Climatic Influence on Shallow Groundwater Quality in Texas

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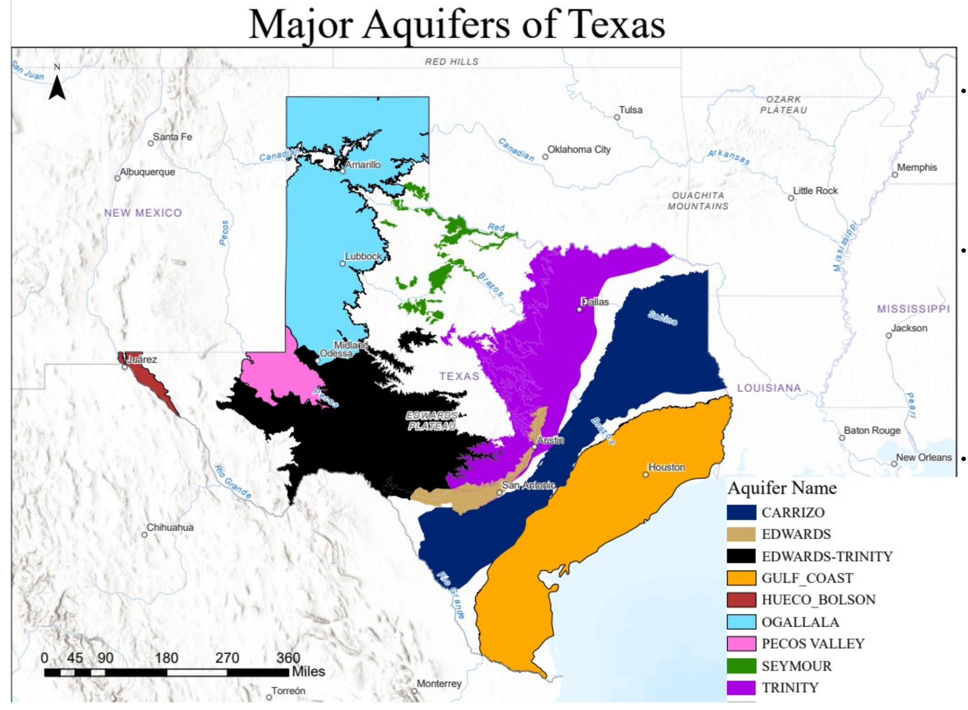
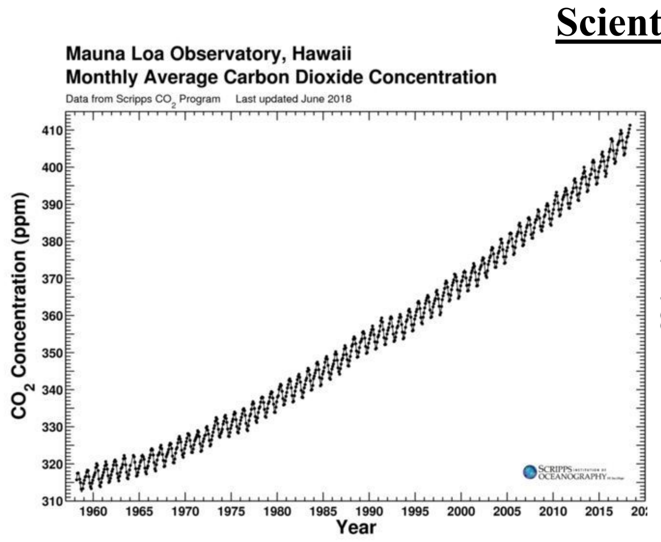
Introduction

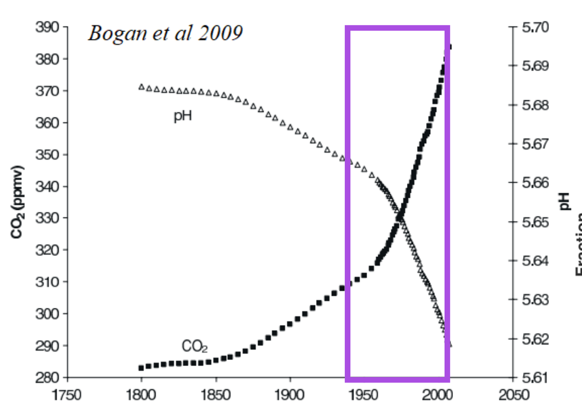
Major Aquifers of Texas



- Groundwater provides 60% of freshwater used by the entire state
- Texas has 9 major aquifers, all with shallow wells in the unconfined regions of the aquifer
- This study analyzes shallow wells under 300 feet in all 9 major aquifers using water quality data is from the pre-1960s to 2015

Scientific Premise

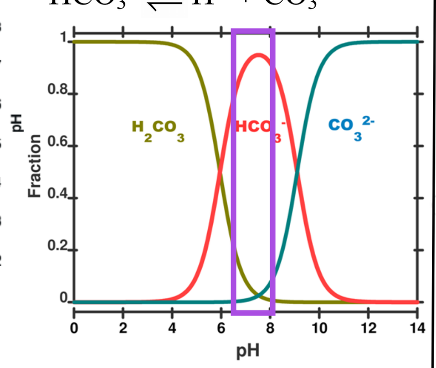




$CO_2 + H_2O \rightleftharpoons H_2CO_3$

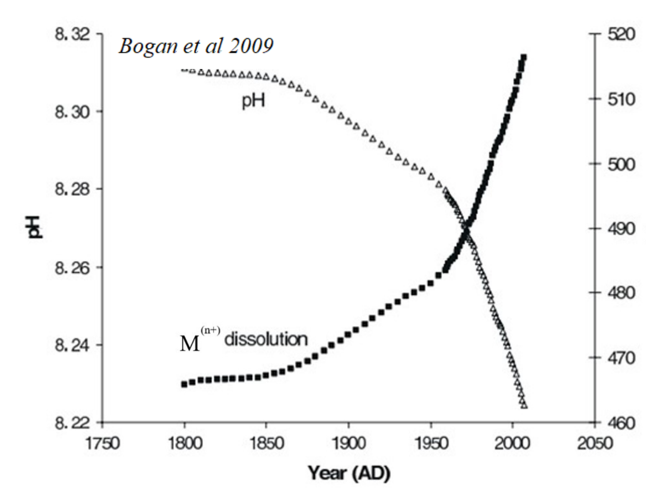
$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

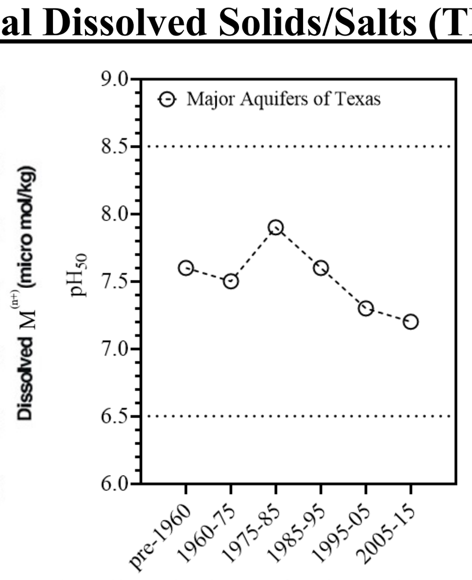
$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

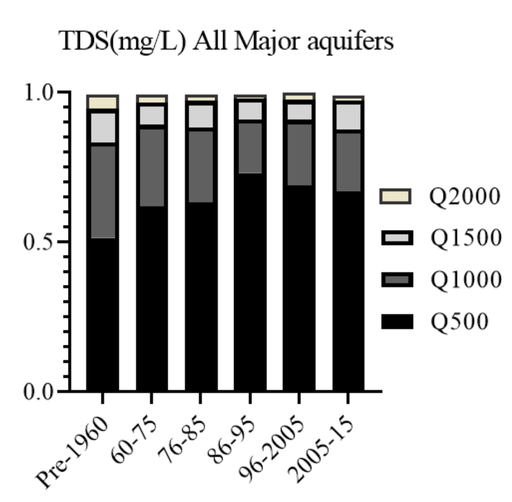


- Increasing atmospheric CO_2, decreases the pH of rain (increases the acidity of the rain)
- The carboxylic acid (H_2CO_3) in rain water dissociates into different ions depending on pH of a system

pH vs Total Dissolved Solids/Salts (TDS)







- Generally, as the pH of groundwater decreases, the dissolution of minerals and salts within aquifers increases
- Increased dissolution of minerals and salts means that the groundwater has a high TDS (salty water)

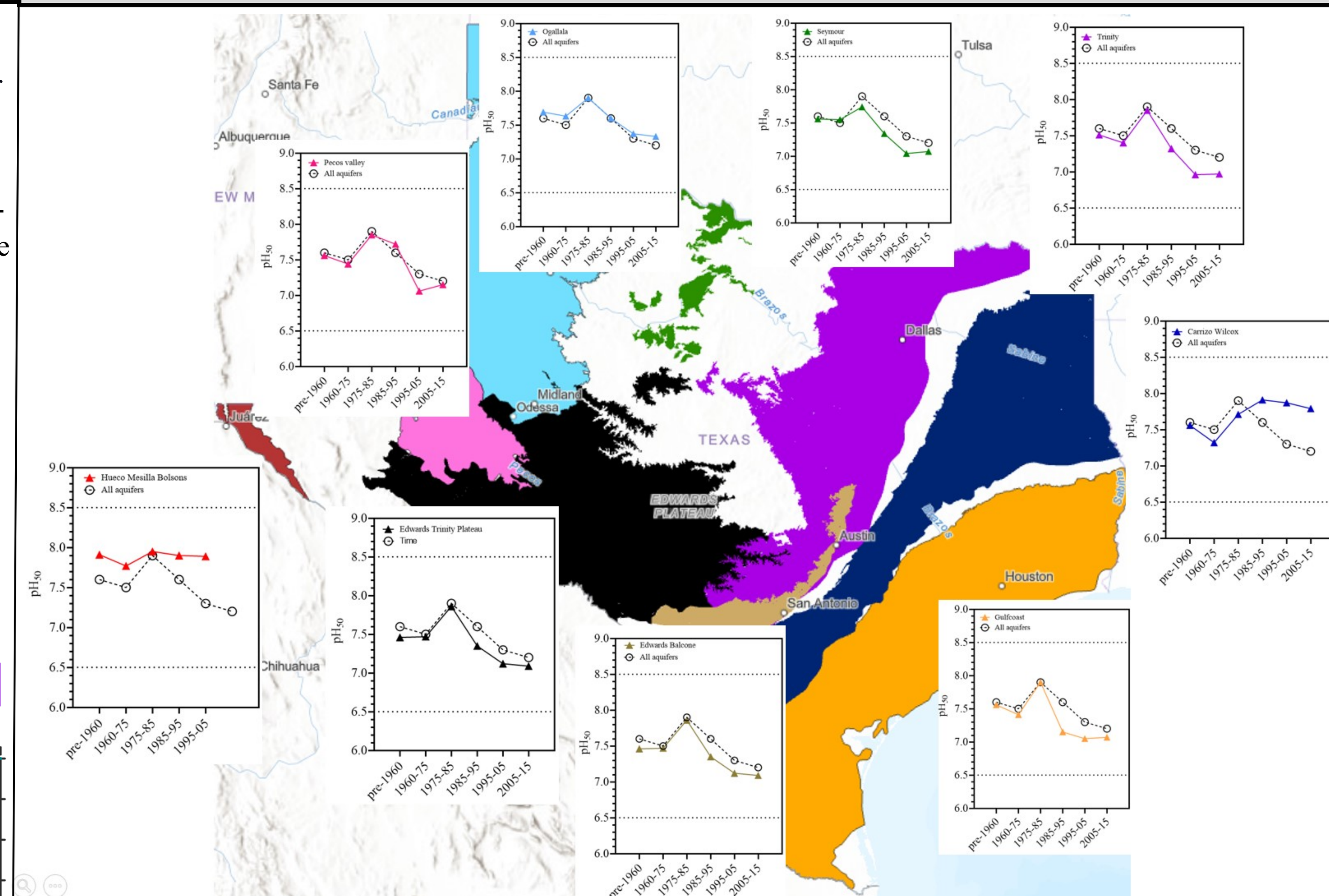
TDS is Aquifer dependent within 3 scenarios

Acidic rain (H_2CO_3) Decreasing pH

- Limestone/Dolomite (buffering capacity): $2HCO_3^- + Ca/Mg^{2+} + CO_3^- \longrightarrow Ca/Mg(CO_3)_{2(s)} + H_2O$ → **Scenario1**: Decrease TDS or stays the same (Fresher water)
- Clays (buffering capacity): $HCO_3^- + M^{n+} \longrightarrow MHCO_{3(s)}$ → **Scenario2**: Decrease TDS or stays the same (Fresher water)
- Sandy (No buffering capacity): $HCO_3^- \longrightarrow$ Dissolution of salts/solids → **Scenario3**: Increase TDS (Salty water)

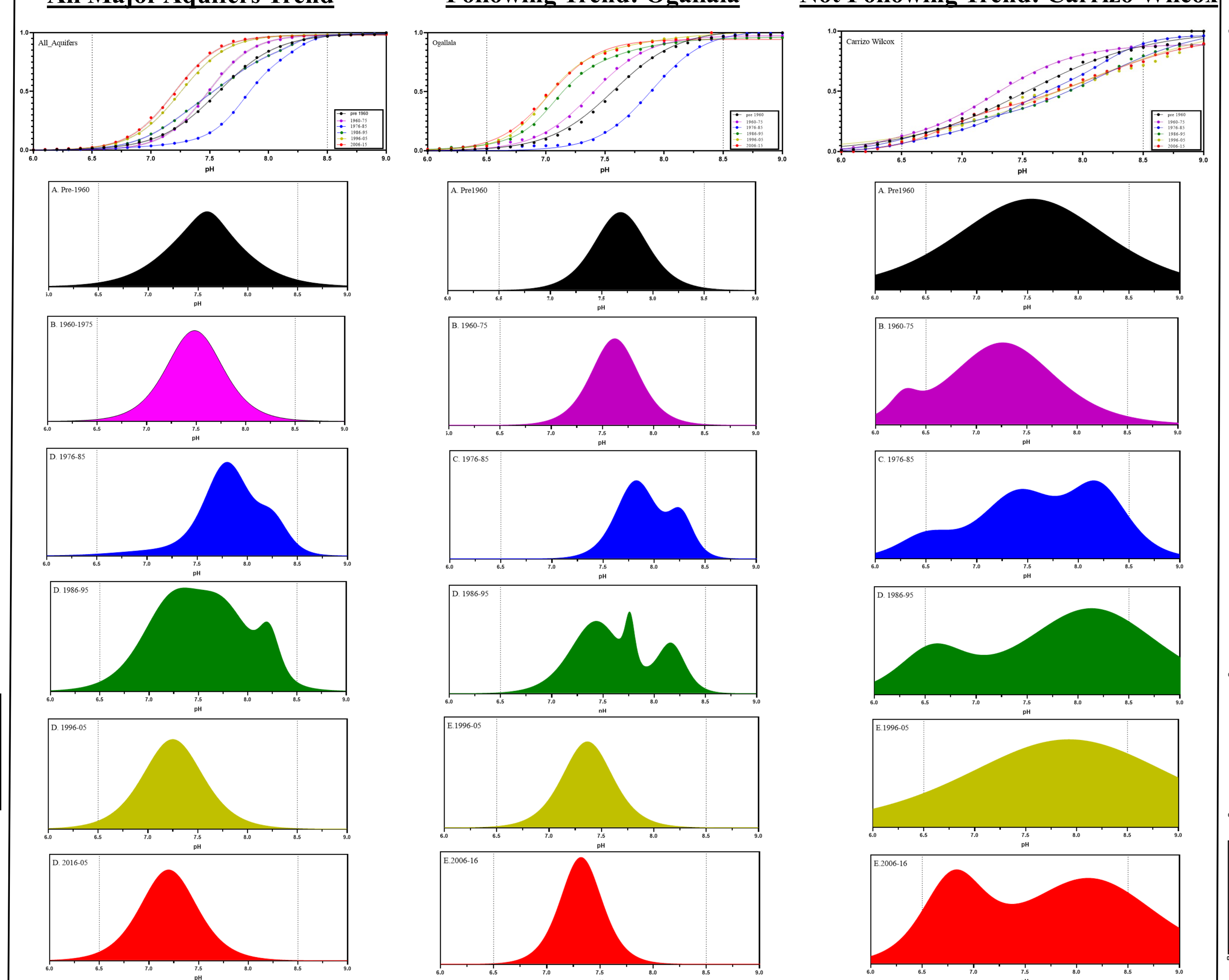
Aquifer	Dominant mineralogy
Carrizo Wilcox	gravel, silt, clay, and lignite
Edwards Balcones	limestone
Edwards Trinity Plateau	limestones and dolomites
Gulf Coast	clays, silts, sands, and gravels
Hueco Mesilla Bolson	clay, silt, sand, and gravel
Ogallala	sand, gravel, clay, and silt
Pecos valley	silts, sands, and gravels
Seymour	poorly sorted gravel, conglomerate, sand, and silty clay
Trinity	coarse-grained sand interbedded with clay and shale

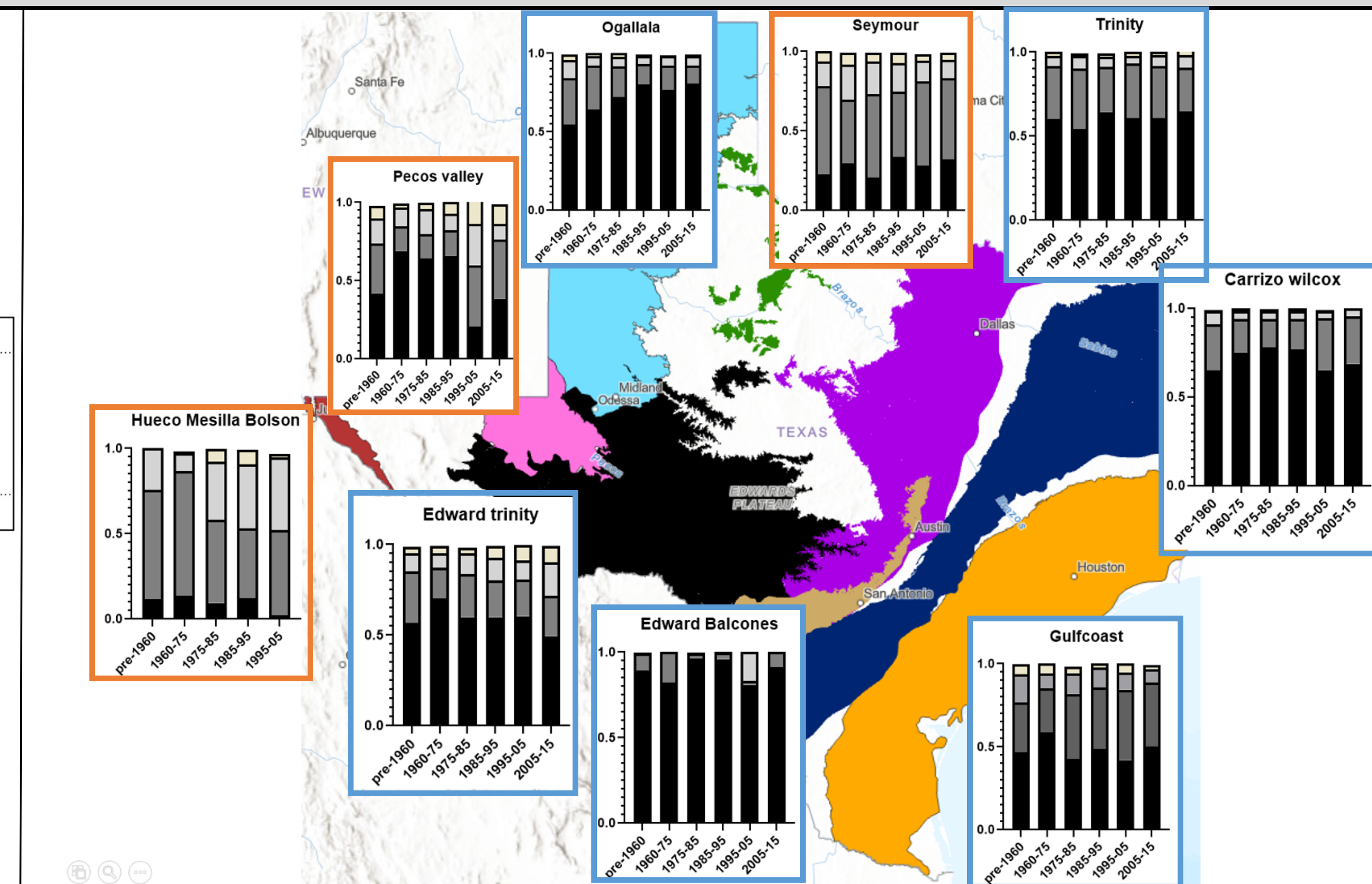
Results: All 9 aquifer exhibit significant changes in groundwater chemistry since the 1960s



- The pH trend for most major aquifers is characterized by a sudden increase between 1975-7985, followed by a drastic decrease from 1985 to 2015
- Below is the pH cumulative distribution for all shallow wells in each aquifer, fit with a logistic growth curve model, and its first derivative.

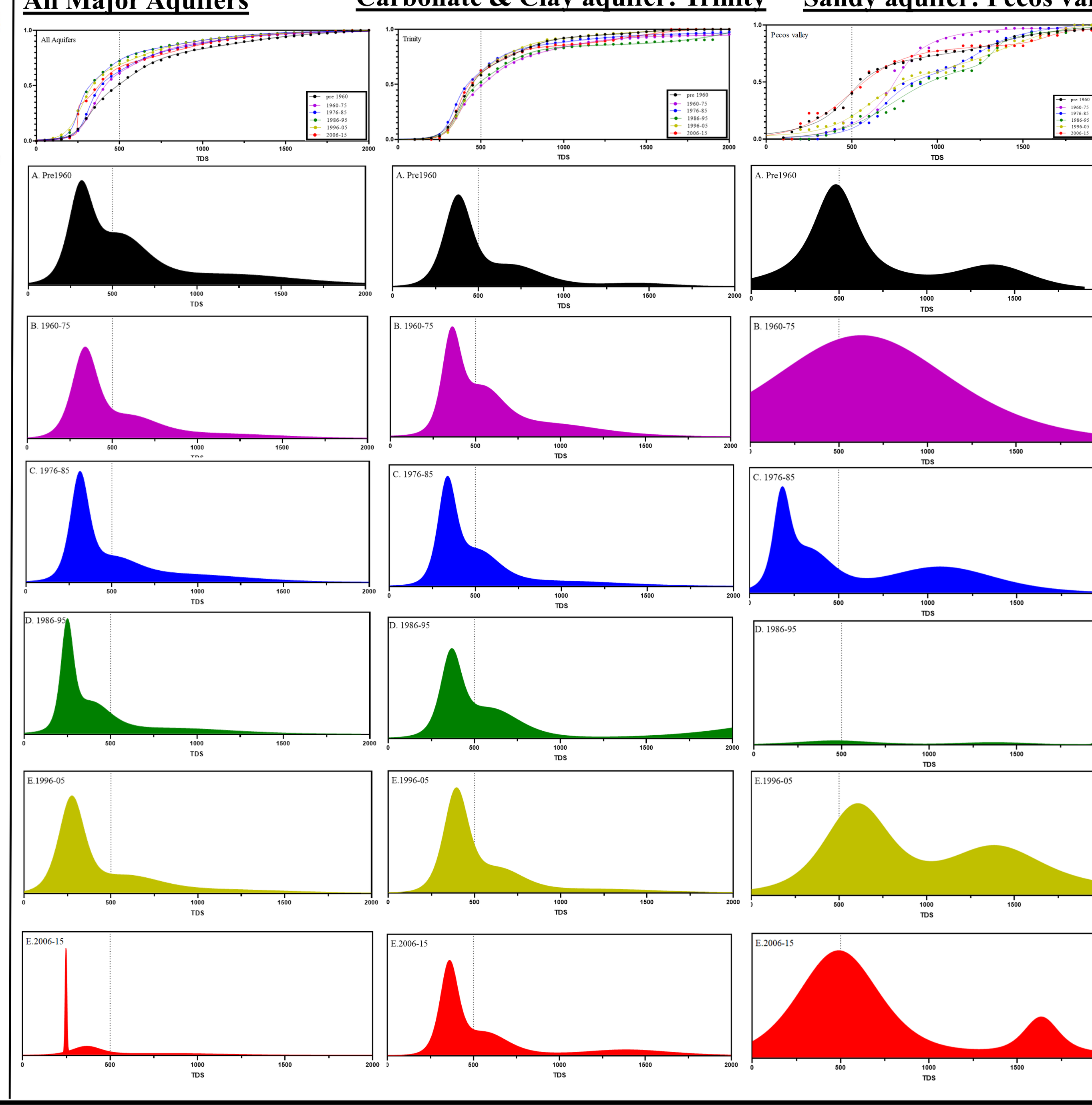
All Major Aquifers Trend | **Following Trend: Ogallala** | **Not Following Trend: Carrizo Wilcox**





- Scenario 1&2: the majority of shallow wells in Texas have limestone/dolomite and clays as the dominant mineralogy in their aquifers; this composition can buffer the acid rain and minimize the dissolution of salts and solids in the aquifer.
- Scenario 3: shallow wells with no buffering capacity have alluvium deposits as the dominant mineralogy in their aquifers; this composition cannot buffer the acid rain leading to the high dissolution of salts and solids in the aquifer.
- Below is the TDS cumulative distribution for all shallow wells in each aquifer, fit with a logistic growth curve model, and its first derivative.

All Major Aquifers | **Carbonate & Clay aquifer: Trinity** | **Sandy aquifer: Pecos valley**



Future Studies

- Look at other groundwater contaminants e.g.: Nitrates, metals, and salts.
- Investigate the effect of changing climatic conditions on the levels of the above contaminants in shallow aquifers of Texas.
- Examine the trend of water contaminants in all major aquifers of Texas

Acknowledgements And citation

- Harvey's Lab Group

- Bogan, R.A.J., Ohde, S., Arakaki, T. *et al.* Changes in Rainwater pH associated with Increasing Atmospheric Carbon Dioxide after the Industrial Revolution. *Water Air Soil Pollution* 196, 263–271 (2009).

Conclusion

- Examine the trend of water contaminants in all major aquifers of Texas
- Although the pH of shallow groundwater in Texas from the 1960s to 2015 is within the EPA permissible drinking water limits, the trends show overall acidification and degradation of water quality in all 9 major aquifers.
- The acidification of shallow groundwater is expected to continue increasing as CO2 atmospheric levels keep rising.
- The amount of total dissolved salts/solids is dependent on the aquifer mineralogy and the pH of the water entering the aquifer.
- The buffering capacity of aquifers may be overridden if the system becomes oversaturated by acidic conditions due to high CO2 levels, which would consequently increase TDS in groundwater and deteriorate the water quality further.