The Meadows Center for Water and the Environment

Texas State University

Texas Stream Team

TEXAS STREAM TEAM RIPARIAN EVALUATION CITIZEN SCIENTIST MANUAL

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Texas Stream Team –
The Meadows Center for Water and the Environment
601 University Drive
San Marcos, TX 78666

Phone: (512) 245-1346
Email: TxStreamTeam@txstate.edu
Web: www.TexasStreamTeam.org

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The Texas Stream Team encourages life-long learning about the environment and people's relationship to the environment through its multidisciplinary citizen science programs. We also provide hands-on opportunities for Texas State University students and inspire future careers and studies in natural resource related fields. Preparation of the Texas Stream Team Riparian Evaluation Citizen Scientist Manual has provided Texas Stream Team with the chance to extend additional outreach and educational opportunities to the citizens of Texas. Texas Stream Team values the staff contributions and recognizes each individual for their role.

The following staff and student workers assisted in the preparation of this manual and are acknowledged for their contributions:

Eryl Austin-Bingamon, Student Research Assistant

Dr. Sandra Arismendez, Senior Watershed Scientist

Anna Huff, Communications Manager

Aspen Navarro, Program Coordinator

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Your Remarkable Riparian: Field Guide to Riparian Plants Found Within Most of Texas, published in 2016 by the Nueces River Authority, and;

Your Remarkable Riparian: Owner's Manual, written by Steve Nelle, published in 2016 by the Nueces River Authority.

Texas Stream Team would like to extend our sincere appreciation and gratitude for the collaborative work from the Nueces River Authority and partners on the creation of *Your Remarkable Riparian Field Guide*. Special thanks and acknowledgment to:

Karen Ford

Kevin Greenblat

Sky Jones-Lewey

Ricky Linex

Kenneth Mayben

Steve Nelle

Melissa Parker

Mary Kate Rogers

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1.0 INTRODUCTION

The Texas Stream Team Riparian Evaluation Citizen Scientist Manual (Riparian Evaluation Manual) presents methods and procedures to become a certified Texas Stream Team Riparian Evaluation Citizen Scientist. Certification enables citizen scientists to perform evaluations and submit data that meet the requirements of the Texas Commission on Environmental Quality approved Texas Stream Team Quality Assurance Project Plan.

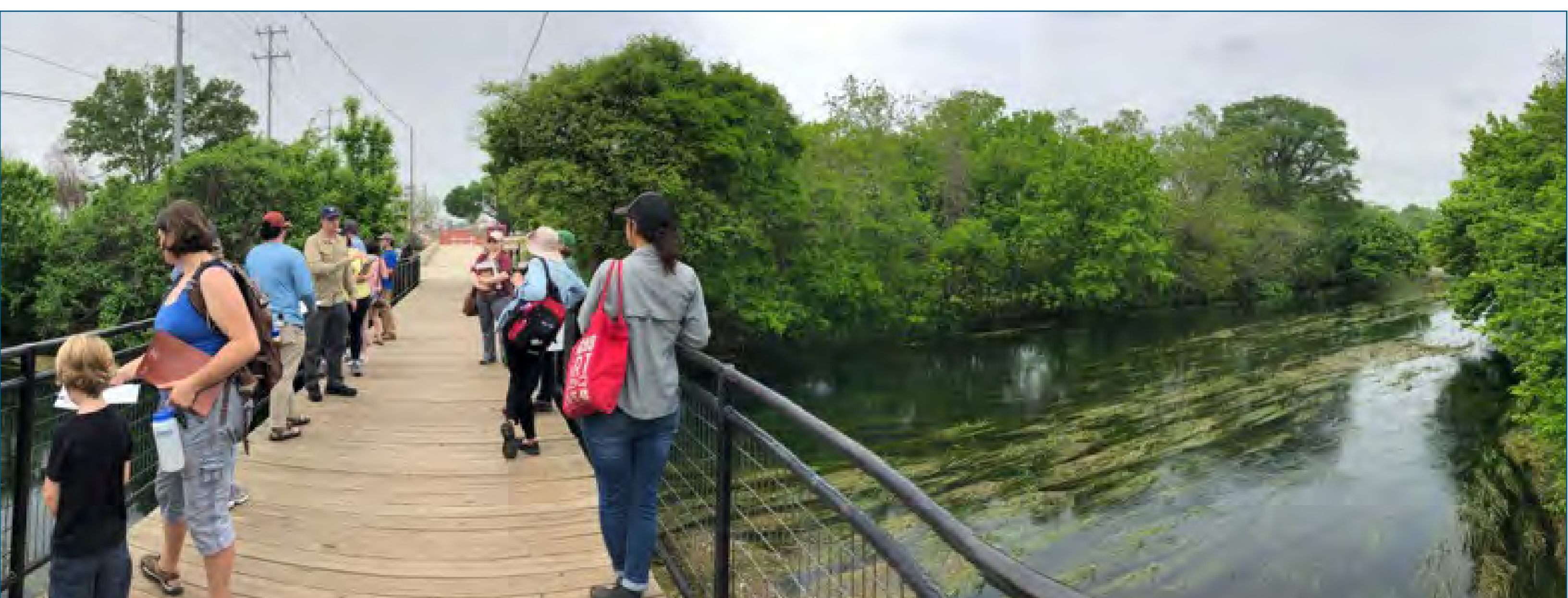
Texas Stream Team has developed this citizen science program with input from the Environmental Protection Agency and the Texas Commission on Environmental Quality to address the following goals and benefits:

- Standardized training and quality assurance procedures help citizen scientists collect accurate, consistent information and improves data quality and integrity which can be used in making environmentally sound decisions.
- As recognized by the Environmental Protection Agency and the Texas Commission on Environmental Quality, citizen scientists collect quality assured data that serves to supplement professionally collected data.
- Collection of quality assured data helps improve understanding of environmental issues and promotes communication and positive cooperation between Texans, professional monitors, and the regulated community.

> A riparian area is the transitional band of vegetation between waterways of all sizes and the adjacent uplands. It is the part of the landscape that borders a creek or river. When a riparian area is healthy and functioning properly it filters and slows runoff and floodwaters, and allows for sediment trapping, water storage, and groundwater infiltration. The water quality benefits of a healthy riparian area are well documented.

The Riparian Evaluation Manual was first developed to provide citizen scientists with clear instructions on how to perform riparian evaluations and to educate citizen scientists about the importance of the monitoring they conduct.

This manual also features an introduction to hydrology, geomorphology, watershed processes, and nonpoint source pollution. Texas Stream Team encourages new and veteran citizen scientists to develop a solid understanding of key concepts such as watersheds, stream order, and eutrophication. By raising awareness of nonpoint source pollution, Texas Stream Team educates citizen scientists on more effective strategies for protecting water resources and for resolving water quality problems that may originate at the community level.



1.1 WHAT IS TEXAS STREAM TEAM?

Texas Stream Team (formerly known as Texas Watch) is an environmental education and volunteer-based citizen scientist water quality monitoring program. Citizen scientists collect environmental and water quality information that may be used to promote and protect a healthy and safe environment for people and aquatic inhabitants.

Texas Stream Team emphasizes communication about the environment, which is based on the premises that water issues are inextricably linked with air, biological, land, and human resource issues, and that the protection of the environment requires the active, positive, collaborative participation of all Texans.

Through Texas Stream Team, community members, students, educators, academic researchers, environmental professionals, and both public and private sector partners are brought together to conduct scientific research and to promote environmental stewardship.

Texas Stream Team encourages everyone to ask:

- What questions do we want to answer about the environment?
- What part of the environment are we most concerned with?
- What can I do to help preserve and protect the environment?

For those whose concerns are centered on water quality, Texas Stream Team helps design water quality monitoring programs to address specific concerns.

Recognizing the size and complexity of the water environment, the time and expense of monitoring water quality, and the significant role that each one of us has in protecting Texas waters, the Texas Commission on Environmental Quality, the Environmental Protection Agency, and Texas State University have formed a cooperative partnership to support Texas Stream Team. Texas Stream Team is partially funded through an Environmental Protection Agency Nonpoint Source Pollution grant under Section 319 of the Federal Clean Water Act.

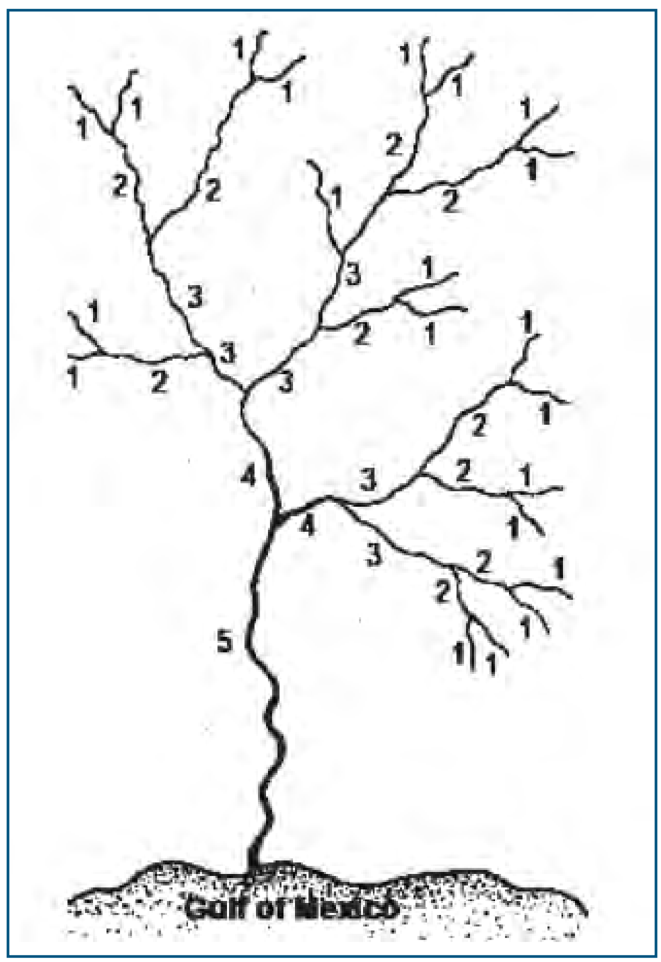
1.2 KEY CONCEPTS

What is a watershed?

Everyone lives in a watershed, which is defined as a geographic area in which water, sediments, nonpoint source pollutants, and dissolved materials drain into a common body of water. The body of water can be a stream, lake, playa, estuary, aquifer, or ocean. A watershed can be large or small. In a city, the gutters that run along the curb on your street are the drainage outlets for your city's watershed. In a neighborhood, water in your gutters flows into the storm drain system and empties into a nearby stream, which drain several neighborhoods in a larger watershed. That stream, in turn, flows into a larger stream or river.

Stream Order

Water quality professionals have developed a simple method to categorize the streams of a river system. Streams that have no tributaries flowing into them are called first order streams. Streams receiving flow from only first order streams are second order streams. When two second order streams combine, the result is a third order stream. This continues until all streams merge into the mainstem or the principal watercourse in a riverine drainage system, which ultimately drains into a lake or ocean. The order of the stream at the watershed outlet is the watershed order.



Texas River Basins

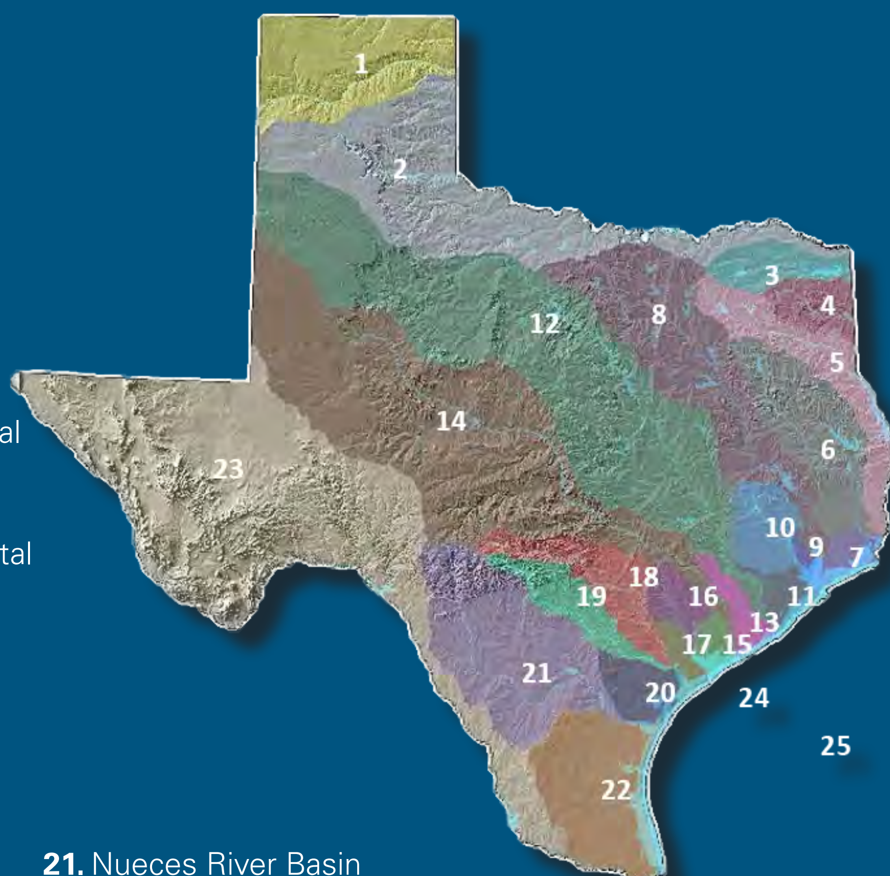
Water resource professionals categorize watersheds into hierarchical levels based on area and common outflow points. In Texas, catchment areas are often categorized into watersheds and river basins. Texas has 23 major river basins that can be subdivided into smaller watersheds. Oftentimes, these smaller watersheds will consist of only one major body of water and its smaller tributaries. For example, the Pedernales River makes up the largest catchment area within the Pedernales Watershed. The majority of this watershed is contained within two counties in Central Texas, Gillespie County and Blanco County.

The Pedernales River is also contained within a higher order classification. The Colorado River Basin, which is one of the 23 major river basins in Texas, is a regional collection of multiple smaller watersheds. In contrast to the size of the Pedernales Watershed, the Colorado River Basin flows from Dawson County in northwest Texas all the way to the Gulf of Mexico. All streams, from the smallest branch of Bee Creek to large tributaries such as the Llano River, comprise the river system of the Colorado River Watershed.

The water flowing through interconnecting rivers, streams, creeks, and lakes that collectively define a Texas River Basin ultimately arrive at the same destination. All of the smaller watersheds and their corresponding streams flow from northwest to southeast Texas and gradually converge. Ultimately, these waterways drain into the Gulf of Mexico.

Texas River Basins

1. Canadian River Basin
2. Red River Basin
3. Sulphur River Basin
4. Cypress Creek Basin
5. Sabine River Basin
6. Neches River Basin
7. Neches-Trinity Coastal Basin
8. Trinity River Basin
9. Trinity-San Jacinto Coastal Basin
10. San Jacinto River Basin
11. San Jacinto-Brazos Coastal Basin
12. Brazos River Basin
13. Brazos-Colorado Coastal Basin
14. Colorado River Basin
15. Colorado-Lavaca Coastal Basin
16. Lavaca River Basin
17. Lavaca-Guadalupe Coastal Basin
18. Guadalupe River Basin
19. San Antonio River Basin
20. San Antonio-Nueces Coastal Basin
21. Nueces River Basin
22. Nueces-Rio Grande Coastal Basin
23. Rio Grande Basin
24. Bays and Estuaries
25. Gulf of Mexico



Flow Classifications

Ephemeral: Ephemeral streams only flow in direct response to recent rain events and have no connection to groundwater sources.

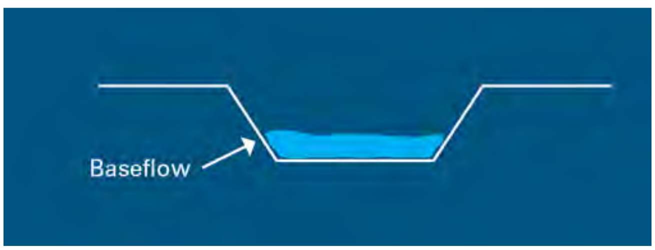
Seasonal/Intermittent: Seasonal/intermittent streams flow occasionally and may flow for extended periods of time. These streams usually have connection to a groundwater source.

Perennial: Perennial streams are usually always flowing (except in cases of extreme drought) and have a connection to a groundwater source.

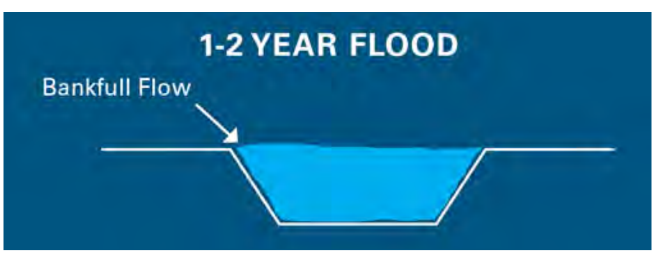
Interrupted: Interrupted streams that may otherwise be flowing can lose their flow to aquifer recharge zones, over pumping, dams and impoundments, channel incision, or climate change.

Common Language

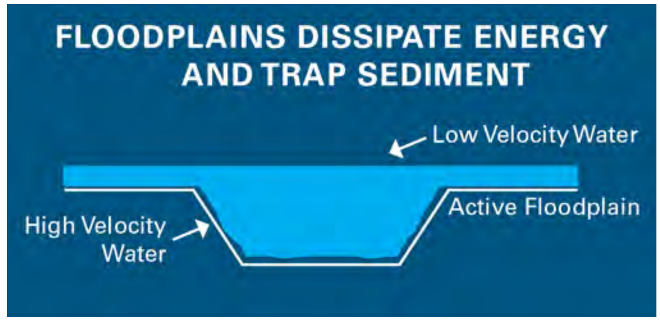
Base Flow: The normal amount of water flowing through a stream, sustained by groundwater and water stored in the banks.



Bank-Full Flow: The flow in a stream that occurs one to two times per year wherein water level reaches the edge of the channel and begins to flow into the floodplain. The maximum amount of discharge a stream can carry without overflowing.



Flood Flow: A high-flow water level wherein the flow of a stream reaches past the edge of the channel and begins to flow into the floodplain. In some areas this flow occurs approximately once every five years.



Cut Bank and Point Bar: In a stream or river, cut banks occur where erosion gradually wears away the channel bank. Point bars occur where the sediment is eventually deposited.

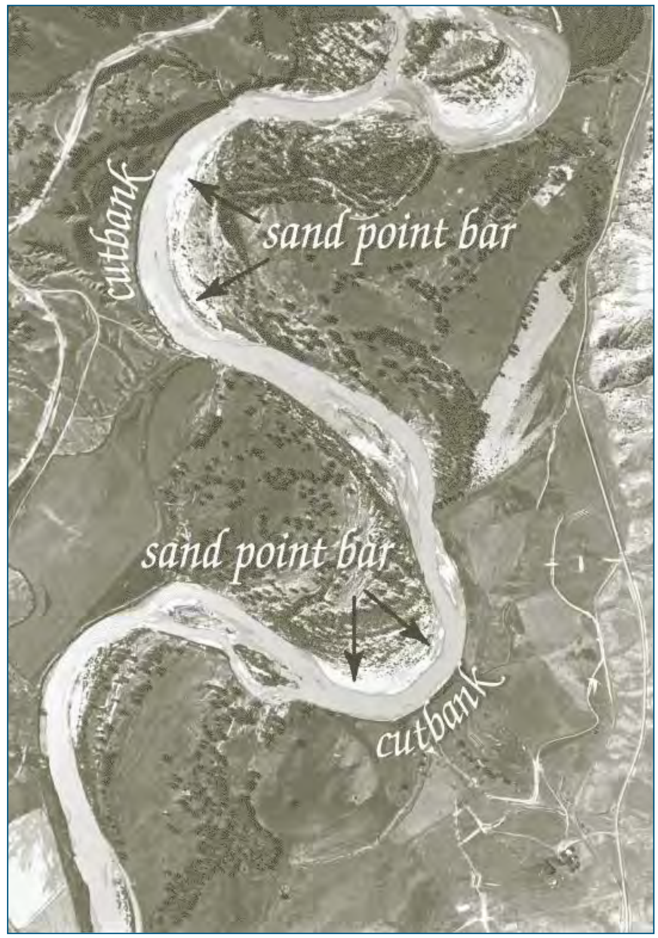
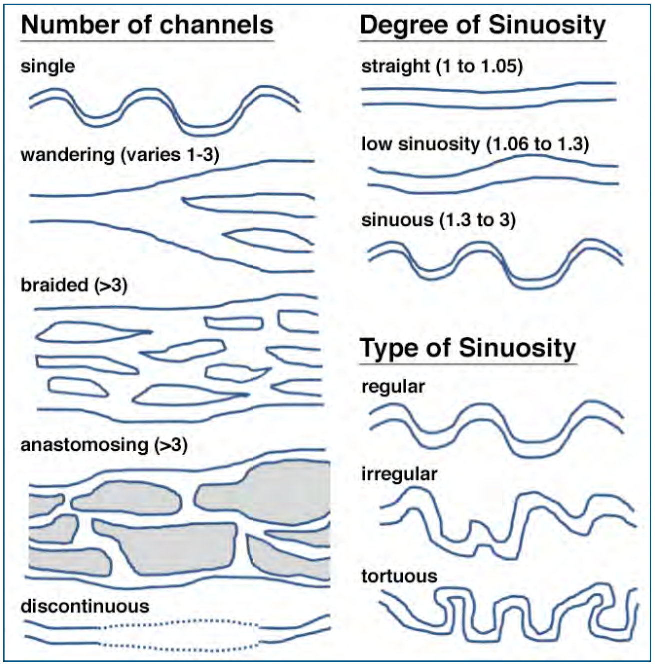


Image obtained from United States Geological Survey.

Bed Load: Bed load is a term that refers to the dislodged or excess sediment in a waterbody channel. Bed load can either be washed into a channel via wastewater as stormwater runoff or dislodged from the surrounding banks through the process of erosion.

Sinuosity: Sinuosity is a measure of the "curviness" of a meandering stream. Meandering streams have a tendency to move back and forth across their floodplain in an S-shaped pattern. A stream with a higher sinuosity will have more frequent, tighter curves. Sinuosity also helps determine the total length and slope of a channel.



Belmont, 2005. Image acquired from Pennsylvania State University's John A. Dutton E-Education Institute, Earth 111: Water: Science and Society, Unit 2, Module 3.

Reach classifications

A stream reach is any length of stream wherein the hydrologic conditions (such as drainage, slope, depth, discharge, etc.) are similar. Reach classifications can be used to divide a waterbody into similar segments so that it can be effectively evaluated.

For the purposes of evaluating riparian areas, streams are often categorized into three reach classifications.

Sediment Production: In this reach, sediment is produced via the erosion and weathering of channel banks. This reach is usually found upstream, in areas of high relative elevation. This reach is characterized by a lower stream order.

Sediment Transport: Dislodged sediment is then transported through the sediment transport reach. This reach is usually comparatively lower in elevation, with a higher stream order and fewer tributaries.

Sediment Deposition: Sediment is ultimately transported and deposited in the last reach. The sediment deposition reach has the lowest elevation and the highest stream order. Often times this reach will also drain directly into a larger river, lake, or into the ocean. Sediment that is deposited here can distort the shape and size of the stream and can result in geographic formations such as alluvial fans and river deltas.

1.3 INTRODUCTION TO HYDROLOGY

The presence of water is a definitive feature of a riparian zone. Therefore, it is useful to have a general understanding of hydrologic principles to better understand the biological, chemical, and physical processes that occur in riparian areas. This section includes information on watershed processes, hydrology, and the water cycle to add context to the methods used by the Texas Stream Team when evaluating riparian areas.

Hydrology is the study of Earth's water, including water's movement across land, the water cycle, the properties of water, and the interactions between water and other materials (USGS staff, n.d.).

The Water Cycle

The water cycle refers to the process by which all of the water on Earth continuously transitions throughout an interconnected, never ending sequence (USGS staff, n.d.). The water cycle can be broken down into evaporation, condensation, precipitation, and infiltration/runoff.

EVAPORATION

Surface water stored on the surface of the earth or within the leaves of plants is heated by the sun, converting it from a liquid to a gas. The gas, called water vapor, rises into the atmosphere by a process called evaporation.

CONDENSATION

Water vapor condenses around a condensation nucleus. Condensation nuclei are small particles of dust, dirt, or other materials that float in Earth's atmosphere. Like the nucleus of a cell, condensation nuclei act as the "center" of a cloud. As water vapor rises, it condenses around these small particles and eventually forms a cloud.

PRECIPITATION

As water vapor continues to accumulate around a condensation nucleus, the cloud becomes heavy with condensed water. When the weight of the cloud reaches a certain threshold, the water succumbs to gravity and falls to the ground as precipitation.

INFILTRATION/RUNOFF

Water that falls to the earth as precipitation either infiltrates into the ground or runs off into surrounding lowlands. When water moves across the land, it is referred to as runoff.

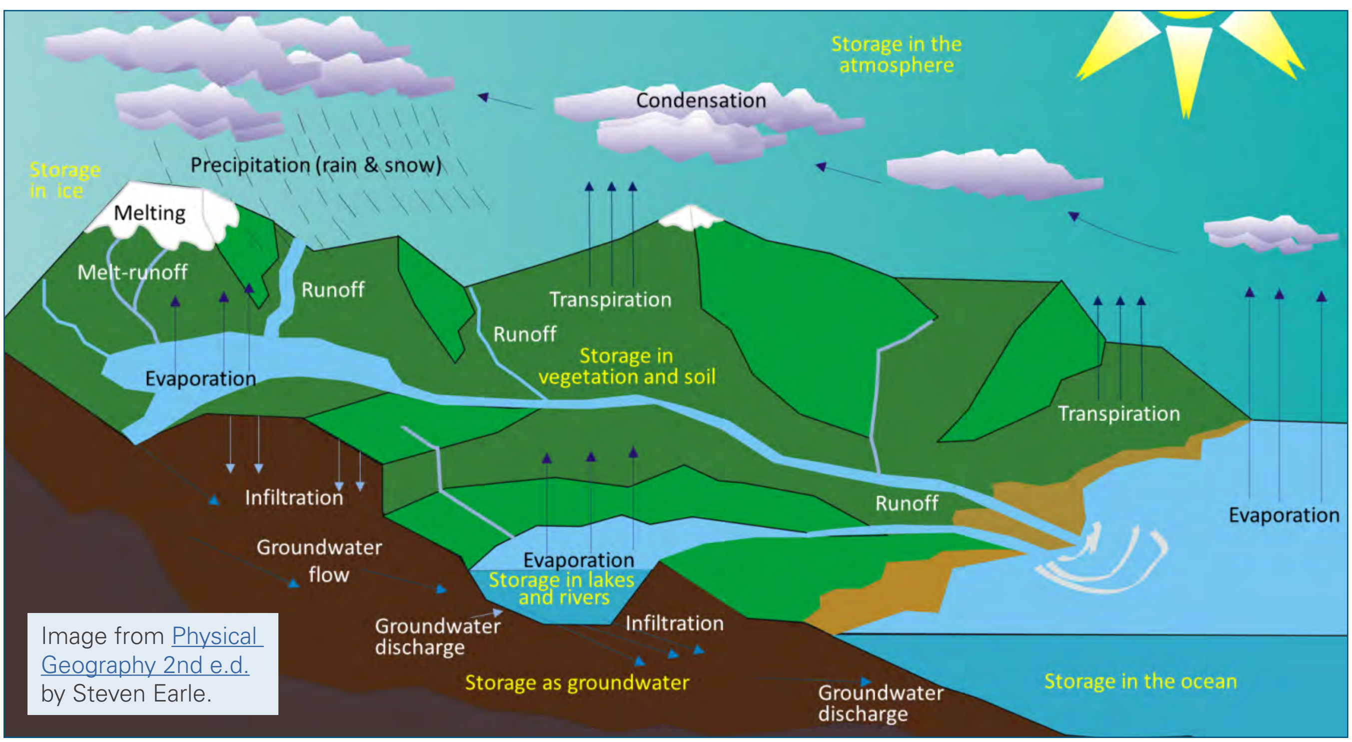


Image from [Physical Geography 2nd e.d.] by Steven Earle.

Water Storage

Water that is between cycles is sometimes referred to as "stored water". In general, water is either stored on the surface (in lakes, rivers, reservoirs, etc.) as surface water or below the surface (as subsurface flow in interstitial sediments or aquifers) as groundwater.

SURFACE WATER

Surface water refers to the water that we see moving across rivers, streams, or within lakes.

FLOW

Hydrologists classify stream flow as either laminar or turbulent (Huggett, 2017) (Ritter, 2012).

Laminar flow is common in slower streams, and is characterized by the smooth movement of water, with little-to-no mixing.

Turbulent flow is common in faster streams, and is characterized by the mixed movement of water, which superimpose onto one another in the direction of the flow. Turbulent flow is the most common type of flow in stream channels.

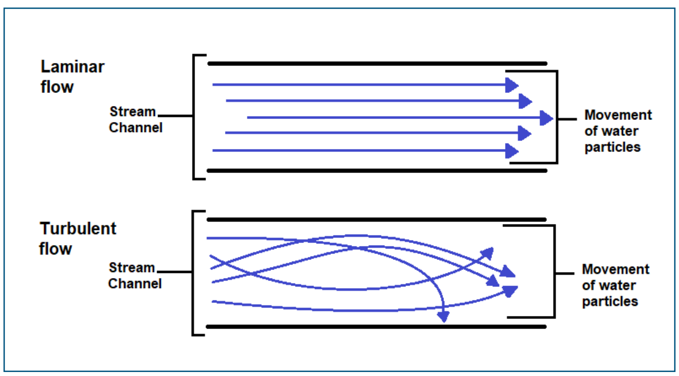


Image by Eryl Austin Bingamon, 2020.

DISCHARGE

Hydrologists refer to the amount of surface water moving through a system as its discharge. Discharge is a measure of water velocity relative to the area of a stream (Ritter, 2012). Oftentimes, streams are divided into cross-sections to make this calculation. Water scientists often measure discharge in cubic feet per second (cfs) (Ritter, 2012). The higher the discharge, the higher the flow.

The San Marcos River, with an average discharge of approximately 250 cfs (image from the U.S. National Parks Service).

The Colorado River, with an average discharge of approximately 22,500 cfs (image from the U.S. National Parks Service).

The Amazon River, with an average discharge of approximately 7,400,000 cfs (image acquired from the U.S. National Parks Service).

GROUNDWATER

Groundwater refers to water between cycles that is stored underneath the land surface. Groundwater exists in two layers, the unsaturated zone and the saturated zone (USGS staff, n.d.).

UNSATURATED ZONE

The small pockets of air between molecules of soil and rock are referred to as pores. In the unsaturated zone, water is present, but does not completely fill the pores between the soil and rock (USGS staff, n.d.).

SATURATED ZONE

The saturated zone is below the unsaturated zone, and groundwater accumulates here due to the force of gravity. In the saturated zone, groundwater fills the pores between soil and rock, completely saturating the bedrock. The saturated zone is where aquifers are found (USGS staff, n.d.)

SPRINGS

Springs can be found in areas where the water table and land surface intersect. Unlike saturation overland flow, springs are a semi-permanent fixture of the water table. This is because flowing springs create pressure gradient differences between the surface and the underlying aquifer, encouraging the movement of water towards the surface opening of the spring (Huggett, 2017).

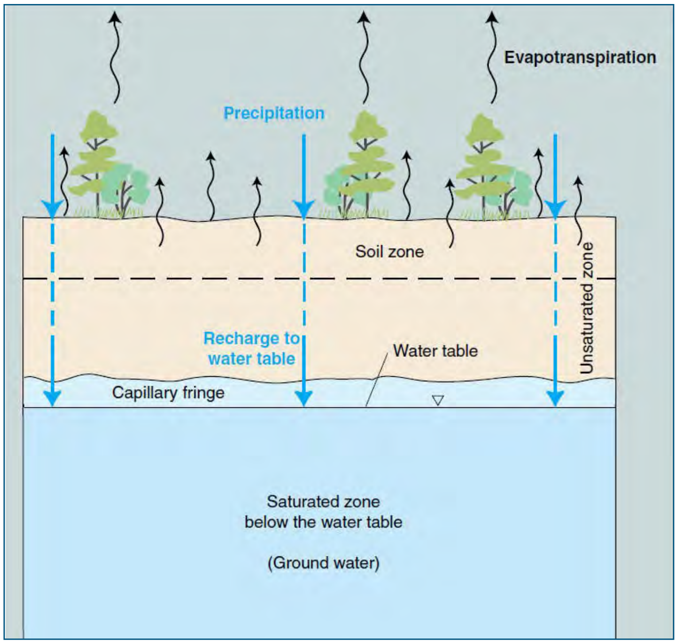
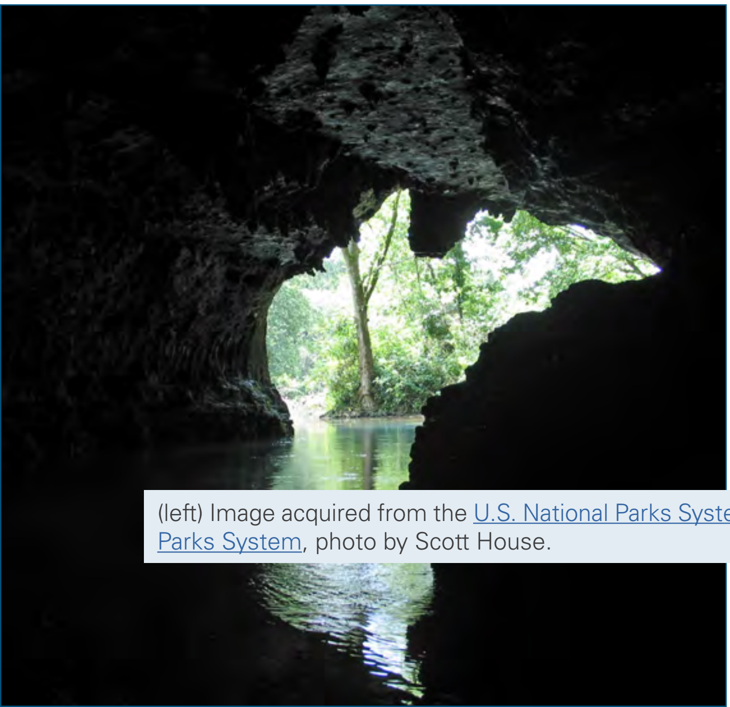


Image acquired from United States Geologic Survey (USGS).

Special note: One type of spring that is especially relevant to Texans is karst springs. Karst springs occur in karst landscapes, which are areas of soluble bedrock composed of carbonate rocks, evaporate rocks, or silicate rocks (Huggett, 2017).

In areas with a carbonate bedrock, water has the ability to act as an efficient solvent, dissolving and sculpting the surrounding landscape (Huggett, 2017). The features that are created due to this interaction are called Karst features. In central Texas, the abundance of aquifers, springs, and limestone channels can be attributed to the unique karst landscape.



(left) Image acquired from the U.S. National Parks System, photo by Scott House. (right) Image acquired from the U.S. National Parks System, photo by Scott House.

1.4 INTRODUCTION TO GEOMORPHOLOGY

Geomorphology is the study of Earth's physical landforms, including their origin, development, form, processes, and interrelations. Geomorphologists study Earth's landforms based on an understanding of geomorphic processes - the chemical and physical means through which landforms undergo change (Huggett, 2017).

Denudation and Deposition

Through the processes of denudation and deposition, Earth is able to move sediment and material across wide areas of land. During the process of denudation, the forces of weathering and erosion act in synchrony to create and transport surface materials (Huggett, 2017). The process of weathering creates these materials, and erosion picks up and transports them through a transporting media (such as water, ice, or wind) (Huggett, 2017).

DENUDATION

Denudation is a term that refers to the combined processes of weathering and erosion. Weathering is the gradual wear-down of the Earth's surface through biological, chemical, and mechanical processes (Huggett, 2017). There are three types of weathering:

- **Mechanical weathering:** The process of mechanical weathering breaks bigger rocks into smaller rocks. Mechanical weathering usually occurs due to changes in the surrounding pressure, temperature, or moisture of a material (Huggett, 2017).
- **Chemical weathering:** Chemical weathering is the breakdown or degradation of rock due to chemical processes. There are six major chemical processes that contribute to chemical weathering, including dissolution, hydration, oxidation and reduction, carbonation, hydrolysis, and chelation (Huggett, 2017).
- **Biological weathering:** Biological organisms can have a profound effect on the weathering of a material. Tree roots are a prominent example of a biological weathering agent. As the roots grow, they impart an increasing pressure on surrounding material, potentially leading to fractures (Huggett, 2017). Other types of biological weathering can result from organisms that bore into surrounding rock and sediments.

Erosion is defined as the sum of all processes through which the products of weathering are picked up and transported (Huggett, 2017). These materials are transported through a transporting media, such as water, wind, or ice. These materials could not be moved if not for an active force. The forces that drive the movement of weathered material include forces such as gravity, fluid forces, wind forces, or biological forces (Huggett, 2017).

DEPOSITION

Deposition is a geomorphic process wherein sediment is laid down onto the surface via chemical, physical, or biological means (Huggett, 2017). Sediment is often deposited when the capacity of the transporting material is no longer sufficient to carry the weight of the sediment load (Huggett, 2017). This is also referred to as stream capacity, or the greatest amount of sediment a stream can carry for a given discharge (Ritter, 2012).

In areas where deposition outpaces erosion, a depositional body or point bar can form. Depositional bodies can be observed along the bends of river channels, at the base of steep slopes, and across areas of flat elevation (Huggett, 2017).

Hydrogeomorphology

The field of geomorphology encompasses the study of complex interactions between a wide variety of Earth's processes. To study these processes in-depth, geomorphology is oftentimes broken down into several sub-fields. For the purposes of this manual, the branch of hydrogeomorphology is highly relevant and important to understand. Hydrogeomorphology, which combines geomorphology and hydrology, is the study of interactions between water and the physical landscape.

FLUVIAL EROSION

Due to the erosional capacity of water, streams can act as powerful geomorphic agents (Huggett, 2017). Streams have the capability to erode, carry, and deposit sediment. The stream power, or the capacity of a stream to do work, is a function of a variety of geomorphic factors. (Huggett, 2017). As discharge and channel slope increases, stream power increases as well (Ritter, 2012).

Stream load is the total material carried by a stream. Stream load is broken down into three categories which combine to create the total load (Huggett, 2017).

- **Dissolved load:** The dissolved load consists of the dissolved ions and molecules within a stream (Huggett, 2017). These materials are carried within the water column and move synchronously with the water molecules.
- **Suspended load:** The suspended load consists of the solid particles that are small and light enough to remain suspended in the water column (Huggett, 2017). These materials include silt, sand, and clay.
- **Bed load:** The bed load comprises the larger minerals, such as cobble, rock, and gravel (Huggett, 2017). These materials are dragged along the bottom of the water body by the current.

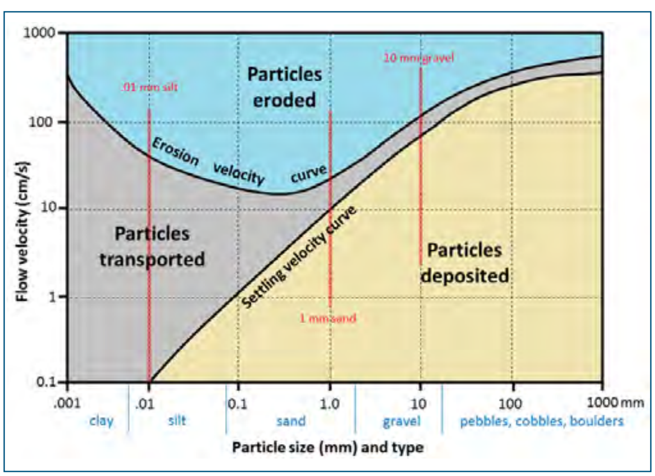


Image from Physical Geography 2nd e.d. by Steven Earle.

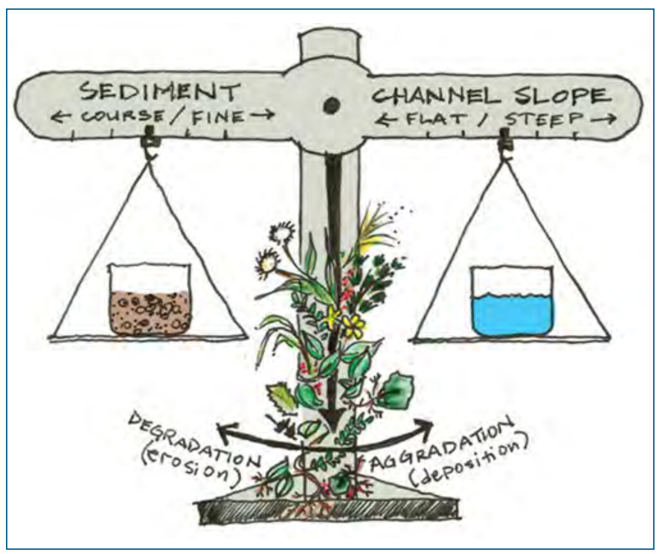
FLUVIAL DEPOSITION

Rivers deposit components of their total load as they move along their course. Deposition is most common at areas of divergence, as well as in areas of relatively low slope (Huggett, 2017). The Hjülstrom diagram, which models deposition as a function of streamflow velocity and sediment particle size, can be used to determine the approximate conditions under which deposition will occur (Huggett, 2017).

LANE'S BALANCE MODEL

Lane's Balance Model is a visual tool that uses four major variables to predict how a stream will react to various changes in its catchment. The variables used by Lane's Balance Model are sediment size, sediment discharge, streamflow, and channel slope.

Using Lane's Balance, predictions can be made about how a stream system will process increases in erosion or deposition. When one variable is altered the changes in a stream channel can be significant. The presence of a healthy riparian zone can substantially reduce and buffer these effects.



DEGRADATION

When an excessive amount of weathering and erosion occurs in a stream channel, the stream bed may experience degradation. Degradation can be seen in streams that have too much flow energy and not enough energy dissipation. A degraded stream will often appear down-cut, or the stream bed may widen and lower in elevation. Degraded streams often have a diminished water table, preventing riparian plants from effectively accessing soil moisture.

This stream is experiencing excessive erosion.

AGGRADATION

When an excessive amount of deposition occurs around a stream channel the stream bed may experience aggradation. When a stream channel cannot effectively process deposited sediment, the sediment build-up can lead to aggradation. A stream experiencing channel aggradation may appear overly wide and shallow, often with large build-ups of sediment in the middle of the channel or along the banks.

This stream is experiencing excessive deposition.

1.5 NONPOINT SOURCE POLLUTION

Getting to the Point

To a large extent, water quality within a watershed is linked to the actions of the people who live, work, and play within its boundaries. Water quality issues caused by human activities can be a result of either point source or nonpoint source pollution. A point source is a single, identifiable source of pollution such as a discharge from a municipal or industrial wastewater treatment plant. Point sources are regulated under the Federal Clean Water Act and Texas state law and are subject to permit requirements. These permits specify effluent limits, monitoring requirements, and enforcement mechanisms. Even though effluent discharges are permitted and regulated, many of these point sources have contributed to water quality degradation.

Nonpoint source pollution is pollution from sources which are diffuse and do not often have a single point of origin or are not introduced into a stream from a specific source. The pollutants are generally carried off the land by runoff. Nonpoint sources of pollution are largely unregulated and have not historically been evaluated in the same rigorous manner as point source pollution. Nonpoint source pollution originates from many different locations and sources. We have all seen trash in our waterways following a rainfall event. Other contaminants, not so easily seen, enter our waters in much the same way.

Nonpoint source pollution occurs when rainfall runoff transports contaminants on the surface of the land into adjacent water bodies. Contaminated stormwater can cause impairment to the beneficial uses of streams, reservoirs, estuaries, and oceans. Pollutants carried by water percolating through the soil and entering aquifer recharge features can contaminate groundwater. Land management activities associated with agriculture, forestry, and residential and urban development can increase nonpoint source pollutants.

Nonpoint Source Pollution's Effects on Aquatic Ecosystems

Dissolved oxygen is a basic requirement for a healthy aquatic ecosystem. Most fish and beneficial insects breathe oxygen dissolved in the water. Some fish and aquatic organisms, such as gar and sludge worms, are adapted to low dissolved oxygen concentrations. However, most desirable fish species, such as largemouth bass and darters, become stressed if dissolved oxygen concentrations are below 4 milligrams per liter (mg/L). Insect larvae and juvenile fish are more sensitive and require even higher concentrations of dissolved oxygen to grow and reproduce.

Oxygen concentrations in the water column fluctuate under natural conditions, but severe depletion may be the result of human activities that introduce large quantities of biodegradable organic materials into surface waters. Biodegradable organic materials which include lawn clippings, raw and treated sewage, food processing wastes, rice field drainage, and pulp paper wastes, are some examples of oxygen depleting organic materials that enter surface waters. As these wastes decompose and break down into essential nutrient-enriched building blocks, many chemical and biological processes are directly affected. Nutrients are fundamental building blocks for healthy aquatic communities, but excess nutrients (especially nitrogen and phosphorus compounds) may over stimulate the growth of aquatic plants and algae. Excessive growth of these plants, in turn, can clog waterways and interfere with boating and swimming. In addition, these plants will out-compete native submerged aquatic vegetation, and with excessive decomposition, lead to oxygen depletion or a condition called eutrophication. Oxygen concentrations often fluctuate widely, increasing during the day as aquatic plants conduct photosynthesis producing oxygen and falling at night as plants and animals respire, consuming oxygen.

Common Nonpoint Source Pollutants

Sediment from croplands, forestry activities, construction sites, and streambank erosion.

Nutrients from croplands, lawn and gardens, livestock operations, septic systems, and land waste application; sediments from erosion can reduce clarity and sun penetration in bodies of water, harming aquatic plant life and fish. Nutrients can also be carried by runoff from over-fertilized areas or decaying leaves and lawn clippings. Excessive nutrients in waterways can cause excess plant and bacteria growth, resulting in eutrophication (oxygen depletion) and fish kills.

Bacteria from livestock, seepage from improperly maintained septic systems, leaking sewer lines, wildlife, and urban runoff.

Man-made chemicals, including pesticides from roadways, croplands, lawns, gardens, and forestry operations. Toxic materials, such as improperly applied pesticides or automotive products such as motor oil, engine degreasers and antifreeze. These toxins can wash from city streets and other areas or can result from illegal dumping.

Surface trash, such as plastic containers or cigarette butts; this trash is not only aesthetically unappealing, but residue from discarded containers can be washed into water bodies.

Fertilizers, malfunctioning septic systems, detergents and organic materials in treated sewage, and manure in agricultural runoff are examples of nutrient sources often responsible for water quality degradation. Rural areas are susceptible to groundwater contamination from nitrates found in fertilizer and manure. Nutrients are difficult to control because they typically recycle among the water column, algae, and bottom sediments. For example, algae may temporarily but significantly reduce phosphorus from the water column, but the nutrients will return to the water column and bottom sediments when the algae die and are decomposed by bacteria. Gradual inputs of nutrients tend to accumulate over time rather than leave the system.






Detecting and Tracking Nonpoint Source Pollution

Nonpoint source pollution is episodic. This means it typically enters our rivers and lakes during episodes of rainfall resulting in runoff, during isolated events such as incidences of illegal dumping, or in a random fashion, as when a sewer line overflows or breaks. It is difficult and expensive to monitor nonpoint source pollution using a fixed monitoring schedule and employing tests for only a few chemical variables. Analyzing data for trends and correlations over space and time provides an effective strategy to investigate nonpoint source pollution.

Conducting chemical tests on water quality is like taking a snapshot of the river or lake at that moment in time. Trend analysis on dissolved oxygen concentrations, Secchi disc transparency measurements, and conductivity measurements provides additional clues in assessing nonpoint source pollution. Looking at this information over an extended period of time provides a strong foundation to infer the corresponding dissolved oxygen values (oxygen concentrations will correspond to plant production and decomposition), rainfall contributions (conductivity values will change with runoff), and nutrient fluctuations (Secchi measurements can be used to determine the productivity status of a system, which is influenced by nutrient loading).

Living organisms in a stream or lake can provide information about what has happened there over time. For example, monitoring a stream that has healthy habitat and chemical water quality that meets local water quality standards, but no living organisms indicates, something may have happened there prior to sampling to account for the lack of biodiversity. Perhaps a heavy rainstorm scoured the site and displaced all the organisms. Perhaps some nonpoint source pollution lowered the dissolved oxygen level, causing the organisms to die or move downstream. There are many possible explanations, but by looking at the biological community of the stream over time, the citizen scientist knows more about the long-term conditions of the stream than if they performed only water chemical tests or field observations.

Water pollution from nonpoint sources are less obvious and more difficult to identify than those from point sources and are not as easy to control through traditional treatment strategies. The variability of rainfall events and the complexity of the landscapes and geologic features lead to nonpoint source pollution phenomena which are highly variable and intricate. The lack of a single identifiable source of pollution makes it difficult to establish specific cause-and-effect relationships but reinforces the importance of analyzing trends and correlations drawn from consistent, long-term monitoring efforts.

1.6 TEXAS STREAM TEAM RIPARIAN EVALUATION

The Riparian Evaluation training assesses the health of lakes, rivers, and streams based on the riparian habitat. Riparian evaluations are coupled with water quality data and used to track ecosystem and habitat health over time in the rivers and streams that flow to the Texas Coast. A riparian area is the transitional band of vegetation between waterways of all sizes and their adjacent uplands. It is part of the landscape that borders a creek or river. When a riparian area is healthy and functioning properly it filters and slows runoff and floodwaters, and allows for sediment trapping, water storage, and groundwater infiltration. The water quality benefits of a healthy riparian area are well documented.

The riparian area is the band of vegetation surrounding the tributary pictured above. Image from the United States Department of Agriculture.

It is important to evaluate riparian habitats because indicators of riparian function can lead to the identification of activities that may be hindering the natural riparian function and recovery process. This training evaluates riparian health using georeferenced photos and the Riparian Bull's-Eye Evaluation Tool. The photos serve to document, visually, riparian habitat conditions at the time an evaluation is conducted. The tool is designed around ten riparian indicators to guide the assessment of riparian landscapes for their function and identify activities that may be hindering the natural riparian recovery process. The goal of these evaluations is to involve citizens in the identification of riparian plants found within Texas and to cultivate awareness and appreciation for riparian plants and the role they play in the protection of clean water.

Using the *Your Remarkable Riparian Field Guide*

The riparian evaluation technique and training presented here were developed based on information presented in the *Your Remarkable Riparian Field Guide*. When conducting a riparian evaluation, you will need to identify and categorize riparian plants present at a site. Identification of the properties of riparian vegetation will provide a window into the overall health of the riparian habitat.

Your Remarkable Riparian Field Guide is a resource that can be used on-site to identify and classify riparian vegetation. More information about classifying vegetation can be found in Section 1.13 - Riparian Vegetation.

1.7 GETTING STARTED WITH TEXAS STREAM TEAM

Please follow these steps to begin a monitoring project:

1. Schedule a training session(s) with a local Texas Stream Team trainer in your area. Texas Stream Team trainer contact information can be obtained by visiting the Texas Stream Team website. All three training phases can be completed in one training session. If training phases are split up into multiple sessions, Training Phases I and II are generally scheduled with a group. After completing Phases I and II, Phase III is scheduled at a later time to complete the Riparian Evaluation training. Phase III will typically take place at the citizen scientist's monitoring site.

2. Select a monitoring site and request a site identification number based on the guidelines included in this manual under Section 2.1 - Site Identification.

3. When establishing a monitoring group, complete a Texas Stream Team Group Citizen Scientist Monitoring Plan. The monitoring plan identifies the objectives of monitoring and specifies the sites and monitoring procedures. A copy of the Group Monitoring Plan and instructions can be obtained on the Texas Stream Team website.

4. Optionally, obtain *Your Remarkable Riparian Field Guide* and/or the *Your Remarkable Riparian Owner's Manual* from the Texas Stream Team Online Store.

5. Begin annual or bi-annual monitoring, record data on the Riparian Evaluation Environmental Monitoring Form, and send the data to your group Data Coordinator, Texas Stream Team, or enter the data directly into the Waterways Dataviewer.

6. Contact Texas Stream Team for information on scheduling a training, completing a Group Monitoring Plan, or for any other questions.

   Phone: (512) 245 -1346
   Email: TxStreamTeam@txstate.edu
   Web: TexasStreamTeam.org

1.8 TRAININGS

Information describing the various levels of certifications and trainings offered by Texas Stream Team is provided here. The longevity of the program is dependent upon the participation of our dedicated citizen scientists, and we encourage you to continue increasing your level of involvement each year by completing the required training to become a certified Texas Stream Team Riparian Evaluation Citizen Scientist Trainer/ Quality Assurance Officer, a Texas Stream Team Core Water Quality Citizen Scientist, or a Texas Stream Team Core Citizen Scientist Trainer.

Texas Stream Team Citizen Scientist Trainings

Texas Stream Team offers a number of additional water quality and environmental monitoring trainings, including:

- Standard Core Water Quality Citizen Scientist Training
- Probe Core Water Quality Citizen Scientist Training
- *E. coli* Bacteria Water Quality Citizen Scientist Training
- Advanced Water Quality Citizen Scientist Training
- Macroinvertebrate Bioassessment Citizen Scientist Training
- Riparian Evaluation Citizen Scientist Training

This manual only includes information for the Riparian Evaluation Citizen Scientist Training.

Visit Trainings.TexasStreamTeam.org to learn more about each training.

Riparian Evaluation Citizen Scientist Training

To receive certification as a Texas Stream Team Riparian Evaluation Citizen Scientist, the three-phase training program described on the following pages must be complete.

Each trainee is required to either fill out the online Training Enrollment Form to become an official Texas Stream Team Riparian Evaluation Citizen Scientist and begin monitoring activities.

PHASE I TRAINING

Phase I begins with an instructional classroom session, either in-person or virtually online, covering an introduction to Texas Stream Team, riparian and watershed processes, the benefits that healthy riparian areas provide, and an introduction to the Riparian Bull's-Eye Evaluation Tool.

The Phase I training transitions to an interactive demonstration of monitoring procedures. A Texas Stream Team certified trainer begins by explaining how the evaluations are conducted. The trainer then demonstrates the evaluation procedures while trainees follow along with the demonstration using a Monitoring Form. The trainees perform the riparian evaluation simultaneously and under close supervision of the trainer.

After all parameters are evaluated and the trainees are comfortable with the riparian evaluation indicators and procedures, the trainee and trainer review the Phase I Monitoring Form. This form signifies the trainee's successful completion of Phase I for the parameters specified and indicates their understanding of the evaluation process and commitment to following all procedures.

PHASE II TRAINING

During Phase II, trainees demonstrate the evaluation procedures they learned during Phase I in the field with the assistance of the trainer. Whenever possible the water body used for Phase II evaluations should be similar to the sites the trainees will eventually monitor as a citizen scientist.

Trainees conduct riparian evaluation procedures on their own, with assistance from a trainer if necessary. The trainers carefully observe the trainees' procedures, answering any questions the trainees may have and assisting with data quality assurance.

After all questions have been answered and the trainee completes the Phase II Monitoring Form, the trainee and the trainer discuss the trainee's strong points and weak points with respect to the evaluation procedures. The Phase II Monitoring Form is retained by the trainee for reference during Phase III.

PHASE III TRAINING

Phase III training can occur at the same time and location as Phases I and II, or it can take place at the trainee's approved monitoring site within three months of completing Phase II. The trainer observes the trainee as they conduct the monitoring at the site. By this time, the trainee should be able to work through the monitoring procedures and complete the Monitoring Form without the assistance of the trainer. After the trainee completes the training, the trainer then discusses next steps and how to set up a monitoring site. The trainee then completes the online Measures of Success Survey.

Once Phase III has been completed, citizen scientists are required to attend one quality control field audit session every two years to comply with the Texas Stream Team Quality Assurance Project Plan. During Phase III, the trainer will conduct the trainees' first field audit session. The field audit session will include a detailed observation of the trainee's evaluation techniques to ensure monitoring is being conducted following the Texas Stream Team protocol as described in this manual without the assistance of the trainer. A field audit session checklist will be used to document the session and to ensure monitoring protocols are adhered to by all trainees.

RIPARIAN INDICATORS	OUTER ZONE Poor, Dysfunctional Condition	MID ZONE At-Risk Condition	BULL'S-EYE High Functional Condition
☐ **1. Active Floodplain** Does floodwater have access to a floodplain? Look for recently deposited debris or silt from recent floods.	Limited or no apparent floodplain where floodwater can spread out and slow down.	Floodplain too far above channel to be very effective.	Floodplain clearly defined, allowing for floodwater to overflow channel, spread out, and slow down.
☐ **2. Energy Dissipation** Check if there is enough "stuff" in channels, on banks and in the floodplain to dissipate flood energy.	Not many energy dissipating features in the channel, on the banks, or in the floodplain.	Only some energy dissipating features present.	Abundance of energy dissipaters present in the channel, on the banks, and in the floodplain.
☐ **3. New Plant Colonization** Look for new plants successfully colonizing on fresh sediment.	Not much colonization; sediment deposits and point bars are bare.	Only some new plant colonization is on fresh sediment.	Abundance of new plants colonizing on fresh sediment.
☐ **4. Stabilizing Vegetation** Look for strong stabilizing plants along banks — those with a stability rating (SR) of 6 or greater.	Not much of bank is covered with stabilizing vegetation and tree roots.	Some gaps present and/ or some vegetation lacks sufficient stability rating.	Banks covered with stabilizing vegetation.
☐ **5. Age Diversity** Look for young, middle-aged and mature riparian plants present.	Few to no young and middle-age trees, shrubs, riparian grasses or sedges.	Only a few young and/ or middle-age riparian plants present.	In addition to older riparian plants, young and middle-aged plants are abundant.
☐ **6. Species Diversity** Look for the presence of several key, native riparian plant species.	No or low diversity: Only 1-2 native species of riparian trees, shrubs, and/or only 1-2 grasses and sedges.	Modest diversity: 3-4 species of native riparian trees, shrubs, and/or 3-4 grasses and sedges.	More than 5 different species of native riparian trees, shrubs, and/or more than 5 species of grasses and sedges.
☐ **7. Plant Vigor** Are riparian plants vigorous and healthy? Consult your Field Guide for information about a particular plant's palatability for grazing and browsing.	Unhealthy riparian plants. Woody plants show signs of heavy or chronic browsing; a Severe browse line can be noted. Riparian grasses and sedges compromised by grazing, mowing, or trampling.	Low vigor: Woody plants show signs of heavy browsing or hedging; A browse line may be present. Grasses and sedges show signs of heavy use, grazing, mowing, or trampling, only in places.	Healthy, vigorous riparian plants. Woody plants show little or no sign of heavy browsing or hedging. Grasses and sedges show little or no sign of heavy grazing, mowing, trampling, or other impairments.
☐ **8. Water Storage** Are the banks and floodplain storing water? Use your Field Guide to identify key Wetland Obligate and Facultative Wetland plants.	No OBL or FACW species are present, indicating a lack of water being stored in the riparian area.	Only a few OBL and FACW plant species present—and only along the stream's edge.	Several wetland plant species present—at water's edge and out on the floodplain too.
☐ **9. Bank/Channel Erosion** Look to see if bank and channel erosion is balanced with deposition on point bars.	Continuous, active and extreme bank erosion with no apparent balancing by point bar deposition. Channel may appear either too wide or too deep.	Widespread bank erosion, beyond meander bends and not balanced by point bar deposition. Channel looks out of balance.	Light and balanced bank erosion on meander bends being compensated by deposition on point bars downstream. Channel appears to be of size and depth to manage sediment.
☐ **10. Sediment Deposition** Look to see if sediment is being deposited in a balanced way —on point bars downstream from eroded banks.	Clearly excessive amounts of sediment, often in middle of the channel.	Some excessive sediment deposition, some mid-channel bars, but otherwise sediment is where it should be, on point-bars.	Normal and balanced Sediment deposition.

Texas Stream Team Trainer

Riparian Evaluation citizen scientists may receive additional certification as a Texas Stream Team Riparian Evaluation Trainer after completing the requirements described below.

- Trainer trainee must be a certified Texas Stream Team Riparian Evaluation citizen scientist who has been actively monitoring for at least two years.
- Trainee assists a certified trainer in planning, coordinating, and presenting at one citizen scientist training session.
- Trainee plans, coordinates, and presents all phases of one citizen scientist training assisted by a certified Texas Stream Team trainer.

Texas Stream Team Quality Assurance Officer Training

TO PERFORM FIELD AUDIT SESSIONS:
Certified trainers concurrently become certified Quality Assurance Officers upon completion of the trainer certification. Citizen scientists can be authorized to perform field audit sessions upon approval as a Texas Stream Team Quality Assurance Officer. Citizen scientists must first observe a field audit session performed by a certified Quality Assurance Officer, then lead a field audit session with a Quality Assurance Officer present.

Certification

Upon completion of training phases I, II, and III, the trainee must complete the online Training Enrollment Form before a certificate of completion can be issued. The trainer will then submit completed forms to the Texas Stream Team to create and distribute the certificates. The certification process serves as the record to document completion of the training and the first field audit session; therefore, it is critical that a legible form is submitted. If the trainer does not receive the completed form, a certificate of completion will not be generated and sent to the trainee.

1.9 QUALITY ASSURANCE

Texas Stream Team data is collected under a Texas Commission on Environmental Quality-approved Quality Assurance Project Plan. Quality assurance consists of citizen scientist activities that involve planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that Texas Stream Team citizen scientist data are of the type and quality needed and expected by the agencies that provide financial support for the program, the Texas Commission on Environmental Quality, and ultimately the Environmental Protection Agency.

The approved Quality Assurance Project Plan documents the procedures Texas Stream Team citizen scientists implement to ensure that the resulting data are of high quality and meet project data quality objectives. The Quality Assurance Project Plan also ensures citizen scientists state-wide use the same methods for evaluating riparian areas to ensure comparable results. For these reasons, it is critical all citizen scientists are aware of the Quality Assurance Project Plan requirements and implement the procedures as stated in the approved document.

Quality Control

Quality control consists of the overall system of citizen scientist activities and compares the Texas Stream Team Riparian Evaluation data against defined standards to verify that they meet the stated requirements approved by the Texas Commission on Environmental Quality.

There are currently three types of quality control measures implemented by Texas Stream Team riparian citizen scientists to achieve the data standards.

1. **Buddy system:** We strongly recommend citizen scientists always monitor using the buddy system for safety purposes, but also to confirm observations by conducting duplicate visual evaluations.
2. **Quality Control Sessions:** Once trained, citizen scientists must attend one field audit session every two years. A field audit session includes observation of a citizen scientist conducting evaluations by either a Texas Stream Team Trainer, Quality Assurance Officer, or Texas Stream Team staff member. Observations are documented on a Field Audit Session Checklist and results must meet the data quality objectives. Other online resources are being developed to assist with compliance of this requirement; please check the Texas Stream Team website for updates.
3. **Data Management:** Quality assurance procedures and checklists are implemented before data is entered to the Dataviewer. See Section 3.1 - Data Management for additional information.

1.10 INTRODUCTION TO RIPARIAN ZONES

Texas is made up of approximately 268,597 square miles of land, making it the largest state in the contiguous United States. Of that land, approximately 255,000 mi² consists of private property, meaning that almost 95% of Texas land is privately owned, the largest percentage of privately owned land in any U.S. state (Ramirez, n.d.).

With so much of Texas' land belonging to private citizens, the conservation and protection of our state's natural resources is largely in the hands of landowners. Reaching out to educate and involve private landowners in the process of riparian evaluations is a significant priority for Texas Stream Team, as the success of riparian restoration will, to a great extent, depend on their active participation and collaboration.

Riparian areas account for only 1% of all land in Texas, but their contributions to water quality and stream health are invaluable. Without functional riparian zones, Texas streams and waterbodies are unable to perform the essential ecosystem services that not only contribute to Texas' natural beauty, but also drive the economic and social wellbeing of the state. Because of the unique abundance of aquifers, streams, and rivers, the management and restoration of Texas riparian zones is especially essential to the current and future wellbeing of Texas.

What is a Riparian Zone?

A riparian zone is the ribbon of land immediately surrounding a waterbody. This land acts as the transition between the dryer uplands and the stream channel. Riparian areas do not include the actual body of water, only the immediately surrounding channel bank and land.

Historically, riparian areas have been widely undervalued and misunderstood. In recent years, however, water professionals have begun to better understand their value and function and recognize their essential contribution to the health of Texas streams.

Why should we value riparian zones?

Riparian zones, which were once largely undervalued, have now come to be known as integral to the function of a water body. Human activities such as land development, riverbank alterations, and construction projects have degraded riparian areas so that they are no longer able to serve their ecological function. As our understanding of riparian zones develops, we begin to better understand how to protect, manage, and restore them.

FUNCTION CREATES VALUE

We value riparian areas because of the functions they serve.

- Dissipate stream energy
- Store water
- Floodwater retention
- Groundwater recharge
- Sustain baseflow
- Trap sediment
- Sustain floodplain
- Reduce erosion

Identifying Hindrances

A hindrance is any activity or circumstance that interferes with the natural function of riparian areas or inhibits riparian areas from recovery. Hindrances are often the result of human or wildlife activity.

Once citizen scientists are trained to evaluate riparian health, they can begin to identify hindrances that may be preventing riparian areas from optimal function.

Common hindrances observed in Texas riparian areas:

- Farming, mowing, or spraying weeds or brush too close to the bank
- Logging and related timber harvest activities adjacent to the creek
- Manicured or altered residential or park landscapes next to the creek
- Prolonged grazing concentrations in creek areas
- Excessive populations of deer, exotics, or feral hogs in creek areas
- Burning in riparian area
- Removal of large dead wood and downed trees
- Artificial manipulation of banks (bulldozing), channels or sediment
- Physical alteration of floodplain
- Excessive vehicle traffic in creek area
- Excessive recreational activity or foot traffic in creek area
- Excessive alluvial pumping or other withdrawals
- In some cases, the excessive growth of invasive species that inhibit the ability of native riparian plants to do their jobs
- Low water dams and large reservoirs
- Poorly designed road crossings and bridges

Functional vs. Dysfunctional Riparian Zone

Because the concept of a riparian zone is still relatively recent, scientists still have a lot to learn about the function and maintenance of these unique areas. It is only recently that water professionals have begun to understand and identify the properties of functional riparian zones.

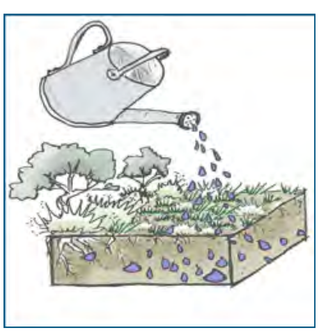
FUNCTIONAL RIPARIAN ZONES

A healthy, functional riparian zone will often look overgrown, unkempt, or shaggy. "Stuff", such as debris, brush, or vegetation, will crowd the banks and serve to dissipate runoff and slow down flood water. Although these areas may look unaesthetic to humans, they provide an essential ecological service and indicate a riparian area that is able to properly serve its function.

DYSFUNCTIONAL RIPARIAN ZONES

Dysfunctional riparian zones often appear more aesthetic to the human eye. There is often little-to-no vegetation, and oftentimes any vegetation that is present is heavily manicured. These riparian zones have a severely impaired function that is often further degraded by heavy flooding. When vegetation is allowed to grow naturally, these dysfunctional zones are able to retrieve much of their original function. When allowed to return to a natural, overgrown condition, these riparian areas can be fully restored.

A healthy riparian zone is often referred to as a "sponge". Productive riparian zones that are serving their functions will be able to slow down, filter, and release runoff from the surrounding catchment. Unproductive or dysfunctional riparian areas inhibit this function, allowing runoff to flow uninhibited, directly into stream channels.



Which side of this creek would you rather own? Many people would instinctively choose side B, because it is easier to access the stream channel and there is no risk of hazardous wildlife and plants. Side A, on the other hand, is dense with vegetation, and may be difficult to navigate. The density of the vegetation on side A, however, is exactly what makes it a more functional riparian area.

If a flood occurred in the catchment basin surrounding this creek, runoff would flow very quickly into the stream from side B and likely result in erosion of the bank. On side A, however, much of the runoff would be stored, filtered, and slowly released into the channel. This not only increases the water quality of the creek, but also sustains flow in the channel for a longer period of time.

OBSERVING VEGETATION TO EVALUATE RIPARIAN FUNCTION

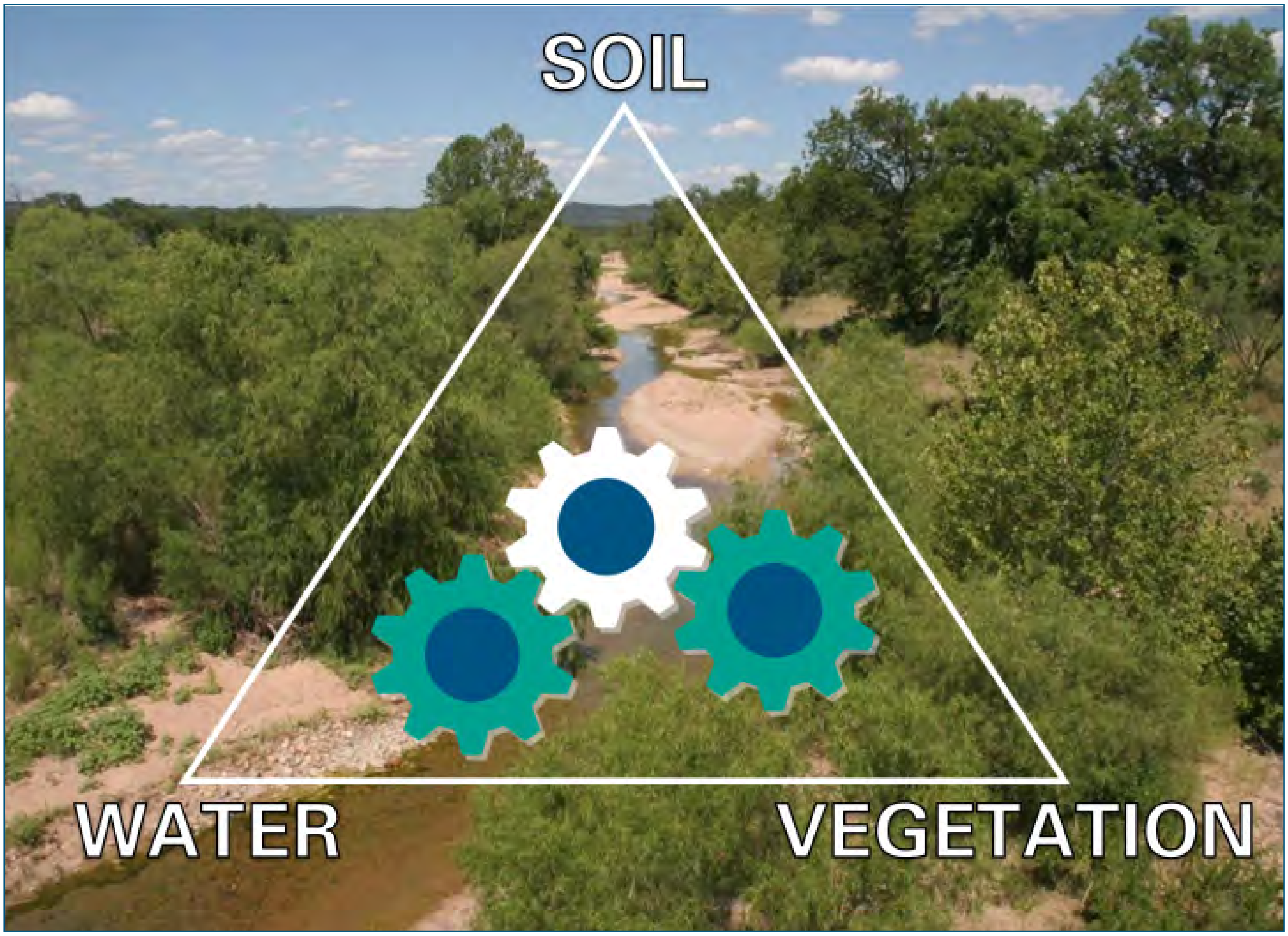
Riparian restoration always begins with a plant. Texas Stream Team citizen scientists become adept at observing the presence, or lack thereof, of riparian vegetation. Using prior knowledge, citizen scientists draw general conclusions about the health of a riparian system by observing the abundancy and richness of riparian vegetation.

FUNCTIONAL

Do not be fooled - while this riparian area is not green and grassy, it is still functional. Large root structures and anchored stabilizer plants line the bank, and the floodplain appears to be well equipped to dissipate excess flow.

DYSFUNCTIONAL

These riparian areas are not well equipped to dissipate flow. Both areas display evidence of excessive erosion and deposition, indicating that the channel is unbalanced and unable to process the amount of energy it is receiving. In addition to this, there is little-to-no structural support lining the bank, evidenced by a lack of stabilizer plants and root structures.



1.11 THE RIPARIAN MACHINE

Riparian areas function because of the interactions between soil, water, and vegetation. These three components interconnect like the gears of a finely tuned machine. If one of these gears is out-of-sync, then the function of the whole machine becomes impaired.

In the following sections, the basic principles of soil science, riparian vegetation, and water quality will be discussed. An emphasis will be placed on the specific properties of these components within a riparian system. Overall riparian function, and its impact on water quality, soil, and surrounding vegetation will also be emphasized and discussed in further detail.

1.12 RIPARIAN SOILS

Introduction to Soils

A soil is a naturally occurring body comprised of solids, liquids, and gasses that occurs on the immediate surface of earth (Soil Survey Staff, 2015). Soils comprise the top layer of unconsolidated earth and host a complicated and unique set of physical, chemical, and ecological interactions. Understanding the properties and abilities of soil plays a prominent role in effective environmental evaluation and management.

Riparian soils are distinctive and unique from upland soils. Due to their proximity to channels, riparian soils experience a variety of geologic and geomorphic processes that contributes to their unique properties.

Soil Composition

Soils are primarily composed of minerals (Soil Survey Staff, 2015). Minerals are categorized according to their size. From largest to smallest, minerals are generally classified as either sand, silt, or clay (Soil Survey Staff, 2015). The texture of soil is categorized by its relative composition of these minerals. Soil scientists use a "Texture Triangle" tool to determine soil texture based on relative percentages of sand, silt, and clay.

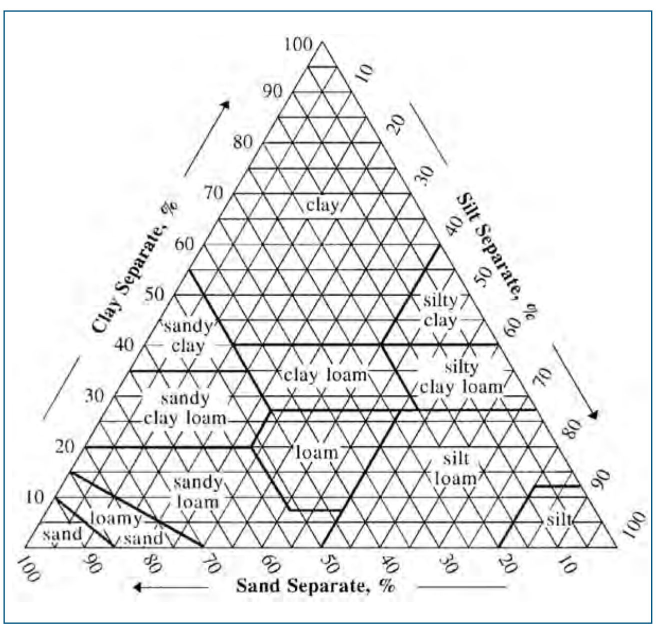


Image from the USDA Soil Survey webpage.

A typical riparian soil is rich in loamy, fine sand, which is deposited in bedding planes. A bedding plane is a layer of depositional sediment, deposited due to the forces of erosion and deposition along channels and banks (Jacob, 2013). In Texas, especially closer to the Gulf of Mexico, riparian soils are also often rich with clay (Jacob, 2013). Clay has the ability to shrink and expand depending on water content and temperature, causing what is called a "shrink-swell" (Jacob, 2013). Evidence of this can be observed along riverbeds during dry periods, where the surrounding soil may look cracked and fragmented.

This image demonstrates the shrinking-capacity of clay. Image from CSIRO Science Image.

SOIL HORIZONS

Soils form over long periods of time with the assistance of various geologic processes, such as erosion and deposition. As soils form, they are deposited in layers. In soil science, these layers are referred to as horizons (Soil Science Society of America, 2017). The presence or absence of certain horizons can be indicative of a soil's properties and natural history. Soil scientists classify these soil horizons using the following method:

- **O - Humus or organic:** this horizon is the top layer of organic matter, such as leaves, grass, and organic debris
- **A - Topsoil:** this horizon is mostly minerals from the parent rock, and contains an

abundance of organic material and living organisms

- **E - Eluviated:** this horizon is a concentration of sand, silt, and other materials that are resistant to leaching (draining away)
- **B - Subsoil:** this horizon is rich in leached minerals from the A or E horizons
- **C - Parent material:** this horizon is defined by the original source material, the deposit from which the soil developed
- **R - Bedrock:** this horizon is a mass of rock such as granite, limestone, or basalt.

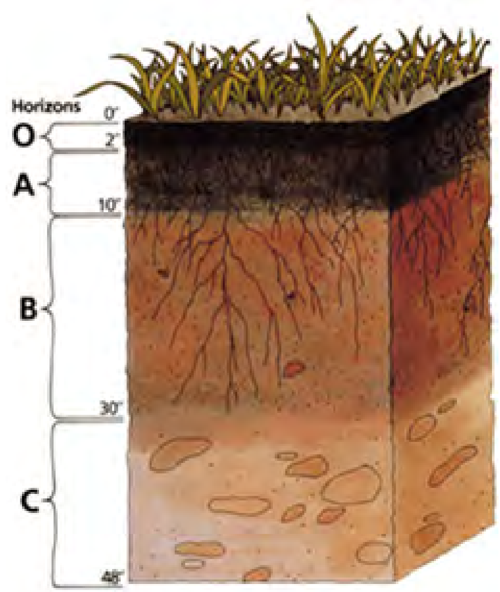


Image from [USDA Soil survey website.]

C.L.O.R.P.T.

The composition and properties of soil are a function of **cl**imate, **o**rganic material, **r**elief, **p**arent material, and **t**ime (**CLORPT**) (Jacob, 2013). Soil scientists use the acronym CLORPT to describe the processes that affect soils.

CLIMATE

On a global scale, climate is the most influential factor that determines the properties and composition of a soil. Riparian soils are heavily subject to the influences of climate. A riparian soil bordering the Rio Grande in the dry, southwestern region of Texas will be remarkably different as compared to a riparian soil bordering Caddo Lake in northeastern Texas (Jacob, 2013).

ORGANIC MATERIAL

Organic materials include both living and dead organisms, including billions of types of bacteria and microorganisms that inhabit the soil and contribute to its unique properties and abilities. (Soil Survey Staff, 2015). Organic material can also include vegetation (Jacob, 2013). Riparian soils have a composition of vegetation that is unique and distinct from upland soils. In addition to this, riparian soils are host to a unique community of various bacteria and microorganisms, all of which contribute to the soil's ability to effectively filter runoff and break down hazardous waste.

RELIEF

Relief refers to the topographical change in elevation over an area of land. Mountains, cliffs, and tall formations will have a high relief. Conversely, most floodplains are relatively flat, with low relief. Relief affects factors such as temperature, direct sunlight, water runoff, erosion and deposition, and organic matter build-up, all of which affect the properties and formation of soils (Jacob, 2013).

PARENT MATERIAL

Soils are primarily composed of minerals, which are produced from the weathering of parent rock material. A parent rock is any material that serves as the original source for a mineral. Oftentimes, this material is comprised of regional bedrock. The bedrock is the solid, lowermost layer that lies below the top layers of unconsolidated earth. Two examples of very common bedrock materials are granite and basalt (Jacob, 2013).

Riparian soils oftentimes consist of a variety of parent sources (Jacob, 2013). This is because minerals from other sources run off of upland areas and deposit into the riparian soils surrounding a catchment basin. Minerals are also frequently transported and deposited from upstream sources, which contributes to a greater diversity of mineral types.

TIME

Time serves as the primary function that differentiates riparian soils from upland soils (Jacob, 2013). Riparian soils are usually very young, underdeveloped soils (Jacob, 2013). Due to regular flooding along the banks of channels, riparian soils experience a high rate of erosion and deposition. This constant turnover contributes to a weakly developed A horizon, and little-to-no profile development (Jacob, 2013).

More information about soil taxonomy can be found on the U.S. Department of Agriculture's Soil Taxonomy webpage at https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/.

Why Do Soils Matter?

The function of a riparian zone is reliant on the well-being of riparian soils. The riparian "sponge" could not function without the filtering effect of soils. This is because soils contain organic material that have the ability to break down hazardous materials found in runoff. Soil also traps excessive runoff, filters it, and slowly releases it back into the channel, contributing to a longer sustained flow.

Both the terrestrial and aquatic habitats of a riparian zone rely on the function of soils. Soils act as the substrate that supports all riparian vegetation, and the vitality and continued growth of riparian vegetation is dependent on the health and functionality of riparian soils. The ability of riparian vegetation to slow and filter runoff, as well as maintain a habitat for riparian organisms, relies on the wellbeing of riparian soils.

Understanding the properties, abilities, and behaviors of riparian soils allows citizen scientists to perform more accurate, nuanced riparian evaluations. Degraded soils, such as a bank that is excessively eroded, cannot effectively support vegetation. Without the support of vegetation, the riparian area loses functionality, and can be considered "at-risk". Sufficient, extensive riparian evaluations are dependent on the understanding of riparian soil's function, composition, and behavior.

1.13 RIPARIAN VEGETATION

Classifying Riparian Vegetation

Perhaps the most significant indicator of riparian health is the presence or absence of certain types of riparian vegetation. When performing a Texas Stream Team riparian evaluation, it is important to make all observations as specific and detailed as possible. For this purpose, citizen scientists will need to classify vegetation according to a variety of predefined categories.

CLASSIFYING VEGETATION BY CATEGORY

For the purposes of the Texas Stream Team Riparian Evaluation training, vegetation can fall into one of five categories for easy identification. These categories include:

Sedges and Rushes: Sedges and rushes are herbaceous plants with long, narrow leaves. Although sedges and rushes look similar to grasses, they can be distinguished by their Wetness Indicator status (see Classifying Vegetation by Wetness Indicator section below). Sedges and rushes usually require a higher soil moisture, while grasses tend to have a wider range of tolerable conditions.

(Left) Spike rush (*Eleocharis palustris).* (Right) Black sedge (*Carex nigra*).

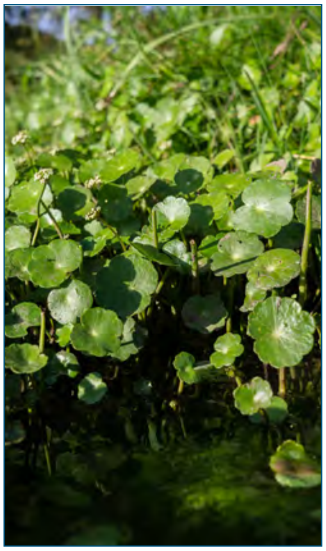
Grasses: Grasses are herbaceous plants with long, narrow leaves. Although sedges, rushes, and grasses are closely related (they all belong to the family Poales), grasses are distinct in their abundance and distribution, often making up the dominant vegetation in a variety of habitats.

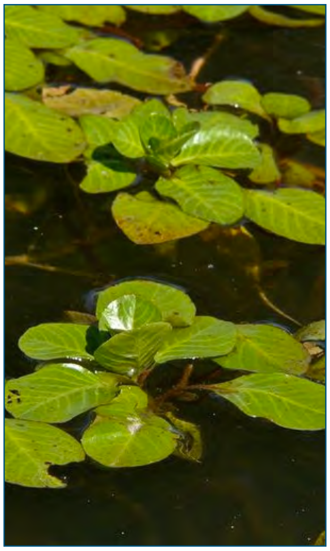
(Left) Switchgrass (*Panicum virgatum*). (Right) Bushy bluestem (*Andropogon glomeratus*).

Woody Plants and Trees: Woody plants are vital components to a healthy riparian area. Woody plants and trees often serve as stabilizers, providing structure and support to the banks and slowing the velocity of runoff. The strong roots of trees support the channel by interlacing with the roots of other riparian vegetation, ultimately forming a supportive matrix of "riparian rebar".

(Left) Little Walnut (*Juglans microcarpa*). (Right) Desert Willow (*Chilopsis linearis*).

Forbs: A forb is a broad-leafed, herbaceous plant. A plant is described as a forb if it is herbaceous (lacking any woody structure), but not grass-like (due to its broad leaves). Examples of forbs include watercress, wild mint, water pennywort, tall asters, sunflowers, clovers, or daylilies.





(Left) Pennywort (*Centella asiatica*). (Right) Water Primrose (*Ludwigia peploides*).

Ferns and Vines: Ferns are herbaceous plants that differ from other types of plants in the way they reproduce. Ferns do not produce flowers or seeds, instead it reproduces via spores. Vines, which often look very similar to ferns, are herbaceous plants with the tendency to climb as they grow. While ferns and vines are often present in riparian habitats, they are usually less abundant than other categories of plant.

(Left) Maidenhair fern (*Adiantum capillus-veneris).* Image acquired from the U.S. National Parks Service. (Right) Morning glory (*Ipomoea leptophylla*). Image acquired from the U.S. National Parks Service.

CLASSIFYING VEGETATION BY WETNESS INDICATOR

Some plants thrive in wetlands, while others prefer the drier soils of upland areas. The types of plants that are growing in an area can indicate the relative soil moisture, as well as connections to groundwater sources. Wetland Indicator (WI) status is assigned to riparian plants based on the amount of soil moisture they require and helps to provide a general overview of the water storage capacity in a riparian zone.

There are five Wetland Indicator categories used.

Obligate Wetland Plants (OBL): Under natural conditions, obligate wetland plants are almost always found in wetland areas. The presence of these plants can indicate connection to a groundwater source.

Cattail (*Typha latifolia*). Image acquired from the U.S. National Parks Service.

Facultative Wetland Plants (FACW): Facultative wetland plants plants are usually found in wetland areas and areas with a high degree of soil moisture.

Knotgrass (*Paspalum distichum*).

Facultative Plants (FAC): Facultative plants occur in both wetland areas and non-wetland areas. These plants usually have a wide tolerance of moisture conditions.

Pecan tree (*Carya illinionensis*). Image acquired from the U.S. National Parks Service.

Facultative Upland Plants (FACU): Facultative upland plants are usually found in drier, upland areas. These plants have a lower tolerance for soil moisture, although they can occasionally be found in wetland areas.

Camphor daisy (*Rayjacksonia phyllocephala).* Image acquired from the U.S. National Parks Service.

Upland Plants (UPL): Under natural conditions, upland plants are almost always found in drier, upland areas with little soil moisture.

Burrobrush (*Hymenoclea monogyra).*

CLASSIFYING VEGETATION BY STABILITY RATING

A stability rating (SR) is used to categorize riparian plants based on a plant's ability to withstand the forces of erosion. Plants with weak roots that are easily dislodged by heavy flow are assigned a lower stability rating, and stronger, rooted plants are assigned a higher rating.

The stability rating runs from one to ten, where one equals bare ground and ten equals the stability of an anchored rock. Assigning riparian plants a stability rating provides a general overview of the structure and strength of a riparian area.

- **SR1:** Bare Ground
- **SR6/7:** Minimum required average stability for riparian health
- **SR10:** Anchored rock

This is a picture of a typical riparian area that might be seen in the Texas Hill Country. Amongst the vegetation are weakly-rooted sycamore trees, with an SR of 6. Their roots are strengthened by interlacing with the sawgrass (SR9).

CLASSIFYING VEGETATION BY FUNCTIONAL GROUP

Plants are assigned categories based on their general ecosystem function and the role that they play in sustaining a riparian zone. There are three Functional Plant Groups used to categorize plants based on their role in a riparian area.

Pioneer Plants: Pioneer plants live where other plants cannot. Because of a pioneer plants ability to withstand a wide range of conditions, they are usually the first plants to show up in newly colonized areas.

In Texas, pioneer plants often establish themselves on large gravel deposits. Although these conditions are harsh, with little shade and poor water retention, pioneer plants are able to survive and prepare more favorable conditions for future riparian plants. Most of these plants are categorized as facultative plants (FAC) or facultative upland plants (FACU).

Brickelbush (*asteaceae*).

Sycamore (*Platanus occidentalis*).

Colonizer Plants: Colonizer plants are quick to show up in newly established riparian areas. Colonizer plants spread quickly and often grow along the edge of the water. These plants serve to trap sediment and create niches for deeper-rooted plants to eventually take hold. Colonizer plants are further categorized into two sub-categories, Early and Late-stage colonizers.

Early-Stage Colonizer Plants: Early-stage colonizers are weak rooted, with an emphasis on fast growth and quick spread. Compared to late-stage colonizers, they have a lower SR (often between SR3-SR5).

(Left) Frogfruit (*Phyla nodiflora)*. (Right) Watercress (*Brasicaceae*).

Late-Stage Colonizer Plants: Late-stage colonizers have comparatively stronger roots, but they do not grow as quickly as early-stage colonizers. Compared to early-stage colonizers, they have a higher SR (often between SR6-SR7).

(Left) Knotgrass (*Paspalum distichum*). (Right) Bushy bluestem (*Andropogon glomeratus*)

Stabilizer Plants: Stabilizer plants are tall, upright, and have a dense root mass. These plants are the slowest to establish, however, they are stronger and more permanent than pioneer and colonizer plants. These plants can be woody (such as a tree), or herbaceous (such as a brush).

Stabilizer plants provide an essential structure and stability to stream banks due to their ability to interweave with the roots of herbaceous plants. Stabilizer plants also slow the velocity of incoming flood water and trap excessive sediment before it has the chance to enter the waterbody.

(Left) Emory sedge (herbaceous) (*Carex emiryi*). (Right) Gulf cordgrass (herbaceous) (*Spartina spartinae*).

(Left) Bald cypress tree (woody) (*Taxodium distichum*). (Right) Burrobrush (woody) (*Hymenoclea monogyra).*

Native vs. Non-native Vegetation

OVERVIEW

The U.S. Department of Agriculture defines a native plant as "a plant that lives or grows naturally in a particular region without direct or indirect human intervention." Texas is home to over 7,000 species of plants, and nearly 5,000 of these are thought to be native (Ward, 2009). Native plants thrive in their natural conditions and serve to sustain and maintain proper ecosystem function.

Native plants play an integral and irreplaceable role in the sustainability of their local habitat because of their evolutionary life history. Native plants that have occupied a habitat for long periods of time have had the opportunity to evolve specific and unique adaptations. For example, the native Texas Lantana bush has defenses against the hot, dry climate of Central Texas. This bush requires less water and can bloom in dryer soils.

Texas Lantana bush (*Lantana urticoides*). Image from the Native Plant Society of Texas.

Native plants are also integral community members. Oftentimes, native plants live long enough in a certain habitat that they experience coevolution. Coevolution occurs when two or more species reciprocally affect each other's evolutionary adaptations. For example, flowers and bees, who have a long coevolutionary history, rely on one-another's existence to survive. Bees obtain nutrients by collecting the nectar of flowering plants, and in turn, flowers are pollinated by visiting bees. Because this relationship is mutually beneficial, many flowers have responded by evolving their scent, appearance, and physical structure to attract bees.

HOW ARE NON-NATIVE PLANTS HARMFUL?

Although an invasive or non-native plant may thrive in foreign conditions, their presence is not always sustainable. These plants often do not have the climactic adaptations that native plants do, and they may require heavier watering and more-frequent landscaping. Over time, many non-native plants have a tendency to reduce the fertility and viability of local soils, making it more difficult for native plants to thrive.

The relationships between species are often held in a delicate balance. When native plants are removed, or when non-native species begin to dominate an area, interactions that had existed between organisms for millions of years can be abruptly disrupted. The maintenance of a healthy ecosystem is reliant on the presence of native vegetation.

In riparian areas, native plants are always preferable to non-natives. Some non-native plants may not be inherently harmful, but they are usually unable to perform the same ecosystem function as native plants. A database of Texas native plants can be found on The Lady Bird Johnson Wildflower Center's webpage www.wildflower.org/plants-main.

INVASIVE PLANTS

Invasive plants are distinct from non-native plants. Invasive plants are species with a tendency to over-dominate an area. These plants are able to reproduce and spread so quickly that they have the potential to deal significant damage to a habitat. A database of invasive species can be found on TexasInvasives.org, at https://texasinvasives.org/plant_database/.

The pictures below include two of the most invasive species in Central Texas, the Paper Mulberry Tree (left) and the Hydrilla (right).

Paper Mulberry Tree (*Broussonetia papyrifera*). Image from TexasInvasives.Org. Picture by J.S. Peterson.

Hydrilla (*Hydrilla verticillate*). Image from TexasInvasives.Org. Picture by V. Ramey, University of Florida.

1. 14 RIPARIAN WATER QUALITY

The health of riparian areas has a direct impact on the stream water quality. Texas Stream Team has worked to incorporate riparian evaluations into our citizen scientist programs in order to provide a comprehensive understanding of water quality in Texas rivers, streams, lakes, bays and estuaries.

E. coli bacteria

E. coli is a bacterium that originates from the wastes of warm-blooded animals. The presence of *E. coli* bacteria indicates that associated pathogens from waste may be reaching a body of water. *E. coli* bacteria often enters a water body after a rain event and can be found in runoff from agricultural and urban areas. A healthy riparian zone helps to slow and filter runoff, preventing *E. coli* bacteria from entering the waterways.

Texas Stream Team citizen scientists can learn to monitor *E. coli* by becoming a certified *E. coli* Water Quality Citizen Scientist.

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen dissolved in the water, as well as the amount of oxygen available to aquatic plants and animals. Dissolved oxygen is a byproduct of plant photosynthesis and atmospheric aeration and is an essential indicator of stream health. Through photosynthesis, riparian vegetation helps to maintain stable, healthy dissolved oxygen levels that are necessary for the functions of aquatic organisms.

Texas Stream Team citizen scientists can learn to monitor dissolved oxygen by becoming a certified Core Water Quality Citizen Scientist.

Temperature

The water temperature in a stream affects feeding, reproduction, and the metabolism of aquatic animals. In addition, temperature affects the solubility of compounds in water, rates of chemical reactions, current movements, and more. Riparian vegetation helps to stabilize the temperature of a water body by providing shade along the bank, decreasing the amount of direct sunlight the stream receives.

Texas Stream Team citizen scientists can learn to monitor temperature by becoming a certified Core Water Quality Citizen Scientist.

Clarity/Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by dissolved or suspended solids that scatter light. High turbidity is harmful to aquatic life because it inhibits photosynthesis, degrades spawning beds, and clogs the gills of aquatic organisms.

The turbidity of a stream is highly influenced by the amount of sediment it is receiving. Riparian areas function to capture and filter the sediment in runoff, increasing the clarity of a stream and helping to maintain livable conditions for aquatic organisms.

Texas Stream Team citizen scientists can learn to monitor dissolved oxygen by becoming a certified Advanced Water Quality Citizen Scientist.

Flow

Streamflow is a measurement of the volume and velocity of water flowing in a stream, river, or channel. When water bodies exhibit a high streamflow, pollutants are transported, degraded, and diluted, improving the health of the system. Riparian areas capture and store floodwaters during periods of heavy rain, releasing it at a slower rate and helping to maintain flow in periods of drought.

Texas Stream Team citizen scientists can learn to monitor flow by becoming a certified Advanced Water Quality Citizen Scientist.

Orthophosphates, Nitrogen, and other Nutrients

When a stream receives an excessive influx of nutrients it can lead to a process known as eutrophication, wherein a waterbody experiences an overgrowth and subsequent die-off of algae. This process can cause dead zones, which are zones where oxygen is consumed so rapidly that the ecosystem becomes deprived of adequate oxygen and is temporarily unable to support life. Riparian areas serve to slow and filter excess runoff, trapping sediment and preventing excess nutrients from reaching the channel.

Texas Stream Team citizen scientists can learn to monitor orthophosphates, nitrogen, and other nutrients by becoming a certified Advanced Water Quality Citizen Scientist.

1.15 RIPARIAN ZONES AND ECOSYSTEM HEALTH

Functional riparian zones promote the health and function of surrounding terrestrial and aquatic ecosystems. There are many organisms that cannot survive without the support of a functional riparian zone.

Macroinvertebrates

Macroinvertebrates are a type of aquatic organism that can be used to determine the biological health of a waterbody. A macroinvertebrate is any animal lacking a backbone which is large enough to see without the use of a microscope (EPA staff, 2012). Aquatic macroinvertebrates can be found in or on the sediment, or free-floating within the water column.

Water professionals use macroinvertebrates as bio-indicators. For example, the presence of "EPT" from Orders Ephemeroptera, Plecoptera or Trichoptera macroinvertebrates in a stream signals that the water quality is relatively high. This is because macroinvertebrates belonging to the order Ephemeroptera (mayflies), Plecoptera (stoneflies), or Trichoptera (caddisflies) are known to be pollution intolerant. The presence of any significant amount of pollution in a water body will usually kill these organisms or drive them to relocate. Texas Stream Team citizen scientists can become certified to monitor macroinvertebrates through the Texas Stream Team Macroinvertebrate Bioassessment training.

Without the filtering effect of riparian areas, pollutants would enter water bodies at a much higher rate and concentration, leading to the degradation of the macroinvertebrate community.

Other Aquatic Organisms

Aquatic organisms are often the first to become affected when riparian zones are not functional. In the United States, one of the most highly imperiled groups of animals is the freshwater mussel. According to the Texas Parks and Wildlife Department, more than 50 species of freshwater mussels exist in Texas, with 15 mussel species currently listed as threatened (Texas Parks and Wildlife, n.d.).

A freshwater mussel, image from the Texas Parks and Wildlife Depatment.

Clean, freshwater is an essential component of the mussel's habitat because they are filter feeders. Mussels derive nutrients by drawing in water, filtering out small particles, and re-releasing the water. They act as a "living filter", and tangibly improve the water quality of their habitat (Texas Parks and Wildlife, n.d.)

An image displaying freshwater mussels significant filtering ability. Image from The Partnership for the Delaware Estuary.

Mussels are very sensitive to changes in their environment. As Texas rivers experience longer periods of drought, followed by flashier, more intense flooding events, mussel species across Texas become increasingly unable to adapt to the changing conditions.

Riparian areas are vital to the healthy hydrologic regulation of Texas rivers. Riparian areas not only effectively store and release water, they also act as buffers and filters for runoff. When riparian areas are functioning correctly, they can lessen the impact of drought and lower the intensity of floods in Texas streams, which creates more livable conditions for sensitive aquatic organisms.

When riparian areas are disrupted, not only does water quality degrade, the aquatic and terrestrial ecosystems are impacted. By maintaining the function of riparian areas, we are also protecting the organisms that depend on it.

How does this impact us?

Riparian zones not only affect the health of aquatic and terrestrial organisms, they also impact the lives of humans. As Texas grows in population, more and more rivers will be relied upon for water resources. To provide for a growing population, it is necessary that Texans have an understanding of the value of riparian areas.

As Texans, we are aware of the intrinsic value of water bodies, but well-intentioned actions often have unforeseen consequences. Streams used for recreation or that flow through urban areas often have degraded, over-developed riparian zones to accommodate an increased amount of foot traffic. The over-development of riverbanks can lead to stream alterations such as sediment build-up and bank erosion, which can alter the shape and size of a stream. An increase in groundwater pumping can deplete the water table, leading to lower flow. When groundwater is over pumped, streams that once had a perennial flow become intermittent or ephemeral. Increased construction and agriculture around streams can lead to an increase in runoff rich in sediment, fertilizer, and waste resulting in harmful algal blooms and eutrophication.

These activities lead to degraded water quality, impaired ecosystem function, and less water for the citizens of Texas. As water scientists become more familiar with the function of riparian areas, more efforts are made to restore them. Texas Stream Team citizen scientists can get involved in riparian evaluation and monitoring to promote stewardship across the state, and so that communities can work to make a positive impact on the health of Texas' streams, rivers, bays and estuaries.

2.0 SAFETY CONSIDERATIONS

General Precautions

1. Read all instructions to familiarize yourself with the monitoring procedures before you begin. Note any precautions in the instructions.

2. Never conduct your evaluation in hazardous weather conditions. If you suspect hazardous weather conditions, do not attempt to travel to your monitoring location to conduct an evaluation. Reschedule for a later time.

3. Follow the advice of all local, regional, state and national weather agencies.

4. Follow all local, regional, state, and national laws while conducting your riparian evaluation monitoring.

5. If you need to access private property throughout the course of your riparian evaluation monitoring, the Private Property Access Form must be submitted to Texas Stream Team PRIOR to accessing private property.

6. Texas Stream Team strongly suggests that you always implement a buddy system and monitor with another person for safety purposes.

Site Safety

1. Park your vehicle safely away from roads and out of the way of traffic. Be cautious of traffic when unloading or loading monitoring equipment and accessing your site.

2. If necessary, sample your site from bridges with pedestrian walkways, from docks, or from stream banks. If you must enter the water, always have a buddy or partner on the shore nearby and always wear a life jacket or U.S. Coast Guard approved personal floatation device if wading is necessary.

3. Approach your site carefully! Look out for traffic on bridges and when crossing roads. Be on the lookout for snakes, fire ants, wasps, poison ivy, Africanized honeybees, wild animals, broken bottles, debris, or briars.

2.1 CHOOSING A MONITORING LOCATION

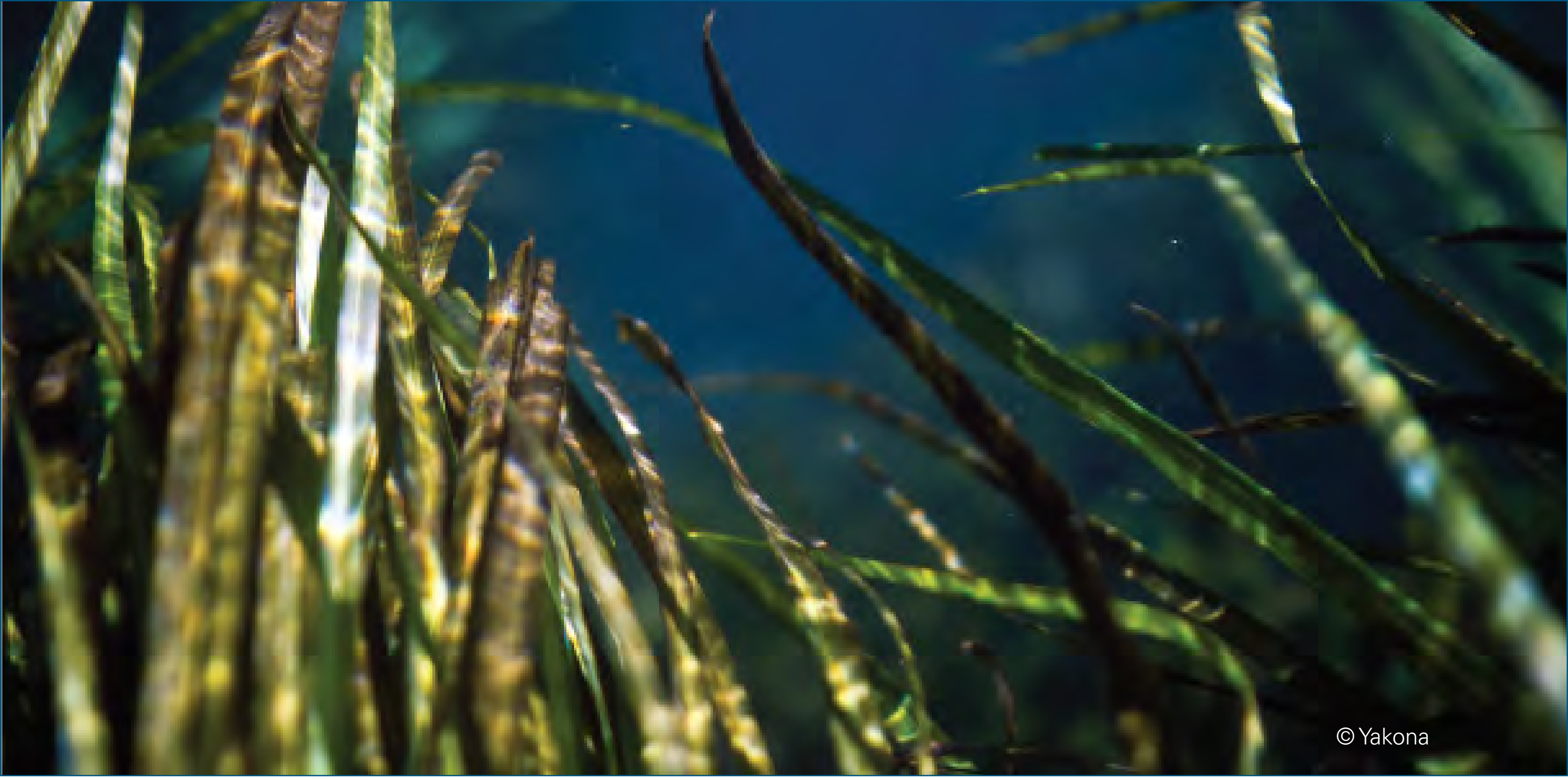
Historical water quality data is very useful in assessing impairments in water bodies. Therefore, it is preferable for citizen scientists conducting the riparian evaluation to use existing monitoring sites with historical water quality data when possible. The Datamap can assist in determining if an established site is available in the citizen scientist's area of interest.

Creating a New Site

The location of a Texas Stream Team water quality monitoring site should be based on the following Texas Stream Team site selection guidelines. Although these guidelines were developed for water quality monitoring sites, we prefer citizen scientists conduct riparian evaluations at previously established water quality monitoring sites with historical water quality monitoring data.

First, ensure that the proposed site is safely accessible year-round. If the site is on private property, obtain the landowner's written permission granting access prior to any monitoring activities taking place. A Private Property Access form must be obtained and submitted to the Texas Stream Team for review before any Texas Stream Team monitoring can take place.

Texas Stream Team recommends selecting monitoring sites that best represent the overall water quality and riparian conditions of a water body. Sites on streams with perennial (year-round) flow are preferable to streams that flow intermittently. Also consider the extent of a riparian evaluation site as that which is visible as far as the eye can see in both directions. For example, if a citizen scientist stands on the bank of a creek, the site at that location would include the visible portion of the creek upstream, downstream and across from the citizen scientist's purview. Another consideration is whether to monitor the right bank, the left bank, or both banks. This decision is made by the individual conducting the evaluation and the purpose for the monitoring. Documentation of this information needs to be included on the monitoring form.



2.2 REQUESTING A SITE

Activating an Inactive Site

Rather than establishing a new monitoring site, citizen scientists have the option of reactivating an inactive site. Inactive sites with historical data are useful for analyzing water quality and riparian data trends. This information can then be used by water and resource professionals to make informed decisions about the management of a water body.

Due to these advantages, Texas Stream Team encourages citizen scientists to reactivate historic sites, if possible, prior to the creation of a new site. Citizen scientists can view all current and historic sites by accessing the Datamap, which can be used to identify an inactive site that appeals to you.

Creating a New Site

To create a new monitoring site, citizen scientists can submit an online New Monitoring Site Request Form to Texas Stream Team. Prior to filling out the form, citizen scientists should review the Texas Stream Team Site Selection Guide.

Once the Texas Stream Team Site Selection Guide has been reviewed and the new site has been confirmed, the New Monitoring Site Request Form is submitted with the new site information. Please note that data cannot be entered in the Texas Stream Team Waterways Dataviewer without a site identification number that includes latitude and longitude coordinates and a short description. To determine the exact location of your site, use Google Maps, a U.S. Geological Survey topographic map (scale of 1:24000), a National Oceanic and Atmospheric Administration (NOAA) nautical chart, one of the several Street Atlas software systems that provide latitude/longitude coordinates or street address, or a calibrated global positioning system (GPS) unit.

Following submission of the New Monitoring Site Request Form, a Texas Stream Team staff member will review the form to make sure the criteria are met and will send an email confirmation with the site identification number once the site has been created. This site identification number will be included on each monitoring form and will link the data collected to that specific site.

2.3 CHOOSING A MONITORING TIME

Choose a convenient time and day to conduct monitoring. Riparian evaluation monitoring should be conducted at least one or two times a year to capture seasonality, or more if desired. It is essential that annual or biannual monitoring is conducted at the same time each year for consistent, comparable documentation of seasonal changes over time.

For example, if an evaluation at a site will occur twice a year and the first evaluation was conducted on June 3, 2019 at 9:00 am, an ideal time to conduct your next Riparian Evaluation would be within the first week of December 2019, to capture a different season. If a riparian evaluation at a site will occur once a year, then we recommend you conduct it in the same month each year to ensure your results are comparable from one year to the next.

SAFETY CHECK: If conditions are not safe, do not monitor.

2.4 EQUIPMENT AND SUPPLY LIST

Your Remarkable Riparian Field Guide

Your Remarkable Riparian Field Guide is a comprehensive guide to riparian plants found within most of Texas. Published by the Nueces River Authority in 2016, this guide provides an introduction to riparian and watershed function as well as instructions on the use of the Riparian Bull's-Eye Evaluation Tool.

Each plant identification includes the common and scientific name, a short description, the Wetland Indicator Status, Stability Rating, and several pictures of the plant. This information will help reliably identify and categorize riparian vegetation at the monitoring location. *Your Remarkable Riparian Field Guide* can be purchased from the Texas Stream Team online store.

Riparian Evaluation Environmental Monitoring Form

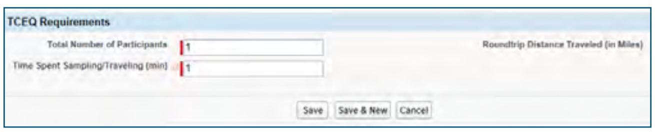
The Texas Stream Team Riparian Evaluation Environmental Monitoring Form is used to record the observations and evaluations. This form includes the Riparian Bull's-Eye Evaluation Tool, as well as a section for observations and basic information.

When filling out the Monitoring Form, make sure to include your name, the date of your evaluation, the site ID and description, the side of the bank evaluated, and any other important information. The Monitoring Form will include a section for documenting observation comments, including the presence of litter, nurdles, and monofilament. The bottom of the form includes the required metric fields. These fields are reported quarterly to the Texas Commission on Environmental Quality for grant match, and include total time spent travelling and monitoring, total roundtrip miles travelled, and number of participants. Lastly, the form will require your signature and date before the data can be entered into the Waterways Dataviewer.

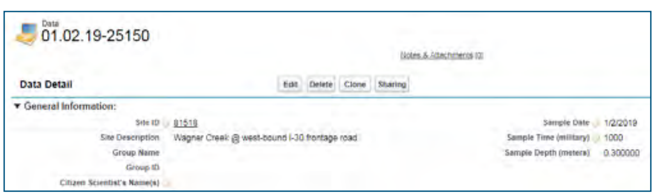
When performing your evaluation, it is important to remember that every observation provides valuable information about the health of the riparian area. As you complete the Monitoring Form, include detailed comments about why you chose certain ratings, as well as any additional observations.

The Monitoring Form can be printed directly from the Texas Stream Team website. Monitoring Forms can be submitted to Texas Stream Team via the Waterways Dataviewer, or by submitting a high-quality scan or photo of the completed Monitoring Form directly to your group Data Coordinator or Texas Stream Team at txstreamteam@txstate.edu

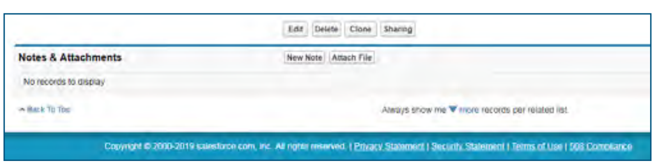
When uploading data to the Waterways Dataviewer, you have the option to include a picture once the data has been entered and saved. Be sure to capture photos of the study area including the right/left bank(s) being evaluated.

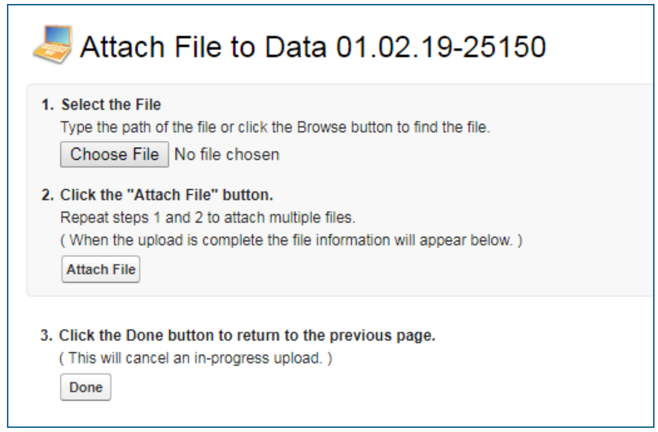


After selecting "save", the data will be presented for review. On the review page, you can select "Notes & Attachments" at the top or scroll down to the bottom of the entry where you will find the "Notes & Attachments" section.



Select "Attach File" to upload a file. Click the "Choose File" button to select a photo, and then click "Attach File." The photo is then uploaded and attached to the data record.





Note: To attach multiple photos, repeat this process.

If you are emailing data sheets to Texas Stream Team, you can attach your photos to the email containing the completed Monitoring Form. Texas Stream Team will review the photos and add them to the Waterways Dataviewer data entry.

Camera

The Riparian Bull's-Eye Evaluation Tool is a useful quantitative method for evaluating riparian areas, however, visual supplements to this data help establish a comprehensive overview of the monitoring location and also serve as a historical record of the site.

If you do not have access to a digital camera, use the camera on your phone to document images at your monitoring location. There are no specific requirements for photo documentation, as long as the pictures uploaded are high quality and accurately document the area evaluated.

2.5 MONITORING SEQUENCE

A typical monitoring sequence for a certified citizen scientist would include the following steps:

1. Print the Monitoring Form or enter your data directly into the Waterways Dataviewer using your account credentials.
2. Before conducting the riparian evaluation, review the field quality control checklist on the Monitoring Form. Use this list as a guideline throughout the monitoring event to ensure protocols are adhered to.
3. Document all observations, such as:
    - Number of recreational swimmers, fishers, boaters, etc.
    - Any unusual water conditions, such as color or smell
    - The presence or evidence of wildlife
    - The presence of litter or trash
4. Take 1-4 photos of your site (See section 2.6-Identified Species and Comments).
5. Begin to evaluate the ten key indicators (See section 2.7- Introduction to the Riparian Bull's-Eye Evaluation Tool). For each rating:
    - Fill in the small, white circles on the appropriate ring of the bull's-eye
    - Document your observations for each indicator
    - Take a picture, if helpful
6. Evaluate for Active Floodplain and record rating (See section 2.8-Indicator Key One: Active Floodplain)
7. Evaluate for Energy Dissipation and record rating (See section 2.9-Indicator Key Two: Energy Dissipation)
8. Evaluate for New Plant Colonization and record rating (See section 2.10-Indicator Key Three: New Plant Colonization)
9. Evaluate for Stabilizing Vegetation and record rating (See section 2.11-Indicator Key Four: Stabilizing Vegetation)
10. Evaluate for Age Diversity and record rating (See section 2.12-Indicator Key Five: Age Diversity)
11. Evaluate for Species Diversity and record rating (See section 2.13-Indicator Key Six: Species Diversity)
12. Evaluate for Plant Vigor and record rating (See section 2.14-Indicator Key Seven: Plant Vigor)
13. Evaluate for Water Storage and record rating (See section 2.15-Indicator Key Eight: Water Storage)
14. Evaluate for Bank/Channel Erosion and record rating (See section 2.16-Indicator Key Nine: Bank/Channel Erosion)
15. Evaluate for Sediment Deposition and record rating (See section 2.17-Indicator Key Ten: Sediment Deposition)
16. Review the field quality control checklist on the Monitoring Form.
17. Make sure the Monitoring Form is completed, then sign and date.
18. Submit the form to a Texas Stream Team Data Coordinator, or Texas Stream Team by emailing a pdf or high-quality picture to TxStreamTeam@txstate.edu

2.6 IDENTIFIED SPECIES AND COMMENTS

It is important to identify and record observed plant species on your Monitoring Form under "Identified Species and Comments".

You can use *Your Remarkable Riparian Field Guide* to identify plants in the field. *Your Remarkable Riparian Field Guide* lists plants by type, including sedges and rushes, grasses, forbs, woody plants and trees, and ferns and vines. If you are unsure how to identify a plant in the field, begin by narrowing down the plant into one of these categories (see section 1.13 - Riparian Vegetation).

When you have identified the riparian vegetation, record the common and/or scientific names on the Monitoring Form, along with any other comments. Comments can include observations about site use, weather, aquatic and terrestrial wildlife, presence of litter or debris, or any noteworthy observations you make while performing the riparian evaluation. You can also describe the general conditions of the site, especially if any noticeable changes have occurred since the last monitoring event.

Taking Pictures

Texas Stream Team recommends taking a photo each time you arrive at your site from the same location, angle, and frame. Photos provide an excellent reference for data managers who are evaluating the recovery of a riparian area.

When taking a photo, be sure to include a point of reference, such as a large boulder, a tree, or other feature that can be used to frame the photo in the same way each time.

The photos to the right are of the same site on the Nueces river from 2007 to 2013 (Jones-Lewey, 2013). This site experienced extensive riparian restoration. Although each photo is taken several years apart, they are all framed identically, and include several points-of-reference.

Texas Stream Team also recommends taking photos of any unusual conditions, such as any newly deposited sediment, any suspected pollution events, or any areas with new vegetative growth. As you fill out the Riparian Bull's-Eye Evaluation Tool, use photo-documentation to provide additional information on each key indicator.

Photos by Sky Jones-Lewey, Nueces River Authority. Acquired from the Texas Riparian Association website.

2.7 INTRODUCTION TO THE RIPARIAN BULL'S-EYE EVALUATION TOOL

The Riparian Bull's-Eye Evaluation Tool is a guided observation tool for use by trained citizen scientists to accurately evaluate the health of a riparian zone using ten key indicators. Using these indicators as a reference, makes it easier to recognize impaired riparian areas and identify the activities that may be hindering their recovery.

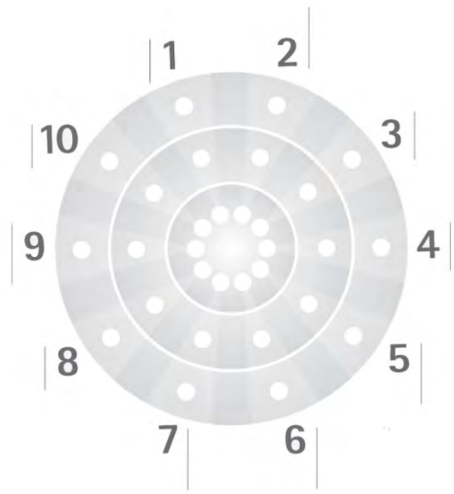
Citizen scientists will use the Riparian Bull's-Eye Evaluation Tool to plot the outcome of each indicator evaluation on the inner, middle, or outer ring.

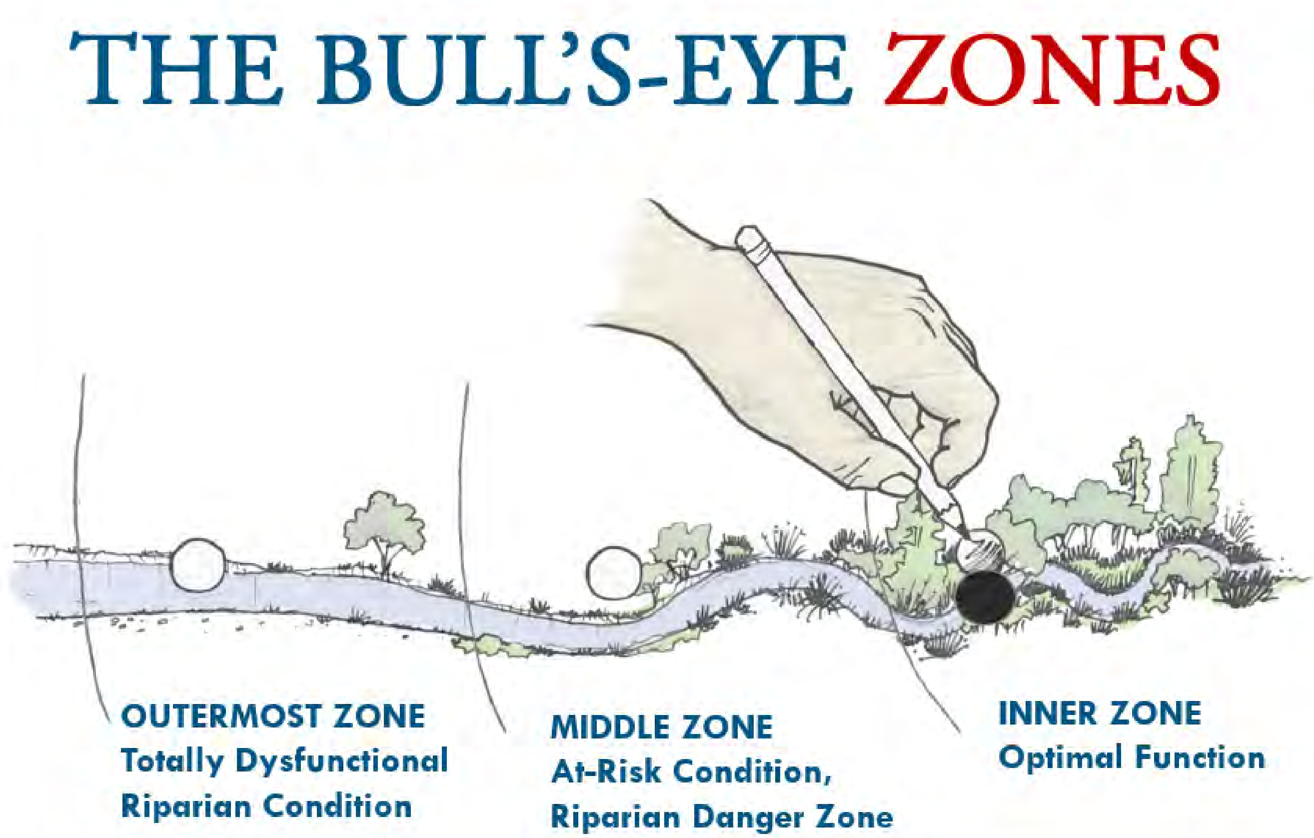
The inside ring, or "bull's-eye," represents optimal riparian function.

The mid zone represents an "at-risk" condition.

The outer zone represents an impaired, dysfunctional condition.

Using the Riparian Bull's-Eye Evaluation Tool trains the eye to recognize components of a riparian ecosystem that may be impaired or dysfunctional.



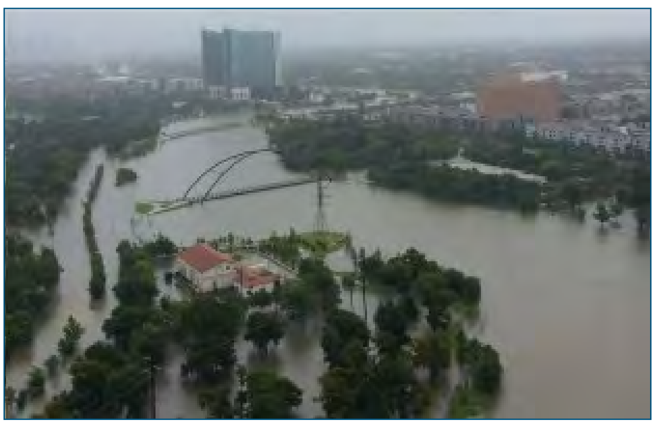


2.8 RIPARIAN INDICATOR ONE: ACTIVE FLOODPLAIN

Overview

DOES FLOODWATER HAVE ACCESS TO A FLOODPLAIN?

A floodplain is any area of low-lying ground that is next to a stream channel. Because floodplains are directly adjacent to channels, they are the first areas to flood after a heavy rain event.



Images taken of a floodplain in Houston, TX before and after Hurricane Harvey in 2017. Photos by Allison McLemore of The Washington Post, 2017.

Access to a floodplain is essential to the health of a riparian area. Floodplains give floodwater the opportunity to spread out and slow down, reducing the chance of excessive erosion along the channel bank and reducing the amount of sediment that is deposited into the channel. Without access to a floodplain, any runoff flowing through a catchment will quickly flow into the nearest channel. This results in an increase in erosion, a decrease in water storage capacity, and an increase in sediment deposition.

What to Look For

Streams that are confined by roads or cement embankments typically do not have floodplain access. Access to the floodplain will also be impaired if streams have been heavily modified by humans, or if they have been severely down cut.

Streams that have good floodplain access will have a well-vegetated riparian area. Look for evidence of a recent flood event. You may find that areas with thick vegetation have trapped new sediment, such as sand, silt, or organic debris. This is evidence that the riparian vegetation is efficiently trapping sediment from floodwaters.

Examples

FUNCTIONAL

This channel has good floodplain access. The channel has not been significantly altered, and the riparian area contains abundant vegetation.

DYSFUNCTIONAL

This channel has poor floodplain access. The stream is severely down cut, restricting access to the floodplain. There is also little vegetation in the riparian area, as well as evidence of excessive erosion.

2.9 RIPARIAN INDICATOR TWO: ENERGY DISSIPATION

Overview

IS THERE ENOUGH "STUFF" TO DISSIPATE FLOOD ENERGY?

Flood energy is a term used to describe the speed and force of floodwaters. Although it may not look dangerous from the surface, floodwaters are usually moving at a hazardous velocity. This is because as the discharge in a stream increases, the force that the water is able to exert increases. This increased discharge is often strong enough to pick up people, cars, and even houses.

Because of the powerful forces of floodwater, the integrity of stream channels is reliant on the ability of a riparian area to effectively dissipate energy. The dissipation of energy is a process wherein energy (in this case, floodwater energy), becomes unavailable and irrecoverable. There are many different ways to dissipate flood energy, but riparian areas specifically function to slow down and spread-out floodwater energy.

What to Look For

Riparian areas are only able to spread out and slow down floodwater when there is plenty of "stuff" present in the floodplain. This stuff can include large, natural debris such as dead wood or fallen trees, as well as unkempt vegetation, rocks, and any other natural features.

Riparian areas with a poor array of natural "stuff", or riparian areas that have been heavily manicured or developed, will not be able to effectively dissipate energy.

Examples

FUNCTIONAL

This riparian area has good energy dissipation. There is a diverse array of unkempt, natural vegetation that can serve to slow and spread floodwater.

DYSFUNCTIONAL

This riparian area has poor energy dissipation. Although riparian vegetation is present, there is little diversity, and the banks immediately adjacent to the channel lack an array of natural "stuff".

2.10 RIPARIAN INDICATOR THREE: NEW PLANT COLONIZATION

Overview

ARE TRAPPED SEDIMENT BEING SUCCESSFULLY COLONIZED BY NEW PLANTS?

As floodwaters flow downslope and into a channel, a healthy riparian area will filter and trap some of the sediment present in the runoff. This sediment, along with sediment deposited throughout the channel, will contribute to the evolving structure of the adjacent bank.

New plants should be consistently colonizing this new sediment for it to be successfully integrated into the riparian habitat. As pioneer and colonizer plants begin to grow on new sediment deposits, the riparian area's ability to store water will increase, and additional plants will begin to grow.

What to Look For

It is a good idea to start by looking for new sediment deposits along the riverbank, which can often be found on point bars. New sediment may consist of gravel, sand, dirt, or other types of substrate. Gravel deposits are especially common in Central Texas.

When you have identified new substrate deposits, begin to look for evidence of plant growth. These plants may appear young and sparse, with poor root structures. It is a good idea to identify these plants using the *Your Remarkable Riparian Field Guide*. Be on the lookout for pioneer or colonizer plants, as these are usually the first plant categories to show up on newly deposited sediment.

Examples

FUNCTIONAL

This riparian area has an abundance of new plant growth. Plants are observed colonizing new sediment deposits.

DYSFUNCTIONAL

This riparian area has poor, inadequate plant colonization. There is no evidence of new plant growth on the gravel deposits.

2.11 RIPARIAN INDICATOR FOUR: STABILIZING VEGETATION

Overview

ARE BANKS COVERED WITH STRONG STABILIZING PLANTS?

Floodwaters often have enough energy to uproot vegetation and disrupt the structure of stream channels. For this reason, functional riparian zones rely on strong-rooted vegetation to withstand flood energy while maintaining the structure and stability of the banks. Good stabilizing plants will have a SR number of 6 or higher.

The healthiest riparian area will have an adequate mixture of high-stability, deep-rooted plants alongside low-stability plants, rocks, and debris. Stabilizer plants have the unique ability to interweave with the roots of lower-stability plants, creating a strong, interlocked root network. Within a riparian area, an average plant stability of SR6 or higher is usually the minimum requirement to weather a flood.

What to Look For

Using *Your Remarkable Riparian Field Guide* or other plant identification resources, identify the major types of riparian vegetation present at your monitoring location, as well as their SR. Your monitoring location should have adequate coverage of riparian vegetation, as well as the presence of larger debris such as fallen trees, wood, or boulders. Your riparian vegetation should have an SR of 6 or more.

Examples

FUNCTIONAL

This area has good stabilizing vegetation. The landscape is adequately covered, with little-to-no areas of bare ground and features a diverse variety of plants that are high on the SR scale (an SR6 or greater).

Vegetation in this image includes Bulrush, SR8/9; Indian grass, SR7; Spikerush, SR6; and Switchgrass, SR8/9.

DYSFUNCTIONAL

This area has poor stabilizing vegetation. The landscape is dominated by bare ground, which has a stability rating of zero.

2.12 RIPARIAN INDICATOR FIVE: AGE DIVERSITY

Overview

ARE YOUNG, MIDDLE-AGED, AND MATURE RIPARIAN PLANTS PRESENT?

The presence of both young and old riparian vegetation is an indicator that the growth and function of the area has not been significantly hindered in recent history. Older plants should be abundantly dispersed alongside younger and middle-aged plants. This indicator of riparian health serves not only to inform us of present conditions, but also provides some insight into the past function of a riparian zone.

In addition, a riparian area with a diverse age distribution will be better equipped to adapt to variations in flow and climate. Older plants with deeper root structures interlock with the root structures of younger plants to form a more resistant, stable, and structurally sound riparian habitat.

What to Look For

Once you have identified the riparian vegetation present at the monitoring site with the *Your Remarkable Riparian Field Guide* or another plan identification resource, you can look for examples of mature, middle-aged, and younger plants.

To identify younger plants, look for new growth in sediment deposits, as well as plants that do not appear to have reached their full growth height. New growth plants are often a brighter green, with more sensitive and fragile leaves and a weaker root structure.

Middle-aged plants can be identified by looking for vegetation that appears to have reached its maximum growth but does not have identifiable wear-and-tear. These plants may be a vibrant green, with in-tact leaves, and may not appear to have been grazed on extensively.

Mature plants include older stabilizer plants established in a riparian area for a longer amount of time. Some trees, such as the bald cypress that often lines creek beds in Central Texas, could be considered mature plants. Mature plants may have more noticeable signs of wear-and-tear, such as broken leaves, areas of stripped bark, or emergent roots that have been worn-down by human and animal activity.

Examples

FUNCTIONAL

This area has a high amount of age diversity. There is evidence of a wide, diverse array of vegetation, including older stabilizer plants and younger colonizer plants.

DYSFUNCTIONAL

This riparian area has little age diversity. Although there is sparse vegetation present, it is mostly comprised of older stabilizer plants, with almost no young or medium growth plants.

2.13 RIPARIAN INDICATOR SIX: SPECIES DIVERSITY

Overview

ARE SEVERAL KEY, NATIVE RIPARIAN PLANT SPECIES PRESENT?

In ecology, species diversity is defined as the number of species (sometimes referred to as species richness) and relative abundance of each species in a particular habitat or location. It is generally recognized that the higher the species diversity of an area, the more productive, healthy, and functional that area will be. In riparian areas, a diverse assortment of vegetation contributes to the stability and resiliency of the system.

A diverse community of riparian plants not only contributes to stabilizing the root system in the banks, it also prepares the riparian area to respond and adapt to climactic variations. More than any single plant species, a diverse array of vegetation contributes to the function of a riparian area by increasing water storage, improving stability, and contributing positively to the overall health of the riparian area. Terrestrial animals in riparian habitats also benefit from a diverse array of vegetation.

What to Look For

To evaluate an area for species diversity, identify the riparian vegetation present at the monitoring location using the *Your Remarkable Riparian* Field Guide. Once you have identified as many plant species as possible, begin to draw conclusions based on how many of each species are present.

A healthy riparian area will have an abundance of high-stability native plants. *Your Remarkable Riparian Field Guide* will help determine when a plant is considered invasive in Texas. Native plants are an important indicator of riparian health as they infer historical function. While not all invasive plants are considered harmful to the function of riparian areas, native plants are always preferred for this indicator.

When evaluating an area's species diversity, you may find that an area is dominated by only a few categories of plants. For example, your monitoring location may have an abundance of grasses and sedges, with a few woody plants. This does not necessarily indicate low species diversity. Place a priority on evaluating the diversity within the present groups, as opposed to the number of different groups.

Examples

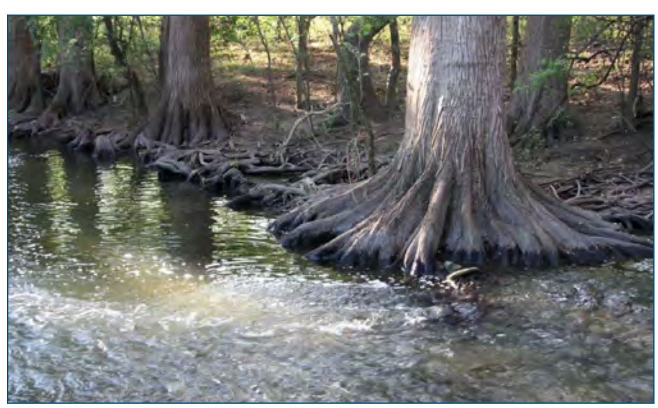
FUNCTIONAL

This riparian area has a good species diversity. Although this area is dominated by woody plants, there is a high amount of diverse plant species to maintain healthy riparian function.

Vegetation in this image includes: Bald cypress, OBL, SR9; Mexican ash, FAC, SR6; Cedar elm, FAC, SR6; Pecan, FAC, SR6; Red mulberry, FACU, SR6; Box elder maple, FACW, SR6; Rough leaf dogwood, FAC, SR6.

DYSFUNCTIONAL

This riparian area has a low species diversity. This area appears to be dominated by one species, the bald cypress. While this woody plant is highly stable, this riparian area would benefit from the addition of a woody understory and some herbaceous cover.



2.14 RIPARIAN INDICATOR SEVEN: PLANT VIGOR

Overview

ARE RIPARIAN PLANTS VIGOROUS AND HEALTHY?

Riparian plants that have been mowed, overgrazed, browsed, or otherwise damaged can become compromised and lose some of their functionality. Riparian plants can become unhealthy when modified or damaged by humans or wildlife. Unhealthy plants may have a diminished root system, which causes them to lose some of the strength, size, and functionality of their roots.

Plants with a compromised root system have a lower ability to dissipate floodwater energy. A weakened root system also decreases their capacity for water storage, as well as their ability to interweave with other riparian roots.

What to Look For

There are several indicators of plant health. One indicator is the state and structure of a plant's leaves. If a plant has missing, cut, or broken leaves, this may be an indicator that the plant has been recently damaged. Other indicators of poor plant vigor include recently cut stems, scabs, and scars on the leaves or trunks of plants, as well as a generalized wilting, drooping, or discolored appearance.

Sometimes riparian areas are mowed or manicured by humans. For example, a river that is adjacent to a park may have a dysfunctional riparian zone if the grass is mowed and the weeds are removed. When adjacent to a stream channel, manicured lawns are a common example of a dysfunctional riparian area.

Examples

FUNCTIONAL

This riparian area has good plant vigor. There are no evident signs of browsing or grazing, and there is no human modification present. The plants appear to be healthy, with their leaves and stems intact.

DYSFUNCTIONAL

This area has poor plant vigor. Although the trees appear healthy, a distinct "browse line", or a noticeable lower boundary of plant growth caused by grazing animals, can be seen in-between the trees.

2.15 RIPARIAN INDICATOR EIGHT: WATER STORAGE

Overview

ARE THE BANKS AND FLOODPLAIN STORING WATER?

Water professionals use the term "water storage" to refer to a stage in the water cycle wherein water "rests" as it moves from one system to another. The system that water settles in, such as a lake, stream, or aquifer, is said to be "storing" the water.

The water storage capability of a system is dependent on factors such as soil type, volume of organic matter, and type/abundance of plants in the area. Riparian areas with a higher capacity for water storage can capture runoff, filter bacteria and sediment, and slowly release it back into the stream channel. This provides water bodies with a consistent source of groundwater flow, even during periods of low precipitation.

What to Look For

The most reliable way to identify a riparian area with a high-water storage capacity is to identify the Wetland Indicator (WI) status of the vegetation. A riparian zone with functional water storage will have a higher percentage of Obligate (OBL) and Facultative Wetland (FACW) plants. Because these plants rely on high soil-moisture, the presence of these plants indicates a connection to a consistent groundwater source.

Also important is the diversity of WI vegetation. While having an abundance of one or two types of WI plants is useful, a healthy, functioning riparian area will ideally have a diverse variety of WI vegetation, both at the water's edge and in the floodplain.

Examples

FUNCTIONAL

This riparian area has a high capacity for water storage, based on the OBL and FACW plants present. Plants found in this area include buttonbush (OBL), black willow (FACW), Texas rush (FACW), bald cypress (OBL), and water pennywort (OBL). This riparian area has both a high presence and a high diversity of WI vegetation.

DYSFUNCTIONAL

This area has poor water storage capacity. There are no FACW or OBL plants present. The species present in this area are Live oaks and King ranch bluestem, with WI statuses of FACU and UPL, respectively.

2.16 RIPARIAN INDICATOR NINE: BANK/CHANNEL EROSION

Overview

ARE BANK AND CHANNEL EROSION BALANCED WITH DEPOSITION ON POINT BARS?

Water professionals use Lane's Balance Model to visualize the interactions between deposition and erosion (see Key Concepts- section 1.2). Like many natural processes, the opposing forces of erosion and deposition are natural components of a riparian system. When these processes are in balance, the riparian system remains functional and sustainable. However, if the force of erosion is not balanced by consistent sediment deposition, stream channels can become eroded, distorted, and down-cut.

What to Look For

When looking for evidence of erosion, survey the channel for meander bends. If there are noticeable deposits of sediment along point bars, the bank immediately upstream may be experiencing excessive erosion.

A stream channel experiencing excessive erosion may also appear down-cut or incised, with poor access to a floodplain. This may look similar to a man-made drainage.

Examples

FUNCTIONAL

Although the left bank of this channel is fairly steep, it still has a healthy, functional riparian area. The presence of vegetative growth along the steeper bank indicates that, although erosion is present, it is not excessive. The right side of the bank has dense, unkempt vegetation with good access to the floodplain.

DYSFUNCTIONAL

This riparian area is experiencing excessive erosion that is out-of-balance with the opposing depositional force. The left side of the bank appears to be incised, with little-to-no vegetation growing adjacent to the channel.

2.17 RIPARIAN INDICATOR TEN: SEDIMENT DEPOSITION

Overview

IS SEDIMENT BEING DEPOSITED IN A BALANCED WAY?

The balance between erosional and depositional forces can be disrupted if a stream cannot process the sediment deposits. Streams use the energy of discharge to move sediment through the channel. If the amount of flow energy in a stream is not adequate, streams cannot effectively process sediment.

Streams lack the required energy to process sediment when the water table is diminished, or during periods of drought and low precipitation. If water is not continuously resupplied to the channel, then flow energy will gradually decrease until sediment begins building up along banks.

Streams cannot process sediment if they receive an unusually large influx. This can be due to heavy precipitation, which causes an increase in erosion and runoff, as well as the influences of humans and animals. Construction sites that are located near channels often contribute large sediment loads during and after rain events.

What to Look For

Unusual build-up of sediment along the banks of a channel is the first indicator that a stream is out-of-balance. Streams that are not able to successfully process sediment loads will often deposit heaps of sediment in illogical places, such as the middle of a channel. These piles of sediment may grow over time to significantly disrupt the natural flow of the channel.

Sediment build-up might also be apparent immediately downstream of an eroded bank or trapped behind a structure with unnatural erosion occurring below.

Examples

FUNCTIONAL

This channel has balanced sediment deposition. There are no signs of sediment build-up along the banks or in the middle of the channel. The flow of water appears to be uninhibited.

DYSFUNCTIONAL

This channel is out-of-balance. A large deposit of sediment has built up along the banks and is reaching out into the middle of the channel. This is inhibiting adequate water flow and preventing the stream from processing sediment adequately.

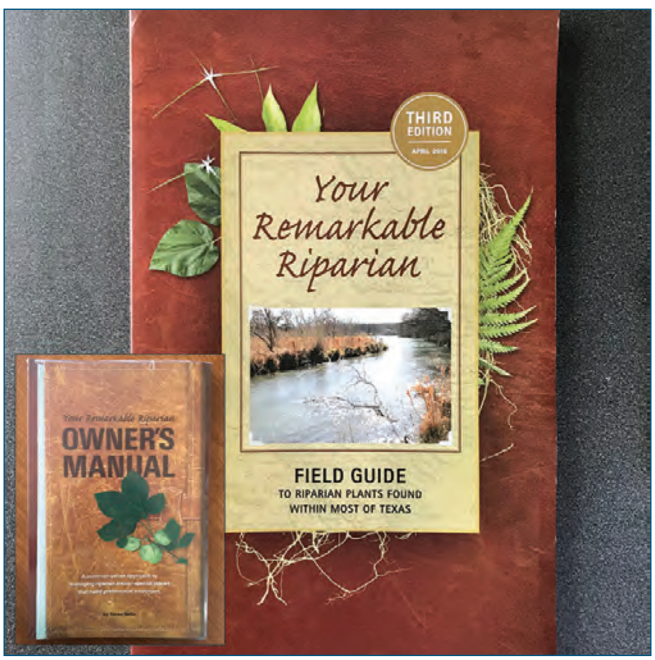
3.0 FOLLOW-UP

Getting Started with Monitoring

Once you have become a certified Texas Stream Team Riparian Evaluation citizen scientist, you can begin monitoring. To get started, certified citizen scientists need to obtain monitoring supplies, select a site, and create a monitoring schedule.

MONITORING EQUIPMENT

To obtain supplies for the Riparian Evaluation training, download and print the Texas Stream Team Riparian Evaluation Environmental Monitoring Form. The Monitoring Form is all that is needed to monitor. Optionally, citizen scientists can purchase *Your Remarkable Riparian Field Guide* and Owner's Manual from the Texas Stream Team online store. The Field Guide is highly recommended, but not mandatory. Other resources are available to assist with plant identifications. Contact the Texas Stream Team for a list of additional resources.



MONITORING SITE

To select a site, citizen scientists can begin by referencing the Datamap. The Datamap includes all historic and current water quality monitoring sites. Citizen scientists can choose to reactivate an inactive site by referencing the Datamap, or they can create a new site using the New Monitoring Site Request Form. For more information on site selection, please reference Section 2.1- Choosing A Monitoring Location.

MONITORING SCHEDULE

Citizen scientists must create a monitoring schedule that allows time to travel to the monitoring site and conduct the evaluation. To ensure data quality, Texas Stream Team requests citizen scientists conduct their evaluations at least once a year, at the same time of the year. Schedule a consistent time and day to monitor your site. For more information on scheduling your sampling time, see Section 2.3- Choosing a Monitoring Time.

SUBMITTING A TRAINING ENROLLMENT FORM

The Training Enrollment Forms must be submitted to participate in the Texas Stream Team program. Note that Texas Stream Team cannot certify individuals who do not submit the Training Enrollment Form.

The trainer will send training documentation to Texas Stream Team to be processed by staff. Your certificate will be emailed to you within the first week of the month following your training.

3.1 DATA MANAGEMENT

Citizen scientists are required to use the Riparian Evaluation Environmental Monitoring Form to record measurements at their monitoring site(s). Test results are always recorded on the form as they are completed in the field. All applicable sections of the Monitoring Form should be completed. For example, if information is not collected for a parameter, the space on the form remains blank.

Recording Data

To ensure compliance with the approved Quality Assurance Project Plan, citizen scientists should observe the following rules when completing the Monitoring Form:

1. Write legibly in ink or pencil if using the hard copy version of the monitoring form.
2. Correct errors with a single line strike-through followed by initials of the individual making the correction and date the correction was made.
3. Complete the Field Quality Control Checklist on the form to confirm protocols were followed.
4. Sign and date the form once complete for validation.

Before monitoring data can be entered into the Dataviewer, it must undergo a quality control check to ensure the data are of the highest quality and meet the following conditions:

1. It is collected by a certified citizen scientist that has met all training requirements as described in this manual.
2. It is collected using the protocols, equipment, and the Field Quality Control Checklist provided on the form described in this manual.
3. All data entries are legible if using the hard copy version of the monitoring form.
4. All Monitoring Forms are complete and include a signature by the citizen scientist that conducted the monitoring.
5. All quality assurance and quality control protocols described in this manual have been implemented and met to the best of the citizen scientist's ability.

Entering Data into Waterways Dataviewer

Once the Riparian Environmental Monitoring Form is complete and meets the quality control checks, the next step is to enter the data into the Waterways Dataviewer. There are two ways to enter the data:

1. Monitoring Forms get forwarded to the group Data Coordinator (if available). The group Data Coordinator conducts a quality control check and enters the data into the Dataviewer. If your group does not have a Data Coordinator, skip to the second option.

2. Monitoring Forms are submitted to Texas Stream Team by emailing scanned or high-quality photocopies (TxStreamTeam@txstate.edu) for entry by Texas Stream Team staff. The Texas Stream Team staff conducts a quality control check and enters the data into the Dataviewer.

Before group Data Coordinators can access the Dataviewer to enter data, they must request an account and receive assigned login credentials. A request for an account can be made by filling out the online Dataviewer Account Request Form.

Once the data from the Monitoring Forms are entered into the Dataviewer, the group Data Coordinator, Texas Stream Team staff, and/or designee verifies the data entry and the data becomes publicly available.

If the data do not meet the checks described above, the data are flagged upon entry to the Dataviewer for further review by Texas Stream Team staff or designee. The purpose of flagged data is to note inconsistencies or identify data that may have excessive variability. The Dataviewer is designed to recognize and flag data that do not meet requirements in the checklist. Therefore, it is critical for citizen scientists to comply with the protocols described in this manual to ensure data measurements are of the highest quality and can be used to promote and protect a healthy and safe environment for people and the aquatic inhabitants.

3.2 REPORTING UNUSUAL ACTIVITY AND UNLAWFUL EVENTS

Illicit discharge

An illicit discharge can have different meanings across different regulatory agencies. For the purposes of Texas Stream Team monitoring activities, an illicit discharge is defined as any event wherein a storm drain has a measurable flow during dry weather conditions (Brown, et. al, 2004). Illicit discharges are usually produced from a singular source or operation and can be further broken down into categories based on their frequency, flow-type, and mode of entry (Brown, et. al, 2004).

Illicit discharges can be either direct or indirect. An illicit discharge has a direct mode of entry when the discharge is directly connected to a storm drain through a sewage pipe, shop drain, or other kind of pipe (Brown, et. al, 2004). An indirect discharge occurs when flows generated outside of the storm drain enter the system, either through inlets, or by infiltrating the joints of a pipe (Brown, et. al, 2004).

Illicit discharges include any instances wherein chemicals or waste are discarded into a sanitary sewer drain. Examples of illicit discharges include improperly discarded oil and grease, runoff from excessive fertilizers and pesticides, and illegal dumping of hazardous chemicals (Brown, et. al, 2004). Other examples include septic tank seepage, laundry wastewater, or illegal sanitary sewer connections (Brown, et. al, 2004). For information about illicit discharge, and additional examples of illicit discharges that might be expected corresponding to land use, visit page 12, table 2 of the Enivornmental Protection Agency's Illicit Discharge Detection and Elimination Guidance Manual for Program Development and Technical Assessments (see Section 4.1- Work's Cited).

Images acquired from the official government website of Knox County, Tennessee.

HOW TO REPORT AN ILLICIT DISCHARGE

To report an illicit discharge, contact your city office. Many cities allow citizens to anonymously report illicit discharges online. Check your city's Department of Water or Department of Public Works for an online form, or, alternatively, you can contact your city office at their main office phone line.

For assistance with reporting illicit discharges, you can also contact Texas Stream Team at TxStreamTeam@txstate.edu or by calling (512) 245-1346.

Wildlife Kills and Pollution Events

The Texas Parks and Wildlife Department's (TPWD) Kills and Spills Team (KAST) is comprised of a group of biologists who investigate fish and wildlife kills. Kills and Spills Team biologists evaluate both unnatural and natural events to assess the impacts to fish and wildlife resources and to determine the causes of the events.

Kills and Spills Team biologists work to:

1. Determine the causes of wildlife kills and/or pollution events
2. Attempt to minimize environmental damage resulting from wildlife kills and/or pollution events
3. Obtain compensation for environmental damage and restore the affected environment

Image acquired from the TPWD KAST webpage.

REPORTING A KILL OR SPILL

Prompt notification is essential to a successful investigation, and the sooner that Kills and Spills Team biologists are notified of a potential wildlife kill or pollution event, the better the chances are that useful evidence can be collected, and conclusive actions can be taken.

When reporting a Kill or Spill, make a note of the:

1. Location, date, and time
2. Water color, clarity, and odor
3. Number, size, and species of affected organisms
4. Recent weather
5. Condition and behavior of animals or organisms
6. Condition of plants/other organisms (Kills and Spills Team, n.d.)

To contact the Kills and Spills Team, call (512) 389-4848 or contact your regional Kills and Spills Team biologist. You can find you regional KAST biologist at www.tpwd.gov/landcover/water/environconcers/kills_and_spills/regions.

Texas Commission on Environmental Quality Compliance and Enforcement

The Texas Commission on Environmental Quality Office of Compliance and Enforcement is responsible for enforcing compliance with state environmental law, responding to emergencies and natural disasters, overseeing dam safety, and monitoring air quality (Office of Compliance and Enforcement, 2020).

The Texas Commission on Environmental Quality. divides the state of Texas into four areas, with further regional divisions. Within their defined administrative region, each regional office is responsible for:

- Investigating compliance at permitted air, water and waste facilities
- Investigating complaints at facilities and operations- permitted or not- from citizens, businesses, and other concerned parties
- Developing enforcement actions and referrals for violations
- Environmental education and technical assistance for communities
- Monitoring the quality of ambient air, surface water, and public drinking water

(Office of Compliance and Enforcement, 2020)

REPORTING AN ENVIRONMENTAL PROBLEM

Concerned citizens can file an Environmental Complaint with the Texas Commission on Environmental Quality. In general, the Texas Commission on Environmental Quality can assist with any complaint, provided that you have:

- Seen water that may be polluted
- Seen or smelled something unpleasant in the air
- Seen land that may be contaminated
- Are having problems with your drinking water
- Have information or evidence about an environmental problem
- Are having problems with an individual or company licensed or registered by the Texas Commission on Environmental Quality
- Need assistance or information regarding environmental laws, possible pollution sources, or other questions relating to Texas Commission on Environmental Quality Compliance and Enforcement

(Office of Compliance and Enforcement, 2020)

For more information on what Texas Commission on Environmental Quality can and cannot help you with, please visit the Texas Commission on Environmental Quality website.

To report an Environmental Problem, contact the Texas Commission on Environmental Quality Office of Compliance and Enforcement at the 24-hour line 888-777-3186 or fill out their online form.

If you would prefer to contact your regional Texas Commission on Environmental Quality Field Office, you can find applicable contact information on the Texas Commission on Environmental Quality website.

4.0 WORKS CITED, APPENDIX, & GLOSSARY

Works Cited

Arthur, M., Saffer, D., & Belmont, P. (2020). *Earth 111: Water: Science and Society, Unit 2: Physical Hydrology, Module 3: Rivers Come in all Shapes and Size*. Penn State's College of Earth and Mineral Sciences: Open Education Resources. Retrieved from: https://www.e-education.psu.edu/earth111/node/871.

Brown, E., Caraco, D., Pitt, R. (2004). *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments.* Retrieved from: https://www3.epa.gov/npdes/pubs/idde_manualwithappendices.pdf.

Atmospheric Research staff. (n.d.). *Effects of drought on the soil*. Commonwealth Science and Industrial Research Organization Science Image. Retrieved from: https://www.scienceimage.csiro.au/image/607/effects-of-drought-on-the-soil//large.

Huggett, R. J. (2017) *Fundamental of Geomorphology.* (4th ed). London, New York: Routledge.

Jacob, J. (2013). *Chapter 5- Riparian Soils*. In Hardy, T., & Davis, N, *Texas Riparian Areas* (pp. 5-1 – 5-37). Retrieved from: https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1004831142_TexasRiparianAreas.pdf.

Jones-Lewey, S. (2016). *Your Remarkable Riparian: A Field Guide to Riparian Plants Found Within Most of Texas*. (3rd ed). Uvalde, TX. Nueces River Authority.

Kills and Spills Team. (n.d.). Texas Parks and Wildlife. Retrieved from: https://tpwd.texas.gov/landwater/water/environconcerns/kills_and_spills/.

U.S. National Parks Service staff. (n.d.). *Multimedia Photo Gallery*. U.S. National Parks Service. Retrieved from: https://www.nps.gov/media/multimedia-search.htm.

Nelle, S. (2016). *Your Remarkable Riparian: Owner's Manual*. Uvalde, TX. Nueces River Authority.

Office of Compliance and Enforcement. (2020). Texas Commission on Environmental Quality. Retrieved from: https://www.tceq.texas.gov/agency/organization/oce.html#8.

Riparian Photos. (2015). Texas Riparian Association. Retrieved from: https://texasriparian.org/riparian-photos/.

Soil Survey Staff. (2015). *Illustrated guide to soil taxonomy, version 2.* U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska. Retrieved from: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/?cid=nrcs142p2_053580.

Stormwater Management staff. (n.d.). Examples of Illicit Discharge. Government of Knox County, Tennessee. Retrieved from: https://www.knoxcounty.org/stormwater/illicit_discharge.php.

Ramirez, S. (n.d.). Why We Need to Protect Private Land in Texas. Texas Land Conservancy. Retrieved from: https://texaslandconservancy.org/why-we-need-to-protect-private-land-in-texas/#:~:text=In%20fact%2C%20Texas%20has%20more,larger%20than%20all%20of%20California.

Ritter, M. E. (2012). *The Physical Environment: An Introduction to Physical Geography.* Accessed on 8/6/2020. Retrieved from: https://www.earthonlinemedia.com/ebooks/tpe_3e/title_page.html.

TexasInvasives.Org. (n.d.). *Invasive Plant Database.* Retrieved from: https://texasinvasives.org/plant_database/index.php.

Texas Nature Trackers. (n.d.). *Texas Nature Trackers: Texas Mussel Watch.* The Texas Parks and Wildlife Department (TPWD). Retrieved from: https://tpwd.texas.gov/huntwild/wild/wildlife_diversity/texas_nature_trackers/mussel/.

USGS staff. (n.d.). *Groundwater Storage and the Water Cycle.* United States Geologic Survey (USGS). Retrieved from: https://www.usgs.gov/special-topic/water-science-school/science/groundwater-storage-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects.

USGS staff. (n.d.). *Nutrients and Eutrophication.* United States Geologic Survey (USGS). Retrieved from: https://www.usgs.gov/mission-areas/water-resources/science/nutrients-and-eutrophication?qt-science_center_objects=0#qt-science_center_objects.

USGS staff. (n.d.). *The Water Cycle for Adults and Advanced Students.* United States Geologic Survey (USGS). Retrieved from: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle-adults-and-advanced-students?qt-science_center_objects=0#qt-science_center_objects.

Ward, B. (2009). *What does it mean to be native?* Native Plant Society of Texas. Retrieved from: https://npsot.org/wp/story/2009/271/.

Appendix

APPENDIX I. ONLINE RESOURCES

Dataviewer Account Request Form

Equipment Form

Funding Guidance

Group Citizen Scientist Monitoring Plan

Measures of Success Survey

New Monitoring Site Request Form

Private Property Access Form

Riparian Evaluation Environmental Monitoring Form

Site Selection Guide

Supply Order Form

Texas Stream Team Calendar

Texas Stream Team Dataviewer Account Request Form

Texas Stream Team Dataviewer and Datamap

Texas Stream Team Online Store

Texas Stream Team Partners List

Texas Stream Team Quality Assurance Project Plan (QAPP)

Texas Stream Team Trainers List

Texas Stream Team Trainings and Programs

Your Remarkable Riparian Field Guide Book Set

YouTube Quality Control and Parameter Videos

For additional forms and resources please visit the Texas Stream Team Forms and Resources page.

Glossary

Algae - Plants that lack true roots, stems, and leaves. For the physical assessment described herein, algae consist of nonvascular plants that attach to rocks and debris or are free floating in the water. Such plants may be green, blue-green, or olive in color, slimy to the touch, and usually have a coarse filamentous structure.

Bank - The portion of the channel that tends to restrict lateral movement of water. It often has a slope less than 90° and exhibits a distinct break in slope from the stream bottom. Also, a distinct change in the substrate materials or vegetation may delineate the bank.

Bloom - The accelerated growth of algae and/or higher aquatic plants in a body of water. This is often related to pollutants that increase the rate of growth.

Channel - That portion of the landscape which contains the bank and the stream bottom. It is distinct from the surrounding area due to breaks in the general slope of the land, lack of terrestrial vegetation, and changes in the composition of substrate materials.

Channelization - Straightening and deepening streams so water will move faster, a method of flood control that disturbs fish and wildlife habitats and can interfere with a water body's ability to assimilate waste.

Conductivity - A measure of the electrical current carrying capacity, in μmhos/cm, of 1 cm of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Conductivity is a measure of how salty the water is; salty water has high conductivity.

Detritus - Decaying organic material.

Ecological Impact - The effect that a manmade or natural activity has on living organisms and their abiotic (non-living) environment.

Energy pyramid – a visual representation of the movement of energy within an ecosystem

Eutrophic - Refers to shallow, murky bodies of water that have excessive concentrations of plant nutrients resulting in increased algal production.

Eutrophication - The slow, aging process during which a lake, estuary or bay evolves into a bog or marsh and eventually disappears.

Family - A group of related plants or animals forming a category ranking above a genus and below an order and usually comprising several to many genera.

Flood Plain - The area adjacent to the channel which is occasionally submerged under water. Usually, the flood plain is a low gradient area well covered by various types of riparian vegetation.

Food Chain - The dependence of organisms upon others in a series for food. The chain begins with producers (plants) and ends with the largest of the consumers (carnivores).

Food Web - An interlocking pattern of several to many food chains.

Genus - A category of biological classification ranking between the family and the species, comprising structurally or phylogenetically (evolutionary relationship) related species and being designated by a Latin or latinized capitalized singular noun.

Groundwater – water that is stored in the ground in rocks and soil

Habitat - The area in which an organism lives.

Indicator Organisms - An organism, species, or community that indicates the presence of a certain environmental condition or conditions. Inorganic - Any compound lacking carbon.

Macrophyte - Any large vascular plant that can be seen without the aid of a microscope or magnifying device (cattails, rushes, arrowhead, water lily, etc.).

Nonpoint Source - Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outfall. The pollutants are generally carried off the land by runoff. The commonly used categories for nonpoint sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal and saltwater intrusion.

Nutrient - Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater, but is also applied to other essential and trace elements.

Orthophosphate (O-P) - Nearly all phosphorus exists in water in the phosphate form. The most important form of inorganic phosphorous is orthophosphate, making up 90% of the total. Orthophosphate, the only form of soluble inorganic phosphorus that can be directly utilized, is the least abundant of any nutrient and is commonly the limiting factor.

pH - The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

Phosphorus - Essential nutrient to the growth of organisms and can be the nutrient that limits the primary productivity of water. In excessive amounts, from wastewater, agricultural drainage and certain industrial wastes, it also contributes to the eutrophication of lakes and other water bodies.

Photosynthesis - The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll using sunlight as an energy source.

Point Source - A specific location from which pollutants are discharged. It can also be defined as a single identifiable source of pollution (e.g., pipe or ship).

Pollution - the man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of water (EPA CWA definition).

Riparian Zone - Generally includes the area of the stream bank and out onto the flood plain which is periodically inundated by the flood waters from the stream. The limit of the zone depends on many factors including native plant community make up, soil moisture levels, and distance from the stream (or the limit of interaction between land and stream processes). It is periodically inundated by the flood waters from the stream. Interaction between this terrestrial zone and the stream is vital for the health of the stream.

River Basin - The land area drained by a river and its tributaries.

Runoff - The part of precipitation or irrigation water that runs-off land into streams and other surface water.

Salinity - The amount of dissolved salts in water, generally expressed in parts per thousand (ppt).

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Texas Stream Team