Texas Riparian and Stream Ecosystem Training

Funding provided through a Clean Water Act Section 319(h) nonpoint source grant from the Texas State Soil and Water Conservation Board and U.S. Environmental Protection Agency.

Texas Water Resources Institute EM-128 October 2019

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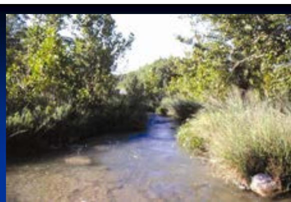

Riparian & Stream Ecosystems

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Texas Water Resources Institute

http://texasriparian.org and
http://www.facebook.com/TexasRiparianAssociation

Funding is provided by the U.S. Environmental Protection Agency through the Texas State Soil and Water Conservation Board.

1

Texas Riparian & Stream Ecosystem Education

- Promote healthy watersheds and improve water quality through riparian and stream ecosystem education
- Increase citizen awareness and understanding of the nature and function of riparian zones, their benefits and management practices to protect them and minimize NPS pollution
- Enhance interactive learning opportunities for riparian education across the state and establish a larger, more informed citizen base working to improve and protect local riparian and stream ecosystems through online tools
- Connect landowners with local technical and financial resources to improve management and promote healthy watersheds and riparian areas

2

Collaborators & Instructors

- Texas Water Resources Institute
- Texas State Soil and Water Conservation Board
- Texas Riparian Association
- Texas A&M Forest Service
- Texas Parks and Wildlife Department
- USDA Natural Resources Conservation Service
- Texas A&M AgriLife Extension Service and Research
- Texas A&M Natural Resources Institute

3

Education

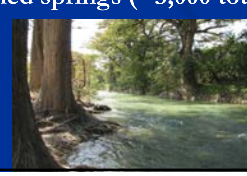
- Deliver 25 riparian education programs to participants in prioritized watersheds, typically watersheds with watershed planning or total maximum daily load efforts due to impaired water quality
- Coordinate 2 statewide riparian conferences: Urban Riparian Symposium, February 2019 in Grapevine and San Marcos in February 2021.

4

Managing for Water is Complicated!

Freshwater Resources

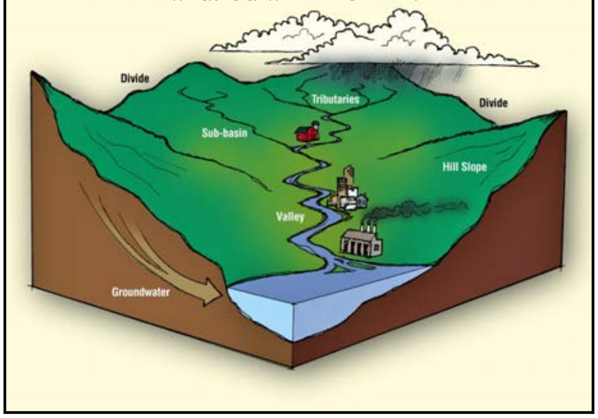
- ~191,000 miles of rivers & streams
  - 20% perennial flow
- >200 major reservoirs ~1.2 million ac.
- 5 million acres of freshwater wetlands
- 9 major aquifers & 21 minor aquifers
- 1,292 named springs (~3,000 total)

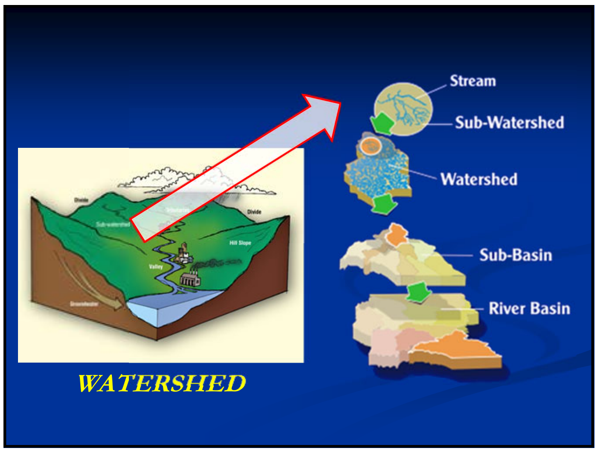


Texas Water Picture

- Population increase from 26 million to 51 million by 2070 *(more than 70%)*
- Water demands are projected to increase from 18.4 to 21.6 million af/yr
- Existing Water Supplies are expected to decline 11%, from 15.2 to 13.6 million
- Potential shortage of 4.8 maf in 2020 to 8.9 maf per year in 2070.
- Total Capital Costs for all 2017 recommended strategies $62.6 Billion
- Estimated economic losses resulting from water shortages are estimated at $73 Billion in 2020 and to $151 Billion in 2070.

What is a WATERSHED?





Texas Rivers

Watershed

A Watershed can be characterized as consisting of:

- Upland
- Riparian zone and
- stream system

Each watershed functions as an ecosystem, i.e., each component affects the rest of the system including the benefits or negative impacts. As water flows through the system the impacts are cumulative.

What is a Riparian Area?

Characteristics of a Healthy Upland Watershed

A Healthy Watershed is a catchment, i.e., rainfall is captured on-site. It acts as a sponge storing water to later release.

"High" infiltration rates due to good vegetation cover and soil organic matter/structure and depth.

Water flowing from the uplands as runoff & subsurface flow to springs and aquifers is "clean" and is slowly released down slope.

Unhealthy Watersheds?

Most streams and rivers in Texas have been adversely affected by past natural and human activities resulting in:

- Increasingly damaging floods
- Lower base flows
- High sediment loads
- Reduced reservoir storage capacity
- Invasion of exotic species
- Loss of natural riparian habitats
- Degraded water quality

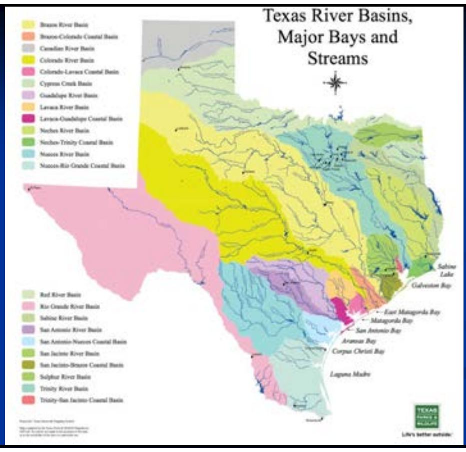
Properly Functioning Riparian Area

Adequate vegetation, landform or large woody material to:

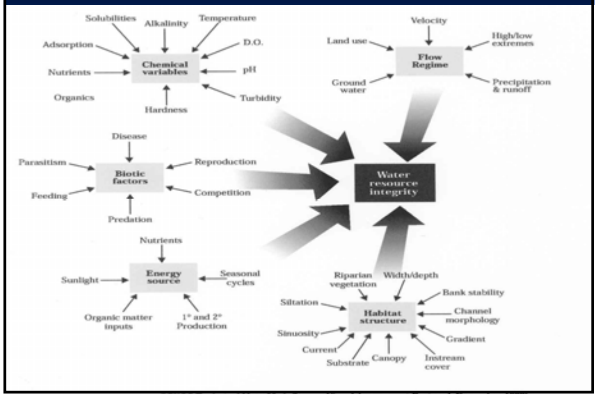
- Dissipate stream energy
- Stabilize banks
- Reduce erosion
- Trap sediment
- Build / enlarge floodplain
- Store water
- Floodwater retention
- Groundwater recharge
- Sustain baseflow

- Water quality
- Water quantity
- Forage
- Aquatic habitat
- Wildlife habitat
- Recreational value
- Aesthetic beauty

Physical Function → Values

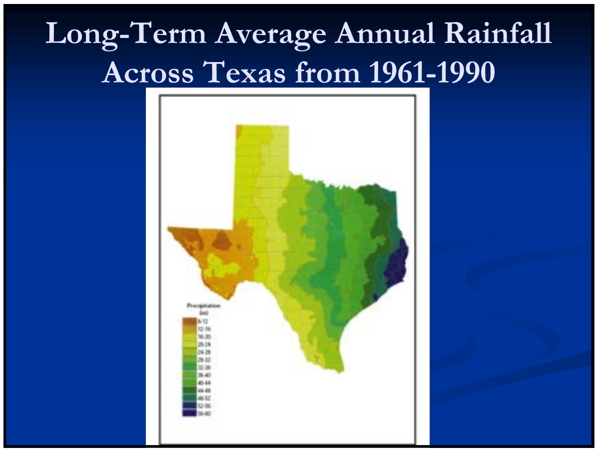


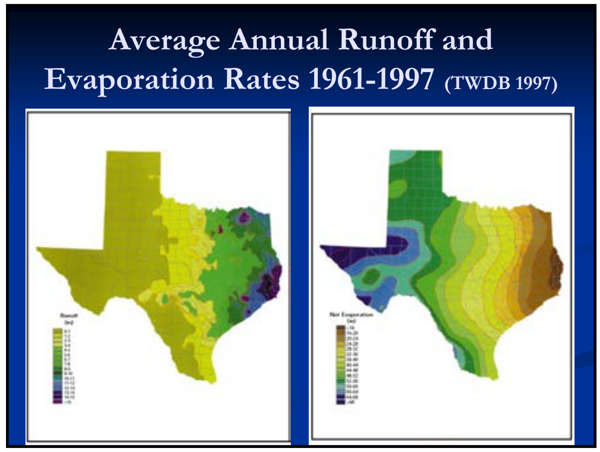
Watersheds are Complex Systems

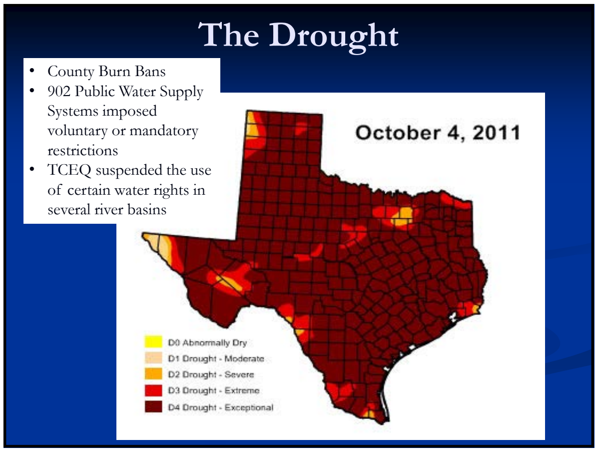


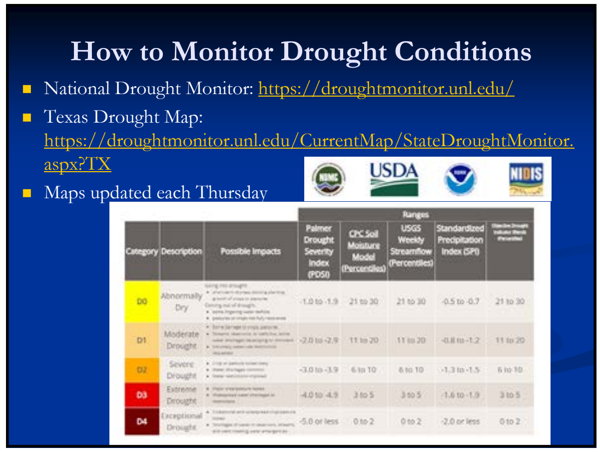
Watershed form is influenced by:

1. Climate
2. Geology & Soils
3. Topography
4. Vegetation
5. Land Uses

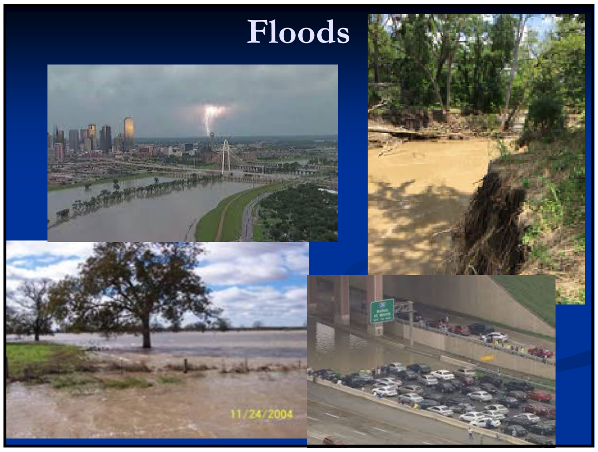


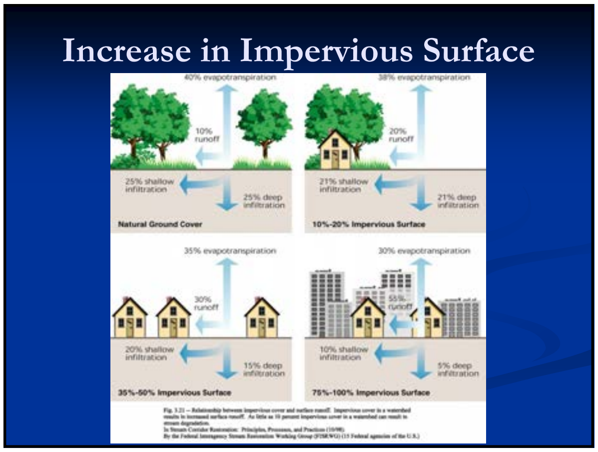


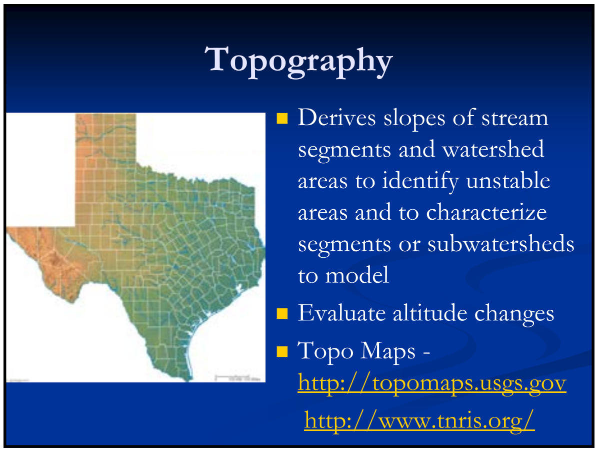


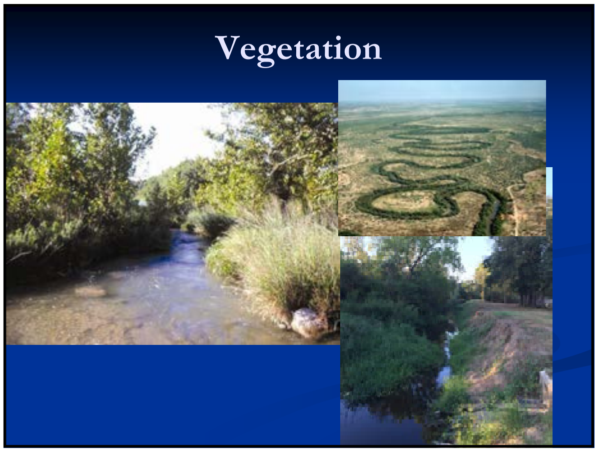


Category	Description	Possible Impacts	Ranges: Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	[illegible]
D0	Abnormally Dry	[illegible]	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	[illegible]	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	[illegible]	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	[illegible]	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	[illegible]	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2




Increase in Impervious Surface
40% evapotranspiration
10% runoff
25% shallow infiltration
25% deep infiltration
Natural Ground Cover
38% evapotranspiration
20% runoff
21% shallow infiltration
21% deep infiltration
10%-20% Impervious Surface
35% evapotranspiration
30% runoff
20% shallow infiltration
15% deep infiltration
35%-50% Impervious Surface
30% evapotranspiration
55% runoff
10% shallow infiltration
5% deep infiltration
75%-100% Impervious Surface

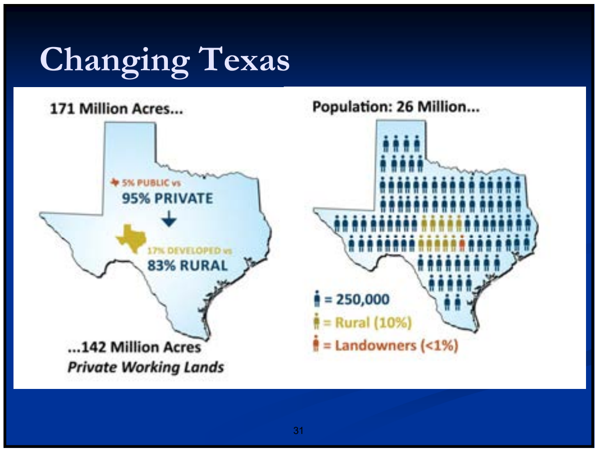

Topography
Derives slopes of stream segments and watershed areas to identify unstable areas and to characterize segments or subwatersheds to model
Evaluate altitude changes
Topo Maps -
http://topomaps.usgs.gov
http://www.tnris.org/

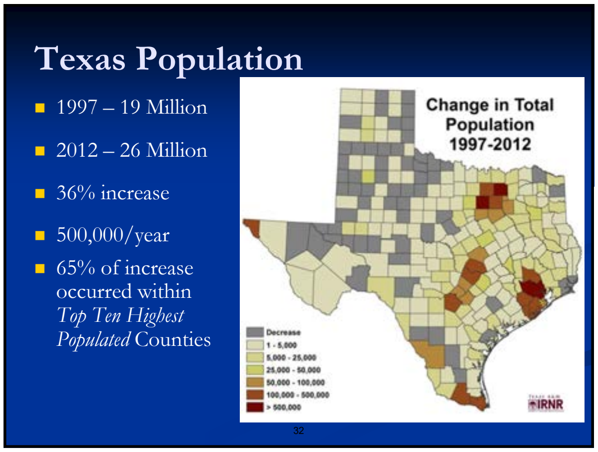

Vegetation

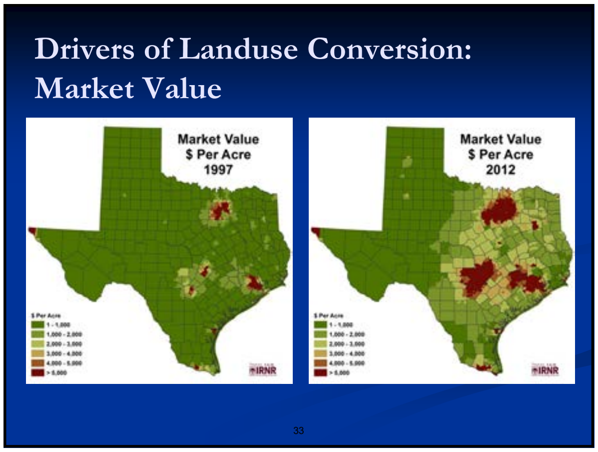

Water Catchment
Water Shed

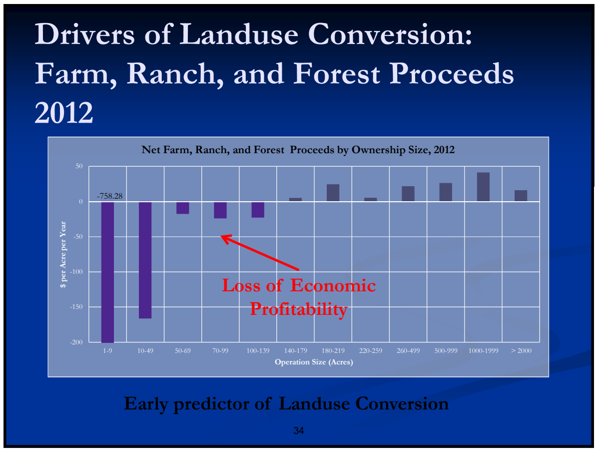

Water Catchment
Water Shed

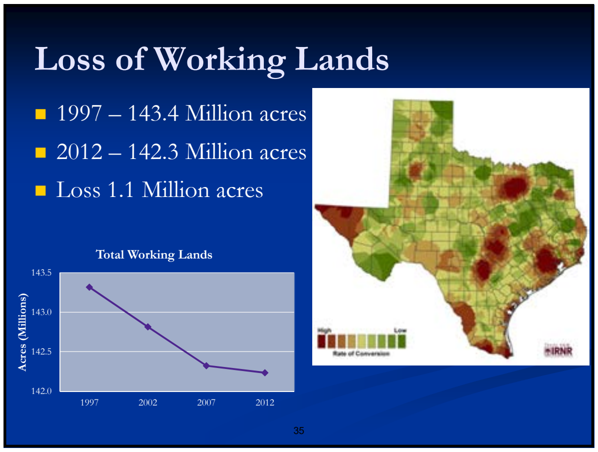

Land Uses: We Live and Work in a Watershed

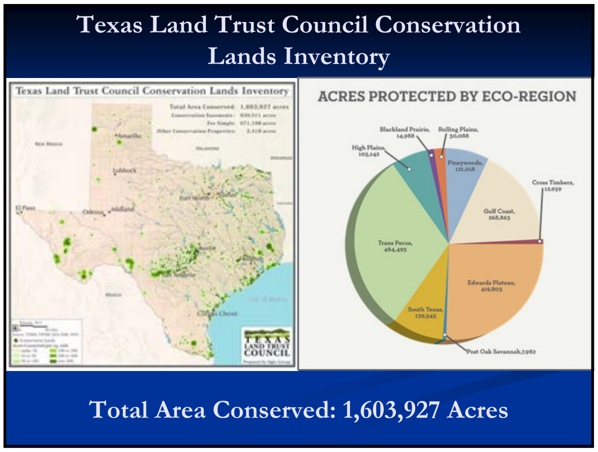

Changing Texas
171 Million Acres...
5% PUBLIC vs
95% PRIVATE
17% DEVELOPED vs
83% RURAL
...142 Million Acres
Private Working Lands
Population: 26 Million...
= 250,000
= Rural (10%)
= Landowners (<1%)
31


Texas Population
1997 – 19 Million
2012 – 26 Million
36% increase
500,000/year
65% of increase occurred within *Top Ten Highest Populated* Counties
Change in Total Population 1997-2012
Decrease
1 - 5,000
5,000 - 25,000
25,000 - 50,000
50,000 - 100,000
100,000 - 500,000
> 500,000
IRNR
32


Drivers of Landuse Conversion: Market Value
Market Value
$ Per Acre
1997
Market Value
$ Per Acre
2012
IRNR
33


Drivers of Landuse Conversion: Farm, Ranch, and Forest Proceeds 2012
Net Farm, Ranch, and Forest Proceeds by Ownership Size, 2012
$ per Acre per Year
-758.28
Loss of Economic Profitability
Operation Size (Acres)
Early predictor of Landuse Conversion
34


Loss of Working Lands
1997 – 143.4 Million acres
2012 – 142.3 Million acres
Loss 1.1 Million acres
Total Working Lands
Acres (Millions)
143.5
143.0
142.5
142.0
1997
2002
2007
2012
High
Low
Rate of Conversion
IRNR
35

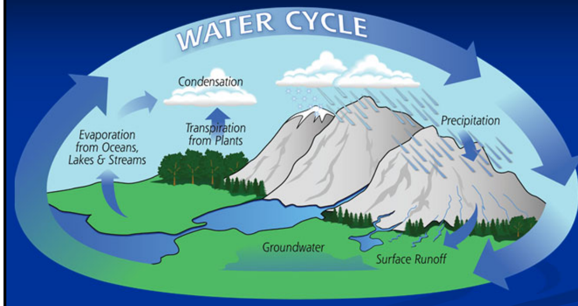

Texas Land Trust Council Conservation Lands Inventory
Texas Land Trust Council Conservation Lands Inventory
ACRES PROTECTED BY ECO-REGION
Total Area Conserved: 1,603,927 Acres

Rain is Precious: Factors Affecting the Fate of Rainfall

Many factors determine what happens to the rainfall received. Some of the primary factors include:

- type, quantity, and density of vegetative cover;
- storm intensity and duration;
- soil moisture prior to the storm event;
- soil water holding capacity;
- and slope.

These factors affect how much evaporates, infiltrates, moves through vegetation, and the amount and velocity of overland flow which may erode the soil surface and enter the stream.



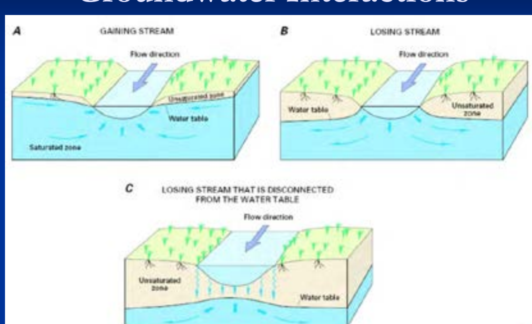
Main Sources of Water in Texas: Surface Water

- Surface Water: streams, rivers, and lakes
- Publically owned
- Requires a permit from state agency for use of surface water

Main Sources of Water in Texas: Groundwater

- Groundwater: Water that is stored underground in aquifers.
- Considered private property in Texas
- Landowners have rights to water under their property and can use the groundwater within the rules of a local groundwater district, if one is established.
- Landowner is responsible for managing water from private wells.

Basic Types of Surface & Groundwater Interactions



Public vs. Private Water Supplies

- SDWA requires public supplies to meet standards
- NO federal regulations for private water supplies
  - 6% of Texans rely on private wells for drinking water
  - TCEQ maintains list of labs that test drinking water samples

Reduce the risk of well contamination

- If well water is shallow and in a floodplain pollutants from the stream can enter and contaminant your well.
- To reduce the risk:
  - Understand the interaction between the stream and well water
  - Monitor conditions of both stream and well water
  - Take action when needed

Why should we be concerned about the health of the stream and riparian areas?

- **Cumulative impacts of natural and man induced disturbances in the drainage area.**
- **Management not only affects the individual landowner but everyone else downstream.**
- **Stream and riparian systems are the water pipeline.**
- **They are one of the most important resources found on private and public lands in Texas.**

Creeks and Riparian Areas are Important

- Texas has more than 191,000 miles of rivers and streams with riparian zones and floodplains that comprise corridors of great economic, social, cultural, and environmental value.
- The 2016 Texas Integrated report assessed 1,453 water bodies that had sufficient data for evaluations with 7-10 yrs.
- 2016 303d List has **574** impaired water bodies on it (-15).
- Many WPP and TMDL Implementation projects are ongoing across the state to improve WQ in watersheds.
- Bacteria is the cause for over 39% of impairments followed by and low dissolved oxygen (nutrients) for 17% and organics in fish tissue at 19%.

Designated Uses

Aquatic Life
- Protect aquatic species
- Dissolved Oxygen, Toxic Chemicals, Total Dissolved Solids

Recreation
- Estimates the relative risk of swimming and other water recreation activities
- Bacteria

Drinking Water
- Indicates if water is suitable as a source of drinking water
- Metals, Pesticides, Toxic Chemicals, Total Dissolved Solids, Nitrates

Fish Consumption
- Protect public from consuming fish that may be contaminated
- Metals, Pesticides, Other Toxic Chemicals

Surface Water Quality

Numeric
- High Aquatic Life Use
  - Dissolved Oxygen – 5.0 mg/L (4-5 stressed <3 can't survive)
  - pH – Optimum Range 6.5-9.0
  - Temperature – 90 F (32.2 C) common range 68-86 F
  - Total Dissolved Solids – *396 mg/L
  - Sulfate – *48 mg/L
  - Chloride - *70 mg/L

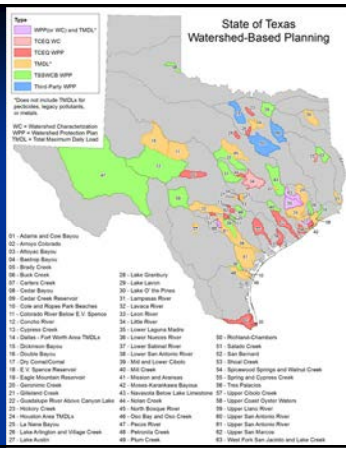
* Specific criteria for segment

Screening Criteria
- Nitrite and Nitrate Nitrogen – 1.95 mg/L
- Phosphorus – 0.69 mg/L
- Ammonia
- Chlorophyll *a* (algae)

Numeric Criteria of bacteria for designated uses of water bodies.

Parameter (indicator organism)	Use	Numeric Criteria (geometric mean)[a b]	Numeric Criteria (single sample max)[a]
E. coli (Freshwater)	Primary Contact Recreation	126	N/A
	Secondary Contact Recreation I	630	N/A
	Secondary Contact Recreation II	1,030	N/A
	Noncontact Recreation	2,060	N/A
Enterococci (Marine Waters)	Primary Contact Recreation	35	89
	Secondary Contact Recreation I	175	N/A
	Noncontact Recreation	350	N/A
Fecal Coliform (Highly Saline Waters)[c]	Contact Recreation	200	400
	Secondary Contact Recreation I & II	1,000	N/A
	Noncontact Recreation	2,000	N/A
Fecal Coliform	Oyster Harvesting Waters	14[b]	N/A

[a]All values are in colony forming units per 100 ml
[b]The standard for Fecal Coliform in Oyster Harvesting Waters is based on the median sample number, not the geometric mean
[c]Fecal Coliform is no longer used for contact recreation except in high salinity waters

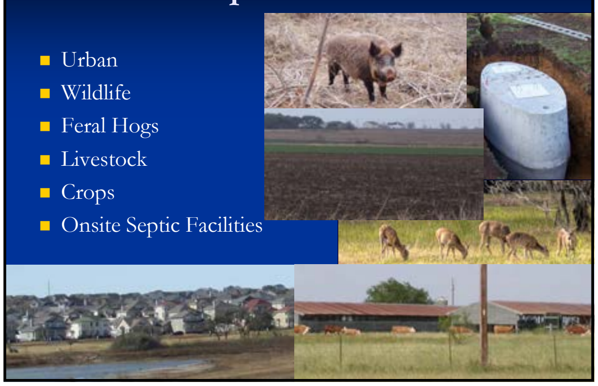


Point Source Pollutant Sources

- Point Source
  - Permitted Discharges
    - Wastewater Treatment Plants
    - Industrial Facilities
    - Confined Animal Feeding Operation
- Stormwater Permit

Nonpoint Sources

- Urban
- Wildlife
- Feral Hogs
- Livestock
- Crops
- Onsite Septic Facilities



- Creeks / Riparian Areas are special places that need preferential management and all landowners are also water managers.
- To manage or restore creeks you must understand them and then address the issues that may be inhibiting natural restoration.

Executive Summary
2016 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)
(August 6, 2019)

Background

The Texas Commission on Environmental Quality (TCEQ) in keeping with its mission to protect the state's natural resources regularly monitors the condition of the state's surface waters and assesses water quality. The *Texas Integrated Report for Clean Water Act, Sections 305(b) and 303(d)* is a statewide report on the status of state surface waters and is prepared and submitted to the U.S. Environmental Protection Agency (EPA) every two years. The report is also published on the TCEQ Web site.

The report describes the condition of the surface water bodies of the state that were evaluated for the given assessment period. The data are gathered by many different organizations that all operate according to approved quality assurance guidelines and sample collection procedures. The quality of waters described in the Integrated Report represents a periodic snapshot of conditions over 7-10 years.

Requirements for the Integrated Report are codified in the Federal Clean Water Act, Sections 305(b) and 303(d). Further requirements are set out in state law in Chapter 26 of the Texas Water Code, Title 30 of the Texas Administrative Code (30 TAC), and guidance established by the TCEQ.

The guidance used to prepare the Integrated Report is based on a set of methods that apply the Texas Surface Water Quality Standards (30 TAC §307) to ambient water quality data. These methods are developed by the TCEQ with the advice of a diverse group of stakeholders, and are detailed in the *Guidance for Assessing and Reporting Surface Water Quality in Texas*.

TCEQ will accept public comment on the 2016 Integrated Report from May 4th, 2018 through June 5th, 2018. Following review of the documentation, the Commission adopts the draft report and submits the information to EPA for approval. Summaries of the comments and the TCEQ's responses will be included with the submittal of the Integrated Report and available on the Agency's website.

Focus for the 2016 Assessment

The TCEQ has prepared a comprehensive assessment in 2016 by evaluating 1,453 water bodies (1,071 of these water bodies had sufficient data to provide an evaluation of the use attainment status). The Commission relied on cooperators such as, local, state, or federal agencies, and water program staff who provided additional information for this assessment. The TCEQ included data collected during the most recent seven-year period (December 1, 2007 to November 30, 2014). If needed, up to ten years of data were included to attain a minimum number of samples for assessment.

Categories Indicate Water Quality Status

The Integrated Report describes the water quality status of Texas surface water management strategies to the public, EPA, and internal agency programs. The five-part categorization of waters (see table below) is an important tool for water quality management throughout the State. Within this framework, higher category numbers correspond to the increased levels of effort required to manage water quality.

Water bodies in Category 1 are meeting all their uses, and simply require routine monitoring and preventive action. Water bodies identified in Category 5, called the 303(d) List, represent situations where water quality criteria are not attained and water quality management actions are needed to address the issue. Alternatively, these could also represent situations where water quality standards revisions may be needed in a specific area to better reflect ambient water quality conditions.

Categories included in the Texas Integrated Report

Category	Definition
1	Attaining the water quality standard and no use is threatened.
2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information are available to determine if the remaining uses are attained or threatened.
3	Insufficient or no data and information to determine if any designated use is attained. Many of these water bodies are intermittent streams and small reservoirs.
4	Standard is not supported or is threatened for one or more designated uses but does not require the development of a Total Maximum Daily Load (TMDL). All TMDLs have been completed and approved by EPA. Other control requirements are reasonably expected to result in the attainment of all standards. Nonattainment is shown to be **caused by pollution**, not by pollutants and that the water quality conditions cannot be changed by the allocation and control of pollutants through the TMDL process.
5	The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants. TMDLs are underway, scheduled, or will be scheduled for one or more parameters. A review of the standards for one or more parameters will be conducted before a management strategy is selected, including a possible revision to the water quality standards. Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

Each water body is assigned uses and criteria (or parameters) consistent with the Texas Water Quality Standards that are evaluated against ambient water quality data for determining support or attainment of the use. When included in Categories 4 or 5, the combination of the water body, use, and the pollutant or condition of concern is called an *impairment*. For example, the concentration of dissolved oxygen is one of the criteria used to determine the support of the aquatic life use. If the assessment of dissolved oxygen data in a specific water body indicates that concentrations are lower than the assigned criteria, this would represent a single impairment of the aquatic life use.

Summary of the 2016 Integrated Report

The 2016 Integrated Report includes a comprehensive water quality evaluation of 1,453 classified and unclassified water bodies throughout the State (freshwater streams, reservoirs, tidal streams, bays, estuaries, and the Gulf of Mexico). All readily available data of known quality was evaluated.

The attachment summarizes the results for the impaired water bodies identified in Category 5

(303(d) List) of the 2016 Integrated Report. The number of impairments decreased in 2016 by 15 as compared to 2014. A total of 574 impairments are now included in Category 5. Recreational use impairments due to elevated bacteria represented the highest percentage (39%) included in Category 5. Dissolved oxygen and organics in fish tissue had the next highest percentages (17% and 19% respectively).

For More Information

The Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) is compiled and published on the TCEQ Web site page at:

http://www.tceq.texas.gov/waterquality/assessment/305_303.html

The water quality management program and role of the Integrated Report in agency planning is described in the publication “Preserving and Improving Water Quality”, available on the TCEQ Web site at:

https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/08twqi/pollution_control.pdf

Attachment

Summary 2016 Texas Integrated Report for Clean Water Act, §305(b) and §303(d)

		Water Bodies Evaluated Water Bodies Assessed	2014 1409 1065 (segments)	2016 1452 1071 (segments)	
Impairment Parameters by Type	Media	Use	2014 Total Number of Segment Impairments	2016 Total Number of Segment Impairments	Change
Bacteria	In water	Recreation	243	223	-20
		General Use	2	2	0
	In shellfish	Oyster Waters	8	10	2
	Beaches	Beach Use	2	2	0
Dissolved Oxygen	In water	Aquatic Life	96	95	-1
Toxicity	In ambient water	Aquatic Life	2	2	0
	In ambient sediment		6	6	0
Organics	In water	Fish Consumption, Aquatic Life	0	0	0
	Chlordane in edible tissue		3	0	-3
	DDE in edible tissue		1	0	-1
	Dieldrin in edible tissue		3	1	-2
	Dioxin in edible tissue		50	55	5
	Heptachlor epoxide in edible tissue		3	0	-3
	PCBs in edible tissue		54	54	0
Metals (except Mercury)	In water	Fish Consumption, Oyster Waters, Aquatic Life	6	12	6
	In fish/shellfish		0	0	0
Mercury	In water	Fish Consumption, Oyster Waters, Aquatic Life	1	1	0
	In fish/shellfish		24	24	0
Dissolved Solids	Chloride	General	17	18	1
	Sulfate		12	16	4
	Total dissolved solids		18	17	-1
Temperature	In water	General	1	0	-1
pH	In water	General	17	16	-1
Nitrate	In water	Public Water Supply	0	0	0
Excessive Algal Growth	In water	General	0	2	2
Biological	Fish community	Aquatic Life	11	10	-1
	Macrobenthos community	Aquatic Life	9	8	-1
		Totals	589	574	-15
		Total AUs	986	987	1

Stream Processes and Riparian Function

Texas Parks and Wildlife Department

Warm thanks and appreciation to

Steve Nelle

Kenneth Mayben

OBJECTIVES

- Basic stream processes
- Watershed and stream relationships
- Stream, floodplain & riparian management

What do creeks and rivers want to do?

Functions of a Stream

- Transport water
- Transport and deposit sediment
- Transport and replenish nutrients
- Biological functions (food, shelter, shading, movement, etc.)

Stream, Floodplain and Riparian Areas are One

- Erosion Control
- Water Quality Improvement
- Wildlife Habitat
- Aquatic Habitat
- Recreation
- Water Storage
- Flood Protection

Stream Facts

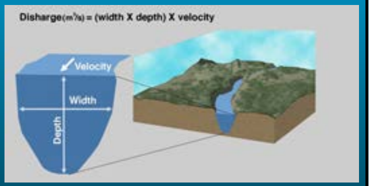
- Streambank and watershed erosion are natural processes
- A dynamic equilibrium exists in stable stream channels
- Floods have beneficial functions
- When changes are made in the watershed or stream, the stream will adjust to fix itself.

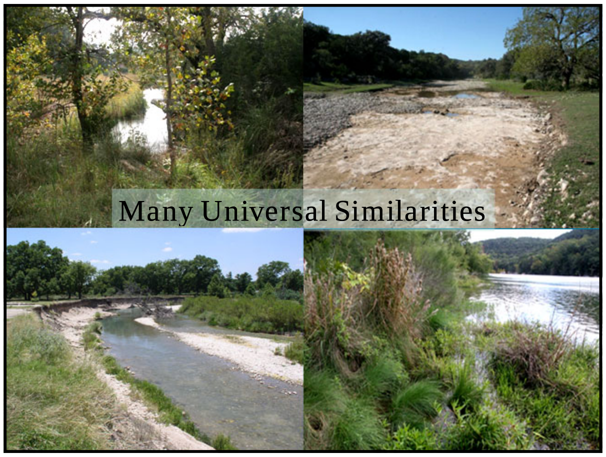
Stable Stream

- A stable stream is one that has a stable dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades (deposits excess sediment) nor degrades (erodes excess sediment).
- Lateral migration and erosion do not necessarily indicate instability. Stable streams are also dynamic.

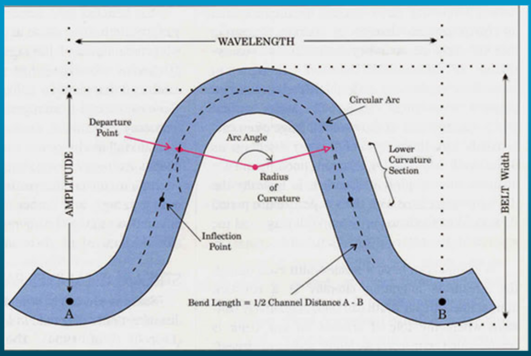
Major Variables Influencing Stream Pattern Morphology

- Channel Width
- Channel Depth
- Velocity
- Discharge
- Channel Slope
- Channel Material & Roughness
- Sediment Load
- Sediment Size



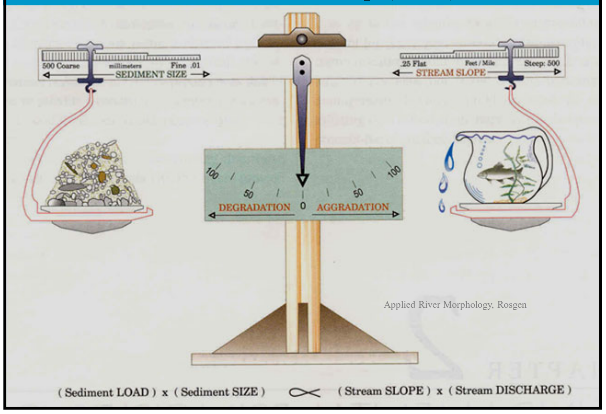


Channel Geometry

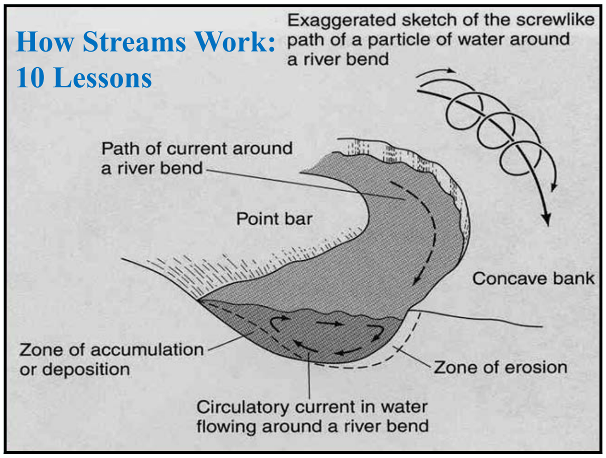


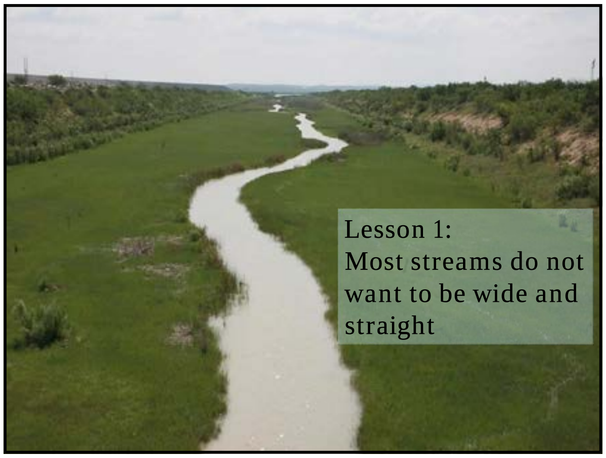
Applied River Morphology, Rosgen

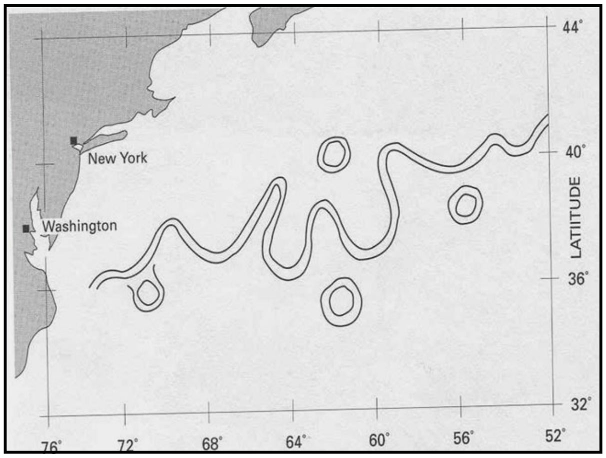
Lane's Relationship (1955)

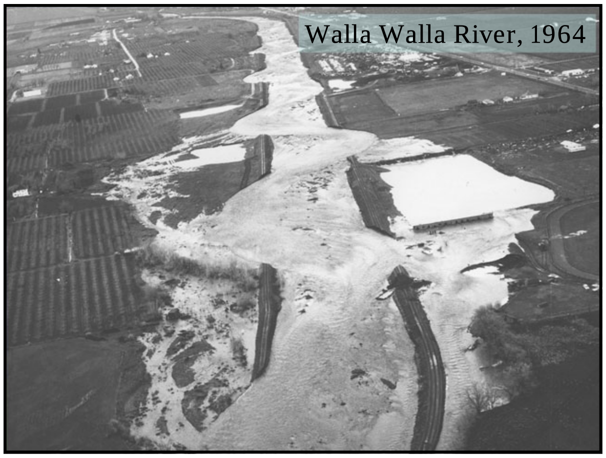


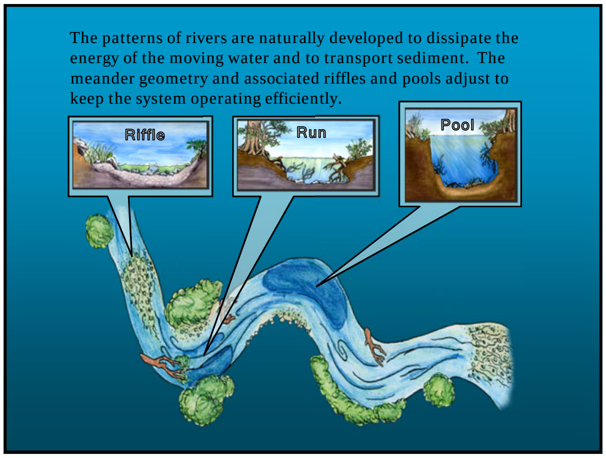
How Streams Work: 10 Lessons

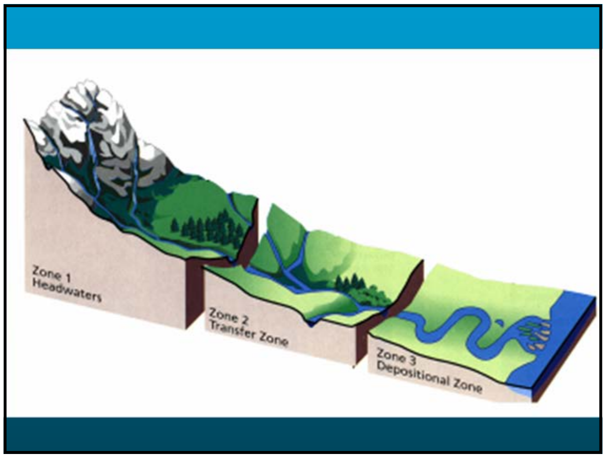


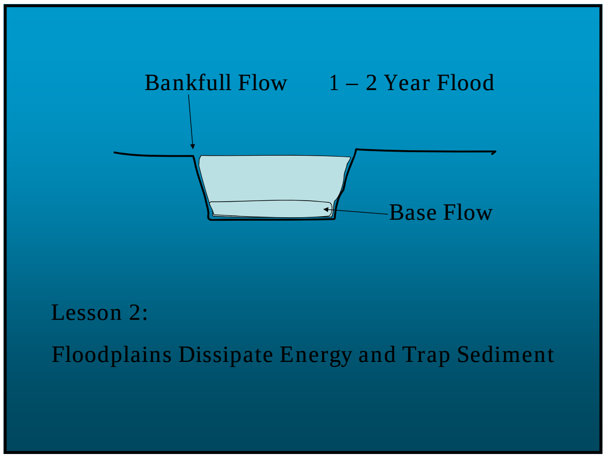

Lesson 1:
Most streams do not want to be wide and straight

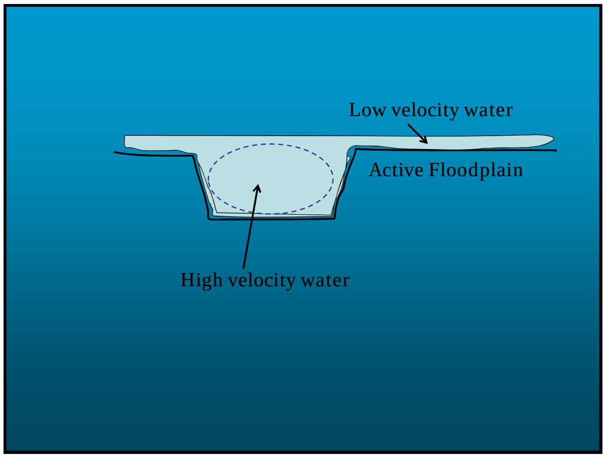

New York
Washington
LATITUDE
44˚
40˚
36˚
32˚
76˚
72˚
68˚
64˚
60˚
56˚
52˚


Walla Walla River, 1964


The patterns of rivers are naturally developed to dissipate the energy of the moving water and to transport sediment. The meander geometry and associated riffles and pools adjust to keep the system operating efficiently.
Riffle
Run
Pool


Zone 1
Headwaters
Zone 2
Transfer Zone
Zone 3
Depositional Zone

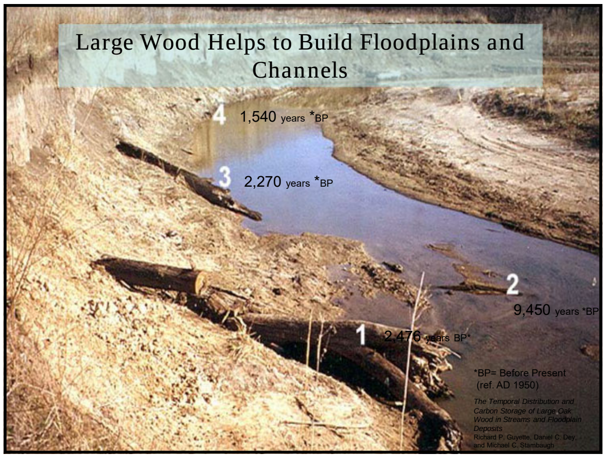

Bankfull Flow
1 – 2 Year Flood
Base Flow
Lesson 2:
Floodplains Dissipate Energy and Trap Sediment

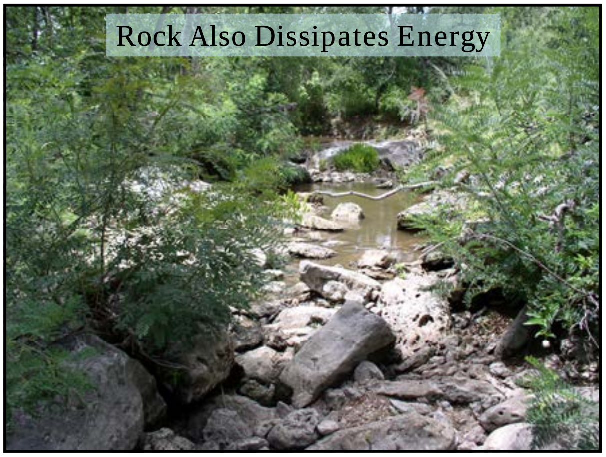

Low velocity water
Active Floodplain
High velocity water

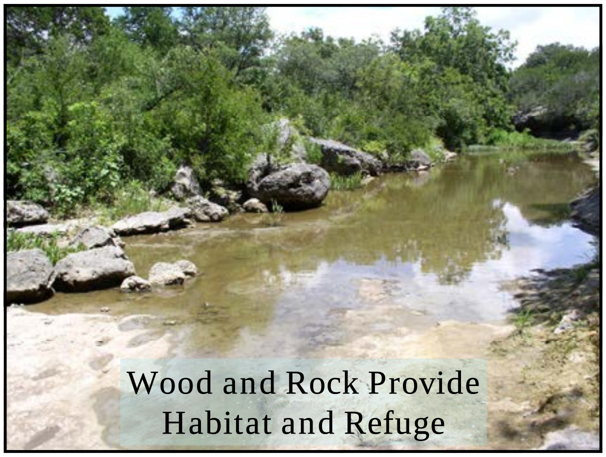

Floodplain

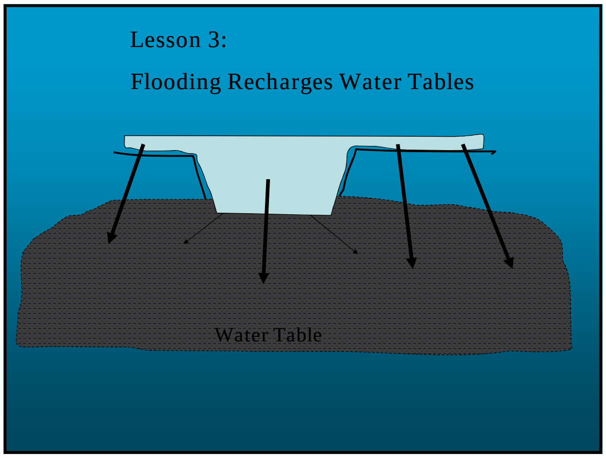

Large Wood Dissipates Energy

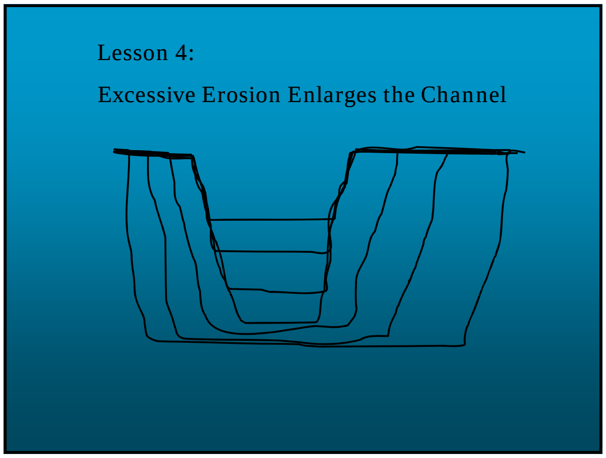

Wood Catches Sediment

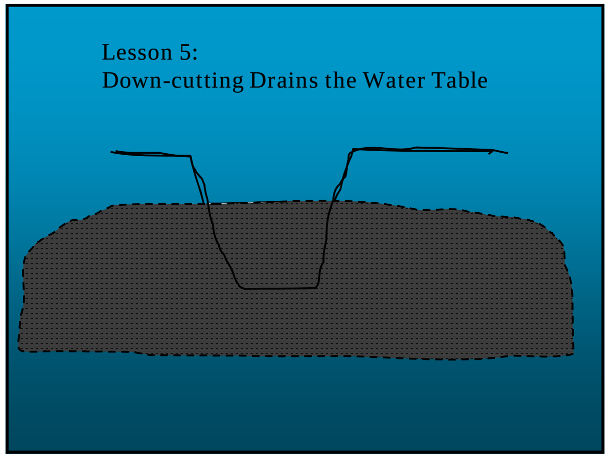

Large Wood Helps to Build Floodplains and Channels
4 1,540 years *BP
3 2,270 years *BP
2 9,450 years *BP
1 2,476 years BP*
*BP= Before Present (ref. AD 1950)
The Temporal Distribution and Carbon Storage of Large Oak Wood in Streams and Floodplain Deposits
Richard P. Guyette, Daniel C. Dey, and Michael C. Stambaugh

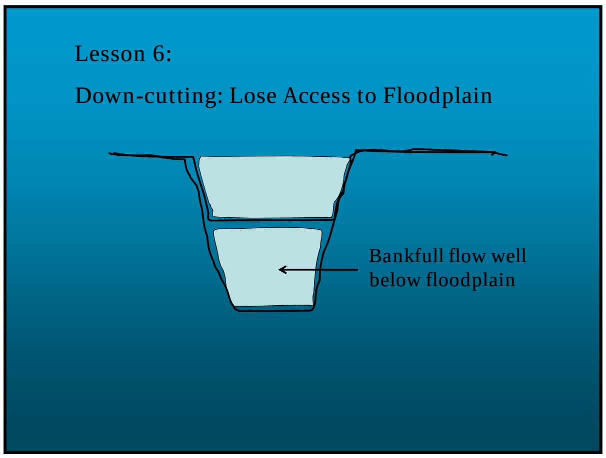

Rock Also Dissipates Energy

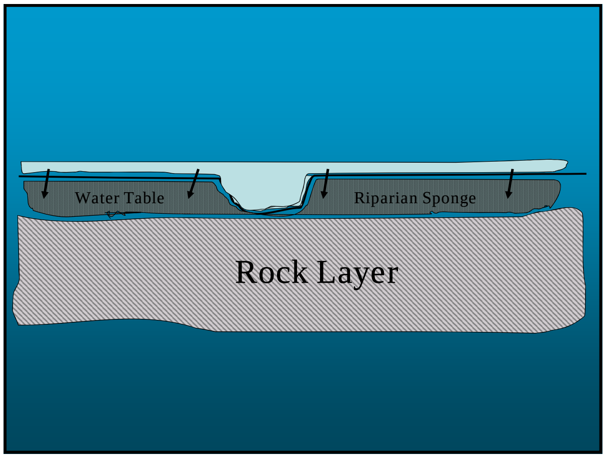

Wood and Rock Provide Habitat and Refuge

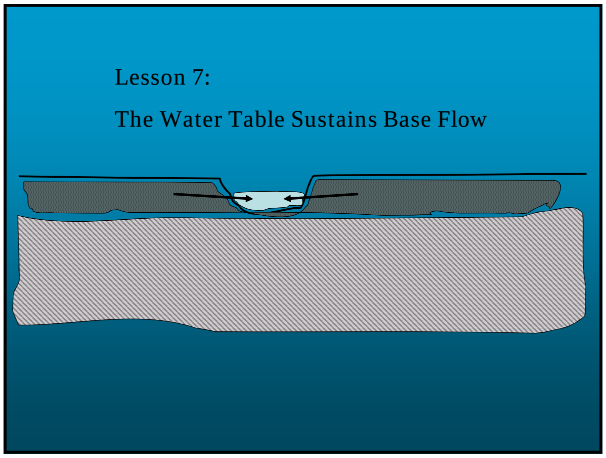

Lesson 3:
Flooding Recharges Water Tables
Water Table


Lesson 4:
Excessive Erosion Enlarges the Channel

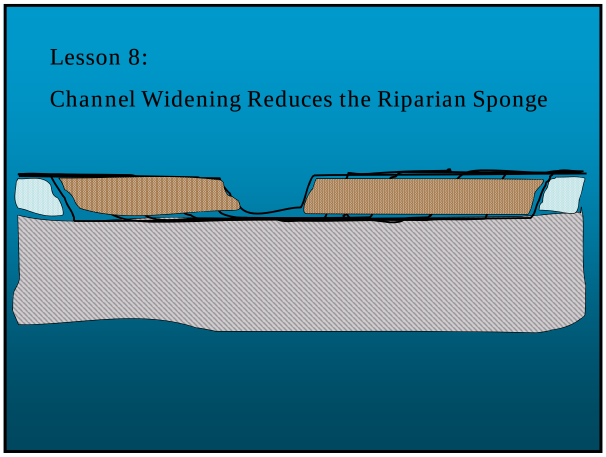

Lesson 5:
Down-cutting Drains the Water Table

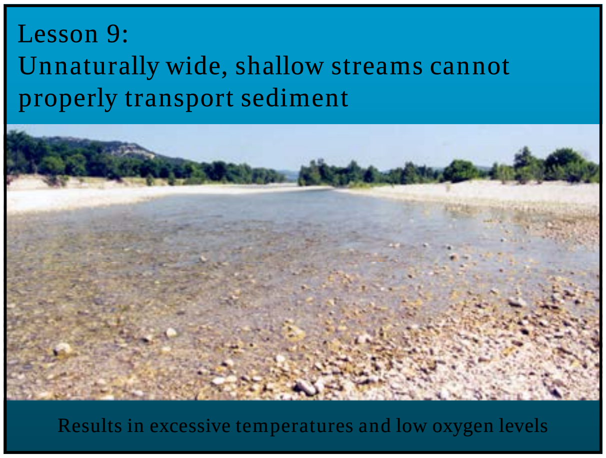

Lesson 6:
Down-cutting: Lose Access to Floodplain
Bankfull flow well below floodplain

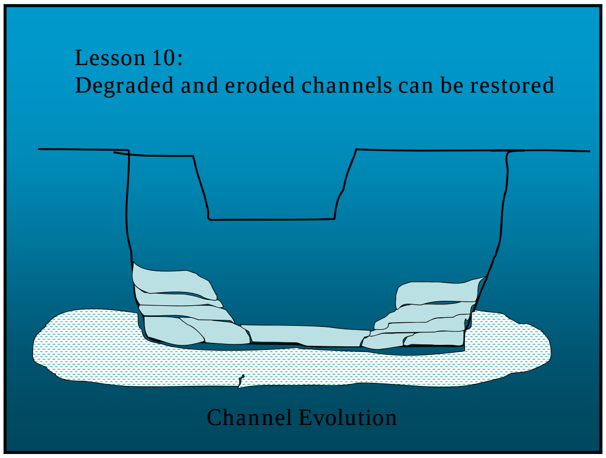

Water Table
Riparian Sponge
Rock Layer

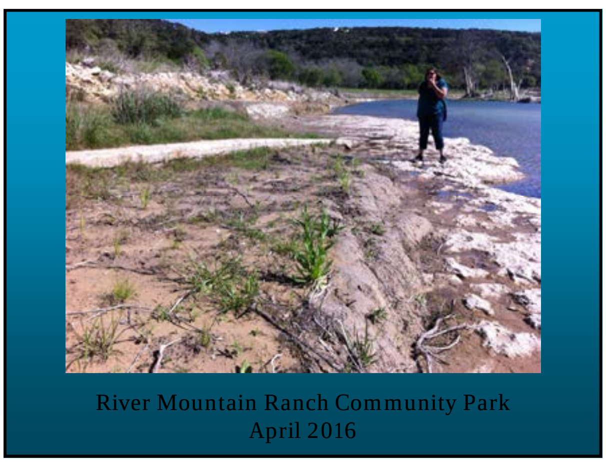

Lesson 7:
The Water Table Sustains Base Flow


Riparian Sponge


Lesson 8:
Channel Widening Reduces the Riparian Sponge


Lesson 9:
Unnaturally wide, shallow streams cannot properly transport sediment
Results in excessive temperatures and low oxygen levels


Lesson 10:
Degraded and eroded channels can be restored
Channel Evolution

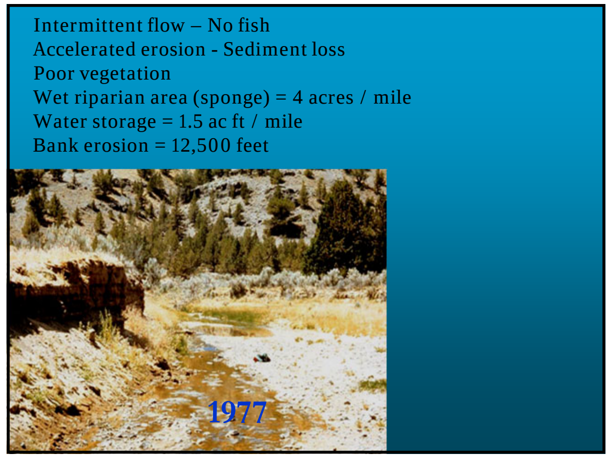

River Mountain Ranch Community Park
April 2016


River Mountain Ranch Community Park
September 2016


River Mountain Ranch Community Park
May 2017


River Mountain Ranch Community Park
May 2017


Bear Creek Riparian Restoration
Central Oregon
3500', 12" Rainfall
Wayne Elmore,
National Riparian Service Team
Full Stream Consulting



A Change in Grazing Management

1977 – 1984: No grazing / Reduced grazing to jump-start recovery

1985 – Present: Short term grazing during late winter to improve riparian vegetation


Aug 1987


1988

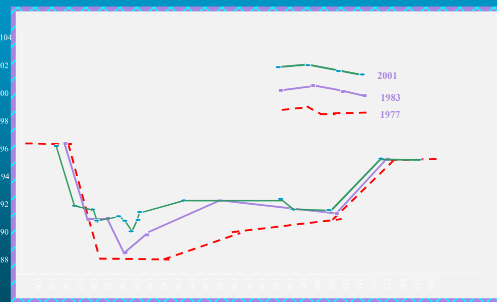

1993


Feb 1996

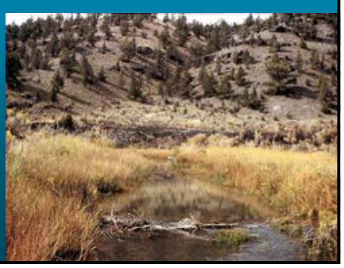

April 1996


Oct 1996

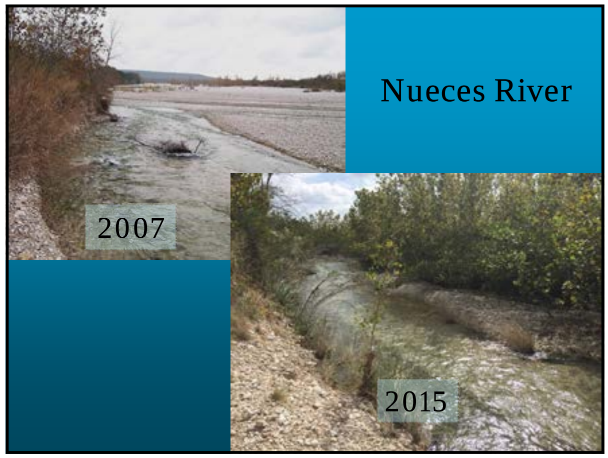
Bear Creek : Change In Channel Profile (1977 – 2001)



- Sediment Captured = 7400 CY/Mile
- Riparian "Sponge" Increased to 12 Ac/Mile
- Water Storage : Net gain of 4.9 ac ft /mile
- Perennial flow; prime fish habitat
- 10x Increase in livestock forage
- Bank erosion reduced to 100 feet



Nueces River



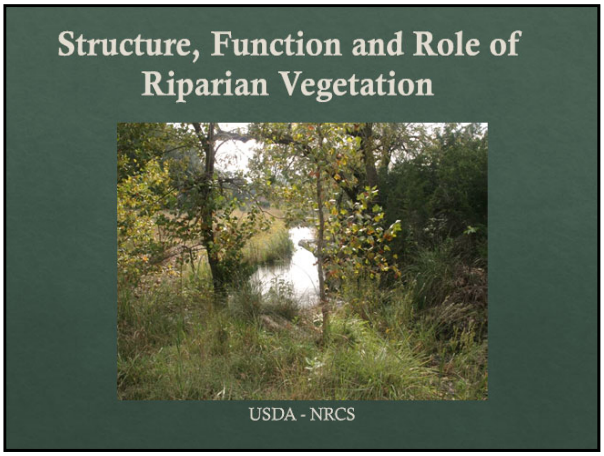
Instream Structures and Stream Restoration

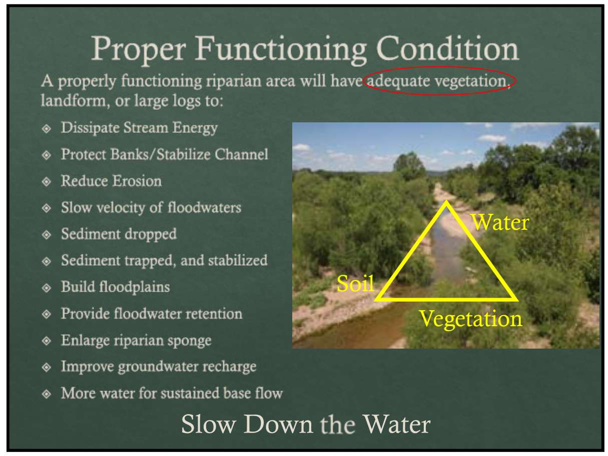
- J-hooks, x-vanes, sloping banks, weirs, bioengineering, etc.
- These may be expensive and unnecessary where improved riparian management is adequate.

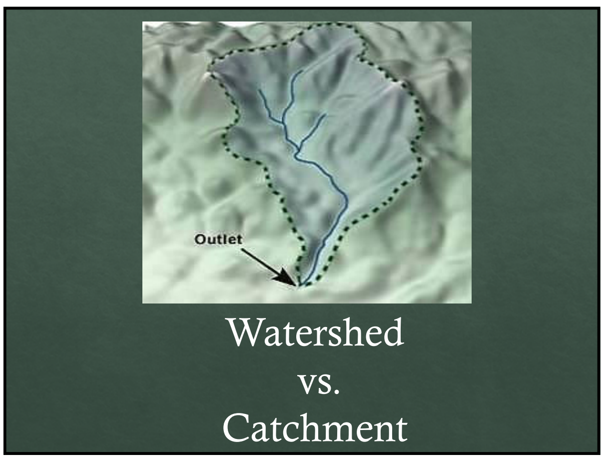
Summary

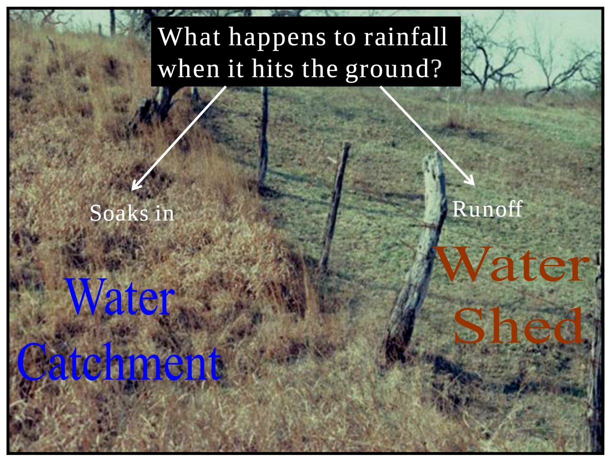
- Streams are dynamic. Their main function is to transport water and sediment.
- A stream's morphology is predictable and measurable. A change in one variable will cause an adjustment in another.
- The stream, floodplain, and riparian area are one system (think watershed!).
- Floods have beneficial functions.
- Lateral and vertical stability maintain base flows, the water table, and the "riparian sponge."

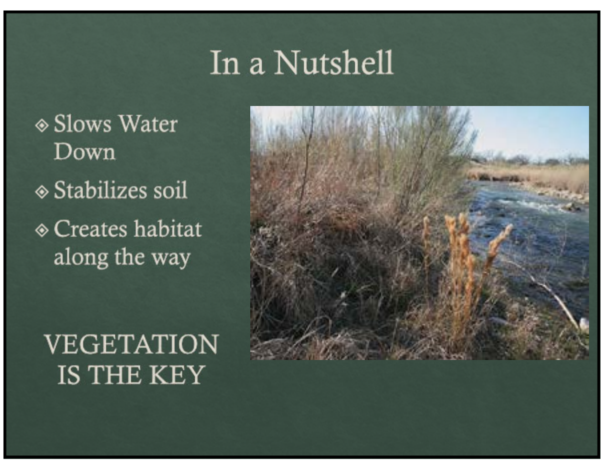

Thank you
Ryan McGillicuddy
Texas Parks and Wildlife Department

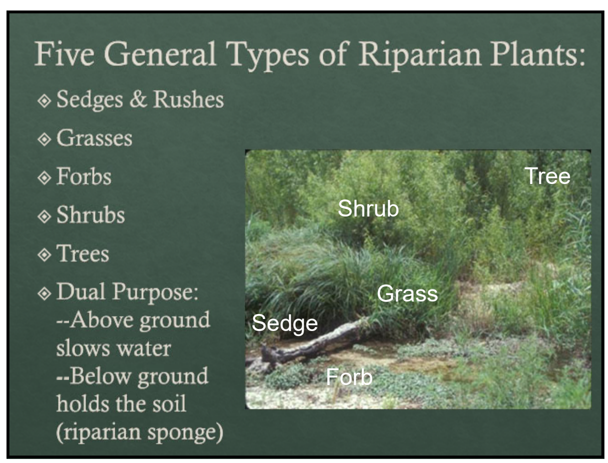

Structure, Function and Role of Riparian Vegetation
USDA - NRCS

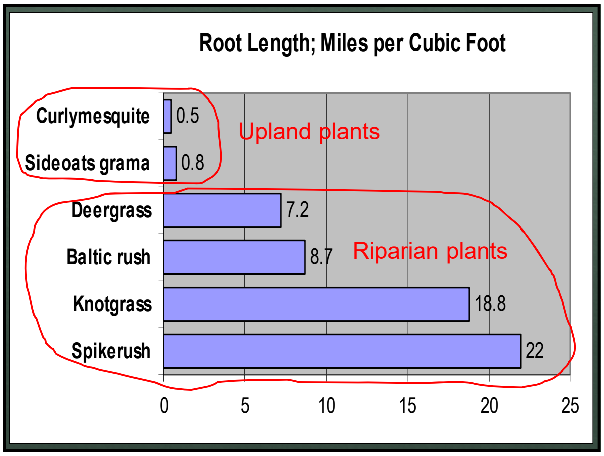

Proper Functioning Condition
A properly functioning riparian area will have adequate vegetation, landform, or large logs to:
Dissipate Stream Energy
Protect Banks/Stabilize Channel
Reduce Erosion
Slow velocity of floodwaters
Sediment dropped
Sediment trapped, and stabilized
Build floodplains
Provide floodwater retention
Enlarge riparian sponge
Improve groundwater recharge
More water for sustained base flow
Water
Soil
Vegetation
Slow Down the Water

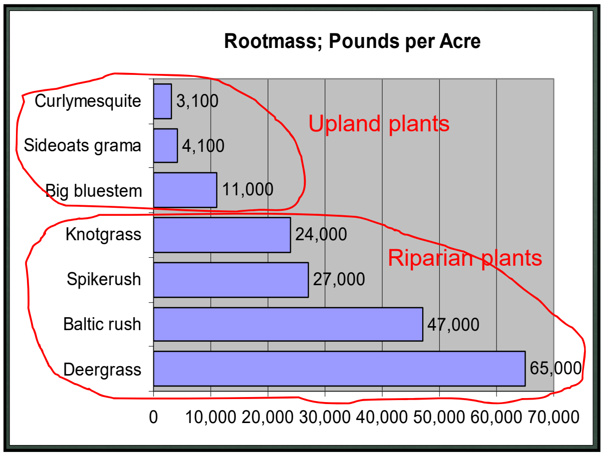

Outlet
Watershed
vs.
Catchment

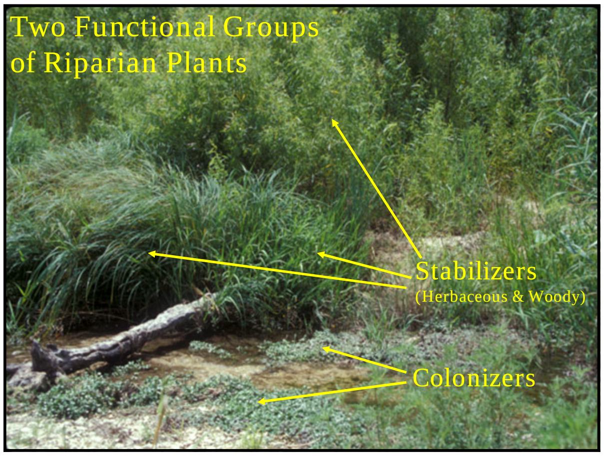

What happens to rainfall when it hits the ground?
Soaks in
Runoff
Water Catchment
Water Shed


In a Nutshell
Slows Water Down
Stabilizes soil
Creates habitat along the way
VEGETATION IS THE KEY


Five General Types of Riparian Plants:
Sedges & Rushes
Grasses
Forbs
Shrubs
Trees
Dual Purpose:
--Above ground slows water
--Below ground holds the soil (riparian sponge)
Tree
Shrub
Grass
Sedge
Forb


Root Length; Miles per Cubic Foot
Curlymesquite
Sideoats grama
Deergrass
Baltic rush
Knotgrass
Spikerush
0.5
0.8
7.2
8.7
18.8
22
Upland plants
Riparian plants
0
5
10
15
20
25


Rootmass; Pounds per Acre
Curlymesquite
Sideoats grama
Big bluestem
Knotgrass
Spikerush
Baltic rush
Deergrass
3,100
4,100
11,000
24,000
27,000
47,000
65,000
Upland plants
Riparian plants
0
10,000 20,000 30,000 40,000 50,000 60,000 70,000


Two Functional Groups
of Riparian Plants
Stabilizers
(Herbaceous & Woody)
Colonizers

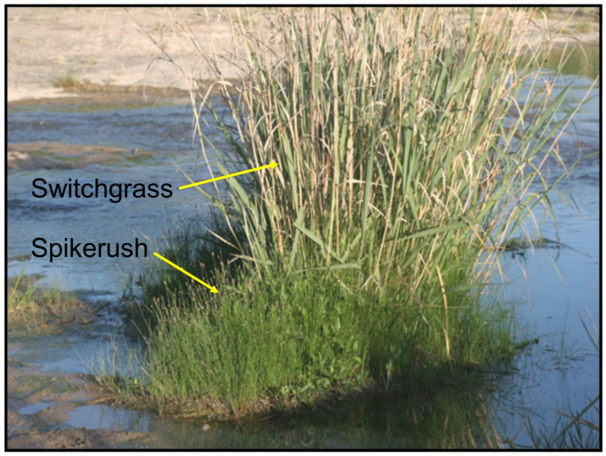

Colonizers
• First plants to establish in freshly deposited sediment
• Often spread rapidly by stolons or rhizomes
• Roots generally shallow and weak
• Critical to recovery


Watercress; Water pennywort - Colonizers


Catching Fine Sediment

Stabilizers

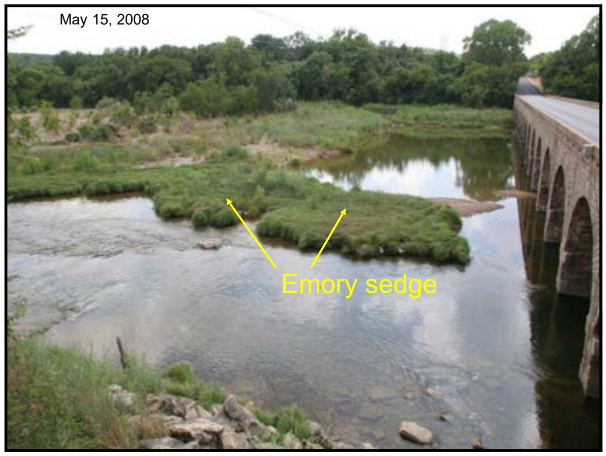
- Strong, upright, robust plants, able to withstand high energy flows
- Strong, deep, fibrous root systems, often rhizomatous
- Provide bank protection and dissipate energy
- Herbaceous and
- Woody Stabilizers

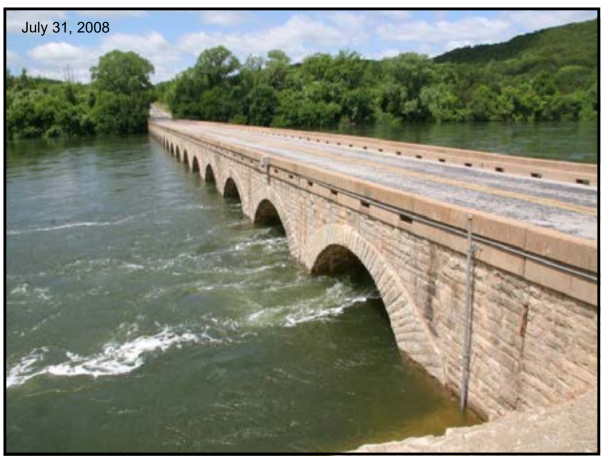


Stability Ratings of Riparian Plants

Scale of 1 to 10

- 1 = The stability of bare ground
- 10 = The stability of anchored rock or large anchored logs
- 7 = Acceptable riparian stability for high gradient (>0.3% slope) streams
- 6 = Acceptable riparian stability for low gradient (<0.3% slope) streams





Strongest Stabilizers

Stability Rating = 10

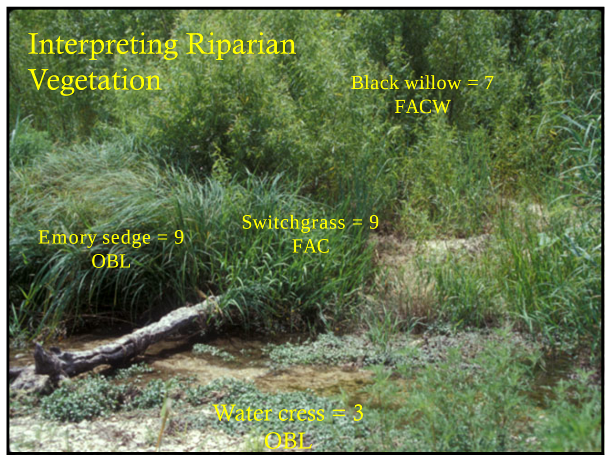
Plant Combinations "Plant Communities"

- ⟐Elm – Sycamore - Willow
- ⟐Sedge – Willow
- ⟐Buttonbush – Switchgrass
- ⟐Switchgrass – Sedge – Willow

= to strength of Anchored Rock

Good Riparian Vegetation = A Mixture of:

- ⟐Colonizers – 2 or more species
- ⟐Stabilizer Sedge-Grass – 2 or more species
- ⟐Stabilizer Woody – shrub & tree species



Five Wetland Indicator Categories

1.	Obligate Wetland	OBL
2.	Facultative Wetland	FACW
3.	Facultative	FAC
4.	Facultative Upland	FACU
5.	Obligate Upland	UPL

Obligate Wetland OBL

Almost always occur in wetlands

99% probability

Spikerush
Colonizer/Stabilizer
OBL; SR= 6

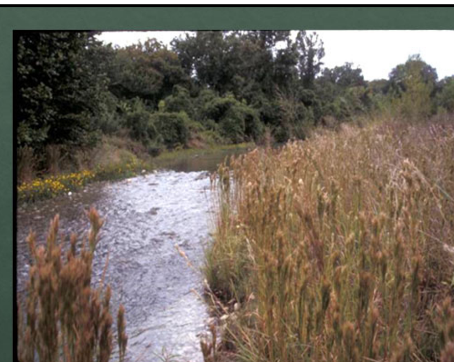
Bulrush (Scirpus)
OBL SR = 9

Facultative Wetland
FACW

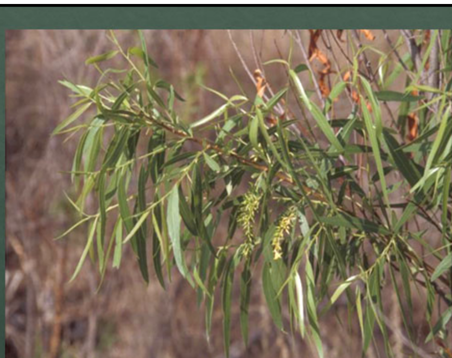
Usually occur in wetlands

66-99% probability

Occasionally occur in non-wetlands.



Bushy bluestem – Weak Stabilizer
FACW; SR = 5/6



Black Willow *Salix*
Colonizer/Stabilizer; FACW; SR = 7

Cottonwood *Populus*
Stabilizer; FACW; SR = 6

Willow Baccharis
Early Stabilizer, FACW, SR = 6

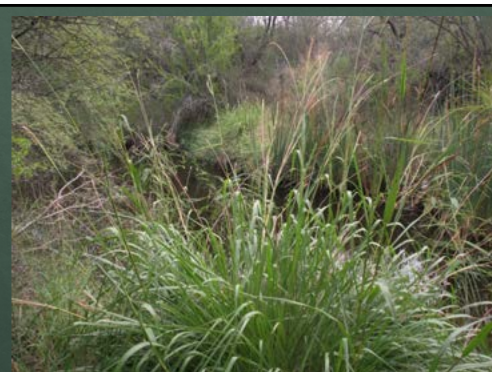
Spiny Aster
stabilizer
FACW-8

Facultative
FAC

Equally likely to occur in wetlands and non wetlands

Frogfruit – Colonizer
FAC; SR = 4

Switchgrass
Stabilizer, FAC, SR = 9



Eastern gammagrass *Tripsacum*
Stabilizer, FAC, SR = 9

Broad-leaf wood-oats *Chasmanthium*
Colonizer, FAC, SR = 5

Facultative Upland
FACU

Usually occur in non wetlands

66-99% probability

Occasionally occur in wetlands.

Bermudagrass FACU; SR=6
Colonizer

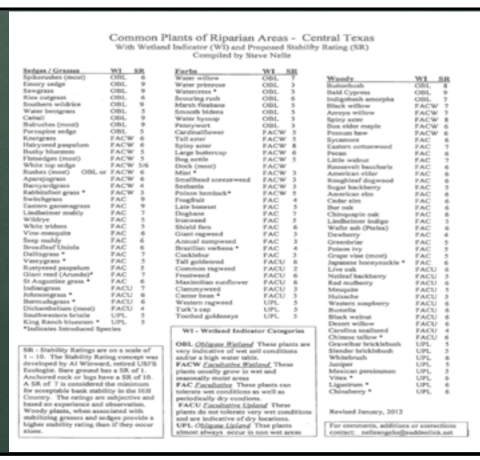
Obligate Upland
UPL

Almost always occur in

Non-wetlands

99% probability

Mesquite
Stabilizer; FACU; SR = 5



Common Plants of Riparian Areas - Central Texas
With Wetland Indicator (WI) and Proposed Stability Rating (SR)
Compiled by Steve Nelle

Sedges / Grasses	WI	SR
Spikerushes (most)	OBL	6
Emory sedge	OBL	9
Sawgrass	OBL	9
Rice cutgrass	OBL	6
Southern wildrice	OBL	9
Water bentgrass	OBL	3
Cattail	OBL	9
Bulrushes (most)	OBL	9
Porcupine sedge	OBL	5
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Bushy bluestem	FACW	5
Flatsedges (most)	FACW	5
White top sedge	FACW	5/6
Rushes (most)	OBL or FACW	6
Aparejograss	FACW	6
Barnyardgrass	FACW	4
Rabbitsfoot grass *	FACW	3
Switchgrass	FAC	9
Eastern gamagrass	FAC	9
Lindheimer muhly	FAC	7
Wildrye	FAC	5
White tridens	FAC	5
Vine-mesquite	FAC	6
Seep muhly	FAC	6
Broadleaf Uniola	FAC	6
Dallisgrass *	FAC	7
Vaseygrass *	FAC	5
Rustyseed paspalum	FAC	5
Giant reed (Arundo)*	FAC	7
St Augustine grass *	FAC	6
Indiangrass	FACU	7
Johnsongrass *	FACU	6
Bermudagrass *	FACU	6
Dichanthelium (most)	FACU	4
Southwestern bristle	UPL	5
King Ranch bluestem *	UPL	5

*Indicates Introduced Species

Forbs	WI	SR
Water willow	OBL	7
Water primrose	OBL	3
Watercress *	OBL	3
Scouring rush	OBL	6
Marsh fleabane	OBL	5
Smooth bidens	OBL	5
Water hyssop	OBL	3
Pennywort	OBL	3
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Bog nettle	FACW	5
Dock (most)	FACW	
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Poison hemlock*	FACW	5
Frogfruit	FAC	4
Late boneset	FAC	5
Dogbane	FAC	7
Ironweed	FAC	5
Shield fern	FAC	6
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Cocklebur	FAC	3
Tall goldenrod	FACU	6
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Clammyweed	FACU	3
Castor bean *	FACU	3
Western ragweed	UPL	5
Turk's cap	UPL	5
Toothed goldeneye	UPL	5

Woody	WI	SR
Buttonbush	OBL	8
Bald Cypress	OBL	9
Indigobush amorpha	OBL	7
Black willow	FACW	7
Arroyo willow	FACW	7
Spiny aster	FACW	8
Box elder maple	FACW	6
Possum haw	FACW	6
Sycamore	FAC	6
Eastern cottonwood	FAC	7
Pecan	FAC	6
Little walnut	FAC	7
Roosevelt baccharis	FAC	6
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Bur oak	FAC	6
Chinquapin oak	FAC	6
Lindheimer indigo	FAC	5
Wafer ash (Ptelea)	FAC	6
Dewberry	FAC	4
Greenbriar	FAC	5
Poison ivy	FAC	5
Grape vine (most)	FAC	5
Japanese honeysuckle *	FAC	6
Live oak	FACU	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Mesquite	FACU	5
Huisache	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Desert willow	FACU	6
Carolina snailseed	FACU	4
Chinese tallow *	FACU	6
Gravelbar brickelbush	UPL	5
Slender brickelbush	UPL	5
Whitebrush	UPL	6
Juniper	UPL	5
Mexican persimmon	UPL	5
Vitex *	UPL	6
Ligustrum *	UPL	6
Chinaberry *	UPL	6

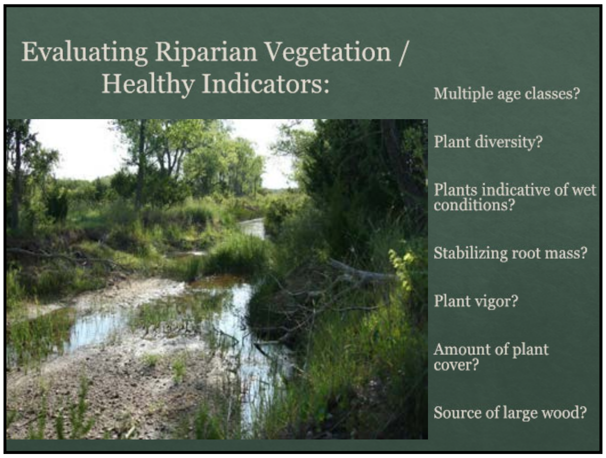
SR - Stability Ratings are on a scale of 1 – 10. The Stability Rating concept was developed by Al Winward, retired USFS Ecologist. Bare ground has a SR of 1. Anchored rock or logs have a SR of 10. A SR of 7 is considered the minimum for acceptable bank stability in the Hill Country. The ratings are subjective and based on experience and observation. Woody plants, when associated with stabilizing grasses and sedges provide a higher stability rating than if they occur alone.

WI - Wetland Indicator Categories

OBL *Obligate Wetland* These plants are very indicative of wet soil conditions and/or a high water table.
FACW *Facultative Wetland* These plants usually grow in wet and seasonally moist areas.
FAC *Facultative* These plants can tolerate wet conditions as well as periodically dry condions.
FACU *Facultative Upland* These plants do not tolerate very wet conditions and are indicative of dry locations.
UPL *Obligate Upland* Thse plants almost always occur in non wet areas

Revised January, 2012

For comments, additions or corrections contact: [illegible]


Evaluating Riparian Vegetation / Healthy Indicators:
Multiple age classes?
Plant diversity?
Plants indicative of wet conditions?
Stabilizing root mass?
Plant vigor?
Amount of plant cover?
Source of large wood?

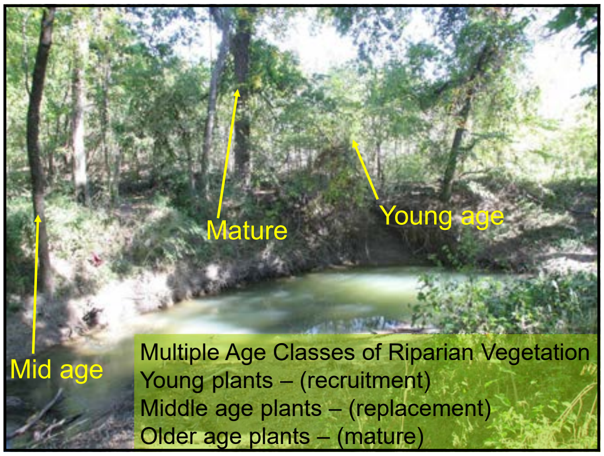

Adequate amount of vegetation cover
70% coverage of stabilizing riparian vegetation

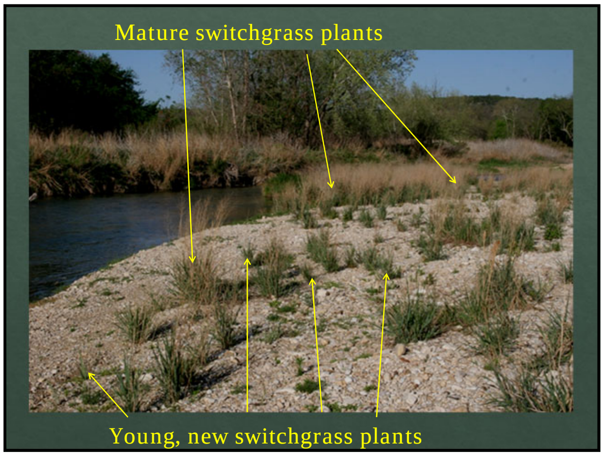

Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows

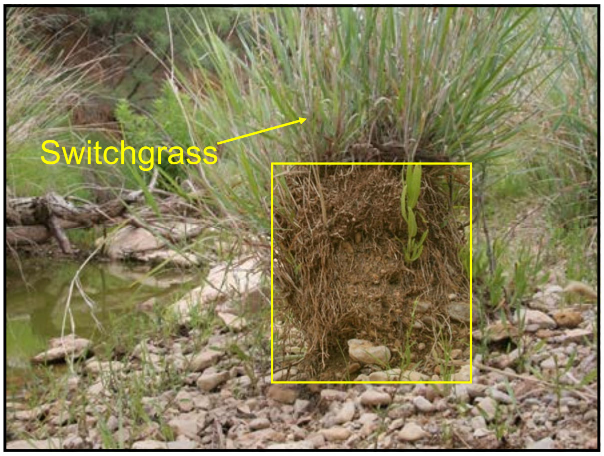

Diverse Composition of Riparian-Wetland Vegetation
3 Types of Vegetation
Woody Plants
Sedge
Grass
Forb


Woody Plants
Forbs
Sedge

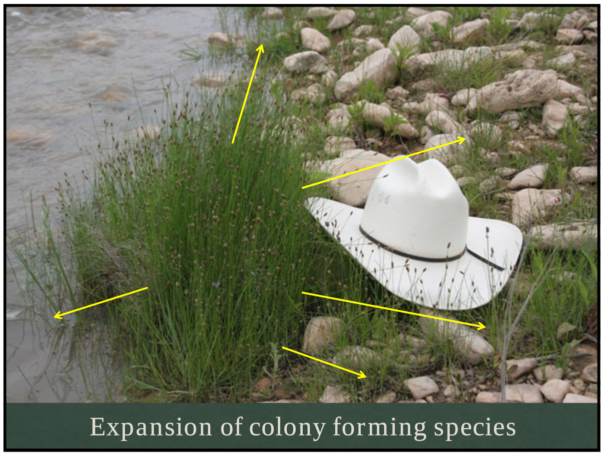

Diverse??


Mature
Young age
Mid age
Multiple Age Classes of Riparian Vegetation
Young plants – (recruitment)
Middle age plants – (replacement)
Older age plants – (mature)


Mature switchgrass plants
Young, new switchgrass plants

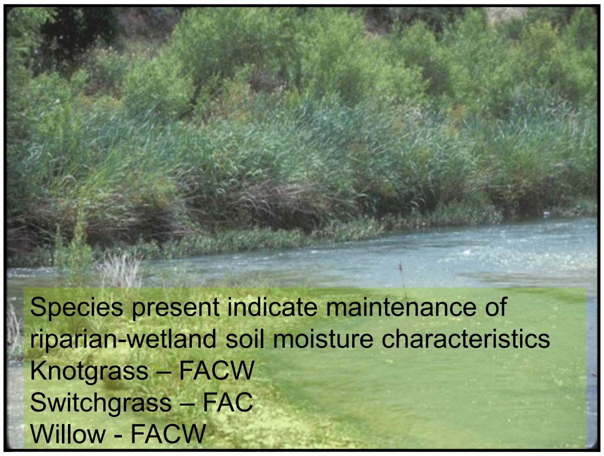

Switchgrass


Plant Vigor

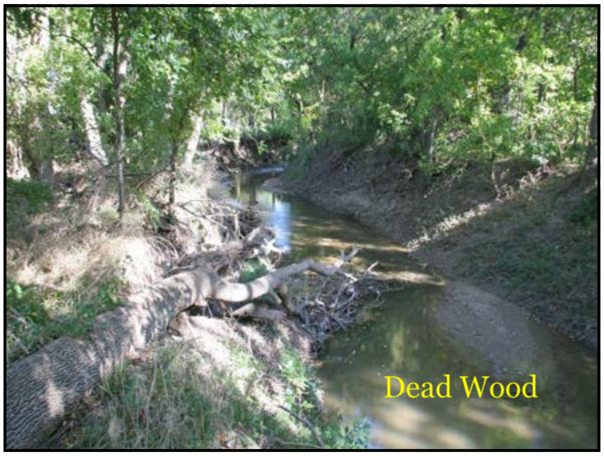

Expansion of colony forming species


Grazing,
Browsing,
Mowing,
Trampling
Determine
Root Health and
Root Density


Species indicative of wet conditions OBL; FACW; (FAC)


Species present indicate maintenance of riparian-wetland soil moisture characteristics
Knotgrass – FACW
Switchgrass – FAC
Willow - FACW


Soil Moisture Maintenance??

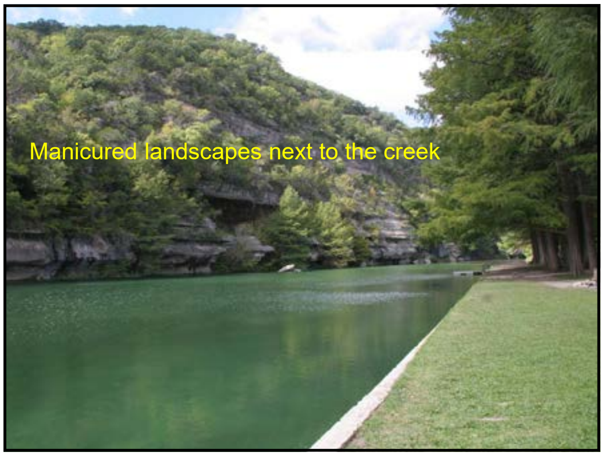

Dead Wood


Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)


Healthy Indicators????

Benefits of Healthy Riparian Areas

- High quality habitat for both aquatic and riparian species
- Dissipation of flood energy and reduced downstream flood intensity and frequency
- Higher, longer-lasting and less variable baseflow between storm events
- Deposition of sediment in the floodplain, stabilizing it and maintaining downstream reservoir capacity longer
- Debris and nutrient use and filtering in the floodplain to improve water quality and dissolved oxygen levels in the aquatic system
- Riparian vegetation canopies to shade streams and reduce their temperatures, providing a food base for aquatic and riparian fauna
- Fewer invasions of exotic undesirable riparian species
- Higher biodiversity than terrestrial uplands
- "Stabilized" banks, which reduce erosion and protect ownership boundaries
- Increased economic value through wildlife, livestock, timber, and recreational enterprises
- Improved rural land aesthetics and real estate values

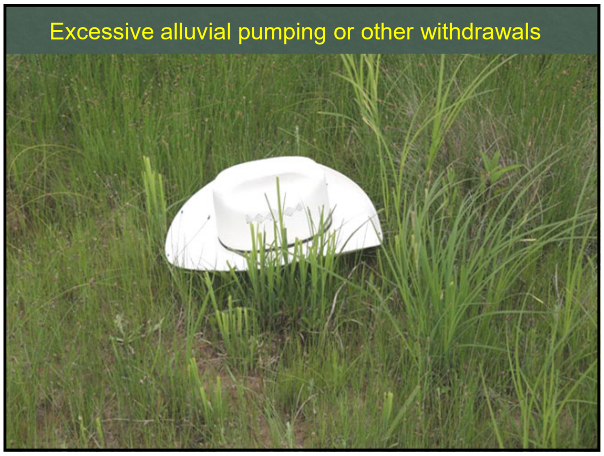

Manicured landscapes next to the creek


Artificial manipulation of banks / sediment

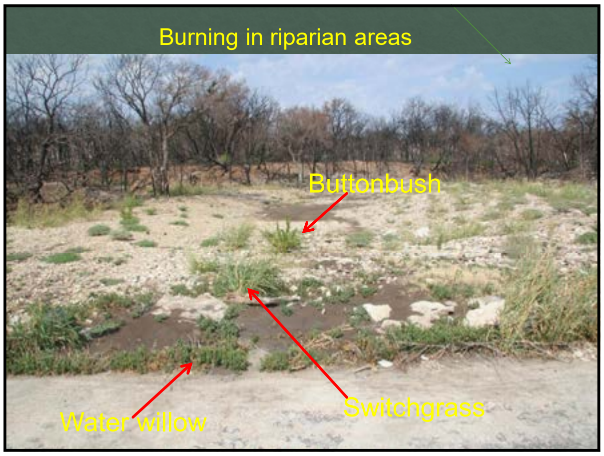

Excessive vehicle traffic in creek area


Removal of large dead wood and downed trees


Excessive recreational foot traffic in creek area

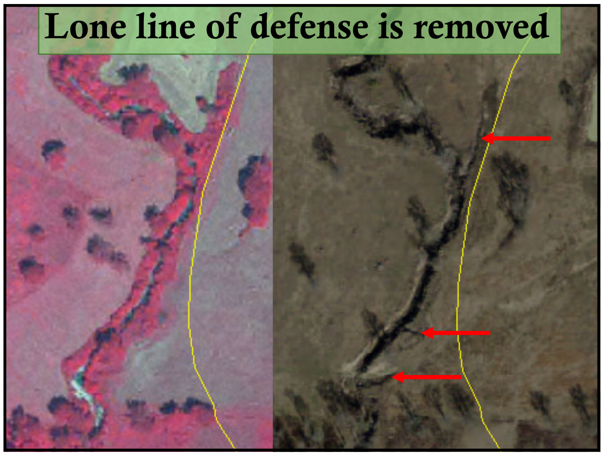

Excessive alluvial pumping or other withdrawals


Poorly designed road crossings / bridges

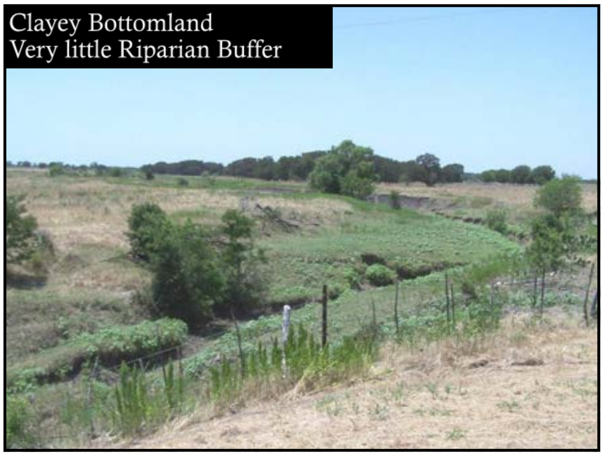

Burning in riparian areas
Buttonbush
Water willow
Switchgrass


Introduction of Invasive Exotic Plants

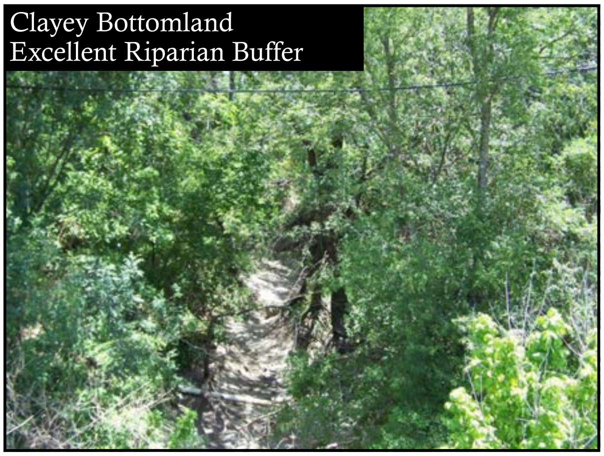

Introduction of Invasive Exotic Plants

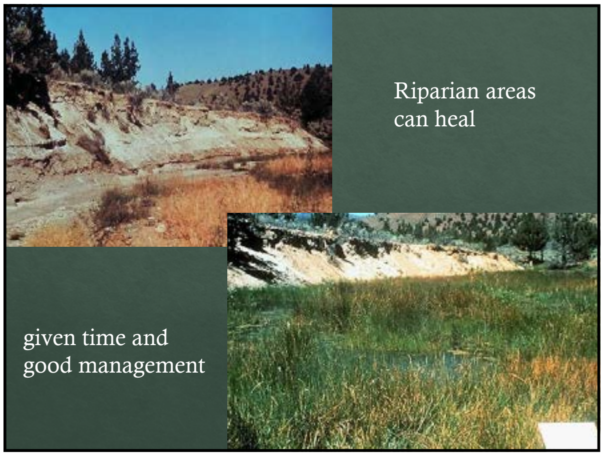

Lone line of defense is removed

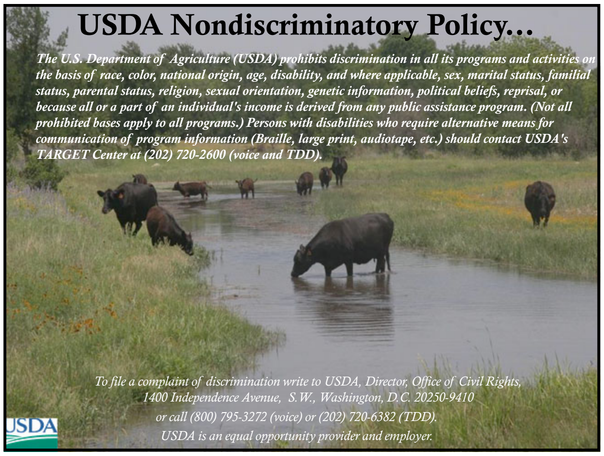

Lone line of defense


Clayey Bottomland
Very little Riparian Buffer


Clayey Bottomland
Better Riparian Buffer


Clayey Bottomland
Excellent Riparian Buffer


Riparian areas
can heal
given time and
good management


USDA Nondiscriminatory Policy…
The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).
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1400 Independence Avenue, S.W., Washington, D.C. 20250-9410
or call (800) 795-3272 (voice) or (202) 720-6382 (TDD).
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USDA

Management Practices and Local Resources

Nikki Dictson & Clare Entwistle

Texas Water Resources Institute

http://texasriparian.org and http://www.facebook.com/TexasRiparianAssociation

Hindrances to Healthy / Functional Riparian Areas:

- Farming too close to the bank
- Mowing, spraying close to the creek
- Manicured landscapes next to the creek
- Chronic grazing concentrations in creek areas
- Excessive deer, exotics, hogs in creek
- Burning in riparian area
- Removal of large dead wood
- Artificial manipulation of banks / sediment
- Excessive vehicle traffic in creek area
- Poorly designed road crossings / bridges
- Excessive recreational foot traffic
- Excessive alluvial pumping or other withdrawals

Visual Indicators of Stream Health Include:

http://texasriparian.org/wp-content/uploads/2013/02/Stream-Visual-Assessment-Protocol-2.pdf

- Channel Condition
- Access to Floodplain and Hydrologic Alteration
- Riparian Zone
- Bank Stability
- Water Appearance
- Nutrient Enrichment
- Barriers to Fish Movement
- Instream Fish Cover
- Pools
- Invertebrate Habitat

Other factors if applicable include:

- Canopy Cover
- Manure Presence
- Salinity
- Riffle Embeddedness
- Macroinvertebrates Observed
- Fish Species Observed

Management and Stewardship

- The impacts of stream flow and water quality are cumulative as the water moves down the system.
- Management upstream can lead to positive or negative impacts downstream.
- As you assess the stream and riparian ecosystem think about what may be hindering it.
- Has something caused a change in the water, sediment or vegetation?
- Management activities should protect healthy systems or allow recovery to return to a healthy functioning system.
- Land and Water Stewardship!

What You Can Do

- Properly Manage:
  - Lawn and garden
  - Fertilizer and Pesticides
  - Household chemicals
  - Water use and conservation
  - Reduce bare ground/erosion

The Role of Management Practices

- Control surface runoff
- Minimize pollutants
- Ensure sound pest and nutrient management
- Optimize production
- Reduce Flows/Erosion
- Water Quality
- Improve Soil Health

Urban/Suburban/Home

Activities

- Construction/paving
- Wastewater disposal
- Fertilizer and pesticide use
- Irrigation
- Disturbing and Creating Bare Ground

BMPs

- Minimize Impervious Surfaces to reduce runoff
- Infiltration Systems
- Detention Systems
- Retention Systems
- Constructed Wetlands systems
- Filtration Systems
- Vegetated Systems

Managing Your Landscape and Garden

- Properly Design Home Landscape
- Minimize impervious surfaces
- Use grasses, trees, and natural landscaping features
- Select native plants adapted to region and climate
- Mulch bare soil or plant with vegetation
- Properly Manage Weeds
- Cut or pull weeds before they go to seed to keep them from spreading
- Minimize areas of disturbance (bare ground) to prevent weeds from establishing
- Select the correct herbicide, follow label and use only as needed

Agricultural BMPs

- Nutrient management
- Pest management
- Irrigation water management
- Grazing Management
- Conservation tillage
- Contour farming
- Buffer/filter strips (Protect Riparian Areas)
- Cover /green manure crops
- Sediment control basins
- Terrace
- Grassed Waterways
- Drop Structure
- Livestock manure and wastewater management

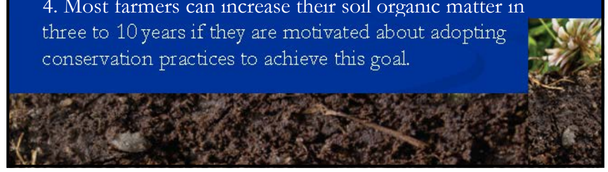
Manage for Soil Health

Follow four basic soil health principles to improve soil health and sustainability:

1. Use plant diversity to increase diversity in the soil.
2. Manage soils more by disturbing them less.
3. Keep plants growing throughout the year to feed the soil.
4. Keep the soil covered as much as possible.

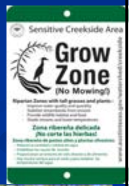
What are the benefits of healthy soil?

1. Healthy soil holds more water (by binding it to organic matter), and loses less water to runoff and evaporation.
2. Organic matter builds as tillage declines and plants and residue cover the soil. Organic matter holds 18-20 times its weight in water and recycles nutrients for plants to use.
3. One percent of organic matter in the top six inches of soil would hold approximately 27,000 gallons of water per acre!
4. Most farmers can increase their soil organic matter in three to 10 years if they are motivated about adopting conservation practices to achieve this goal.



Austin Grow Zone

- Establish a "Grow Zone" along both banks of the creek, approximately 25 ft.
- Allow for passive/natural plant growth in entire buffer area.
- Monitor for changes over time and apply adaptive management approaches where necessary.
- Coordinate periodic trash removal, weed/invasive vegetation management, and native seeding/planting.
- Install educational and demarcation signage where appropriate



Access to Streams

- Restricting access to specific points along a stream should be a primary goal.
- This will eliminate most of the bank erosion caused by livestock and human traffic as well as potential livestock injuries.
- Develop access ramps or trails with hardened surfaces such as coarse gravel over geotextile and slopes of 6:1 or flatter.
- These should allow easy access to pools within the stream that livestock prefer over riffles.
- Locating shade, salt, minerals, and winter feeding sites in portions of the pasture away from the stream will help reduce the time livestock spend at or adjacent to the water.

Managing Invasive Species

- Noxious and Invasive species Plant any species that has a serious potential to cause economical or ecological harm to agriculture, native plants, ecology and waterways.
- Invasives are affecting aquatic, riparian and upland areas throughout the state, and critical habitats are at risk.
- The Texas Department of Agriculture currently lists 30 noxious weeds proliferating in Texas: giant salvinia, giant cane (Arundo donax), Chinese tallow tree are some of the most potent invaders.
- Feral Hogs are estimated to cause an estimated $52 Million in damage annually in Texas and are increasing in numbers.
- Manage to reduce invasive species.

Pesticides

- Whether in agricultural operations or in urban environments, the improper application, handling or disposal of pesticides can lead to water pollution.
- AgriLife Brush Busters Website: http://texnat.tamu.edu/about/brush-busters/
- TDA Website: https://texasagriculture.gov/RegulatoryPrograms/Pesticides.aspx
- Spray formulations can drift with the wind or vaporize into the air.
- Other formulations can leach into ground water or be carried into surface water by rainfall or irrigation runoff.
- Even pesticides in formulations that bind them to soil particles can find their way into surface waters if soil is eroded by wind or water.

B:6050 Pesticide Properties that Affect Water Quality. By: Paul A. Baumann, John A. Jackman, Douglas Stevenson

Use of Pesticides and Fertilizers

Pesticides

- Apply carefully and ONLY the amount needed
- Consult qualified pest professional
- Never discard leftover product down household drains or toilets
- Dispose old or unused products at local hazardous material collection events

Fertilizers

- Test your soil!
- Use ONLY the amount needed
- Apply when plants are actively growing, not when they are dormant
- Calibrate spreaders to obtain proper rate
- Sweep up excess off sidewalks/driveways

Actions to Protect your Water Supply

- Keep records on each well: location, maintenance, and WQ test results
- Manage potential sources of contamination (i.e. septic systems, animal feedlots, animal waste)
- Monitor the quality of stream and well water
- Have water tested whenever you suspect contamination or notice change is color, taste, or odor.

Water Well Testing FAQs

How often should the well be tested?

- Annually for bacteria.
- Every few years for general chemistry such as nitrates and salts.
- As frequently as needed for other contaminants of concern (http://water.epa.gov/drink/contaminants/index.cfm)

How much will it cost?

- Varies depending on analyses selected.
- Basic *E. coli* test should be less than $50.

How do I find a lab?

- County Health Departments
- NELAC-certified labs on TCEQ website

Local Resources

- TSSWCB / SWCD
- USDA NRCS
- AgriLife Extension
- TPWD
- Texas A&M Forest Service
- Regional water and groundwater districts
- River Authority
- Watershed Partnership
- Feral Hog Resources

Texas State Soil and Water Conservation Board

- Headquarters in Temple, Texas
- Nonpoint source Program: http://www.tsswcb.texas.gov/managementprogram
- Contact: Loren Warrick, Riparian Project Manager
  - lwarrick@tsswcb.texas.gov, 254-773-2250 ext. 248
- Website: http://www.tsswcb.texas.gov/
- TSSWCB Field Representative
  Adrian Perez
  aperez@tsswcb.texas.gov

USDA Natural Resources Conservation Service Programs

- Technical Assistance Programs
  - Conservation Technical Assistance (CTA)
- Financial Assistance Programs
  - Environmental Quality Incentive Program (EQIP)
  - Conservation Stewardship Program (CSP)
  - Agricultural Management Assistance Program (AMA)
- Easement Programs
  - Agricultural Conservation Easement Program (ACEP)
  - Healthy Forests Reserve Program (HFRP)
- Partnership Programs
  - Regional Conservation Partnership Program (RCPP)

USDA Natural Resources Conservation Service Programs

- The web link for this information can be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/
- http://efotg.sc.egov.usda.gov//efotg_locator.aspx (Field Guide)
- http://plants.usda.gov/java/ (Plants Database)
- http://websoilsurvey.nrcs.usda.gov/app/ (Soil Survey)

Texas AgriLife Extension Service

AgriLife Extension provides research-based information, educational programs, and technical assistance in the following core service areas:

- Agriculture
- Health and Family Development
- Community & Economic Development
- Environmental Stewardship
- Youth Development

AgriLife Extension Website:
http://agrilifeextension.tamu.edu/

Texas Parks and Wildlife Department

- Melissa Parker, Conservation Ecologist
  - Melissa.Parker@tpwd.texas.gov /512-754-6844 e. 235
- Ryan McGillicuddy, Conservation Ecologist
  - ryan.mcgillicuddy@tpwd.texas.gov / (512) 389-8622
- Find local regional biologists:
  - http://www.tpwd.state.tx.us/landwater/land/technical_guidance/biologists/

Texas A&M Forest Service

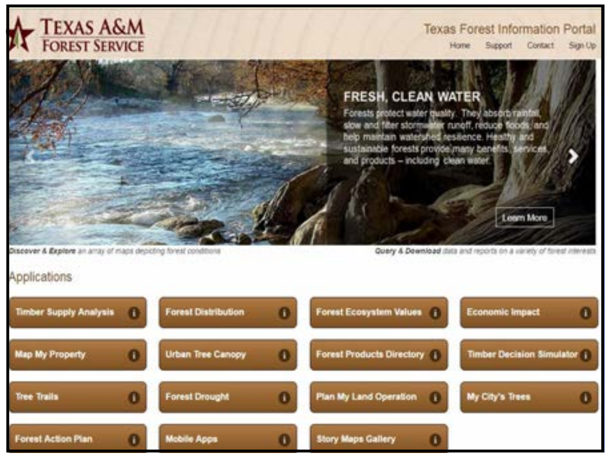
- Contact Texas A&M Forest Service Programs:

http://texasforestservice.tamu.edu/main/article.aspx?ctrl=13

- Hughes Simpson, Department Head in College Station
  - Email: hsimpson@tfs.tamu.edu /979-458-6658
- Shane Harrington, Program Lead in College Station
  - Email: sharrington@tfs.tamu.edu /979-458-6650
- Lori Hazel, Water Resources Staff Forester II in Temple
  - Email: lhazel@tfs.tamu.edu /254-773-8481
- Thomas Dimmitt, Staff Forester I in Lufkin
  - Email: thomas.dimmitt@tfs.tamu.edu /936-639-8182
- Mac Martin, Staff Forester I in Houston
  - Email: mac.martin@tfs.tamu.edu / 713-688-8931
- Jeffrey McFall, Staff Forester I in San Antonio
  - Email: jmcfall@tfs.tamu.edu / 210-494-1742
- Donna Work, Biologist IV in Lufkin
  - Email: dwork@tfs.tamu.edu / (936) 639 - 8191

Texas A&M Forest Service

- Texas Forest Service Best Management Practices: http://texasforestservice.tamu.edu/main/article.aspx?id=15307
- Texas Forest Service: Forests and Water: http://texasforestservice.tamu.edu/main/article.aspx?id=15306
- Texas A&M Forest Service: Water Resources Blog
- Texas Forest Information: http://www.texasforestinfo.com/
- Texas Forest Info Mobile Apps: http://texasforestinfo.tamu.edu/MobileApps/Index.html



TCEQ – NPS Program

- Central Office: TCEQ -

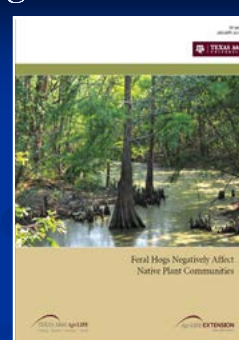
  12100 Park 35 Circle, Austin, TX, 78753

  512-239-6682

  nps@tceq.texas.gov
- Website: https://www.tceq.texas.gov/waterquality/nonpoint-source/

Feral Hogs

•http://pcwp.tamu.edu/FeralHogs/
•http://feralhogs.tamu.edu/
•http://overton.tamu.edu/topics-new/wild-pigs/#.WBi5qC0rKUl
•http://feralhogreports.tamu.edu/
•Publication links
•Site visits for landowners
•Presentations for groups



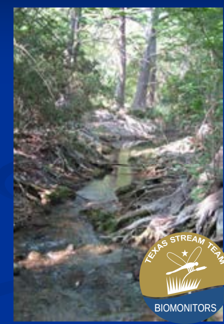
Josh Helcel
Burnet, TX 78611
512-554-3785
Josh.Helcel@tamu.edu

Texas Stream Team

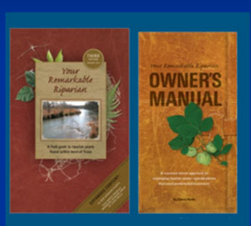
- Texas Stream Team works with partners to train citizens as certified water quality monitors.
- Texas Stream Team provides education to the public and at schools about nonpoint source pollution that harms water quality.
- Environmental data is made available to the public via our online Dataviewer - http://www.meadowscenter.txstate.edu/Service/TexasStreamTeam/datamaps/Dataviewer.html

Texas Stream Team's Riparian Evaluation & Macroinvertebrate Bioassessment Program

- Assess the health of waterways based on the riparian habitat and the aquatic insects that are present there.
- TST's biomonitor citizen scientists assess the health of lakes, rivers, streams or estuaries based on the riparian habitat and the aquatic insects that are present there.
- TST's Riparian Assessment Trainings focus on the nature and function of stream and riparian zones, and the benefits and direct impacts from healthy riparian zones.



Your Remarkable Riparian



- Field Guide to riparian plants found within most of Texas
- Cultivates awareness and appreciation for riparian plants and the role they play in the production of abundant, clean water
- Used as a companion to complete and submit forms with one to four photos to report observations to Texas Stream Team

Riparian Bull's-Eye Evaluation Tool

Ten riparian indicators to guide your eye in assessing riparian landscapes for their function and identifying activities that may be hindering the natural riparian recovery process

More Information on Texas Stream Team

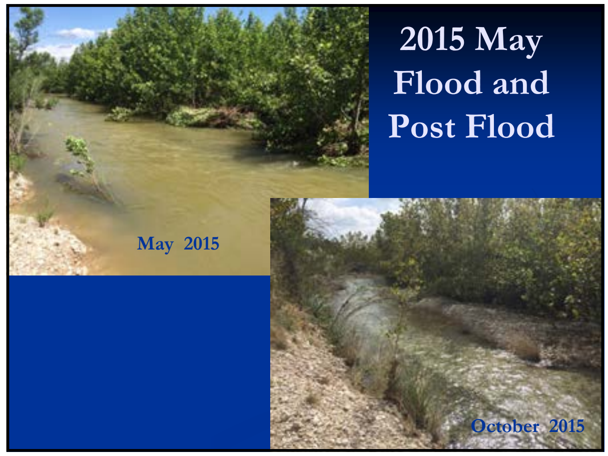
THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STREAM TEAM

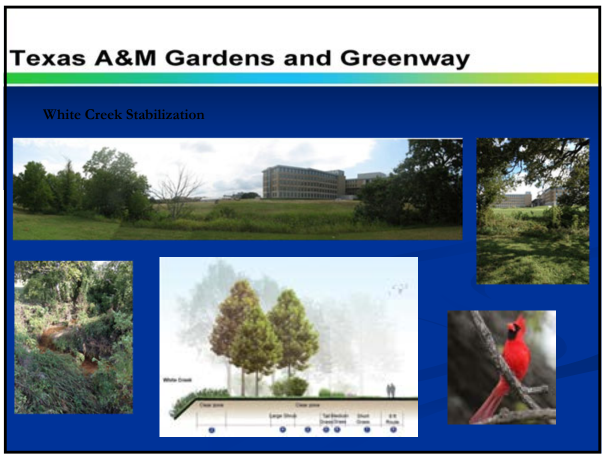
- Jenna Walker, Program Manger
  - 512-245-9148
  - jjwalker@txstate.edu
- Website: http://www.meadowscenter.txstate.edu/Service/TexasStreamTeam.html

Photo Monitoring

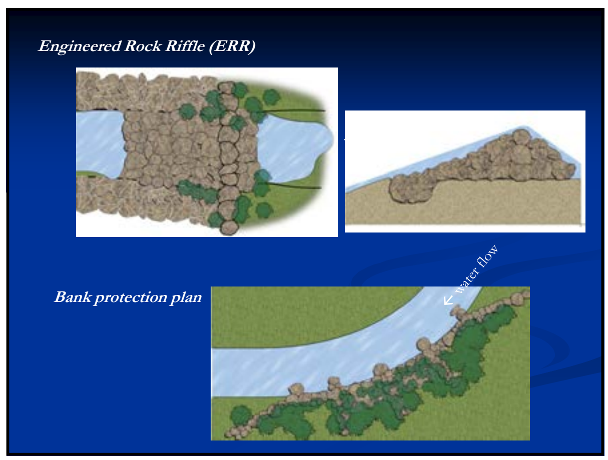
- Repeating photographs at set locations will allow better assessment of current conditions and changes over time.
- Location selection: critical sites along the stream where the force of moving water has the potential for detrimental impacts
  - A tributary or high runoff location
  - Where the stream changes course – point bar or bend
  - Sites that are easily accessible and representative

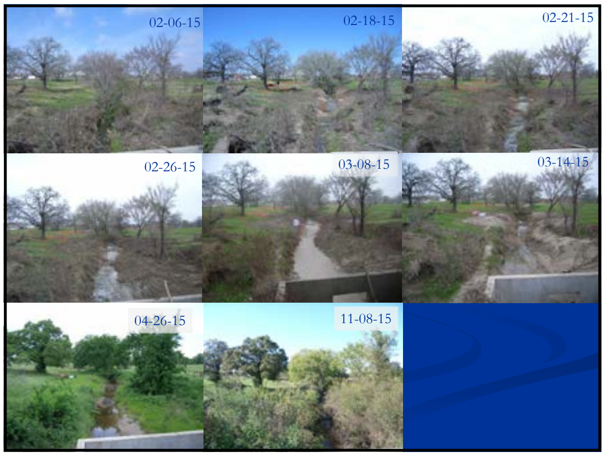

December 2007
June 2014


2015 May Flood and Post Flood
May 2015
October 2015


Texas A&M Gardens and Greenway
White Creek Stabilization


Site Investigation Analysis
white creek restoration concept
Developed - May 28, 2014
Texas A&M
white creek restoration


Engineered Rock Riffle (ERR)
Bank protection plan
water flow

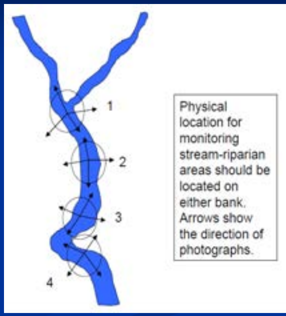


Permanent Photo Point Method

- Four photographs should be taken at each observation site:
  - 1) upstream showing the nearest bank , stream channel and opposite bank if possible,
  - 2) perpendicular to the stream of the opposite bank,
  - 3) perpendicular to the stream away on the bank where the observer is standing, and
  - 4) downstream showing the channel and both banks if possible.
- With a felt pen and a yellow paper pad (white is too bright), make a sign to include in the photo scene.
- Include some identification (stream name, range site, etc.) concerning the specific scene being photographed and the date.

Key Locations to Monitor

- Each location should be permanently marked for future evaluations using a steel stake or on-the-ground reference plus GPS coordinates if possible.
- locate the permanent reference point a "safe" distance inland
- Make a map of the stream showing the location of each permanent marker and the monitoring point.



Thank You!

Clare Entwistle	Nikki Dictson
Texas Water Resources Institute	Texas Water Resources Institute
Clare.Entwistle@ag.tamu.edu	ndictson@ag.tamu.edu
(210)277-0292 Ext. 205	(979)575-4424

healthy, productive soils checklist for growers

unlock the SECRETS IN THE SOIL

Managing for soil health is one of the best ways farmers can increase crop productivity while improving the environment.

Results are often realized immediately and last well into the future. Following are four basic principles to improving the health of your soil.

1. Keep the soil covered as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops

Use the checklist on the back of this page to determine if you're using core Soil Health Management System farming practices. It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. These core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

USDA United States Department of Agriculture

www.nrcs.usda.gov

USDA is an equal opportunity provider and employer.
June 2013

Soil Health Management Systems Include:

What is it?		What does it do?	How does it help?
Conservation Crop Rotation Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.		• Increases nutrient cycling • Manages plant pests (weeds, insects, and diseases) • Reduces sheet, rill and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Improves nutrient use efficiency • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
Cover Crop An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction	• Improves crop production • Improves water quality • Conserves water • Improves nutrient use efficiency • Decreases use of pesticides • Improves water efficiency to crops
No Till A way of growing crops without disturbing the soil through tillage.		• Improves water holding capacity of soil • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity
Mulch Tillage Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.		• Reduces soil erosion from wind and rain • Increases soil moisture for plants • Reduces energy use • Increases soil organic matter	• Improves water quality • Conserves water • Saves renewable resources • Improves air quality • Improves crop production
Mulching Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.		• Reduces erosion from wind and rain • Moderates soil temperatures • Increases soil organic matter • Controls weeds • Conserves soil moisture • Reduces dust	• Improves water quality • Improves plant productivity • Increases crop production • Reduces pesticide usage • Conserves water • Improves air quality
Nutrient Management Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.		• Increases plant nutrient uptake • Improves the physical, chemical and biological properties of the soil • Budgets, supplies, and conserves nutrients for plant production • Reduces odors and nitrogen emissions	• Improves water quality • Improves plant production • Improves air quality
Pest Management Managing pests by following an ecological approach that promotes the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.		• Reduces pesticide risks to water quality • Reduces threat of chemicals entering the air • Decreases pesticide risk to pollinators and other beneficial organisms • Increases soil organic matter	• Improves water quality • Improves air quality • Increases plant pollination • Increases plant productivity

USDA United States Department of Agriculture

Soil Health Key Points

What's critical about soil health now?

1. World population is projected to increase from 7 billion in 2013 to more than 9 billion in 2050. To sustain this level of growth, food production will need to rise by 70 percent.
2. Between 1982–2007, 14 million acres of prime farmland in the U.S. were lost to development.
3. Improving soil health is key to long-term, sustainable agricultural production.

Soil health matters because:

1. Healthy soils are high-performing, productive soils.
2. Healthy soils reduce production costs—and improve profits.
3. Healthy soils protect natural resources on **and** off the farm.
4. Franklin Roosevelt's statement, "The nation that destroys its soil destroys itself," is as true today as it was 75 years ago.
5. Healthy soils can reduce nutrient loading and sediment runoff, increase efficiencies, and sustain wildlife habitat.

What are the benefits of healthy soil?

1. Healthy soil holds more water (by binding it to organic matter), and loses less water to runoff and evaporation.
2. Organic matter builds as tillage declines and plants and residue cover the soil. Organic matter holds 18-20 times its weight in water and recycles nutrients for plants to use.
3. One percent of organic matter in the top six inches of soil would hold approximately 27,000 gallons of water per acre!
4. Most farmers can increase their soil organic matter in **three to 10 years** if they are motivated about adopting conservation practices to achieve this goal.

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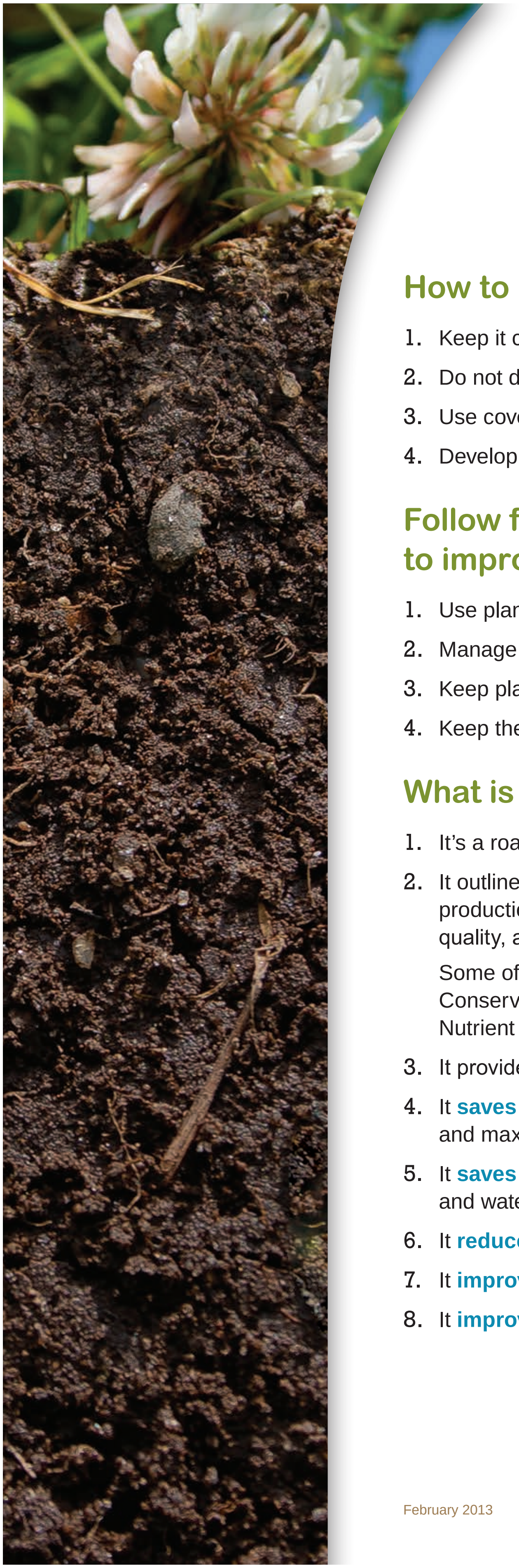
Helping People Help the Land



How to begin your path to Healthy Soils:

1. Keep it covered.
2. Do not disturb.
3. Use cover crops and rotation to feed your soil.
4. Develop a **soil health management plan** with the help of NRCS.

Follow four basic soil health principles to improve soil health and sustainability:

1. Use plant diversity to increase diversity in the soil.
2. Manage soils more by disturbing them less.
3. Keep plants growing throughout the year to feed the soil.
4. Keep the soil covered as much as possible.

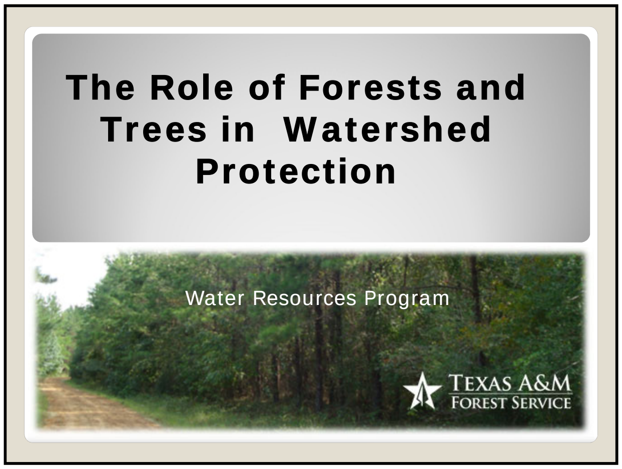
What is a Soil Health Management Plan?

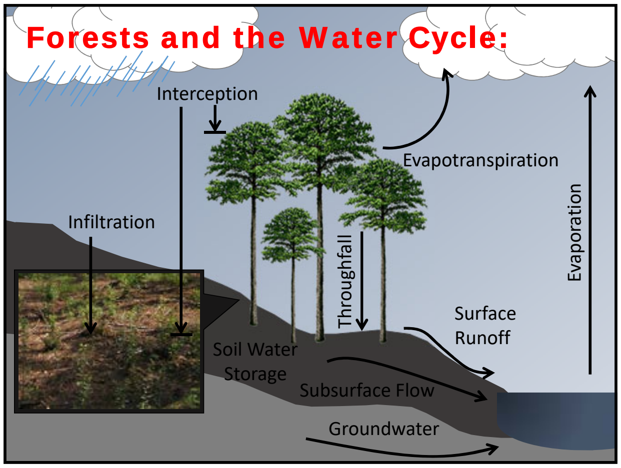
1. It's a roadmap to soil health.
2. It outlines a system of practices needed to enhance crop production and soil function, and improve or sustain water quality, air quality, energy efficiency and wildlife habitat.

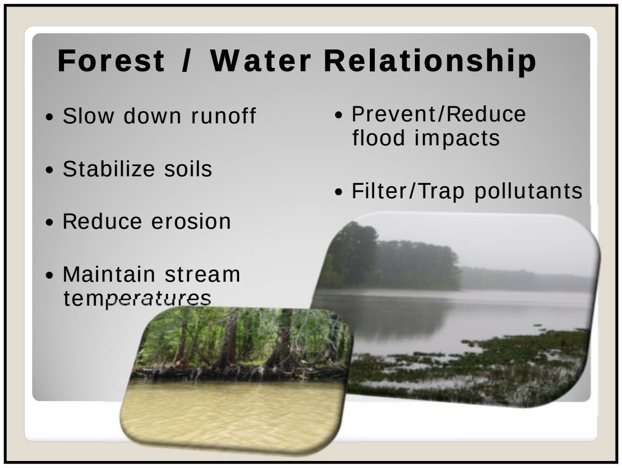
   Some of the recommended conservation practices include: Conservation Crop Rotation, Cover Crops, No Till, Mulching, Nutrient Management, and Pest Management.
3. It provides environmental, economic, health, and societal benefits.
4. It **saves energy** by using less fuel for tillage, and maximizes nutrient cycling.
5. It **saves water** and increases drought tolerance by increasing infiltration and water holding capacity as soil organic matter increases.
6. It **reduces disease** and pest problems.
7. It **improves income sustainability** for farms and ranches.
8. It **improves plant health**.

February 2013

United States Department of Agriculture
Natural Resources Conservation Service

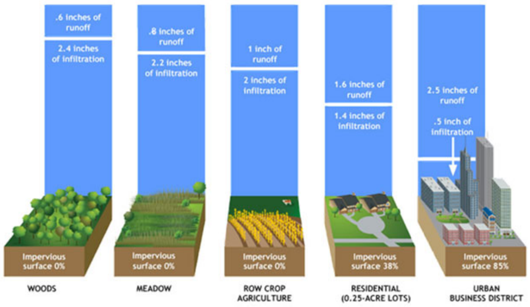






Increased Runoff:

- Increased frequency and severity of flooding
- Reduced ground water recharge
- Decreased base flow in streams
- Increased erosion
- Reduced natural filtration of the water
- Negative impact on stream health



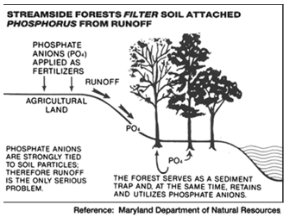
Polluted Runoff:

"Nonpoint Source Pollution"

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems

Forests Act as Pollutant Filters:

- Riparian vegetation **can remove metals, nutrients, and other chemicals from runoff** via plant uptake, and by facilitating bacterial transformation.



  - Studies have shown that buffers along streams can **reduce Nitrogen and Phosphorous pollution by 80-90%**

Effects on Water Temperature:

- Trees shade streams lowering water temperatures
  - Very important for aquatic species
  - Maintains higher dissolved oxygen

- Infiltrated water enters streams at lower temperatures than surface runoff from paved areas

Watershed Protection

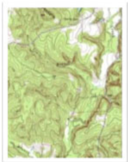
Best Management Practices

- Landowner level
  - Farm
  - Ranch
  - Forest

- Large or small acreage
- We can all make a difference!
  - Big and small efforts: All make up a piece of the pie!

Planning around Streams and Riparian Areas

Aerial Photos



Topographic Maps

USDA Soil Surveys

Field Reconnaissance

Landowner Maps

Weather Reports

3 Types of Streams

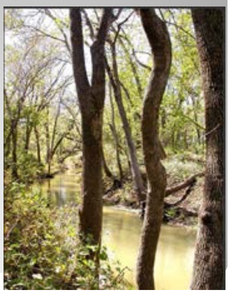
- Perennial
- Intermittent
- Ephemeral

Common Indicators for Classifying Streams

- Stream flow (What percentage of the year is the stream flowing?)
- Definition of the stream channel
- Shape of the stream channel
- Presence of water pools
- Vegetation in and around the stream
- Presence of aquatic insects or wildlife
- High water marks
- Soil Type and Debris movement

Perennial Streams

- Flow 90% of the time during a normal year
- May pool or dry up during drought years
- Have well-defined channels in a serpentine pattern
- Little to no vegetation growing in the channel
- May have visible aquatic insects and wildlife present



Intermittent Streams

- Flow 30-90% of the time during a normal year
- May pool or dry up during summer months
- Have well-defined channels *usually* in a serpentine pattern
- Some growing vegetation may be present in the stream channel

Ephemeral Streams

- Flow less than 30% of the time during a normal year usually immediately after rain events or shortly thereafter
- May or may not have well-defined channels
- Channel is primarily straight
- Growing vegetation may be present in the stream channel

Resources to Help with Determining Stream Type

- USGS Topographical Maps
- Historical Knowledge
- Time of Year/Current Weather Patterns

USGS Topographical Maps

According to this USGS topographic map, this is a perennial stream, and this is an intermittent stream.

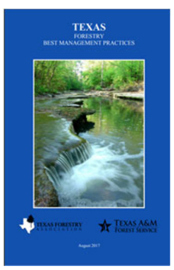
Historical Information

I know from being at this site several times throughout the year that this stream is present throughout most of the year. I've only seen it dry during drought years.

Forestry Best Management Practices (BMPs)

Conservation practices implemented to protect water quality from nonpoint source (NPS) pollution

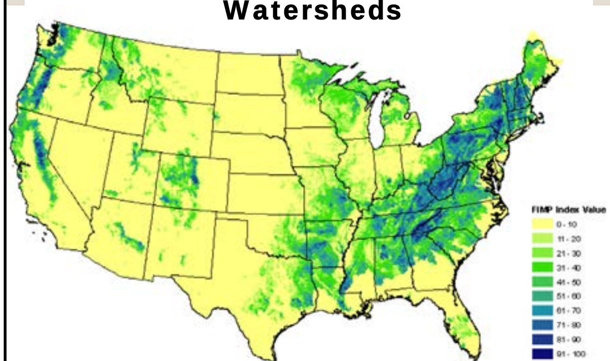
- Sediment
- Organic Material
- Herbicide/Fertilizer Chemicals
- Thermal Changes



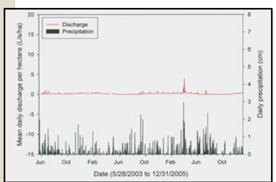
Riparian Forest Buffers

- Maintain riparian forest buffers along perennial and intermittent streams
- Minimize disturbance within these zones
- Avoid stream crossings if possible
- Don't push debris into stream
- Keep roads outside RFBs

Forests to Faucets – Key Forested Watersheds

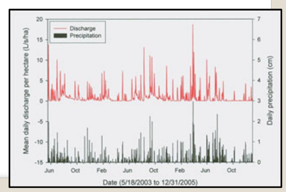


Changes in land use alter the forest-water relationship



Forested Watershed

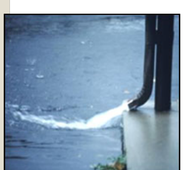
Urban Watershed



Unplanned urbanization threatens the health of the watershed

- Increased Flooding
- Lower Groundwater Recharge
- Impacts to Water Quality, Aquatic Life
- Human Health
- Costly restoration

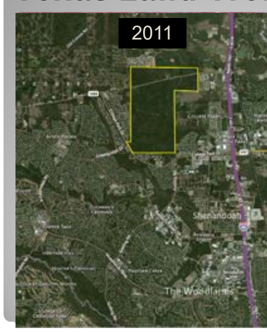
In urban watersheds, when it rains, a large amount of water . . .

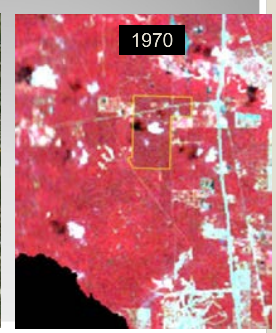


Runs off of impervious surfaces ➡ Enters the stormdrain system ➡ Is directed straight to the stream

Center for Watershed Protection

Texas Land Trends



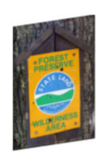


W. G. Jones State Forest, Conroe, Texas

Urbanizing area stream changes flow in W.G. Jones State Forest

Strategies to Protect Water Resources in Developing Areas

- Watershed protection plan
- Land Conservation
  - Acquisition / Easements
  - Restoration
  - Private Land Stewardship
- NPS Management
  - BMPs / Low Impact Development
  - Urban Forest Canopy



NPS Management

BMPs / Low Impact Development (LID)

- Landowner
- Developer
- Construction
- Homeowners

We can all make a difference!

- Big and small efforts: All make up a piece of the pie!

Best Management Practices (BMPs)

Conservation practices implemented to protect water quality from nonpoint source (NPS) pollution

- Sediment
- Nutrients
- Pathogens (Bacteria)
- Thermal Changes

Riparian Buffers

- ➢ Maintain vegetative buffers along streams
- ➢ Minimize disturbance within these zones
- ➢ Careful management

Developer BMPS

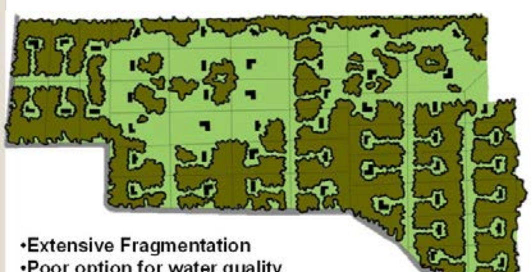
LID

- Treat water where it falls
- Vegetated rooftops

Conservation Design

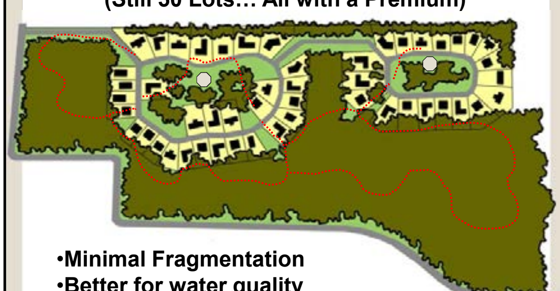
- Incorporate green space

2-Acre "Large Lot" Development



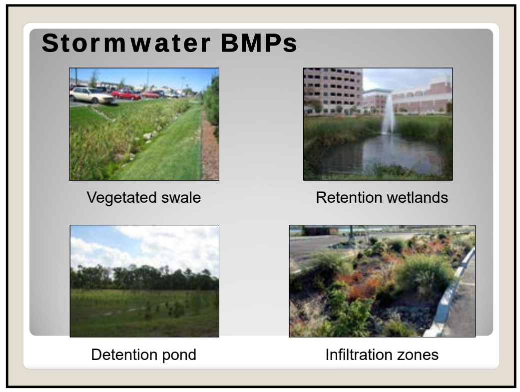
- **Extensive Fragmentation**
- **Poor option for water quality**
- **Maintain 2 Acres, Access 2 Acres**

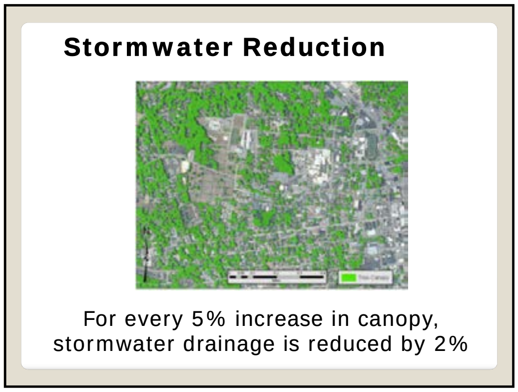
1/2 Acre Conservation Development (Still 50 Lots… All with a Premium)

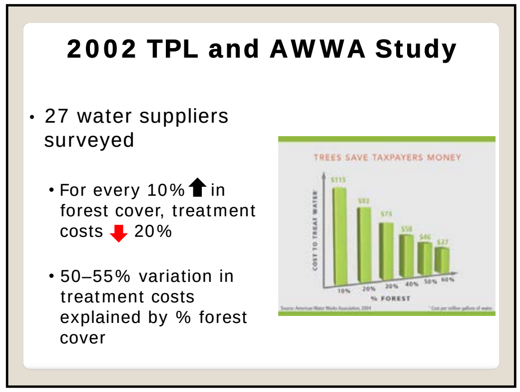


- **Minimal Fragmentation**
- **Better for water quality**
- **Maintain 1/2 Acre, Access 75.5 Acres**


Construction BMPS
Minimize Paved Surfaces
Protect Residual trees
Manage Stormwater


Stormwater BMPs
Vegetated swale
Retention wetlands
Detention pond
Infiltration zones


Stormwater Reduction
For every 5% increase in canopy, stormwater drainage is reduced by 2%

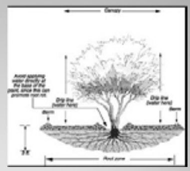

2002 TPL and AWWA Study
• 27 water suppliers surveyed
• For every 10% ⬆ in forest cover, treatment costs ⬇ 20%
• 50–55% variation in treatment costs explained by % forest cover
TREES SAVE TAXPAYERS MONEY


Increasing Urban Forest Cover


Urban Forest Cover
➢Stormwater Reduction
➢Water Quality Improvement
➢Energy Savings
➢Air Quality
➢Other co-benefits
i-Tree

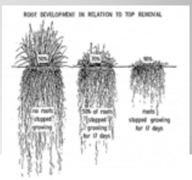
Caring for Urban Trees

- Plan installing utility lines / digging trenches
- Avoid compaction to soil in tree drip zone
- NO mulch Volcanos!



Homeowner BMPS

- Avoid mowing close to creek or drainage area
  - Mow high if you must mow close to creek
  - Aerate compacted soil to promote water filtration and root growth
- Right Plant, Right Place
  - Species requirements



Homeowner Pollution Sources

- Yard clippings/tree limbs or brush in creek = Physical pollution + clogs storm drains
- Fertilizers/Herbicides/Pest Control Supplies = Chemical pollution
- Dumping cleaning supplies/paint cans etc. near trees or down storm drains

Summary

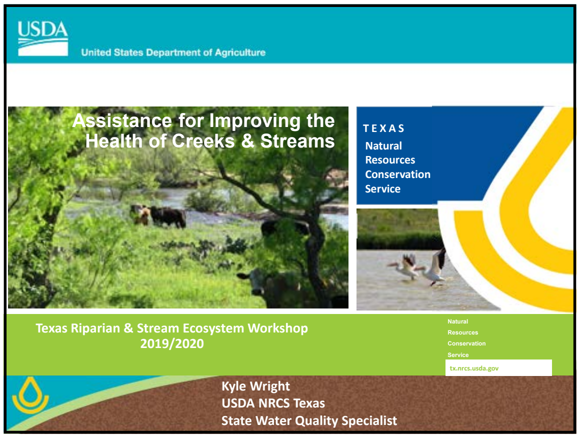
- Forests provide a number of ecosystem services – including clean water
- The more forests and trees in the watershed the better the water quality is likely to be
- Best Management Practices / LID / Urban Forest Cover can be used to manage NPS and protect water resources in developing areas

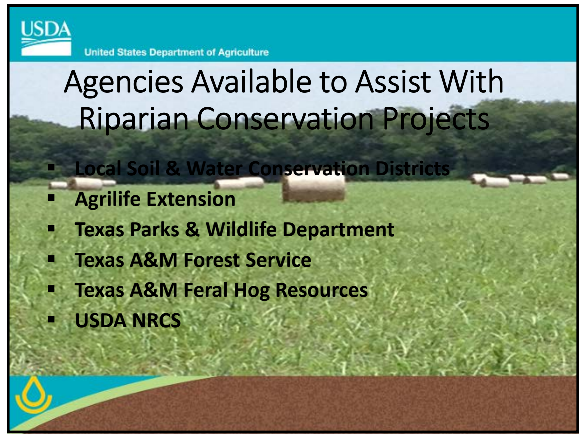
Always know where the low water crossings are located

Do not operate on saturated soils. If you have to…

Information Sources:

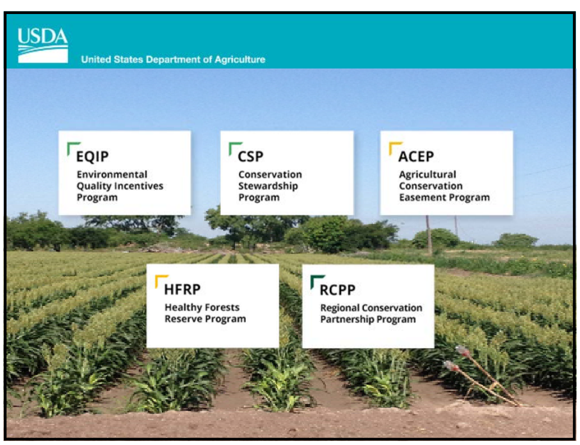
- http://texasforestinfo.com
- https://websoilsurvey.sc.egov.usda.gov
- http://texastreeplanting.tamu.edu
- http://tfsweb.tamu.edu/BMP
- Google Earth


USDA
United States Department of Agriculture
Assistance for Improving the Health of Creeks & Streams
TEXAS
Natural Resources Conservation Service
Texas Riparian & Stream Ecosystem Workshop
2019/2020
Kyle Wright
USDA NRCS Texas
State Water Quality Specialist


USDA
United States Department of Agriculture
Agencies Available to Assist With Riparian Conservation Projects
Local Soil & Water Conservation Districts
Agrilife Extension
Texas Parks & Wildlife Department
Texas A&M Forest Service
Texas A&M Feral Hog Resources
USDA NRCS


USDA
United States Department of Agriculture
Conservation Programs Available through the USDA-NRCS


USDA
2018
FARM
BILL


USDA
United States Department of Agriculture
EQIP
Environmental Quality Incentives Program
CSP
Conservation Stewardship Program
ACEP
Agricultural Conservation Easement Program
HFRP
Healthy Forests Reserve Program
RCPP
Regional Conservation Partnership Program


USDA
United States Department of Agriculture
EQIP
Environmental Quality Incentives Program
The Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, and improved or created wildlife habitat.

USDA United States Department of Agriculture

The Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

USDA United States Department of Agriculture

The Agricultural Conservation Easement Program helps landowners, land trusts, and other entities protect, restore, and enhance wetlands, grasslands, and working farms and ranches through conservation easements.

USDA United States Department of Agriculture

The Healthy Forests Reserve Program (HFRP) helps landowners restore, enhance and protect forestland resources on private and tribal lands through easements and financial assistance. Through HRFP, landowners promote the recovery of endangered or threatened species, improve plant and animal biodiversity and enhance carbon sequestration.

USDA United States Department of Agriculture

The Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and RCPP conservation program contracts.

USDA United States Department of Agriculture

The ACT

Avoid, Control or Trap

- **Use a "systems approach" to address your resource concerns.**
- **Select appropriate practices for Avoiding, Controlling, or Trapping contaminants**

USDA United States Department of Agriculture

Avoid

Practices such as ***Nutrient Management***, ***Cover Crop***, and ***Conservation Crop Rotation*** help producers avoid pollution by reducing the amount of nutrients available in runoff or leaching into water bodies and watersheds. Practices such as cover crops and crop rotation help take up nutrients to avoid potential runoff and pollution. Crop rotations that include differing crops, such as legumes, can limit amounts of commercial nutrients applied.

USDA
United States Department of Agriculture

Control

Land treatment in fields or facilities that prevent the loss of pollutants includes practices such as conservation tillage and residue management, which improve infiltration, reduce runoff, and control erosion. Specific practices such as ***No-till/Strip/Till/Direct Seed***, ***Mulch Tillage***, and ***Ridge Till*** are foundation practices to recommend to producers. Practices such as ***Cover Crop*** will also do double duty by helping with Avoidance as well as Controlling. Other facilitating practices, such as ***Terraces*** or ***Stripcropping***, help control erosion and may manage runoff to reduce nutrients loading.

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Trap

The last line of defense against potential pollutants is to trap them. Practices such as ***Contour Buffers***, ***Filter Strips***, ***Riparian Buffers*** and the suite of ***practices to create, enhance, and/or restore wetlands*** all serve to trap and uptake nutrients and sediments before entering water bodies.

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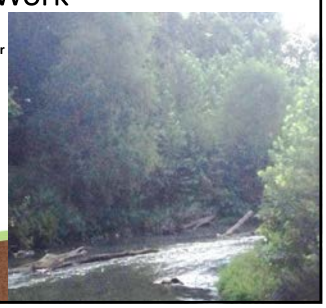
Practices utilized in Riparian Area Conservation Work

- **Riparian Forest Buffer**
- **Riparian Herbaceous Buffer**
- **Fencing**
- **Alternative Water Sources**
- **Filter Strips**
- **Grassed Waterways**
- **Prescribed Grazing**
- **Livestock Exclusions**
- **Brush Control**
- **Others as needed**



USDA
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Questions?

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State Water Quality Specialist
United State Department of Agriculture
Natural Resources Conservation Service
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Common Plants of Riparian Areas - Central Texas

With Wetland Indicator (WI) and Proposed Stability Rating (SR)

Compiled by Steve Nelle

Sedges / Grasses	WI	SR
Spikerushes (most)	OBL	6
Emory sedge	OBL	9
Sawgrass	OBL	9
Rice cutgrass	OBL	6
Southern wildrice	OBL	9
Water bentgrass	OBL	5
Cattail	OBL	9
Bulrushes (most)	OBL	9
Porcupine sedge	OBL	5
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Bushy bluestem	FACW	5
Flatsedges (most)	FACW	5
White top sedge	FACW	5/6
Rushes (most)	OBL or FACW	6
Aparejograss	FACW	6
Barnyardgrass	FACW	4
Rabbitsfoot grass *	FACW	3
Switchgrass	FAC	9
Eastern gammagrass	FAC	9
Lindheimer muhly	FAC	7
Wildrye	FAC	5
White tridens	FAC	5
Vine-mesquite	FAC	6
Seep muhly	FAC	6
Broadleaf Uniola	FAC	6
Dallisgrass *	FAC	7
Vaseygrass *	FAC	5
Rustyseed paspalum	FAC	5
Giant reed (Arundo)*	FAC	7
St Augustine grass *	FAC	6
Indiangrass	FACU	7
Johnsongrass *	FACU	6
Bermudagrass *	FACU	6
Dichanthelium (most)	FACU	4
Southwestern bristle	UPL	5
King Ranch bluestem *	UPL	5

*Indicates Introduced Species

Forbs	WI	SR
Water willow	OBL	7
Water primrose	OBL	3
Watercress *	OBL	3
Scouring rush	OBL	6
Marsh fleabane	OBL	5
Smooth bidens	OBL	5
Water hyssop	OBL	3
Pennywort	OBL	3
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Bog nettle	FACW	5
Dock (most)	FACW	
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Poison hemlock*	FACW	5
Frogfruit	FAC	4
Late boneset	FAC	5
Dogbane	FAC	7
Ironweed	FAC	5
Shield fern	FAC	6
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Cocklebur	FAC	3
Tall goldenrod	FACU	6
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Clammyweed	FACU	3
Castor bean *	FACU	3
Western ragweed	UPL	5
Turk's cap	UPL	5
Toothed goldeneye	UPL	5

Woody	WI	SR
Buttonbush	OBL	8
Bald Cypress	OBL	9
Indigobush amorpha	OBL	7
Black willow	FACW	7
Arroyo willow	FACW	7
Spiny aster	FACW	8
Box elder maple	FACW	6
Possum haw	FACW	6
Sycamore	FAC	6
Eastern cottonwood	FAC	7
Pecan	FAC	6
Little walnut	FAC	7
Roosevelt baccharis	FAC	6
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Bur oak	FAC	6
Chinquapin oak	FAC	6
Lindheimer indigo	FAC	5
Wafer ash (Ptelea)	FAC	6
Dewberry	FAC	4
Greenbriar	FAC	5
Poison ivy	FAC	5
Grape vine (most)	FAC	5
Japanese honeysuckle *	FAC	6
Live oak	FACU	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Mesquite	FACU	5
Huisache	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Desert willow	FACU	6
Carolina snailseed	FACU	4
Chinese tallow *	FACU	6
Gravelbar bricklebush	UPL	5
Slender bricklebush	UPL	5
Whitebrush	UPL	6
Juniper	UPL	5
Mexican persimmon	UPL	5
Vitex *	UPL	6
Ligustrum *	UPL	6
Chinaberry *	UPL	6

SR - Stability Ratings are on a scale of 1 – 10. The Stability Rating concept was developed by Al Winward, retired USFS Ecologist. Bare ground has a SR of 1. Anchored rock or logs have a SR of 10. A SR of 7 is considered the minimum for acceptable bank stability in the Hill Country. The ratings are subjective and based on experience and observation. Woody plants, when associated with stabilizing grasses and sedges provide a higher stability rating than if they occur alone.

WI - Wetland Indicator Categories

OBL *Obligate Wetland* These plants are very indicative of wet soil conditions and/or a high water table.

FACW *Facultative Wetland* These plants usually grow in wet and seasonally moist areas

FAC *Facultative* These plants can tolerate wet conditions as well as periodically dry condions.

FACU *Facultative Upland* These plants do not tolerate very wet conditions and are indicative of dry locations.

UPL *Obligate Upland* Thse plants almost always occur in non wet areas

Revised January, 2012

For comments, additions or corrections contact: nelleangelo@suddenlink.net

Common Plants of Riparian Areas - Central – Southwest Texas

With Wetland Indicator (WI) and Proposed Stability Rating (SR)

Sedges / Grasses	WI	SR
Spikerushes (most)	OBL	6
Emory sedge	OBL	9
Sawgrass	OBL	9
Rice cutgrass	OBL	6
Water bentgrass	OBL	5
Cattail	OBL	9
Bulrushes (most)	OBL	9
Porcupine sedge	OBL	5
Black sedge	OBL	6
Teal lovegrass	OBL	4
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Bushy bluestem	FACW	5/6
Flatsedges (most)	FACW	5/6
Common reed	FACW	9
Gulf cordgrass	FACW	9
White top sedge	FACW	5/6
Rushes (most)	OBL or FACW	6
Aparejograss	FACW	6
Spike bentgrass	FACW	5
Barnyardgrass	FACW	4
Junglerice *	FACW	4
Rabbitsfoot grass *	FACW	3
Carolina canarygrass *	FACW	3
Wetland sprangletops	FACW	4
Switchgrass	FAC	9
Eastern gammagrass	FAC	9
Big sacaton	FAC	9
Alkali sacaton	FAC	7
Lindheimer muhly	FAC	7
Wildrye	FAC	5/6
White tridens	FAC	5
Vine-mesquite	FAC	6
Seep muhly	FAC	6
Nimble-will	FAC	5
Broadleaf Uniola	FAC	5
Dallisgrass *	FAC	7
Vaseygrass *	FAC	5/6
Rustyseed paspalum	FAC	5
Giant reed (Arundo)*	FAC	7
St Augustine grass *	FAC	6
Buffalograss	FACU	3
Indiangrass	FACU	7
Johnsongrass *	FACU	6
Bermudagrass *	FACU	6
Big sandbur	FACU	7
Dichanthelium (most)	FACU	4
Southwestern bristle	UPL	5
King Ranch bluestem *	UPL	5
Creeping muly	UPL	6

*Indicates Introduced Species

SR - Stability Ratings (Draft) on a scale of 1 – 10. Based on USFS GTR-47, by Al Winward. Bare ground has a SR of 1. Anchored rock or logs have a SR of 10. A SR of 7 (or 6) is considered the minimum for acceptable bank stability. Woody plants, when associated with stabilizing grasses and sedges provide a higher stability rating that shown

Forbs	WI	SR
Water willow	OBL	7
Ludwigia	OBL	3
Watercress *	OBL	3
Scouring rush	OBL	6
Marsh aster	OBL	3
Marsh fleabane	OBL	5
Smooth bidens	OBL	5
Water hyssop	OBL	3
Burhead	OBL	3
Pennywort	OBL	3
Monkeyflower	OBL	3
Swamp rosemallow	OBL	5
California loostrife	OBL	5
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Smartweed (most)	FACW	3
Bog nettle	FACW	5
Dock (most)	FACW	3/4
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Frogfruit	FAC	4
Late boneset	FAC	5
Ironweed	FAC	5
Shield fern	FAC	6
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Cocklebur	FAC	3
Tall goldenrod	FACU	6
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Heath aster	FACU	5
Illinois bundleflower	FACU	4
Clammyweed	FACU	3
Castor bean *	FACU	3
Western ragweed	UPL	5
Field ragweed	UPL	5
Mexican sagewort	UPL	5
Turk's cap	UPL	5
Toothed goldeneye	UPL	5

WI - Wetland Indicator Categories
(Region 6 USFWS)

OBL *Obligate Wetland* Almost always occur in wet areas.
FACW *Facultative Wetland* Occur in wet areas 67-99% probability.
FAC *Facultative* About equally likely to occur in wet and non wet areas.
FACU *Facultative Upland* Occur in wet areas 1-33% probability; otherwise, in uplands
UPL *Obligate Upland* Almost always occur in non wet areas

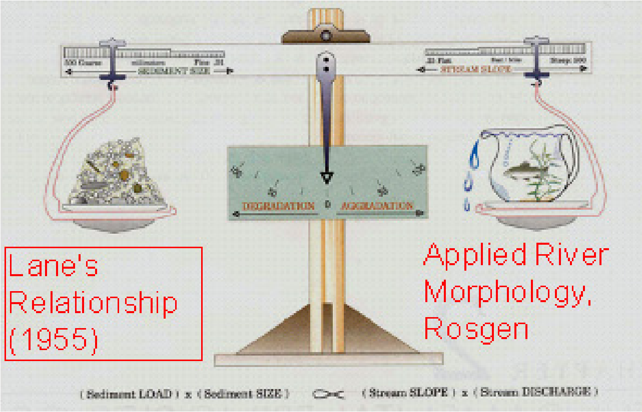
Woody	WI	SR
Buttonbush	OBL	8
Bald Cypress	OBL	9
Indigobush amorpha	OBL	7
Seepwillow baccharis (B. salicifolia)	FACW	6
Black willow	FACW	7
Arroyo willow	FACW	7
Sandbar willow	FACW	7
Spiny aster	FACW	8
Box elder maple	FACW	6
Retama	FACW	6
Possum haw	FACW	6
Sycamore	FAC	6
Eastern cottonwood	FAC	7
Pecan	FAC	6
Little walnut	FAC	7
Roosevelt baccharis (B. neglecta)	FAC	6
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Mexican ash	FAC	6
Bur oak	FAC	6
Chinquapin oak	FAC	6
Lindheimer indigo	FAC	5
Wafer ash (Ptelea)	FAC	6
Dewberry	FAC	4
Greenbriar	FAC	5
Poison ivy	FAC	5
Grape vine (most)	FAC	5
Japanese honeysuckle *	FAC	6
Live oak	FACU	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Mesquite	FACU	5
Huisache	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Desert willow	FACU	6
Carolina snailseed	FACU	4
Chinese tallow *	FACU	6
Gravelbar bricklebush	UPL	5
Slender bricklebush	UPL	5
Burrobush	UPL	6
Whitebrush	UPL	6
Juniper	UPL	5
Mexican persimmon	UPL	5
Spiny hackberry	UPL	5
Bois d'arc	UPL	6
Vitex *	UPL	6
Ligustrum *	UPL	6
Chinaberry *	UPL	6

Revised May, 2009

For comments, additions or corrections contact: steve.nelle@tx.usda.gov

What is a Functional Creek?

Creeks and riparian areas function properly when there is:
Adequate Vegetation, Landscape formations, or Large wood to:



→ Dissipate stream energy

→ Protect banks / stabilize channel

→ Reduce erosion

→ Slow the velocity of floodwaters

→ Sediment dropped

→ Sediment trapped, and stabilized

→ Build floodplains

→ Provide floodwater retention

→ Enlarge riparian sponge

→ Improve groundwater recharge

→ More water for sustained base-flow

Results:

- Improved water quality
- Sustained flow over time
- Increased forage for livestock
- Excellent fish and wildlife habitat

How:

- Smaller pastures; Rotational grazing
- Riparian pastures; Abbreviated grazing periods; Long rest periods
- Off site water for livestock; Offsite salt, minerals and feeding
- Retain tall dense vegetation with good stabilizing root mass
- Reduced human traffic, Limited mowing, Light grazing

Key Points:

- Slow the water down with dense vegetation
- Keep water on the land longer
- Think Water-catchment, not Water-shed

Common Plants of Riparian Areas - Central/West Texas

With Wetland Indicator (WI) and Proposed Stability Rating (SR)

Sedges / Grasses	WI	SR
Spikerushes (most)	OBL	6
Emory sedge	OBL	9
Sawgrass	OBL	9
Rice cutgrass	OBL	6
Southern wildrice	OBL	9
Water bentgrass	OBL	5
Cattail	OBL	9
Bulrushes (most)	OBL	9
Porcupine sedge	OBL	5
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Bushy bluestem	FACW	5
Common reed	FACW	9
Flatsedges (most)	FACW	5
White top sedge	FACW	5/6
Rushes (most)	OBL or FACW	6
Aparejograss	FACW	6
Alkali muhly	FACW	6
Barnyardgrass	FACW	4
Rabbitsfoot grass *	FACW	3
Switchgrass	FAC	9
Eastern gammagrass	FAC	9
Lindheimer muhly	FAC	7
Deer grass muhly	FAC	9
Big sacaton	FAC	9
Alkali sacaton	FAC	7
Wildrye	FAC	5
White tridens	FAC	5
Vine-mesquite	FAC	6
Seep muhly	FAC	6
Broadleaf Uniola	FAC	6
Dallisgrass *	FAC	7
Vaseygrass *	FAC	5
Rustyseed paspalum	FAC	5
Giant reed (Arundo)*	FAC	8
St Augustine grass *	FAC	5
Indiangrass	FACU	7
Johnsongrass *	FACU	6
Bermudagrass *	FACU	5
Dichanthelium (most)	FACU	4
Southwestern bristle	UPL	5
King Ranch bluestem *	UPL	5
Bulb panicum	UPL	8

*Indicates Introduced Species

SR - Stability Ratings are on a scale of 1 – 10. The Stability Rating concept was developed by Al Winward, retired USFS Ecologist. Bare ground has a SR of 1. Anchored rock or logs have a SR of 10. A SR of 7 is considered the minimum for acceptable bank stability in the Hill Country. The ratings are subjective and based on experience and observation. Woody plants, when associated with stabilizing grasses and sedges provide stability higher than what is indicated.

Forbs	WI	SR
Water willow	OBL	7
Water primrose	OBL	3
Watercress *	OBL	3
Scouring rush	OBL	6
Marsh fleabane	OBL	5
Smooth bidens	OBL	5
Water hyssop	OBL	3
Pennywort	OBL	3
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Bog nettle	FACW	5
Dock (most)	FACW	5
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Poison hemlock*	FACW	5
Frogfruit	FAC	4
Late boneset	FAC	5
Dogbane	FAC	7
Ironweed	FAC	5
Shield fern	FAC	6
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Cocklebur	FAC	3
Tall goldenrod	FACU	6
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Clammyweed	FACU	3
Castor bean *	FACU	3
Western ragweed	UPL	5
Turk's cap	UPL	5
Toothed goldeneye	UPL	5

WI - Wetland Indicator Categories

OBL *Obligate Wetland* These plants are very indicative of wet soil conditions and/or a high water table.
FACW *Facultative Wetland* These plants usually grow in wet and seasonally moist areas
FAC *Facultative* These plants can tolerate wet conditions as well as periodically dry condions.
FACU *Facultative Upland* These plants do not tolerate very wet conditions and are indicative of dry locations.
UPL *Obligate Upland* Thse plants almost always occur in non wet areas

Woody	WI	SR
Buttonbush	OBL	8
Bald Cypress	OBL	10
Indigobush amorpha	OBL	7
Black willow	FACW	7
Arroyo willow	FACW	7
Sandbar willow	FACW	7/8
Seepwillow baccharis	FACW	6
Spiny aster	FACW	8
Box elder maple	FACW	6/7
Possum haw	FACW	6
Sycamore	FAC	6
Eastern cottonwood	FAC	7
Pecan	FAC	6
Little walnut	FAC	7/8
Roosevelt baccharis	FAC	6
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Bur oak	FAC	6
Chinquapin oak	FAC	6
Lindheimer indigo	FAC	5
Wafer ash (Ptelea)	FAC	6
Dewberry	FAC	4
Greenbriar	FAC	5
Poison ivy	FAC	5
Grape vine (most)	FAC	5
Japanese honeysuckle *	FAC	6
Live oak	FACU	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Mesquite	FACU	5
Huisache	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Desert willow	FACU	6
Carolina snailseed	FACU	4
Chinese tallow *	FACU	6
Gravelbar bricklebush	UPL	5
Slender bricklebush	UPL	5
Whitebrush	UPL	6
Burrobrush	UPL	6
Juniper	UPL	5
Mexican persimmon	UPL	5
Vitex *	UPL	6
Ligustrum *	UPL	6
Chinaberry *	UPL	5

Revised May 2013

For comments, additions or corrections contact: Steve Nelle
nelleangelo@suddenlink.net

Common Plants of Riparian Areas - East CentralTexas

With Wetland Indicator (WI) and Proposed Stability Rating (SR)

Sedges / Grasses	WI	SR
Spikerushes (most sp.)	OBL	6
Emory sedge	OBL	9
Sawgrass	OBL	9
Rice cutgrass	OBL	6
Southern wildrice	OBL	9
Water bentgrass	OBL	5
Cattail	OBL	9
Bulrushes (most)	OBL	9
Porcupine sedge	OBL	5
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Florida paspalum	FACW	6
Bushy bluestem	FACW	5
Common reed	FACW	9
Flatsedges (most)	FACW	5
White top sedge	FACW	5/6
Rushes (most)	OBL or FACW	5/7
Aparejograss	FACW	6
Barnyardgrass	FACW	4
Rabbitsfoot grass *	FACW	3
Carolina canarygrass	FACW	3
Switchgrass	FAC	9
Eastern gammagrass	FAC	9
Lindheimer muhly	FAC	7
Wildrye	FAC	5
White tridens	FAC	5
Vine-mesquite	FAC	6
Seep muhly	FAC	6
Broadleaf Uniola	FAC	6
Dallisgrass *	FAC	7
Vaseygrass *	FAC	5
Rustyseed paspalum	FAC	5
Giant reed (Arundo)*	FAC	9
St Augustine grass *	FAC	5
Knotroot bristlegrass	FAC	4
Indiangrass	FACU	7
Johnsongrass *	FACU	6
Bermudagrass *	FACU	5
Dichanthelium (most)	FACU	4
Southwestern bristle	UPL	5
King Ranch bluestem *	UPL	5
Bulb panicum	UPL	8

*Indicates Introduced Species

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Forbs	WI	SR
Water willow	OBL	7
Water primrose	OBL	3
Watercress *	OBL	3
Scouring rush	OBL	6
Marsh fleabane	OBL	5
Smooth bidens	OBL	5
Water hyssop	OBL	3
Pennywort	OBL	3
Water hemlock	OBL	6
Monkeyflower	OBL	3
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Bog nettle	FACW	5
Dock (most)	FACW	5
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Poison hemlock*	FACW	5
Frogfruit	FAC	4
Late boneset	FAC	5
Dogbane	FAC	7
Ironweed	FAC	5
Shield fern	FAC	6
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Cocklebur	FAC	3
Tall goldenrod	FACU	6
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Clammyweed	FACU	3
Castor bean *	FACU	3
Western ragweed	UPL	5
Turk's cap	UPL	5
Toothed goldeneye	UPL	5

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UPL *Obligate Upland* Thse plants almost always occur in non wet areas

Woody	WI	SR
Buttonbush	OBL	8
Bald Cypress	OBL	10
Indigobush amorpha	OBL	7
Black willow	FACW	7
Arroyo willow	FACW	7
Green ash	FACW	6
Spiny aster	FACW	8
Box elder maple	FACW	6/7
Possum haw	FACW	6
Salt cedar	FACW	7
Sycamore	FAC	6
Eastern cottonwood	FAC	7
Pecan	FAC	6
Little walnut	FAC	7/8
Roosevelt baccharis	FAC	6
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Oaks	FAC	6
Lindheimer indigo	FAC	5
Wafer ash (Ptelea)	FAC	6
Dewberry	FAC	4
Greenbriar	FAC	5
Poison ivy	FAC	5
Grape vine (most)	FAC	5
Japanese honeysuckle *	FAC	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Mesquite	FACU	5
Huisache	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Carolina snailseed	FACU	4
Chinese tallow *	FACU	6
American beautyberry	FACU	4
Osage orange	UPL	6
Gravelbar bricklebush	UPL	5
Slender bricklebush	UPL	5
Whitebrush	UPL	6
Juniper	UPL	5
Mexican persimmon	UPL	5
Vitex *	UPL	6
Ligustrum *	UPL	6
Chinese privet *	UPL	6
Chinaberry *	UPL	5

Revised June 2015

For comments, additions or corrections contact: Steve Nelle
nelleangelo@suddenlink.net

Common Plants of Riparian Areas - North Central Texas
With Wetland Indicator (WI) and Draft Stability Rating (SR)

Sedges / Grasses	WI	SR
Spikerushes (most)	OBL	6/7
Emory sedge	OBL	9
Sedges (most)	OBL	7/8
Sawgrass	OBL	9
Rice cutgrass	OBL	5
Southern wild rice	OBL	9
Water bentgrass *	OBL	5
Cattail	OBL	9
Bulrushes (most)	OBL	9
Rush (most)	OBL	6
Knotgrass	FACW	6
Hairyseed paspalum	FACW	6
Bushy bluestem	FACW	5/6
Flatsedges (most)	FACW	5/6
Inland saltgrass	FACW	6
Common reed	FACW	9
Barnyard grass	FACW	6
Florida paspalum	FACW	4
Winter bentgrass	FACW	5
Junglerice *	FACW	4
Rabbitsfoot grass *	FACW	3
Carolina canarygrass *	FACW	3
Wetland sprangletops	FACW	4
Switchgrass	FAC	9
Eastern gammagrass	FAC	9
Wildrye	FAC	5/6
White tridens	FAC	5
Vine-mesquite	FAC	6
Lindheimer muhly	FAC	7
Western wheatgrass	FAC	7
Dallisgrass *	FAC	7
Broad-leaf wood-oats	FAC	5
Knotroot bristle grass	FAC	5
Big sacaton	FAC	9
Alkali sacaton	FAC	7
Deergrass	FAC	8
Giant reed *	FAC	9
Buffalograss	FACU	3
Indiangrass	FACU	7
Little bluestem	FACU	5
Johnsongrass *	FACU	6
Bermudagrass *	FACU	6
Big sandbur	FACU	7
Southwestern bristle	UPL	5
Bulb panicum	UPL	8
Texas wingergrass	UPL	5
Texas bluegrass	UPL	6
Purpletop tridens	UPL	5
King Ranch bluestem *	UPL	5
Creeping muly	UPL	6

***Indicates Introduced Species**

SR - Stability Ratings (Draft) on a scale of 1 – 10. Based on USFS GTR-47, by Al Winward. Bare ground has a SR of 1. Anchored rock or logs have a SR of 10. A SR of 7 in high gradient (>0.3% slope) streams or a SR of 6 in low gradient (<0.3% slope) streams is considered the minimum for acceptable bank stability.

Forbs	WI	SR
Water willow	OBL	8
Scouring rush	OBL	7
Marsh fleabane	OBL	5
Water primrose	OBL	3
Watercress *	OBL	3
Marsh aster	OBL	3
Arrowhead	OBL	3
Water hyssop	OBL	3
Pennywort	OBL	3
Monkeyflower	OBL	3
Cardinalflower	FACW	5
Tall aster	FACW	5
Spiny aster	FACW	8
Large buttercup	FACW	6
Bog-hemp	FACW	5
Smartweed (most)	FACW	3
Dock (most)	FACW	3/4
Swamp milkweed	FACW	3
Mint *	FACW	3
Smallhead sneezeweed	FACW	3
Sesbania	FACW	3
Missouri violet	FACW	3
Late boneset	FAC	5
Frogfruit	FAC	4
Joe pye weed	FAC	4
Giant ragweed	FAC	3
Annual sumpweed	FAC	3
Brazilian verbena *	FAC	4
Tall goldenrod	FACU	7
Common ragweed	FACU	2
Frostweed	FACU	6
Maximilian sunflower	FACU	6
Heath aster	FACU	5
Illinois bundleflower	FACU	4
Carolina snailseed	FACU	4
Clammyweed	FACU	3
Western ragweed	UPL	5
Field ragweed	UPL	5
Mexican sagewort	UPL	5
Pigeonberry	UPL	3

WI - Wetland Indicator Categories
(Region 6 USFWS)

OBL *Obligate Wetland*
almost always occur in wetlands.

FACW *Facultative Wetland*
Usually occur in wetlands;
67-99% probability.
Occasionally occur in non wetlands.

FAC *Facultative*
Equally likely to occur in wetlands and non wetlands.

FACU *Facultative Upland* Usually occur in non wetlands;
67-99% probability;
Occasionally occur in wetlands.

UPL *Obligate Upland* species;
almost always occur in non wetlands

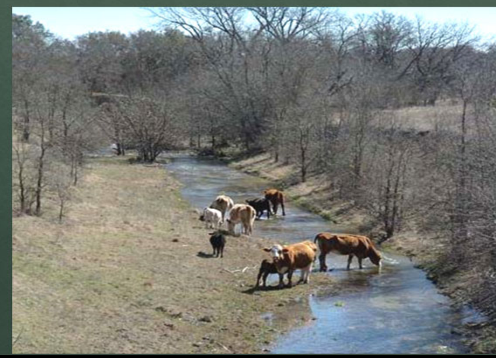
Woody	WI	SR
Buttonbush	OBL	8
Indigobush amorpha	OBL	7
Overcup oak	OBL	7
Water hickory	OBL	7
Swamp privet	OBL	7
Willow oak	FACW	6
River birch	FACW	6
Black willow	FACW	7
Sandbar willow	FACW	7
Green ash	FACW	6
Saltcedar *	FACW	7
Possomhaw	FACW	6
Box elder maple	FACW	6
Eastern cottonwood	FAC	7
Water oak	FAC	6
Shumard red oak	FAC	6
Dewberry	FAC	4
Sycamore	FAC	6
Pecan	FAC	6
Little walnut	FAC	6
Roosevelt baccharis (B. neglecta)	FAC	6
Japanese honeysuckle *	FAC	5
American elder	FAC	6
Roughleaf dogwood	FAC	6
Sugar hackberry	FAC	5
American elm	FAC	6
Cedar elm	FAC	6
Slippery elm	FAC	6
Bur oak	FAC	6
Chinquapin oak	FAC	6
Virginia-Creeper	FAC	4
Honey locust	FAC	6
Wafer ash (Ptelea)	FAC	6
Sweet gum	FAC	6
Green briar	FAC	5
Rusty blackhaw	FACU	6
Live oak	FACU	6
Netleaf hackberry	FACU	5
Red mulberry	FACU	6
Winged elm	FACU	6
Mesquite	FACU	5
Western soapberry	FACU	6
Bumelia	FACU	6
Black walnut	FACU	6
Desert willow	FACU	6
Elbowbush	FACU	5
American beauty-berry	FACU	4
Coralberry	FACU	4
Eastern red cedar	FACU	6
Osage Orange	UPL	6
Whitebrush	UPL	6
Mexican persimmon	UPL	5
Chinese privet *	UPL	5
Juniper	UPL	5
Fourwing saltbush	UPL	4

Adapted by Ricky.Linex@tx.usda.gov from Common Plants of Riparian Areas – Central and Southwestern Texas by Steve Nelle

Grazing Practices and Web Soil Survey

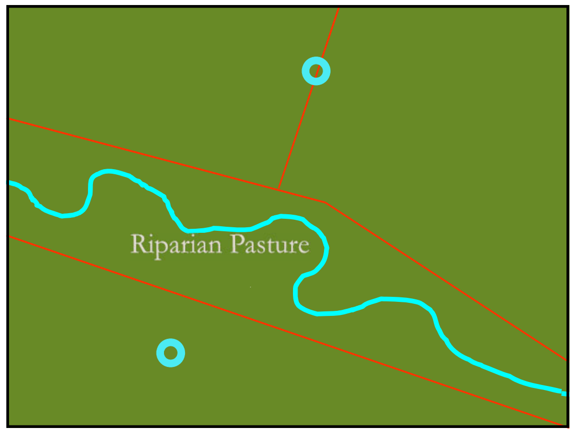
USDA NRCS

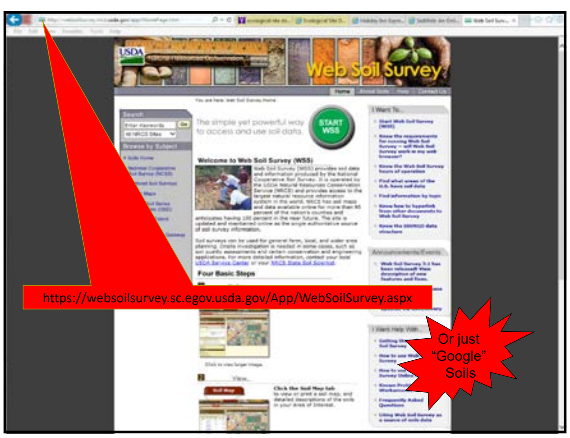
Disproportional Grazing in Riparian Areas

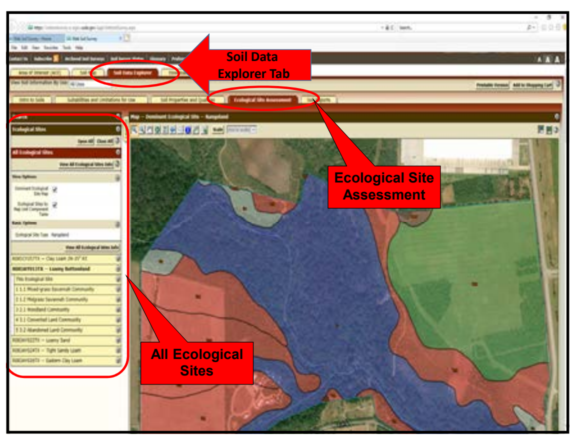


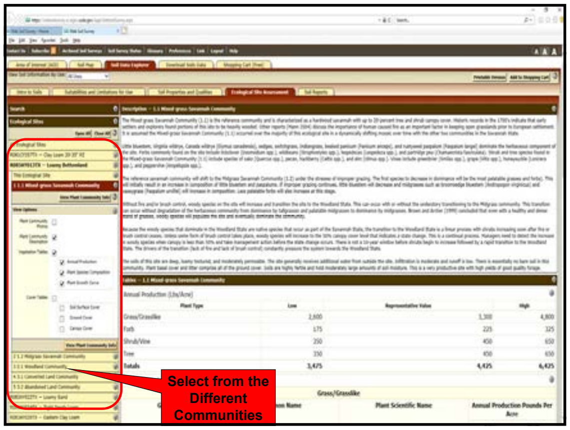
Solutions

- Riparian pasture (abbreviated grazing, long rest)
- Off site water/mineral sites
- Riparian buffers
- SMZ (streamside management zones)
- Population management
- Upstream management
- Time
- Water catchment not watershed





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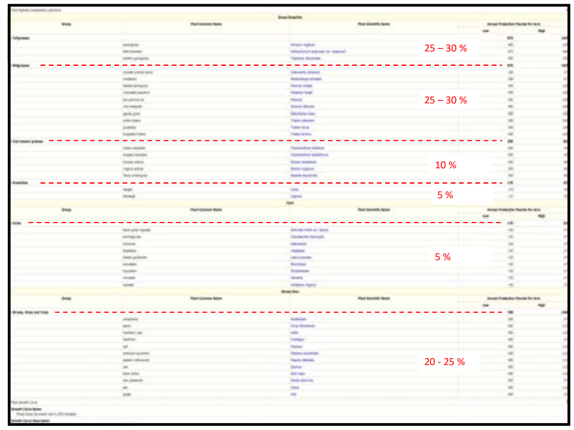
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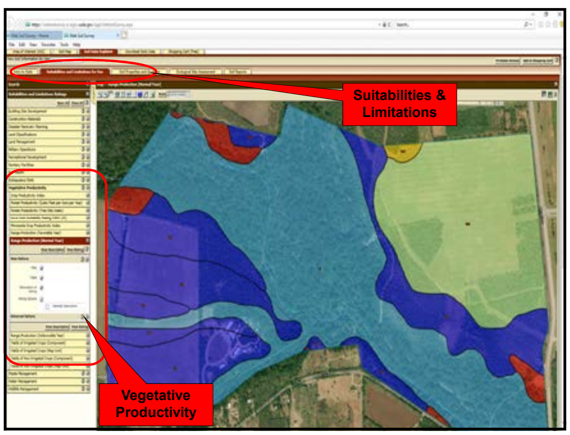
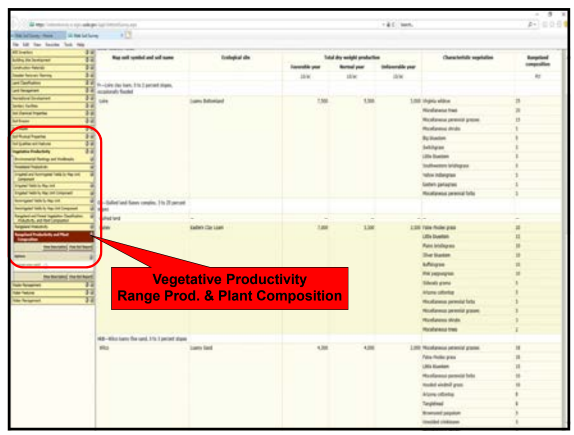
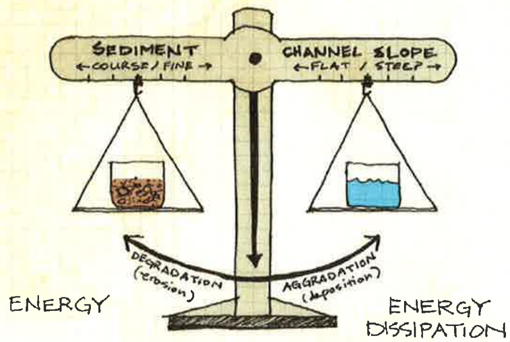

Suitabilities &
Limitations
Vegetative
Productivity


Vegetative Productivity
Range Prod. & Plant Composition

There is a Balance

Lane's Balance models the dynamic relationship between water and sediment, or degradation (erosion) and aggradation (deposition), respectively, in a stream channel at bank-full and above. Two additional variables also influence this relationship—sediment size (cobble, gravel, fine silt, sand, clay) and channel slope (flat vs steep, determined mainly by crookedness or meander patterns).



$Q_s \cdot D_{50} \propto Q_w \cdot S$

Q_s = Sediment discharge Q_w = Streamflow
D_{50} = Sediment particle size S = Channel Slope

(Lane, E.W., 1955. Design of Stable Channels. Transactions, Am. Soc. Civil Eng. 120:1234.)

Consider that a stream's "job" is to move water and sediment downhill. Stream channels evolve naturally to balance and transport the water and sediment generated within their catchment areas. Changes within a catchment area that affect either volume of water or amount of sediment load can cause the stream to become out-of-balance. The channel can react by degrading or aggrading. However, the balance will eventually return in accord with Lane's model.

Degradation/Erosion:
Here's an example of how it works.

Upland clearing, large-scale brush control, overgrazing, road building, more rooftops or increased impervious cover, can increase the volume of rainwater run-off that ends up in the stream channel. One immediate result can be channel **degradation** seen as excessive **erosion,** down-cutting and/or widening the stream channel — too much energy, not enough energy dissipation. (See Figure A.)

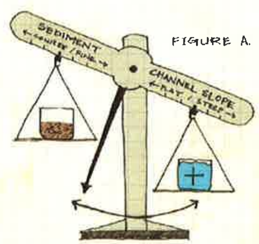
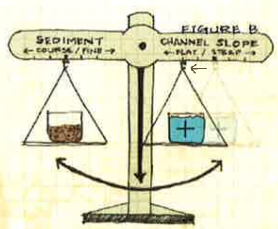


FIGURE A.

This erosion of the materials from beds and banks will add even more sediment to the stream. As a means of re-balancing, the channel may adjust its slope by incorporating the newly mined sediments to become flatter. This happens by the creation of meander bends that add to the overall length and ultimately reduce the slope of the stream channel. (See Figure B.)

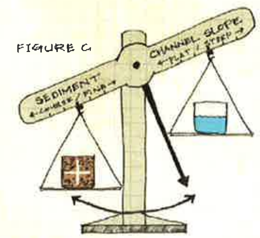
FIGURE B.



$Q_s \cdot D_{50} \propto Q_w \cdot S$

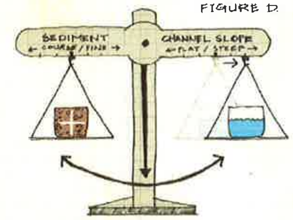
Aggradation/Deposition:
Here's an example of how it works.

FIGURE C.



Gravel mining or other mechanical disturbances of sediments can release more sediment to a channel than it has the water, or energy, to manage. When the sediment side of the balance experiences an increase without a corresponding increase in water energy to move sediments through the system, the stream can experience **aggradation,** visible in build-up of sediment within a channel. Mid-channel lumps of gravel or sand are sometimes obvious. (See Figure C.)

FIGURE D.

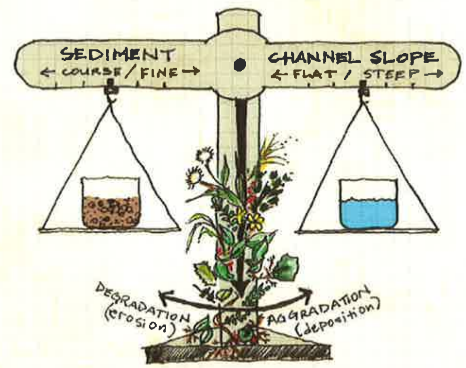


$Q_s \cdot D_{50} \propto Q_w \cdot S$

One way a channel can re-balance itself from an increase in sediment is to increase its slope. Channels become more steep by becoming straighter and therefore shorter in length. This steepening of the channel slope helps to focus stream energy to more efficiently move the increased sediment. (See Figure D.)

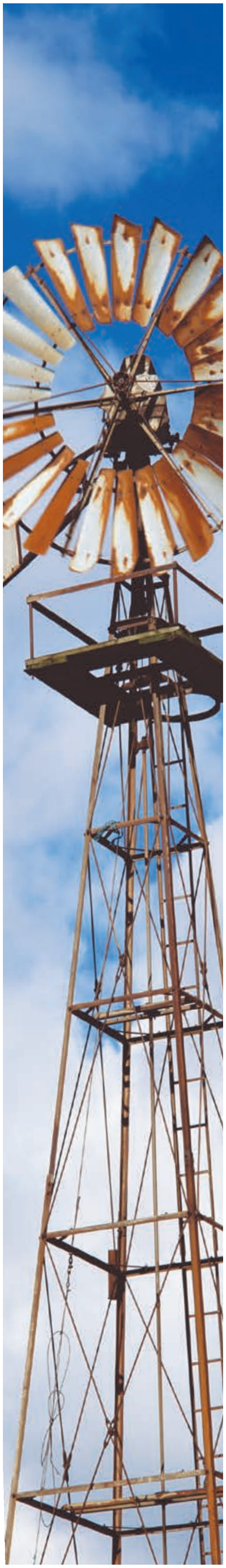
Plants are the Key to Balance

Riparian plants help buffer Lane's model and are essential to balance extreme effects in changes of either volume of water or amount of sediment.



A more detailed demonstration demonstration on Lane's Balance is on the Nueces River Authority's Remarkable Ripairan YouTube channel at: **http://bit.ly/1ncyOIP**

Introduction



TEXAS A&M AGRILIFE EXTENSION
ERM-014
03-15

Water Wells in Floodplains

What you need to know

Alyson K. McDonald, Assistant Professor and Extension Range Specialist
Diane E. Boellstorff, corresponding Author; Assistant Professor and Extension Water Resources Specialist
Drew M. Gholson, Extension Water Resource Program Specialist
` The Texas A&M University System

If your water well is shallow and located in the floodplain of a river or stream, pollutants from the stream can contaminate the well water. You can reduce the risk of well contamination by:

- Understanding the interactions between the stream and your well water
- Monitoring the conditions of both
- Taking action when needed

The two main sources of water for Texans are groundwater, which is the water stored underground in aquifers, and surface water, which includes streams, rivers, and lakes.

In Texas, these two types of water sources are managed separately:

- Surface water is publicly owned, and its use generally requires a permit from the state.
- Groundwater in Texas is private property. Landowners may put groundwater to beneficial uses within the rules of a local groundwater conservation district, if one has been established. Texas landowners are responsible for managing the water from their private wells.

Although groundwater and surface water may seem to be separate, they are physically linked. These linkages can become pathways for contamination of your well.

Water movement between streams and aquifers

As you drive along a river or creek in Texas, you may notice that the flow varies from place to place. The channel at one crossing may be dry; at another, the water may be deep and swift.

Changes in flow are sometimes caused by interactions between surface water and groundwater that cause the river to gain or lose flow. Some rivers have predominantly gaining reaches (sections); some have mostly losing reaches; others have both.

Gaining reach: Gaining streams receive water from nearby shallow aquifers when the water table is higher than the river surface; the hydraulic pressure causes the aquifer to discharge water to the river through the saturated streambed and banks (Fig. 1A).

Although you may not notice the increase in the amount of water in a gaining stream, it will often have a distinct difference in temperature. Because the groundwater temperature is relatively constant, the groundwater inflow in the summer will be cooler than the water in the stream, and in the winter it will be warmer.

Losing reach: Losing streams supply water to aquifers, via seepage through the streambed and banks, when the river surface is higher than the water table in the aquifer (Fig. 1B).

Disconnected reach: In dry regions, rainfall and direct runoff into streams is small and infrequent and the water table is often below the stream channel.

Draws or arroyos may flow only during and after a rain. Although these ephemeral (short-term) channels are disconnected from the aquifer (Fig. 1C), they may help recharge (replenish) it with rainfall during storms.

Effects of pumping wells: Pumping wells located along a gaining reach withdraw water that would otherwise contribute to streamflow (Fig. 2). Excessive groundwater pumping in the river floodplain can actually reverse groundwater flowpaths near the river (Fig. 2C) by creating a cone of depression (Fig. 3).

A pumping well creates a zone around it that is cone shaped. The size and shape of the cone depends on the amount of water stored in the aquifer and the rate that water can move through the aquifer to the pumping well. With continued pumping, the cone will expand until it reaches a source of recharge such as a river.

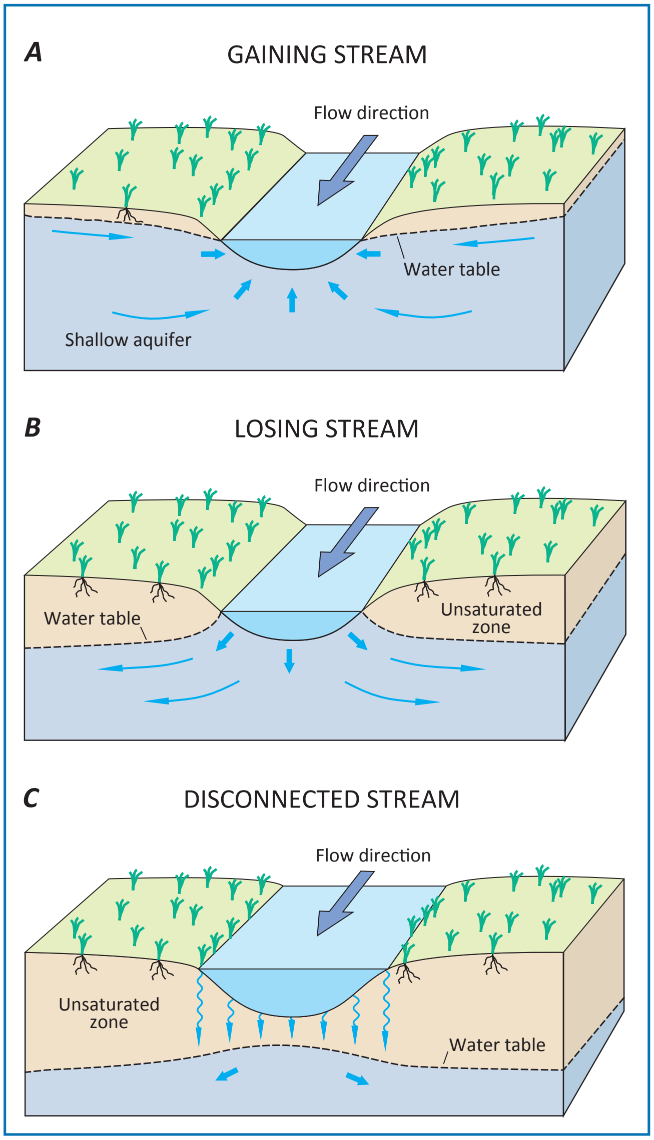
Conditions to monitor

Keep an eye out for any changes in the quality or quantity of water from the well and in the nearby stream.

Well water quality: Changes in the water's color, taste, or odor could indicate contamination in the well. Also take note if anyone who drinks the well water experiences a suspicious illness.

Reduced streamflow: If your water well is located near a losing reach, you are essentially pumping river water that has seeped into the aquifer. The well may produce less water if the streamflow has been reduced by a dam, drought, or both. You may notice air bubbles in the water or hear the pump sucking air.

If this occurs, shut down pumping to prevent damage to the pump and the well, and monitor the streamflow or river stage upstream from your property. You can monitor the streamflow of many Texas rivers via the U.S. Geological Survey (USGS) website.



Source: Modified from Winter and others, 1998

Figure 1. Interaction between streams and groundwater. Gaining streams receive water from the groundwater system (A); losing streams lose water to the groundwater system (B); and disconnected streams are separated from the groundwater system by an unsaturated zone (C).

The USGS measures streamflow at 509 gage stations in Texas. To view current streamflow data (Fig. 4) at each of these gauges, visit http://waterdata.usgs.gov/tx/nwis/current/?type=flow.

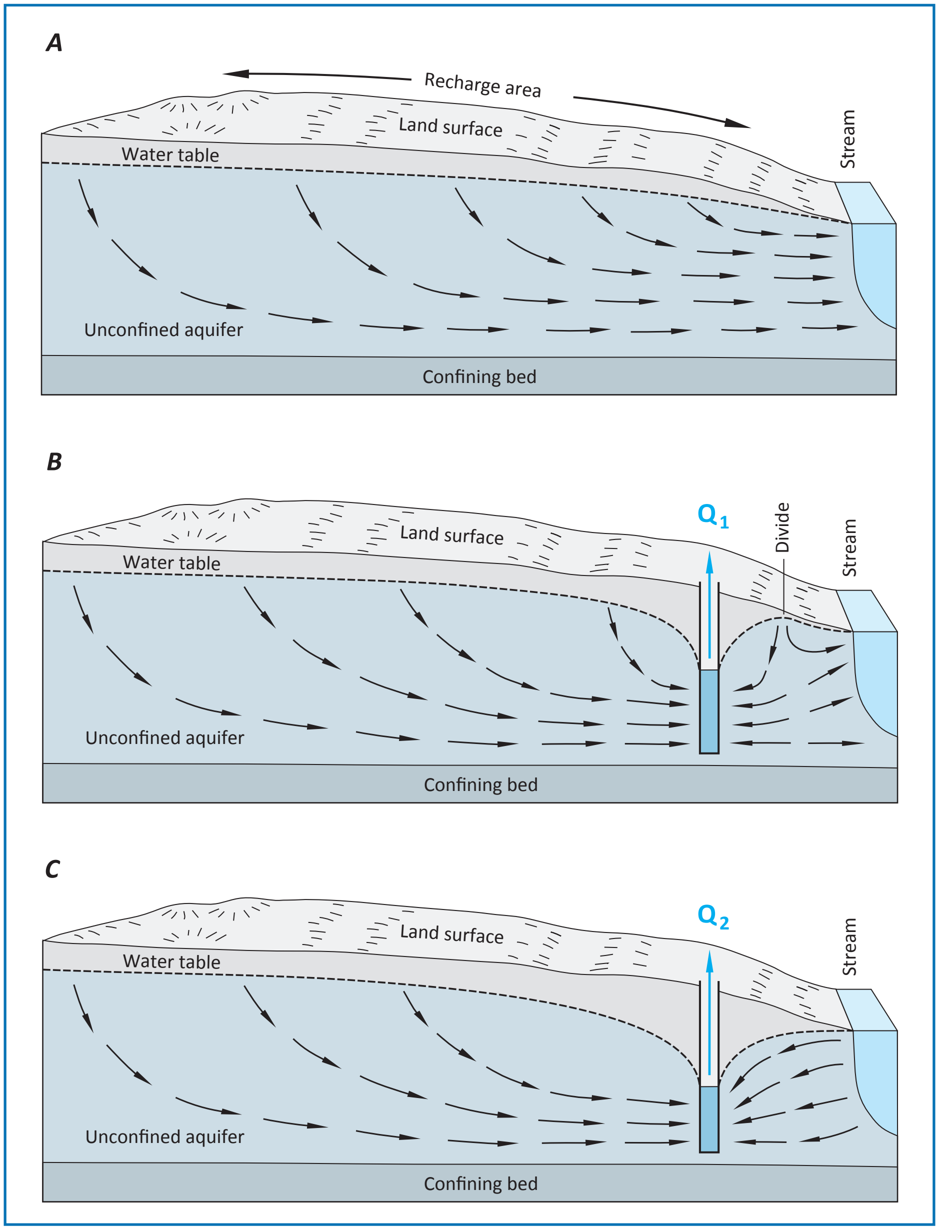
Stream pollution: About 10 percent of Texas streams are sampled and analyzed to detect pollutants each year by the Texas Commission on Environmental Quality (TCEQ). Results are available through the TCEQ surface water quality viewer at https://www.tceq.texas.gov/gis/segments-viewer or the Texas Integrated Report of Surface Water Quality at https://www.tceq.texas.gov/waterquality/assessment/305_303.html.

Flooded wells: Flooding streams can affect water wells in floodplains. Texas state law addresses construction of wells in flood-prone areas [16 Texas Administrative Code, section 76.100(a)(5)]:

> *A well shall be located at a site not generally subject to flooding; provided, however, that if a well must be placed in a flood prone area, it shall be completed with a watertight sanitary well seal, so as to maintain a junction between the casing and pump column, and a steel sleeve extending a minimum of thirty-six (36) inches above ground level and twenty-four (24) inches below the ground surface.*

If your well has been flooded, it needs to be decontaminated. For instructions on how to decontaminate a flooded well, see AgriLife Extension publication ER-011, *Decontaminating Flooded Wells,* which is available at agrilifebookstore.org.

Shallow wells: Water from shallow (especially hand-dug) wells, particularly if it is derived from a river or stream, is likely to contain disease-causing bacteria and may need to be treated to meet recommended drinking water standards.



Source: Modified from Winter and others, 1998

Figure 2. Effects of pumping from a hypothetical groundwater system that discharges to a stream. Where groundwater discharges to a stream under natural conditions (A), placement of a well pumping near the stream will intercept part of the groundwater that would have discharged to the stream (B). If the well is pumped at an even greater rate, it can intercept additional water that would have discharged to the stream in the vicinity of the well and can draw water from the stream to the well (C).

Actions to take

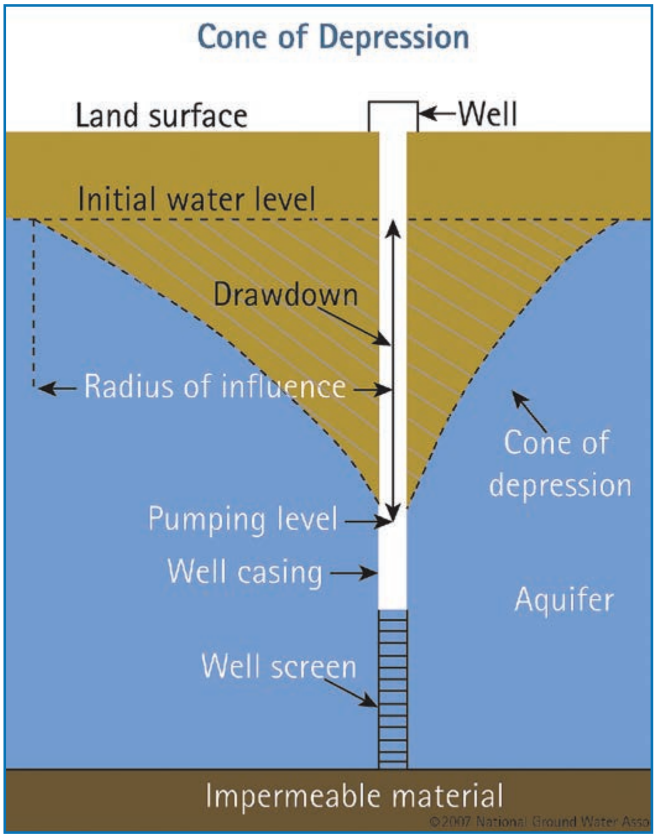
To protect your water supply, you need to:

- Keep records on each well for information such as location, maintenance and water test results. Manage potential sources of contamination such as septic systems, hazardous materials used or stored near the well, animal feedlots and dog runs, and stored animal wastes.
- Monitor the quality of your well water and of the nearby stream.
- If you use the well for drinking water, have the water tested for the contaminants that are most likely to be in it. At a minimum, test it **every year** for nitrate, total dissolved solids (TDS), and *E. coli* or fecal coliform (bacteria from human or animal waste).
- Have the water tested whenever you suspect contamination; when you notice a change in the water's color, taste, or odor; after the pump or well is maintained; and after anyone who drinks the well water experiences a suspicious illness.

To find a laboratory, call your county health department or choose a certified drinking water laboratory from the National Environmental Laboratory Accreditation Program at http://www.tceq.texas.gov/goto/certified_labs.

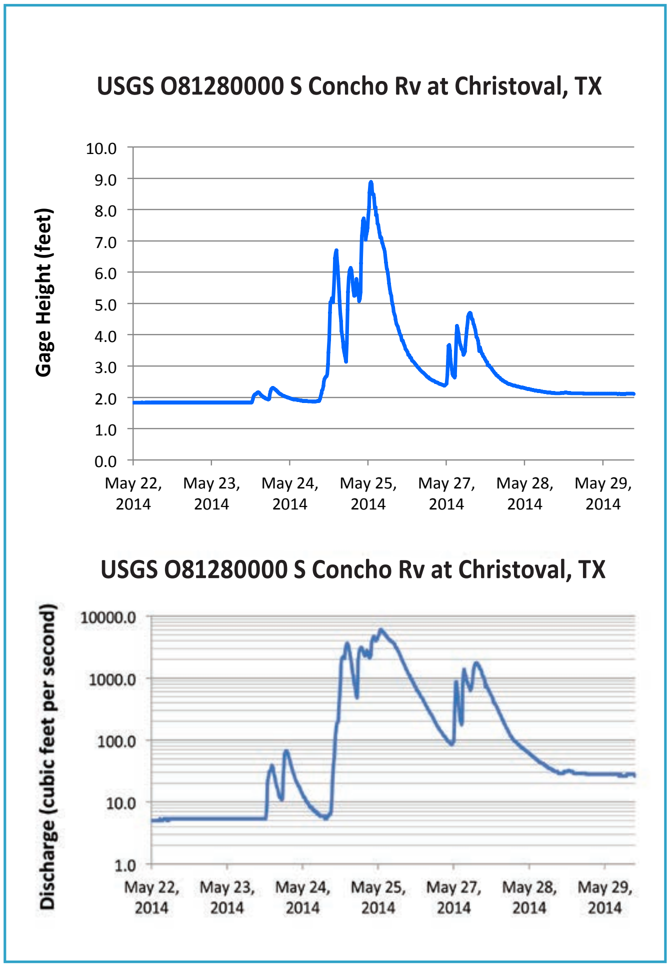
Irrigation water testing: The Texas A&M AgriLife Extension Soil, Water, and Forage Testing Laboratory (SWFTL) can test irrigation water for irrigation and livestock purposes. Forms and information for water sampling and testing are available at http://soiltesting.tamu.edu. Commercial laboratories are also available.

- If the well has been flooded, or if tests show that the water contains fecal coliform or *E. coli* bacteria:
  - Decontaminate the water using a distillation, ozone, ultraviolent (UV), or continuous chlorination treatment method.
  - Or, find another source of water, such as by drilling a deeper well or using bottled water.



Source: National Groundwater Association 2007 at http://www.ngwa.org/Fundamentals/hydrology/Pages/Unconfined-or-water-table-aquifers.aspx

Figure 3. Cone of depression created by a pumping well in an unconfined aquifer. Pumping a well in an unconfined aquifer causes actual dewatering of the material within an inverted, roughly cone-shaped volume, called a cone of depression.



Source: U.S. Geological Survey National Water Information System

Figure 4. Stream hydrographs of gage height and estimated discharge, May 22–29, 2014, South Concho River near Christoval, TX.

For more information

- Local county Extension office: http://counties.agrilife.org/
- Alyson McDonald (akmcdonald@ag.tamu.edu, 432-336-8585).
- Diane Boellstorff (dboellstorff@tamu.edu, 979-458-3562).
- Drew Gholson (dgholson@tamu.edu, 979-845-1461).

Decontaminating Flooded Wells. By M. L. McFarland, D. E. Boellstorff, T. L. Provin, M. C. Dozier and N. J. Dictson. 2006. Texas A&M AgriLife Extension publication ER-011, 2 pp.

Ground Water and Surface Water A Single Resource. By T. C. Winter, J. W. Harvey, O. L. Franke and W. M. Alley. 1998. U.S. Geological Survey Circular 1139, 87 pp.

Texas Well Owner Network: http://twon.tamu.edu/

Texas Well Owner Network: Texas Well Owner's Guide to Water Supply. By K. Uhlman, D. Boellstorff, M. L. McFarland, B. Clayton, and J. W. Smith. 2013. Texas A&M AgriLife Extension publication B-6257, 96 pp.

Texas Groundwater Protection Committee:
General information on water wells: http://tgpc.state.tx.us/water-wells/

Acknowledgment

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Photo by Kristine Uhlman, former Texas A&M AgriLife Extension Program Specialist–Water Resources

Texas A&M AgriLife Extension Service

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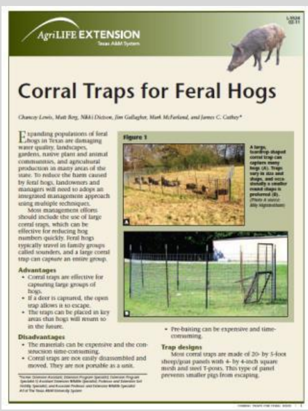
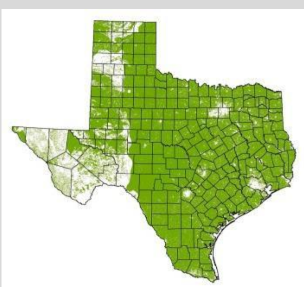
Texas A&M AgriLife Extension Service
Wildlife & Fisheries Sciences Unit

Responses to the Feral Hog Problem

TEXAS A&M AGRILIFE EXTENSION





Potential Feral Hog Habitat

The Feral Hog Problem

Approximately 2.6 million feral hogs occupy 79% of Texas' landscape. Feral hogs are an invasive, exotic species that cause approximately $52 million in damages to Texas agriculture producers annually. This estimate does not include damage to habitat used by native wildlife or suburban areas. Feral hog damage can be significantly reduced through effective education and outreach to private landowners. This document is a snapshot of the Wildlife & Fisheries Extension Unit's feral hog education and outreach efforts from 2009–present.

Wildlife and Fisheries Extension Response to the Feral Hog Problem

- **Feral Hog Community of Practice (CoP)**
  - The Feral Hog CoP will concentrate on the control, adaptive management, biology, economics, disease risks, and the human interface of feral hogs across the United States
  - 15 Leaders and 50 members representing 23 states, several state and federal agencies, numerous academic institutions and NGOs
  - 103 FAQs and 54 articles published
  - Feral Hog CoP Facebook (2,049 Likes)
  - 4 National Webinars
  - Ask an Expert
  - Launched – May 2012
- **Plum Creek Watershed Feral Hog Project (Travis, Hays & Caldwell counties)**
  - 65 site visits
  - 30+ presentations in the tri-county area and 3,792 participants
  - 376 feral hogs reported removed via online reporting tool
  - Radio and newspaper interviews
- **Feral Hog Abatement Project (2006-2012)**
  - Mass Media Contacts: 172
  - Educational Programs: 138 for 19,924 clientele
  - Economic Value of Information Received by Program Participants: $8,849,741
  - Benefit to Cost Ratio of Extension Outreach Efforts: 26.52 to 1.00 or $26.52 return for each $1.00 invested in outreach
- **Feral Hog Related Publications, Videos & Websites**
  - 26 publications in print with 7 translated into Spanish
  - 2,838 online and 10,960 print copies shipped from Texas AgriLife Extension Bookstore
  - 18,866 online views from Scribd
  - 17 YouTube videos with 51,470+ views
  - Several webinars (Biology, Control, Diseases, Current Research) : TWA Feral Hog CoP
  - Coping With Feral Hogs: 50,000+ unique visitors, 108,000+ pages accessed
  - Wild Wonderings Blog: 284,000+ page views
  - Widespread social media presence
- **Feral Hog Take Study**
  - 700 landowners were surveyed statewide and asked to characterize their feral hog control efforts for 2010. There were 36,664 feral hogs removed from 1.8 million acres. Trapping was responsible for 57% of the hogs removed, shooting and hunting 35%.
  - Data from this study were used to calculate an annual hog harvest of 754,000 by all legal methods of removal.

Extension Demonstrations and Translational Research

- **Impact of Northern Bobwhite Quail Nest Success**
  - Dr. Rollins of Wildlife and Fisheries Extension conducted research in 1993 which determined feral hogs had an 11.4% negative impact on nest success.
  - Populations have increased significantly since that time, likely increasing the impact.
- **Techniques for Excluding Feral Hogs from Wildlife Feeding Stations**
  - Research conducted which determined ideal methods of fencing wildlife (i.e. deer) feeding stations to minimize feral hog utilization while allowing continual desirable wildlife use of some 300 million pounds of supplement fed annually.
- **Trap Designs for Increasing Catch Rates of Feral Hogs**
  - Research conducted produced six publications to provide the public with effective, proven methods of trapping and snaring feral hogs to maximize take. Additional research to maximize trapping efficiency is on-going.

Wildlife and Fisheries Extension Feral Hog Online Resources

- **Feral Hog Reporting**
  - Feral Hog Reporting
- **Feral Hog Publications**
  - Recognizing Feral Hog Sign: English Spanish
  - Placing And Baiting Feral Hog Traps: English Spanish
  - Corral Traps For Capturing Feral Hogs: English Spanish
  - Box Traps For Feral Hogs: English Spanish
  - Making A Feral Hog Snare: English Spanish
  - Snaring Feral Hogs: English Spanish
  - Door Modifications for Feral Hog Traps: English Spanish
  - Using Fences To Exclude Feral Hogs From Wildlife Feeding Stations
  - Feral Hog Population Growth, Density And Harvest In Texas
  - Feral Hogs Negatively Affect Native Plant Communities
  - Feral Hog Approved Holding Facility Guidelines In Texas
- **Feral Hog Fact Sheets**
  - Feral Hogs Impact Ground Nesting Birds
  - Feral Hogs Laws and Regulations In Texas
  - Feral Hog Transportation Regulations
  - Feral Hogs And Disease Concerns
  - Feral Hogs And Water Quality in Plum Creek
- **Feral Hog YouTube Videos**
  - How to Build a Figure-C Feral Hog Trap
  - How to Build a Corral Trap for Feral Hogs
  - Trapping Feral Hogs: Corral Trap Designs
  - Exclusion Fencing for Feral Hogs at Wildlife Feeders
  - Improving Feral Hog Box Trapping Efforts
  - Strategic Shooting Of Feral Hogs For Population Control
  - Texas Invaders: Feral Hogs
  - Identification of Deer and Feral Hog Tracks
  - History, Biology, and Population Dynamics of Feral Hogs
  - Feral Hog Impacts on Agriculture and Wildlife in Texas
  - Control Techniques and Regulations for Feral Hogs in Texas
  - Trapping Feral Hogs: Using Remote Cameras
  - Trapping Feral Hogs: Laws and Regulations
  - Trapping Feral Hogs: Non-Target Species and Trigger Type
  - Trapping Feral Hogs: Time of Year
  - Trapping Feral Hogs: Gates And Baits

Feral Hog Consuming Rio Grande Wild Turkey Nest

Trapped feral hog

Feral hog wallow

Feral hog fitted with a tracking

Feral Hog Management App

- **Feral Hog YouTube Videos- Wild Pig Minute Video Series**
    - Episode 1- Wild Pig Trapping Tips: Rainfall and Wild Pigs
    - Episode 2- The Impacts of Temperature on Wild Pig Movements
    - Episode 3- Understanding Wild Pig Wallowing Behavior
    - Episode 4- Understanding Wild Pig Signs
    - Episode 5- Landowner Cooperatives for Wild Pig Management
    - Episode 6- Selecting a Wild Pig Trapping Site
    - Episode 7- Wild Pig and Riparian Habitats
    - Episode 8- Wild Pig Impacts to Reptiles and Amphibians
- **Feral Hog YouTube Videos- Wild Pig Management Video Series**
    - Episode 1- Series Trailer
    - Episode 2- How to Corral Trap Wild Pigs
    - Episode 3- Corral Trapping Wild Pigs: A Success Story
    - Episode 4- How to Snare Wild Pigs
    - Episode 5- How to Box Trap Wild Pigs
    - Episode 6- Shooting Techniques for Wild Pigs
- **Mobile Applications (Apps)**
    - Feral Hog Management
- **Wild Wonderings Blog**
    - Pre-baiting and Conditioning Feral Hogs for Trapping
    - Porcine Epidemic Diarrhea Virus (PEDv) and Feral Hogs
    - Potential for a Sodium Solution: Sodium Nitrite as a Toxicant for Feral Hogs
    - Thoughts on Gaining Land Access for Feral Hog Hunting in Texas
    - Using a Corral Trap to Capture Feral Hogs
    - New Feral Hog Reporting Tool for Texas
    - The Five Footed Feral Hog
    - The Best Choice for a Corral Trap Gate
    - Economics of Trapping Feral Hogs: Box Traps Vs. Corral Traps
    - My Trap isn't working!
    - High Tech Hog Trapping: Incorporating Technology into Feral Hog Trapping
    - Urban Feral Hogs: Concern, Challenges and Control
    - Urban Feral Hogs: Why did they damage my yard?
    - Feral Hog Hunting: The Good, the Bad and the Ugly Truth
    - Feral Hogs: Adaptable, Efficient and Effective
    - Feral Hog Trapping Tips: Hard Mast- The Storm before the Calm
    - Feral Hog Trapping Tips: What happens when it rains?
    - Feral Hogs: Do my population reduction efforts even make a difference?
    - The Porkchopper: Aerial Hunting of Feral Hogs
    - Feral Hog Trapping Troubles: Rooter Gates
    - Feral Hogs: Why do they Wallow?
    - Managing Feral Hogs on Your Property: Where do I start?
    - Landowner Cooperatives: Teaming Up on Feral Hogs
    - DIY Hog Traps
    - Feral Hogs: Take Your Little Piggies to Market
    - Feral Hogs: Coming to a Town Near You
    - Are Feral Hogs Contributing to Quail Decline?
    - Wildlife Management Property Tax Valuation: Feral Hog Trapping
    - How to select a feral hog trapping site
    - Advanced Feral Hog Trapping: Understanding behavioral drivers
    - Using Seasonal Resource Availability to Increase Feral Hog Trapping Success
    - Baiting Feral Hogs: Why Hog Sign is Important

Feral hog sounder

Corral trap with feral hogs

Trail camera installation

Feral hog track

Hog hair on fence

- **Wild Wonderings Blog**
    - Understanding the Differences Between Javelinas and Feral Hogs
    - Feral Hog Impacts on Reptiles and Amphibians
    - DIY Game Feeder Corral Trap for Wild Pigs
    - Wild Pig Trapping: Does Corral Trap Gate Size Matter?

- **Wildlife and Fisheries Extension Social Media**
    - **Twitter**
        - Feral Hogs Community of Practice
    - **Facebook**
        - Wildlife and Fisheries Extension
        - Feral Hogs Community of Practice
    - **Scoop.it! Newsletter**
        - Wild Pigs (Feral Hogs)
    - **Pinterest**
        - Feral Hogs Community of Practice

Educational video series

Educational outreach

Feral hog snare

Pre-baiting feral hogs

Feral hog rooting damage

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Notes

More information about Texas Water Resources Institute's trainings can be found at:

twri.tamu.edu

or

texasriparian.org