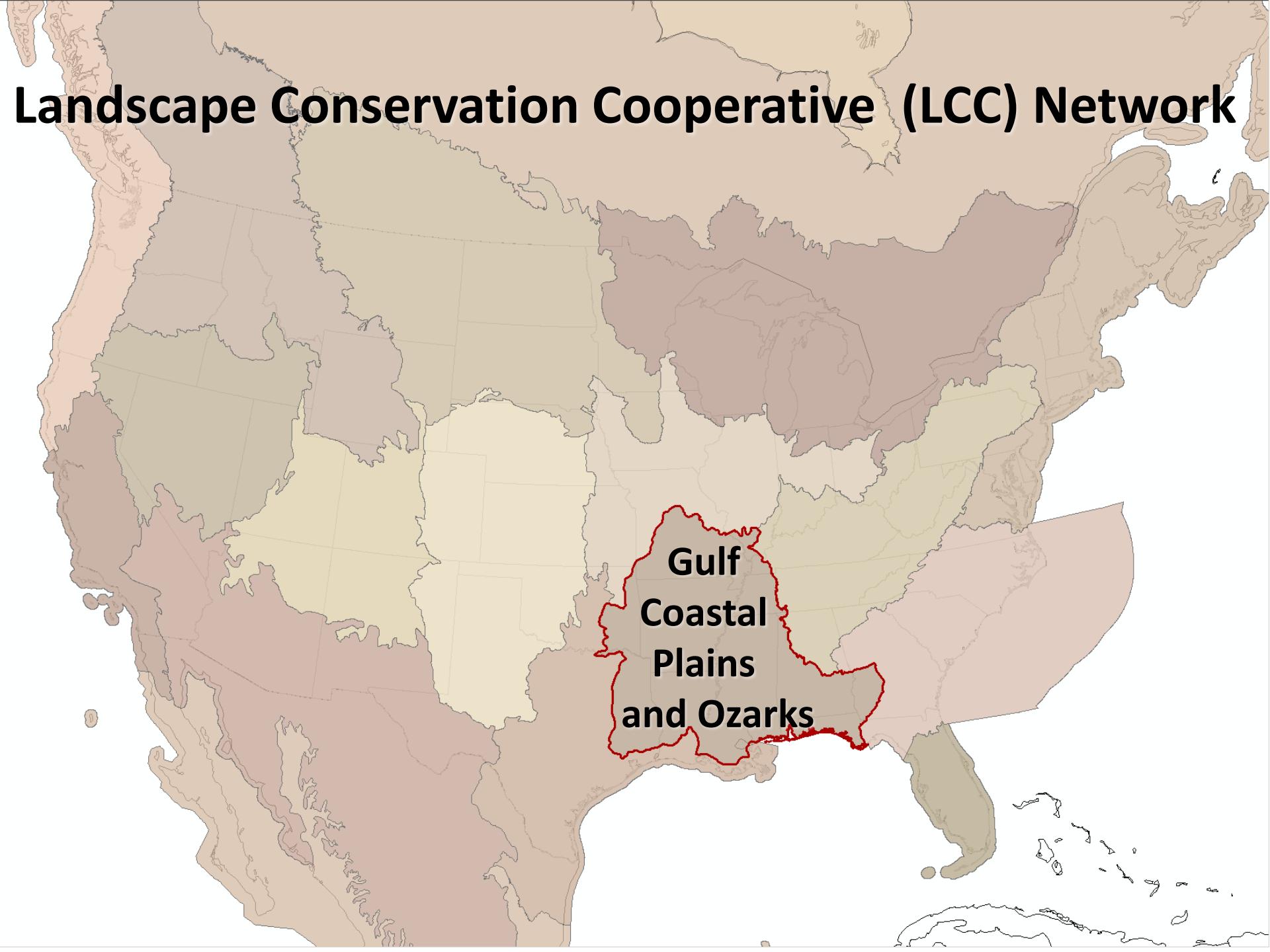
**USFWS Baton Rouge, LA**



# Outline

- Introduction to the Gulf Coastal Plains and Ozarks (GCPO) Landscape Conservation Cooperative and priority habitat assessments
- Development of floodplain inundation product
- Quick floodplain inundation virtual tour
- Relating floodplain inundation to ground conditions
- Applications of floodplain inundation product
- Other remote sensing applications for aquatic habitat assessment

# Landscape Conservation Cooperative (LCC) Network



The map shows the continental United States with various ecoregions shaded in different tones of brown and tan. A specific region in the central-southern part of the country is outlined in red and labeled "Gulf Coastal Plains and Ozarks". This region includes parts of the Great Plains, the Mississippi River basin, and the southern Appalachians.

**Gulf  
Coastal  
Plains  
and Ozarks**

# Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC)

- 180 million acre region
- A conservation science partnership – federal, state, NGO, private
- GCPO LCC mission (in part):
  - design conservation strategies to sustain natural resources
  - **Conduct a current assessment of priority habitats**

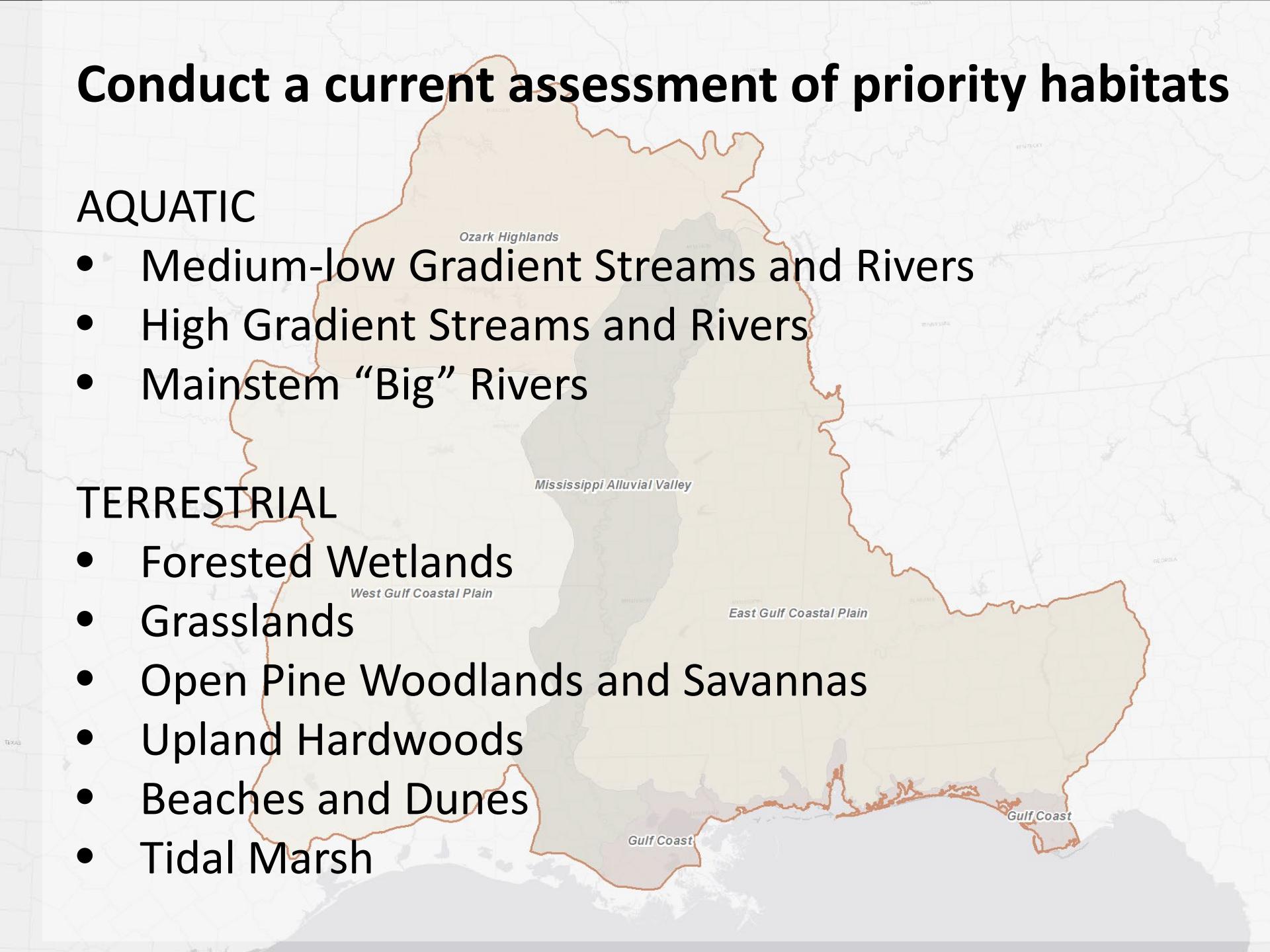
# Conduct a current assessment of priority habitats

## AQUATIC

- Medium-low Gradient Streams and Rivers
- High Gradient Streams and Rivers
- Mainstem “Big” Rivers

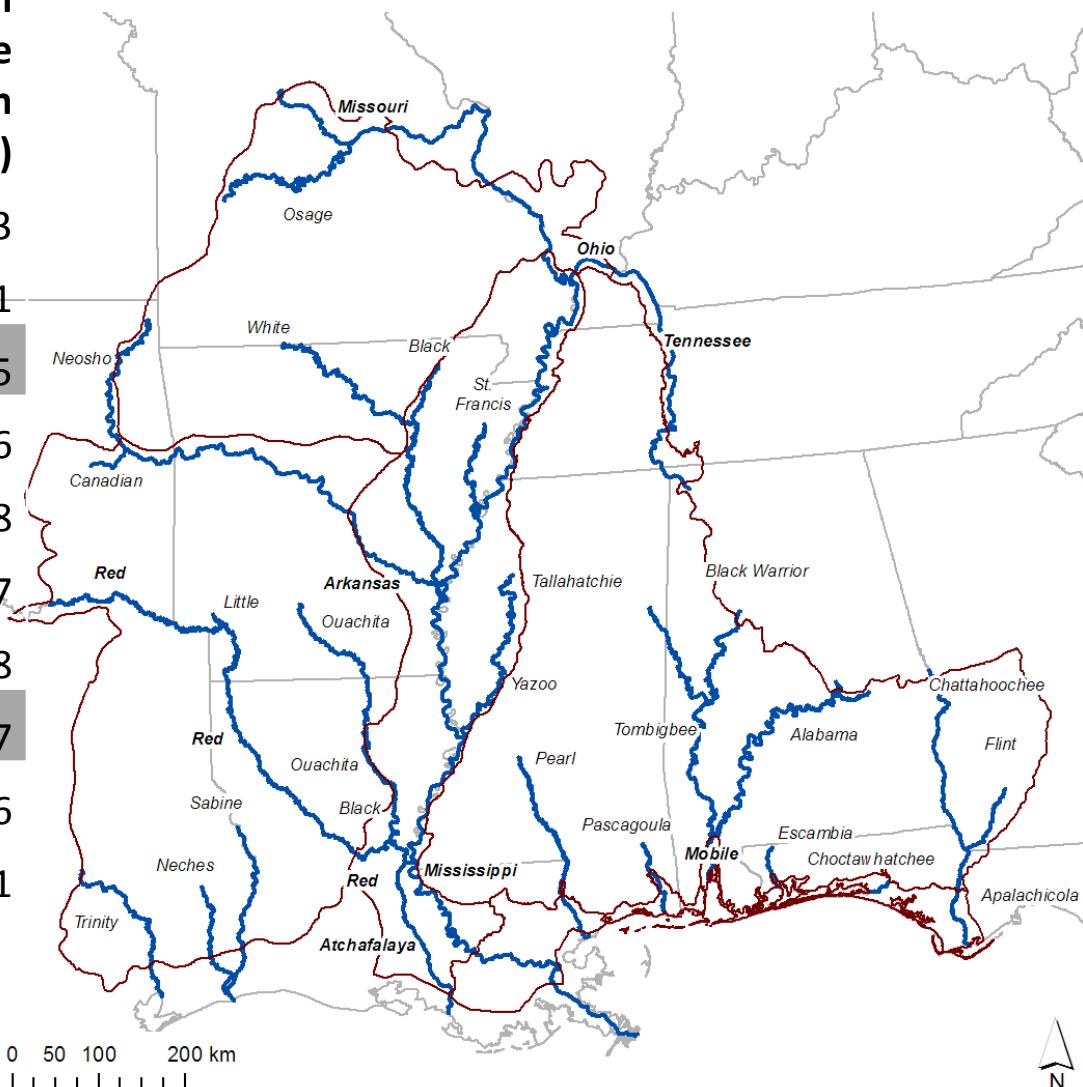
## TERRESTRIAL

- Forested Wetlands
- Grasslands
- Open Pine Woodlands and Savannas
- Upland Hardwoods
- Beaches and Dunes
- Tidal Marsh

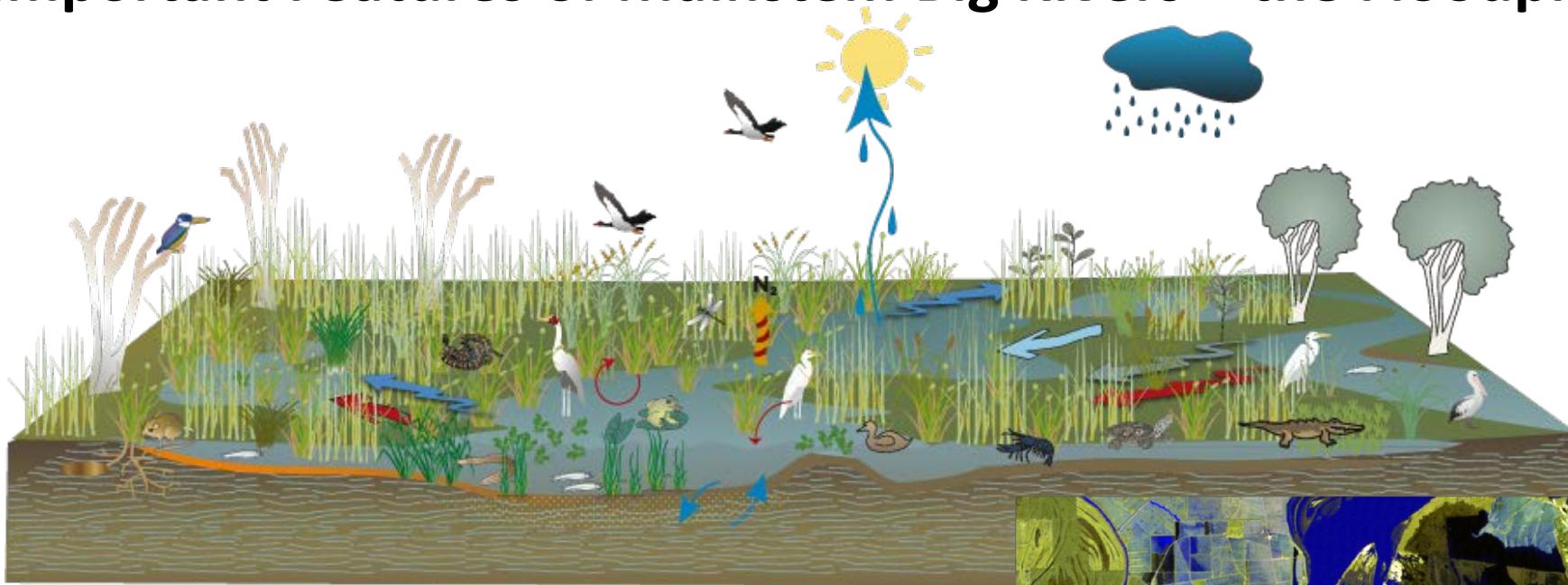


# Mainstem Big Rivers in the GCPO

Rank	River	State	Avg Ann Discharge at mouth (1,000 cfs)
1	Mississippi	Louisiana	593
2	Ohio	Illinois	281
3	Columbia	Oregon	265
4	Missouri	Missouri	
5	Tennessee	Kentucky	
6	Mobile	Alabama	
7	Atchafalaya	Louisiana	58
8	Snake	Washington	57
9	Red	Louisiana	56
10	Arkansas	Arkansas	41

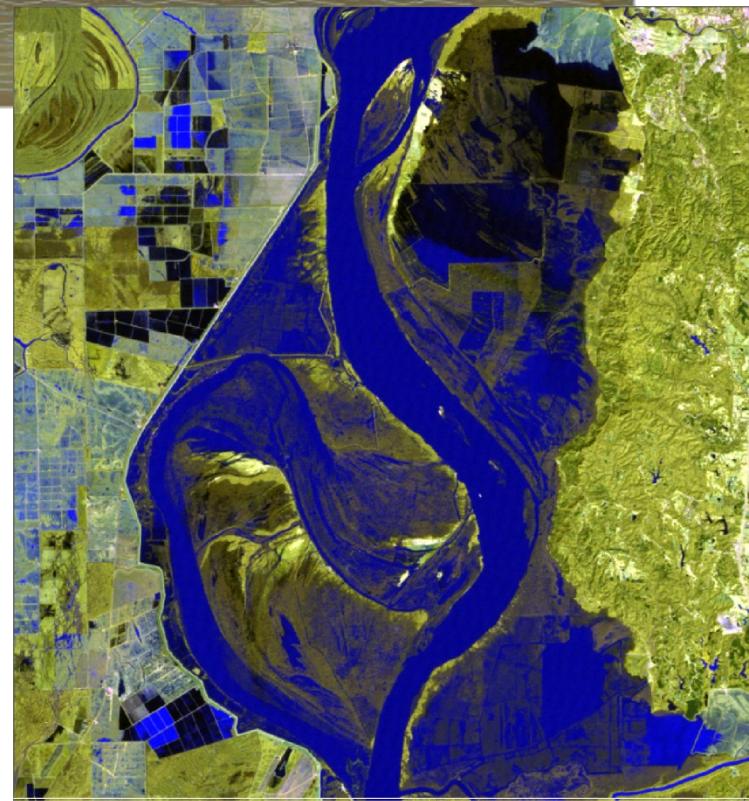
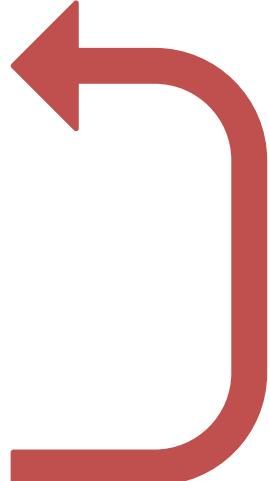


# Important Features of Mainstem Big Rivers – the Floodplain



## Floodplain Ecosystem Services

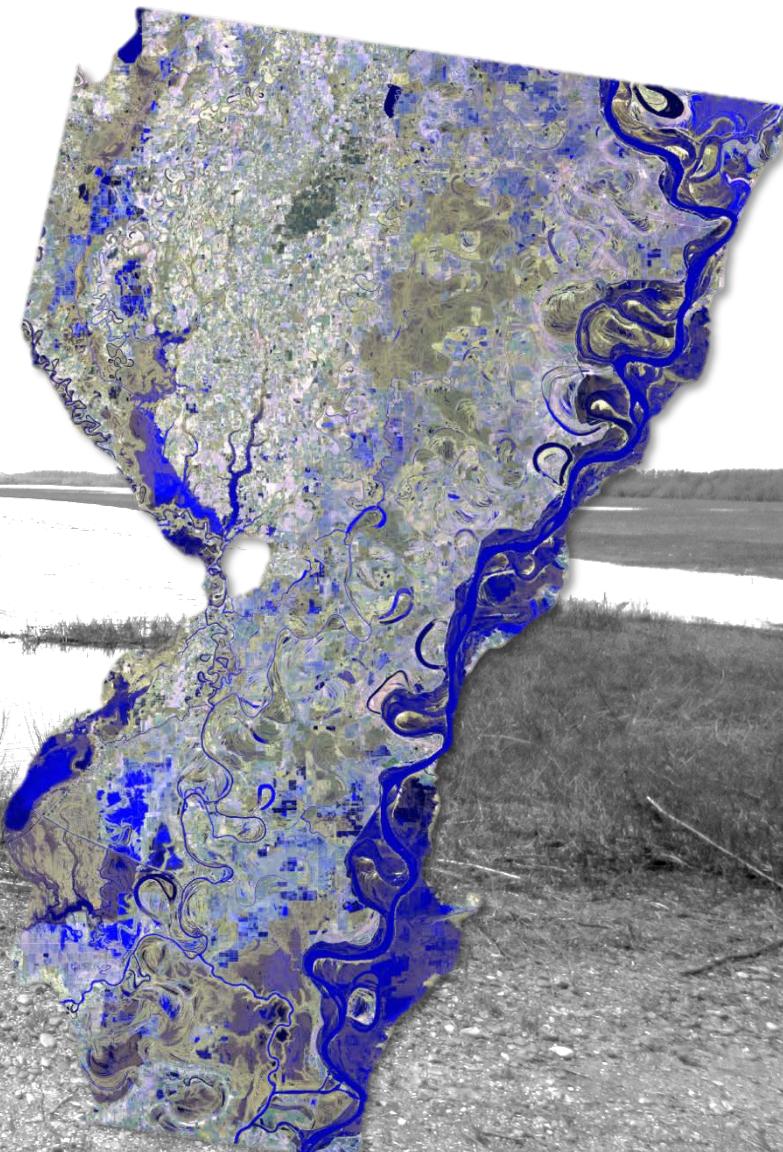
- habitat for aquatic species
- habitat for terrestrial species
- nutrient cycling
- flood risk reduction
- Hydrograph drives *floodplain inundation extent*
- *inundation extent and frequency* drive the delivery of ecosystem services



# Methodology to Assess Floodplain Inundation:

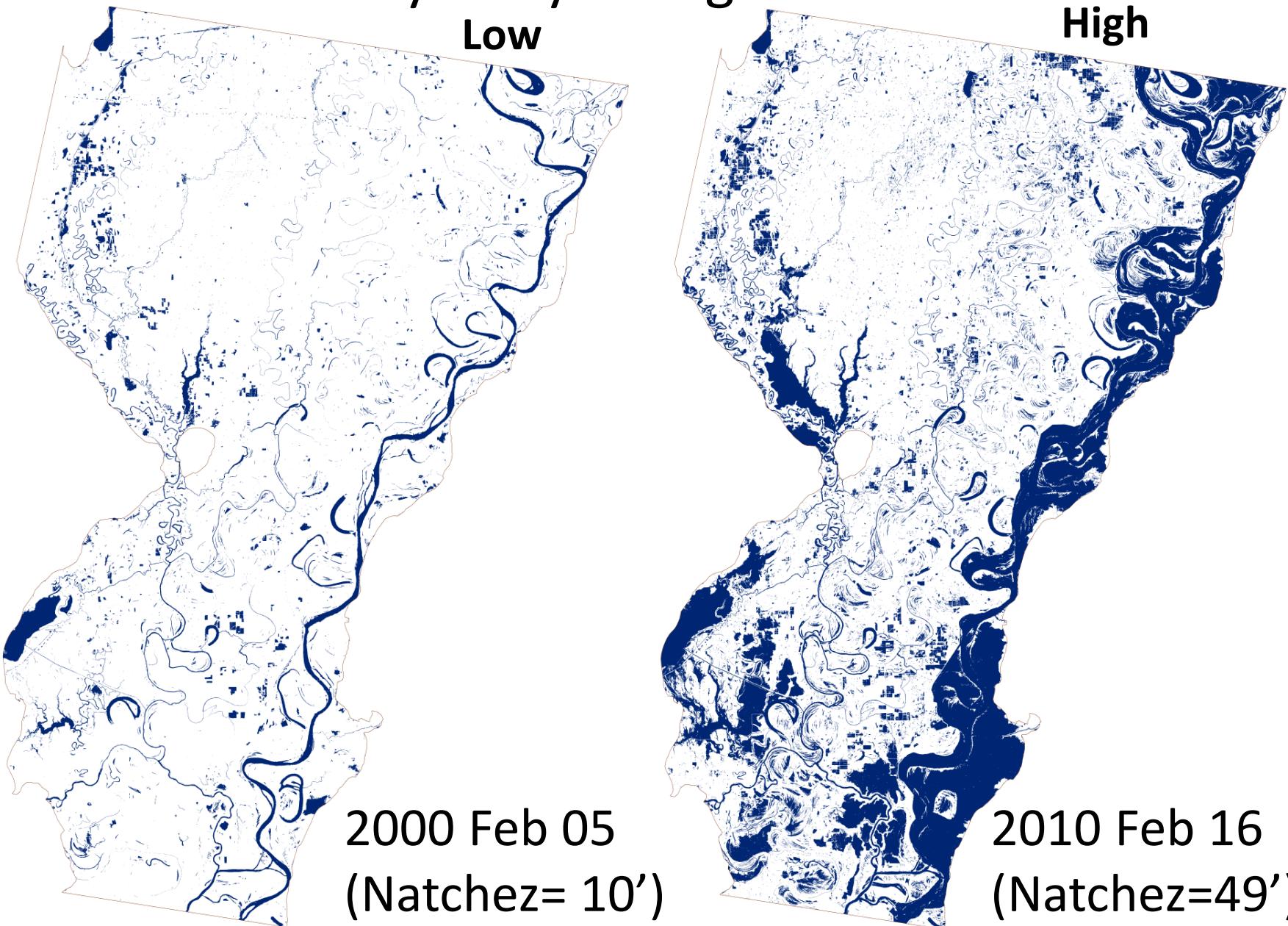
- Repeated observation of inundation extent using satellite imagery

- USGS Climate Data Records  
Landsat 5 and 7 (1982-2011)  
Cloud Free
- Acquired **Dec-Mar** (Apr)  
to reduce obscuring from  
vegetation  
(ground, floating, canopy)

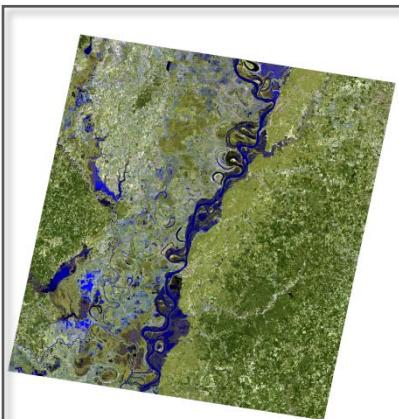




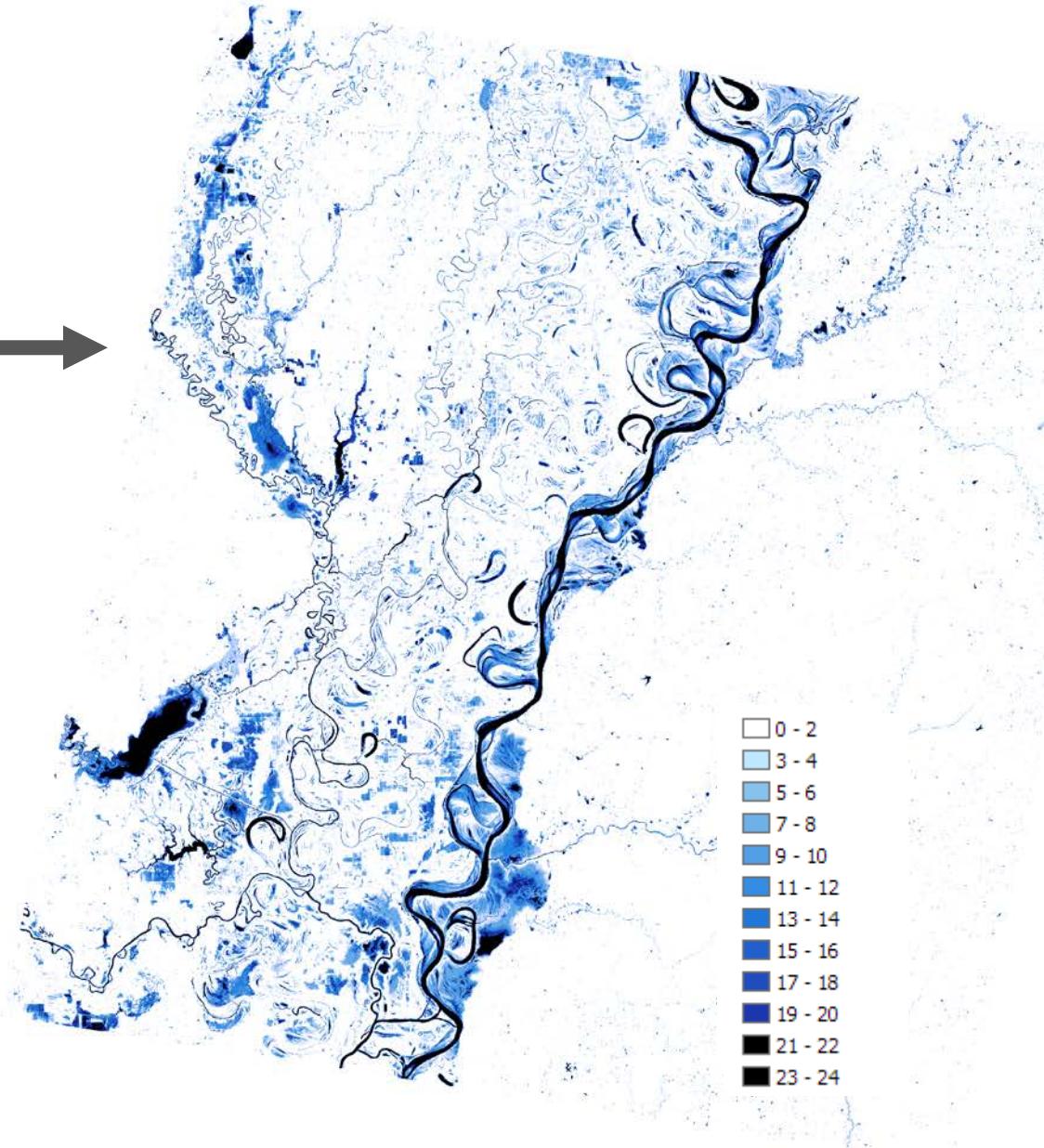
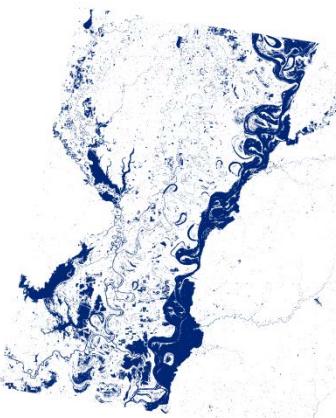
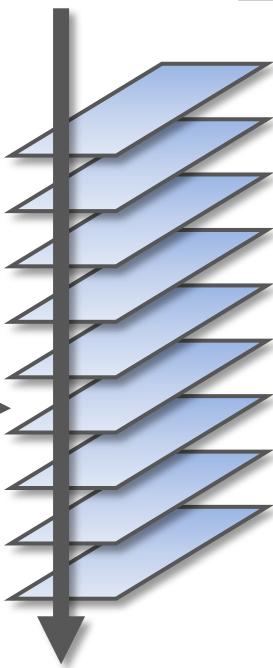
# Repeated observation of inundation extent at a variety of hydrologic conditions...



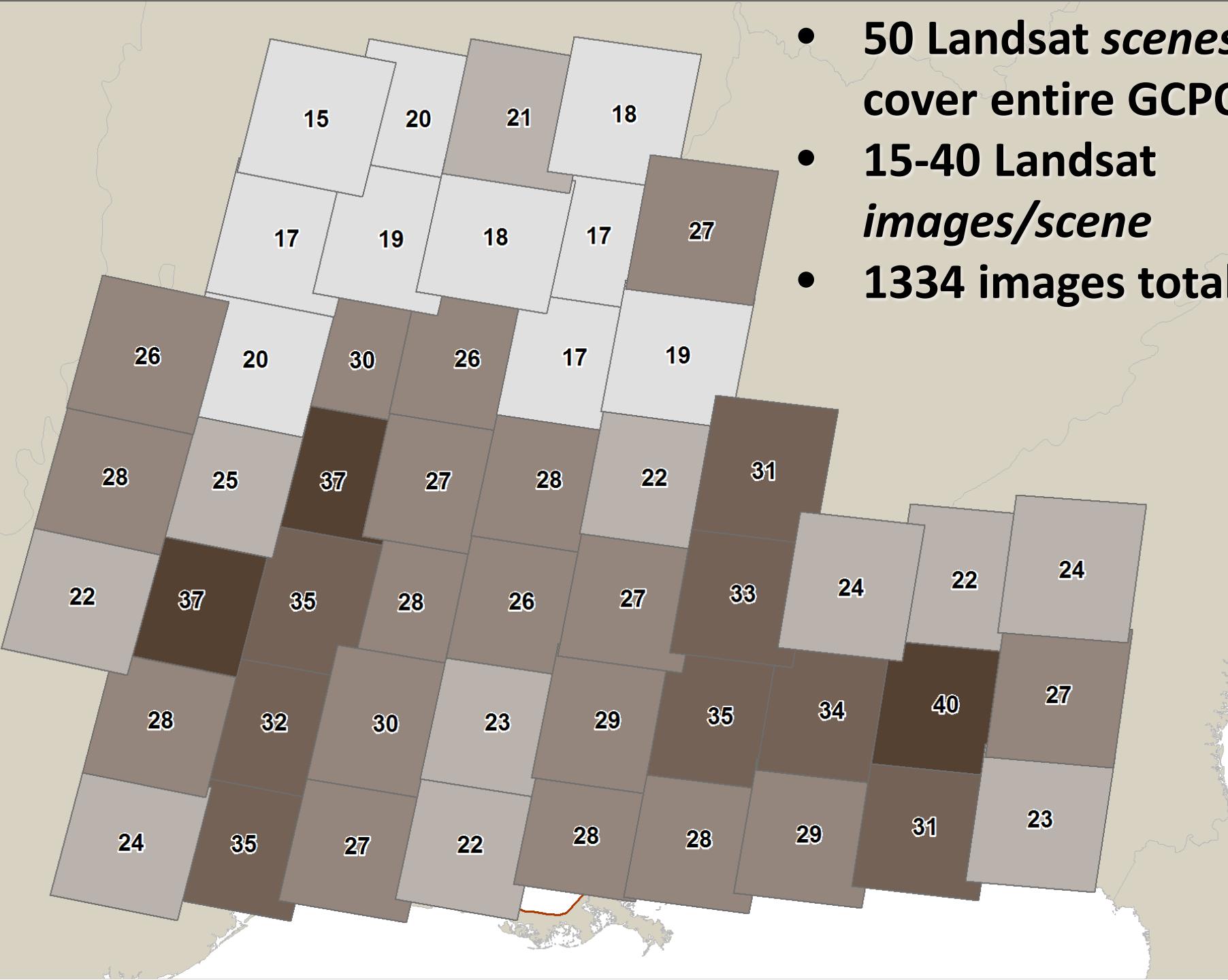
# Spatial Distribution and Frequency of Inundation



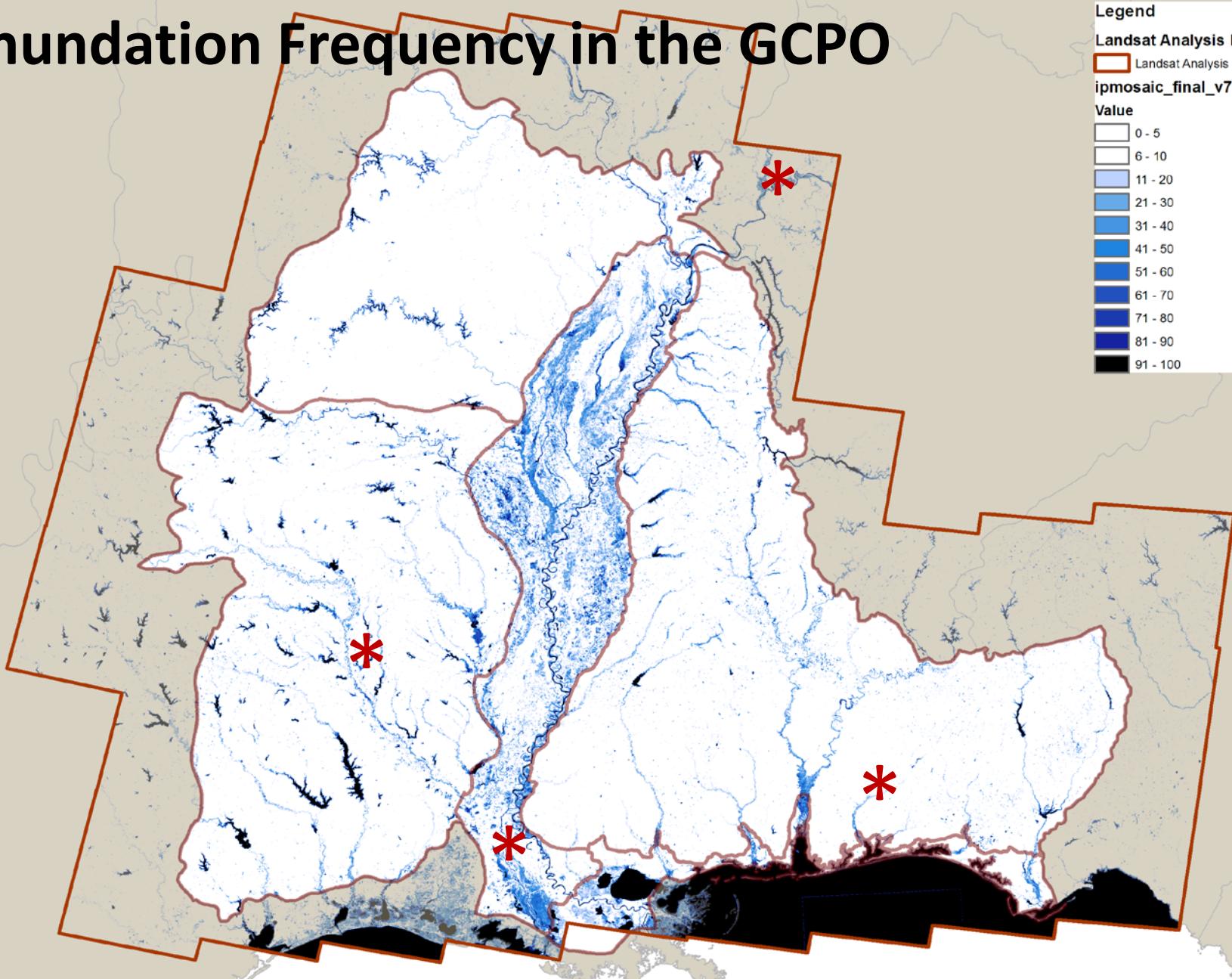
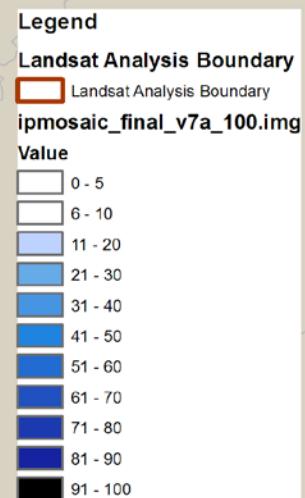
Sum  
Dry-Wet  
Classifications  
At Many River  
Levels



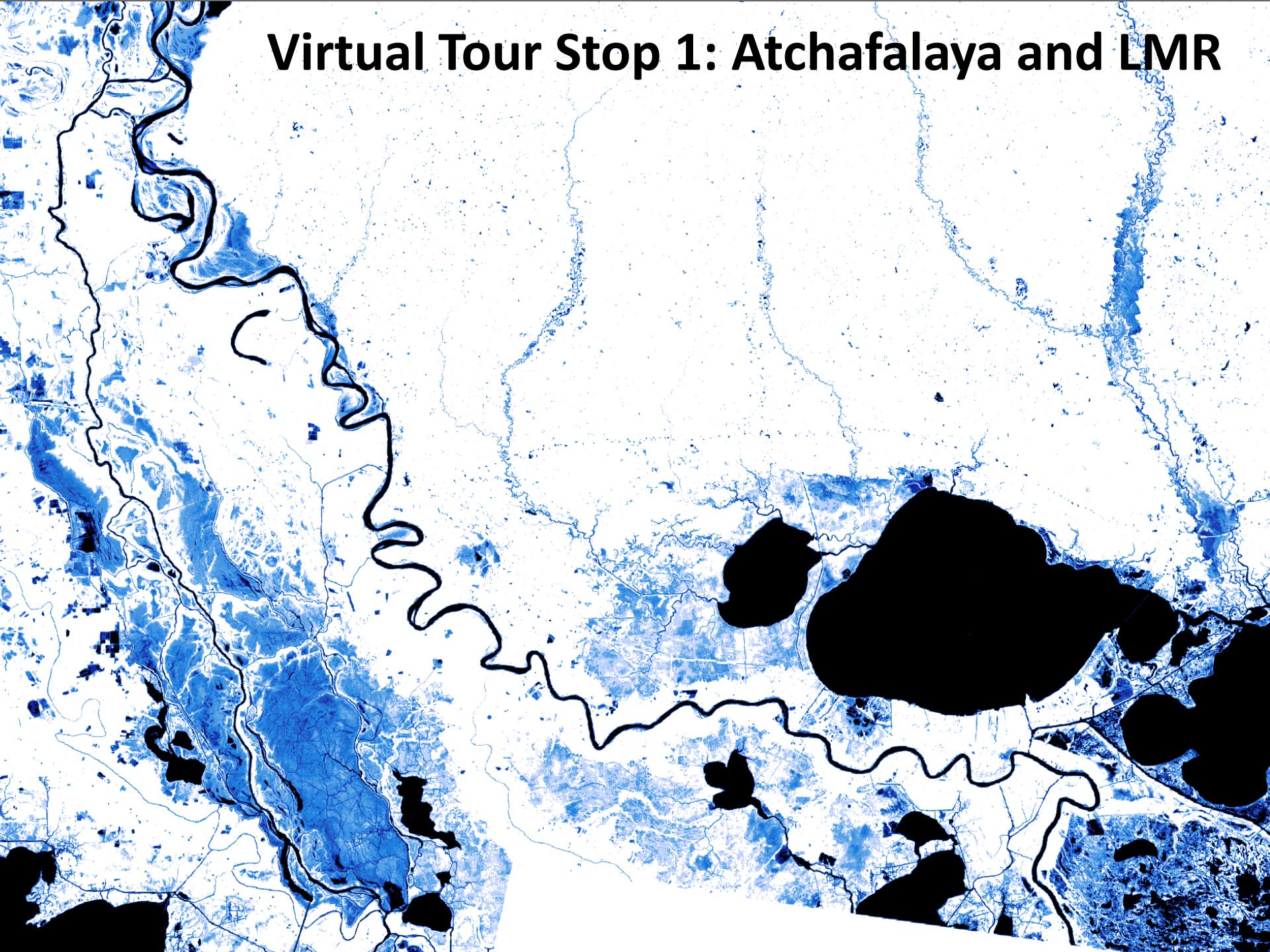
- 50 Landsat scenes to cover entire GCPO
- 15-40 Landsat *images/scene*
- 1334 images total

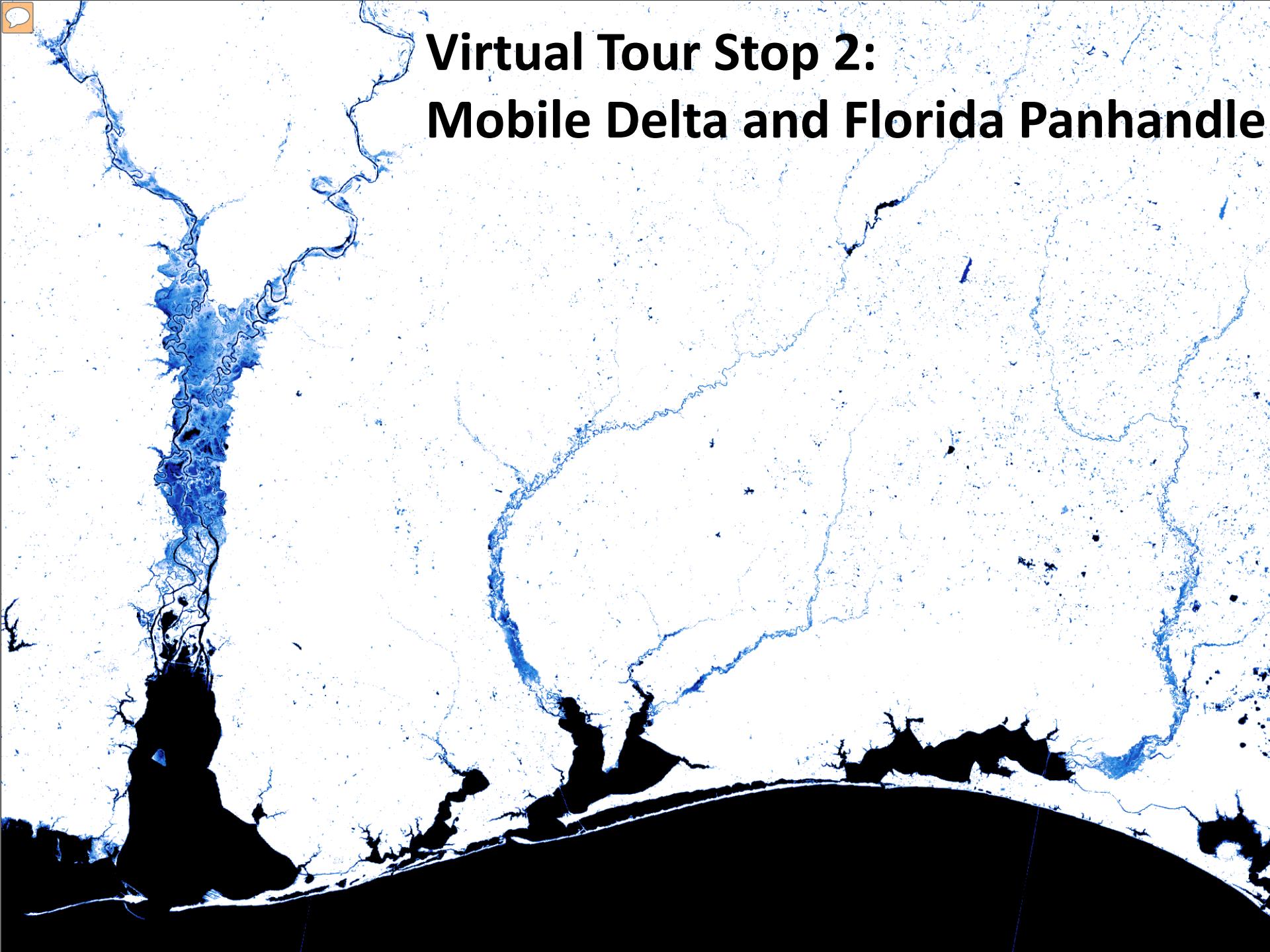


# Inundation Frequency in the GCPO

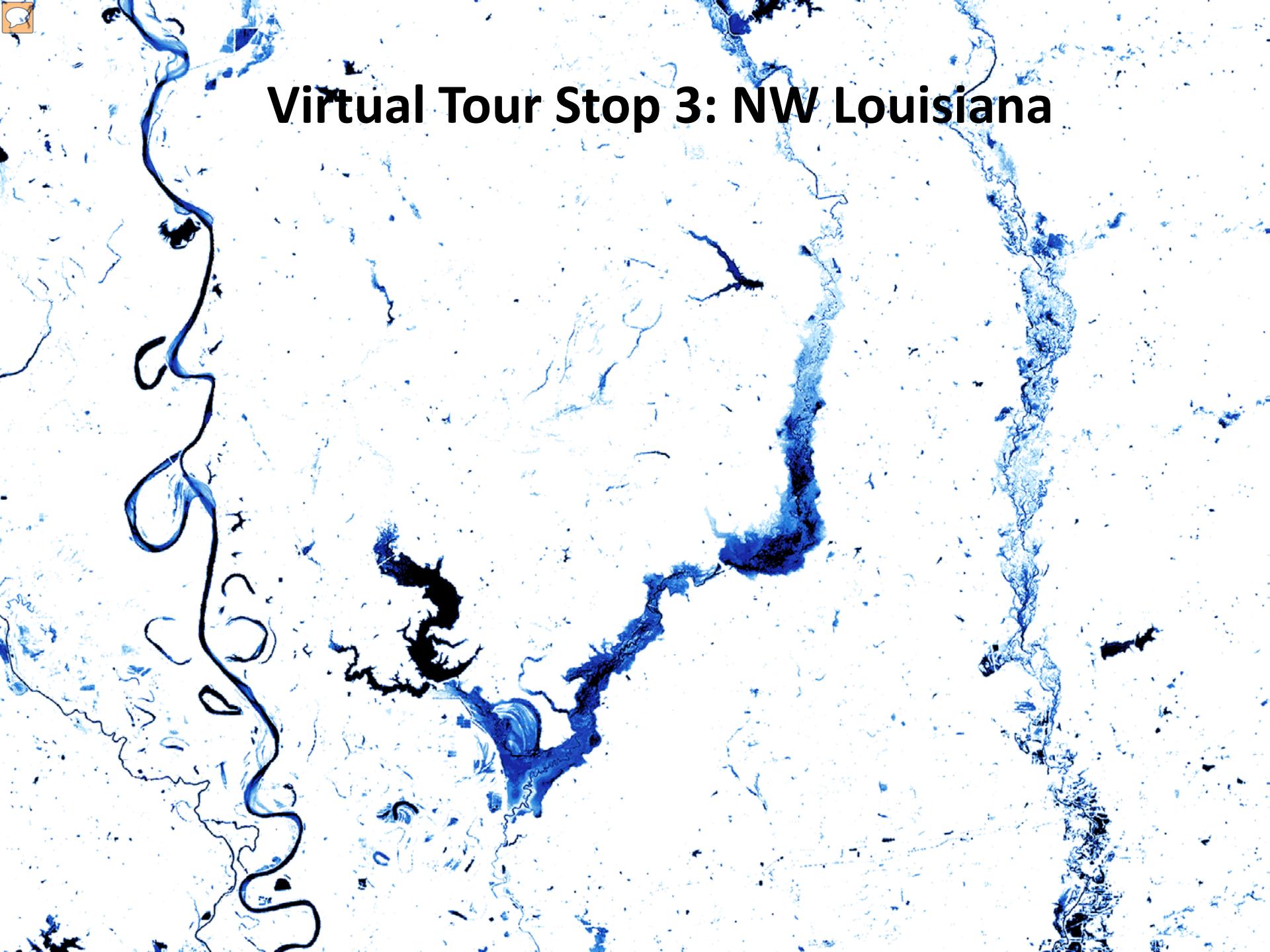


# Virtual Tour Stop 1: Atchafalaya and LMR



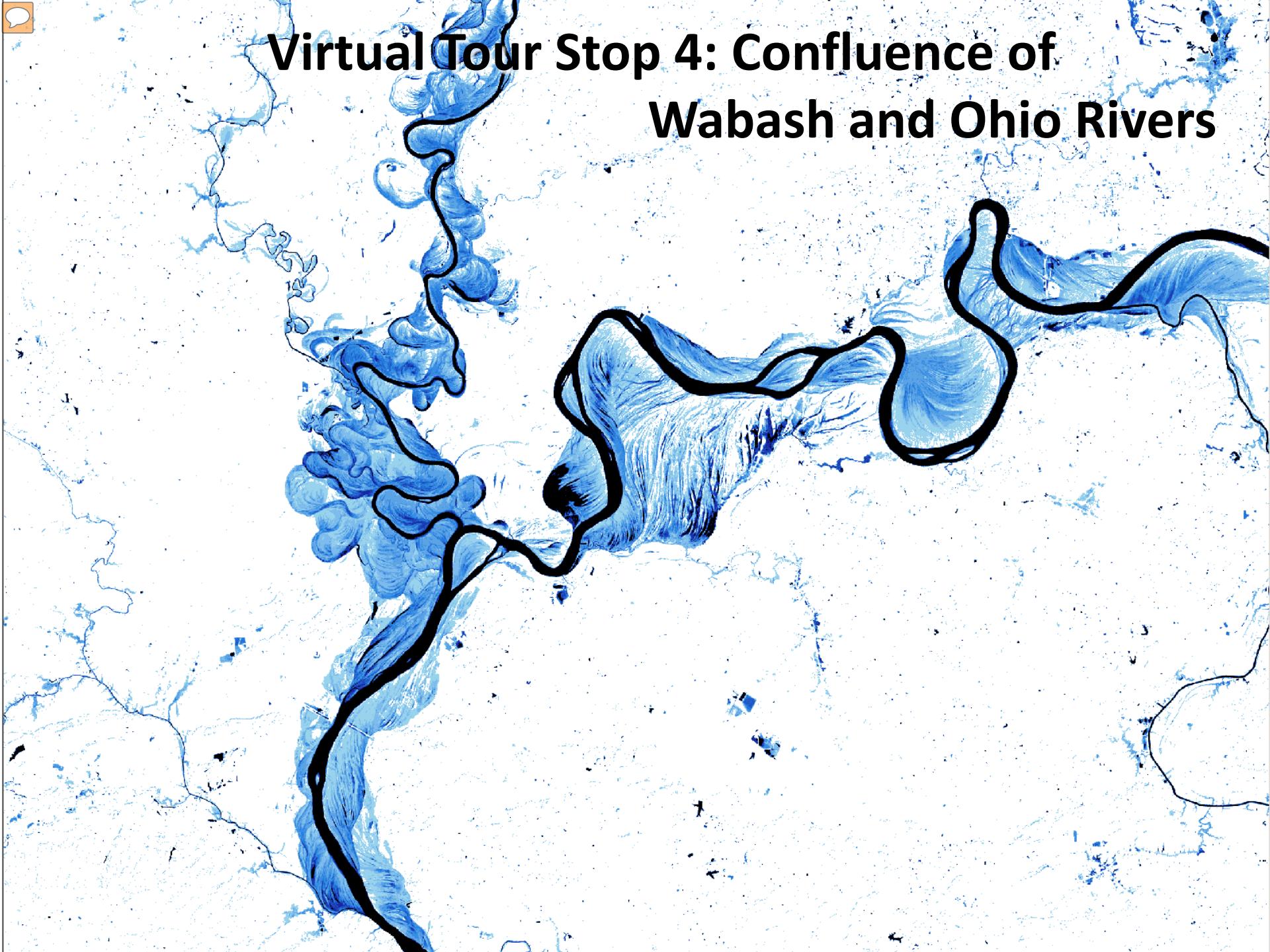
An aerial photograph showing the complex network of the Mobile River delta in Alabama and the coastal area of the Florida Panhandle. The delta features numerous channels and marshy areas. The coastline is visible at the bottom, with the Gulf of Mexico to the west and the Atlantic Ocean to the east.

## **Virtual Tour Stop 2: Mobile Delta and Florida Panhandle**



# Virtual Tour Stop 3: NW Louisiana



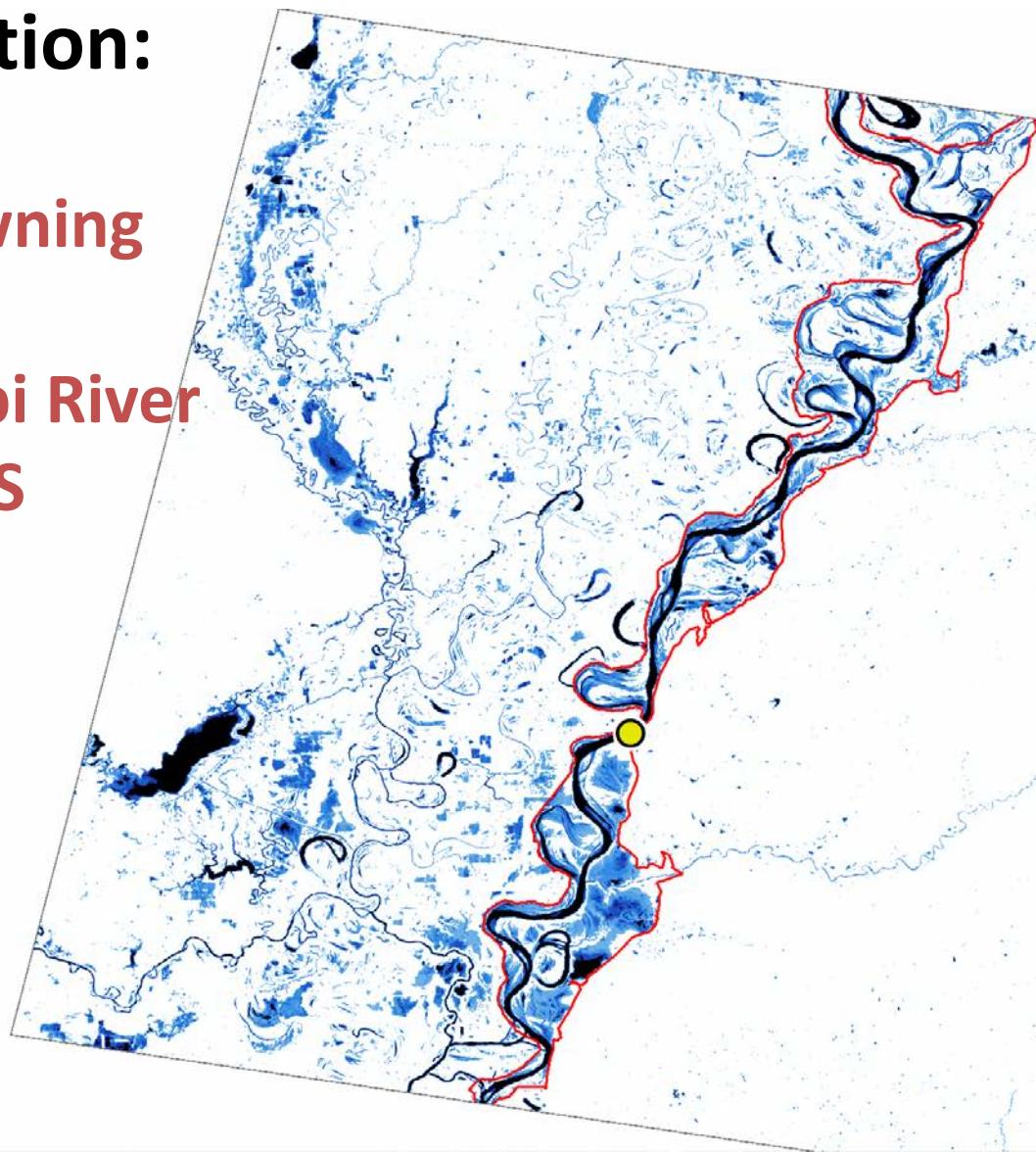


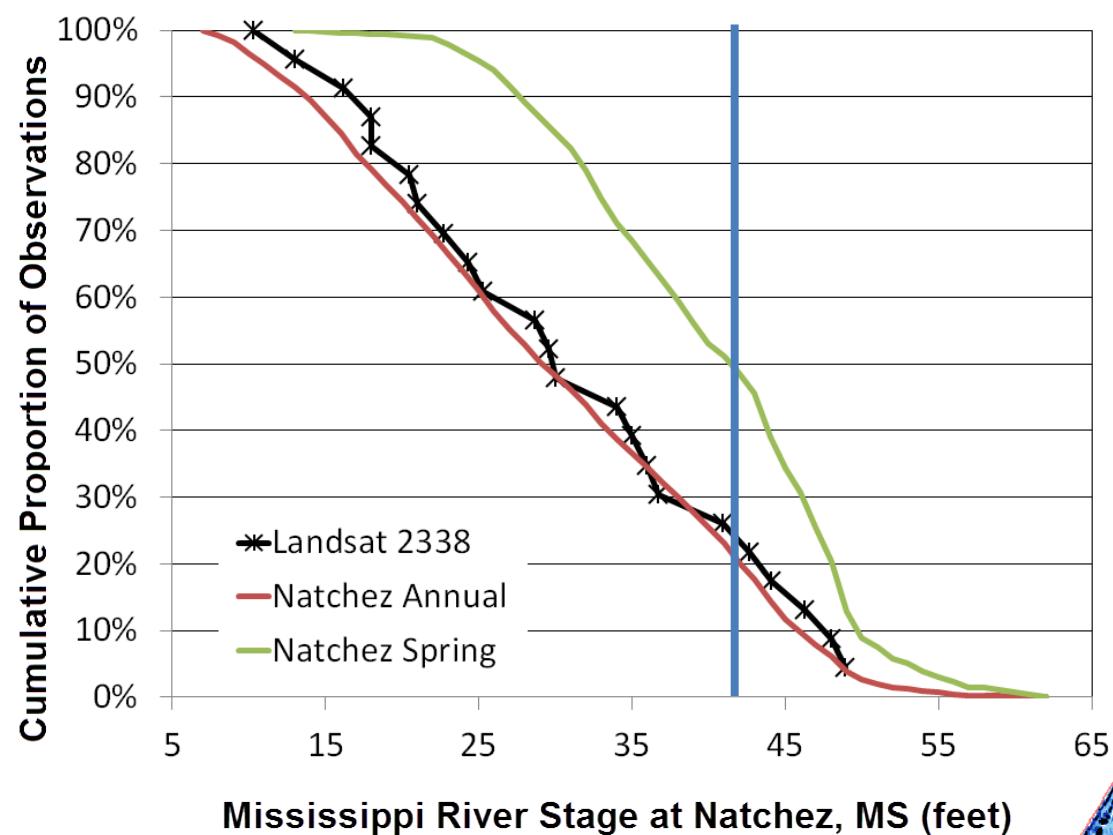
A map of the Ohio River basin, featuring a dense network of blue lines representing water bodies. A prominent, thick black line traces the course of the Ohio River, which joins the Wabash River at its confluence. The Wabash River is also outlined in black. The map shows various tributaries and the complex hydrology of the region.

## Virtual Tour Stop 4: Confluence of Wabash and Ohio Rivers

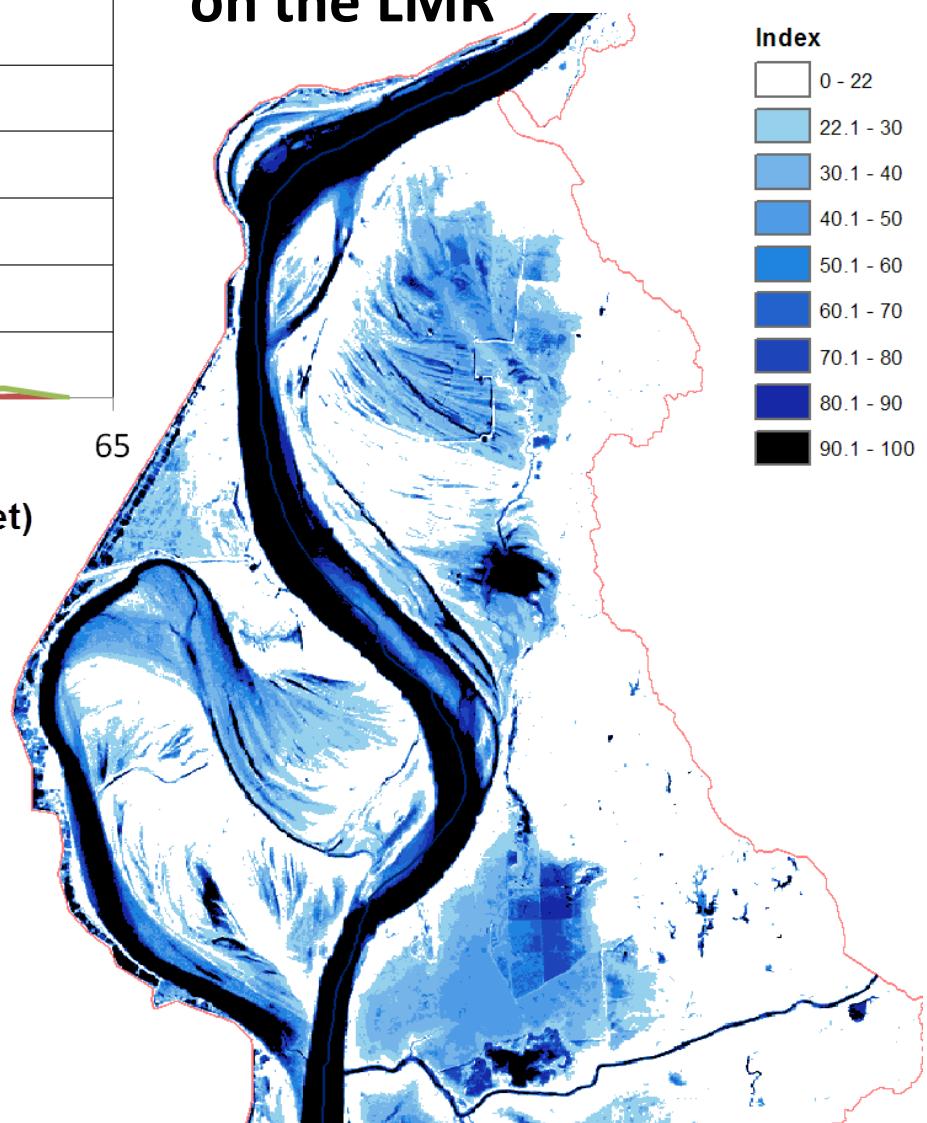
- Application: Relate relative IF to ground conditions
- First define the question:

- Why? Alligator Gar Spawning
- Where? Path 23 Row 38  
Lower Mississippi River
- What Gage? Natchez, MS
- When? April-June
- How often? 50% of time





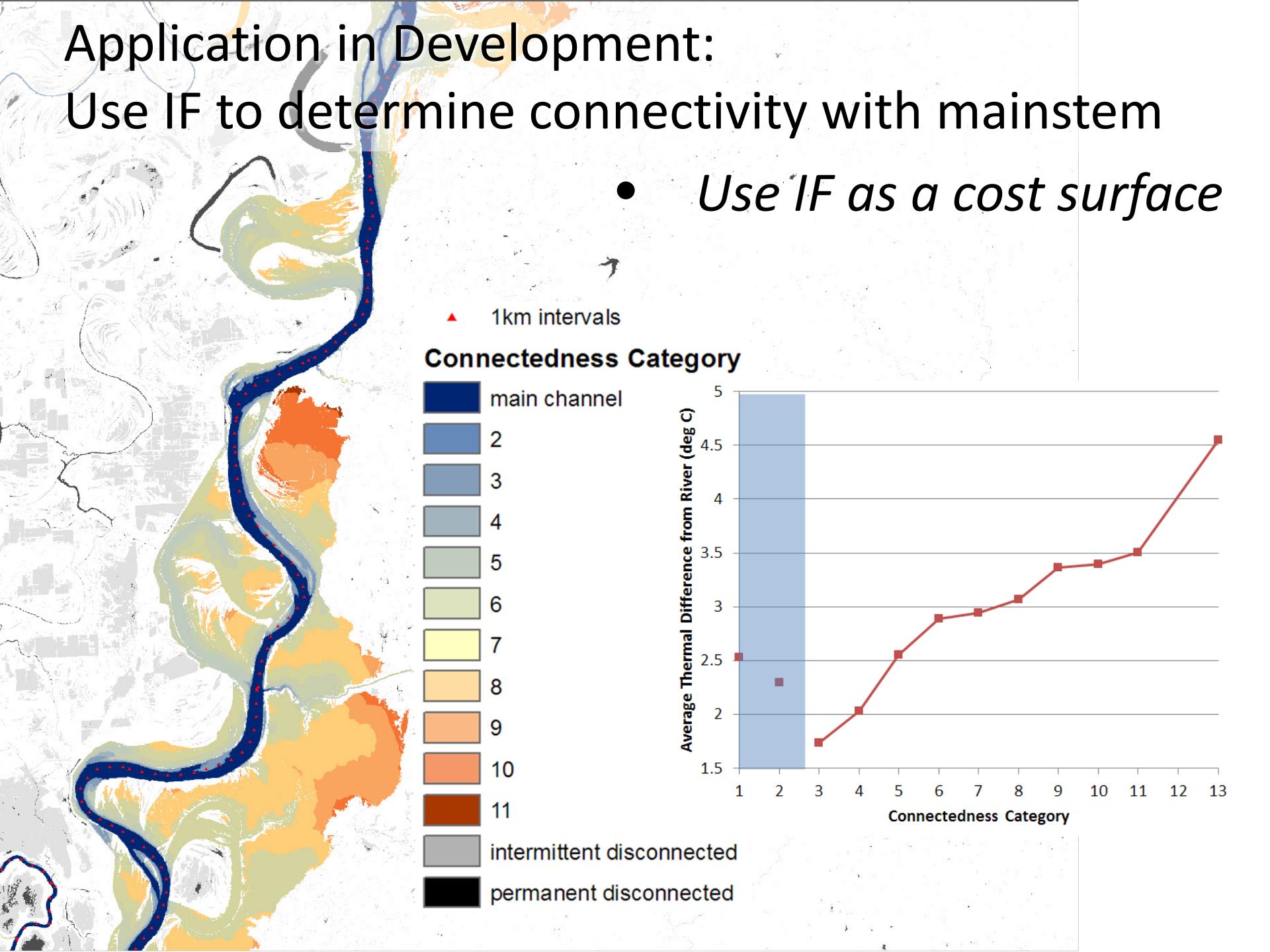
## Application: Core Floodplain Habitat for Alligator Gar Spawning on the LMR



- **Mississippi River Gage**
- **April-June**
- **50% of time**
- **Natchez=42'**
- **Inundation Index = 22**

# Application in Development: Use IF to determine connectivity with mainstem

- *Use IF as a cost surface*



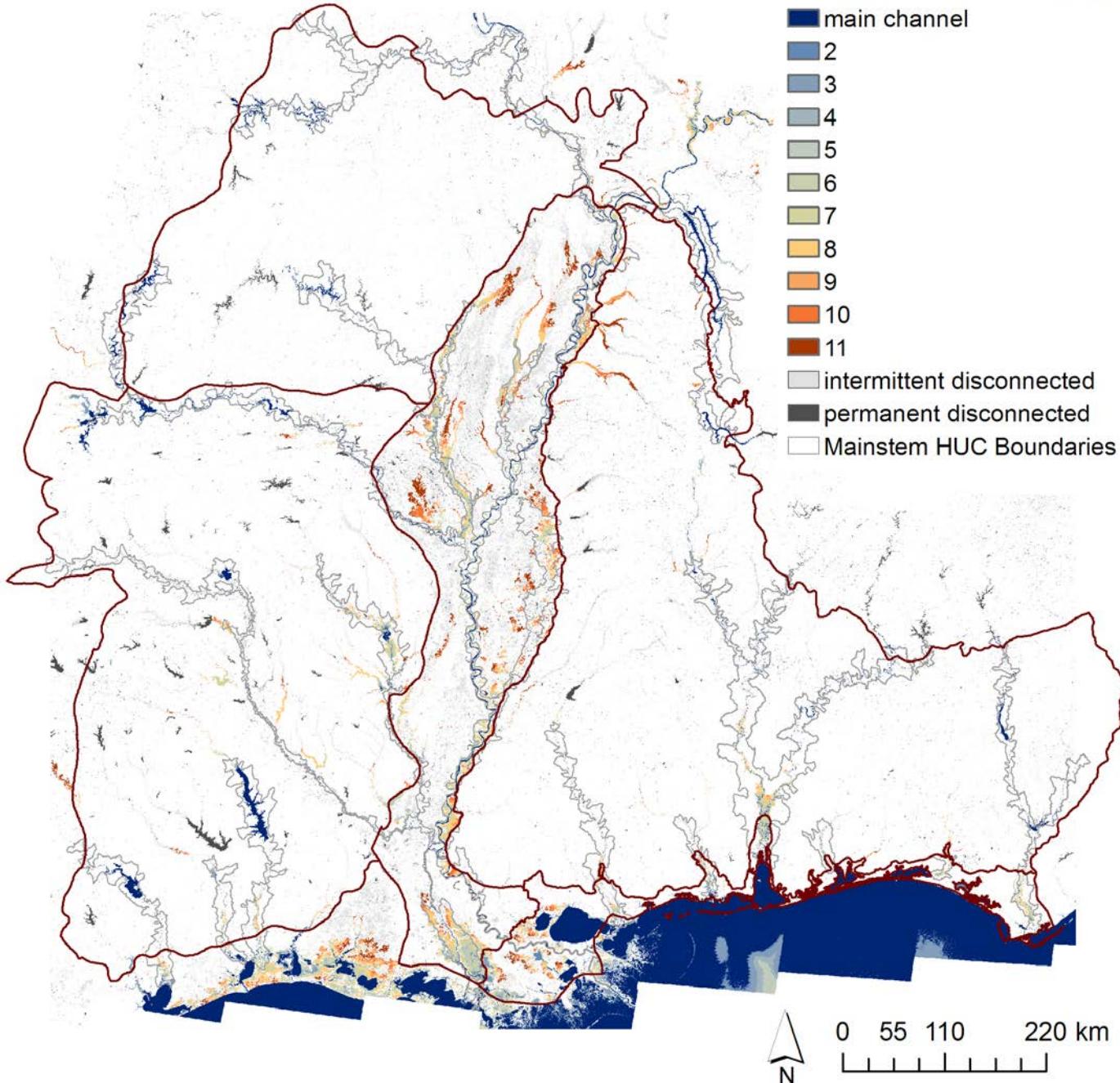
### Connectedness Category

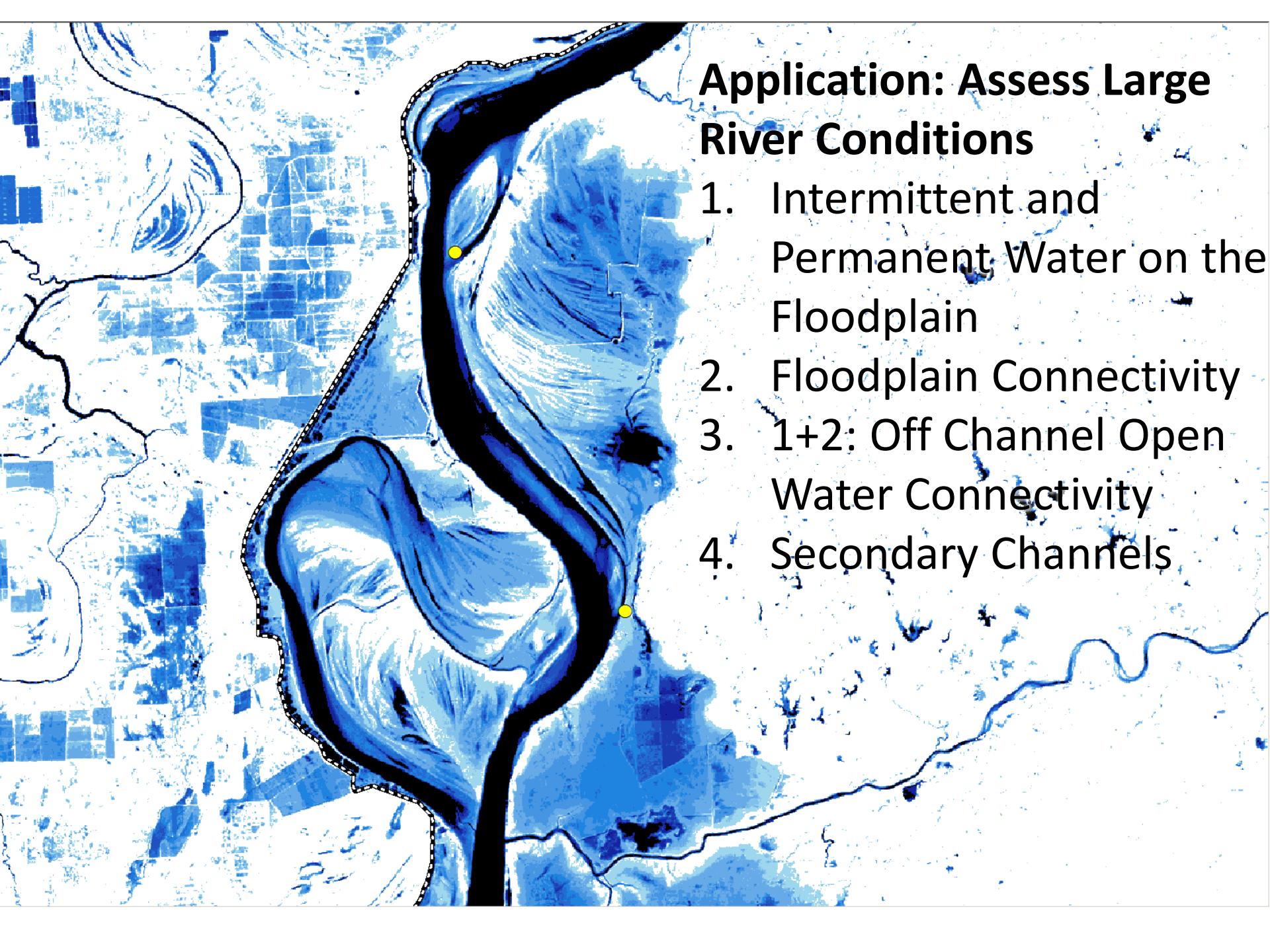
- main channel
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

intermittent disconnected

permanent disconnected

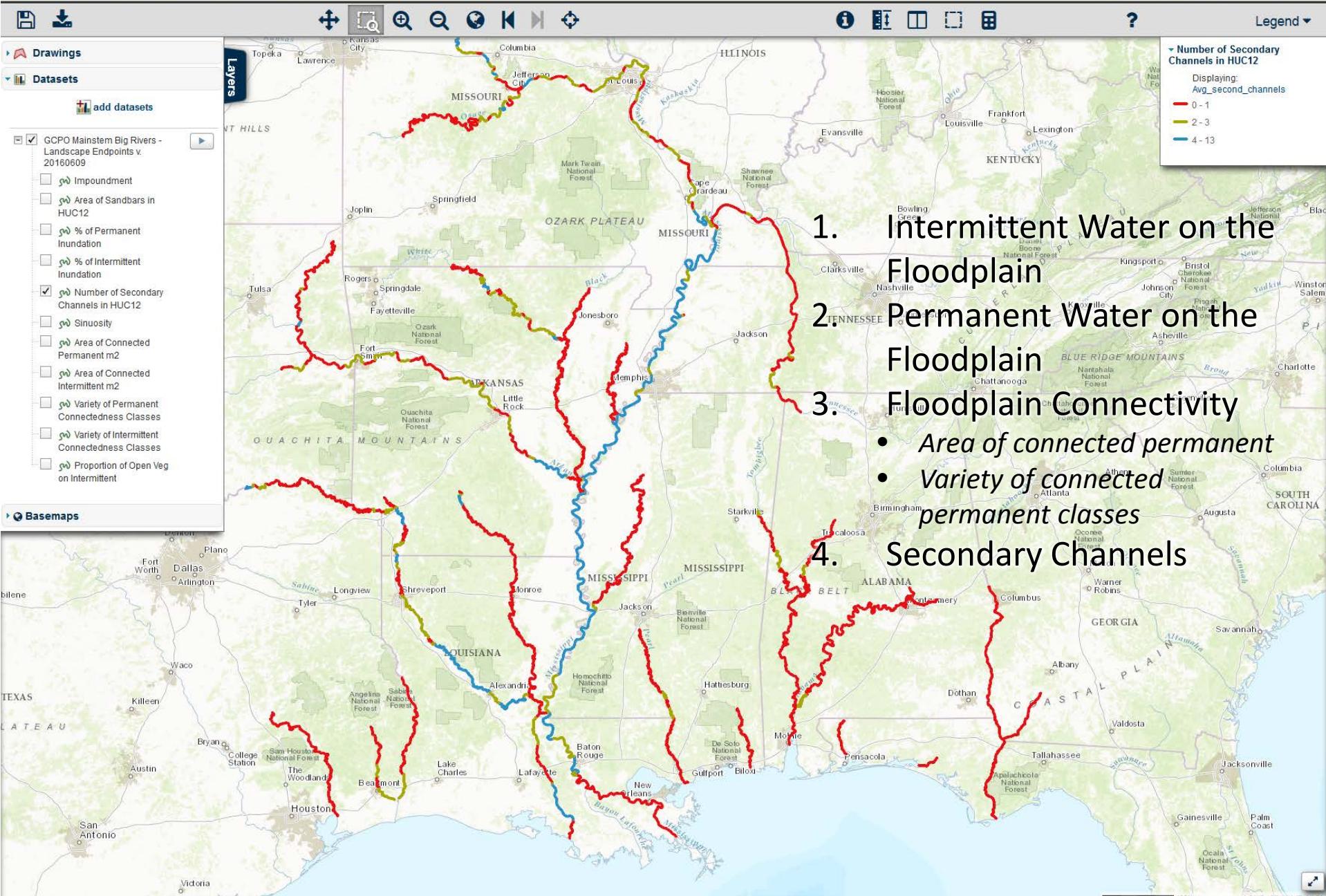
Mainstem HUC Boundaries



An aerial photograph of a large river system, likely the Mississippi River, showing its meanders and floodplain. A thick black line outlines a specific reach of the river, and two yellow dots mark specific locations along this line. The surrounding land is a mix of blue (water) and various shades of green and brown (land).

## Application: Assess Large River Conditions

1. Intermittent and Permanent Water on the Floodplain
2. Floodplain Connectivity
3. 1+2: Off Channel Open Water Connectivity
4. Secondary Channels



# Applications of Floodplain Inundation Frequency:

- Critical habitat location and condition for aquatic floodplain dependent species (*LMR*)
- Oxbow fish community composition and connectivity with mainstem (*LMR, MSU*)

**Flexible** data product that has also been used to estimate:

- Nutrient assimilation (*Atchafalaya River Basin, SIU*)
- Estimated inundation extent during LiDAR acquisition (*many locations, USGS*)
- Locations for potential cypress regeneration based on inundation return frequency (*Atchafalaya River Basin, TNC*)
- Identify BLH vulnerable/resilient to climate change (*Trinity River NWR, FWS*)
- Habitat availability for waterfowl and forest breeding birds (*Mississippi Alluvial Valley, LMVJV*)
- Floodplain change and flooding regime (*Pearl River Basin, St. Tammany Parish*)

# Looking Forward....

- More and more ***multispectral*** birds in the sky (*Sentinel 2, Planet Labs, Digitalglobe*)
  - *More frequent coverage and higher resolution*
- More and more ***analysis*** of Landsat inventory

# Comparison with Recent Global Water Distribution Dataset

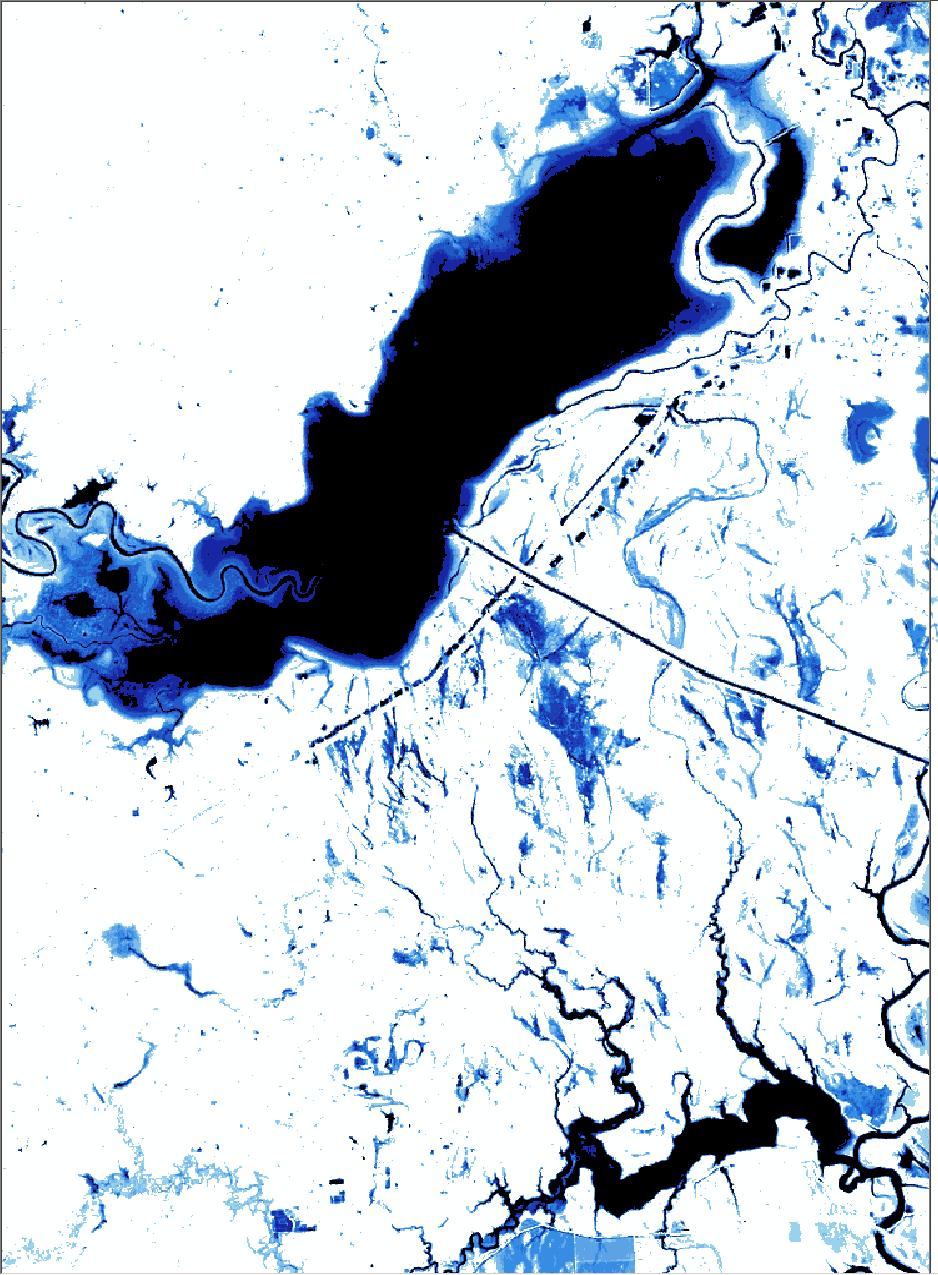
## Released Dec 2016

<https://global-surface-water.appspot.com/>

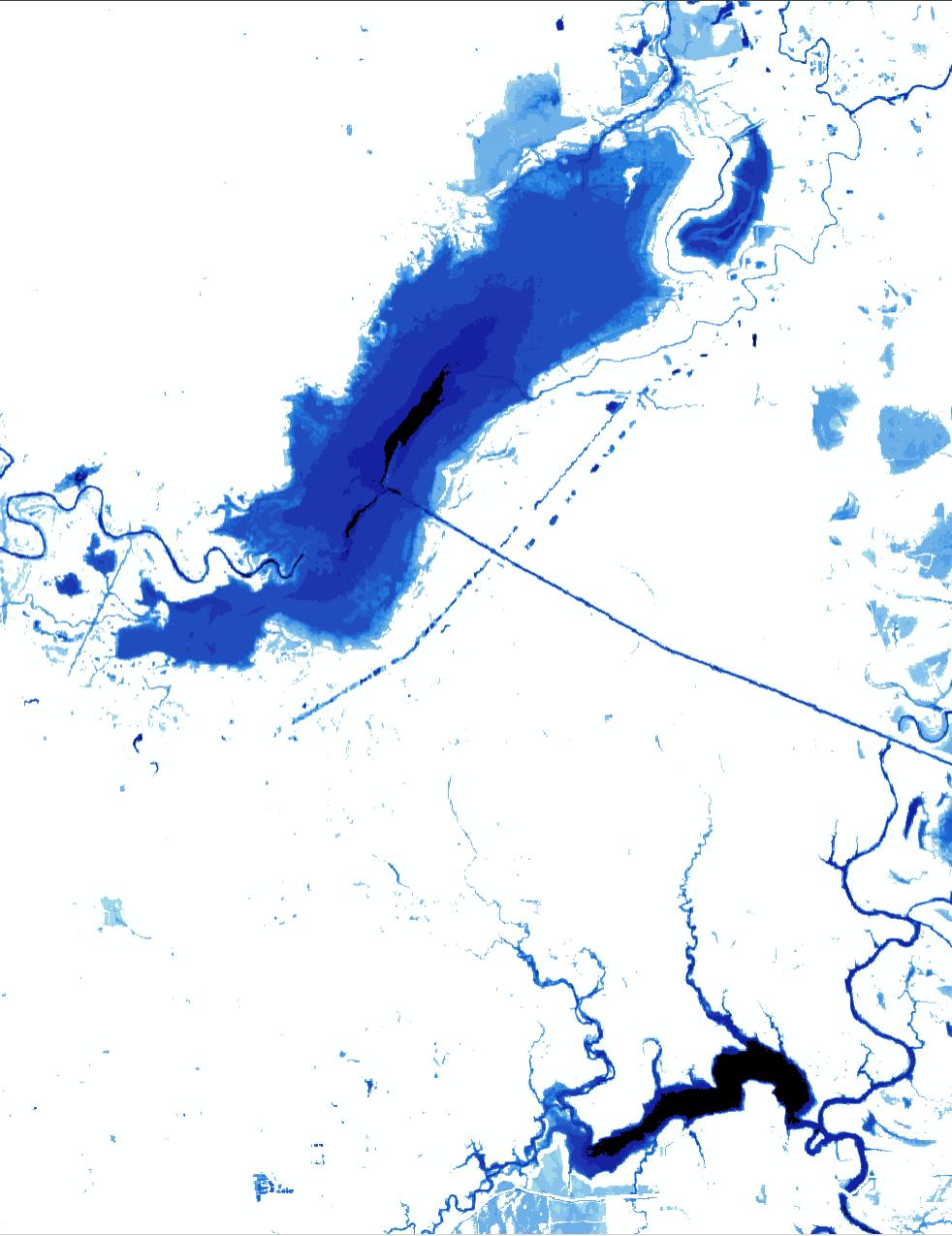
- Used Landsat to inventory *global* water distribution!
- Good at detecting open water – objective rigorous estimate

Comparison with GCPO estimate:

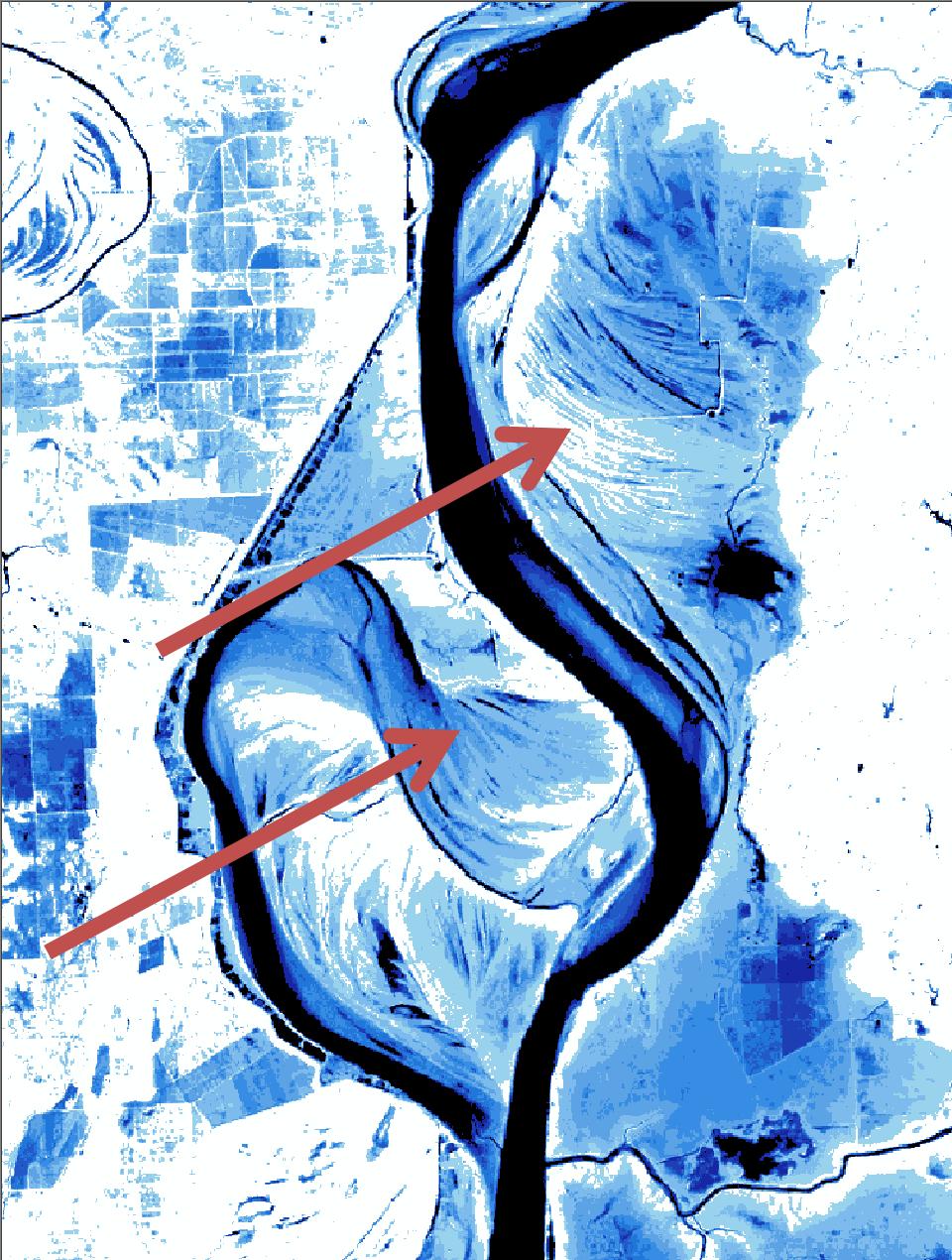
- Global Water Database is good for identifying timing of lake occurrence – e.g dam building or seasonal drying
- Regional Limitations: inaccurate over locations that have seasonal vegetative cover (ground, floating or canopy)



GCPO Inundation Index



Global Water Database

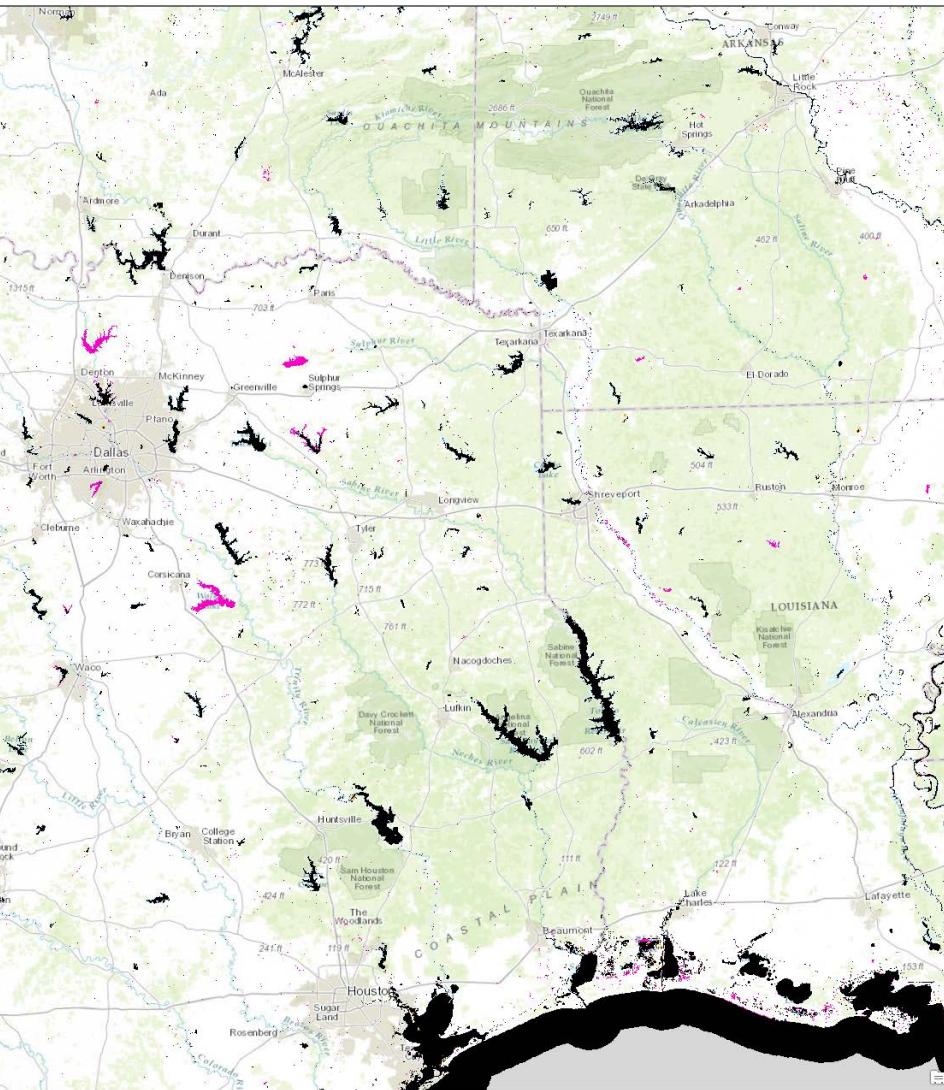


GCPO Inundation Index

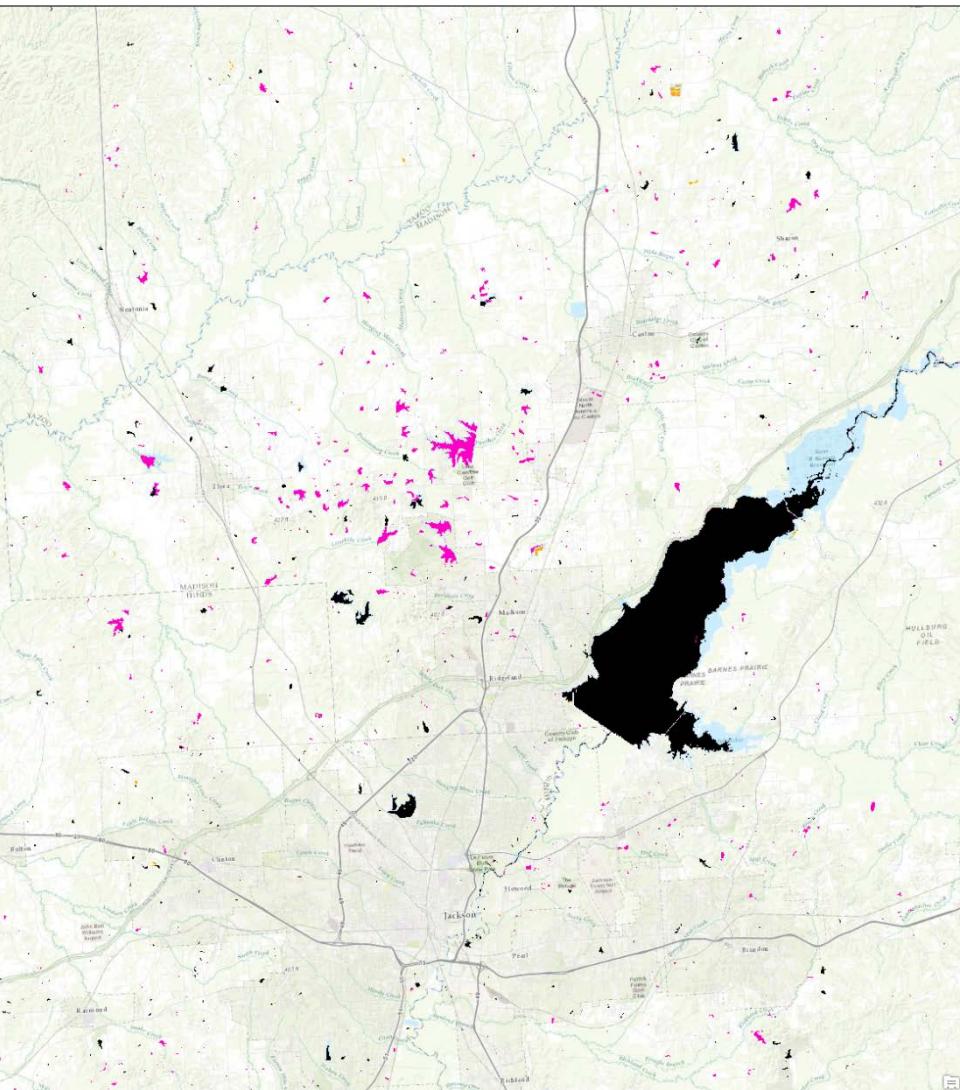


Global Water Database

# Using the Global Water Database: identify dam dynamics



Creation of large reservoirs  
around Dallas



Creation of smaller impoundments  
north of Jackson, MS

# Looking Forward....

- More and more *multispectral* birds in the sky (*Sentinel 2, Planet Labs, Digitalglobe*)
- More and more *analysis* of Landsat inventory

## Continued Applications of Remote Sensing in Aquatic Habitat Assessment:

- Turbid water -> WQ (*Atchafalaya Basin and Coastal Louisiana*)
- Surface water temperature (*plumes*)
- Give larger spatial footprint to *in situ* data
- Evaluation of restoration success
- Historical record of change
- Acoustic sensors: bathymetry, substrate (*Pearl River*)

# Questions?

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## GCPO LCC Conservation Planning Atlas & Science Base

<http://gcpolcc.databasin.org/>

<https://www.sciencebase.gov/catalog/item/5617e3c3e4b0cdb063e3fc35>

### Gulf Coastal Plains and Ozarks LCC

Conservation Planning Atlas

← GCPO LCC Home

Search by keyword or location 

powered by DATA BASIN

Get Started

Browse

Create

Community

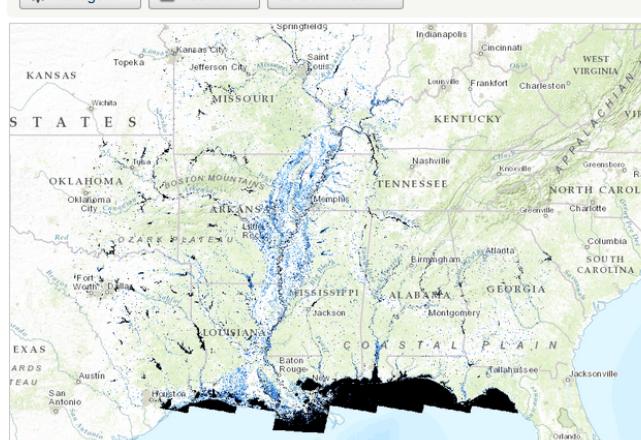
My Workspace

GULF COASTAL PLAINS AND OZARKS LCC CPA | DATASETS | GCPO INUNDATION FREQUENCY MOSAIC

#### GCPO Inundation Frequency Mosaic

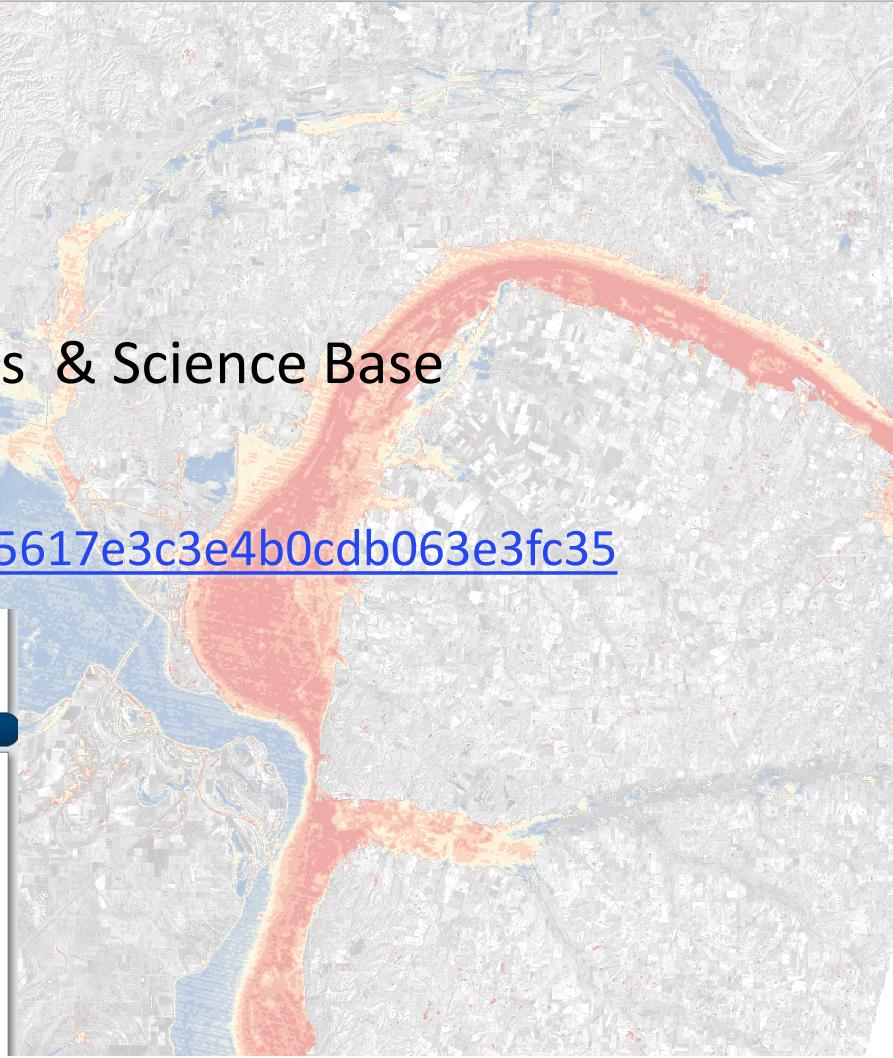
Uploaded by Yvonne Allen

[Open in Map](#)



Recommended by CPA Administrator

**Description:**  
In large river ecosystems, the timing, extent, duration and frequency of floodplain inundation greatly affect the quality of fish and wildlife habitat and the supply of important ecosystem goods and services. Seasonal high flows provide connectivity from the river to the floodplain, and seasonal inundation of the floodplain governs ecosystem function. River regulation and hydrologic alteration have altered many rivers with their adjacent impacting the function of wetlands and in turn, impacting the main conservation and management floodplain resources can be better understood through the spatial frequency of inundation at scales of species and/or ecological. Spatial data products describing floodplain inundation are now available. This study used Landsat imagery to generate multiple observations under varying hydrologic conditions to estimate inundation frequency. Inundation frequency was estimated for 50 Landsat scenes images within the Gulf Coast Landscape Conservation Coop.



#### RIVER RESEARCH AND APPLICATIONS

*River Res. Appl. (2015)*

Published online in Wiley Online Library  
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#### LANDSCAPE SCALE ASSESSMENT OF FLOODPLAIN INUNDATION FREQUENCY USING LANDSAT IMAGERY

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