



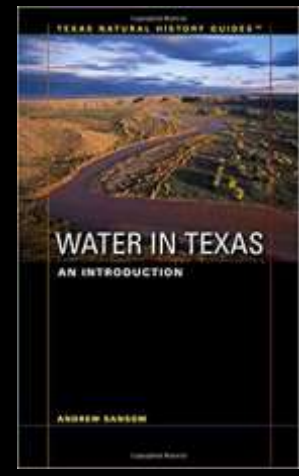
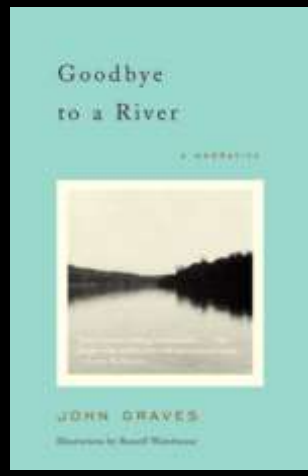
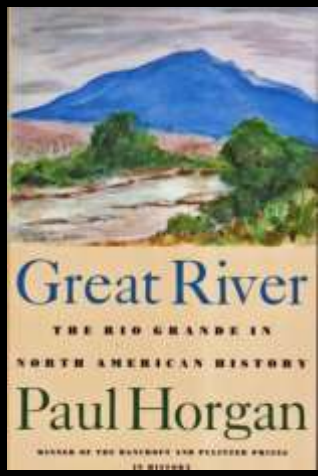
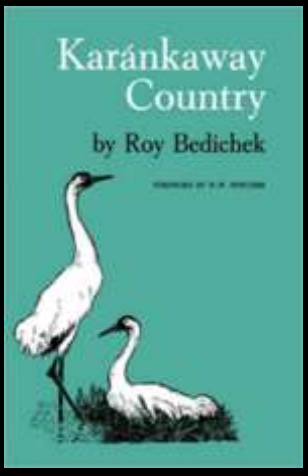
Center for Environmental Research at Hornsby Bend



Waters the Land: Rivers and Water in Texas

Kevin M. Anderson, Ph.D.

Austin Water – Center for Environmental Research



We crossed the wild Pecos



We forded the Nueces



We swum the Guadalupe



Red River runs rusty



The Wichita clear



The Trinity's muddy



Now the fair Angelina
Runs glossy and gliding



The crooked Colorado
Runs weaving and winding



The slow San Antonio Courses the plain



But down by the Brazos
I courted my dear



Angelina River	Navasota River
Aransas River	Neches River
Blanco River	Nolan River
Bosque River	Nueces River
Brazos River	Paluxy River
Colorado River	Pease River
Concho River	Pecos River
Canadian River	Pedernales River
Comal River	Prairie Dog Town Fork
Devils River	Red River
Frio River	Rio Grande
Guadalupe River	Sabine River
James River	Sabinal River
Lampasas River	San Antonio River
Lavaca River	San Bernard River
Leon River	San Gabriel River
Little River	San Jacinto River
Llano River	San Marcos River
Medina River	San Saba River
Navidad River	Sulphur River
	Trinity River

Rivers in Texas



0 200 400
Miles

0 500 1,000
Kilometers

Average Flow in cubic feet per second (cfs):

1,000 2,500 10,000 50,000 250,000 650,000



The Rio Grande - Shared River - International and Interstate

Paul Horgan 1903-1995

Great River: The Rio Grande in North American History (1954)



Great River

THE RIO GRANDE IN
NORTH AMERICAN HISTORY

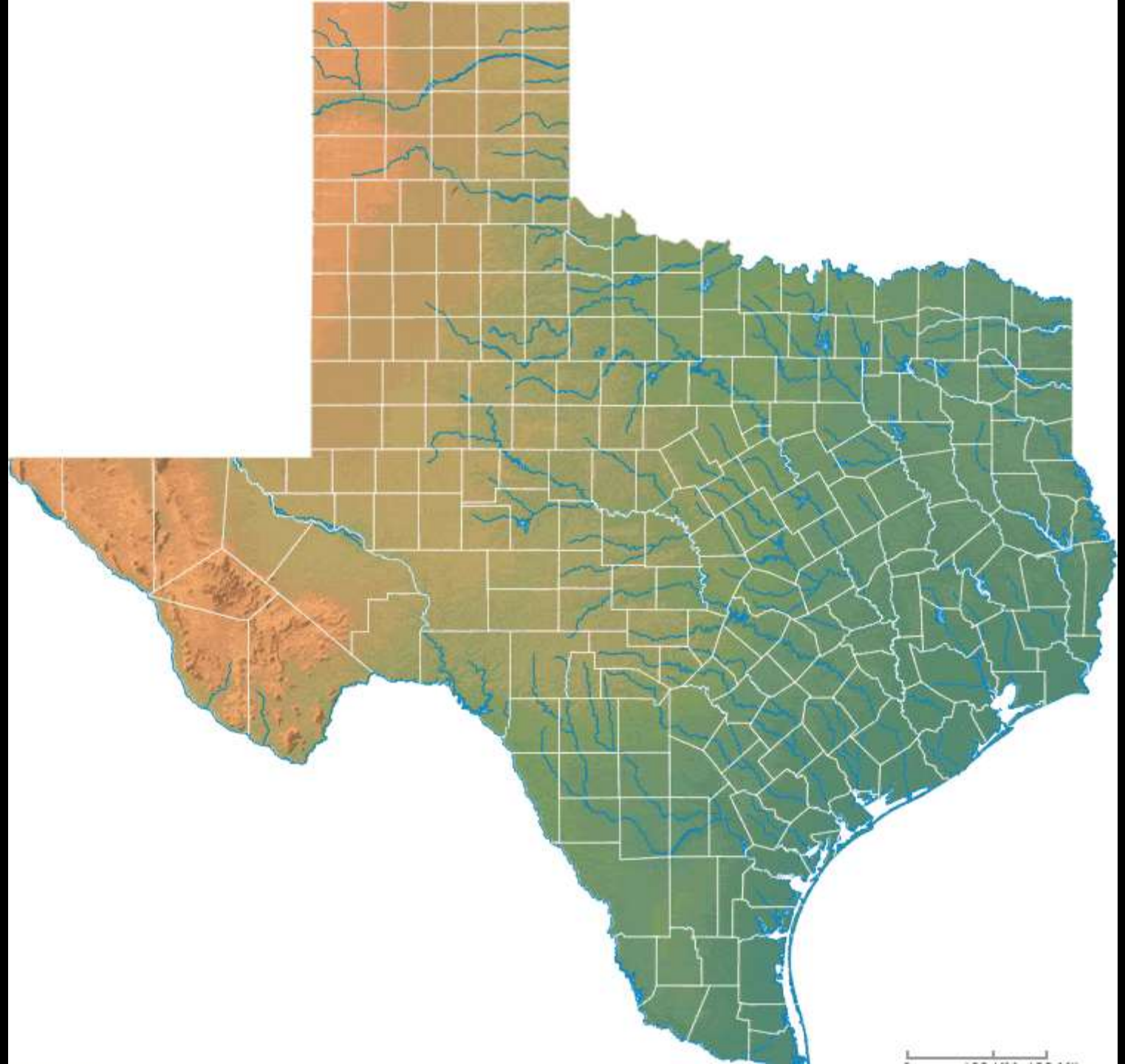
Paul Horgan

WINNER OF THE BANCROFT AND PULITZER PRIZES
IN HISTORY



Texas River Basins







RIVER BASIN MAP OF TEXAS

1996

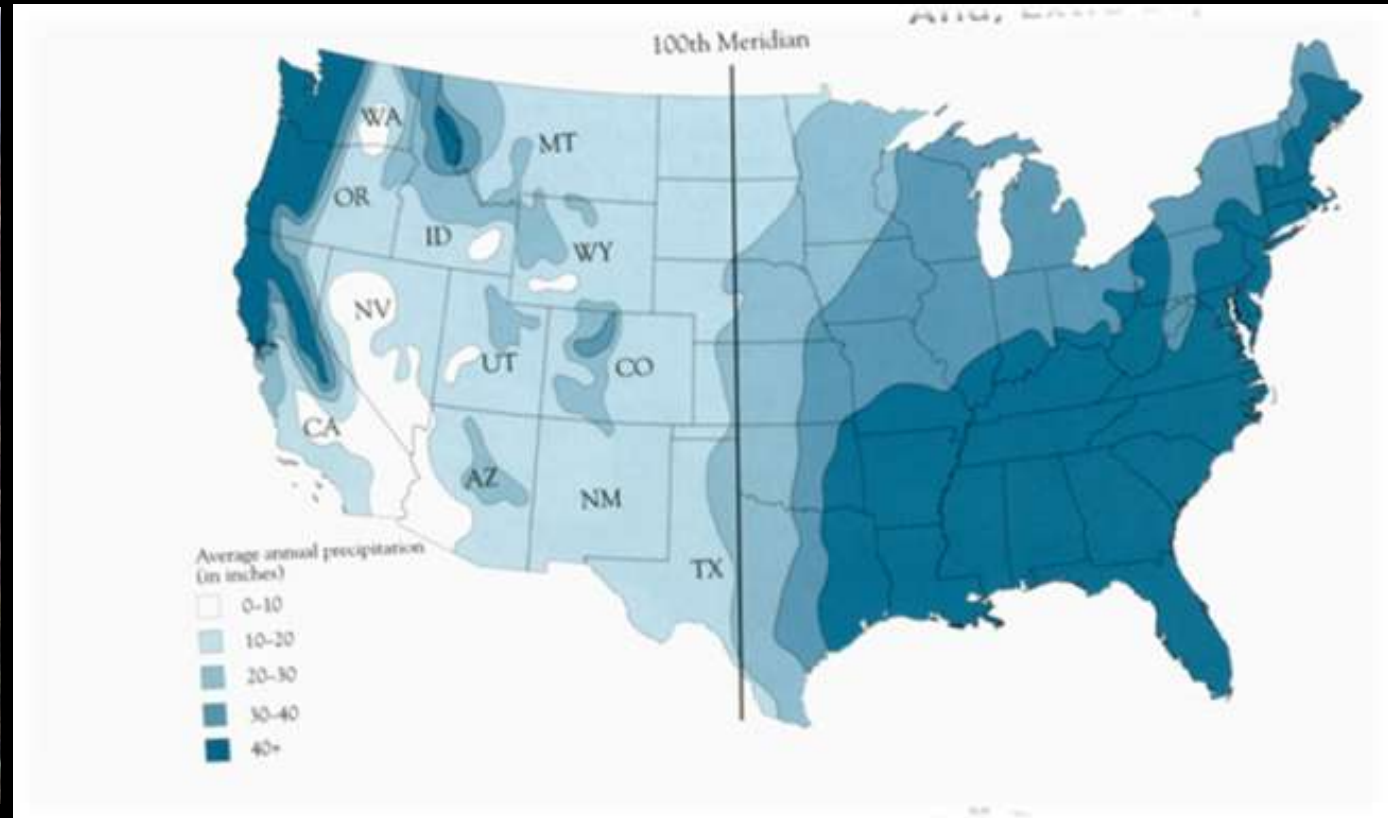
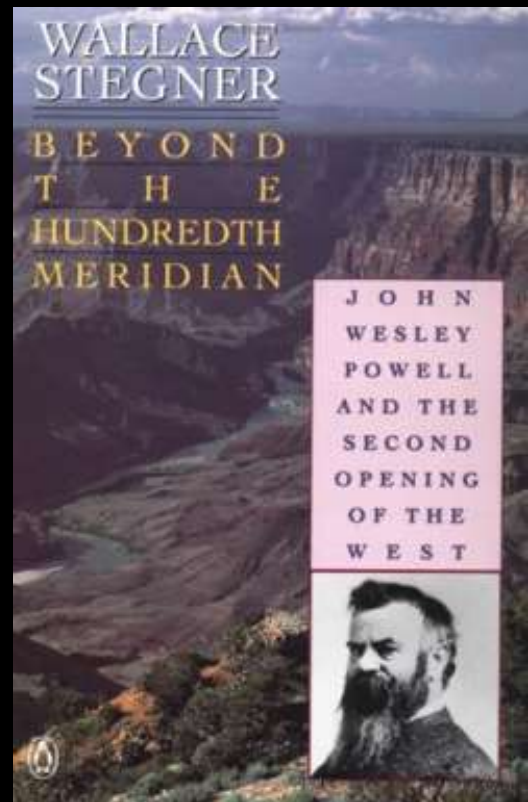
BUREAU OF ECONOMIC GEOLOGY
 THE UNIVERSITY OF TEXAS AT AUSTIN
 University Station, Box X
 Austin, Texas 78713-8924
 (512) 471-1534



River basins	Texas length (miles)	Texas area (sq mi)	Number of major reservoirs*	Conservation storage (acre ft)*	Storage (acre ft/sq mi)
Brazos	840	42,800	19	3,322,980	75
Canadian	200	12,700	2	560,900	44
Colorado	600	39,893	11	3,803,900	95
Guadalupe	250	6,070	2	420,000	70
Lavaca	74	2,309	1	157,900	68
Neches	416	10,011	4	3,455,500	345
Nueces	315	18,950	2	931,640	60
Red	680	30,823	7	4,593,480	149
Rio Grande	1,250	48,259	3	3,772,000	78
Sabine	360	7,426	2	6,041,300	814
San Jacinto	70	5,600	2	570,400	102
Trinity	560	17,686	14	6,969,710	388

*Data from Texas Water Development Board.

Beyond the 100th Meridian and The Great American Desert



Powell's expeditions led to his belief that the arid West was not suitable for agricultural development, except for about 2% of the lands that were near water sources.

His *Report on the Lands of the Arid Regions of the United States 1878* proposed irrigation systems and state boundaries based on watershed areas (to avoid squabbles).

For the remaining lands, he proposed conservation and low-density, open grazing.



Railroad Empire - "Rain follows the plow"

Railroad companies owned vast tracts of lands granted in return for building the lines, did not agree with Powell's opinion.

They aggressively lobbied Congress to reject Powell's policy proposals and to encourage farming instead, as they wanted to develop their lands. The politicians agreed and developed policies that encouraged pioneer settlement based on agriculture.

They based such policy on a theory developed by Professor Cyrus Thomas and promoted by Horace Greeley. They insisted that agricultural development of land causes arid lands to generate higher amounts of rain - "Rain follows the plow"





At an 1883 irrigation conference, Powell would remark:

"Gentlemen, you are piling up a heritage of conflict and litigation over water rights, for there is not sufficient water to supply the land."

25th Anniversary Edition



DUST

The Southern Plains in the 1930s

BOWL

DONALD WORSTER

Winner of the Bancroft Prize

Texas Rivers and Roy Bedichek

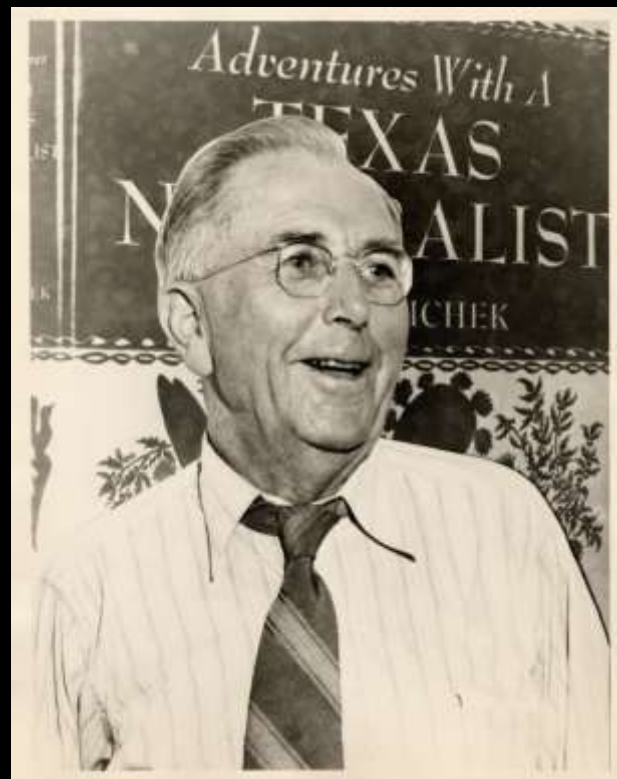
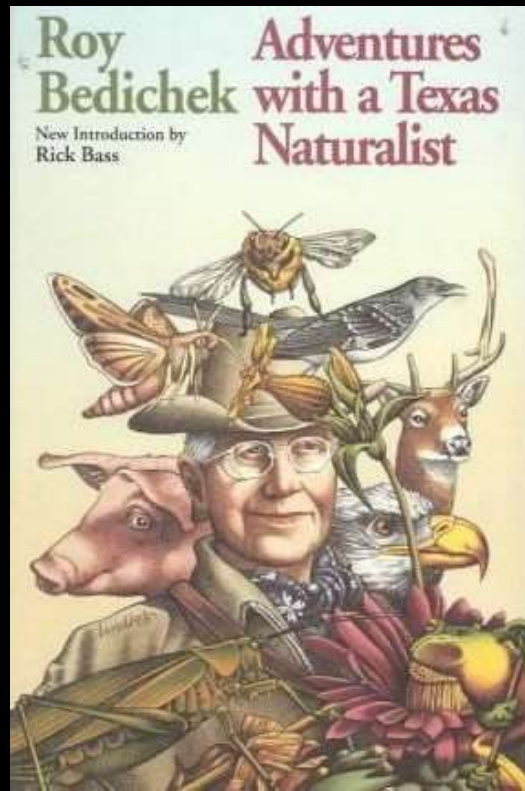
Walter Prescott Webb and J. Frank Dobie arranged for him to spend a year before his retirement writing his first book at Webb's Friday Mountain ranch, about sixteen miles southwest of Austin.

Adventures with a Texas Naturalist (1947)

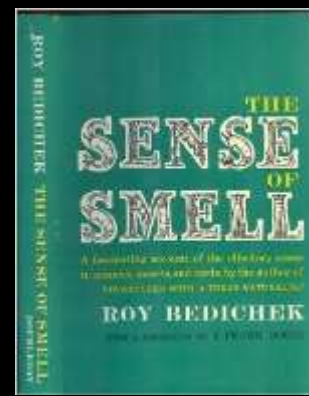
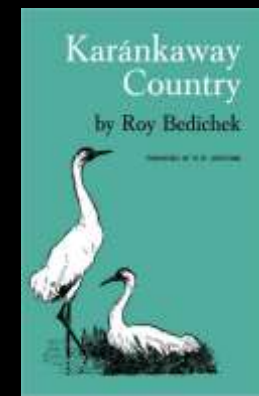
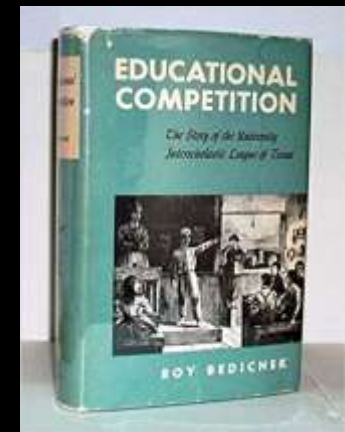
Karankaway Country (1950)

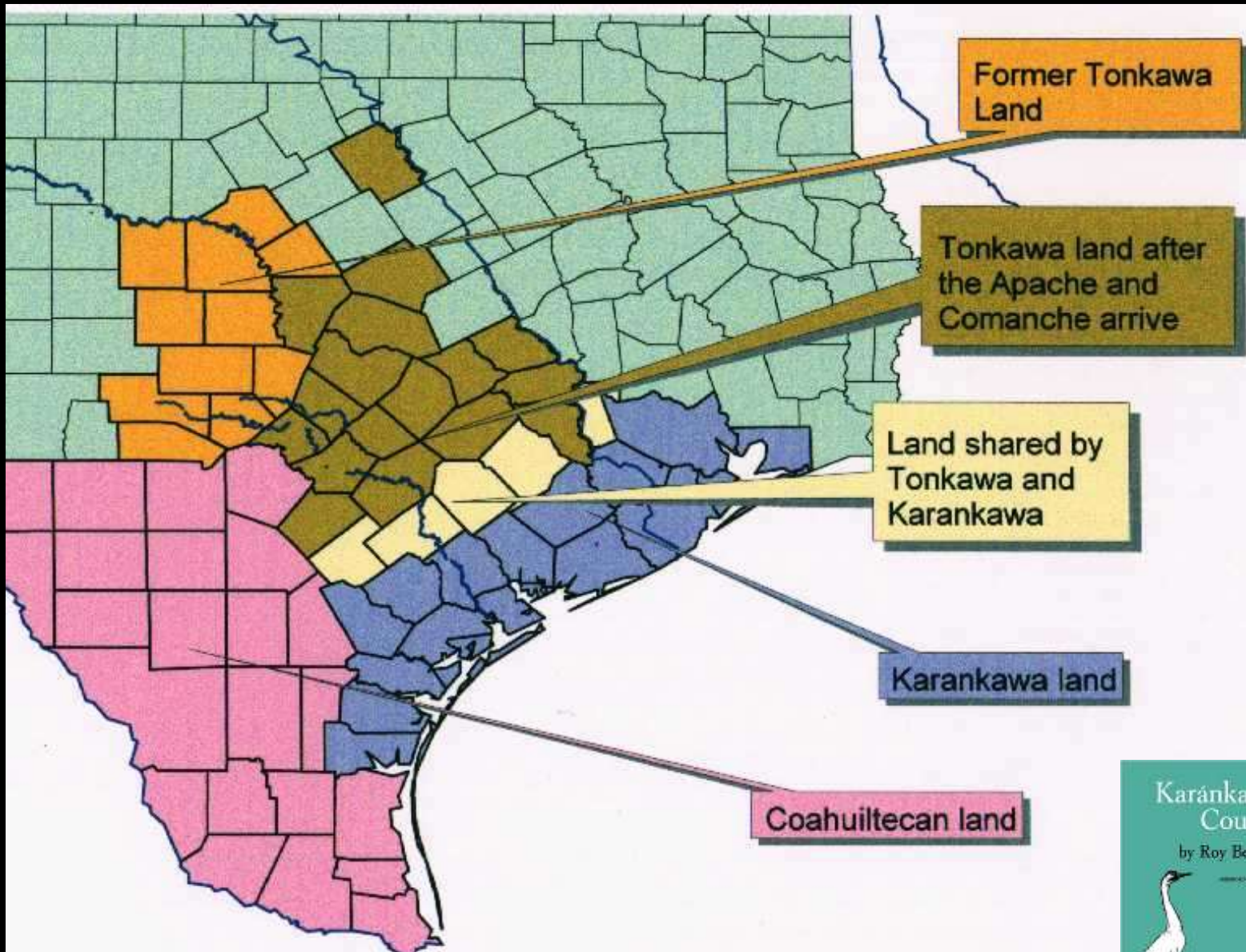
Educational Competition: The Story of the University Interscholastic League of Texas (1956)

The Sense of Smell (1960)

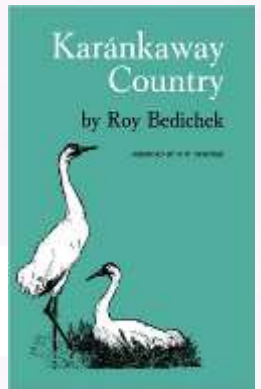


(1878-1959)





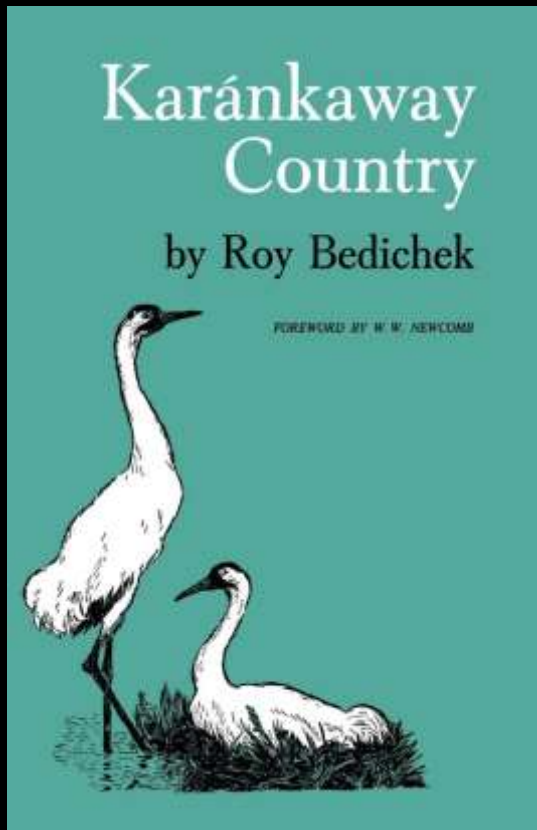
The Karáńkawa Country



The Colorado and The Brazos

The two longest rivers in Texas empty in the Karánkaway Country only fifty miles apart. Their drainage basins spread out to a width of 250 miles to take in the very heart of the state, and finally come again within shouting distance of each other at their sources, six hundred miles as the crow flies from the Gulf.

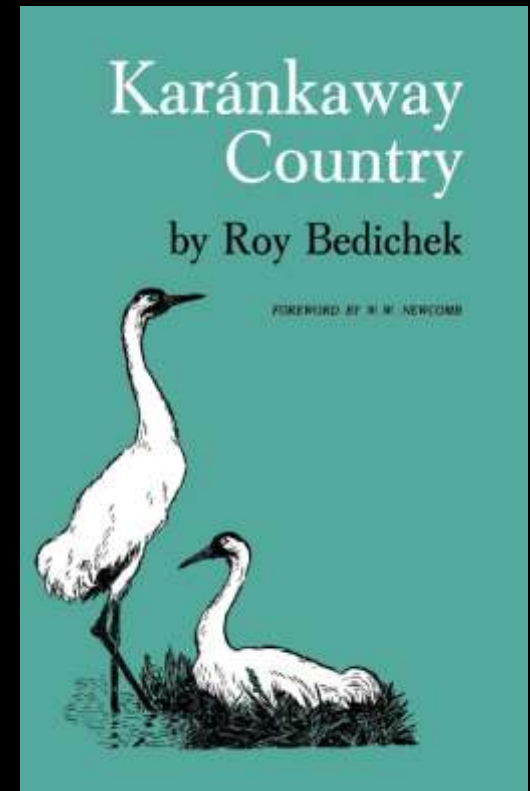
Each delivers an immense burden of silt; and extensive impounding and hydroelectric developments have been completed along their courses, with others in progress, and much more on paper. These are my reasons for selecting this Karánkaway Country for observation...



Karánkaway Country - Texas Rivers

“Texas has a river unity which invites unified treatment of Texas rivers”

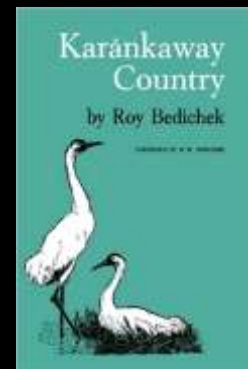
- “Rivers intrigue me. I can sit on a log and look upon a flowing stream for an hour at a time without feeling those twinges of conscience which come while idling in other environments.”
- “The river is a living organism, or at least it presents characteristics so similar to those of a living organism that to speak of it as such is more than mere metaphor.”
- “A river system is one of Nature’s units, and it must be dealt with as such if it is to be dealt with successfully for serving human needs.”



Bedichek – Environmental Transformation

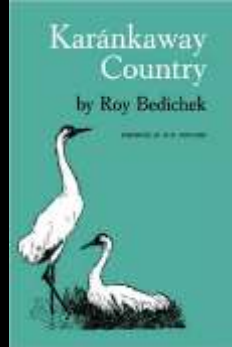
“I have seen in my boyhood days the crown and upper slopes of gentle hills, on which the black soil is mixed with fragmented limestone, produce ninety bushels of oats to the acre. Now many of these slopes are all bleached out, pale as death, and really dead in so far as ability to support vegetable life is concerned.

Many old-timers have seen bale-to-the-acre land in 1883 abandoned as worthless in 1903.”



Bedichek – Texas Rivers and the Brush/Cedar Problem

“I hear landlord and lease holder discussing brush clearance and quoting the learned bulletins of agricultural experimental stations, and when I see them readying the terrific machines for action, I can imagine the debouchment areas of the Nueces and of other Texas rivers yawning for the gargantuan mouthfuls of soil which have been detained in their place for the best part of a century by invasion of the despised brush.”



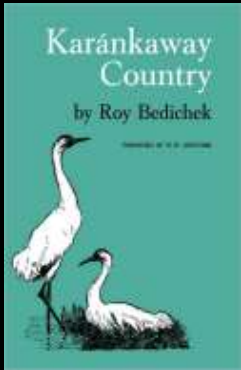
Bedichek – Brush, Soil, Rivers, and Watersheds

“Ignorance of the conservation function of brush has hung like a pall of smoke over popular thinking since remotest antiquity.

Land stripped of forest or of grass seems to know that nakedness is sin. It hastily grabs up anything within reach with which to cover its shame. (Weeds, invading shrubs, vines)...

Nature abhors an organic vacuum as much as she does an inorganic one.

In spite of its cinema reputation, Texas is not tough, that is, ecologically. It is really a tender land, and cannot stand the buffetings that certain other areas of the world have endured and still support a human population in health and vigor.”



Bedichek - The Little Waters

“Under natural conditions, the whole expansive watershed was a giant sponge which was pressed by gravity ever so gently, ever so steadily, to drain its life-giving contents...

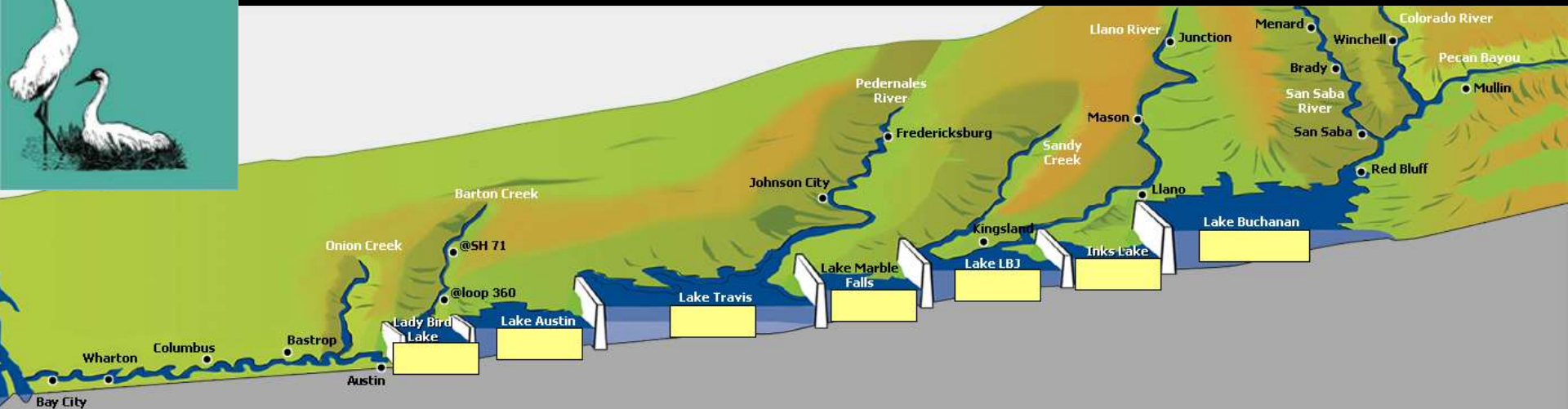
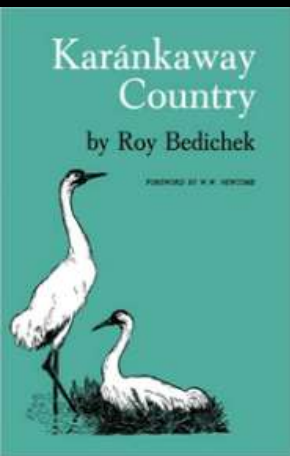
Floods came then as now – ten, fifteen inches of rainfall in a day over limited space – but the soil, well covered, took no pounding, and waterways were lined with vegetation which cushioned the assaults and tamed the rage of plunging waters. The Little Waters people simply propose to reinstate Nature’s plan in so far as it can now be re-established.”



Texas River Management – The Big Waters

“It is a mistake to assume that the big dams catching water from eroded and still eroding watersheds store more than was stored in the days when natural forces detained rainfall in the highlands and let it gradually leak away.

Compared with the original uses to which rainfall on Texas watersheds was put, big dams merely salvage rather than conserve. We have relocated the reservoir and changed its character, each for the worse.”



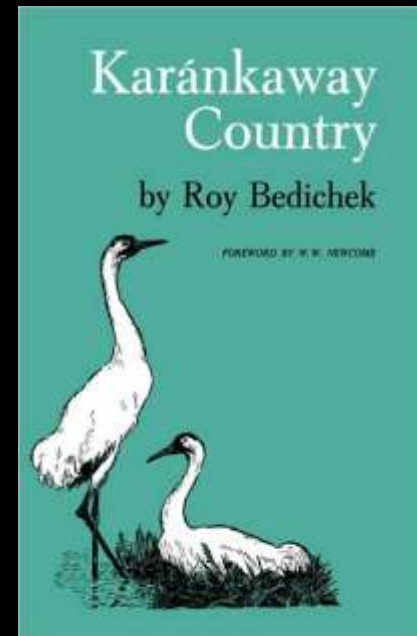
Bedichek – “The Little Waters” vs “The Big Waters”

A Hydrological Vision

“Formerly, timbered bottoms, brushy hillsides, and wide grasslands, thickly sodded, soaked up rain water like a sponge. It seeped into the subsoil and eventually filled sandy underground strata from which it found its way by devious paths into bubbling springs at lower levels, trickling off to join other trickles to form (on still lower levels) streamlets whose confluence made streams – all moving unhurried in a widespread network toward the river channel...

Nature was not interested in turning turbines or floating barges, but in producing just as much vigorous, varied, and abundant life as possible, dispersed along the way from plains to sea.

Some think this is a dream. Not so: the overwhelming proof lies in the land richness and life richness which we found here.”

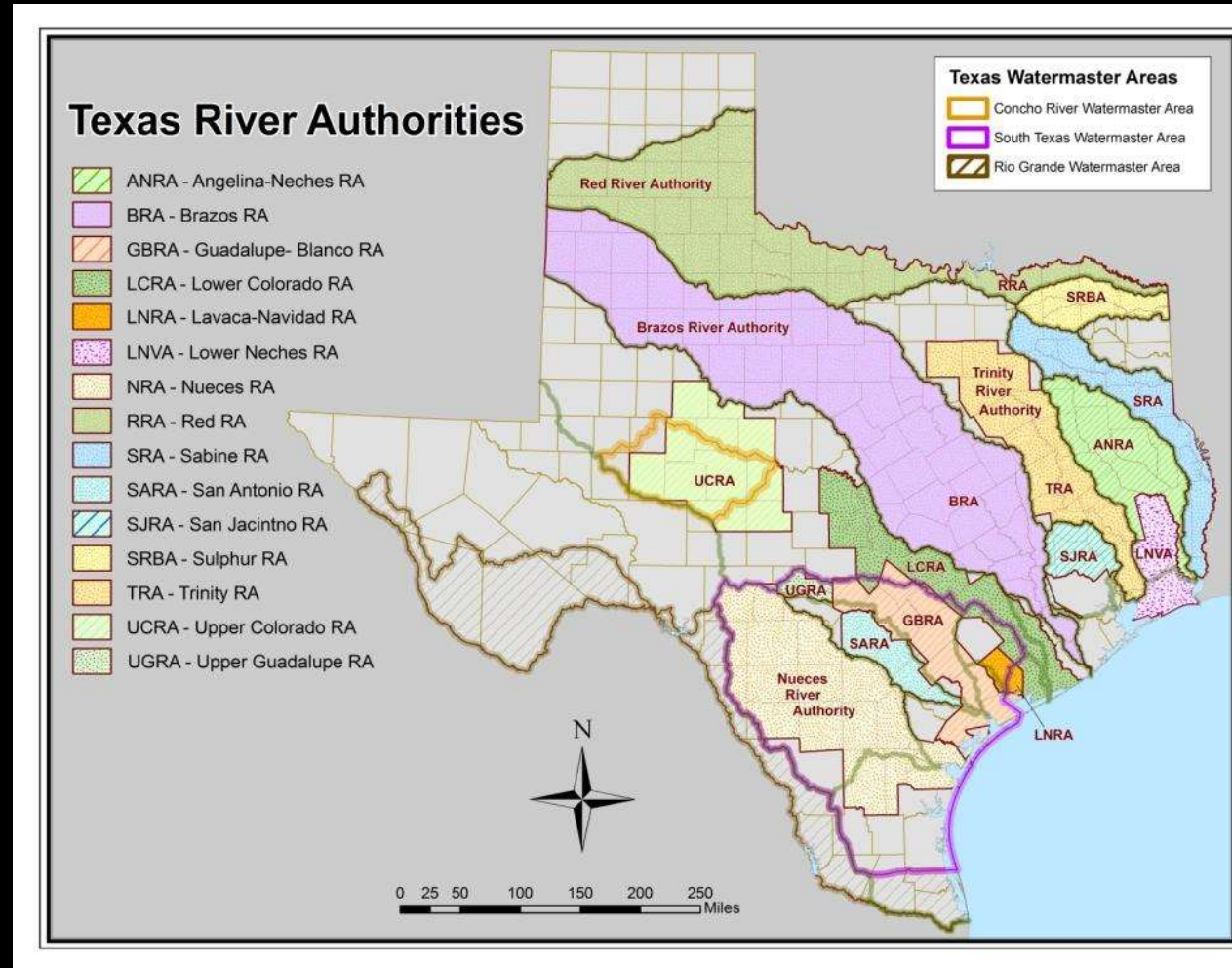
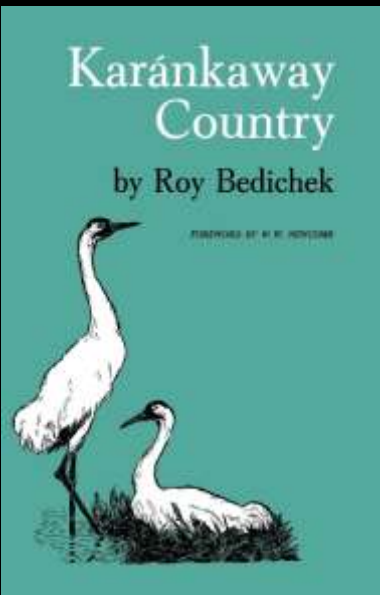


Controlling Texas Rivers Bedichek's Warning

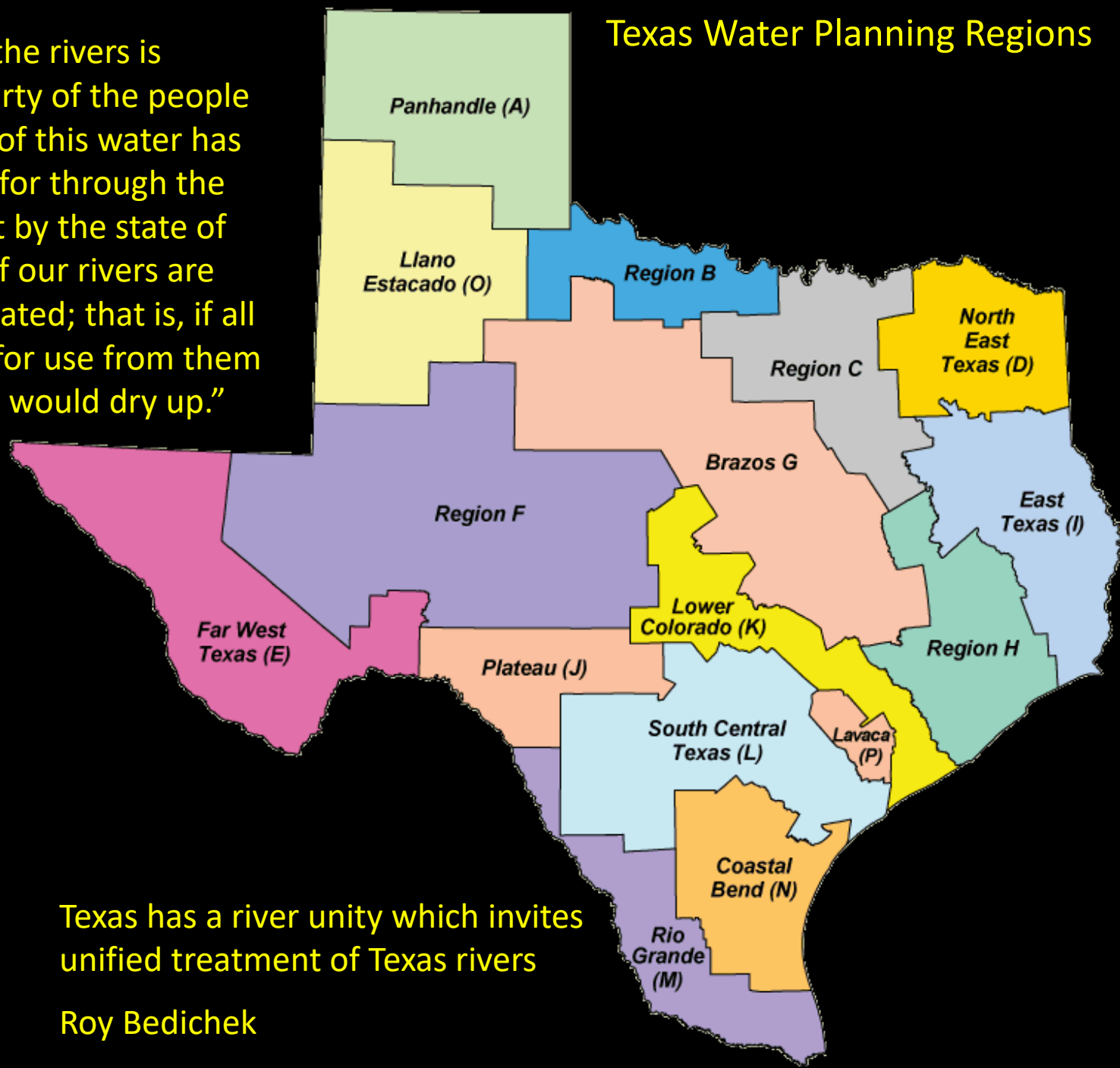
"A river is not a colt to be 'broken,' trained, stalled, and depended upon thereafter to do the will of his master.

It is eccentric, unaccountable, either has no law of behavior or often keeps it secret from human investigators.

Centuries, even, do not delimit its extremes."



Texas Water Planning Regions

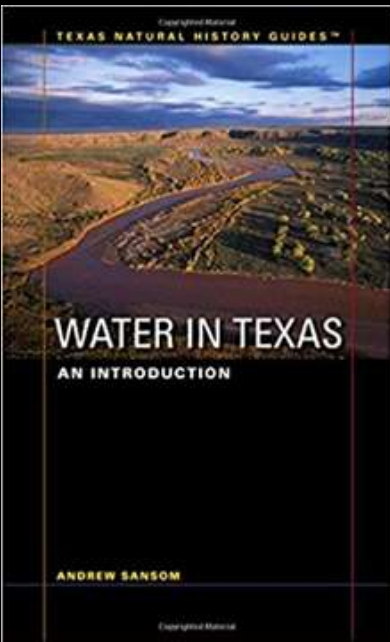


Texas has a river unity which invites unified treatment of Texas rivers

Roy Bedichek

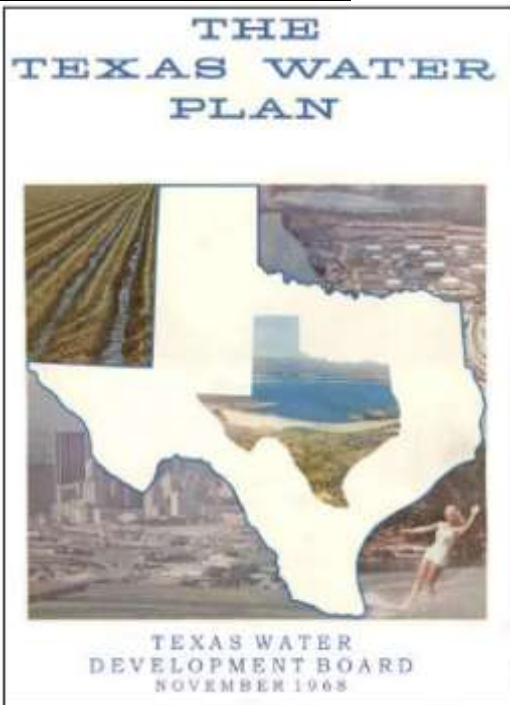
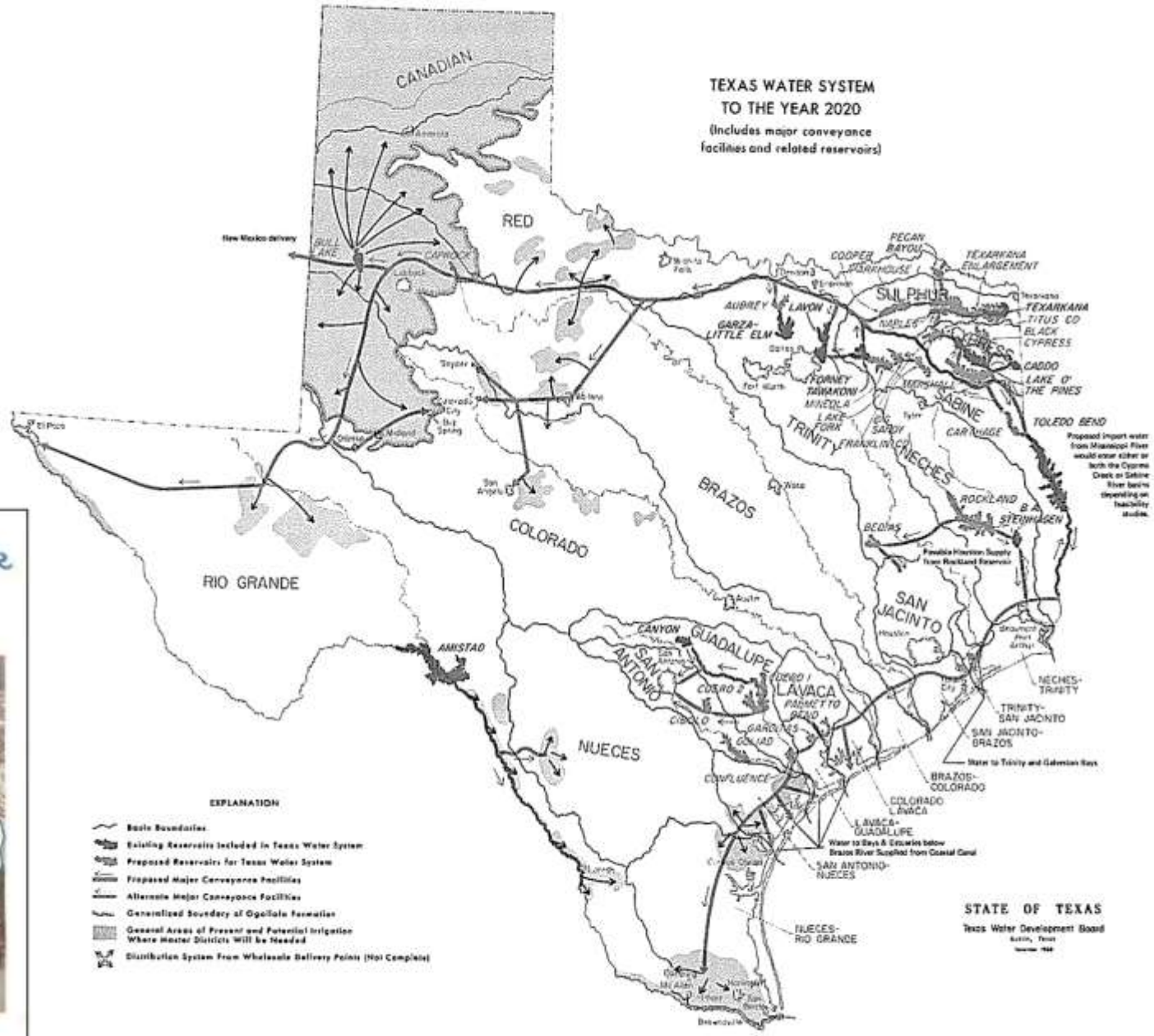
“By law the water in the rivers is considered the property of the people of Texas. Today most of this water has already been spoken for through the granting of rights to it by the state of Texas. In fact, some of our rivers are actually overappropriated; that is, if all the water permitted for use from them were withdrawn they would dry up.”

Andy Sansom



Interbasin Transfers

In 1968 the Texas Water Development Board put forward the Texas Water Plan to prepare for the year 2020.



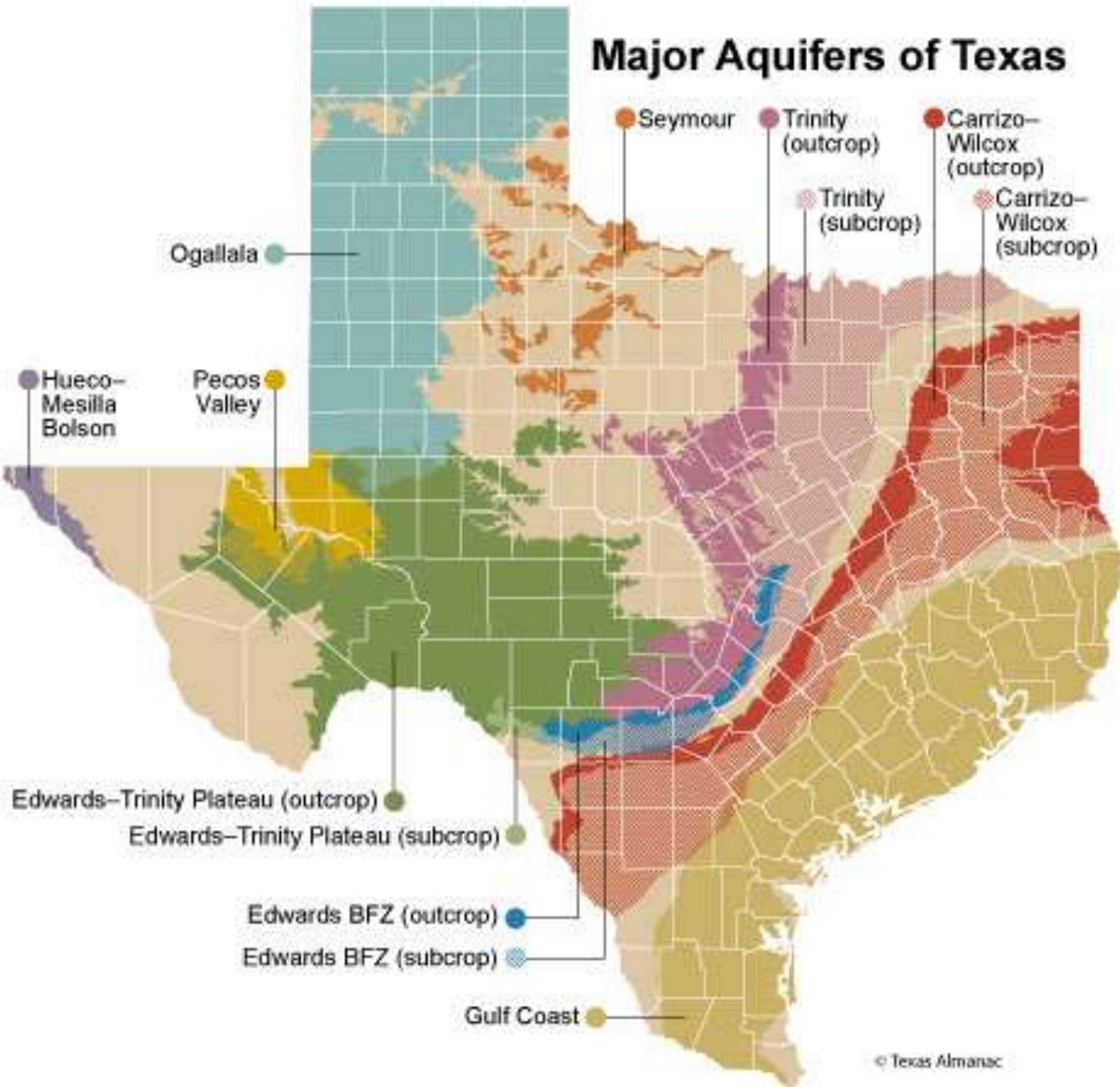
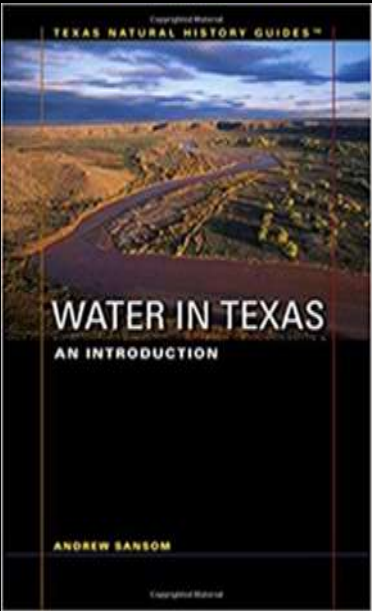
1968 State Water Plan

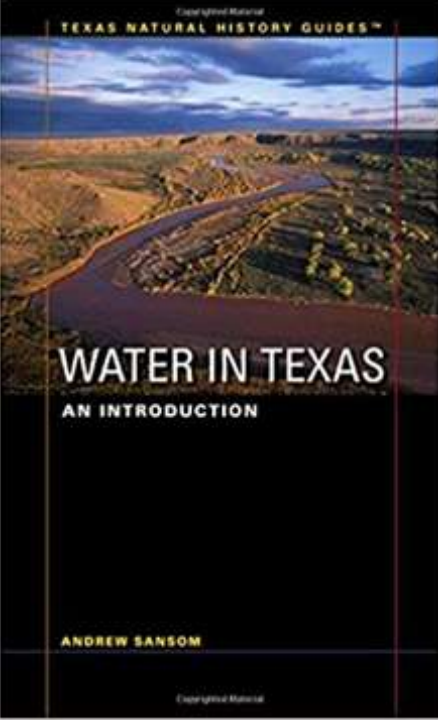


A major obstacle to the plan's implementation was a report issued by the Bureau of Reclamation and the Mississippi River Commission in 1973.

The report found that excess water is available from the Mississippi River, but concluded that, "while it is feasible to divert water from the Mississippi River to the High Plains, the cost of moving the water would be very high and the environmental impacts to the Gulf area and along the diversion route could be significantly adverse."

Interbasin transfers apply only to surface water - when it comes to transferring groundwater, an entirely different set of rules apply.



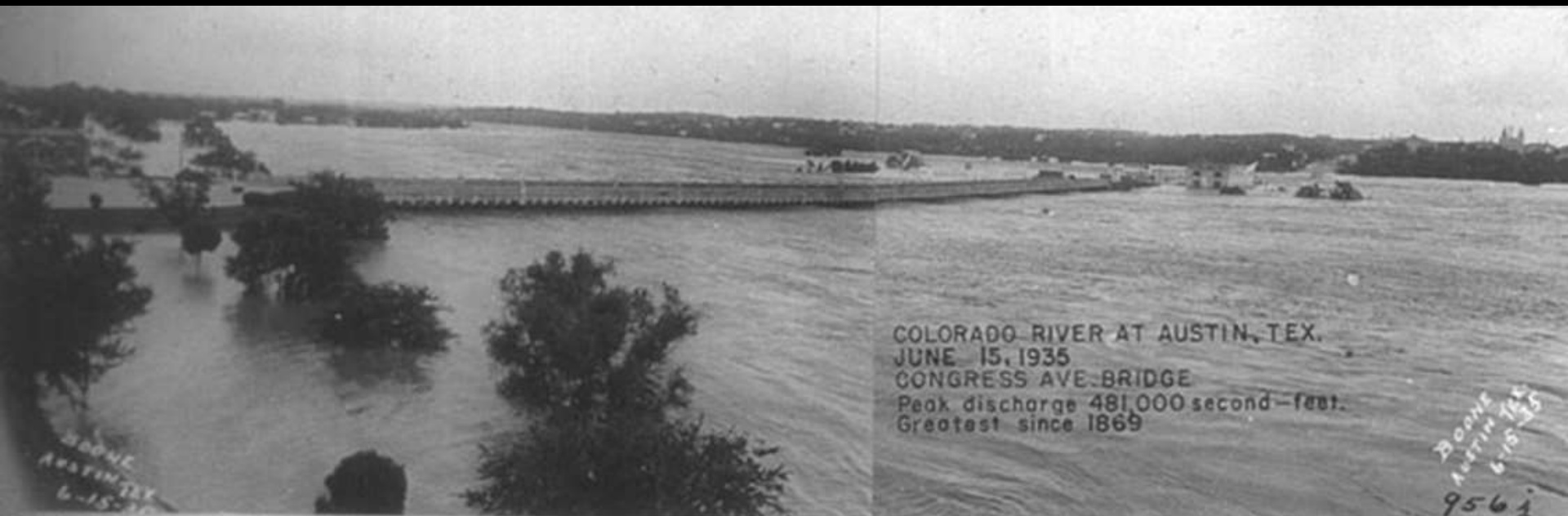


Water in Texas

Drought and Flood



All modern water planning in Texas for the past fifty years has been based on the notion that the drought of the 1950s is as bad as it is going to get.



Historic Droughts 1918

“In 1918, the whole current of the river plowed a narrow furrow through the silt above the dam, and the channel was so narrow that it was easy to hop across it at one jump.

At this time, the whole discharge of the Colorado River was only nine second-feet immediately above the dam.”

University of Texas Bulletin

No. 2439: October 15, 1924

SILTING OF THE LAKE AT AUSTIN, TEXAS

By

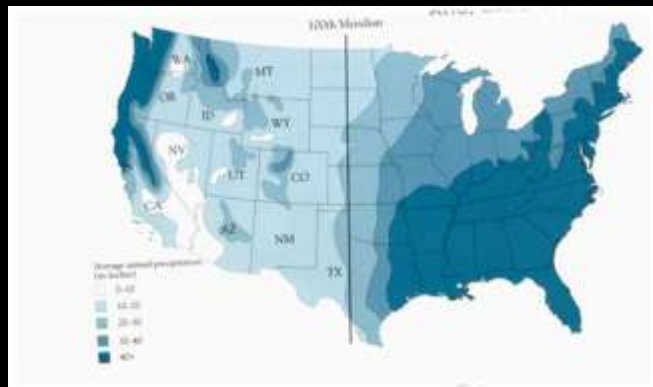
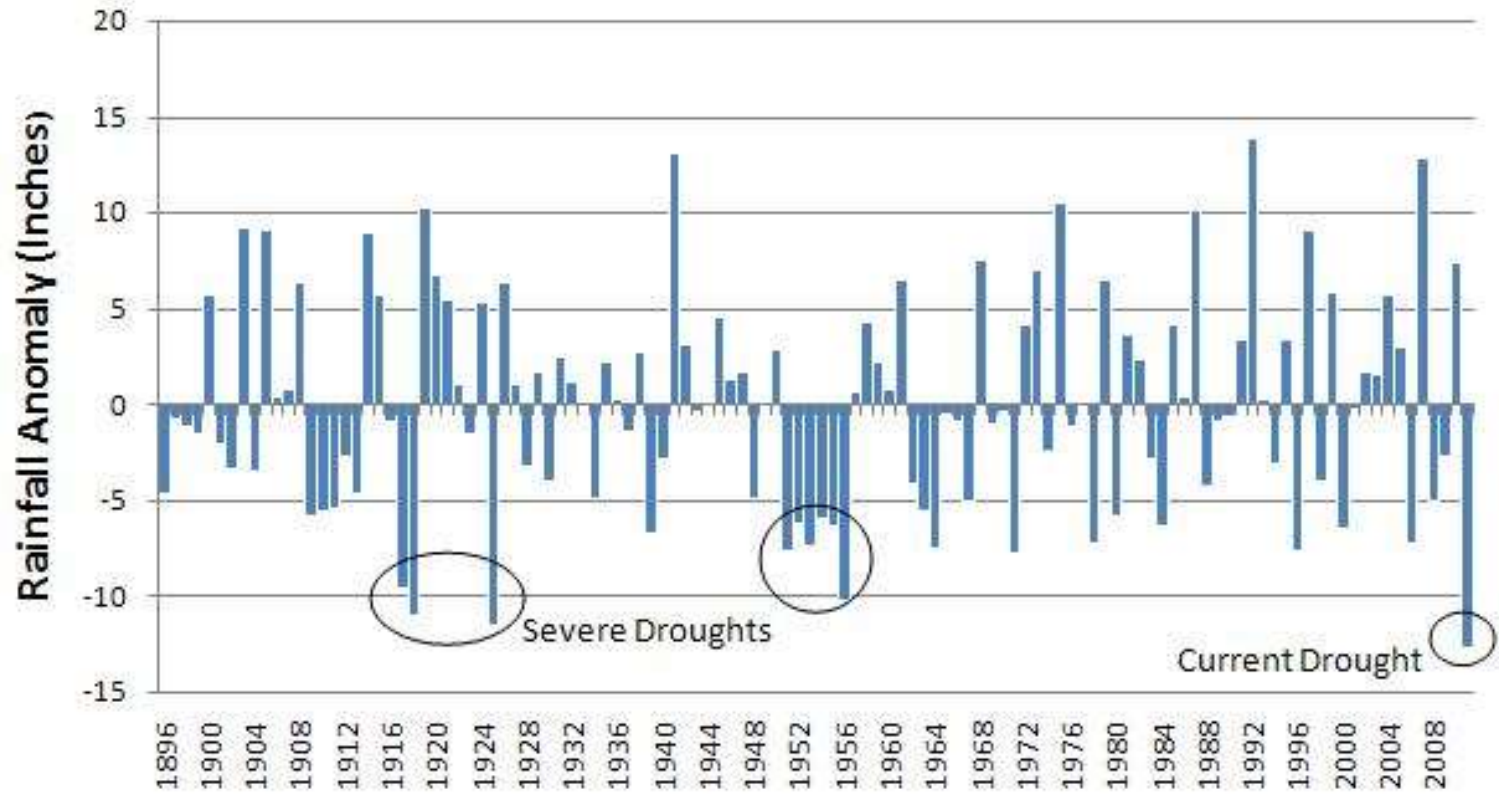
T. U. TAYLOR

Professor of Civil Engineering

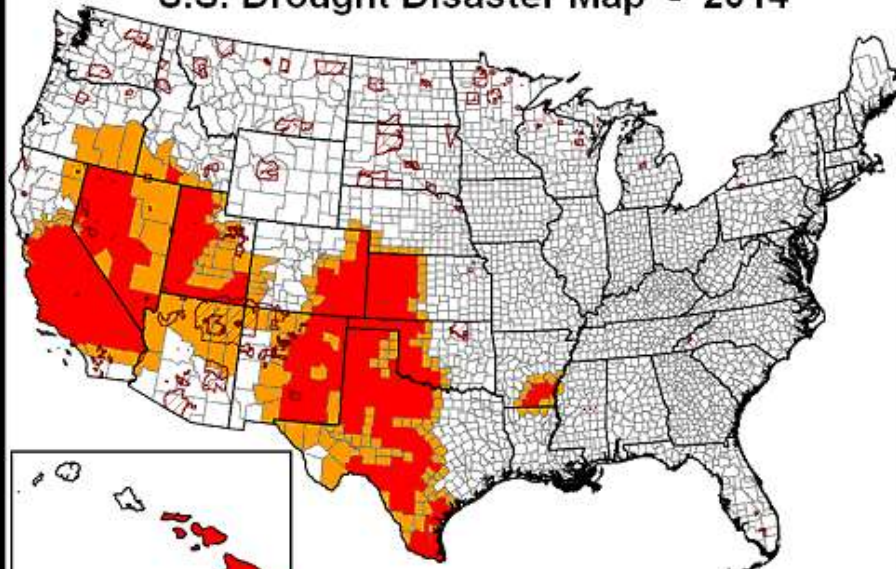
illustrates the width of the stream where the man in the bathing suit is astride the whole channel of the river, as it flowed along the narrow furrow that it had cut in the silt. The stream at this point was about four feet wide.



Texas Precipitation, August-July



U.S. Drought Disaster Map - 2014



Hawaii 1:19,740,053

Secretarial Drought Designations for 2014

Disaster Incidents as of January 15, 2014

- State Boundary
- County Boundary
- Tribal Lands
- January 15, 2014
- Primary Counties: 252
- Contiguous Counties: 177



USDA Farm Service Agency
Production, Emergencies and Compliance Division
Washington, D.C.
January 15, 2014

1:23,520,203

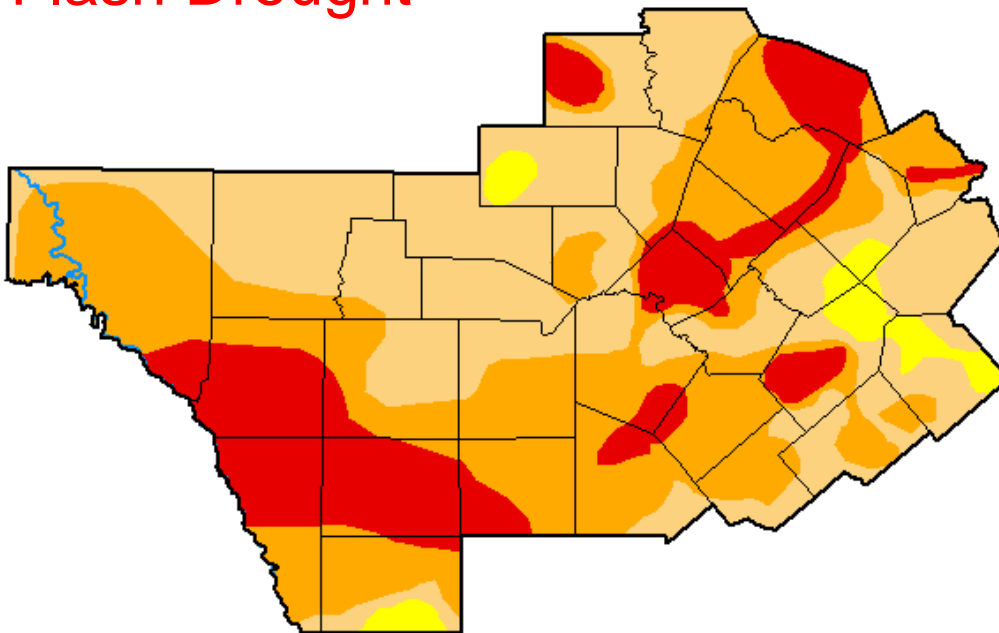


U.S. Drought Monitor

Austin/San Antonio, TX WFO

October 1, 2019
 (Released Thursday, Oct. 3, 2019)
 Valid 8 a.m. EDT

2019
 Central Texas
 Flash Drought



Drought Conditions (Percent Area)

	None	D0	D1	D2	D3	D4
Current	0.00	3.46	39.33	38.37	18.84	0.00
Last Week <i>09-24-2019</i>	0.59	4.79	42.39	41.35	10.88	0.00
3 Months Ago <i>07-02-2019</i>	96.60	3.40	0.00	0.00	0.00	0.00
Start of Calendar Year <i>01-01-2019</i>	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year <i>10-01-2019</i>	0.00	3.46	39.33	38.37	18.84	0.00
One Year Ago <i>10-02-2018</i>	79.29	20.71	0.00	0.00	0.00	0.00

Intensity:



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

Brian Fuchs
 National Drought Mitigation Center



Hottest Septembers

IN-DEP

FIRST WARNING

WEATHER
ON THE 1S

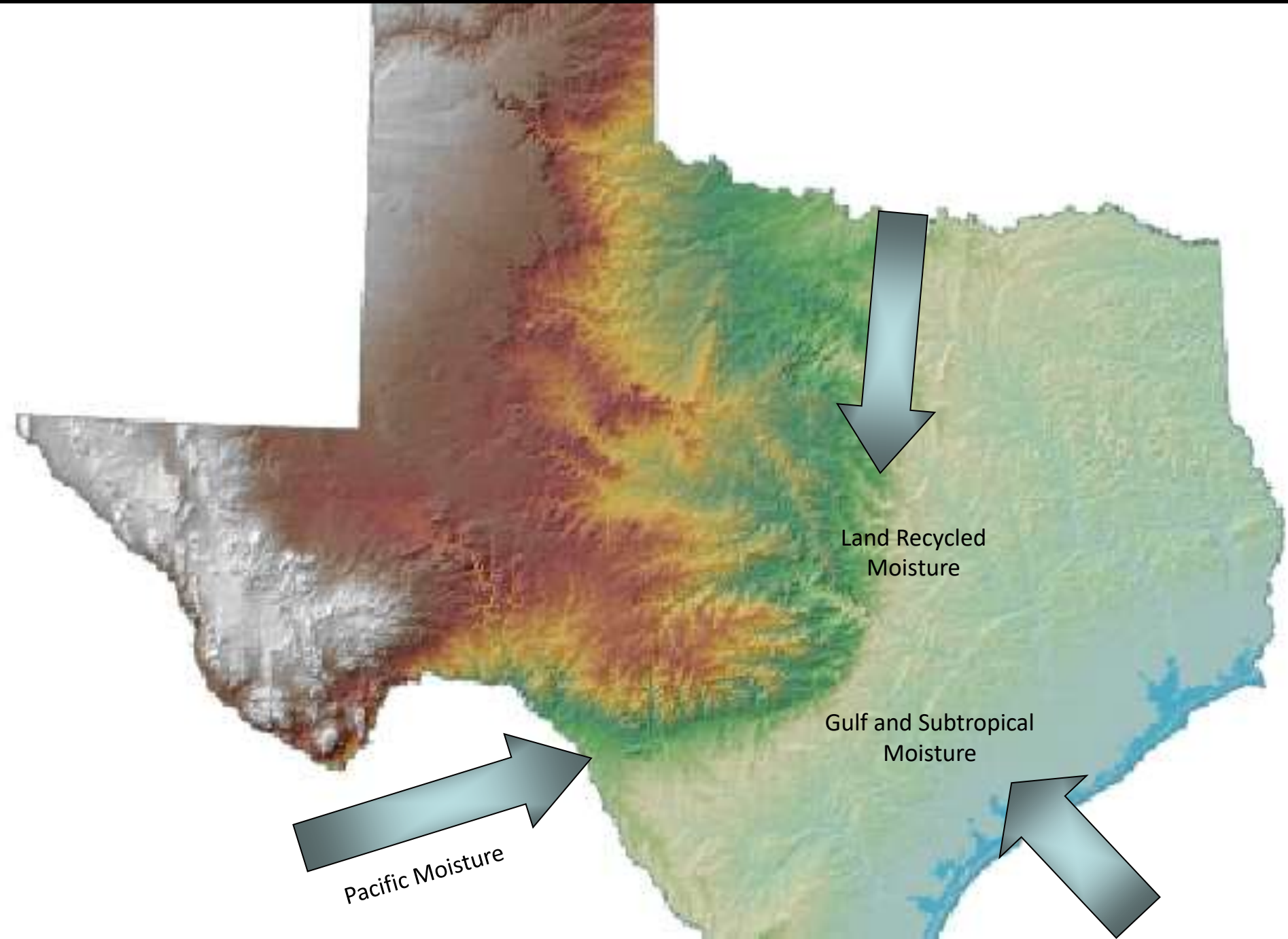
HOTTEST SUMMERS

METRO AUSTIN (SINCE 1897)

1. 88.8 2011
2. 87.5 2019
3. 87.4 2009
4. 86.9 2013
5. 86.9 2018

1998	82.9	2
2016	82.5	0
1972	82.4	0

How Texas Droughts End - Floods



Flash Flood Alley

The Central Texas Hill Country is the most flash flood-prone area of North America.



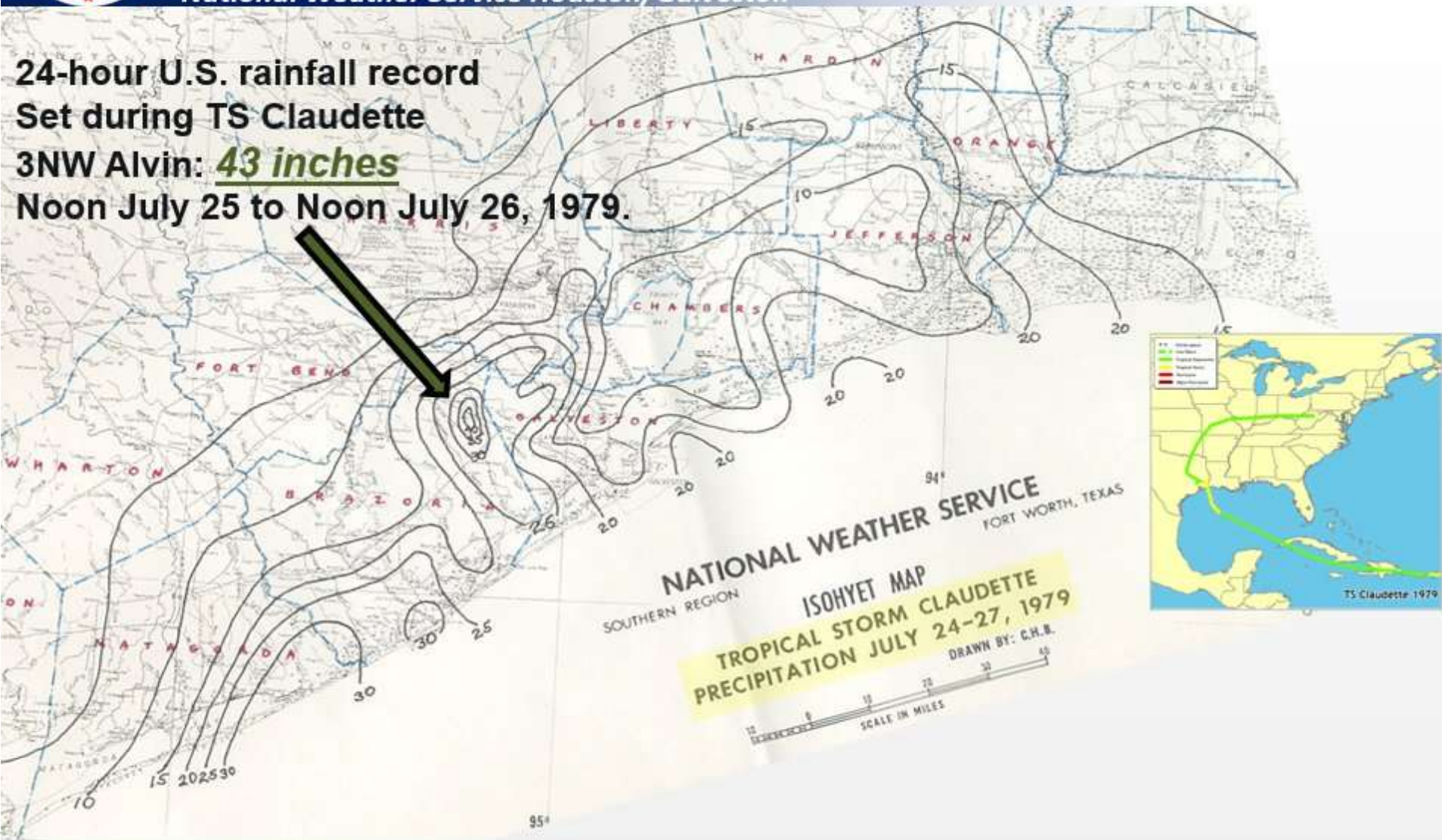
Copyright 2005
FloodSafety.com



24-hour U.S. rainfall record

National Weather Service Houston/Galveston

24-hour U.S. rainfall record
Set during TS Claudette
3NW Alvin: 43 inches
Noon July 25 to Noon July 26, 1979.



@NWSHouston
weather.gov/houston

Image 7/26/2017
Produced 7:34 AM

Remains of Amelia
July 30-August 5, 1978
571 sites

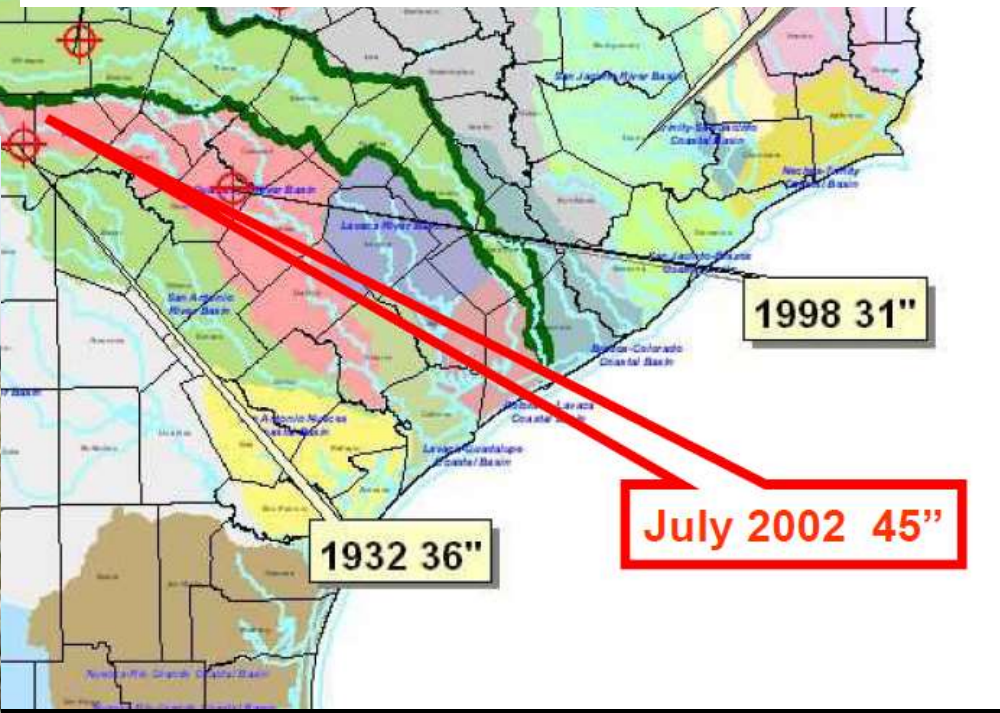
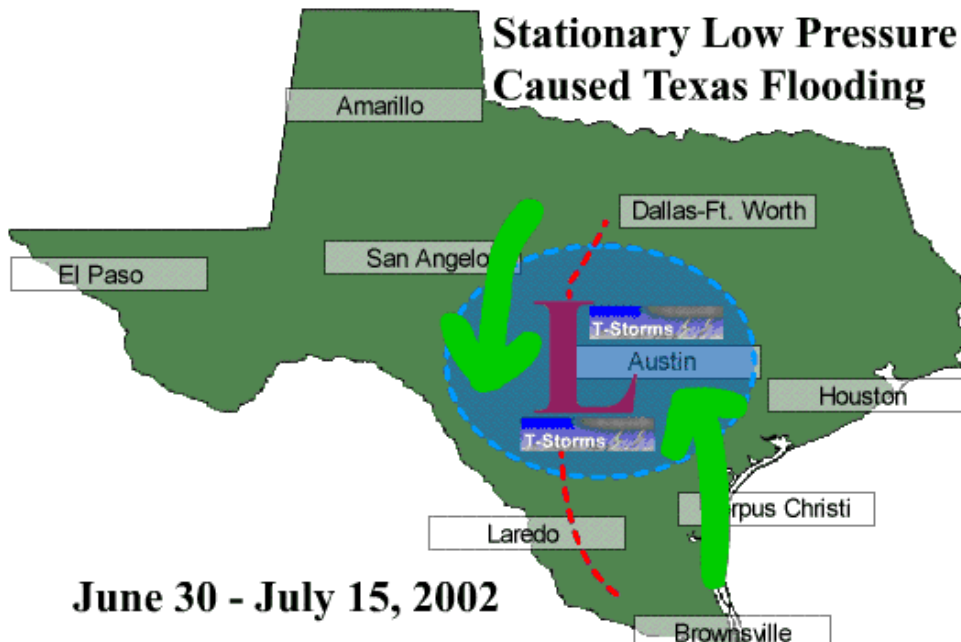
30+

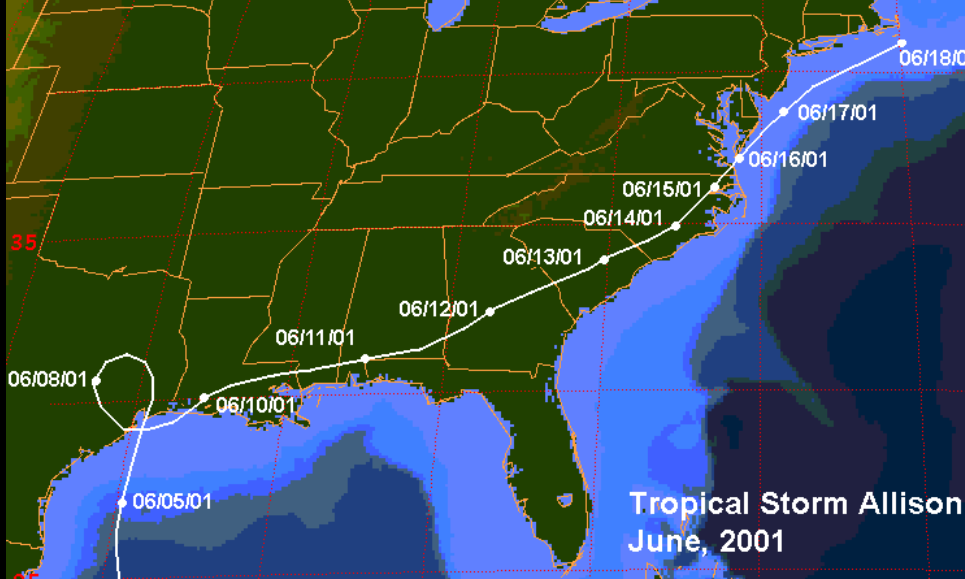
45+

Maximum: 48.00"
Medina, TX

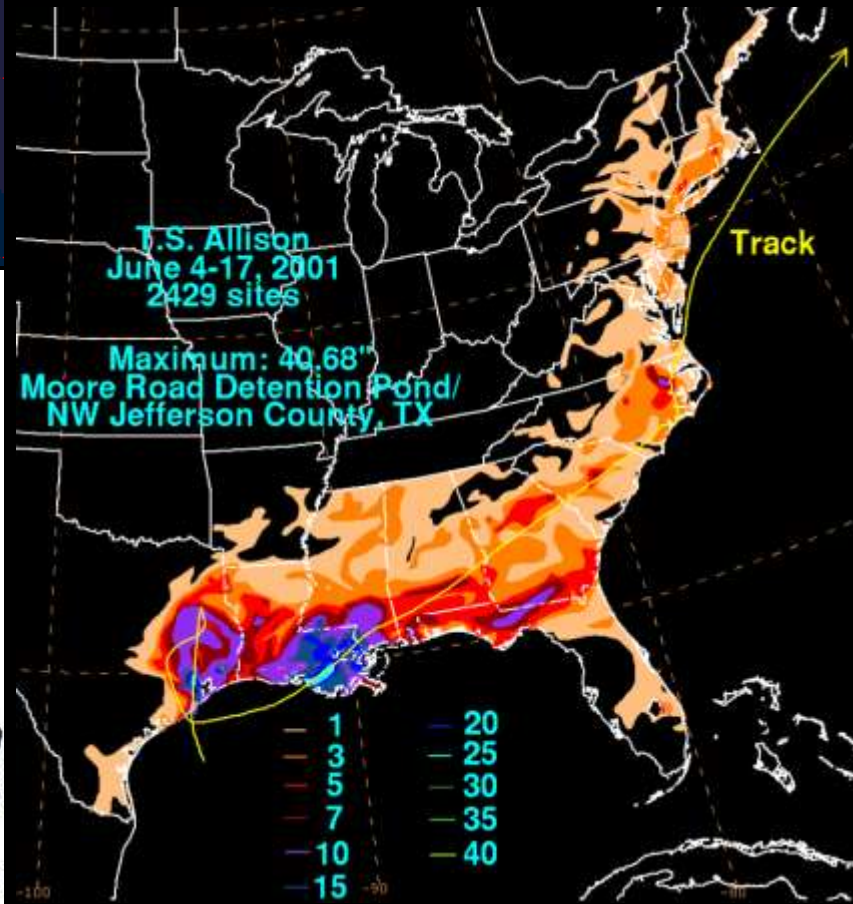


The storm total of 48 inches measured at Medina was the wettest known storm total rainfall in the continental US

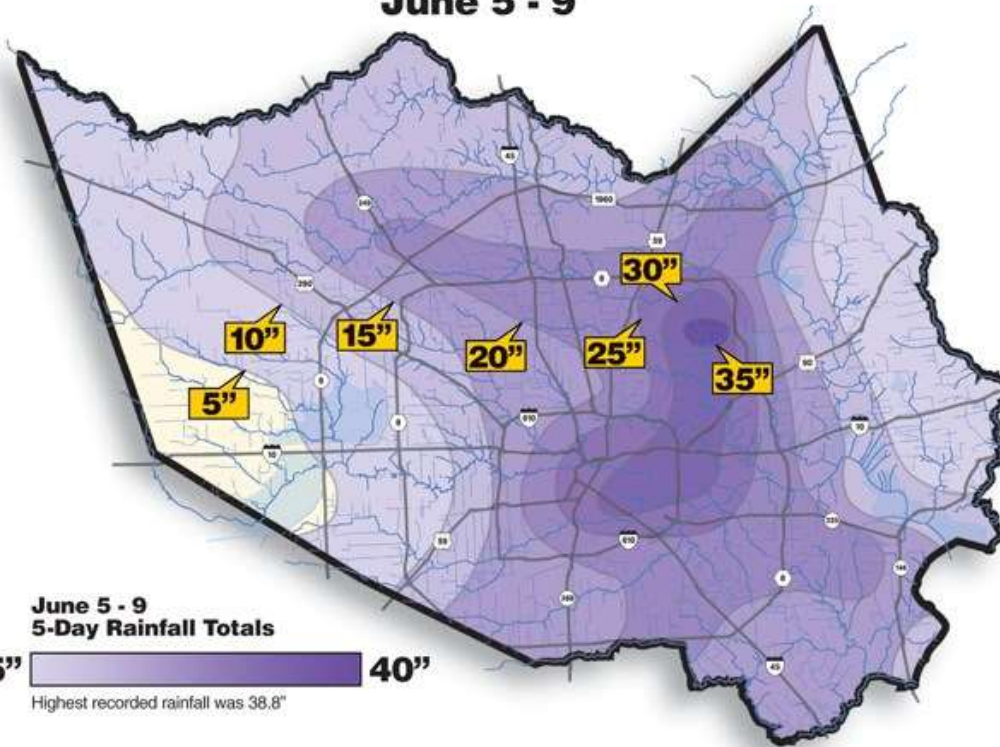




Tropical Storm Allison June 2001



5-Day Rainfall Totals June 5 - 9



HARVEY RAINFALL AUGUST 25-30, 2017

Nederland, TX	60.58"
Groves, TX	60.54"
Fannett, TX	49.25"
Beaumont, TX	49.06"
Port Arthur, TX	47.99



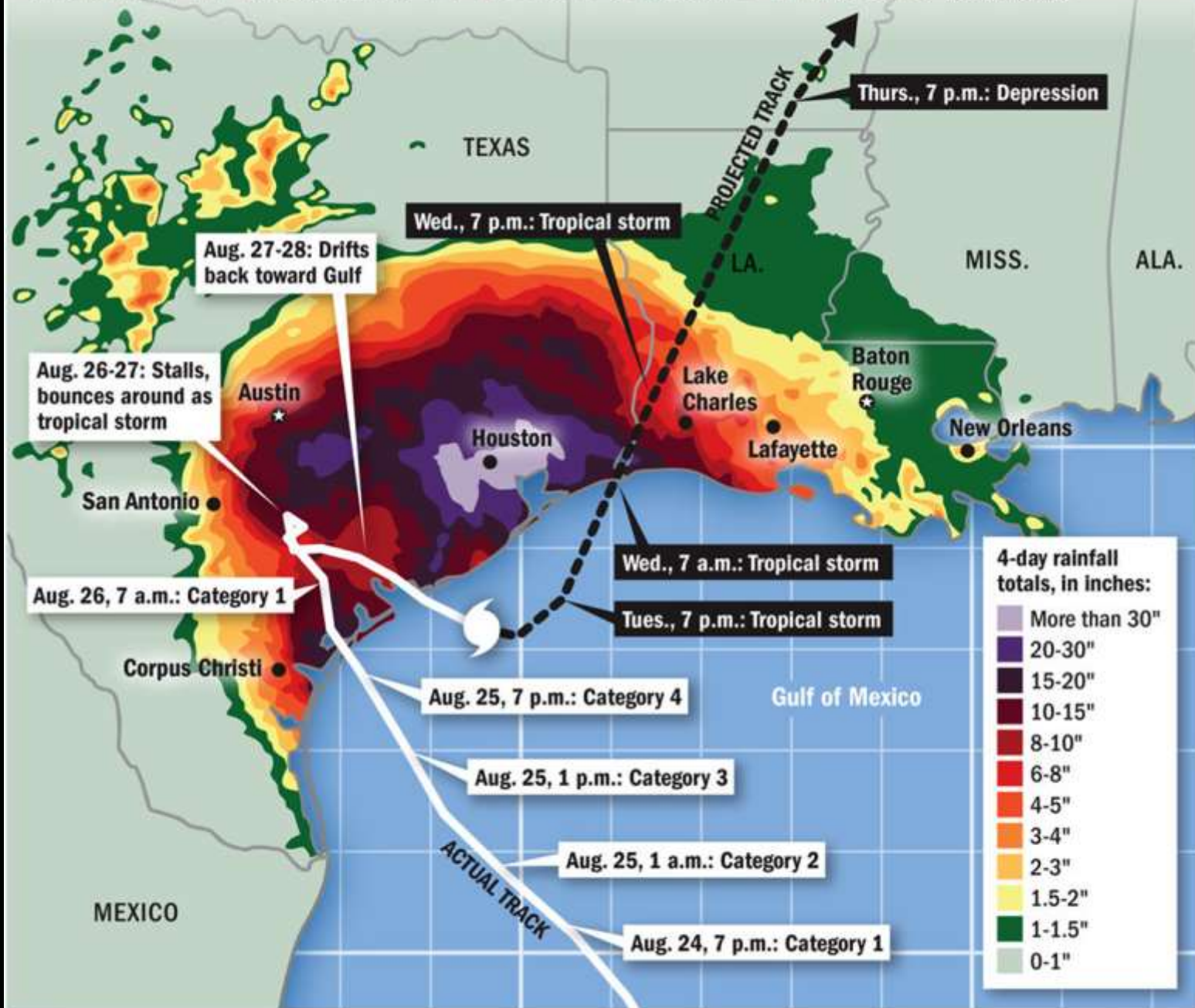
HARVEY'S HISTORY

AUGUST 2017



HARVEY RAINFALL TOTALS AND TRACK

As of Monday



Aug. 27-28: Drifts back toward Gulf

Aug. 26-27: Stalls, bounces around as tropical storm

Aug. 26, 7 a.m.: Category 1

Wed., 7 p.m.: Tropical storm

Wed., 7 a.m.: Tropical storm

Tues., 7 p.m.: Tropical storm

Aug. 25, 7 p.m.: Category 4

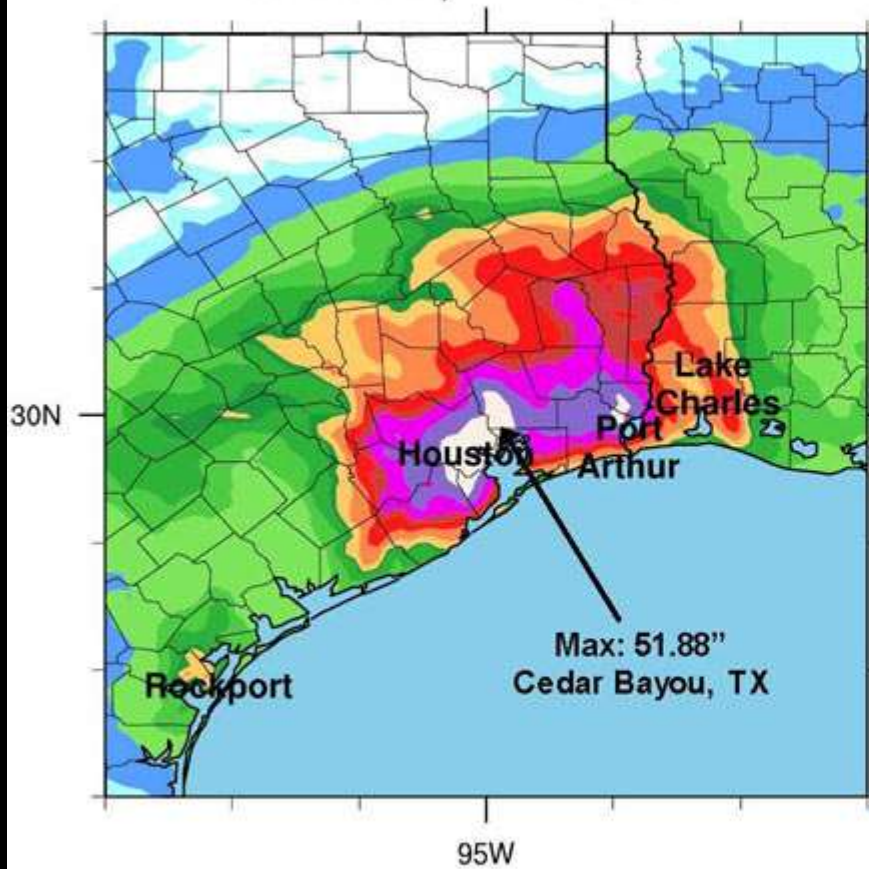
Aug. 25, 1 p.m.: Category 3

Aug. 25, 1 a.m.: Category 2

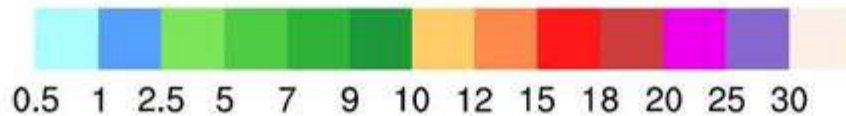
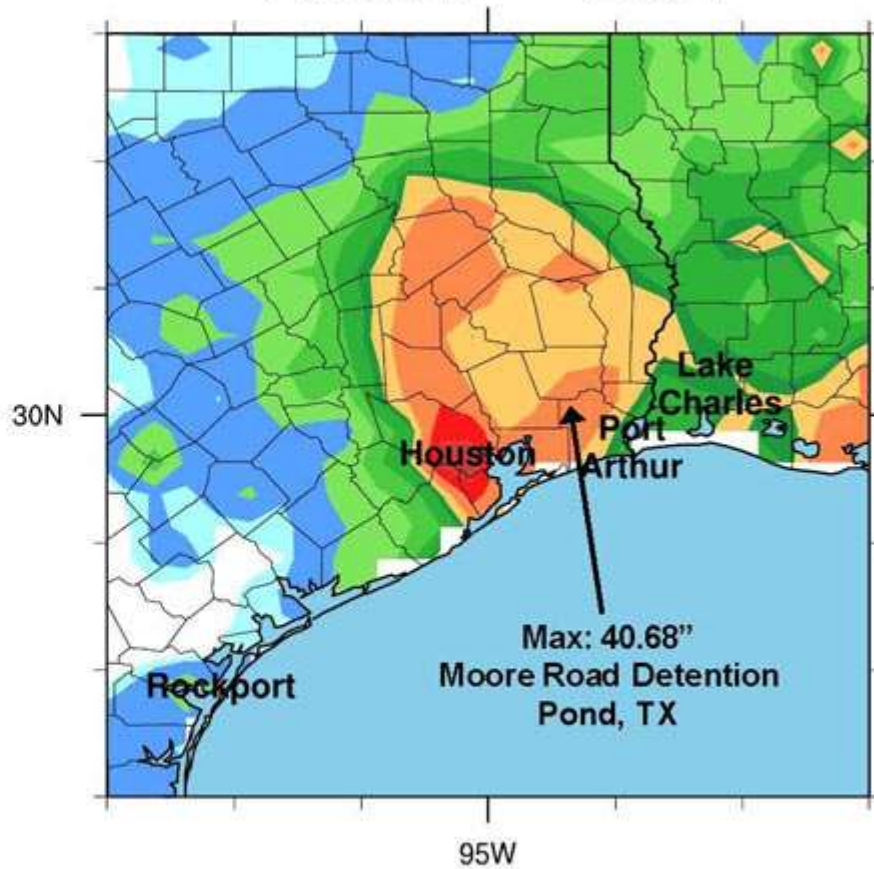
Aug. 24, 7 p.m.: Category 1

Thurs., 7 p.m.: Depression

Harvey – 2017



Allison – 2001



TROPICAL STORM IMELDA SEPT. 17-18, 2019

DEPRESSION STORM HURRICANE CAT. 3+

MADE LANDFALL
SEPT. 17 AT 1PM CDT

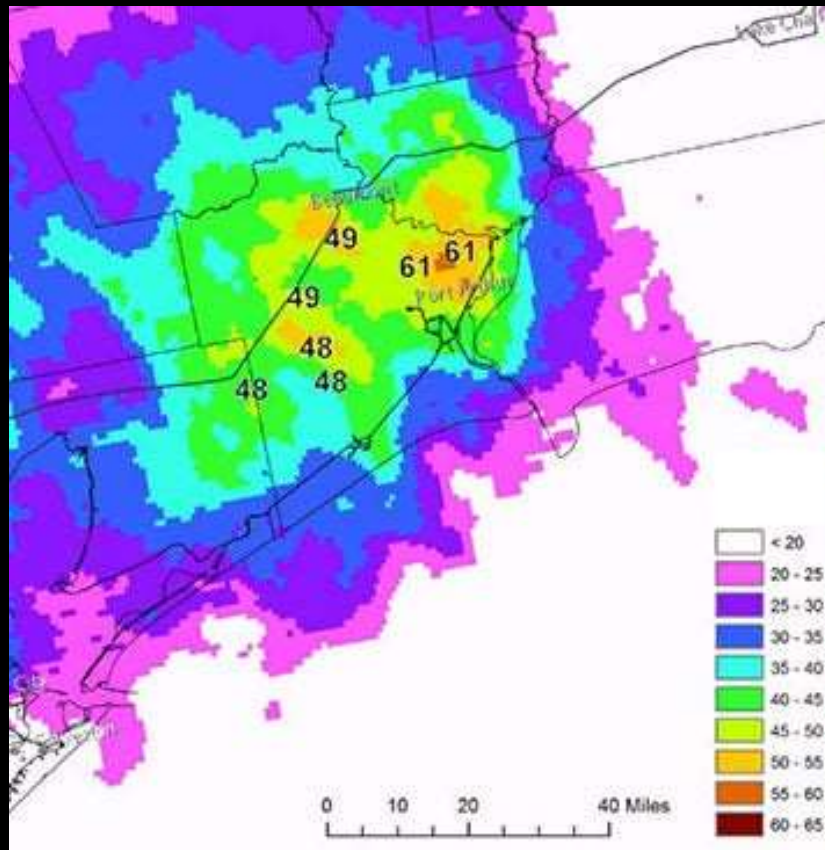
BECAME A TROPICAL STORM
SEPT. 17 AT 12:45PM CDT

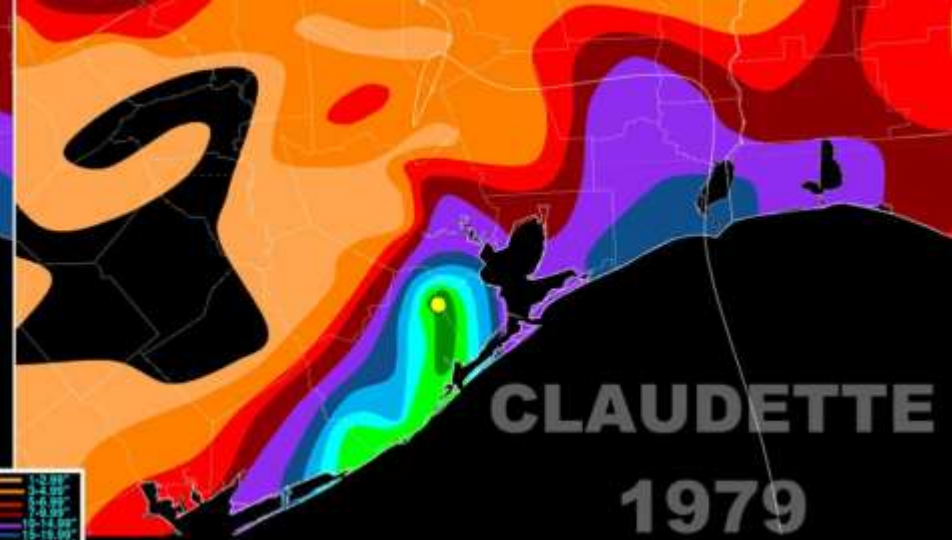
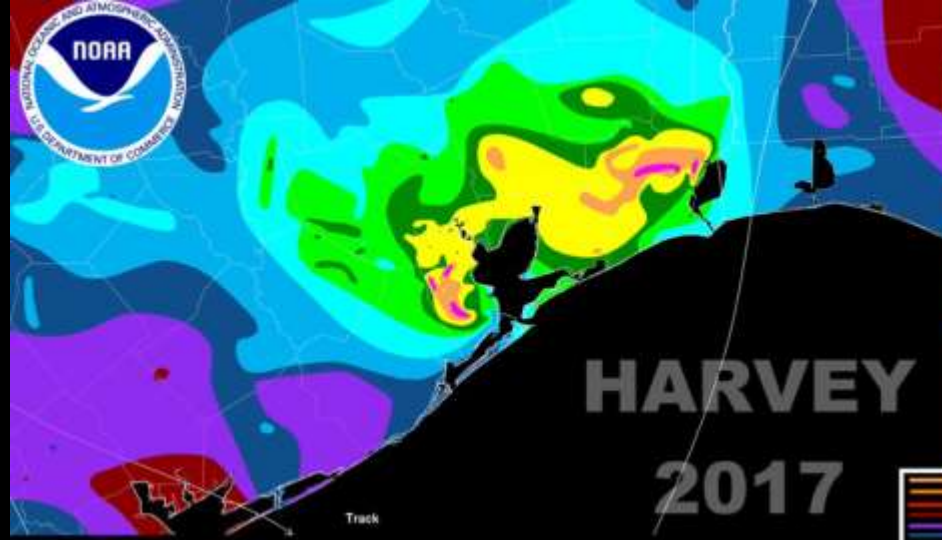
TROPICAL DEPRESSION
FORMED SEPT. 17
AT 12PM CDT

Gulf of Mexico



Tropical Storm Imelda was the 5th wettest tropical cyclone on record in the continental United States with some areas experiencing over 43 inches





IN-DEPTH

FIRST WARNING WEATHER

TEXAS' WETTEST TROPICAL CYCLONES

- 1. HARVEY (2017): 60.58"**
- 2. AMELIA (1978): 48.00"**
- 3. CLAUDETTE (1979): 45.00"**
- 4. IMELDA (2019): 41.81"**
- 5. ALLISON (2001): 40.68"**

DRMS TROPICAL STORMS

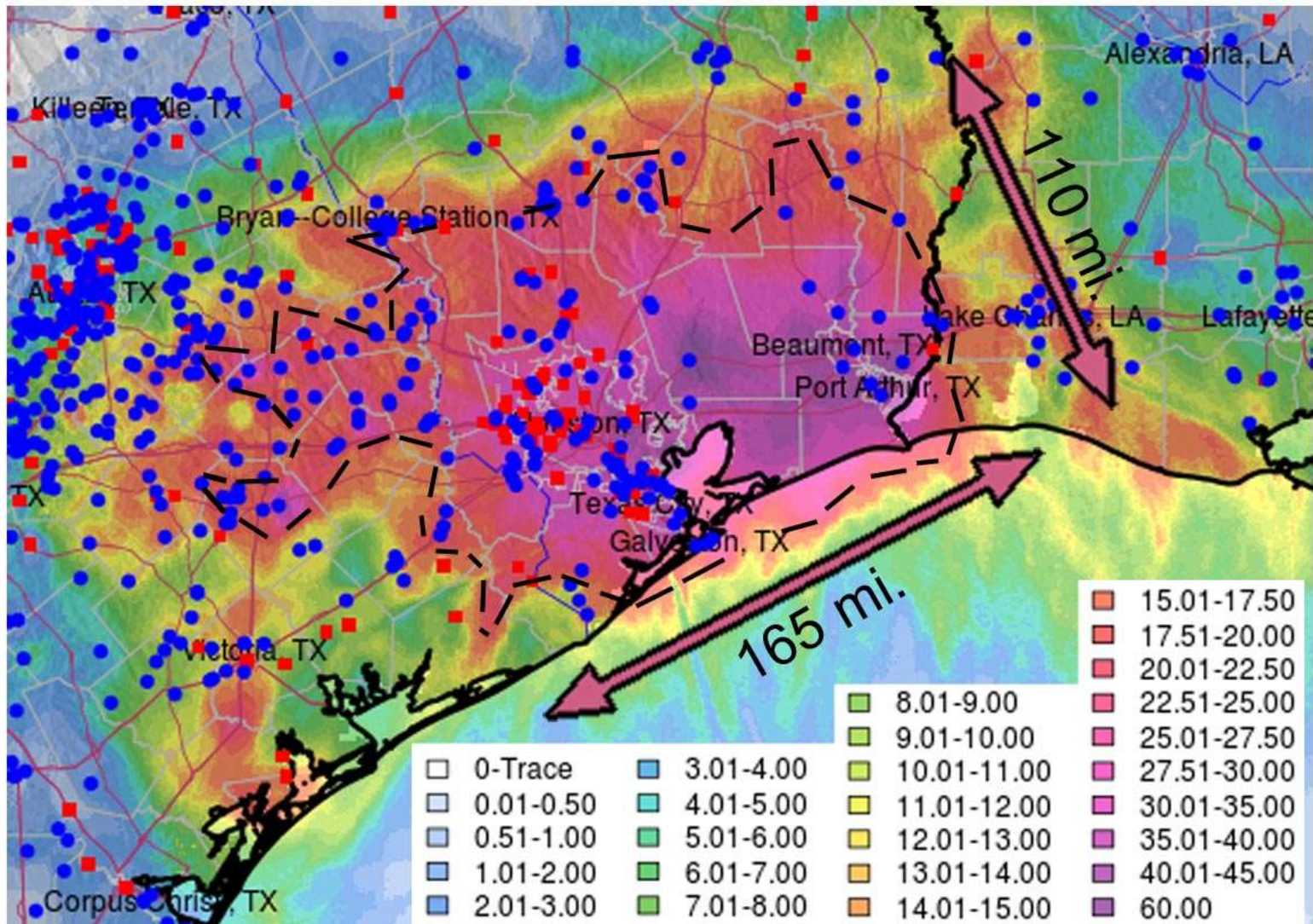
NOAA's Atlas 14: Texas

The 100-year Storm, Now the 25-year Storm

Hurricane Harvey Rainfall

August 25 to August 30, 2017

Dashed line is rainfall in excess of 20 to 27.5 inches



Atlas 14: Texas – The 100-year Storm is Now the 25-year Storm

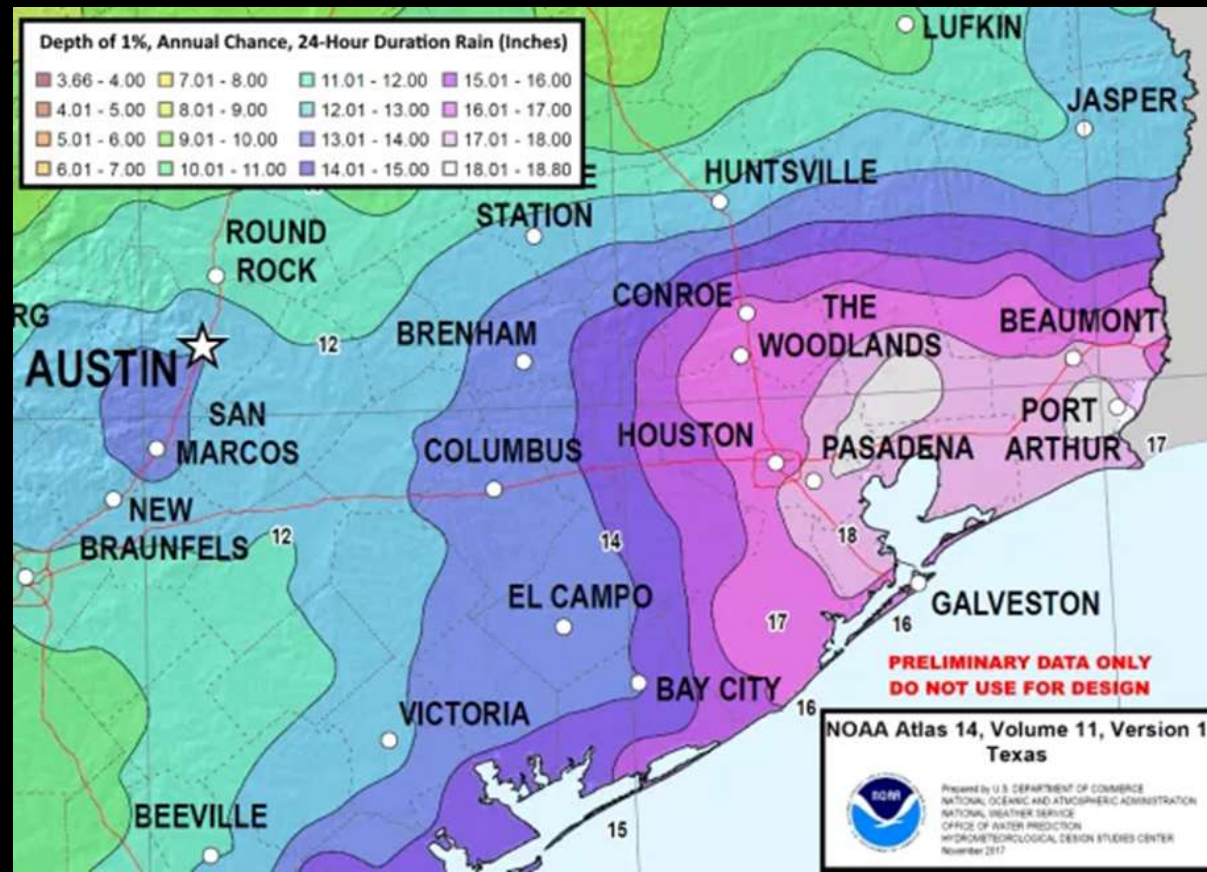
In Houston, the 100-year storm was 12.5 inches in 24 hours.

- The new 25-year storm total is now 12.1 inches.
- The 100-year storm total has increased to 17.9 inches, an increase of 43 percent.

In Austin, the 100-year storm was 10 inches in 24 hours.

- The new 100-year storm rainfall amount for 24 hours is 13 inches.
- The Austin 50-year storm is now 10.6 inches and the 25-year storm is 8.86 inches.

The new values are more accurate than estimates developed 40 to 50 years ago due to decades of additional rainfall data, an increase in the amount of available data, both in the number of stations and their record lengths, and improved methods used in the analysis.



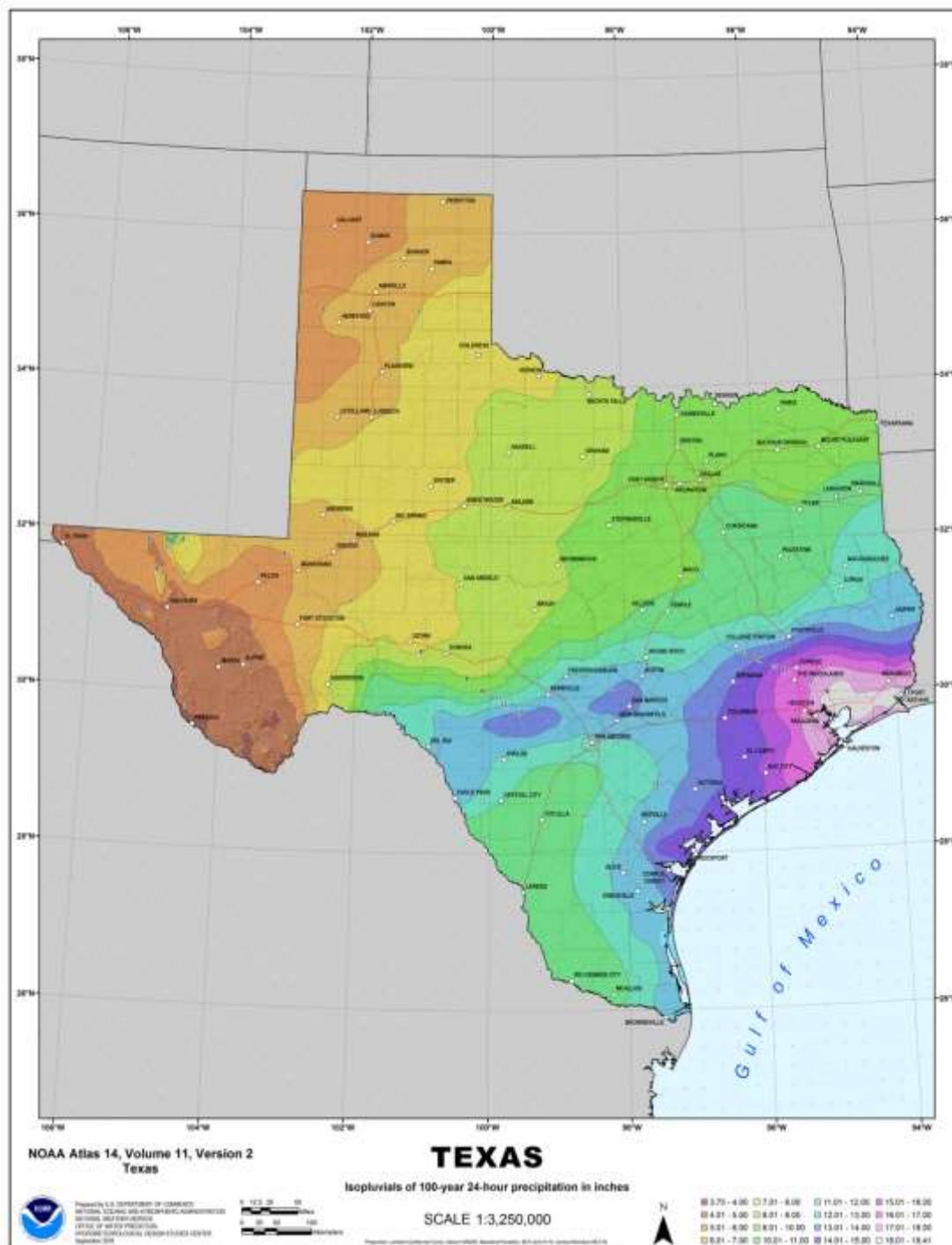
This graphic shows where and how much rainfall has increased for the new NOAA Atlas 14 vs. the old NOAA evaluations from the 20th century. Many areas have remain unchanged, but changes in others have been large. This reflects fairly accurately the general rainfall projections under a warmer climate where inland areas will become drier and coastal areas will become wetter. Only it's happening much ahead of schedule.

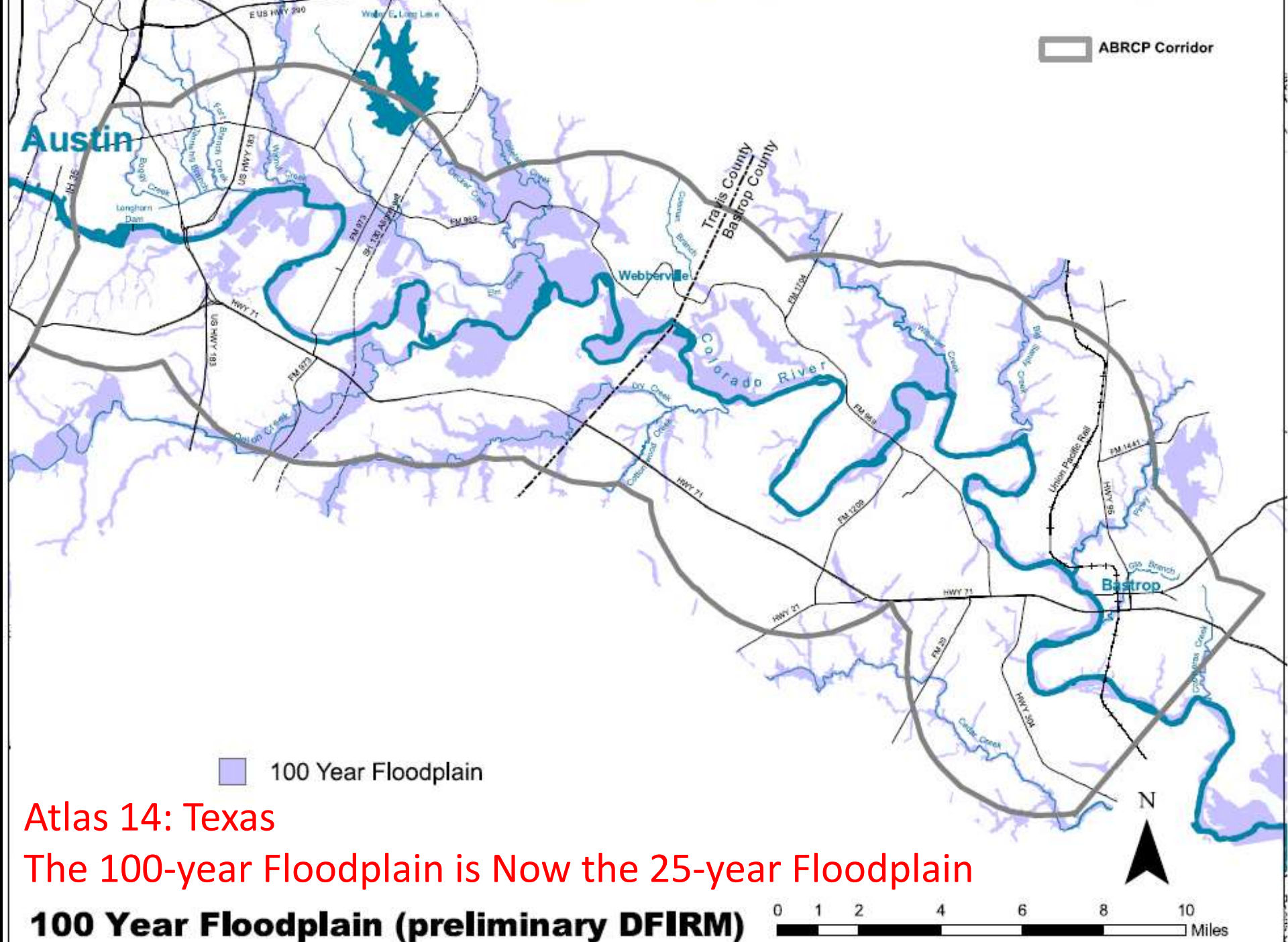


Atlas 14 Impacts

NOAA Atlas 14 rainfall values are used for infrastructure design and planning activities under federal, state and local regulations.

They also help delineate flood risks, manage development in floodplains for FEMA's National Flood Insurance Program and are used to monitor precipitation observations and forecasts that can indicate flooding threats by NOAA's National Weather Service.





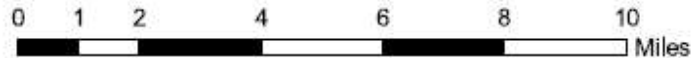
ABRCP Corridor

100 Year Floodplain

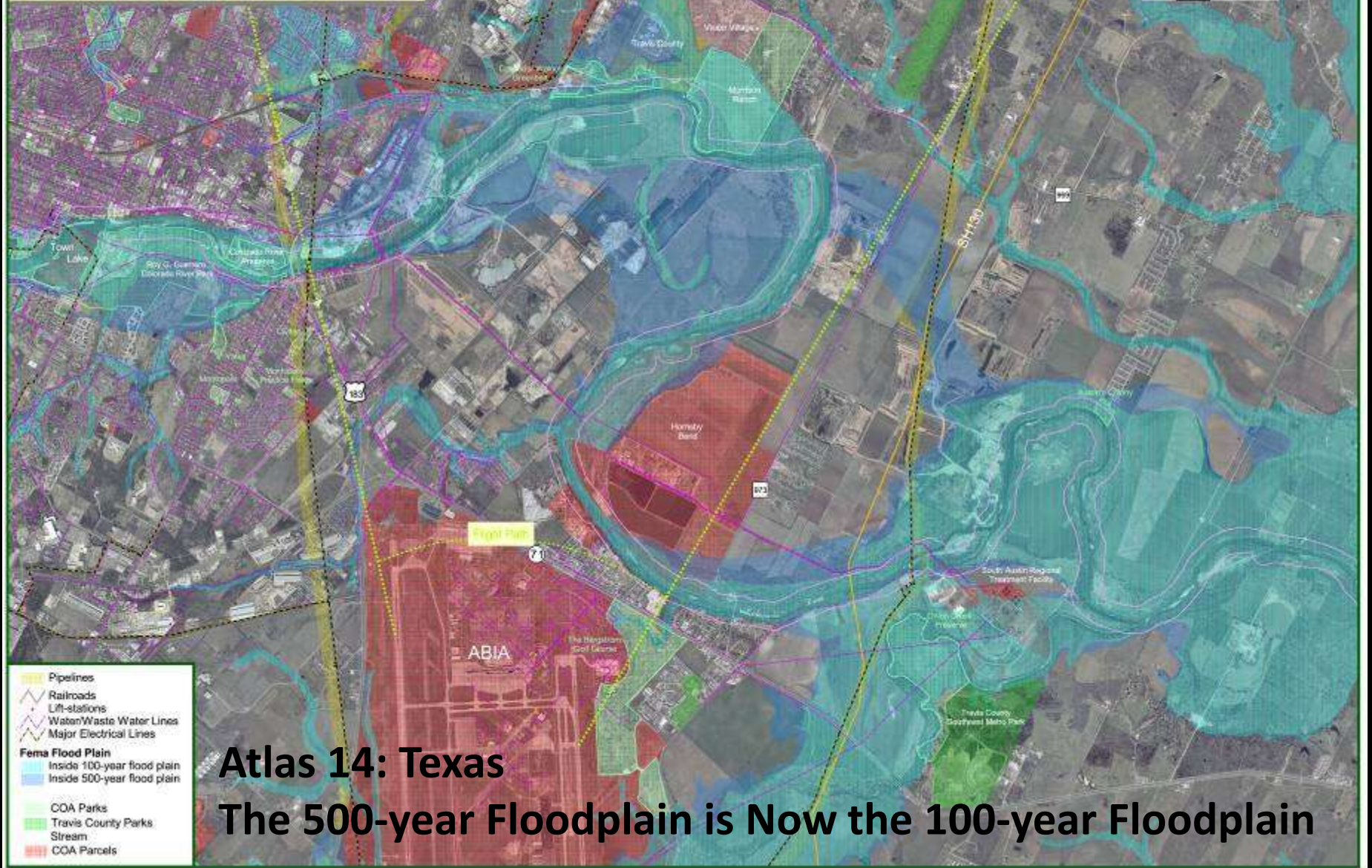
Atlas 14: Texas

The 100-year Floodplain is Now the 25-year Floodplain

100 Year Floodplain (preliminary DFIRM)



*Study Area: Colorado River Corridor:
Longhorn Dam to Onion Creek
Utilities and Floodplain*



Atlas 14: Texas

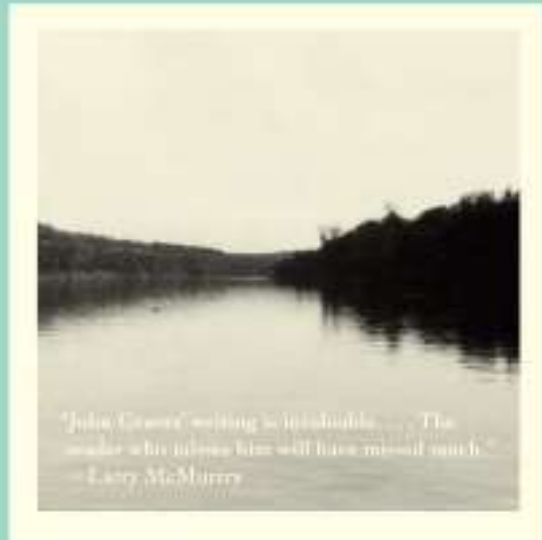
The 500-year Floodplain is Now the 100-year Floodplain

- Pipelines
- Railroads
- Lift-stations
- Water/Waste Water Lines
- Major Electrical Lines
- Fema Flood Plain**
- Inside 100-year flood plain
- Inside 500-year flood plain
- COA Parks
- Travis County Parks
- Stream
- COA Parcels

One More Essential Book about a Texas River

Goodbye to a River

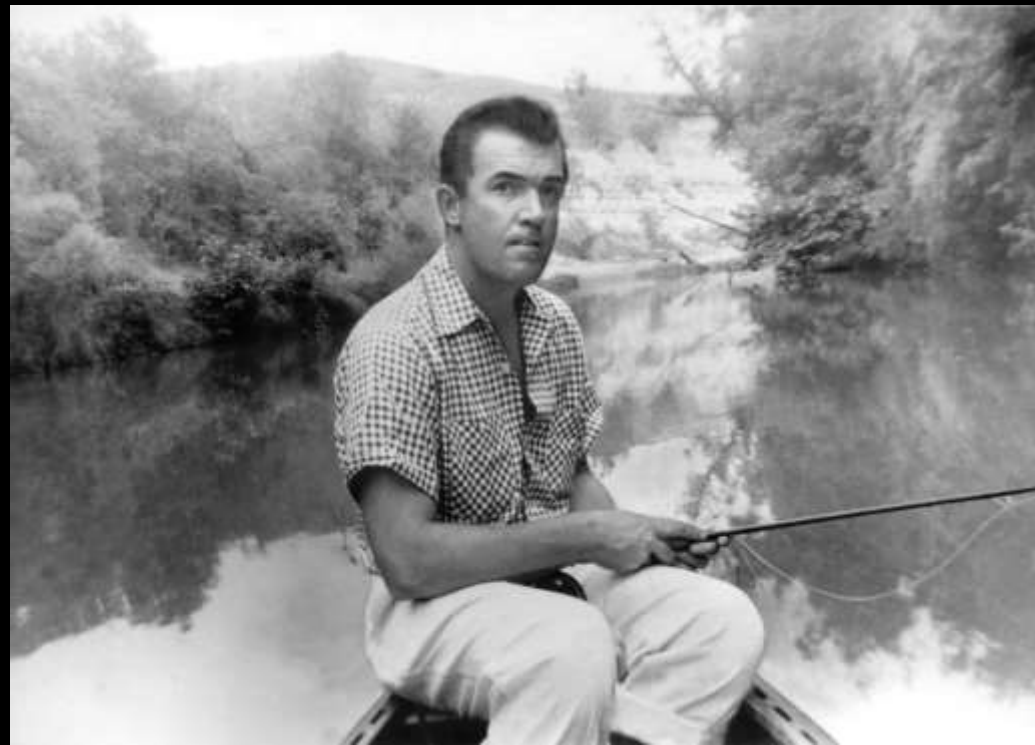
A NARRATIVE



"John Graves' writing is irresistible. . . . The reader who knows him will have missed much."
—Larry McMurtry

JOHN GRAVES

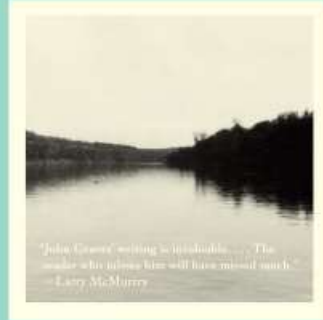
Illustrations by Russell Waterhouse





Goodbye to a River

A NARRATIVE



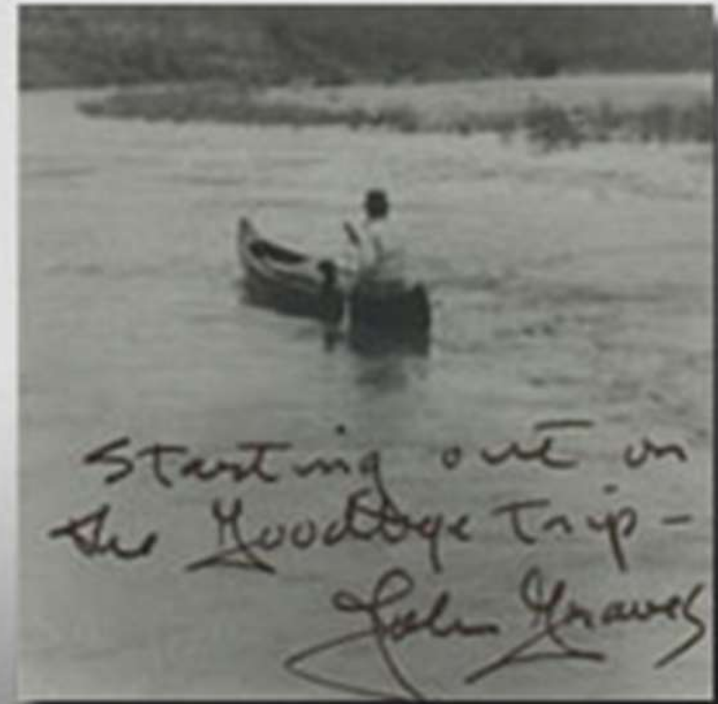
JOHN GRAVES

Illustrations by Russell Waterhouse

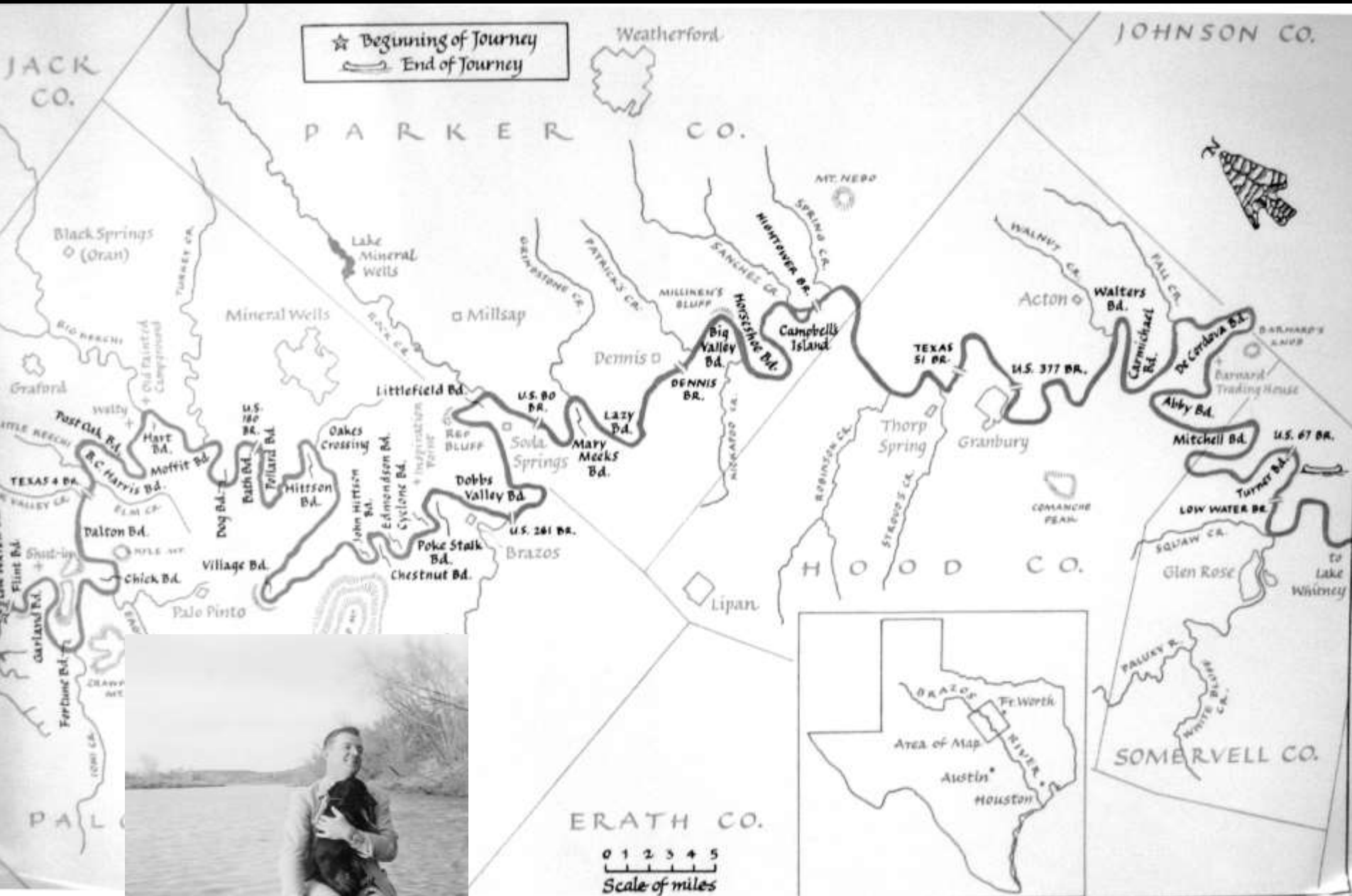
Goodbye to a River (1960)

“One river, seen right, may well be all rivers that flow to the sea...”

John Graves 1920-2013



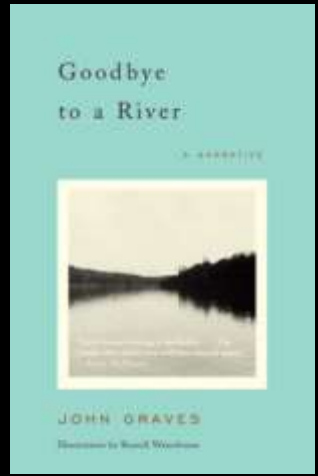
A three week trip down the Brazos River in November 1957



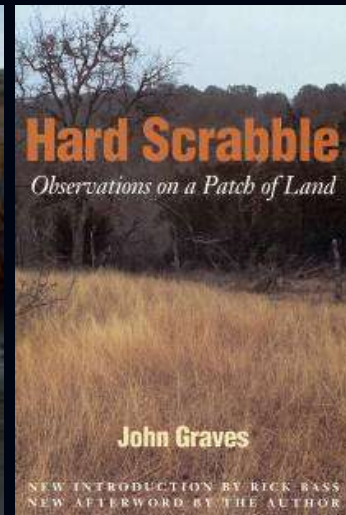
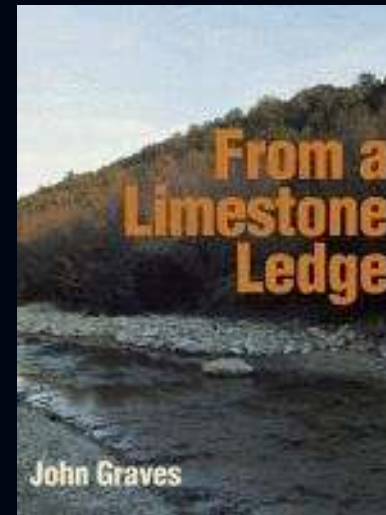
Shadowed Inheritance

“Neither a land nor a people ever starts over clean. Country is compact of all its past disasters and strokes of luck—of flood and drouth, of the caprices of glaciers and sea winds, of misuse and disuse and greed and ignorance and wisdom—and though you may doze away the cedar and coax back bluestem and mesquite grass and side-oats grama, you're not going to manhandle it into anything entirely new.

It's limited by what it has been, by what's happened to it. And a people, until that time when it's uprooted and scattered and so mixed with other peoples that it has in fact perished, is much the same in this as land. It inherits.”



The Legacy - books by John Graves



Hard Scrabble [1974]

From a Limestone Ledge [1980]

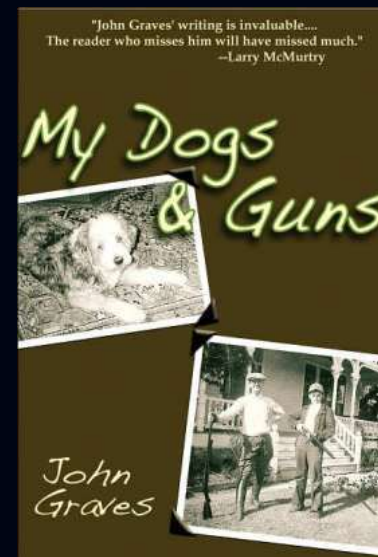
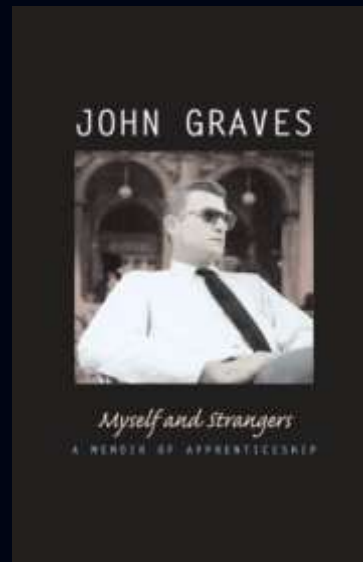
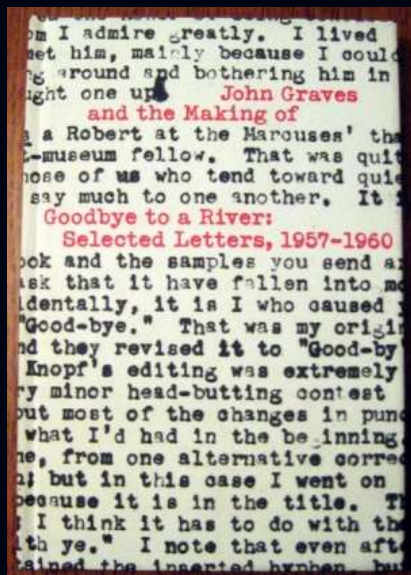
Self Portrait, with Birds [1991]

A John Graves Reader [1996]

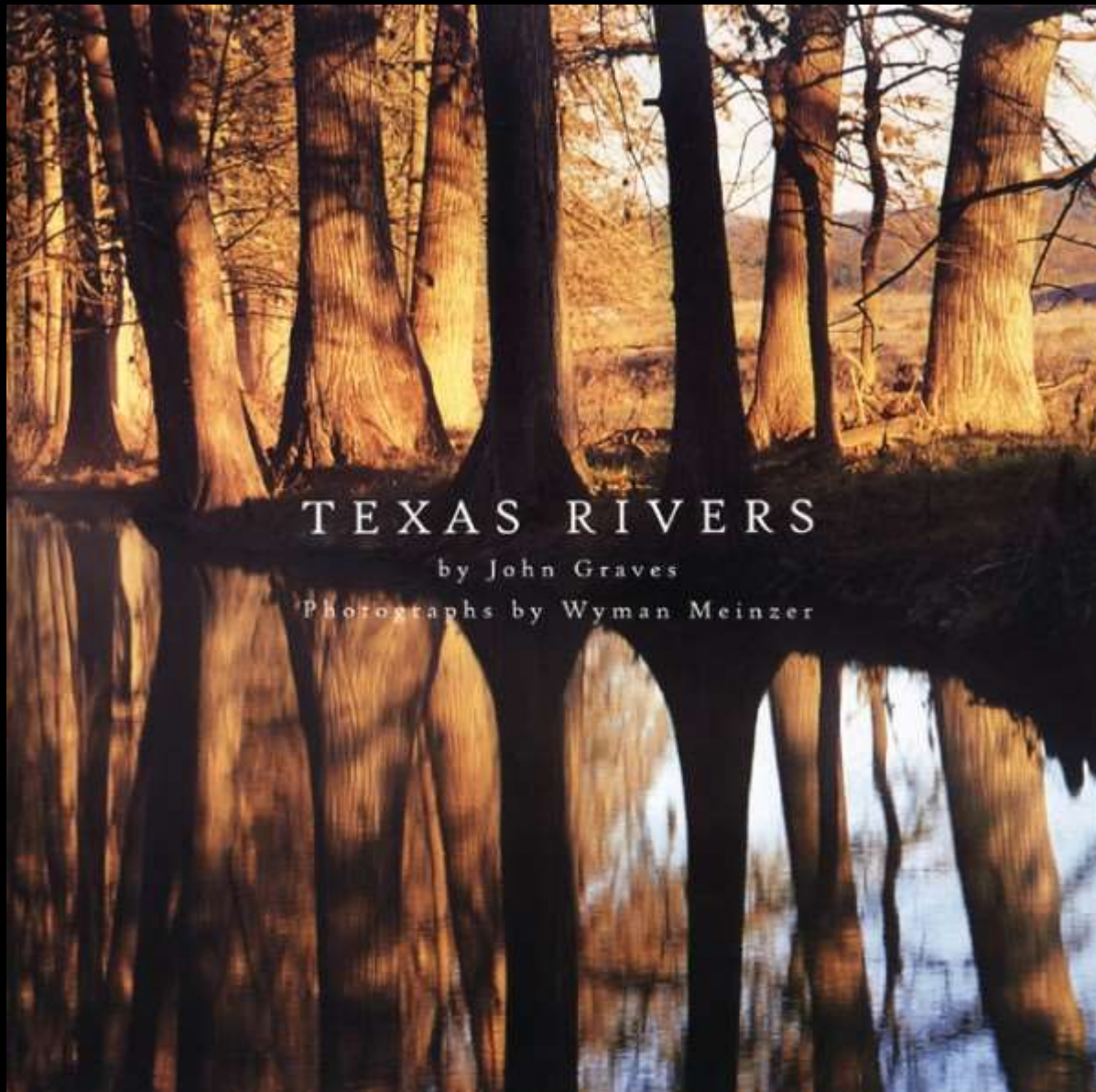
John Graves and the Making of Goodbye to a River [2002]

Myself and Strangers [2004]

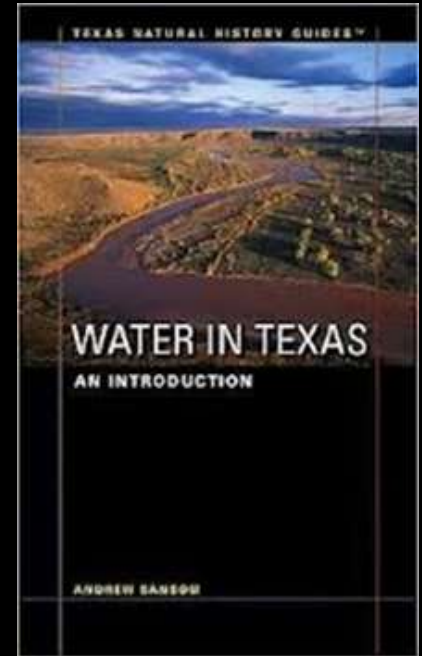
My Dogs and Guns [2007]



2002

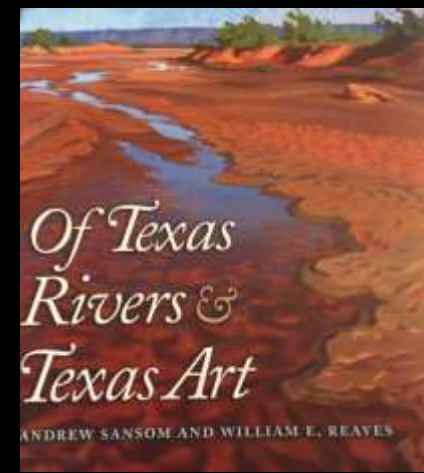
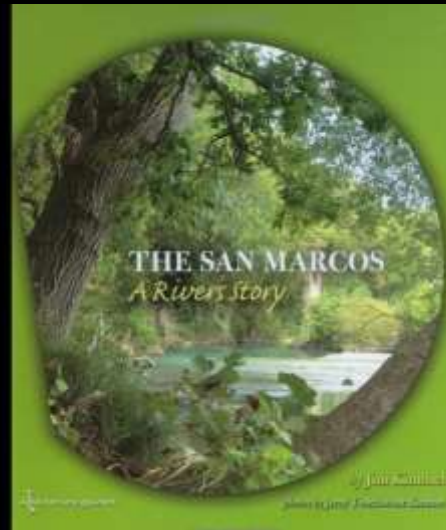
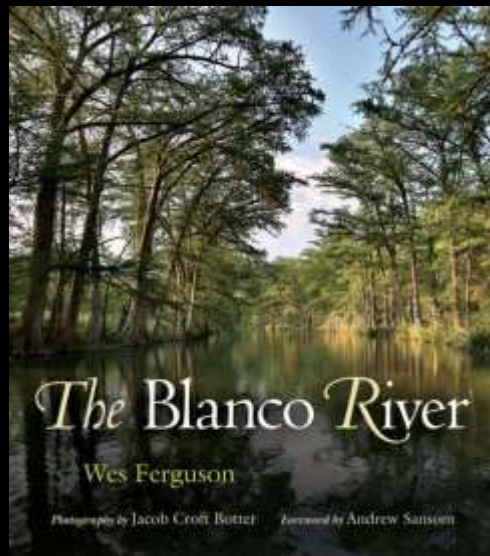
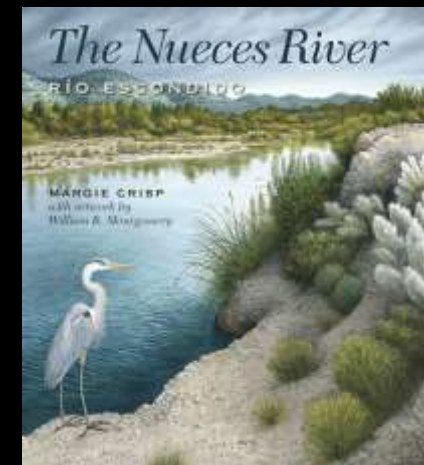
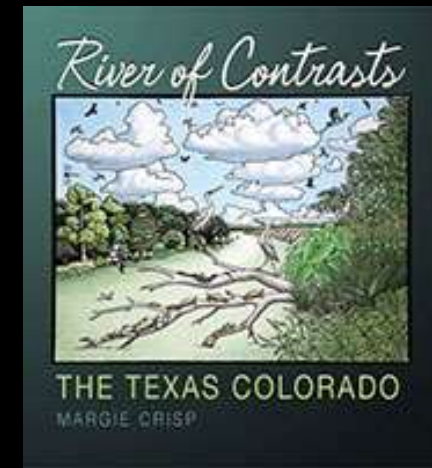
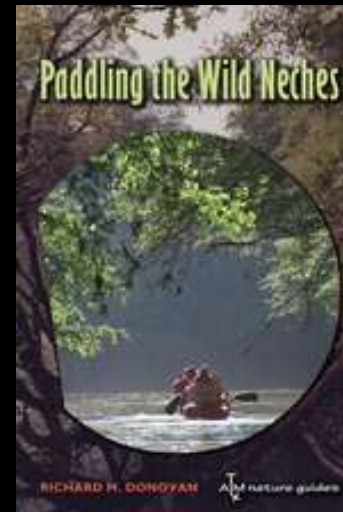
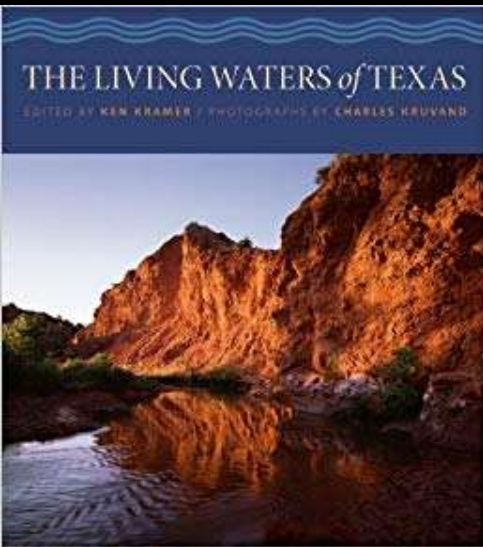


Published by
University of Texas Press



2008

Texas River Books Published by Texas A&M Press



The Real Whole River

“A whole river is mountain country and hill country and flat country and swamp and delta country, is rock bottom and sand bottom and weed bottom and mud bottom, is blue, green, red, clear, brown, wide, narrow, fast, slow, clean, and filthy water, is all kinds of trees and grasses and all the breeds of animals and birds and men that pertain and have ever pertained to its changing shores, is a thousand differing and not compatible things in-between that point where enough of the highland drainlets have trickled together to form it, and the wide, flat, probably desolate place where it discharges itself into the salt of the sea.

It is also an entity, one of the real wholes, but to feel the whole is hard because to know it is harder still.”

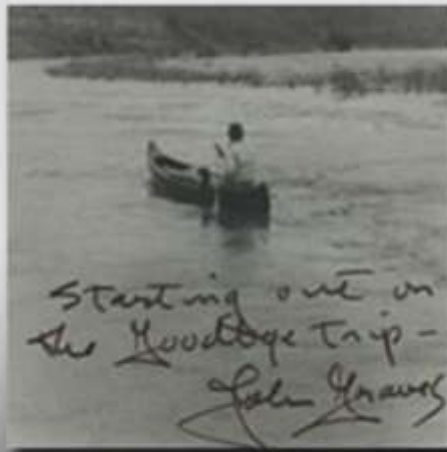
Goodbye to a River

A NARRATIVE



JOHN GRAVES

Illustrations by Russell Warrhouse



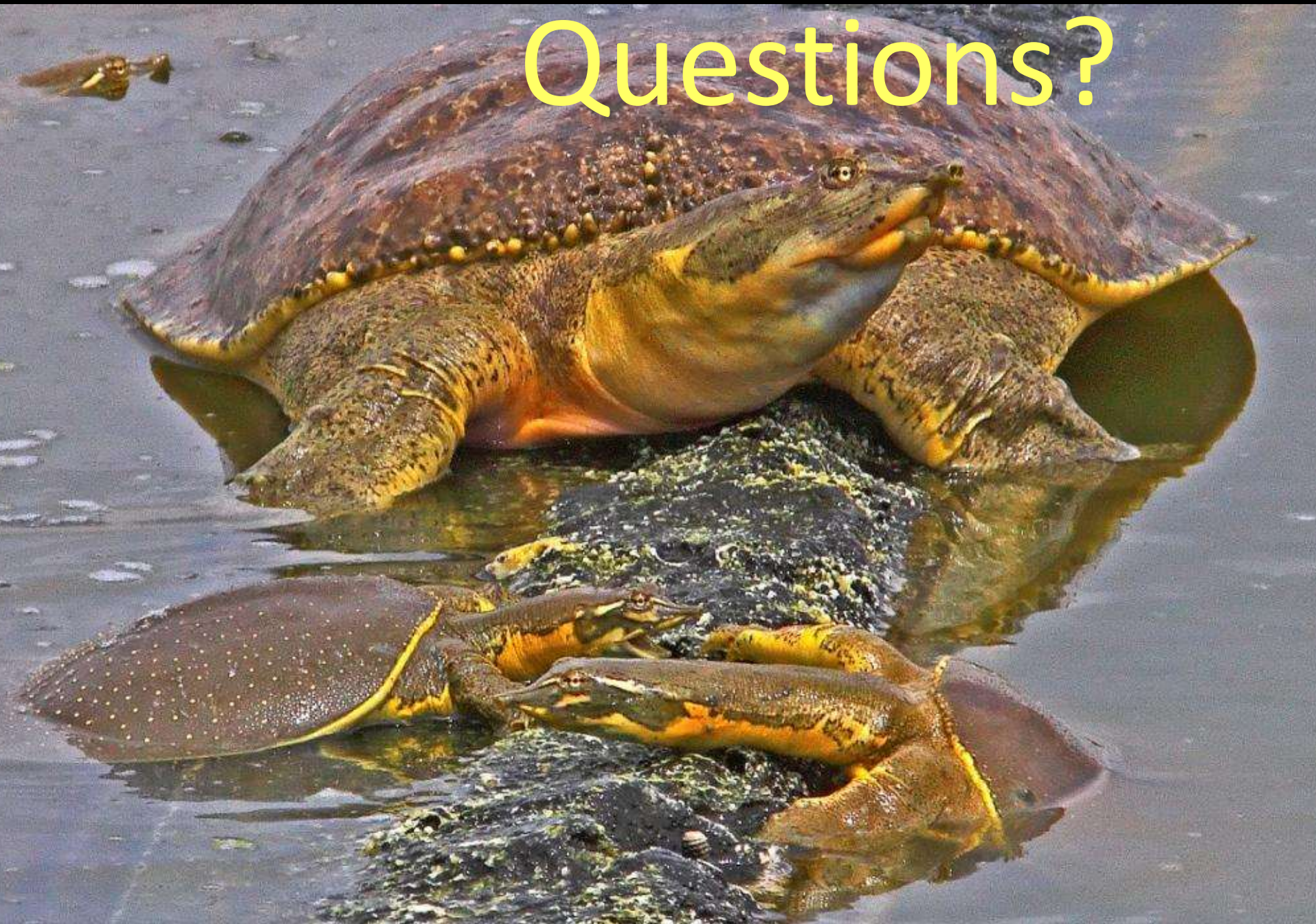
Starting out on
the Hoodoge trip -
John Graves





Applause!

Questions?



Questions?



The Cultural Geography of Flowing Water

September - Rivers of Empire: American Environmental History and Waterways

October - Waters the Land: Rivers and Water in Texas

November - Another Colorado: Austin and the River

December – The Urban Stream: Life on Waller Creek

