Texas Cooperative
EXTENSION
The Texas A&M University System

SP-318
8/07

Linking Water Conservation & Natural Resource Stewardship in the

Trinity River Basin

Trinity River Initiative

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ACKNOWLEDGEMENTS

This document represents the first in a series of publications involving a partnership between Texas A&M University, Texas Cooperative Extension, Department of Wildlife and Fisheries Sciences, Institute of Renewable Natural Resources, and Texas Parks and Wildlife Department. We thank the Texas Parks and Wildlife Department for funding for this work. Additional funding was provided from the Renewable Resources Extension. We thank John Cooper (Texas Cooperative Extension, Denton County), the Elm Fork Chapter of the Texas Master Naturalist Program, and Gary and Sue Price (77 Ranch) for providing examples of rural and urban land stewardship. The Trinity Basin Conservation Foundation was a catalyst for this work, and we appreciate the collaboration with their members concerning this publication. Photos were provided by James C. Cathey. We appreciate the efforts of Anna Munoz, Clark Adams and Stephen Davis for providing editorial review of this manuscript.

INTRODUCTION

As we head into the 21st century, water conservation has quickly become a core issue facing citizens of Texas. Texans commonly hear that demand for water by the human population has already outgrown the supply in Texas. Currently, plans for new reservoir construction or inter-basin transfers of water are increasingly controversial. Many believe that the confrontations are because society may be reluctant to pay for ecological and monetary costs associated with these water supply proposals. Also, rural interests are a growing force demanding more balance in water issues. Fortunately, this factionalized forum brings opportunities for innovations and non-traditional approaches to enhancements for water supplies. The purpose of this publication is to stimulate further creative thinking about opportunities through land stewardship that benefit water and wildlife.

Slowing human population growth is an unlikely fix to water shortage issues. To put this into perspective, the human population in Texas is projected to be 34-41 million by 2030, which is nearly twice the population of the year 2000. The Bureau of Reclamation predicts that by 2025, a significant number of areas, including Dallas-Fort Worth, will fail to meet water demands for people, farms and the environment (http://www.doi.gov/water2025/supply.html). Water and wildlife habitat conservation efforts aimed at the Trinity River Basin will likely become a conservation focal point in the state since the river connects the huge population centers of Dallas-Fort Worth and Houston. To meet these ever-increasing water needs, Texans, now more than ever, are required to critically think of the interconnected relationship between population growth and ecosystem health.

The dramatic increase of impervious surfaces (e.g., pavement, rooftops or other surfaces) related to urban and suburban development and other land-use changes has not only decreased potential groundwater recharge associated with rainfall events, but also has led to problems for municipalities that must deal with increased rates of stormwater flow into stream corridors. Nutrient loading associated with stream pulses can also negatively impact water quality and ecosystem health during times of intense rainfall. Considering these trends of increased water demand and the subsequent decreases in water quality and quantity associated with urbanization and other land-use practices, a need clearly exists to re-examine how we develop and manage existing as well as new sources of water.

Although many methods for capturing water are available for human and agricultural uses, responsible land stewardship is a key process. In this publication, we describe the Trinity River watershed, define land stewardship and explore its relationship to ecosystem health. Further, we describe how responsible land stewardship can be applied in urban and rural settings, explore connections between ecosystem function and land stewardship, and answer important questions about the Trinity River Basin.

THE TRINITY RIVER BASIN

The Trinity River begins near the Texas-Oklahoma border in Clay, Archer and Montague counties. Lost, Hurricane, Grayson, White Rock, Denton and Clear Creeks eventually merge with the West, Elm and East forks to form the Trinity River. It extends southeast about 512 miles, traversing five of the state's ten ecoregions (Figure 1) before emptying into the Gulf of Mexico via the Trinity Bay near Houston, Texas (Figure 2). The entire Trinity River Watershed encompasses over 18,000 square miles (7% of the total land area of Texas) and travels through 38 Texas counties (Figure 3). Average annual precipitation within the Trinity River Basin ranges from 52 inches near the Gulf of Mexico to less than 36 inches at the headwaters, with extensive water-related human alterations throughout its length (e.g., construction of reservoirs and energy production facilities, development of urban areas and livestock operations, and cultivation of large areas of land).

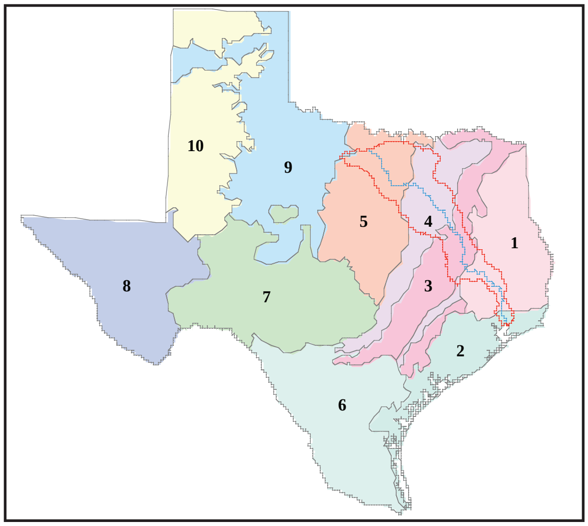

Figure 1. Because of differences in climate, soil types, and communities of plants and animals, 10 natural regions are commonly recognized in Texas: 1) Piney Woods, 2) Gulf Coastal Prairies and Marshes, 3) Post Oak Savannah, 4) Blackland Prairie, 5) Cross Timbers, 6) South Texas Brush Country, 7) Edwards Plateau, 8) Trans-Pecos ,9) Rolling Plains, and 10) High Plains. The Trinity River Basin (red polygon) and Trinity River (blue line) traverses several ecoregions within Texas.

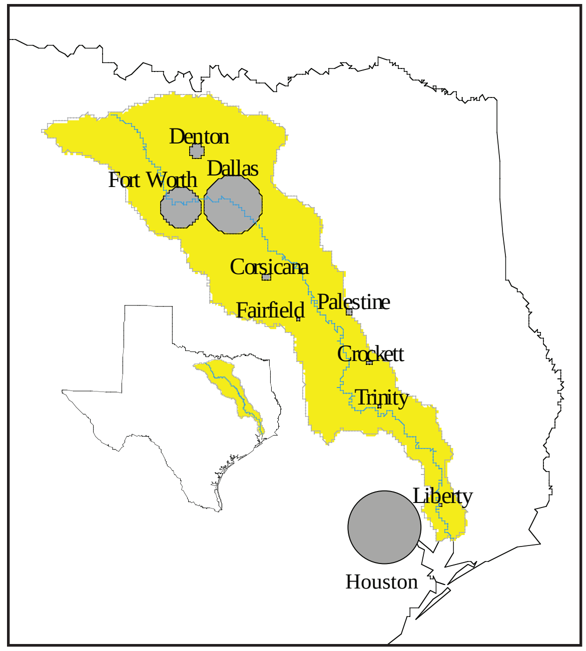

Figure 2. The head waters of the Trinity River begin northwest of Dallas-Fort Worth and empty into the Gulf of Mexico via the Trinity Bay near Houston. Cities (gray circles) are scaled to their relative population size.

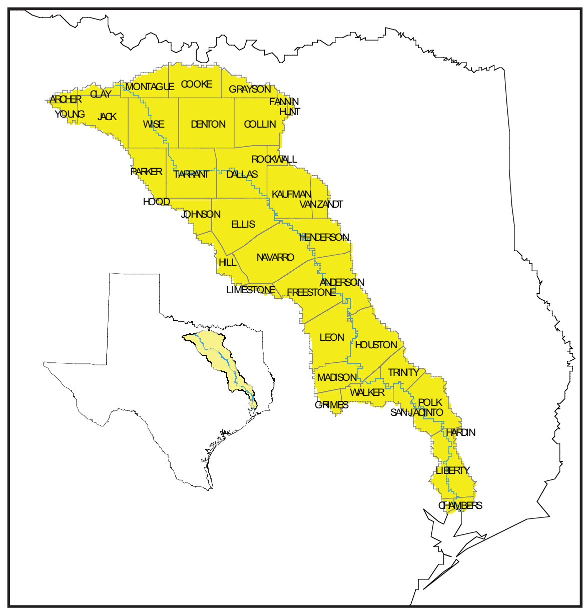

Figure 3. Thirty-eight counties comprise the Trinity River Basin in Texas.

As the Trinity River flows southward from the Dallas-Fort Worth Metroplex to the Trinity Bay, it is directly affected by many human activities occurring on the landscape. In addition, 22 major reservoirs within the Trinity River Basin provide drinking water to urban and rural communities. The river is affected in many ways by the variety of land uses practiced in the watershed. Some of the more important activities on basin lands include urbanization, commercial/industrial development, row-crop farming, livestock production, outdoor recreation and timber production. All of these major land uses have direct effects on the water quality and quantity as it moves through the basin. Importantly, responsible land stewardship is among the essential tools to safeguard and improve water resources for present and future generations.

Human Demographics and Water Use Within the Trinity River Basin

More than 5.5 million people are dependent on the Trinity River as a main source of water. These people are unevenly spread throughout the basin and beyond, with large numbers congregating in urban areas such as Dallas-Fort Worth (Dallas and Tarrant Counties) and Houston (Harris County). Intervening counties along the water course have lower population densities (Table 1). The number of people per household (pph) in counties located in the Trinity River Basin are remarkably similar (average = 2.6 pph).

Demographics of the Trinity River Basin play an important role in the management and use of water resources. Water use generally falls into three dominant categories: municipal (city), industrial (manufacturing, steam electricity, and mining), and agricultural (irrigation and livestock [Table 1, Figure 4]). Municipal use, though already substantial (Figure 5), is expected to dramatically increase (Figure 6).

Patterns of water use are changing. Statewide irrigation use will likely shrink from 57% to 43% of total water consumption, while municipal use is expected to grow from 25% to 35% by 2050. However, the rural aspect of the Trinity River remains important because total cropland and improved pasture are greater than 10,000 square miles (55% of the total land area of the Trinity River Basin).

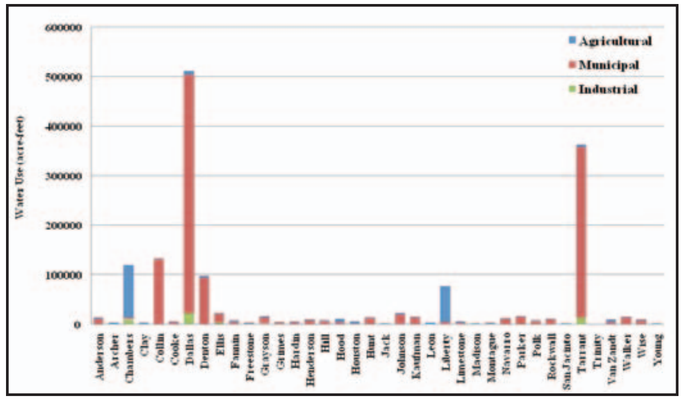

Figure 4. Water use (acre-feet) by county within the Trinity River Basin in 2004.

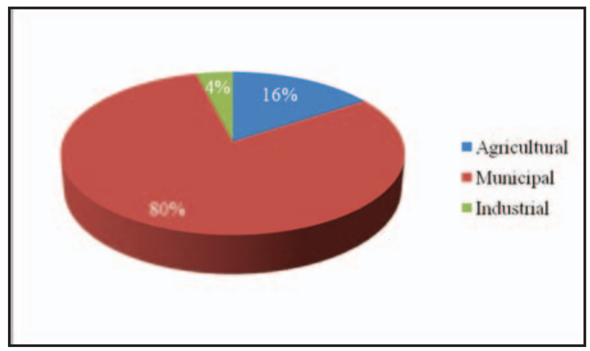

Figure 5. Percent water use (2004) within the Trinity River Basin.

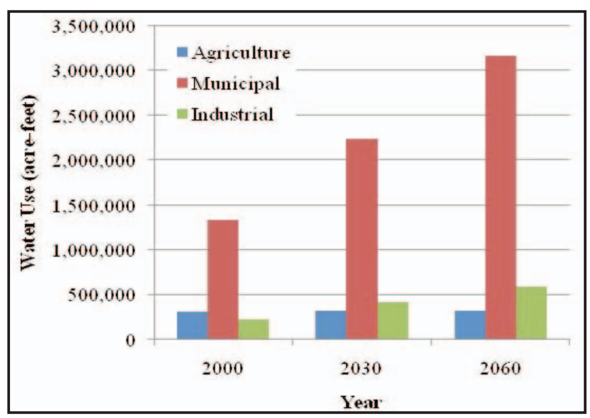

Figure 6. Water use projections (acre-feet) for the Trinity River Basin.

The Trinity River Knowledge Gap

A recent survey conducted by the University of North Texas demonstrated an apparent information gap for residents in the Trinity River Basin. For instance, 92% of 1,000 respondents in the upper Trinity River Basin were unaware that they lived in a watershed. Forty-five percent of the urban respondents did not know the source of their drinking water, yet 66% reported extreme concern for the adequacy of water supplies. The vast majority of respondents had little understanding of watershed concepts but indicated concern with environmental issues. They advocated better land stewardship practices to make

Table 1. Demographic and water use data by county for the Trinity River Basin.

County	Population[a]	Households[a]	Land area (mi^2) [a]	Persons/mi^2 [a]	Water Use (acre-feet)[b]		
Year cited	2006	2000	2000	2000	Agricultural[c]	Municipal	Industrial
Anderson	57,064	15,678	1,070.78	51.50	1,769	11,151	15
Archer	9,266	3,345	909.70	9.70	2,950	1,258	0
Chambers	28,779	9,139	599.31	43.50	106,111	3,326	9,972
Clay	11,104	4,323	1,097.82	10.00	2,441	1,110	0
Collin	698,851	181,970	847.56	579.56	2,305	130,305	1,296
Cooke	38,946	13,643	873.64	41.60	1,877	5,208	127
Dallas	2,345,815	807,621	879.60	2,521.50	7,745	481,485	22,489
Denton	584,238	158,903	888.54	487.00	3,000	94,501	437
Ellis	139,300	37,020	939.91	118.50	1,177	17,035	4,179
Fannin	33,337	11,105	891.45	35.10	2,505	5,180	9
Freestone	18,803	6,588	877.43	20.40	1,673	2,327	0
Grayson	118,478	42,849	933.51	118.40	2,971	11,348	1,969
Grimes	25,552	7,753	793.60	29.70	1,603	3,693	269
Hardin	51,483	17,805	894.33	53.80	458	5,940	199
Henderson	80,222	28,804	874.24	83.80	1,468	7,775	723
Hill	35,806	12,204	962.36	33.60	1,456	6,046	10
Hood	49,238	16,176	421.61	97.40	6,097	5,210	17
Houston	23,044	8,259	1,230.89	18.80	4,237	2,550	98
Hunt	83,338	28,742	841.16	91.10	1,115	11,986	606
Jack	9,110	3,047	916.61	9.60	1,006	1,054	0
Johnson	149,016	43,636	729.42	174.00	1,600	19,445	1,210
Kaufman	93,241	24,367	786.04	90.70	1,605	12,498	593
Leon	16,538	6,189	1,072.04	14.30	2,159	1,134	533
Liberty	75,685	23,242	1,159.68	60.50	71,269	5,208	270
Limestone	22,720	7,906	908.88	24.30	1,961	4,088	9
Madison	13,310	3,914	469.65	27.50	972	2,027	190
Montague	19,810	7,770	930.66	20.50	1,575	2,889	0
Navarro	49,440	16,491	1,007.66	44.80	1,513	9,217	889
Parker	106,266	31,131	903.51	97.90	1,562	13,732	550
Polk	46,995	15,119	1,057.26	38.90	432	6,622	375
Rockwall	69,155	14,530	128.79	334.00	129	10,669	10
San Jacinto	24,760	8,651	570.65	39.00	355	2,395	10
Tarrant	1,671,295	533,864	863.42	1,675.80	4,313	344,656	13,551
Trinity	14,296	5,723	692.84	19.90	458	1,518	0
Van Zandt	52,916	18,195	848.64	56.70	2,827	5,553	362
Walker	63,304	18,303	787.45	78.50	618	13,724	269
Wise	57,891	17,178	904.61	53.90	1,626	6,418	1,351
Young	18,021	7,167	922.33	19.50	1,001	2,127	24
Mean	184,380	58,378	854.94	192.77	6,577	33,484	1,648
Median	49,339	15,399	890.00	48.15	1,616	5,747	269

[a] Data were obtained from www.census.gov.
[b] Water use data (2004) were obtained from the Texas Water Development Board and combines surface and ground water use. An acre-foot is defined as the amount of water required to cover 1 acre (43,560 ft2) of ground to a depth of 1 foot of water. (1 acre-foot = 325,829 gallons)
[c] Agricultural water use includes irrigation and livestock use.

positive management decisions but simply lacked the guidance and resources to do so.

DEFINING LAND STEWARDSHIP

What is Land Stewardship?

Land stewardship implies environmental sensitivity, knowledge and understanding of the resources, and empowerment to sustain natural resources through management. In other words, a land steward is someone who manages his or her land to assure natural systems are maintained or enhanced for the future. Land stewards also recognize that natural resources extend beyond boundaries (e.g., fence lines, or political or government boundaries). To make correct decisions that maintain land in a "healthy" and productive condition, one must have a knowledge and understanding of natural systems. Therefore, a good land steward is someone who understands the land – soil, water, flora and fauna – he or she is managing and has the knowledge and expertise to apply techniques that enhance ecosystem function.

Rural and urban communities are similar in their central need for water. Actions of both communities have the potential to affect water quality and quantity available, both locally and elsewhere. However, rural and urban settings differ greatly in culture, experience, needs, problems, resources and property size. This necessitates development of stewardship values for each setting.

Aldo Leopold's Land Ethic

The concept of land stewardship has deep roots in the work of Aldo Leopold, commonly regarded as the "Father of Modern Wildlife Management." Leopold first proposed the concept of a "land ethic," which in essence stresses "a conviction for individual responsibility for the health of the land." Leopold summarized this philosophy best with the following quote:

"*A land ethic ... reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.*"
-**Aldo Leopold**

Leopold understood the irrefutable connectivity between humans and nature and expanded the "boundaries of communities to include soils, waters, plants, and animals, or collectively: the land." He understood that human actions directed towards the land have consequences associated with them that affect it in either a positive or negative way. It is difficult, if not impossible, to alter one aspect of an ecosystem without impacting the entire system as a whole. Natural resources and the results of management are rarely contained within the fence lines of a single property, but are shared by all.

Dan Lay, who is considered by some to be the "Father of Modern Texas Wildlife Management," thoroughly subscribed to Leopold's land ethic. Dan's corollary emphasizes a dimension that is essential to meaningful results. He noted that only through the will of the landowner can substantial achievements be made. That is, belief must be translated into real actions on individual properties across the landscape. Consequently, the role of private landowners is critical to providing land stewardship in a way that brings outcomes useful to water issues. Fortunately, this approach is growing in awareness and producing programs that allow landowners realistic options in order to practice the principles of land ethics.

Recognizing Exemplary Land Stewards

Texas Parks and Wildlife Department (TPWD) uses the basic principles of Leopold's land ethic and Lay's corollary to evaluate the quality of land management applied on private lands. Private landowners throughout Texas who exemplify quality values are recognized annually through the organization's Lone Star Land Stewards Awards Program (LSLSAP). This program recognizes private landowners from each of the state's 10 ecological regions whose management is aimed towards sustaining land in a healthy and productive state. The grand prize of the LSLSAP is named the Leopold Conservation Award and is presented by the Sand County Foundation to the landowner who is selected as the statewide winner.

The LSLSAP emphasizes the importance of private landowner efforts in habitat management and wildlife conservation. This recognition is based upon a system that seeks to publicize the best examples of (1) sound natural resource management, (2) youth education and participation effort that promotes responsible habitat management and improved ecosystem health, (3) long-term conservation of unique natural and cultural resources, (4) ecosystem awareness and conservation practices in the state's 10 ecoregions, (5) enhanced relationships between private landowners and Texas' natural resource agencies, and (6) illustrations of the role of Texas' private landowners in the future of our natural resources. Explicit in these measures are the ethical and social responsibilities to nature and the realization that stewardship affects ecosystems today and in the future.

An Example of Rural Land Stewardship
Recently, the Leopold Conservation Award was awarded to Gary and Sue Price (Figure 7), owners of the 77 Ranch, near Blooming Grove, Texas, in Navarro County. The 77 Ranch is situated between Richland Creek and Chambers Creek (tributaries of the Trinity River), which both drain into Richland-Chambers Reservoir, a supplier of municipal water to Tarrant County. The Prices have embraced long-term sustainability by restoring native grasslands for livestock forage. They implemented an intensive rotational grazing plan that mimics the grazing habits of bison, a once dominant species that helped maintain the Blackland Prairie ecoregion. Further, they manage invasive woody species through prescribed burning and use of herbicides, and they integrate practices that stabilize soil, leading to better wildlife habitat. Management actions taken by these landowners demonstrate a thorough understanding of the ecological processes and management techniques required to help the land function optimally. Management actions on the 77 Ranch are a model of sustainability and will have a positive influence

Figure 7. Gary and Sue Price, owners of the 77 Ranch were recently rewarded the Leopold Conservation Award for their land stewardship

on water quality and quantity within the Trinity River Basin.

Gary and Sue Price recognize the true nature of sustainable land stewardship in the context of the future as well as the present. They know that future generations need the knowledge they have acquired. True to these beliefs, they recently offered their property and their knowledge as practitioners to the Texas Wildlife Association (TWA) for use in field demonstrations for an ambitious education program that TWA is launching in the Trinity Basin. Through this focused program, TWA and allied school systems can connect the student communities throughout the watershed by means of "sister" fourth grade classes that exchange information they collect and by shared experiences. The outcome is expected to unite the people of the basin in respect of resources, as well as provide widespread and novel educational opportunities. Hopefully, the urban/rural boundaries will fade in the minds of these students, and a common appreciation for the treasure in natural resources will prevail into adulthood. In this way, a truly functional network for sustainability comes into being.

Additionally, TPWD is working with Mr. and Mrs. Price and adjacent landowners to restore and improve habitat for bobwhite quail over about 20,000 acres. These actions clearly demonstrate (1) the impacts of land stewardship as landowners optimize ecosystem services with a set of management actions, and (2) the interconnectivity of private lands as landowners work together to create better habitat than could be achieved over any one land holding.

An Example of Urban Land Stewardship

Positive land and resource management in urban areas is increasingly important as these stewards realize the impact of their actions locally and on downstream rural areas. This has given rise to urban groups dedicated to positive management actions in their communities. One such organization is the Elm Fork Chapter of the Texas Master Naturalists (Figure 8), which is dedicated to providing environmental stewardship and natural resources conservation information and assistance to community members. The Elm Fork of the Trinity River is rich in public natural resources, including the 5,848 acre Ray Roberts State Park (the second-most visited park in the state), the 2,700-acre Clear Creek Natural Heritage Center, and the 2,200-acre Lewisville Lake Environmental Learning Area, all located in Denton County, where the Elm Fork Chapter Texas Master Naturalists focus their work. This organization has initiated many stewardship practices, including water quality assessment, creek restoration, citizen outreach and education on conservation issues, and vegetation monitoring and restoration in terrestrial and riparian areas.

Figure 8. The Elm Fork Chapter of the Texas Master Naturalists is dedicated to providing environmental stewardship and natural resource conservation information and assistance to community members.

Challenges for Rural and Urban Land Stewardship

Management practices that disregard impacts on landscape often lead to degraded ecosystems. Rural communities often depend on agriculture or other land-dependent activities for economic or cultural lifestyles.

However, degraded ecosystems lead to a decreased capacity of the environment to sustain these land-based activities. Repair to these systems often requires years or decades. However, changes in management practices that reflect sound stewardship can prevent severe disruptions in ecosystem function before they occur.

Urban communities typically have high human density and, consequently, high levels of water consumption and waste production. Rivers have always served as important sites for township establishment due to nearby water availability, waterborne human migration, trade goods movement, and military or expeditionary movements. However, close proximity of high density human populations to adjacent waterways requires the initiation of actions to support growing municipalities, resulting in infrastructure such as port construction, effluent discharge, water withdrawals for drinking or industry, and more.

CONNECTIONS BETWEEN ECOSYSTEM FUNCTION AND LAND STEWARDSHIP

Ecosystem Function and Ecosystem Service

An ecosystem is defined as a functional unit consisting of plants, animals and all of the physical and chemical components of a habitat. Examples of an ecosystem include prairie grasslands, forests and watersheds, such as the Trinity River Basin. Ecosystem function refers to the processes within an ecosystem that contribute to its wellbeing. These include the flow of energy (e.g., through food chains and food webs) and the cycling of materials (e.g., nutrient cycling) within the system. Ecosystem services or items an ecosystem provides to people and wildlife stem from ecosystem functions. Some general examples of ecosystem function and their respective services are carbon capture and storage (also known as carbon sequestration) through the regulation of the atmosphere's chemical composition, soil formation from the accumulation of organic matter and weathering rock, and pollination through the movement of pollen (generally by wind, water and wildlife). Ecosystem services and functions specific to watersheds such as the Trinity River are included in Table 2. These ecosystem functions and their related services not only have intrinsic value to people, such as those mentioned in Table 3, but also have a monetary value in the form of consumables, such as raw materials, food and water. In addition to providing intrinsic value, clean water, clean air, and healthy land, they contribute to healthier human lifestyles.

The Role of Responsible Land Stewardship on Ecosystem Functions and Services

As pressures on ecosystem functions increase, the services they provide degrade when they are exploited beyond natural limits. In Texas, these pressures generally come in the form of increased development and water consumption due to an ever-increasing population. Impacts from technology (e.g., increased water consumption, pollution and increasing water temperatures) also play a role in ecosystem degradation. Poor land stewardship can impair systems to a point where functions and their respective services can no longer be performed properly, if at all. These include such services as cleaning air, filtering water, and controlling floods - services most people take for granted.

Though the problem seems daunting, positive stewardship efforts can reverse some of the negative effects caused by years of ecosystem impairment. With the help of sound management practices and knowledge of watersheds and their functions, landown-

Table 2. Ecosystem services provided by watersheds (Costanza et al. 1997).

Ecosystem Service	Ecosystem Function
gas regulation	regulation of the atmosphere's chemical composition
climate regulation	regulation of temperature, precipitation, and other biologically controlled climatic processes
disturbance regulation	regulation of environmental fluctuations
water regulation	regulation of water flow
water supply	storage and retention of water
erosion control	soil retention
nutrient cycling	storage, cycling, and processing of nutrients
waste treatment	uptake, removal, and breakdown of nutrients
biological/pest control	regulation of populations due to food webs
wildlife habitat	habitat for resident and migratory wildlife
food production	production of plants, animals, etc.
raw materials	production of extractable raw materials
genetic resources	source for unique biological materials and products
recreation	opportunities for recreational activities
cultural aspects	opportunities for non-commercial use (i.e. aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems)

Table 3. Intrinsic values of nature as they pertain to ecosystems and their descriptions (Kellert 1984).

Intrinsic Values	Description
naturalistic	interest and affection for the out-of-doors
ecological	concern for ecological systems and the relationships between wildlife and their respective habitats
humanistic	interest and affection for individual animals
moralistic	concern for animal welfare
scientific	interest in the physical and biological functioning of animals
aesthetic	interest in artistic and symbolic aspects of animals
utilitarian	concern for the practical and material value of wildlife and their respective habitats
dominionistic	interest in the control of animals
negativistic	avoidance of animals due to a dislike or fear

ers can improve the health of their local ecosystems. For example, Richland Creek Wildlife Management Area (RCWMA), located within the Trinity River floodplain in Freestone and Navarro Counties, has made great strides in improving its management area. This nearly 14,000-acre property was deeded to TPWD as mitigation for the loss of bottomland hardwood habitat resulting from the construction of Richland-Chambers Reservoir. In 1996, TPWD partnered with the Tarrant Regional Water District (TRWD) to develop up to 2,000 acres of water treatment wetlands on RCWMA. The objectives of the project were to produce high quality water and a wetland habitat for wildlife, as well as to demonstrate the concept of water reuse. The project functions by pumping water out of the Trinity River, filtering it through native wetland vegetation, and then pumping the treated water into Richland-Chambers Reservoir, where it is ultimately piped back to customers in the Dallas-Fort Worth Metroplex. This project serves as a model of how to meet increasing water needs in an environment-friendly manner without the construction of additional reservoirs which would reduce the function of bottomland habitat. At the same time, the wetlands and bottomland hardwood forests have created quality habitat for deer, waterfowl, and other game and nongame species that provide consumptive and non-consumptive uses (e.g., duck hunting and bird watching) to the public.

A similar project sponsored by the North Texas Municipal Water District is now under construction on the East Fork of the Trinity between Crandall and Seagoville, Texas. The decision by the water district to use this approach was largely driven by the need for an efficient means for an alternative water supply, and its implementation has been bolstered by the success of the TRWD model at RCWMA. These projects are tangible examples of how ecological processes operating in managed systems can be effective alternatives to more traditional approaches to water supply. Importantly, the scientific facts and the ecological functions are available. Breaking through the barriers obstructing innovations is the major obstacle. Perhaps, however, we are beginning to think more wisely and creatively. Such attitudes and behavior are essential to sustainable land stewardship and use of land resources for all citizens.

QUESTIONS AND ANSWERS

A series of answerable questions resulted from the University of North Texas survey concerning citizen knowledge and understanding of water and watershed issues in the Upper Trinity River Basin. We address those questions below.

What are rainwater and stormwater and why are they important?

Rainwater
Rainwater is water that reaches the ground and either infiltrates the soil (groundwater) or moves to surface water bodies (surface water). The path it chooses is based largely on soil permeability and rate and location of precipitation.

Stormwater
Stormwater is defined as rainwater that does not permeate the ground and instead runs over the surface of the land or impervious surfaces. Stormwater runoff potentially accumulates pollutants (e.g., oil, grease, chemicals or bacteria) and deposits them in surface waterways, such as storm sewers, creeks or rivers.

Importance
Human management actions can have enormous impacts upon the conversion of rainfall to stormwater. While this conversion greatly depends on rate and length of moisture deposition (e.g., rainfall, snow melts), ground permeability is the main factor in moisture absorption and is greatly influenced by humans. This management can affect soil-water absorption and drastically alter stormwater presence and intensity.

Urban Stormwater
Due to widespread development of natural topsoil and green spaces, urban environments have reduced soil permeability and increased potential for stormwater runoff. In the absence of well-developed storm drainage, overland runoff can quickly overwhelm storm systems, resulting in flooding. Urban and suburban development in natural flood plains and flooding corridors contributes to the potential for more intense flooding.

Rural Stormwater

Poor management practices in agricultural areas, such as overgrazed pastures, increase amounts of bare soil. Bare soil creates a crusting effect on the soil surface that lowers the rate of water infiltration, increases the amount of runoff and leads to severe soil erosion. Resulting soil erosion reduces the soil's productivity and impacts water quality by washing sediment into major sources of drinking water (i.e., streams, rivers and reservoirs). The increased sedimentation lowers Texas' capacity to store water and increases maintenance costs (e.g., water treatment and dredging).

Watershed-Level Stormwater

Stormwater serves as an effective transporter and an important example of interconnectivity between urban and rural areas. Although stormwater can benefit the system through cyclical flooding (e.g., deposition of nutrients, impacts on plant succession), it has great potential to degrade the ecological function of the system by transporting pollutants. As stormwater navigates through the watershed, it is continually gathering ground-based debris until it merges into major water bodies, such as the Trinity River. Essentially, the watershed is scoured of dead plant litter, nutrients, chemicals, and garbage, and the river serves as a drain that transports the materials from their point of origin. For example, garbage and chemicals originating in the Dallas area often find their way into the Trinity River and are deposited dozens to hundreds of miles from their original source (Figure 9). Transport of these materials to waterways often results in reservoir pollution. Currently, the Trinity River Basin has 22 major reservoirs and hundreds of smaller ones that serve to control and regulate water discharge; however, they also serve as traps for nutrients and pollutants. Since reservoirs serve as major sources of water, pollution from stormwater presents important concerns.

Figure 9. Debris can be deposited dozens of miles from the original source. Landowner James Reed collects debris from upstream sources.

Stormwater and its impacts are managed through a variety of means (e.g., channelization and diversion, wetland construction, retaining walls, range management and restoration). Current and future management include goals beyond stormwater containment. With the increasing populations in both urban and rural Texas, stormwater capture and use as a dependable water supply has gained importance. However, besides dwindling water supplies and growing populations, it is stormwater pollution that presents one of the most onerous land stewardship issues.

Where does much of the pollution come from? What forms does it take?

According to the U.S. Environmental Protection Agency (EPA), there are two types of pollution: point source and nonpoint source. Point source pollution enters a system directly from a defined, identifiable point of discharge, such as pollution from industrial and sewage treatment plants. Nonpoint source pollution, on the other hand, occurs when precipitation moves water over and into the ground, and the exact locations of discharge or "source" of the contaminated water is difficult to identify. Water runoff collects and deposits natural and man-made pollutants into water bodies such as wetlands, watersheds, lakes, coastal waters and even drinking water from underground springs and rivers. The EPA lists nonpoint source pollution as the following:

- excess fertilizers, herbicides and insecticides from agricultural and residential areas;
- oil, grease and toxic chemicals from urban runoff and energy production;
- sediment from improperly managed construction sites, crop and forest lands and eroding stream banks;
- salt from irrigation practices and acid drainage from abandoned mines;
- bacteria and nutrients from livestock, pet waste and faulty septic systems; and
- atmospheric deposition.

Within the last few decades, the EPA has made an effort to prevent point source pollution through regulation. Nonpoint source pollution, unfortunately, is harder to pinpoint and more difficult to regulate, though there are an increasing number of state and federal laws addressing the issue. Damage from nonpoint source pollution, according to the EPA, is now the single largest cause of declining water quality in the United States.

What is the path of water?

The path of water from the river to the user and back to the river is a complicated and ambiguous aspect of living within a watershed (Figure 10). As precipitation hits the ground, a portion of it flows over the ground as surface runoff while another portion infiltrates the ground. Once the ground has been infiltrated, water becomes soil moisture or replenishes groundwater (e.g., aquifers). Surface runoff flows to streams and rivers and can either be stored in freshwater lakes or discharged into the ocean. Surface water from rivers and reservoirs is captured, treated for human consumption and distributed to consumers within homes, businesses and industries. Waste water produced by consumers is treated and discharged back into the river.

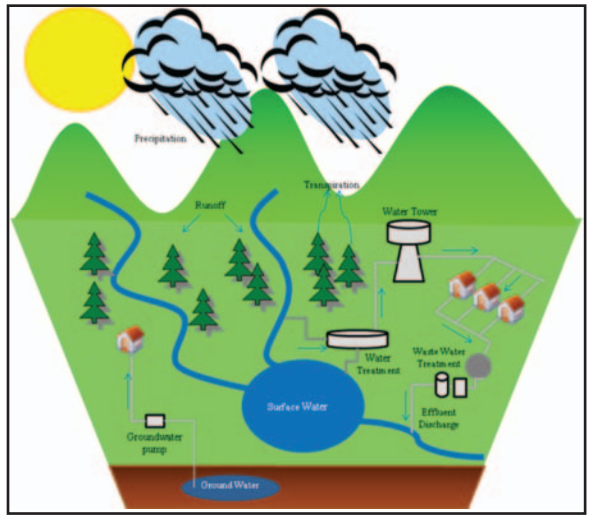

Figure 10. Path of water from river to consumer. Arrows indicate direction of water.

Who are the major regulators and sources of information for the Trinity River Basin?

A number of agencies are involved in the regulation of water resources and/or serve to research and develop information leading to management and conservation of water in Texas. Several leading groups are listed in Appendix A. In addition, each agency maintains websites where more information may be obtained.

SUMMARY

As the population of Texas continues to grow, water issues will become a central focus. Water supplies are not growing. Clearly, we must consider alternative ways and seek new innovations for conserving water to meet future demands. Conservation efforts are particularly important in the Trinity River Basin because the river supplies water to approximately 40% of the state's residents. Faced with water shortage and quality issues, Texans have a growing interest in gaining information regarding watershed and land management practices. This improved information is necessary to bridge the watershed and water-use knowledge gap.

Within the Trinity River watershed today, municipalities use more water than agricultural and industrial-related activities. Over the last several decades, people have migrated from rural areas to predominately urban areas. Managing this change will require a shift in thinking as individuals and civic leaders redefine how they influence water conservation. Having knowledge of soil, water, flora, fauna and the management practices necessary to enhance ecosystem function will become more important for those engaged in water and land stewardship. Past and current winners of the LSLSA and work done by Texas Master Naturalist offer good examples of how to conduct conservation efforts on large and small landscape scales within the framework of their own land ethic.

Good management maximizes both environmental health and output. However, bad management impairs the ability of the environment to provide essential services both now and in the future. To aid decision-making, we provide contacts and sources of more information needed by landowners and stakeholders to further educate themselves on water-related issues. Accurate information is vital for the specific and positive land management required to ensure the availability of quality water in a growing and changing Texas.

As the 512-mile course of the Trinity River passes through 38 counties and several major ecoregions, it delivers ecosystem services that benefit nature and humans. Although our tendency is to remove ourselves from nature, it is obvious that we are intimately connected, and conservation efforts need to be employed now in order to provide water in the future.

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Appendix A. Natural Resource Agencies and Trinity River Conservation Organizations for the Trinity River Basin.

Texas Commission on Environmental Quality
2309 Gravel Drive
Fort Worth, TX 76118-6951
Phone: 817-588-5900
Fax: 817-588-5704
http://www.tceq.state.tx.us/index.html

Texas Water Development Board
Stephen F. Austin Building
P.O. Box 13231
Austin, TX 78711-3231
Phone: 512-463-7847
Fax: 512-475-2053
http://www.twdb.state.tx.us

Texas Rural Water Association
1616 Rio Grande Street
Austin, Texas 78701
Phone: 512-472-8591
http://www.trwa.org

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744-3291
Phone: 512-389-4800
http://www.tpwd.state.tx.us

Texas Cooperative Extension
http://texasextension.tamu.edu/
For individual counties:
http://type county here-tx.tamu.edu
Example: http://anderson-tx.tamu.edu

Trinity River Authority
5300 South Collins Street
Arlington, TX 76018
Phone: 817-467-4343
Fax: 817-465-0970
http://www.trinityra.org

Tarrant Regional Water District
600 East Northside Drive
Fort Worth, TX 76102
Phone: 817-335-2491
http://www.trwd.com

U. S. Army Corps of Engineers-Fort Worth District
P. O. Box 17300
Ft. Worth, TX 76102-0300
Phone: 817-886-1326
http://www.swf.usace.army.mil/

USDA-Natural Resources Conservation Service
101 South Main
Temple, TX 76501
Phone: 254-742-9800
Fax: 254-742-9819
http://www.tx.nrcs.usda.gov/

Websites

Department of Wildlife & Fisheries Sciences
http://wfscnet.tamu.edu/

Institute of Renewable Natural Resources
http://irnr.tamu.edu/

Rainwater Harvesting
http://rainwaterharvesting.tamu.edu/

Texas Cooperative Extension
http://texasextension.tamu.edu/

Texas Water Resources Institute
http://twri.tamu.edu/

Texas Water Matters
http://www.texaswatermatters.org

Trinity Basin Conservation Foundation
http://www.trinityfix.org/

Trinity River Basin Environmental Restoration Initiative
http://trinityriverbasin.tamu.edu/

Texas Wildlife Association
http://www.texas-wildlife.org/Water%20Reports.htm

TEXAS A&M SYSTEM

Texas Cooperative EXTENSION The Texas A&M University System

TEXAS PARKS & WILDLIFE

TEXAS A&M Institute of Renewable Natural Resources

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Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas Cooperative Extension, The Texas A&M System.