RRED

Red River Environmental Defense

Group 5

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UAPP411: Regional Watershed Management

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Mission Statement

R.R.E.D.'s goal is to analyze and mitigate negative impacts on the Red River Basin watershed and improve water quality to support the health of local ecosystems. We will lead strategic efforts for the long-term protection and preservation of the watershed and its surrounding environment. Our goal is to improve the overall quality of this basin by 2045.

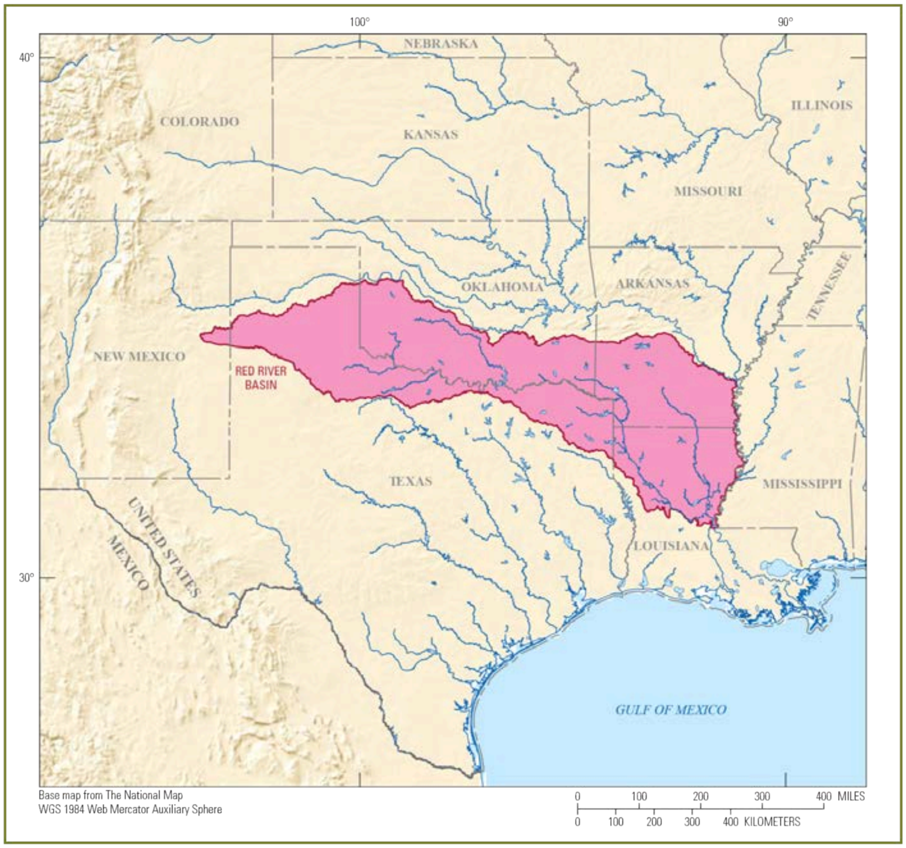
Background

Geographical Context:

The Red River, a significant waterway in the Southern United States, serves as a major tributary to the Atchafalaya and Mississippi Rivers. Rising in the high plains of eastern New Mexico and the Texas Panhandle, the river flows generally eastward for approximately 1,290 to 1,360 miles (2,189 km) before emptying into the Atchafalaya River in Louisiana. The river has a Latitude of approximately 31∘01'10" N and a longitude of 91∘44'52" W at its mouth.

The Red River forms the boundary between the states of Texas and Oklahoma for nearly half of its length, and also forms a short border between Texas and Arkansas before flowing south into Louisiana. The total drainage area for the basin is approximately 93,000 square miles (241,000 km^3), making it the second-largest river basin in the southern Great Plains.

The basin is characterized by diverse ecoregions, including the Red Prairies, Broken Red Plains, and the Red River Bottomlands. It contains approximately ten major tributaries, including the North Fork of the Red, the Kiamichi, the Washita, and the Ouachita (Black) River. Major urban centers and agricultural hubs along its course include Wichita Falls, Texarkana, Shreveport and Alexandria. Key infrastructure such as the Denison Dam, completed in 1944, forms Lake Texoma, which is a vital reservoir for flood control, water supply, and regional development.



Physical Characteristics of the River:

The Red River is a classic example of meandering alluvial river, where the channel loops and curls extravagantly along its broad floodplain. Its name is derived from the reddish color of its water, a result of the river carrying high concentrations of silt and clay as it passes through the Permian red beds in its upper watershed. Historically, the Red River was recorded to carry a sediment load up to five times that of the Mississippi River.

The channel morphology varies from the rapid, intermittent flows of the dry western reaches to a network of marshes and swamps in the lower reaches. In the upper basin, the river originates from an elevation of approximately 3,440 feet (1,050 m) and drops to just 30 feet (9.1m) at its mouth, indicating a low overall gradient that causes its high sinuosity.

A unique physical feature of the river's history was the "Great Raft," a 160 mile (260 km) naturally occurring log jam that once impeded navigation above Natchitoches, Louisiana, until its removal in the 19th century. Today, the riverbanks are characterized by fertile agricultural plains in the middle reaches and a system of oxbow lakes and abandoned branches in the lower course.

Water Quality and Composition:

The water quality of the Red River is influenced by both natural geology and human stressors. A significant characteristic of the upper Red River is its natural salinity. The river passes through Permian salt deposits, causing salt, primarily sodium chloride, to leach through natural seeps in tributaries above Lake Texoma. These seeps can contribute up to 3,450 tons of salt per day to the river's flow, making the water naturally brackish in western stretches. The pH typically ranges between 7.0 to 8.5, reflecting slightly alkaline conditions which are common in the limestone Great Plains. Water temperatures fluctuate seasonally, ranging from roughly 32∘F (0∘C) to 95∘F(35∘C). The mean average flow at the river's mouth is over 57,000 cubic feet per second (1,600m^3/s), though this varies widely due to the arid nature of the upper basin and climate driven precipitation shifts. Dissolved oxygen levels are inversely related to temperature, with critical low oxygen (hypoxia) conditions occurring during hot summer months and periods of low flow due to nutrient runoff.

Biological Diversity:

The Red River Basin supports a rich array of aquatic life, though many species face potential extinction due to habitat fragmentation and climate change. The river is home to several endemic and specialized fish species, including the Red River Pupfish, Prairie Minnows, Alligator Gar and catfish. The ecosystem is currently threatened by invasive species, like the

Saltcedar, which consumes large amounts of water and increases soil salinity, and the Red Swamp Crayfish, which can reduce local biodiversity and damage infrastructure. Human activities, like groundwater extraction and the construction of dams, have led to habitat fragmentation, making it difficult for native fish to complete their life cycles.

Human Activities and Ecological Factors:

The Red River is utilized for a diverse array of human purposes, including agriculture, forestry, municipal water supply, road and highway construction and recreation. It serves as a vital source of water for irrigation and supports significant river development across the four states it goes through. Large scale water infrastructure projects, notably the Denison Dam and Lake Texoma, are central to the region's stability, providing essential flood control and acting as a primary water supply for the surrounding basin.

These infrastructure projects, while supporting human development, have significantly impacted the ecological health of the river. Dams and poorly designed culverts lead to habitat fragmentation, which is a primary cause in the disruption and potential extinction of fish species with high recreational and ecological value. Also, human land-use patterns, specifically the runoff from agricultural fertilizers and livestock waste, contribute to approximately 80% of the nutrient overload in many regional watersheds, leading to eutrophication and hypoxia in the dead zone of the Gulf of Mexico.

The management of these human and ecological factors is governed by several key policies and agencies. The International Red River Watershed Board (IRRWB) follows a directive to support the Aquatic Ecosystem Integrity of the basin through strategic monitoring and preservation efforts. Also, the Red River Compact (1978) serves as the legal framework for dividing water usage rights between Arkansas, Louisiana, Oklahoma and Texas. The basin is divided into five subbasins, where each state maintains specific percentages of use rights to ensure the sustainable development of the river's resources. RRED's mission is to remediate these stressors by 2045, focusing on collaborative action between stakeholders, city wastewater plant upgrades, and the implementation of urban stormwater mitigation like rain gardens and bioswales.

Policies

To determine the water usage rights of the Red River Basin due to the basin spanning multiple states, the Red River Compact was ratified in 1980. This compact is an agreement between Texas, Oklahoma, Arkansas, and Louisiana that determines each state's usage rights, by dividing the basin into five reaches. Reach I accounts for the upper tributaries of the basin, and spreads across all four states. Within this reach, all four states can freely use water from tributaries located within their state boundaries and there are no sharing requirements over state lines. If the tributary originates in one state, then that state can freely use that water. Reach II only encompasses Texas and Oklahoma, and covers the main portion of the Red River that flows along the Texas-Oklahoma border, which also includes Lake Texoma. The water rights in this reach are divided equally between the two states, with each state allotted up to 25% of the average annual flow of the river in that reach. Reach III consists of tributaries in Oklahoma where, similar to Reach I, the state can freely use the tributary water if the tributary originates from that state. This reach also does not have any interstate sharing requirements. Reach IV includes the lower Red River and spans across all four states. For tributaries located within this reach, the same rules apply where a state can freely use tributaries as long as they originate from that state. Regarding the main Red River in this reach, there is usage shared between all four states. While there are no percentage restrictions on usage, the water usage by the states cannot restrict the ability of the downstream states from access to river flow. Reach V involves the lowest portion of the basin, and is located within Louisiana. Louisiana mainly controls this reach, but must allow flow to continue downstream to the Mississippi River System.

This compact is the main governing document for the Red River Basin, and is still in place today. While this document does not focus on mitigating environmental impacts or improving water quality, it is essential for the division of usage between four different governing bodies.

Economics

The Red River Basin is a critical economic resource for agriculture, municipal water supply, industry, and recreation activities. It supports around 4 million people, making it critical for the economic activity of both rural and urban communities.

Agriculture is one of the largest water demands as the basin supports crop production and livestock farming through Texas, Oklahoma, Arkansas, and Louisiana. The need for irrigation makes agricultural productivity reliant on water availability. The growing population and increasing urbanization are causing a higher demand for water resources on top of the demand during drought periods. These conditions disrupt agriculture, increase water costs, and increase operational costs for farmers and industries.

In addition, the basin also supports forestry, fisheries, and recreation activities. According to the Louisiana Department of Environmental Quality, maintaining a healthy aquatic system and water quality is essential for the economy, as pollution and lower quality limit recreational use. Degraded water quality can also harm fish populations, reduce biodiversity, and increase the cost of maintaining the natural resource environment. Overall, the Red River Basin's economy depends on effectively managing water demand, protecting water quality, and supporting the growth and stability of the basin.

Problems

Problem	**Description**	**Causes**
P1: Disruption of Basin Fish Species	The fish that belong to the Red River Basin hold a great recreational and ecological value to its surrounding areas. Different factors can affect the prosperity of certain species, and reports show projections of disruption and even extinction of certain species found in the basin.	● Declining water availability ● Climate change ● Water quality issues ● Habitat fragmentation
P2: Nutrient Overload	Excess nutrients like Nitrogen & Phosphorus lead to eutrophication and harmful algae blooms that deplete oxygen levels, this is called hypoxia. This lowers local water quality and contributes to the “dead zone” in the Gulf of Mexico, harming aquatic life and ecosystem health.	● Runoff from agricultural fertilizers and livestock waste ● Discharge from municipal wastewater treatment plants ● Urban stormwater runoff from developed areas
P3: Water Scarcity	Climate change has led to extreme weather conditions with severe drought and heavy precipitation. Along with that the higher water temperatures lead to higher evapotranspiration causing further stress.	● Climate change ● Less precipitation in western side and more in eastern

Problem 1: Disruption of Basin Fish Species

The Red River Basin was once abundant with various fish species that provided recreational and ecological value to the basin. However, due to climate change, declining water availability, water quality issues, and habitat fragmentation there has been a steep decline in fish populations in recent years. Climate change produced many issues within the Red River Basin, primarily increasing the temperatures and creating more extreme weather. This weather promotes long droughts, ultimately declining water availability. This creates lowered oxygen levels forcing fish species to relocate to separate areas of the basin, or die off trying. Water quality issues contribute the same motivations to leave for fish populations in the area, as it creates “dead zones” in the water and off balance habitat pH.

The main contributor to declining fish populations is habitat fragmentation. Habitat fragmentation arises through breaking up connectivity through dams, culverts, and road crossings. In the Red River Basin, particularly flat areas need to be treated through the use of culverts. They restrict flow slightly during high-water events so the downstream isn’t the only section flowing greatly. While culverts help with the distribution of water in the flatter areas of the basin, they are a major contributor to habitat fragmentation. They act as a physical barrier that isolates fish populations, and they fragment habitats by changing water velocity and creating shallow or impassable conditions that prevent fish from moving upstream.

Goal 1:

RRED’s objective is to promote different water regulation strategies that do not fragment habitats or greatly impact fish populations. The removal of unnecessary structures can truly open up the basin, and promote expanding/traveling fish populations. Ditches and levees that are designed to drain wetlands by cutting off rivers from side channels and floodplains can also be removed to combat habitat fragmentation. Fish passes and ladders can be implemented in areas where dams must stay fully functional to allow migratory fish to bypass dams to reach upstream.

When it comes to culverts, there are new modern designs that can help stimulate fish migration. For example, retrofitting and “stream simulation” of culverts are a great way to improve existing structures. Retrofitting culverts implements internal baffles that help break up water speed so fish can safely pass through. Stream simulation in culverts is in reference to the culvert matching the width, velocity, and slope of the surrounding stream to try and match the natural stream rather than break it up.

All in all, RRED will implement these new designs and prospects to stop the disruption of fish species and bring back populations to the Red River Basin.

Problem 2: Nutrient Overload

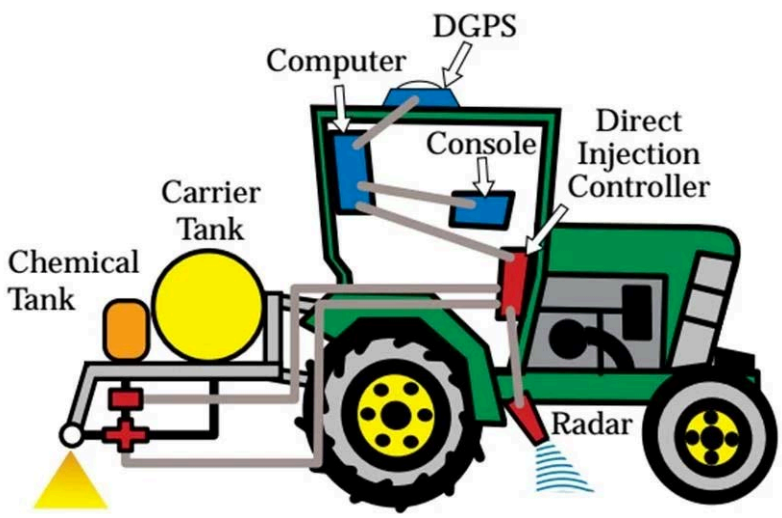
The Red River Basin is currently categorized as a heavily impacted watershed, primarily due to the excessive loading of Nitrogen and Phosphorus into its system. These high nutrient levels are the primary causes of widespread eutrophication within the watershed, leading to the spread of harmful algae blooms and the onset of hypoxia, or depleted dissolved oxygen levels. While these factors significantly degrade local water quality and aquatic habitat integrity, the Red River's position as a major tributary means these pollutants are transported downstream, serving as a significant contributor to the dead zone in the Gulf of Mexico.

The primary causes of this degradation are multifaceted and linked to regional land use patterns. Runoff from agricultural fertilizers and poorly managed livestock waste accounts for a substantial portion of the nutrient load. In urbanized and developing parts of the basin, municipal water discharge and uncontrolled urban stormwater runoff introduce concentrated amounts of nutrients directly into the river channel. Also, specific land intensive activities like forestry, road construction and aging sewage systems contribute to soil instability and organic matter transport, stressing the basin's ecological balance.

Goal 2:

RRED's objective is to remediate these stressors and restore the baseline water quality of the Red River Basin by 2045. This will be achieved through a multi-tiered approach focusing on precision agricultural management, natural biological filtration and significant upgrades to existing infrastructure.

To address agricultural runoff, RRED recommends the basin-wide adoption of Variable Rate Technology (VRT). This system utilizes an integrated suite of hardware, including DGPS for precision geolocation, on-board computers and direct injection controllers to regulate the application of fertilizers in real time. By using radar sensors to assess field conditions, the system ensures that nutrients are applied only where necessary, allowing fertilizers to stay in the soil and be absorbed by crops rather than leaching into the watershed.



A simplified diagram of Variable Rate Technology (VRT)

A cornerstone of our recommendation is the large-scale restoration of wetlands and the establishment of riparian forest buffers along river banks. By restoring native trees and vegetation, a natural biological barrier is created that intercepts surface runoff. These systems act as a natural filter, sequestering nitrogen and phosphorus before they reach the river channel while simultaneously reducing habitat fragmentation.

On a municipal level, RRED advocates for the modernization of city wastewater treatment plants to enhance nutrient removal protocols, effectively stripping excess nitrogen and phosphorus that trigger downstream algae blooms. To supplement this, urban environments must construct rain gardens and bioswales. These green infrastructure elements are designed to soak up urban precipitation naturally through engineered soil and plants, checking for breakthrough times and pressure drops to ensure performance, rather than allowing contaminated water to flow over impervious concrete directly into the system.

RRED recommends that these mitigation strategies be strictly applied to road construction zones and home sewage system maintenance to ensure a holistic reduction in the basin's nutrient footprint.

Problem 3: Water Scarcity

Another problem the Red River Basin is currently facing is water scarcity. The basin is lacking sufficient available water resources due to the combination of drought and increasing water demands. It is predicted that if these conditions continue, future water temperatures will continue to increase as much as 6℃ with nighttime temperatures increasing more than daytime. Along with that the probability of longer, deeper droughts across the basin as well as more intense floods is high. The Red River Basin is a vital water source both for ecosystems and people and has been facing extreme stress in recent years.

This is majorly due to the impacts of climate change. Climate change has led to extreme weather conditions including severe droughts in the western side of the basin, and heavy precipitation on the eastern side. Along with this severe weather, the higher water temperatures has led to higher evaporation rates which is causing further stress. Along with the stress on water resources from climate change, increasing demands from metropolitan areas in Texas and Oklahoma has been severely impacting the water supply as well.

Goal 3:

To alleviate the issue of water scarcity, REDD's target is to create a drought management plan as well as water consumption initiatives. These strategies will help to mitigate droughts and also create a comprehensive plan for managing droughts when they do occur.

Water consumption initiatives can be implemented in areas where there is little to no water scarcity, because some areas in the basin face droughts while others do not. This can be done by utilizing a case study done by the U.S. Fish & Wildlife service, where they classified the 38 reservoirs within the basin by how often they face water scarcity (U.S. Fish & Wildlife Service, 2020). Areas that do not face water scarcity will be focused on, and will be provided incentives to reduce their water consumption. When residents replace features like turf with more drought resistant landscaping, they will receive a rebate for those improvements. Rebates will encourage residents to install these upgrades, and help to reduce the water consumption in these areas. This can apply to high efficiency appliances and upgrading plumbing features, all which will have a positive impact on residents as well as the basin itself.

In areas that are more vulnerable to droughts, management plans will be developed. Drought management plans are a necessity when in arid areas, especially when facing water scarcity due to climate change as well. These plans should prepare for high demand while managing low consumption in order to mitigate the effects of the drought. Within areas that are water scarce, more reservoirs and storage areas will be constructed. These structures will store water that can then be used in times of drought. In addition to this, working with other basins that are not as water scarce can help to ease the intensity of the drought. Areas that are experiencing heavy rainfall can store their water, which can then be used in areas that are facing water shortages.

RRED will implement these strategies in targeted areas, where these methods can have the most impactful effect on water scarcity. By focusing on specific areas, different reservoirs within the basin will also be able to assist each other in preparing and mitigating droughts.

Recommendations

The overall goal is to remediate the disruption of the Basin fish species, nutrient overload, and water scarcity, and to restore water quality to the Red River Basin. This is done through five main goals:

1. Focus on certain land types such as agriculture, forestry, home sewage systems, urban stormwater runoff, and road and highway construction
2. Replace poor infrastructure and remove any with negative impacts on the basin
3. Implement better nutrient management
4. Work to restore the wetlands
5. Create future plans to prepare for droughts

Our first goal of focusing on specific land types, especially those that are high sources of issues such as agricultural land use leading to potential nutrient overload, will be addressed at the source. Regarding goal number two, older or poorly designed systems may lead to various issues such as leakage of nutrients or pathogens, blockage of fish movement, or increased flooding and erosion. In fixing this infrastructure both water quality and the ecosystem can be improved. For our third goal, better nutrient management will directly improve the issue of nutrient overload, helping remediate issues due to eutrophication. Goal number four is important since wetlands can be considered natural treatment systems, restoring them will help with water quality, biodiversity, as well as water storage. Finally, following our fifth goal ensures a sustainable water supply, better allocations of water use between ecosystems and human use, as well as reduced stress on fish populations during low flow periods.

Conclusion

The Red River serves as a critical economic and agricultural resource for the Southern United States, supporting approximately 4 million people across four states, but it is threatened by over-exploitation, rapid urbanization and climate change. Taking immediate and sustainable long-term action is necessary to ensure the health and viability of this valuable basin for future generations. Disruption of fish species, nutrient overload and water scarcity are the primary challenges facing the Red River. These issues are interconnected, climate-driven droughts cause habitat fragmentation and increase nutrient pollutants, therefore requiring integrated solutions to restore the basin water quality and ecological integrity.

Solutions and actions taken on the Red River should always involve key local stakeholders and require continuous monitoring and evaluation. Involving the public through education and incentive programs is essential to ensure that watershed goals are upheld as environmental conditions continue to change. The agriculture sector will need to make the most changes to its practices, as it remains the largest water consumer and a primary contributor to nutrient runoff. However, this transformation is achievable through widespread adoption of precision technologies like Variable Rate Technology and the restoration of natural wetland barriers. The Red River is a beautiful, diverse and highly important watershed that RRED is determined to protect and sustain.

Sources

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