LREWater, LLC
a Leonard Rice Engineers Company

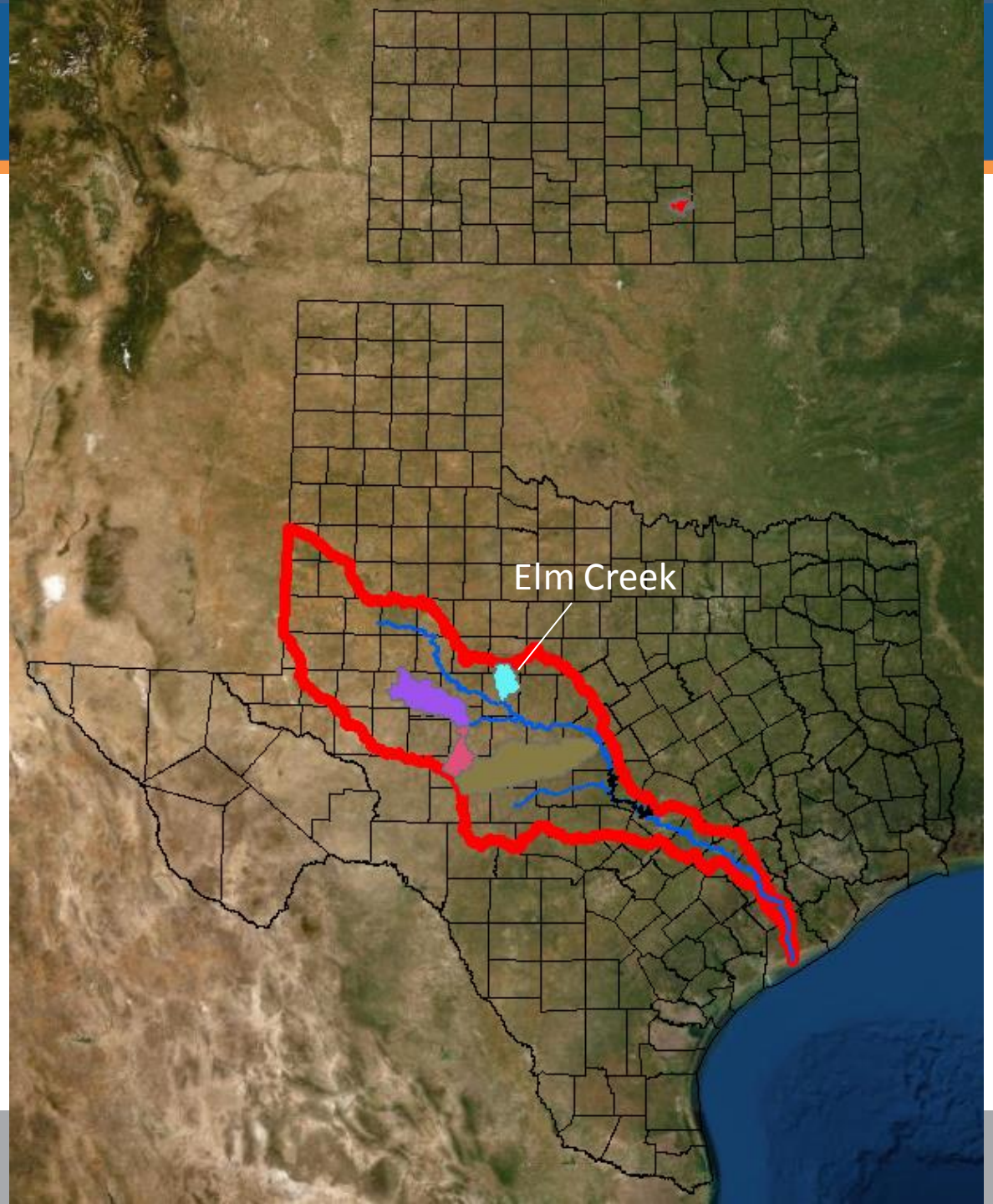
Evaluation of Rainfall-Runoff Trends in Texas with applications for Kansas water supplies?

Governor's Conference on the Future of Water in Kansas

November 8, 2019

Project Funded Through TWDB Contract Number 1800012283

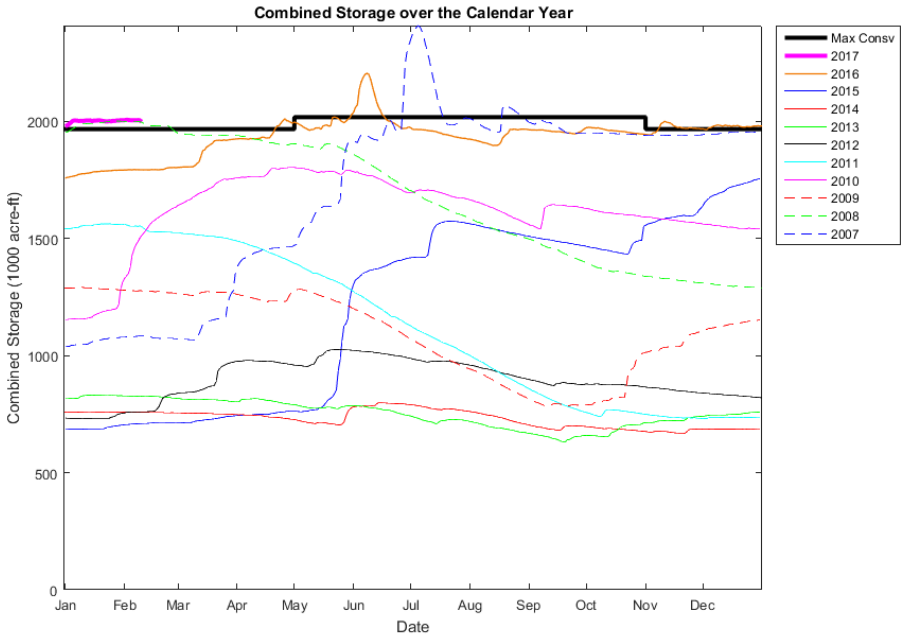
Project Study Area & Background



Colorado River Basin (of Texas)

Highland Lakes:
Drinking water supplies for City of Austin
Population: 950,000 (2017)

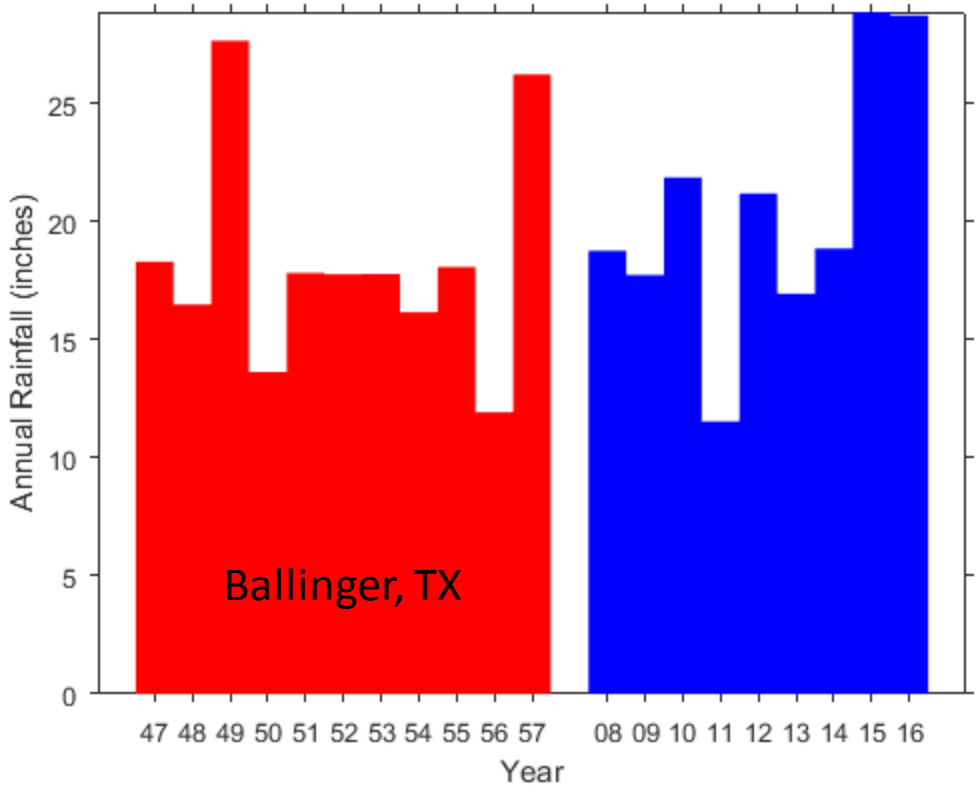
Large rural areas (ranches & farms)



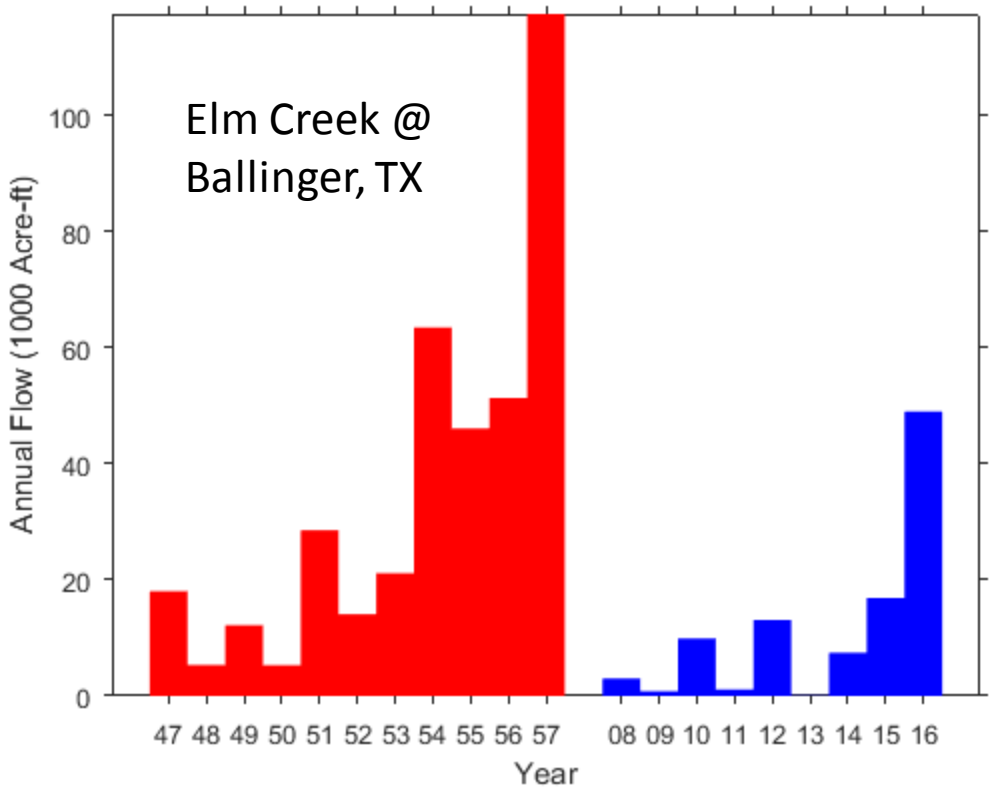
Rainfall – Runoff – Response: 1950's vs 2010's Drought

"Rainfall in the 1950's was similar to that in the recent drought – yet recent streamflow was much lower"

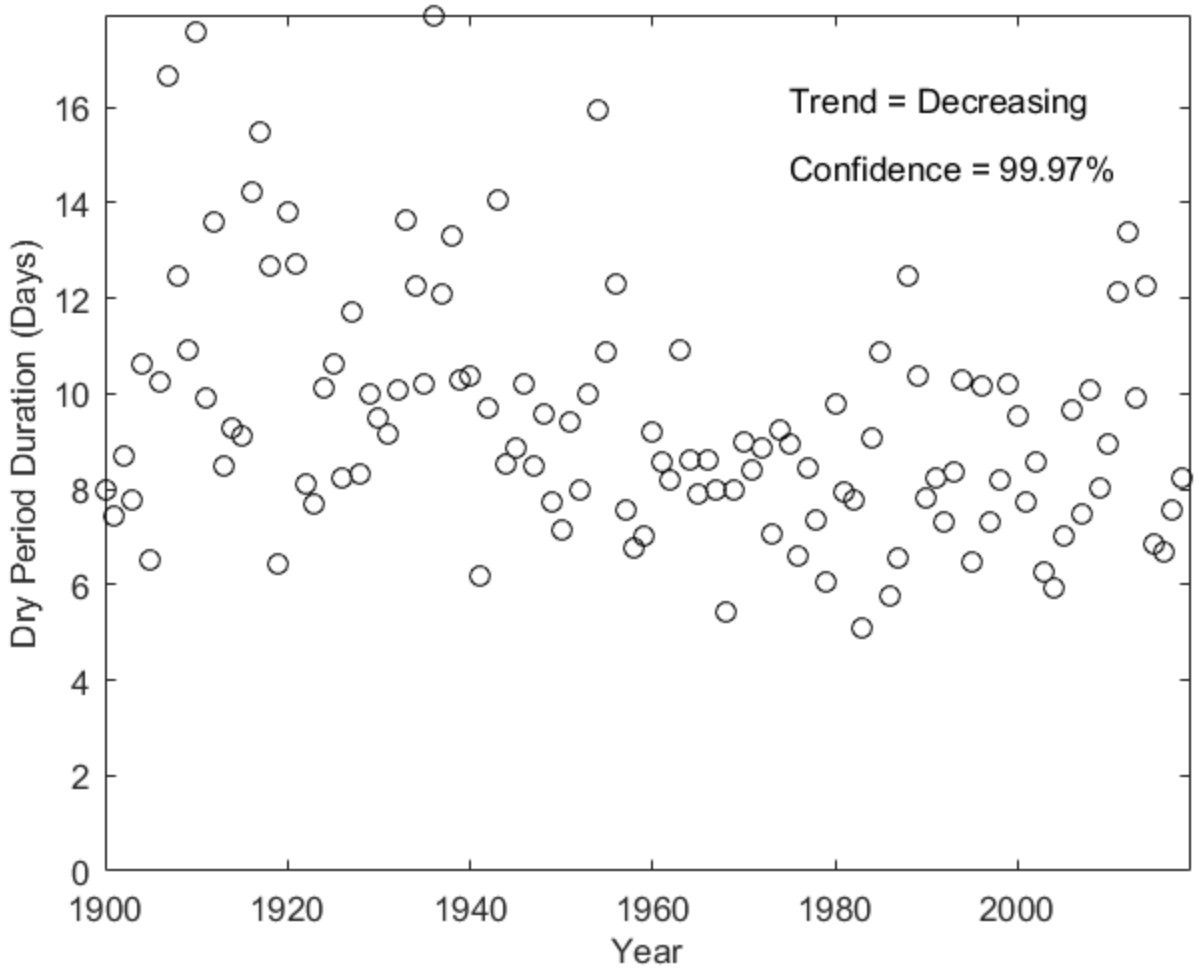
RAINFALL (inches)



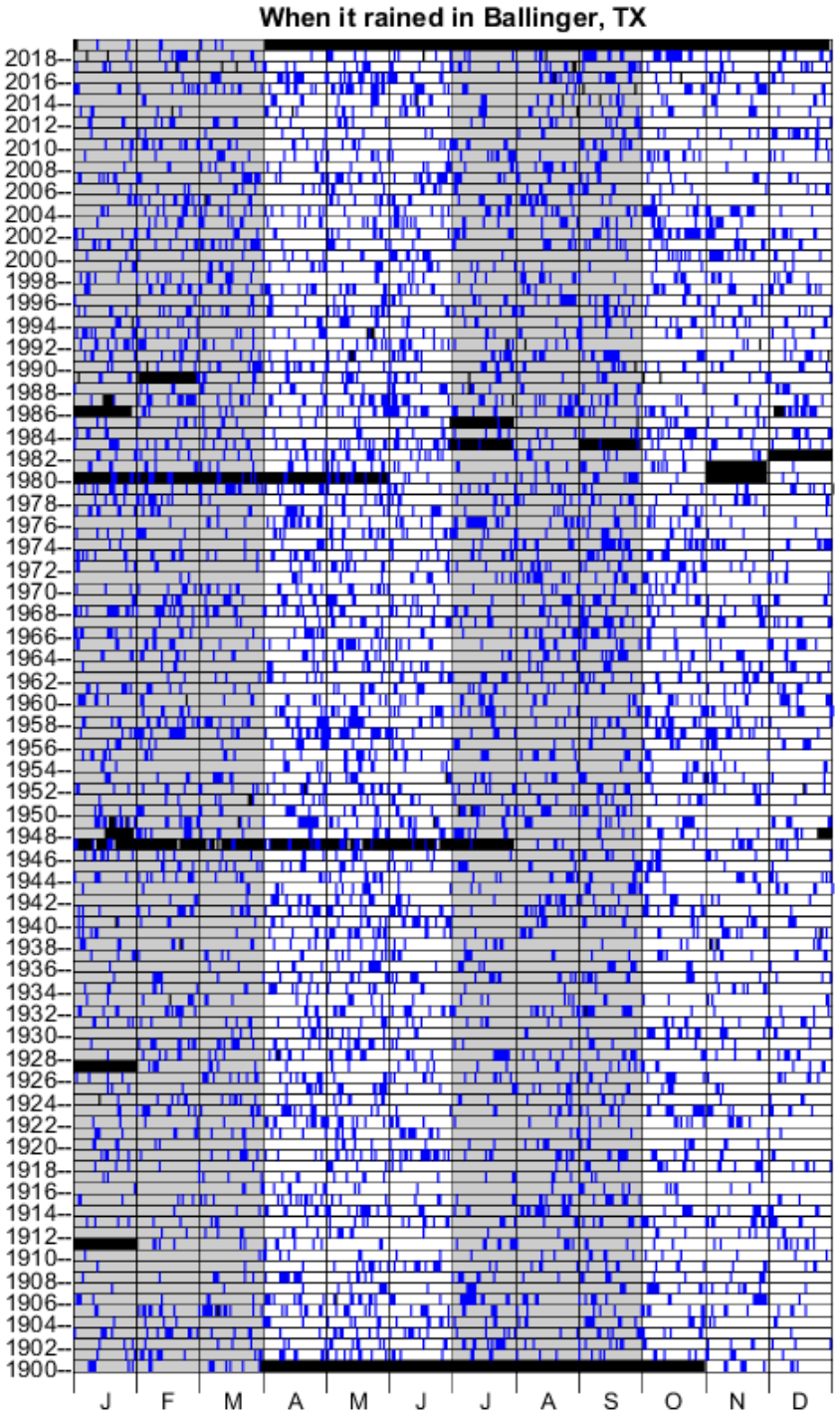
Streamflow (1000 acre-ft)



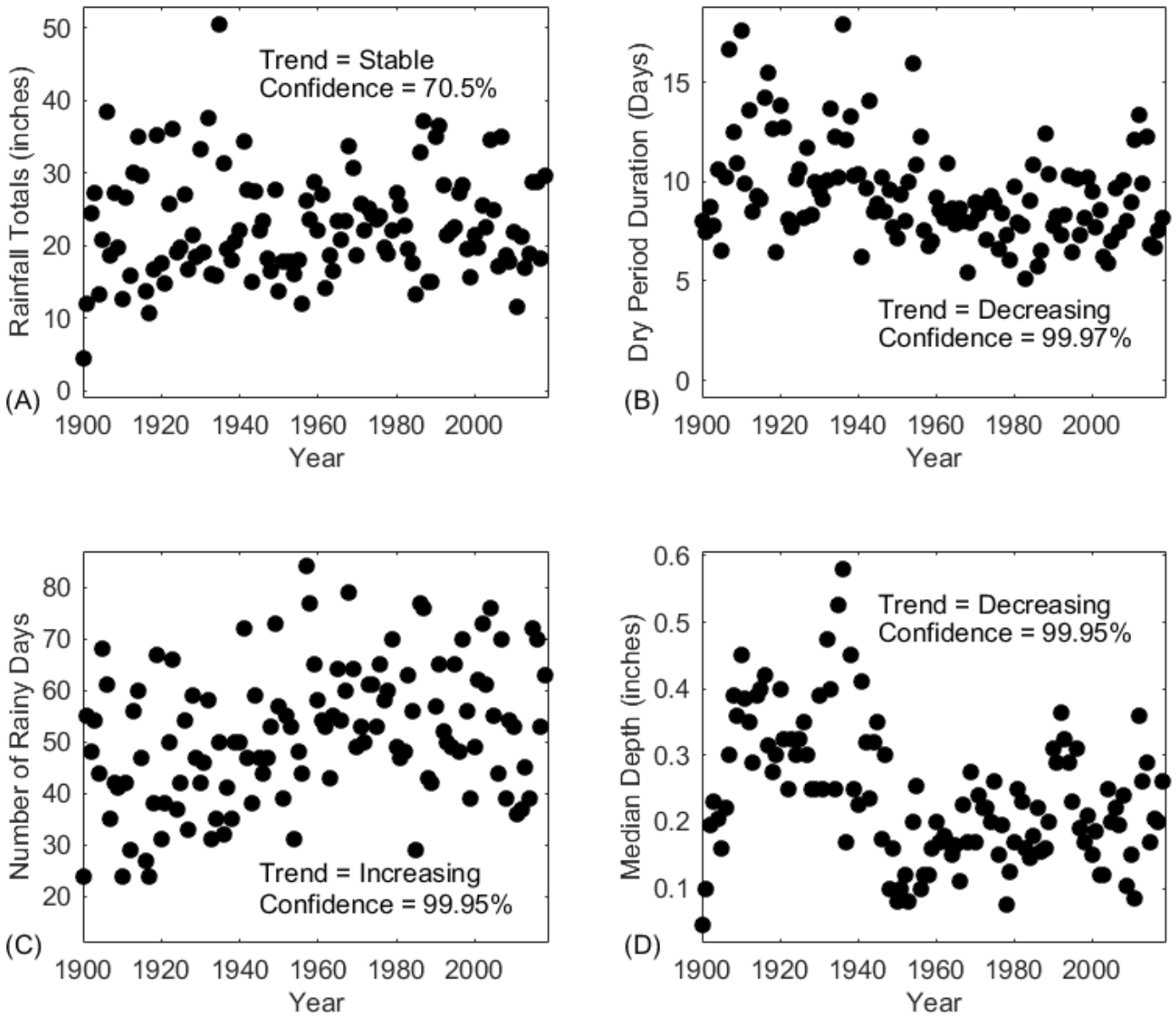
Precipitation Trend Analysis



Significant Decrease in length of dry periods



Task 5 – Precipitation Trend Analysis – Ballinger, TX



Total Annual Rainfall: Stable

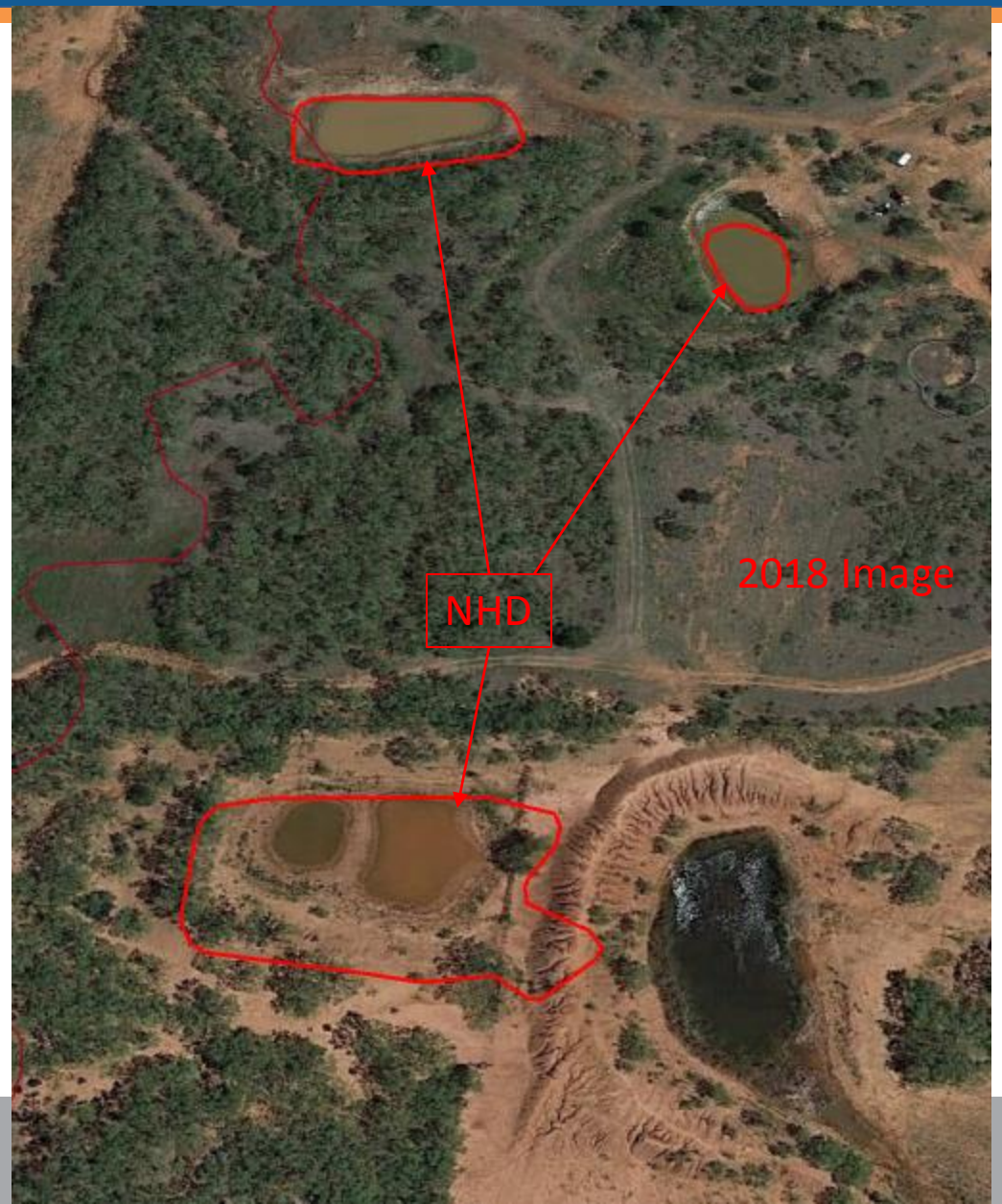
Dry Period Duration: Decreasing

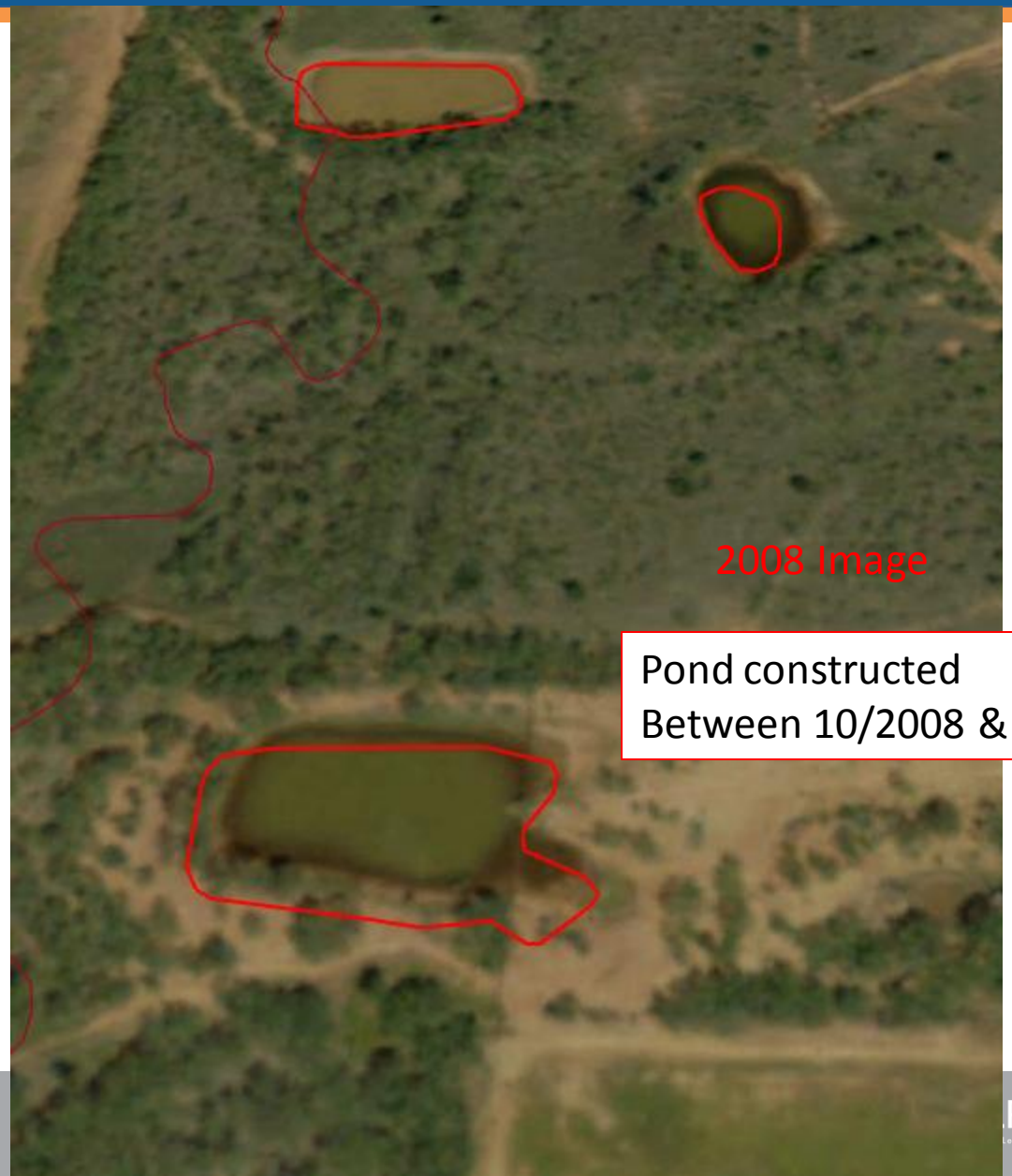
# of Rainy Days: Increasing

Median Depth of Rain: Decreasing

January	Stable	61.12%
February	Increasing	94.13%
March	Increasing	96.53%
April	Decreasing	90.37%
May	Stable	61.21%
June	Increasing	95.43%
July	Stable	6.23%
August	Increasing	79.79%
September	Stable	46.02%
October	Stable	14.22%
November	Stable	67.73%
December	Stable	28.32%
Spring	Stable	70.39%
Summer	Increasing	99.23%
Fall	Stable	30.54%
Winter	Stable	44.42%
Annual	Stable	70.50%

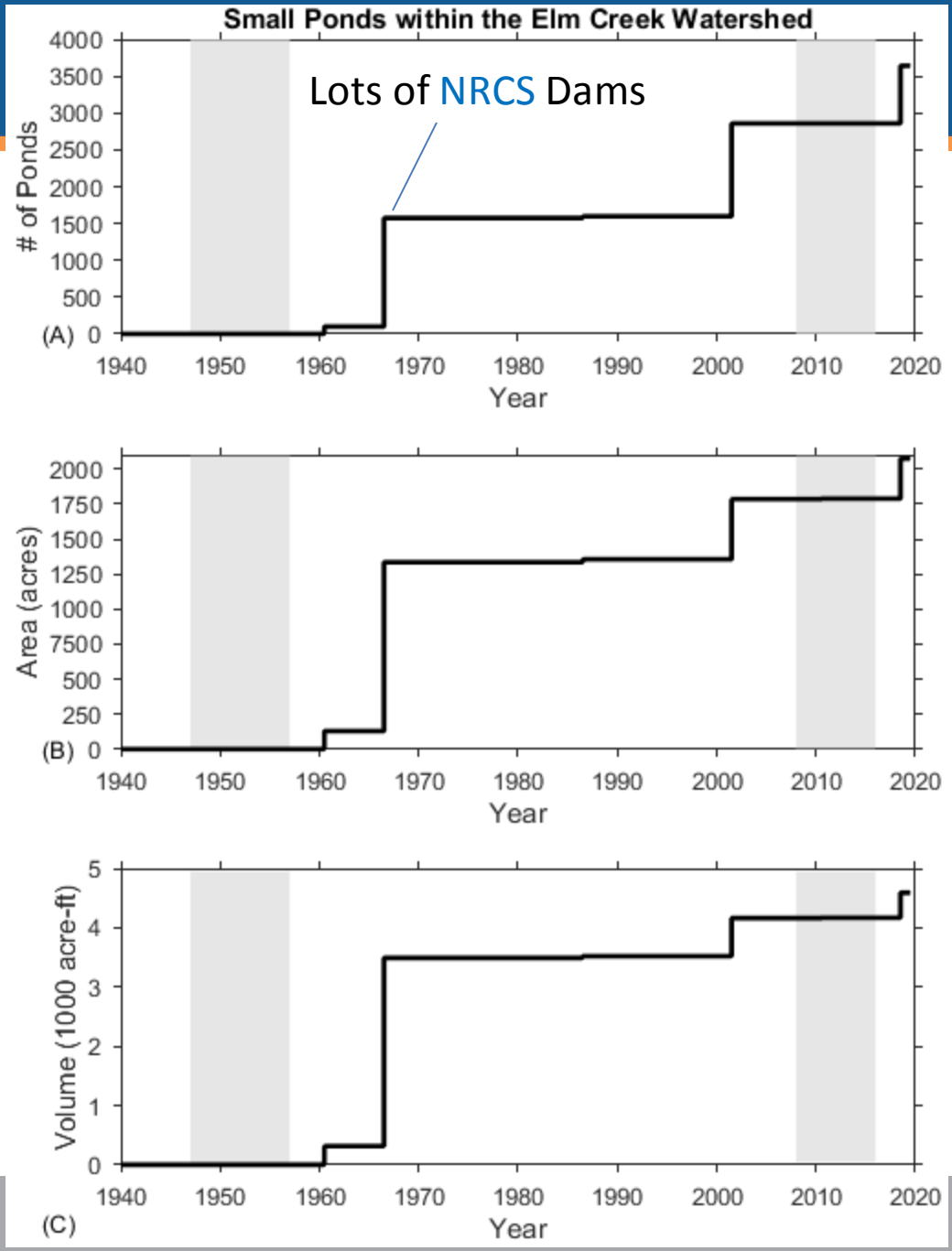
Proliferation of Small Ponds in Watersheds





Pond constructed
Between 10/2008 & 3/2010

Proliferation of Small Ponds in Watersheds



Refining with Google Earth Engine: 1984-Present

Also Manual Review in Google Earth
Manual Review – USGS Topographic Maps

600 Additional Small Impoundments
Present in 2019 – Identified in Google Earth
Not Present in 2002 NHD

Small Impoundments:

- Water Loss to Evaporation
- Prevent runoff from reaching streams

**Volume estimated from WAM storage vs area relationship

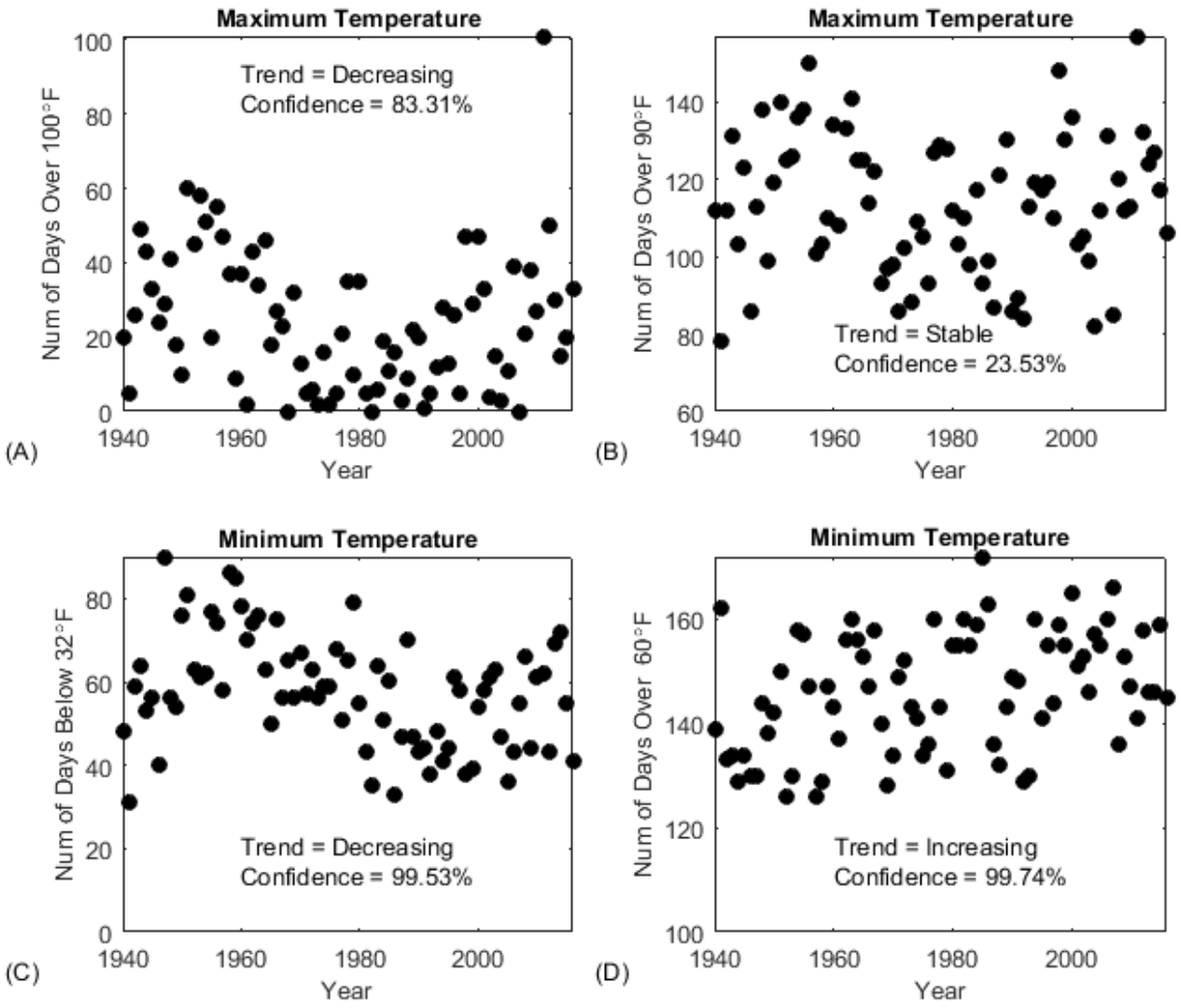
Temperature Trend Analysis – Ballinger, TX

Ballinger TX – Extreme High Temperatures
– Decreasing or Stable

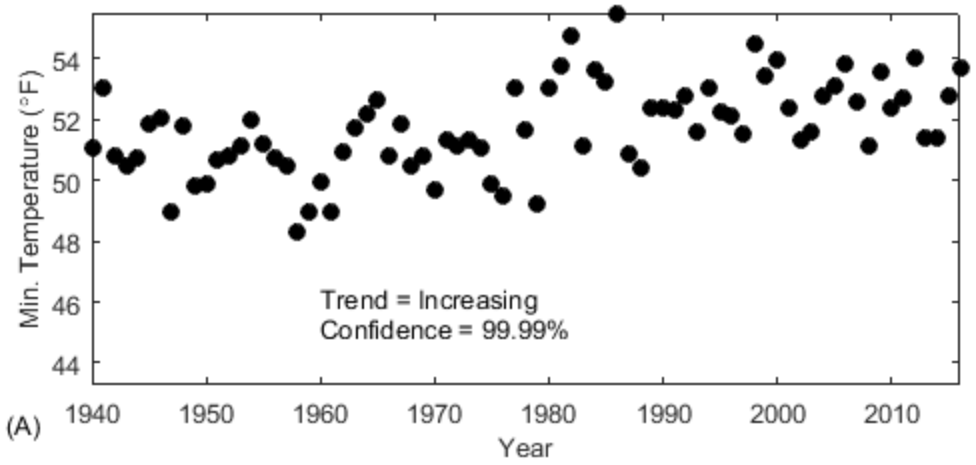
Ballinger TX – Minimum Temperatures
- Increasing

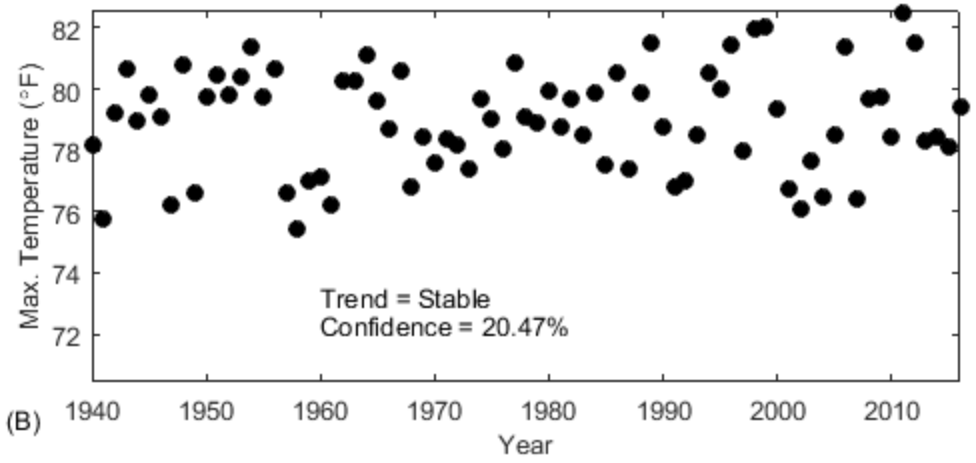
Ground is not cooling as much as it used to!

Increase in Evapotranspiration == Decreased Streamflow



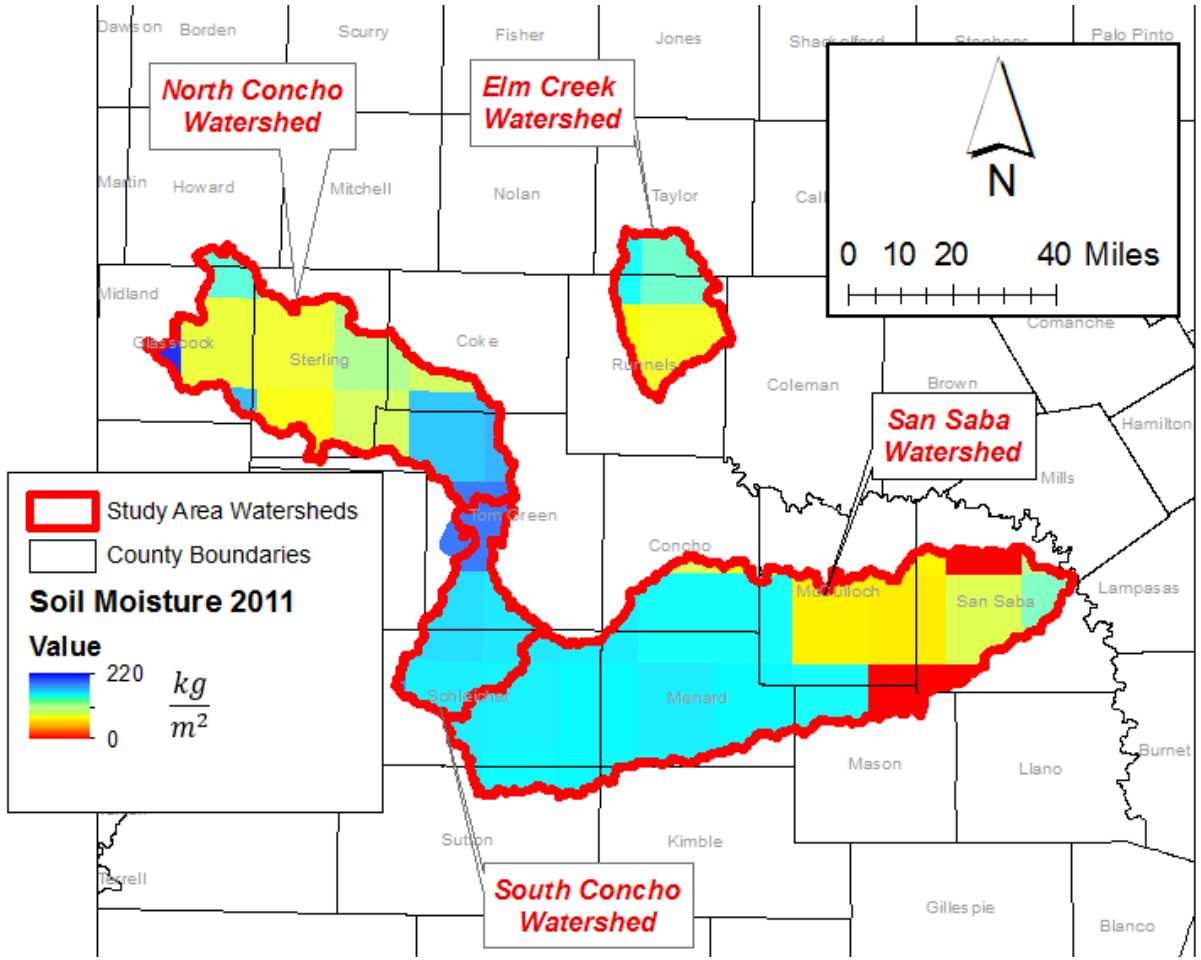
Temperature Trend Analysis – Ballinger, TX

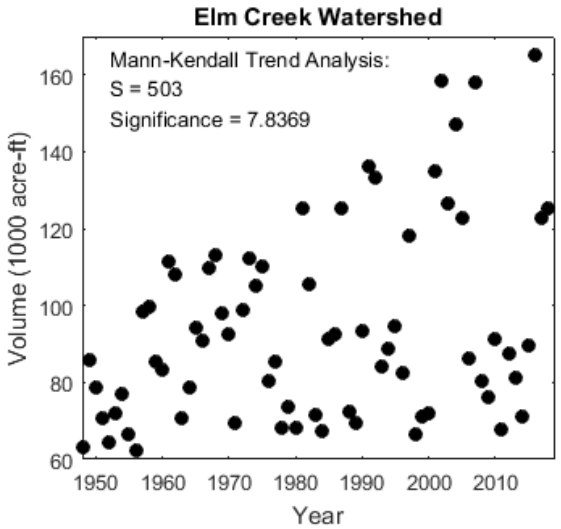


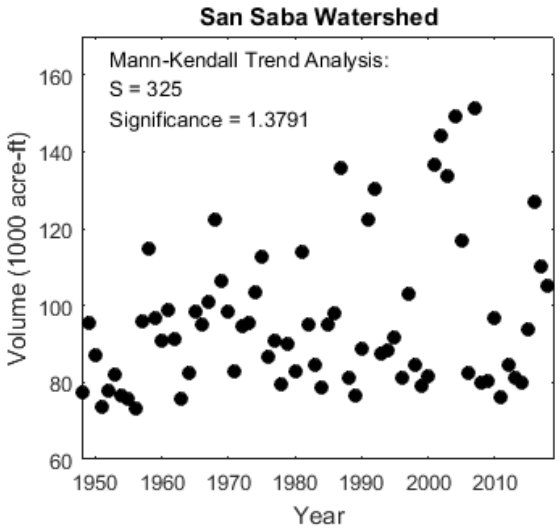


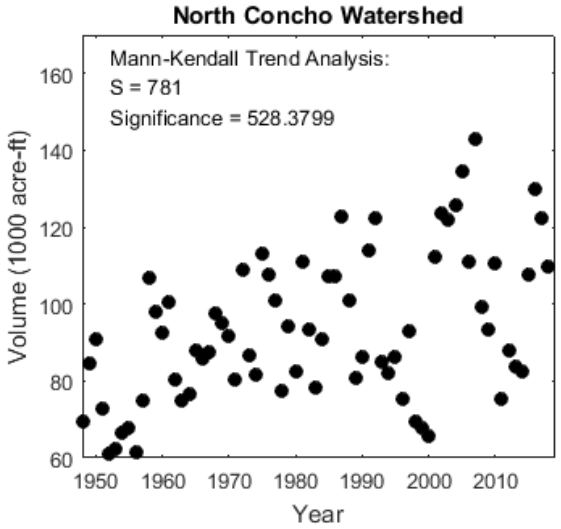
	Minimum Temperatures		Maximum Temperatures	
Period	Trend	Confidence	Trend	Confidence
January	Increasing	94.75%	Stable	60.16%
February	Increasing	92.50%	Stable	47.28%
March	Increasing	99.94%	Stable	44.44%
April	Stable	68.40%	Stable	37.46%
May	Increasing	94.76%	Stable	67.33%
June	Increasing	98.84%	Stable	63.28%
July	Increasing	96.38%	Decreasing	76.75%
August	Increasing	99.36%	Stable	64.91%
September	Increasing	96.85%	Stable	6.31%
October	Increasing	96.98%	Stable	50.46%
November	Increasing	99.83%	Stable	69.01%
December	Stable	70.09%	Stable	39.79%
Spring	Increasing	99.89%	Stable	66.05%
Summer	Increasing	99.51%	Decreasing	88.85%
Fall	Increasing	99.95%	Stable	33.27%
Winter	Increasing	95%	Stable	21.33%
Annual	Increasing	99.99%	Stable	20.47%

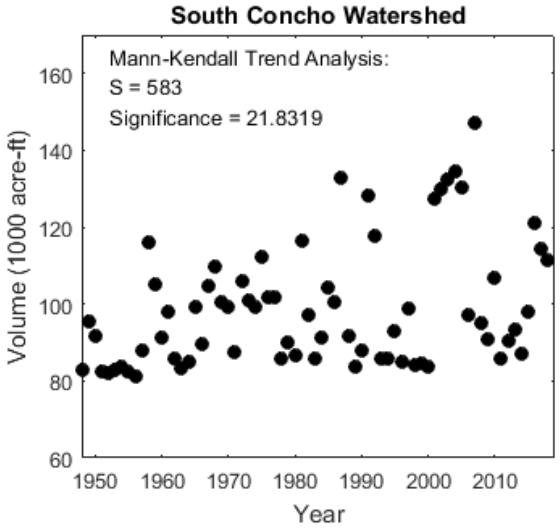
Soil Moisture Data Analysis – NLDAS





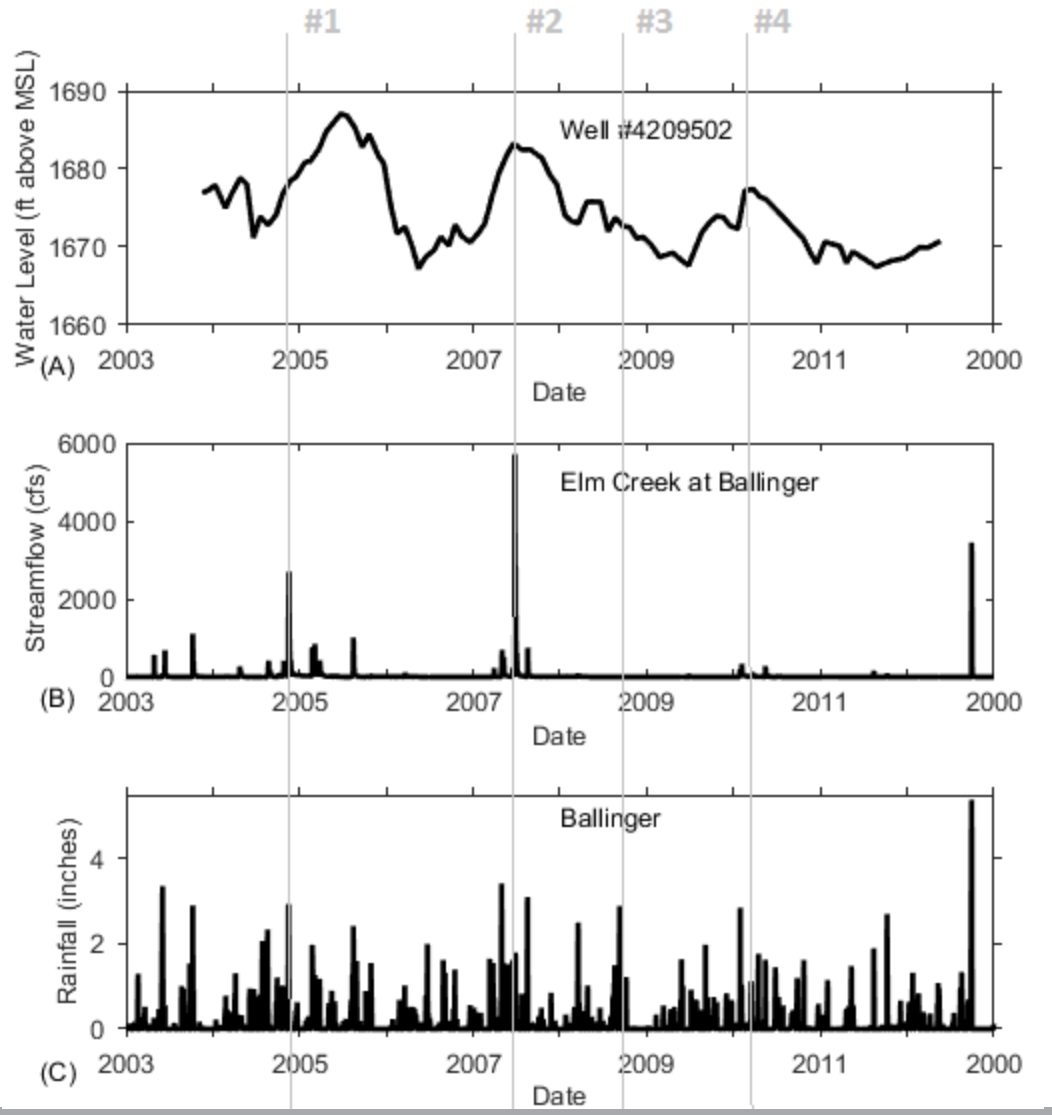






Increase tied to Increasing Rainfall frequency w/ lower intensity?

Groundwater Level Evaluations



Apparent Linkage:

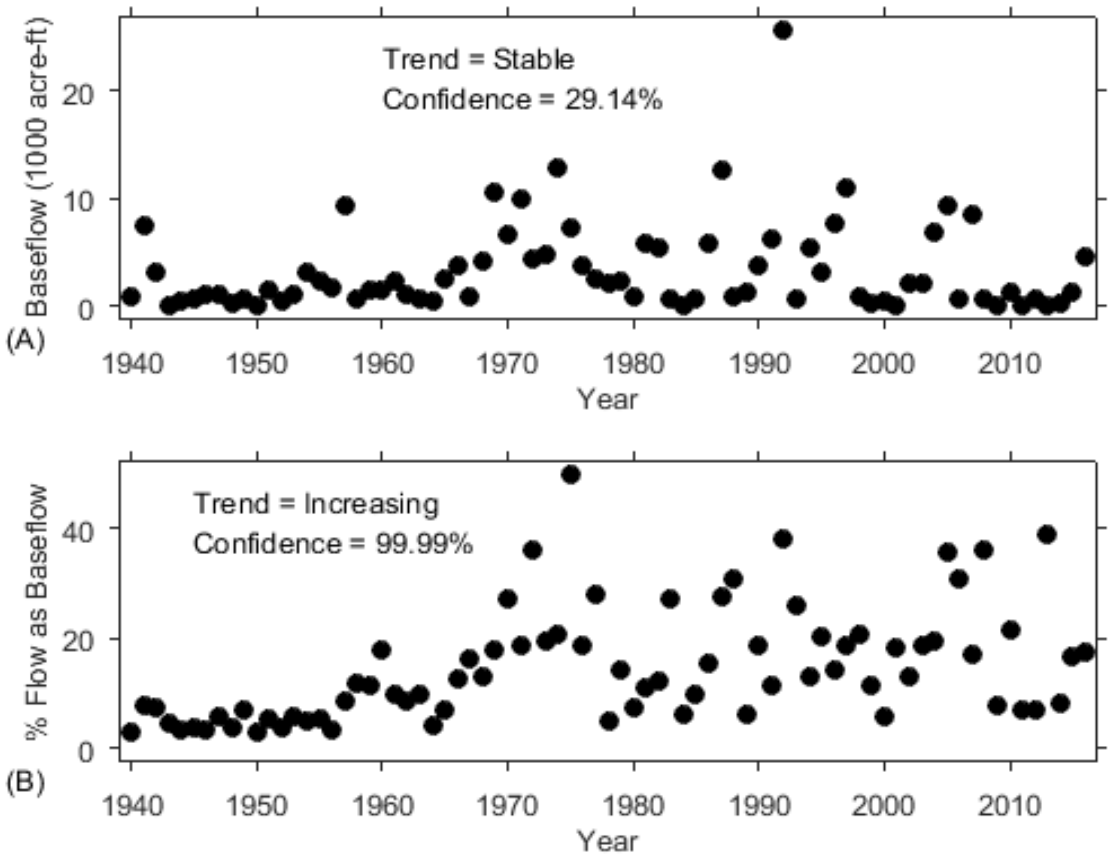
Groundwater levels : Streamflow : Rainfall

Lack of Groundwater level data from shallow wells

Texas law does NOT recognize a connection between Groundwater and surface water

Groundwater pumping records – spotty & unreliable

Baseflow Analyses of Streamflow



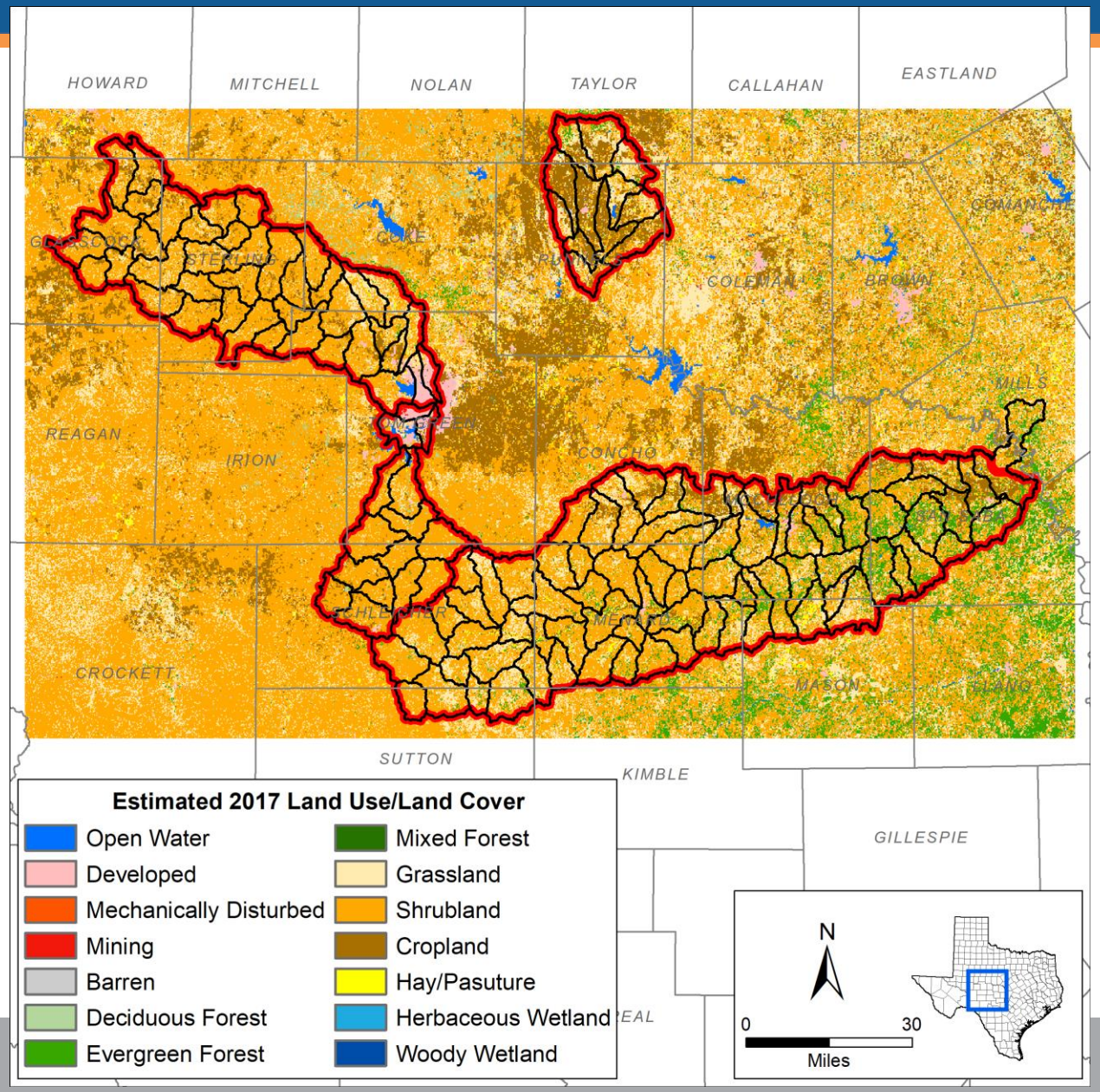
Separated Baseflow from Streamflow using USGS techniques

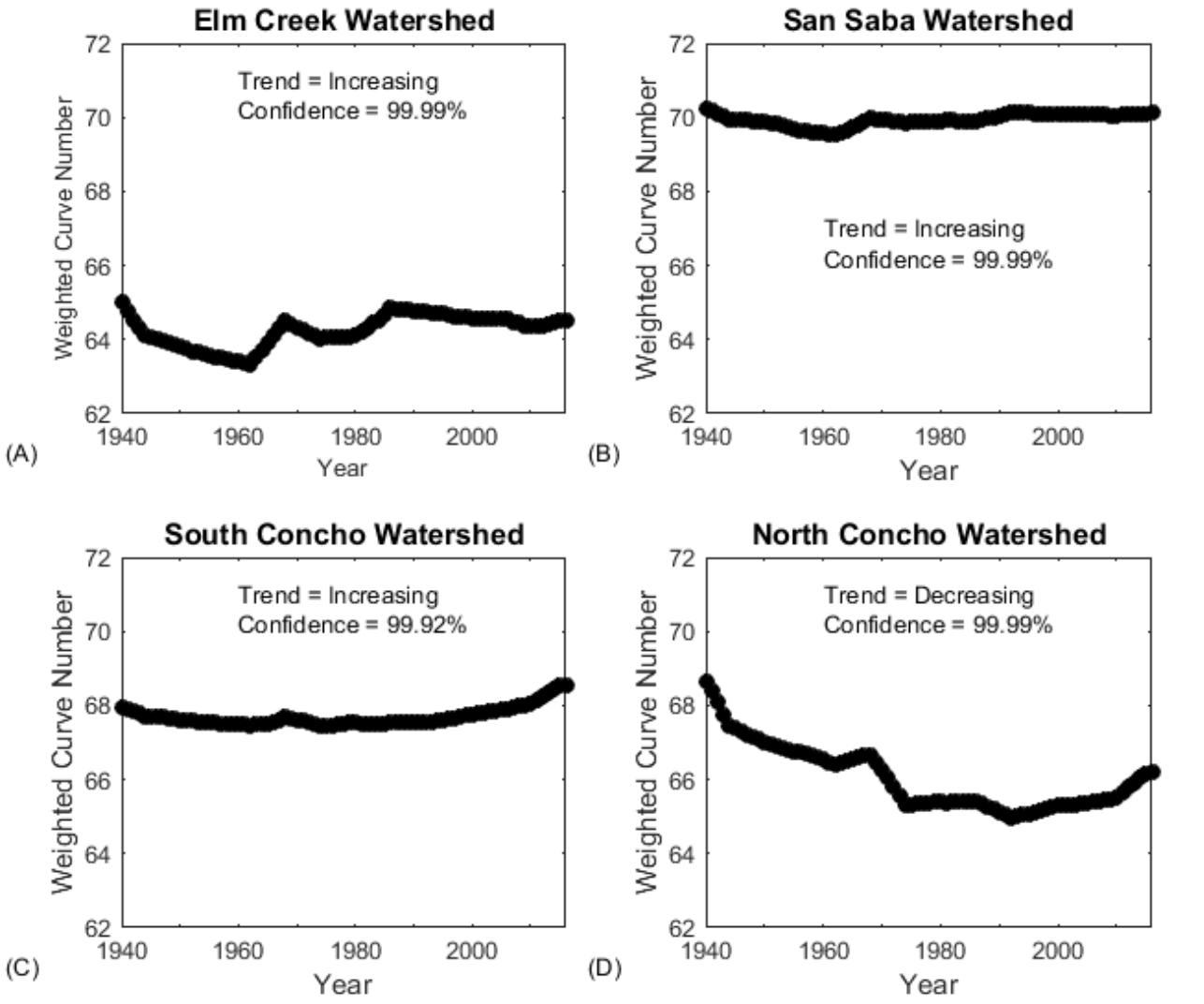
Baseflow represents local groundwater contribution to streamflow

Baseflow remains stable – yet % flow as baseflow is increasing

Thus – Surface runoff is decreasing!

Land Use – Land Cover Changes – Curve Number Analysis





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Demonstrating Cause and Effect

Upper Colorado Water Balance Model (UCWBM)

Uses Measured daily Rainfall
Applies SCS Curve Number Method to compute Q
Incorporates land use/land cover change
Accounts for small ponds:

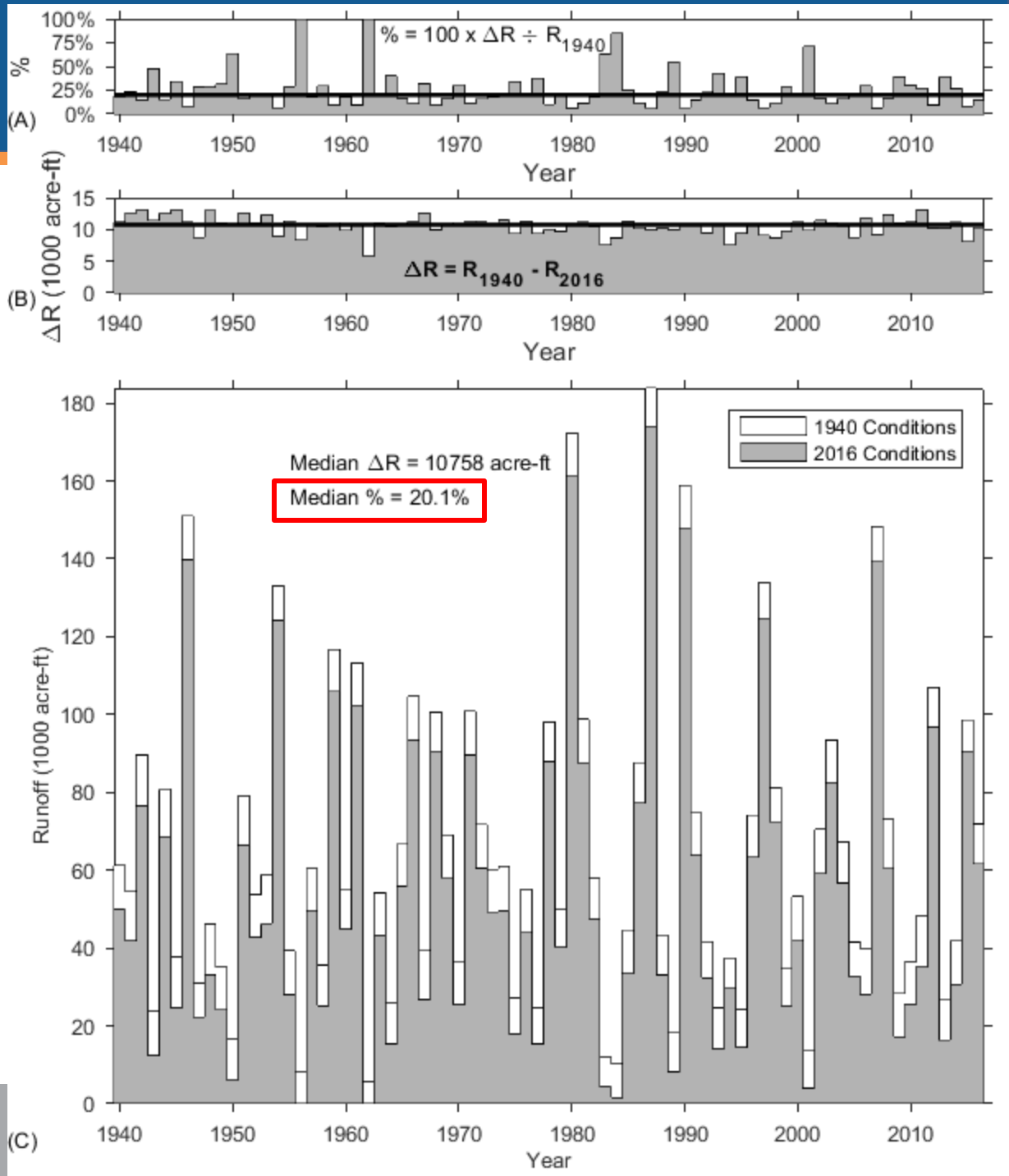
- Storage prior to discharge downstream
- Evaporation loss from ponds

$$q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad I_a = 0.2S$$

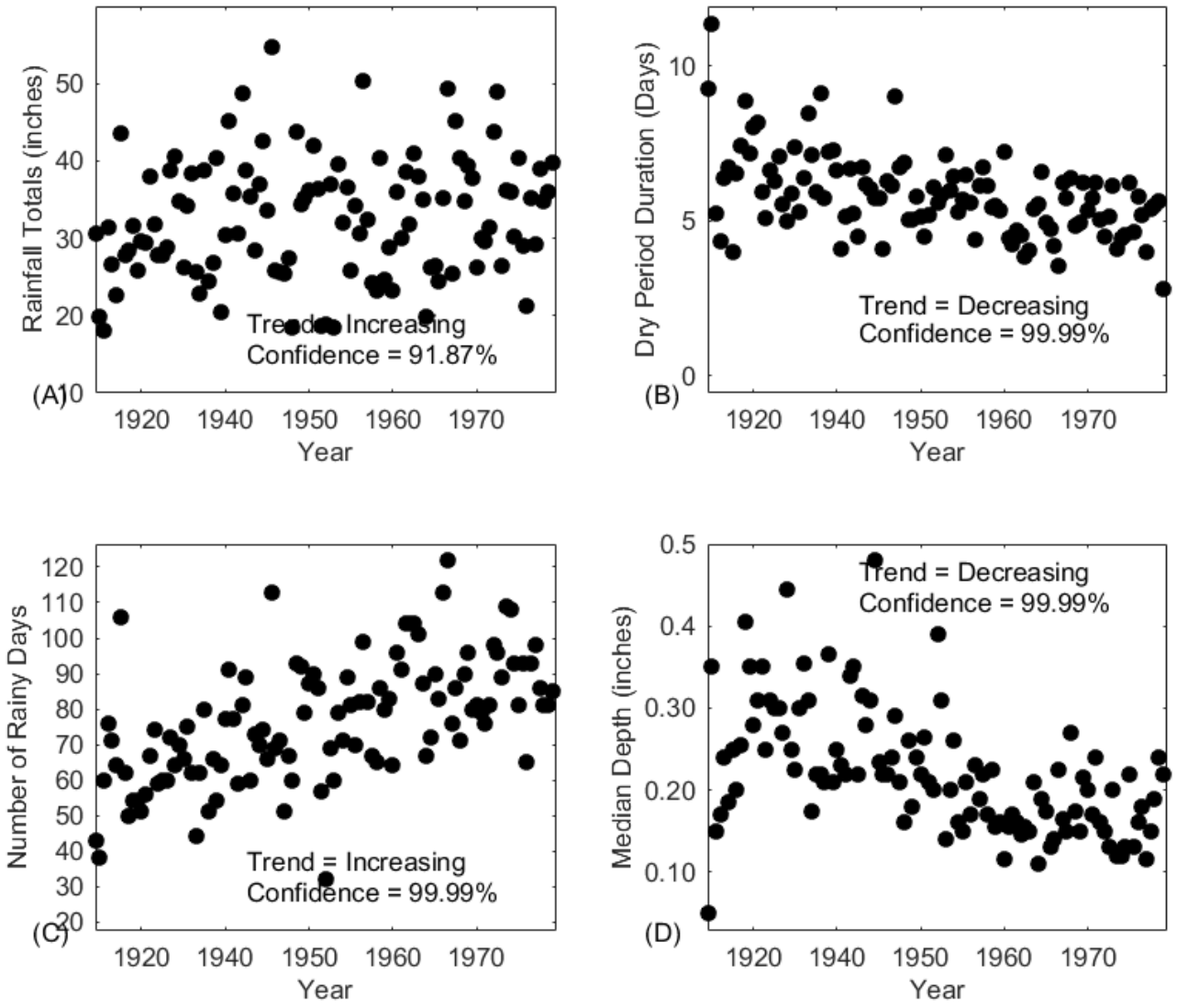
$$S = \frac{1000}{CN} - 10$$

Median 20% Decrease in Streamflow

Designed for comparing modeled Q
– not for matching measured Q



Application for Kansas?



Rainfall & Temperatures near Council Grove, KS
1909-2018

	Minimum Temperatures		Maximum Temperatures	
Period	Trend	Confidence	Trend	Confidence
January	Stable	69.36%	Decreasing	76.78%
February	Stable	23.58%	Decreasing	80.21%
March	Increasing	91.79%	Stable	55.54%
April	Stable	57.42%	Decreasing	94.83%
May	Increasing	96.49%	Decreasing	94.26%
June	Increasing	98.65%	Decreasing	86.99%
July	Increasing	99.86%	Decreasing	99.05%
August	Increasing	81.37%	Decreasing	99.38%
September	Stable	3.13%	Decreasing	97.56%
October	Decreasing	76.65%	Decreasing	98.02%
November	Stable	69.53%	Decreasing	94.79%
December	Stable	13.49%	Stable	55.70%
Spring	Increasing	96.50%	Decreasing	91.88%
Summer	Increasing	99.83%	Decreasing	99.87%
Fall	Stable	1.90%	Decreasing	99.63%
Winter	Decreasing	75.17%	Decreasing	82.77%
Annual	Stable	74.52%	Decreasing	99.76%

Final REPORT – Approved by TWDB October 11, 2019

Available soon:

http://www.twdb.texas.gov/publications/reports/contracted_reports/index.asp

Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin Phase II

November 8, 2019

QUESTIONS/DISCUSSION

Jordan Furnans, PhD, PE, PG
Jordan.Furnans@LREWater.com
(512) 736-6485