

# **Small Pond Identification in the Highland Lakes Watershed Using Satellite Imagery**

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**LCRA Board of Directors Meeting  
June 18, 2024**



# Why do we need to study ponds in the watershed?

- To understand the impact to the inflows of system
- To help determine if there is any impact to the firm yield of the system

# History of Small Pond Identification Studies

- **2011 – Texas Water Development Board**
  - Studied the impact of exempt reservoirs on two reservoirs
  - Lake Coleman and Cedar Creek Reservoir
- **2017 and 2019 – Texas Water Development Board**
  - Used the National Hydrography Dataset, U.S. Geological Survey topo maps, ArcGIS aerial images and Google Earth images in the San Saba watershed
- **2023 – LCRA**
  - Staff used GIS techniques to estimate the number of ponds that appear to have been constructed in eight separate watersheds
  - Added the small ponds into LCRA models to determine the potential effects to the firm yield
- **2024 – LCRA**
  - Used remote sensing to identify ponds within the watersheds

# Staffing

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Dr. Jennifer Jensen, Texas State University

Garrett Pugh, Texas State University

Grayson Wylie, Texas State University

Ron Anderson, LCRA Chief Engineer

Hank Zook, LCRA Cartographer



# Regulation of Small Ponds

**Exempt from state water rights permitting if:**

- **Located entirely on private property (on a non-navigable stream or off channel)**
- **Store no more than an average annual amount of 200 acre-feet of water**
- **The pond is used solely for:**
  - Domestic and livestock purposes
  - Certain types of wildlife management

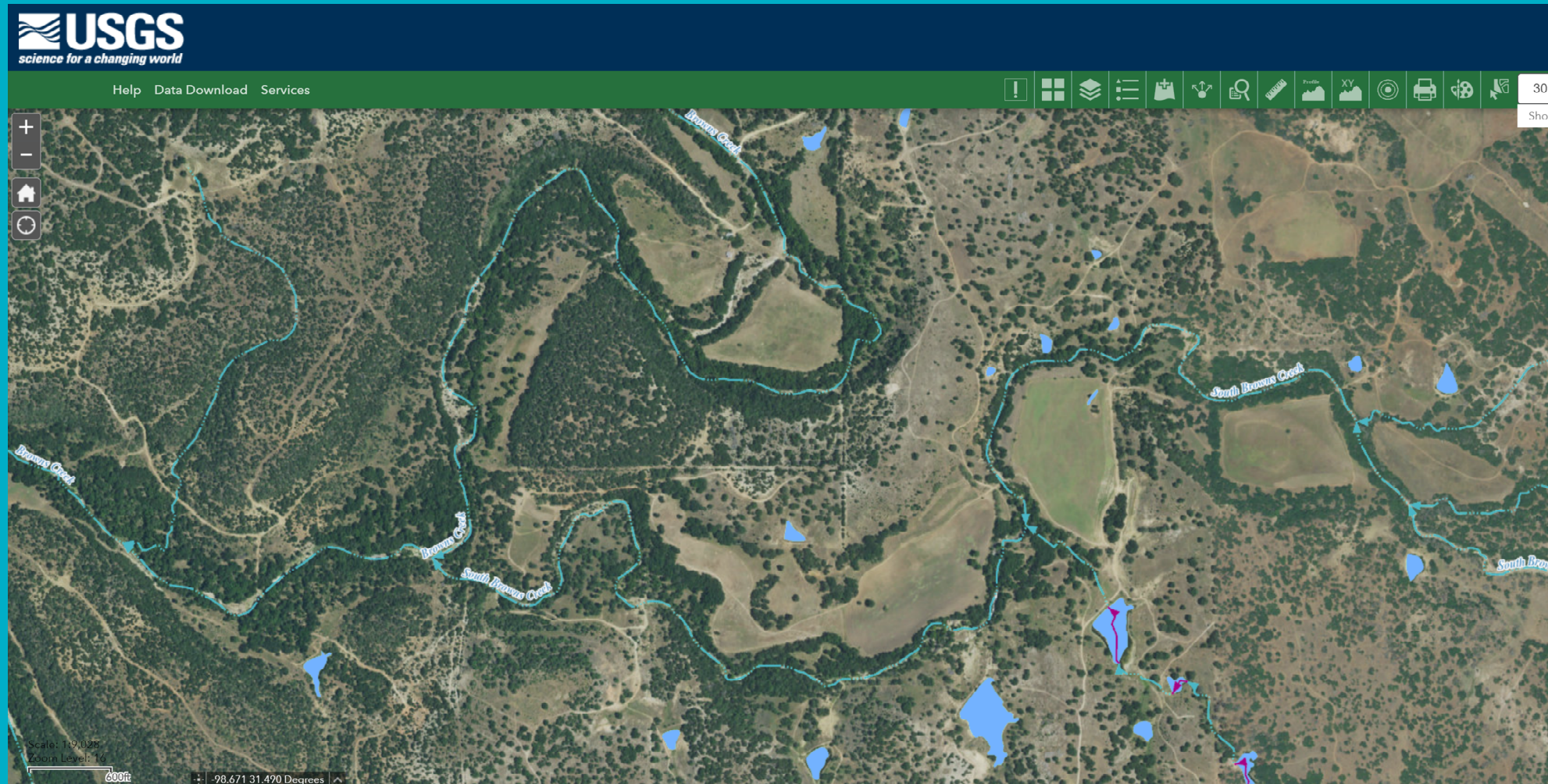
# **Regulation of Small Ponds (Continued)**

**Exempt from state water rights permitting if:**

- **No commercial operations**
  - No industrial operations, aquaculture, fish farming, housing developments
  - May allow hunting, trapping for a fee, certain other incidental uses
- **No limit on the number of ponds a landowner can have**
- **Exempt ponds are not included in the Texas Commission on Environmental Quality's Water Availability Models**

# Examples of Small Ponds

Ponds near Brown Creek in the Pecan Bayou watershed

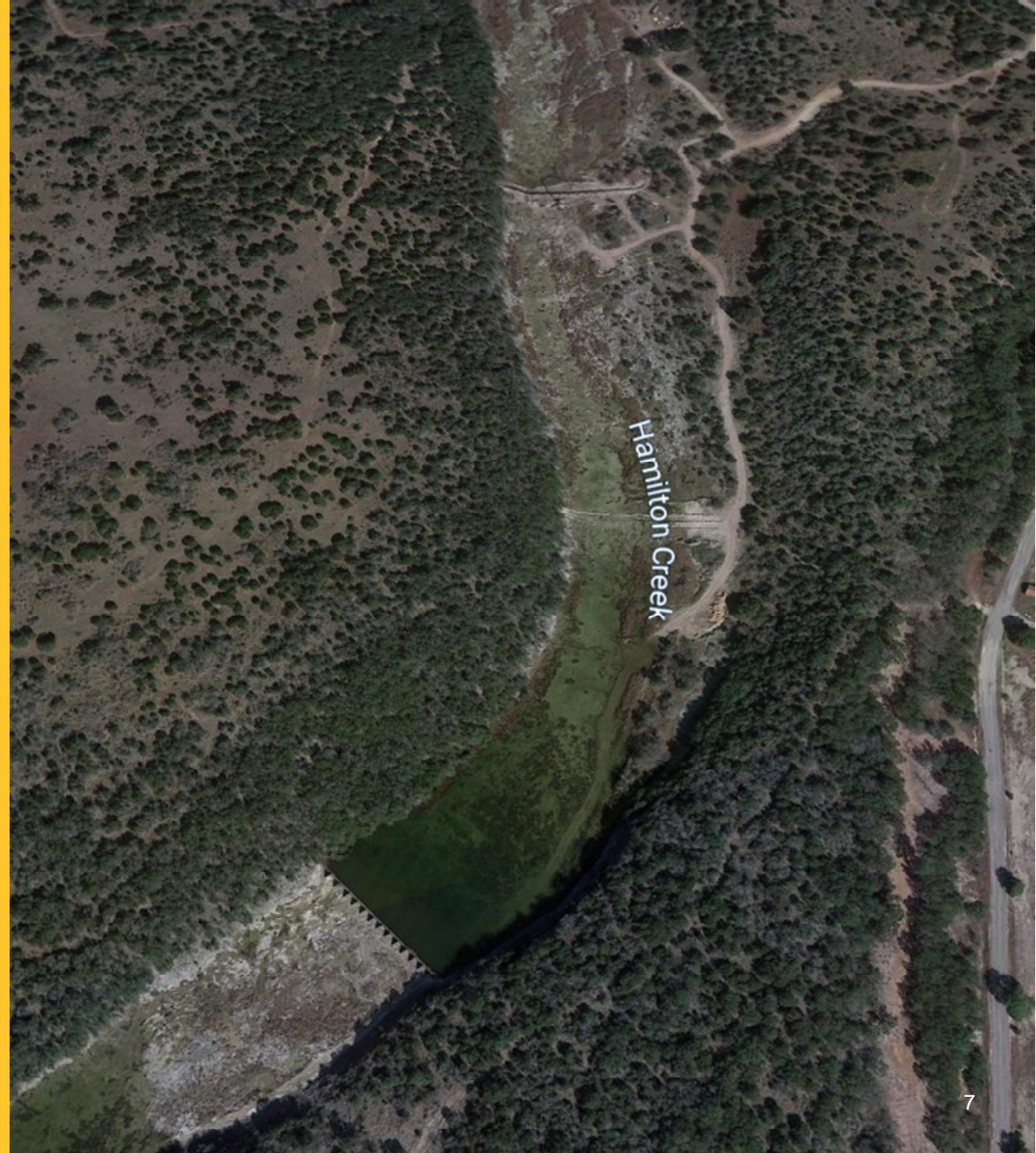


# Examples of Small Ponds

(Continued)

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Hamilton Creek, Burnet





# Area of LCRA Study

## Watersheds



## Watershed Area (square miles)

Pecan Bayou	2,205
San Saba River	2,296
Brady Creek	804
Main Stem/Other	2,545
<b>Lake Buchanan Watershed Total</b>	<b>7,850</b>
Llano River	4,466
Pedernales River	1,281
Main Stem/Sandy Creek/Other	1,083
<b>Lake Travis Watershed Total</b>	<b>6,830</b>
<b>Total Watershed Area</b>	<b>14,680</b>

# Overall Project Objectives

Ponds in the Highland Lakes watershed for 2015, 2019 and 2023

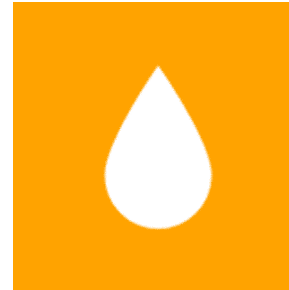
## Assess

Perform quality control review of methods and found ponds



## Inventory

Inventory ponds within subwatersheds and summarize water body distributions by size per year



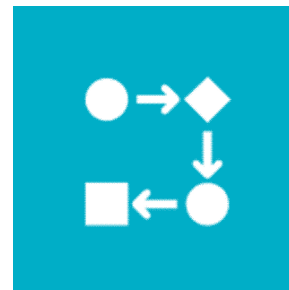
## Compare

Compare results of classified inventory with the United States Geological Survey database



## Quantify and summarize

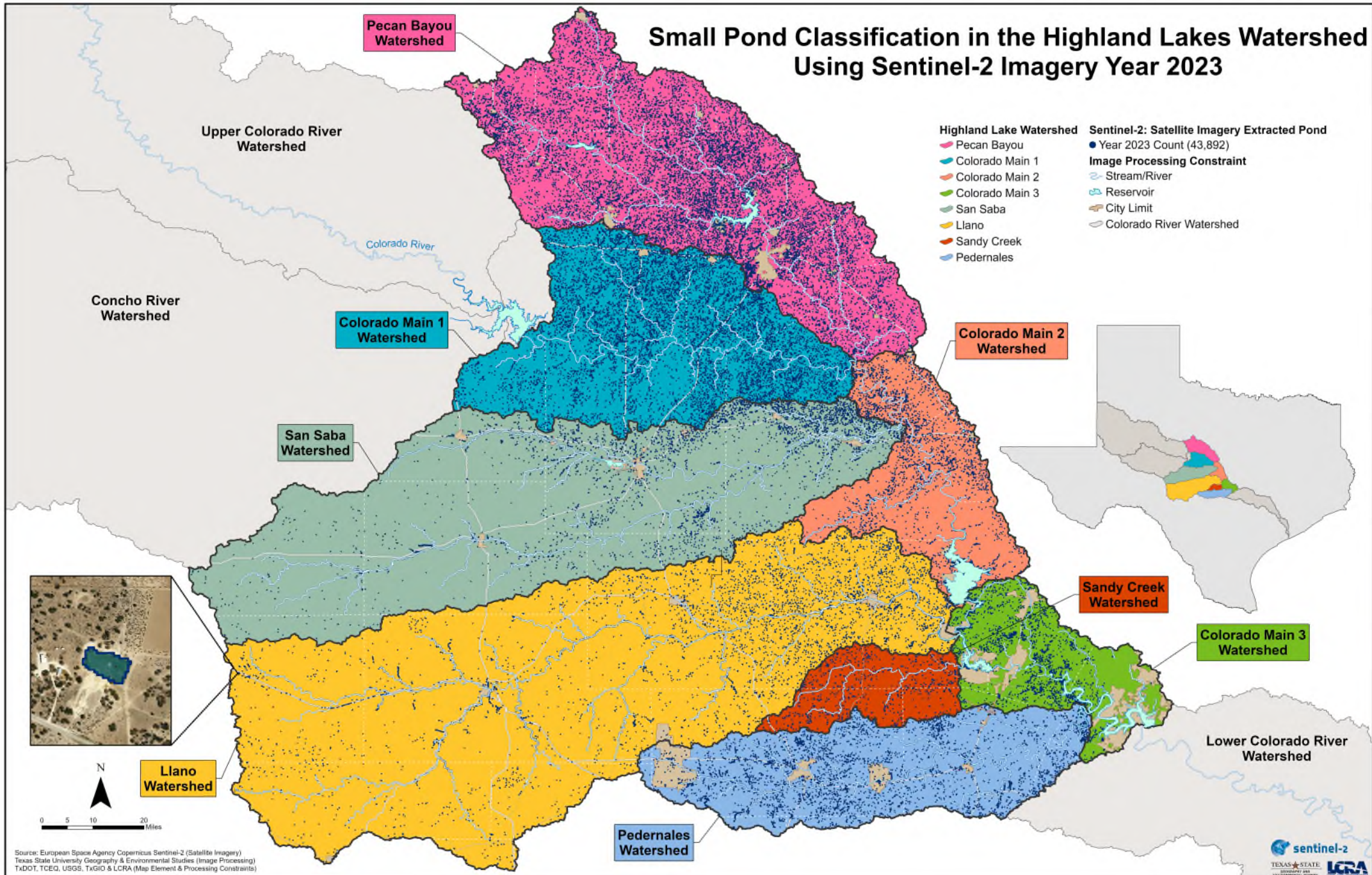
Compute inventory change statistics



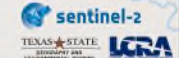
# Results

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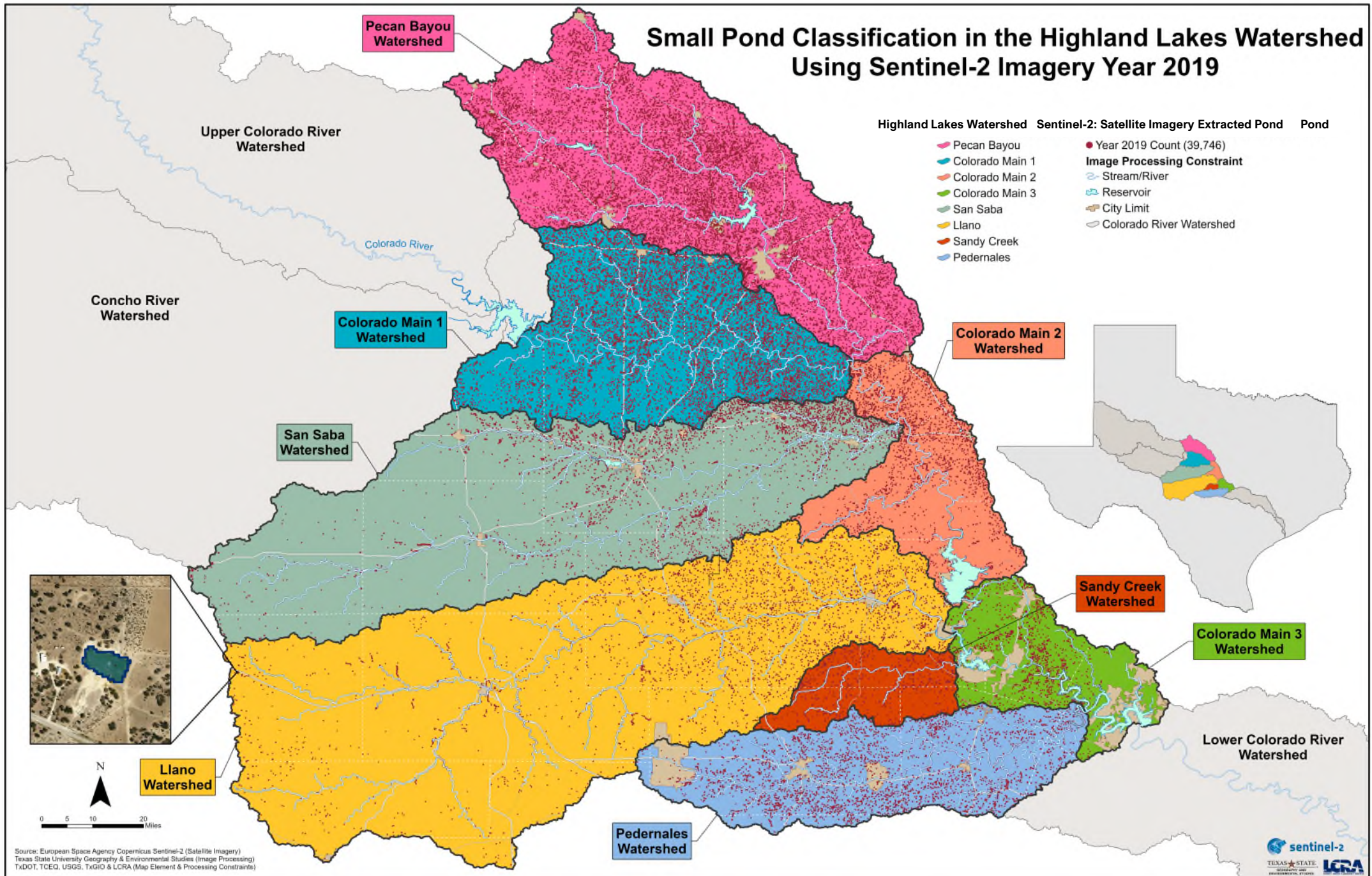
# Small Pond Classification in the Highland Lakes Watershed Using Sentinel-2 Imagery Year 2023



Source: European Space Agency Copernicus Sentinel-2 (Satellite Imagery)  
 Texas State University Geography & Environmental Studies (Image Processing)  
 TxDOT, TCEQ, USGS, TxGIG & LCRA (Map Element & Processing Constraints)

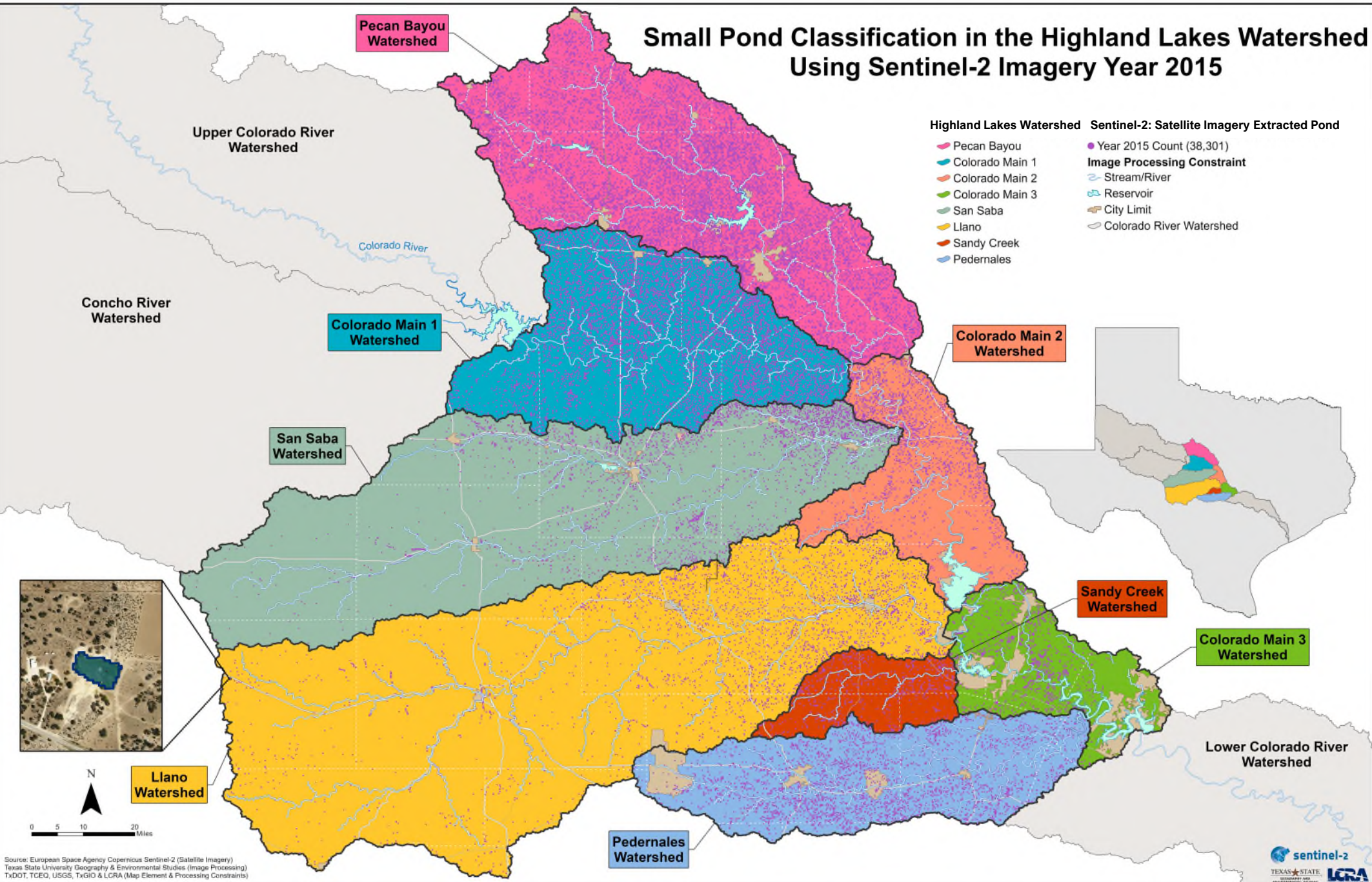


# Small Pond Classification in the Highland Lakes Watershed Using Sentinel-2 Imagery Year 2019

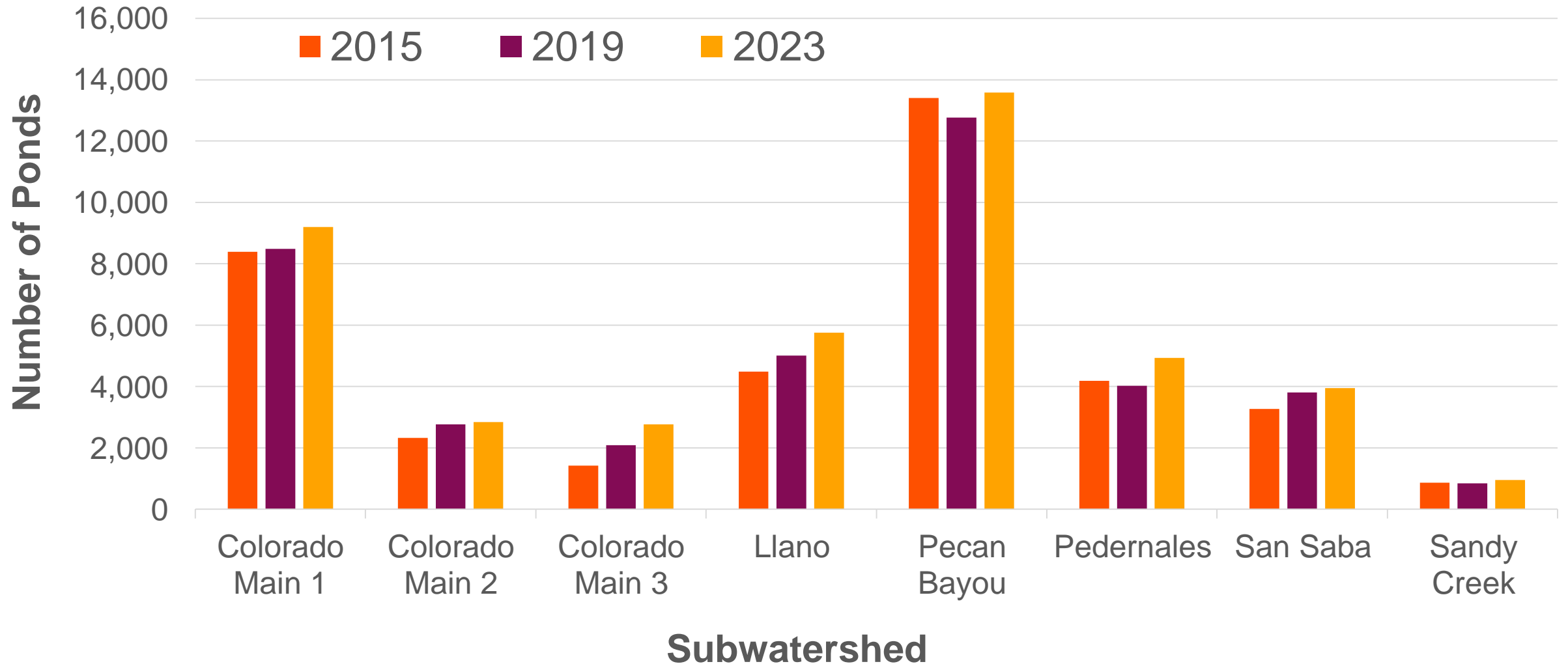


Source: European Space Agency Copernicus Sentinel-2 (Satellite Imagery)  
 Texas State University Geography & Environmental Studies (Image Processing)  
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# Small Pond Classification in the Highland Lakes Watershed Using Sentinel-2 Imagery Year 2015

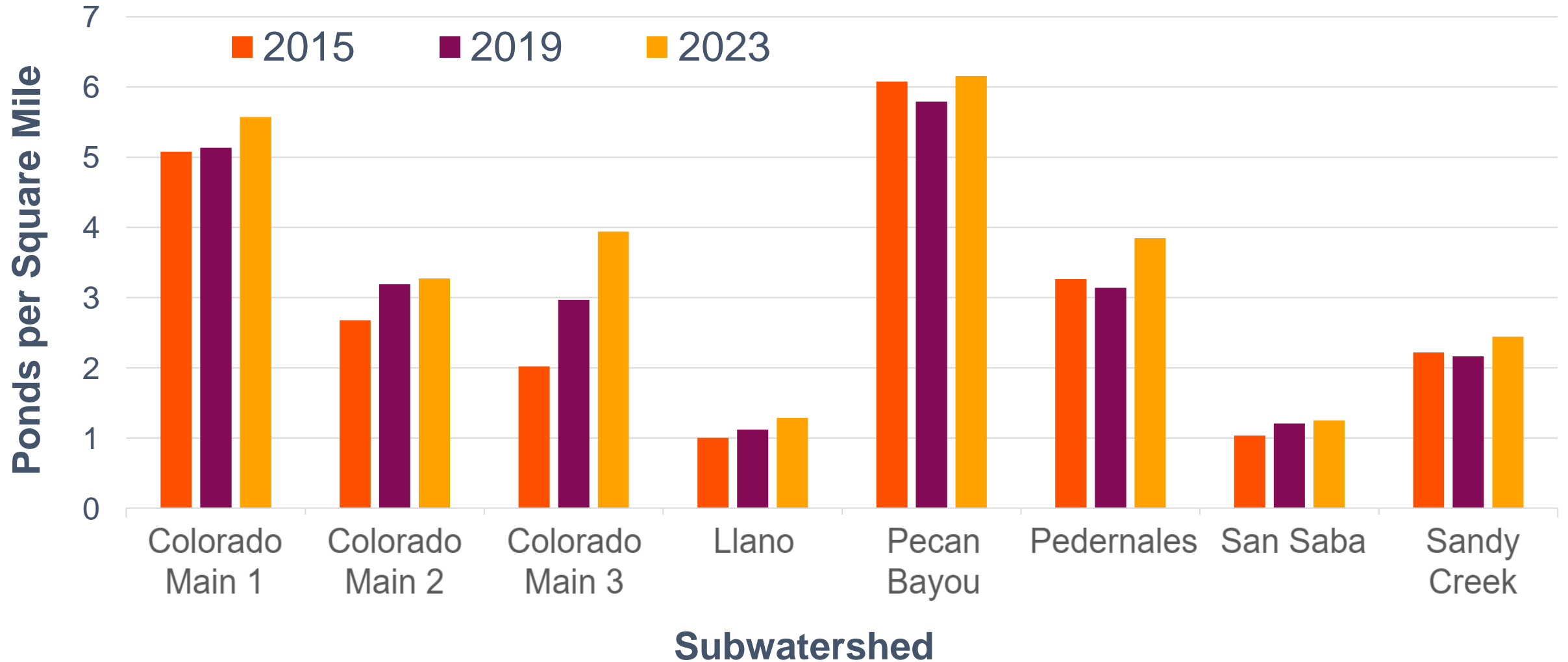


# Highland Lakes Subwatersheds Pond Count



# Highland Lakes Subwatersheds

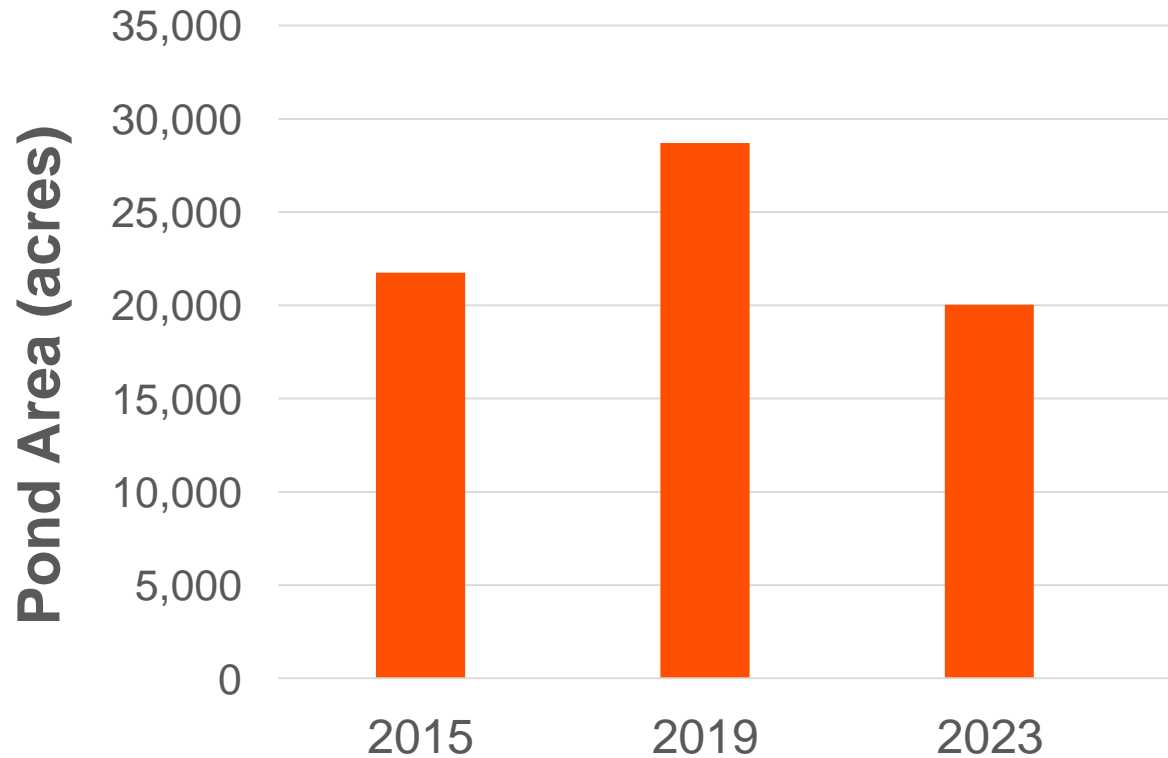
## Pond Density



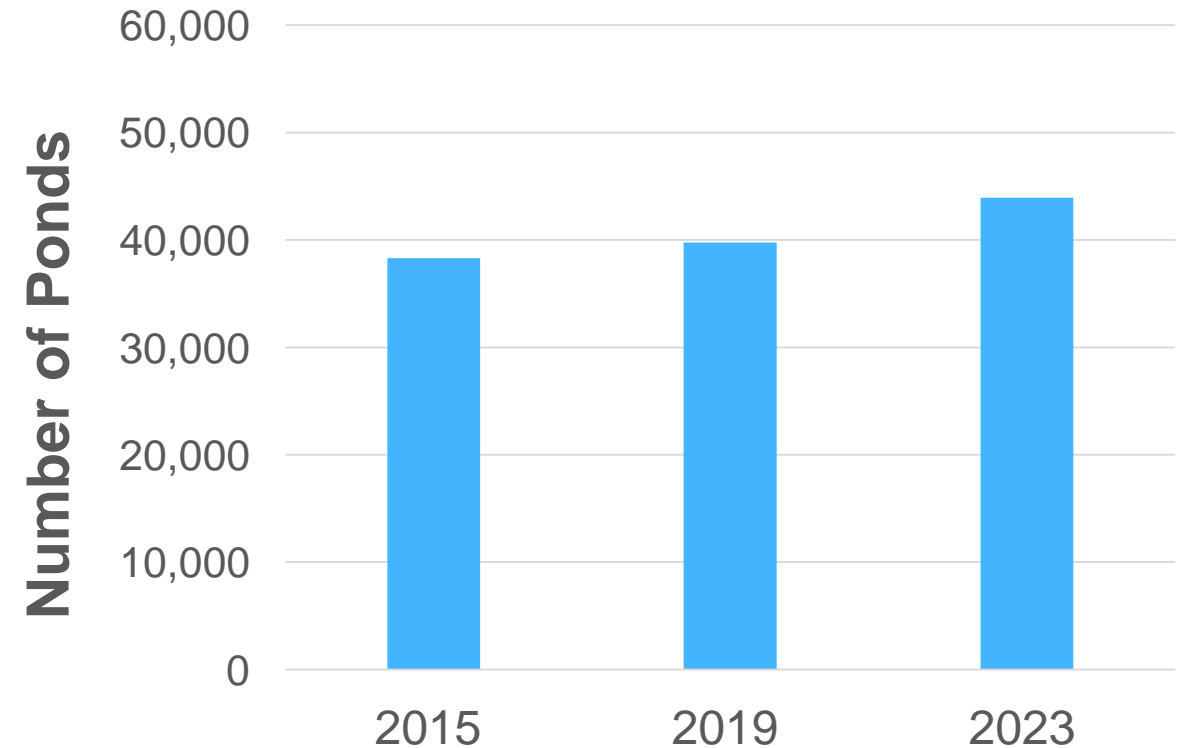


# Highland Lakes Watershed Pond Area and Counts (December 2015-March 2023)

## Total Pond Surface Area



## Total Pond Counts



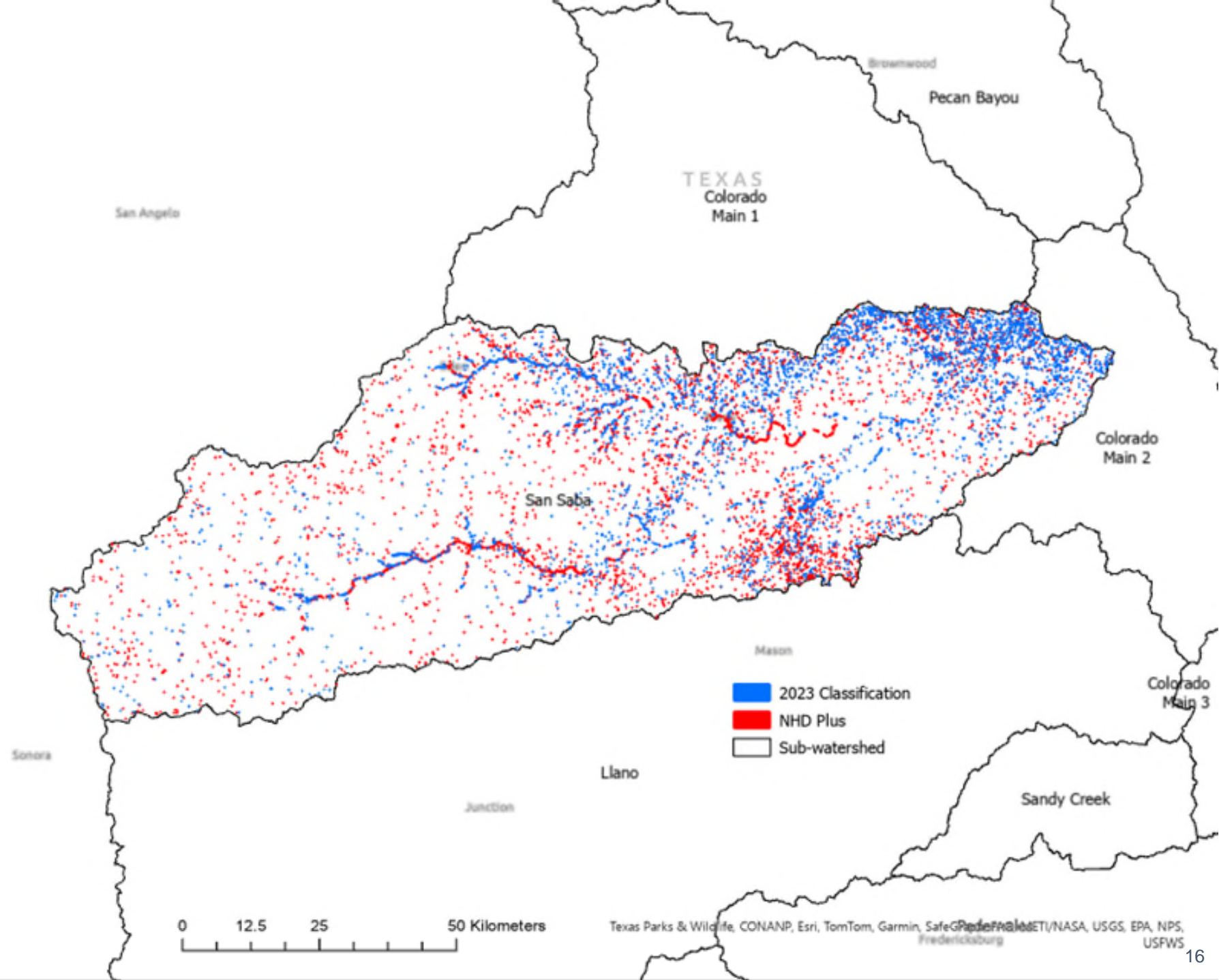
# Pond Counts\*

Subwatershed	December 2015	February 2019	May 2023
Colorado Main 1	8,387	8,480	9,198
Colorado Main 2	2,322	2,766	2,837
Colorado Main 3	1,418	2,084	2,766
Llano	4,481	5,005	5,752
Pecan Bayou	13,402	12,761	13,575
Pedernales	4,181	4,022	4,927
San Saba	3,265	3,800	3,943
Sandy Creek	860	839	948
Total	38,316	39,757	43,946
Increase		1,441	4,189
<b>% Increase</b>		<b>3.8%</b>	<b>11%</b>

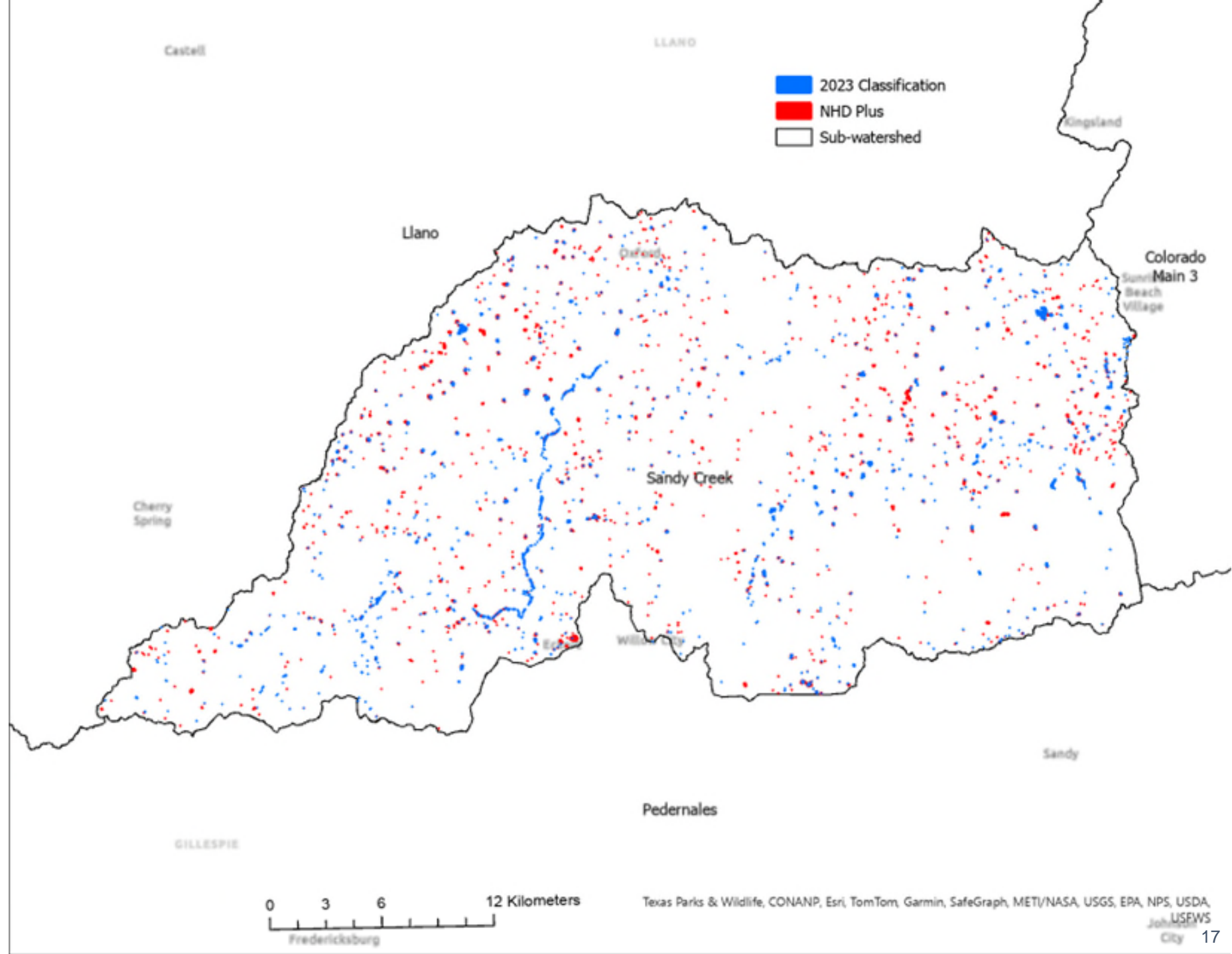
- **5,630 new ponds were added from 2015 to 2023**
- **Pond construction increased in the 2019-2023 four-year period compared with the 2015-2019 four-year period**
- **Pecan Bayou has the greatest number of ponds**
- **Sandy Creek has the fewest ponds**

\*For all ponds greater than 1,076 feet<sup>2</sup> (100 m<sup>2</sup>)

# San Saba Pond Inventory



# Sandy Creek Pond Inventory



# Annualized Percent Increase in Number of Ponds\*

Subwatershed	Percent of Watershed	December 2015-February 2019	February 2019-May 2023	December 2015-May 2023
Colorado Main 1	11%	0.35%	2.01%	1.28%
Colorado Main 2	6%	5.68%	0.62%	2.80%
Colorado Main 3	5%	12.93%	7.18%	9.65%
Llano	30%	3.55%	3.47%	3.50%
Pecan Bayou	15%	-1.54%	1.53%	0.18%
Pedernales	9%	-1.22%	5.10%	2.29%
San Saba	21%	4.91%	0.91%	2.64%
Sandy Creek	3%	-0.78%	3.04%	1.35%

\*For all ponds greater than 1,076 feet<sup>2</sup> (100 m<sup>2</sup>)

# Study Summary

- **Ponds are increasing in number and density, varies by watershed**
- **The approach:**
  - Provides a high level of accuracy and confidence in the results
  - Identified discrepancies with USGS database
  - Can be used to track changes over time, including future years

# Firm Yield Impacts

- **Assumptions made:**
  - Assumed a maximum water depth of 10 feet for each pond
  - Each upstream pond fully fills and spills to the next pond
  - All the water in the ponds would eventually make it to the river as inflows
  - Each pond is storing state water (not groundwater)
- **Results from the analysis indicate that the pond's water surface area and the watershed area translate to the reduction of inflows during the critical period**
- **Modeled impacts to firm yield**

