STATE OF THE HILL COUNTRY

8 Key Conservation and Growth Metrics for a Region at a Crossroads

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By

SIGLO GROUP

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Texas Hill Country Conservation Network Manager, John Rooney.

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Dear Reader,

The Texas Hill Country is a region at a crossroads. This iconic landscape, filled with natural beauty and heritage-rich rural communities, is facing tremendous threats from sprawling growth and development.

The Hill Country's open spaces, clear springs and streams, natural habitat and abundant wildlife, dark night skies and small town charms can't be taken for granted. The region's idyllic lifestyle could vanish due to land fragmentation, unregulated development, and overconsumption of water resources. Increased groundwater pumping and rapid expansion of impervious cover from new buildings, roads and parking lots jeopardize the area's waterways and aquifers.

The window of opportunity to keep the Hill Country rural, natural, and vibrant will likely close within our generation.

Looking across our beautiful but threatened landscape from above Jacob's Well, David Baker, Executive Director of the Wimberley Valley Watershed Association, envisioned a way to bring together the myriad conservation organizations working in the region to scale the collective ambition and impact of those working to preserve and protect the Hill Country. Over years of work, David and many others invested time, talent, and treasure in developing what has grown into the Texas Hill Country Conservation Network. The Network, a partnership of dozens of organizations working across an 18-county region of Central Texas, is squarely focused on maximizing the protection of the Hill Country's natural resources through enhanced collaboration.

This report represents a step in the evolution of the Network and its work, and we hope it will inform and inspire you to get involved in the pressing work of conservation. This region is on the verge of becoming a victim of its own success. The secret is out, and people are moving to the Hill Country in droves for its beauty and high quality of life. The other side of this growth is an unsustainable demand on the resources upon which life in the region, both human and otherwise, depend.

The metrics that have been selected in this report will serve as a means of tracking what we believe to be the most important indicators of the natural Hill Country's health. The choices we collectively make now will determine whether the region and its inhabitants survive and thrive, or whether we willfully live beyond the means and carrying capacity of this place we call home.

The challenges are many – insufficient regulatory tools for land use and water management; a rapidly changing climate bringing more frequent flooding and severe droughts; a rapidly increasing population bringing both its demands on resources and its waste – but there is reason for hope. Some of the brightest minds in conservation are bringing their energy and innovative thinking to meet the moment and, through the Network, are working together in common purpose. There are ways of growing that protect and even enhance the natural resources that define this place that we can and must pursue if we are to protect the Hill Country. We simply need your help – elected officials, business and community leaders, developers and the residents of this region.

The destiny of the Texas Hill Country is not set in stone. We can choose to travel together on the road that protects this special place we call home. Consider this your invitation to roll up your sleeves and join us.

Sincerely,

John Rooney
Texas Hill Country Conservation Network Manager

EXECUTIVE SUMMARY

This project defines and calculates **eight metrics** for tracking trends related to changes in the natural resources of the Texas Hill Country. Dozens of organizations — nonprofits, government agencies, academic institutions and aligned private businesses — endeavor to protect the land, water and sky of this unique region. The metrics defined here will support these entities as they work individually and collectively through the Texas Hill Country Conservation Network (the Network) to both tell the story of the need for conservation and preserve the natural resources and heritage of the Texas Hill Country.

Consistent with the priority goals outlined by the Network, these metrics focus on:

- Population growth in unincorporated areas
- Amount of conserved lands
- Amount of developed lands
- Pristine streams
- Per capita water consumption
- Spring flow
- Night sky visibility
- Conservation investment

In addition, we looked at two case studies:

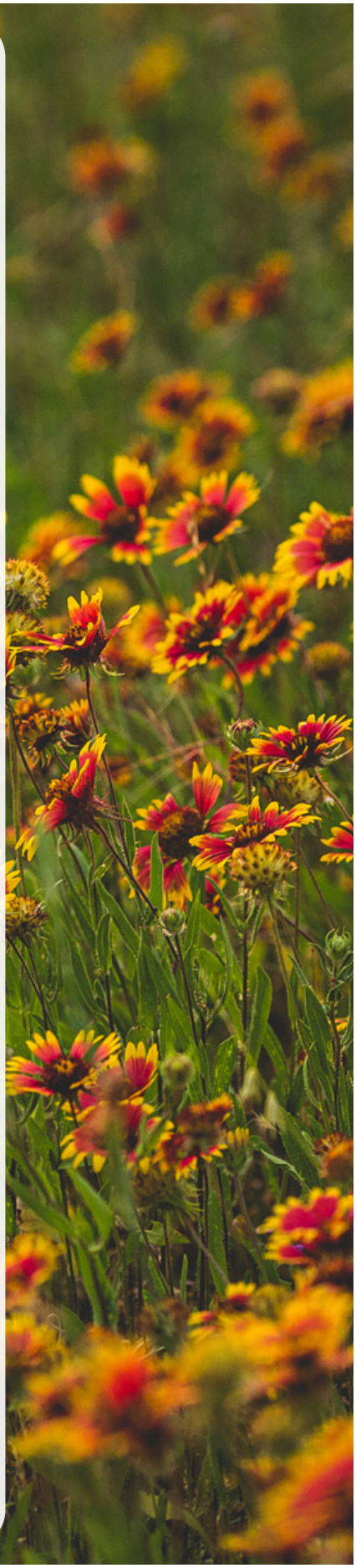
- The success of the **San Antonio Edwards Aquifer Protection Program**
- The ongoing struggle to keep **Jacob's Well** flowing

All metrics are based on best practices with measurements analyzed at the watershed and county levels.

The baseline data offers a snapshot of the Texas Hill Country and will serve as a tool to gauge progress in protecting, conserving and stewarding its natural resources.

How will we collectively respond to the threats facing the Texas Hill Country?

While there is uncertainty, there is also hope. Working together, Hill Country residents, businesses, ranchers, farmers and elected officials can preserve the natural beauty and resources that drew so many to this special place.



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All photos courtesy of HCA except as noted.

INTRODUCTION

The Texas Hill Country encompasses more than 11 million acres in 18 counties in Central Texas, including the rapidly growing cities of San Antonio and Austin, as well as extensive rural areas. It is a landscape of rugged natural beauty, rich biodiversity and unique ecological systems.

The Texas Hill Country is home to the headwaters of 12 Texas rivers, sustaining life from the rural ranchlands and thriving cities of Central Texas to Corpus Christi, Port Aransas and the coastal estuaries of the Gulf of Mexico.

This region is at a crossroads, facing tremendous threats.

Booming population growth and sprawling development, groundwater overuse, changing climate patterns leading to increasingly extreme droughts and floods, and a unique set of regulatory challenges threaten the very natural resources that define this region.

The window of opportunity to protect and sustain the Texas Hill Country's treasures will likely close within our generation. Understanding how to balance development and conservation will be key to that sustainability.

Without collaboration, we will not keep pace with the loss of open space, the threats to water resources and other challenges facing our region.

Because of this, since 2017 dozens of organizations across the Hill Country have been working together as part of the Texas Hill Country Conservation Network (the Network), a voluntary partnership focused on deepening existing collaborations and supporting new ones for increased conservation results. These metrics amplify the work that Network partners are already doing and provide quantitative evaluations of the progress of cross-organization efforts to help inform future strategy. The metrics in this report are built on a strong foundation of theory, methods and best practices. Recent work in Texas, Florida, Oregon and Colorado has calculated the societal value of ecosystem services —including resources such as drinking water, flood protection, recreation and tourism. Drawing on these established methods, meta-analyses and available data, the metrics outlined here will be used over time to connect that progress to values for both human and natural communities.

This report's eight metrics focus on the following topics:

Conservation and land stewardship
- Metric 1: Development in Unincorporated Areas
- Metric 2: Conserved Land
- Metric 3: Developed Land
- Metric 7: Night Skies
- Case Studies: San Antonio Edwards Aquifer Protection Program and Jacob's Well

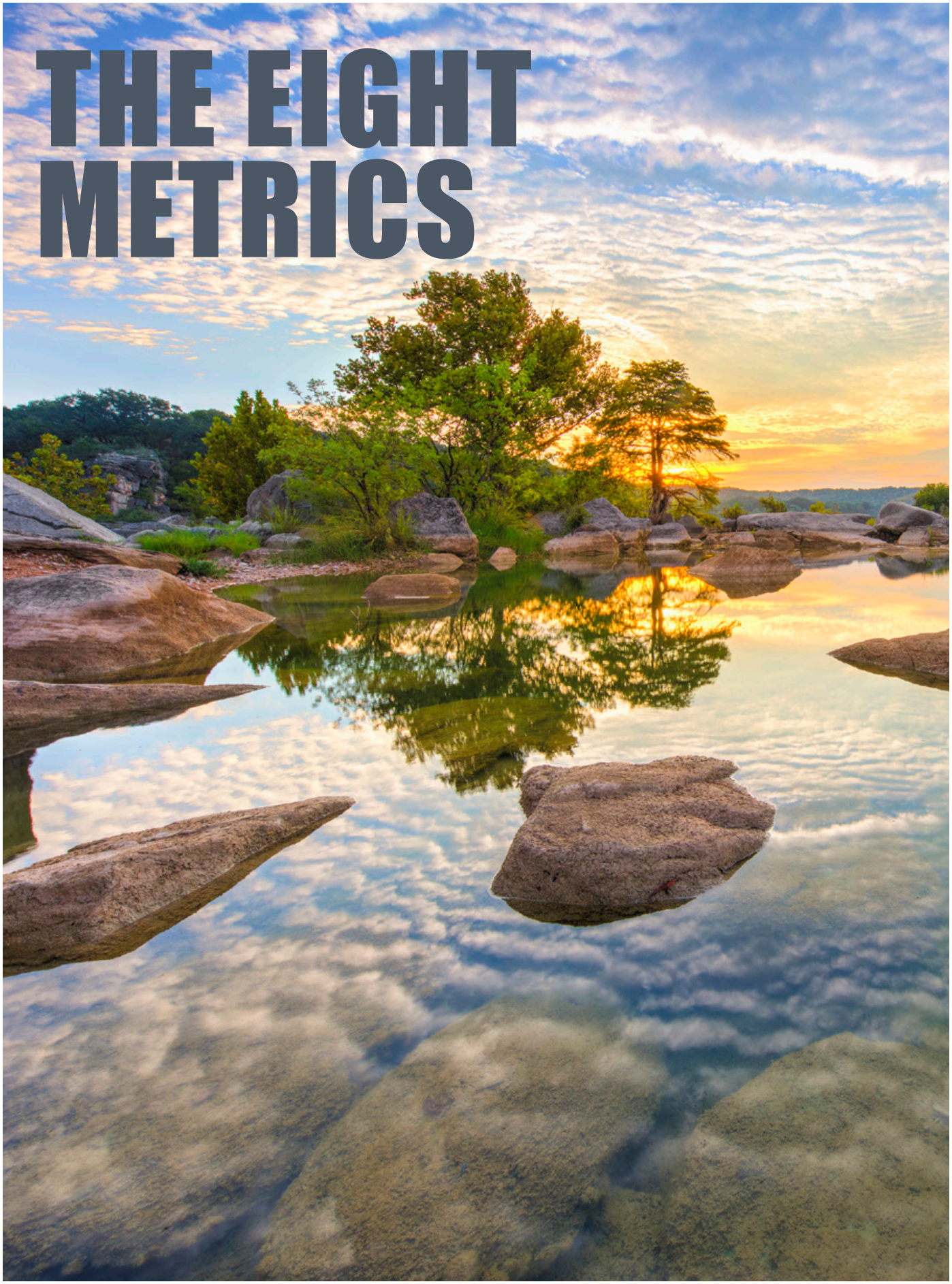
Water quality stewardship
- Metric 4: Pristine Streams
- Case Studies: San Antonio Edwards Aquifer Protection Program and Jacob's Well

Water quantity
- Metric 1: Development in Unincorporated Areas
- Metric 5: Water Consumption
- Metric 6: Spring Flow
- Case Studies: San Antonio Edwards Aquifer Protection Program and Jacob's Well

Fiscal investment
- Metric 1: Development in Unincorporated Areas
- Metric 8: Conservation Investment
- Case Studies: San Antonio Edwards Aquifer Protection Program and Jacob's Well

Network partnerships
- Addressed by all metrics

Public awareness
- Addressed by all metrics


THE EIGHT
METRICS

These metrics were defined using stakeholder input and established geographic assessment methods. The data comes from multiple sources: Texas Water Development Board, Texas Demographic Center, U.S. Census Bureau, U.S. Geological Survey, National Oceanic and Atmospheric Administration, Texas Natural Resources Information System, Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Land Trust Council, Hill Country Alliance, the Meadows Center for Water and the Environment, Trust for Public Land and others.

1) COMMUNITY: *Unincorporated population*

Population data examines growth in unincorporated areas over time. This metric provides a means of quantifying the potential impact of population growth on the region's resources. **Land fragmentation and loss of ecological connectivity in these areas have negative impacts on water quality, water quantity, biodiversity and night sky visibility.**

2) LAND: *Conservation lands*

Texas Land Trust Council and San Antonio Edwards Aquifer Protection Program data assesses the impact of voluntary easement programs on conservation lands over time. Additional data includes state, county, and city parks and other public land. This metric tracks the acreage and locations of conserved land. **These natural areas, working farms and ranches and public lands store and cleanse the Hill Country's water supply and wildlife habitat while preserving space for residents and visitors.**

3) LAND: *Developed lands*

In contrast to conservation lands, we analyze the expansion of urban land cover over time using the National Landcover Dataset. By studying it in conjunction with conservation lands, we can assess the positive/negative correlation between the two. **The long-term goal is for Central Texas to be conserving lands at least as fast as we are developing them.**

4) WATER: *Pristine streams*

Texas Commission on Environmental Quality data creates a metric that can track amounts of phosphorus found in streams. High levels of phosphorus lead to algal blooms and are a key indicator that water is unsafe for drinking, recreation, and wildlife habitat. In addition to increased run-off generated by new impervious cover from the region's rapid development, treated wastewater effluent created by population growth is increasingly threatening Hill Country waterways. **The Hill Country's drinking water, clear swimming holes and wildlife habitat are all dependent on the cleanliness of the rivers that course through the region and the aquifers that lie beneath it.**

5) WATER: *Consumption*

Texas Water Development Board data tracks gallons used per capita per day for each Water User Group within the study area. Tracking consumption will help cities, residents, and conservation partners to understand regional and seasonal trends. **A better understanding of trends will help inform strategies to maintain clean water supply for wildlife, plants, agricultural lands and Hill Country residents.**

6) WATER: *Spring flow*

U.S. Geological Survey (USGS) data tracks spring flow in cubic feet per second (cfs) within the study area. By monitoring trends in spring flow, we can better understand the effects of climate trends and water consumption on the Hill Country's landscape. **Spring flow, which provides critical baseflow for Hill Country streams, is necessary to sustain the unique flora and fauna of the Hill Country and recreational activities like fishing and swimming.**

7) NIGHT SKY VISIBILITY: *Light pollution*

The Hill Country has been called "the edge of night" — the inky black skies offer clear views of stars and eclipses. National Oceanic and Atmospheric Administration satellite data measures the amount of nighttime light pollution, also an effective way to measure urban and suburban growth. **By studying artificial light changes over time, organizations can explore alternative solutions that benefit residents and wildlife.**

8) INVESTMENT: *Public investment in land conservation*

Trust for Public Land data quantifies public investment in conservation through bonds and tax incentives. By analyzing this data in conjunction with the region's Gross Domestic Product (GDP) we can understand if allotted conservation investment has kept up with Central Texas' booming economy. **Hill Country organizations can in turn use this data to advocate for conservation funding that increases proportional to economic growth.**

COMMUNITY

Metric 1: Growth in Unincorporated Areas

METRIC BASELINE:

Unincorporated Population 2020:

864,336

30-Year Unincorporated Population Change 1990-2020:

103%

The Texas Hill Country is among the fastest-growing regions in the nation. The population, currently 3.8 million, has grown by nearly 50 percent in the last 20 years. It is expected to grow by another 35 percent over the next 20 years, reaching 5.2 million in 2040.

Most of this growth will occur along the I-35 corridor, in Bexar, Comal, Hays and Travis counties. Neighboring counties — Bandera, Blanco, Burnet, Kendall, Llano and Medina — are also experiencing very high levels of population growth. [1,2]

People are moving to the Hill Country in unprecedented numbers not only due to a strong economy, but also the natural landscape and climate. Young people seek a healthy place to start careers and families. Older folks move here to retire in quiet beauty. Most communities welcome these steady streams of transplants — new neighbors and friends, entrepreneurs and workers.

"I traded for a songbird and a bigger piece of sky."

– Robert Earl Keen

WHERE WILL THE GROWING POPULATION LIVE?

Subdivisions on the rise

Increasingly, subdivisions are popping up outside of our region's cities and towns in unincorporated areas of counties. Unincorporated areas are those outside of established city boundaries within a county.

In Bandera County, for instance, the population in unincorporated areas has more than doubled since 1990, while the population within Bandera's city limits stayed practically level.

The story in Medina County is similar. In 1990, just over half the population (57%) lived within the city limits of Medina County's several municipalities. Since then, the population in unincorporated areas has grown significantly faster than those within city limits. By 2020, less than 40% of the county's population lived in one of the county's municipalities.

Even communities adding a lot of new housing within the city limits to keep up with growing demand are unable to stem the growth in unincorporated areas.

In Kendall County, Boerne has more than quadrupled its population since 1990, growing from 4,274 to 19,066 people. Despite this impressive effort to house a growing population in the city limits, the county's unincorporated areas grew by 176%, from 9,785 to 27,000 people during the same period.

While the City of Boerne is able to manage the impacts of its population surge through effective planning and development ordinances, Kendall County, like all Texas counties, has almost no land use planning authority to help guide and thoughtfully manage growth.

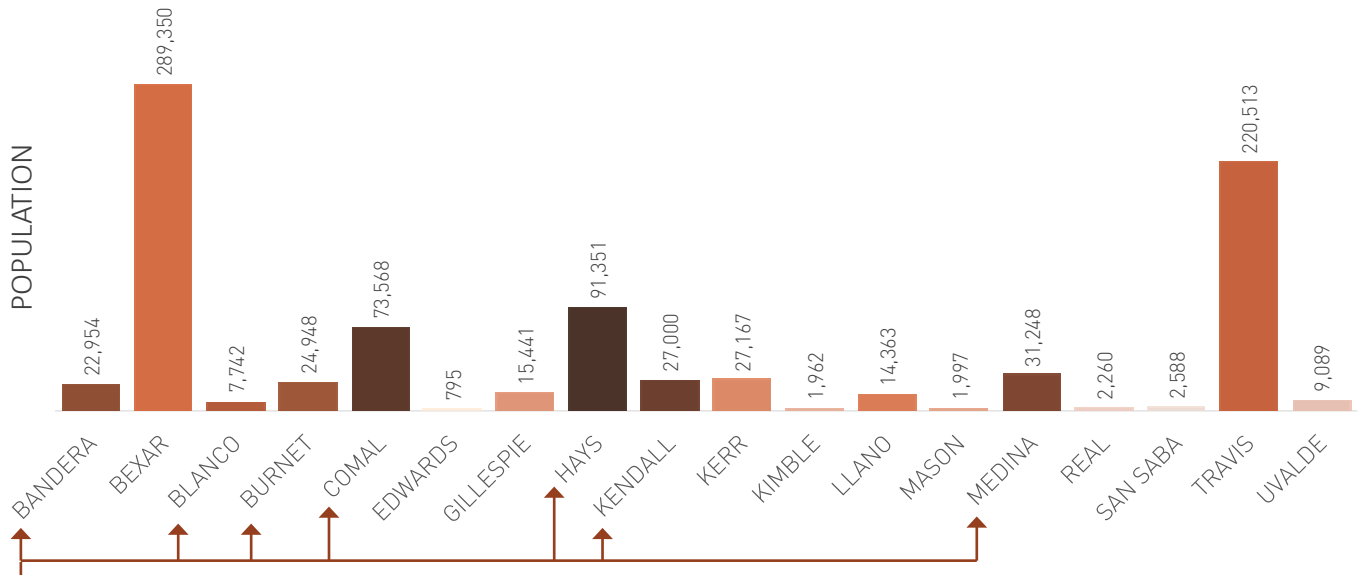
Ranchettes and second homes

Elsewhere in the region, new folks are moving into ranchettes, homes on plots within a subdivided ranch with a distinctly more rural feel. Ranchettes are typically between 5 and 50 acres - too small to make a living in ranching or agriculture.

Kimble County, for instance, has only grown by 7% since 1990, but during this period the unincorporated parts of the county have grown by 34%, while the City of Junction, where more than half the residents live, shrunk by 8%.

The 34% growth in unincorporated Kimble County represents, by and large, ranches that have been fragmented into ranchettes. Importantly, this figure does not account for the number of second homes (weekend getaways) built in unincorporated Kimble County, as the census does not track weekenders.

Population in Unincorporated Areas, by County, 2020

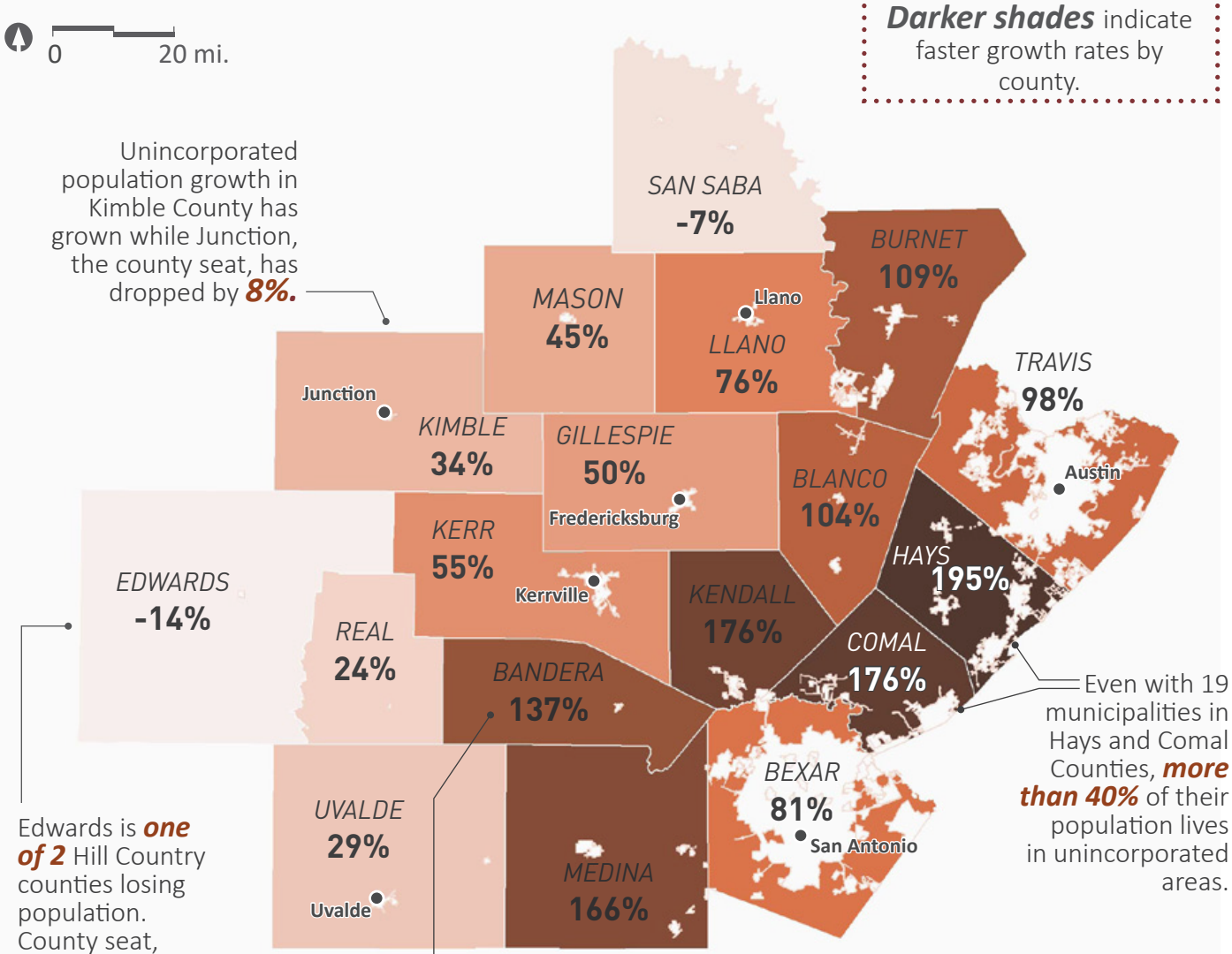


Bandera, Blanco, Burnet, Comal, Hays, Kendall and Medina counties have experienced the fastest growth in the Hill Country, with little support. Unlike the unincorporated populations in Bexar and Travis counties, these areas have no big-city economy to serve them. The natural systems that these communities depend on for clean water and air, outdoor recreation and wildlife habitat are being severely impaired by the demands of an increasing and unmanaged growth in unincorporated areas.

Image by William Luther, San Antonio Express-News staff.

Population Growth in Unincorporated Areas, 1990 - 2020

The Hill Country population in unincorporated areas has grown by ***103%*** since 1990. ***Darker shades*** indicate faster growth rates by county.



Unincorporated population growth in Kimble County has grown while Junction, the county seat, has dropped by ***8%.***

Edwards is ***one of 2*** Hill Country counties losing population. County seat, Rocksprings, the county seat, is shrinking at a similar rate.

96% of Bandera County's rapidly growing population lives in unincorporated areas.

Even with 19 municipalities in Hays and Comal Counties, ***more than 40%*** of their population lives in unincorporated areas.

White spaces indicate incorporated areas.

Why does population growth in unincorporated areas matter?

The reasons for rapid growth in unincorporated areas — in some cases far exceeding the growth in towns — are complex. Factors include lower land prices, less regulation for developers to navigate, lower taxes and, for some, the appeal of "country" living.

Population growth, for all of its benefits, can present significant challenges, many of which are exacerbated when the growth occurs outside the city limits. This defines the need for this metric.

Texas county governments possess no authority to do land use planning and have very limited authority to set development standards. As a result, developers determine where residential and commercial subdivisions will be built, usually based on the availability of cheap and marketable land.

The county can't adequately prepare for growth by building out a gridded road network or requiring developers to do so. Consequently, new neighborhoods are rarely adjacent, making interconnectivity impossible. Instead, subdivisions link only to the nearest highway through one or two entryways, creating inefficient and dangerous traffic patterns.

These unincorporated subdivisions can be fiscal drains on the county's resources. Cost of Community Services studies conducted in 2002 by the American Farmland Trust (AFT) in Bandera, Bexar and Hays counties found that for every dollar of tax revenue generated from residential property, the average costs in services provided to those properties (for schools, roadways, water and wastewater, courts and public safety) ranged from $1.10 to $1.26. Farm and ranch land, as well as commercial and industrial properties, on the other hand, are revenue positive: typically requiring only $0.25 in services for every dollar of revenue they provide to the county in taxes. [3, 4, 5, 6]

The net costs of residential subdivisions to the county government must be offset by revenue from industrial, commercial and agricultural properties. Because counties cannot plan land use, the industrial developments — gravel and sand mines,

limestone quarries, concrete and asphalt batch plants, and other industrial operations —frequently appear next to the new unincorporated residential neighborhoods.

These land use conflicts add to traffic and safety concerns, diminish residential real estate values, and jeopardize water and air quality, severely impacting quality of life for residents and our communities.

The region's unincorporated areas provide many necessary ecological services to our communities: aquifer recharge, flood reduction, agricultural products, wildlife habitat and outdoor recreation opportunities.

As populations increase in these areas, their ability to serve these vital functions decreases. The result?

- More residential water use *draws down the aquifers*
- Municipal Utility Districts and Water Control and Improvement Districts are established to provide water and wastewater services that include the *direct discharge of effluent (treated wastewater*) into Hill Country creeks
- Subdivisions significantly *increase impervious surface coverage* in water catchments, causing increased flooding while negatively affecting the land's ability to recharge the aquifer
- Iconic land that may have been ideal for a regional park becomes a residential neighborhood, *reducing potential parkland* while increasing the demand for outdoor recreation

Texas county governments have their hands tied by lack of authority.

Counties cannot zone for land uses or set development standards for impervious surface coverage, water and wastewater system performance or fire suppression systems to the same extent as municipalities. Counties cannot require buffers between incompatible neighboring land uses, nor can they require residential developers to preserve open space for recreation and ecological function. They cannot require developers to improve the roads that lead to the new developments, nor can they charge impact fees to cover the costs of services that the new home buyers will expect. These are just a few examples of the unaccounted costs of this type of development. When compounded with impacts on water resources and added flooding risk, it is clear that these developments create a financial drain on our long-term economy and quality of life.

The ability to employ any of the tools mentioned above would be helpful to rapidly growing counties; all would require changes to state law that are unlikely in the near term.

The Hill Country, like all places, has a carrying capacity. Housing our growing population without depleting the natural resources is a fundamental challenge faced by our region today. Sustainability is possible through the use of low-impact development practices that minimize the human footprint, but counties in Texas are unequipped to effectively influence developers to utilize those practices due to their lack of land use planning authority.

Until county officials have the tools they need and the will to use those tools, population growth in unincorporated areas will continue to be an important indicator of the threats that jeopardize our region's prosperity in the long-term.


LAND
Metric 2: Conserved Lands
Metric 3: Developed Lands

METRIC BASELINES:

Conserved Land Acres 2021:	*Developed Land Acres 2016:*
546,301	**828,066**

In a region prone to both prolonged drought and catastrophic floods, the way we steward and develop our lands is critical to our ability to sustain a consistent quality of life in the Hill Country. Undeveloped natural areas provide benefits to society and our environment, known as ecosystem services.

What are **ecosystem services**? Think about riparian areas that naturally slow and clean our creeks and rivers, upland forests that purify the air we breathe, recharge features that channel rainwater deep underground to sustain our aquifers, and critical habitats that support wildlife communities, some found only in the Hill Country.

When we grow as a region, some ecosystem services are reduced or lost as development causes land fragmentation, impervious cover reduces aquifer recharge and impairs stream health, and biodiversity is diminished by habitat loss.

We can grow as a region while protecting the natural areas that sustain us.

Two metrics are evaluated in tandem to track critical elements of land use:

- Conservation Lands: how much land has been permanently protected in its natural state
- Developed Lands: how much land has been developed

This analysis highlights the need to invest in protecting the ecosystem services that sustain the water supply, clean air and quality of life in the Hill Country.

"Saving the water and the soil must start where the first raindrop falls."

—President Lyndon B. Johnson

Image courtesy of Siglo Group.

METRIC 2: CONSERVATION LANDS

Conservation lands are the green engine that keeps our regional economy moving. These areas provide our communities with clean water and air, soil creation, flood protection, recreation, wildlife habitat, plant habitat, natural relief, scenic views, climate moderation, food production and a long list of other services.

Land uses are changing; the impacts of developing land require multiple generations to repair. As more land is developed, at least a corresponding percentage of wild land should be conserved.

Conservation biologists have suggested that 30% of an ecosystem should remain intact in order to maintain basic function. [7] In addition, watershed scientists have suggested that no more than 10% of a watershed should be impervious cover or hydrologic function may be lost. [8] With these types of benchmarks in mind, we can look at what lands are currently managed for conservation in the Hill Country.

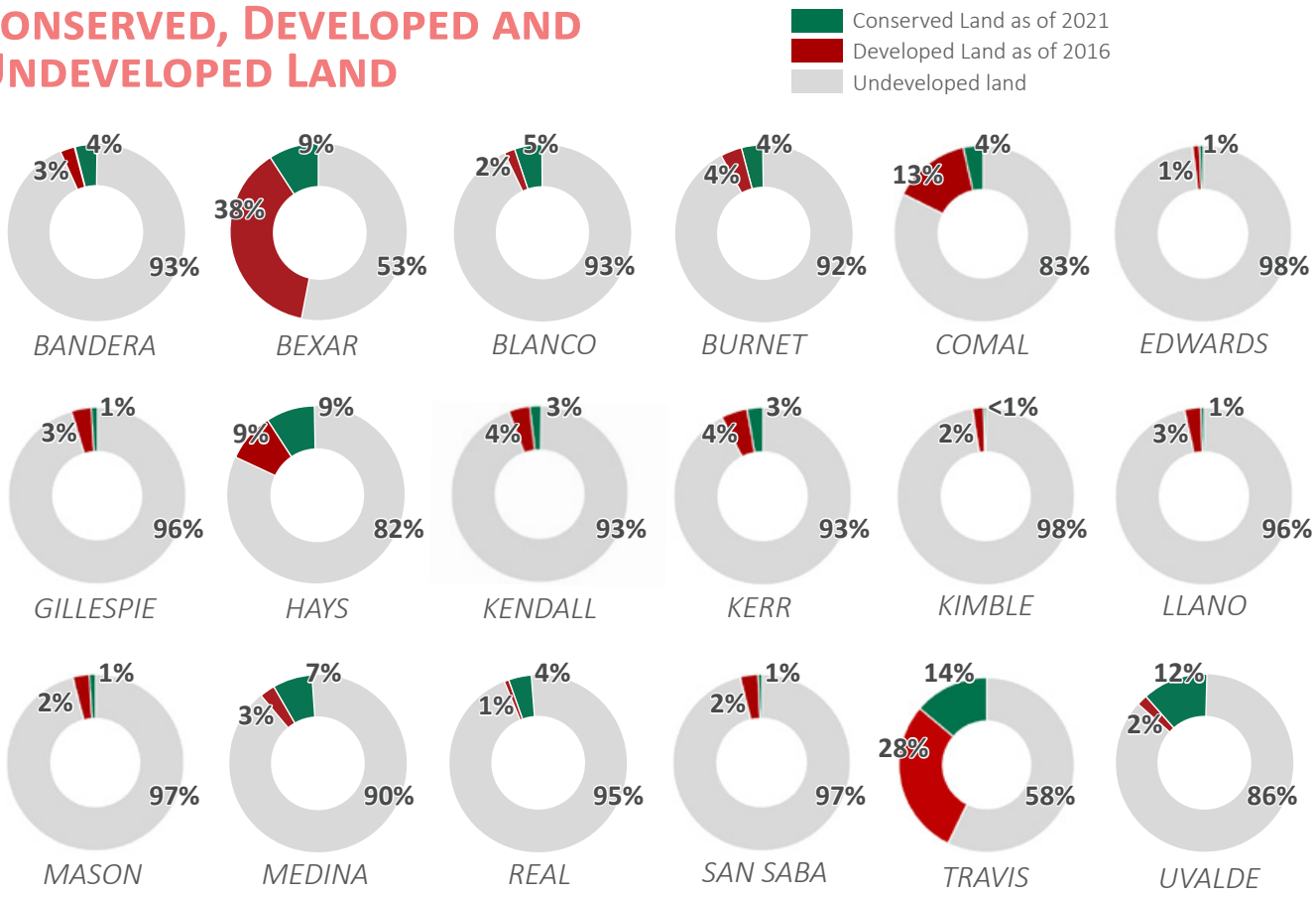
Why isn't more Texas land protected by public ownership?

As a young republic, Texas accrued a large amount of debt. Those debts were paid by selling off land, by reimbursing soldiers and others with land, and by attracting new sellers and businesses with the promise of land. In the end, we were left with very little in public hands. About 2% of Texas land is publicly held with a conservation focus. In a state and region that prides itself on vast open spaces, almost all of that space lacks formal protection. Collectively, we are a far cry from the 30% suggested by conservation scientists to maintain ecological function.

Conservation easements

Thankfully, there is a parallel solution to this situation that seems designed for Texas — the **conservation easement**. This increasingly popular tool allows a willing landowner to voluntarily form a partnership for the preservation of their property in perpetuity. It has some of the same protections

Conserved, Developed and Undeveloped Land

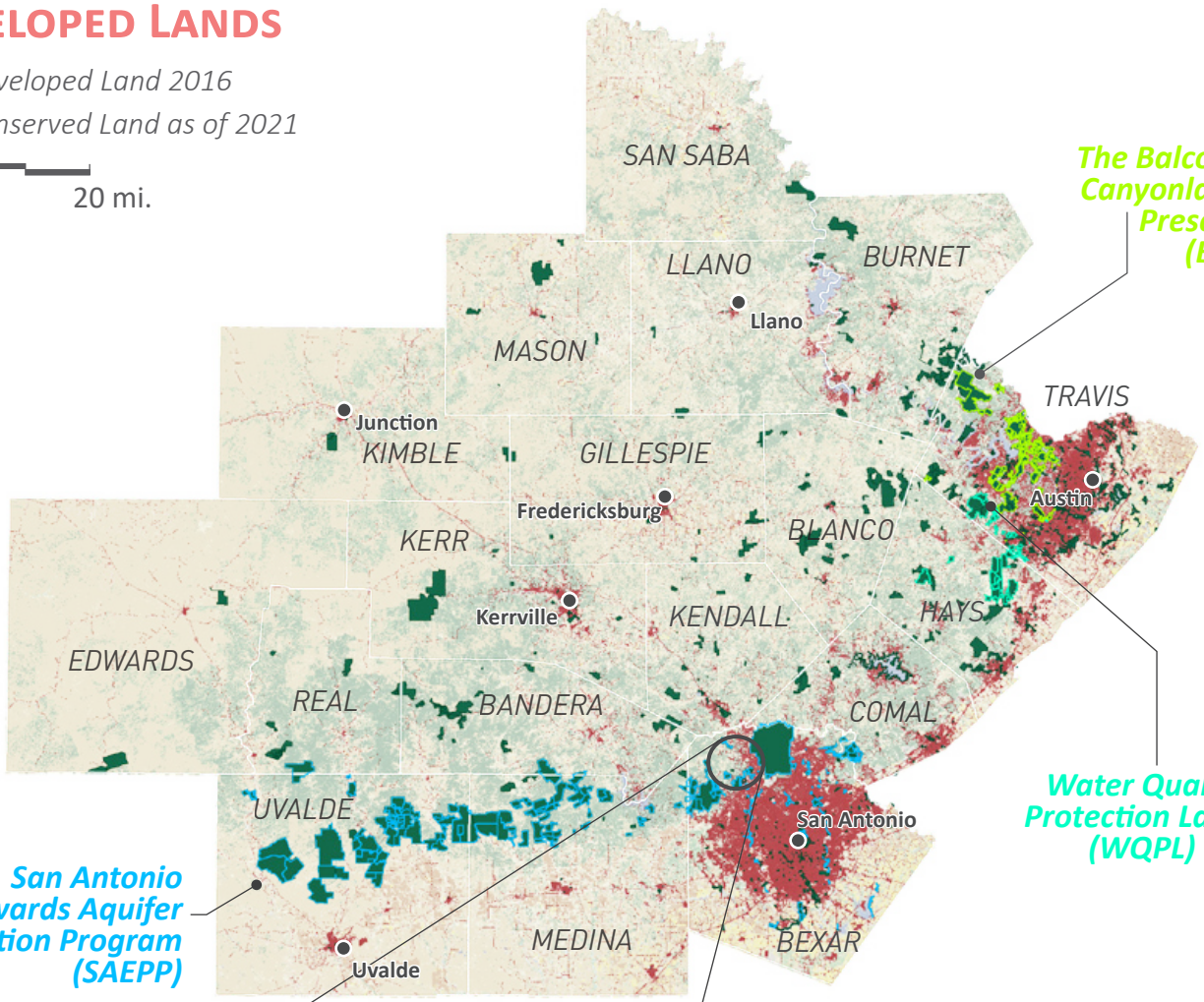


Conserved Lands vs. Developed Lands

Developed Land 2016

Conserved Land as of 2021

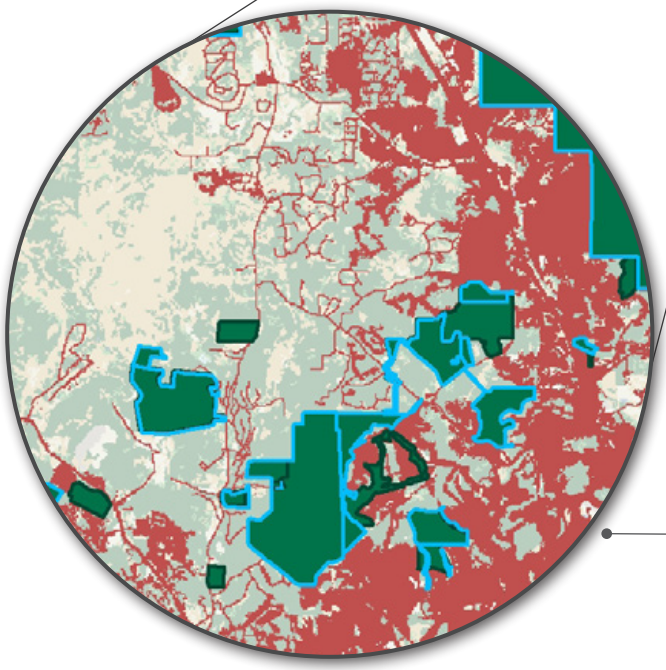
0 20 mi.



The Balcones Canyonlands Preserve (BCP)

Water Quality Protection Lands (WQPL)

San Antonio Edwards Aquifer Protection Program (SAEPP)



Land near the small towns and open country outside urban centers like San Antonio and Austin is being rapidly lost to development as the population in and around cities continues to boom. Healthy growth in the region means conserving the land most critical to ecological function and concentrating development in big cities and Hill Country towns so critical open land isn't lost to sprawl.

Image courtesy of Siglo Group.

as a park or a preserve, but the property continues to be privately owned. The partnering organization, generally a land trust, is set up specifically to support these types of agreements.

The landowner has many motivations for entering into this arrangement: a desire to keep the land intact, tax benefits, direct payment or reimbursement or a desire to continue working the land. The result can be an agreement that benefits the owner while permanently protecting a part of the Hill Country landscape.

Organizations holding conservation easements in partnership with landowners in the Hill Country include the Hill Country Conservancy, Texas Land Conservancy, The Nature Conservancy, Texas Agricultural Land Trust, the Colorado River Land Trust, the Guadalupe-Blanco River Trust, the Cibolo Conservancy, Wimberley Valley Watershed Association, and the Green Spaces Alliance of South Texas.

To measure conservation lands in the Hill Country, we used the Texas Land Trust Council Conservation Lands Inventory. [9] Additionally, records from the Texas Parks and Wildlife Department, municipalities and land trusts throughout the Hill Country help to quantify the number of acres that have been put into long-term conservation as of 2021.

The total land in conservation as of 2021 is 546,301 acres, or 5% of the Hill Country.

Looking at the distribution of conservation lands we find they coincide with population centers along the eastern bounds of the Hill Country along the I-35 corridor and expand outward from San Antonio towards Uvalde County to the west. The bulk of permanently protected lands in the Hill Country are found in Travis, Bexar, Hays, Uvalde and Medina counties. This relative abundance is a result of the significant tax base of major municipalities and counties that enables more spending on conservation lands, funded through bond referendums and sales tax revenue. In addition, these areas have the greatest need for conservation as development threatens sensitive natural resources.

Notably missing from this list is Comal County. The Edwards Aquifer Recharge Zone — and the I-35 corridor — run through the county, which is experiencing substantial pressure from development.

There's a long way to go before we meet the standard of protecting 30% of land.

Prior to 2016, trends showed that about 8,000 acres a year were converted to developed land. However, population growth over those years was much less than the period after 2016 and unfortunately, we can expect the conversion to developed lands to match the population trendline. The good news is that we now have a model for land conservation, with a coalition of capable organizations and a community of landowners working on it together. We need to follow successful examples from our region such as the San Antonio Edwards Aquifer Protection Program (see page 50).

More funding will be required to reach conservation goals, but there is clear evidence that land conservation is both very popular with voters and an efficient use of financial resources (see Metric 8). With a catalyzed effort, the conservation lands of the Hill Country can help support a sustainable future for the Hill Country.

METRIC 3: DEVELOPED LANDS

Two million new residents are on their way to the Hill Country over the next two decades. [10] Planning for their arrival and determining how they will create a high quality of life without degrading the landscape will be crucial to maintaining the Hill Country we know today.

To more carefully consider how the land is being used, this metric evaluates the amount of area that is considered "developed" throughout the Hill Country.

Developed lands are those that are intensely utilized for buildings, roads, parking lots and other infrastructure. Once built out, it is very difficult to undo development. Lands covered by impervious cover are rarely returned to a natural state. Developed lands are denser in urbanized areas, become more diffuse in suburban areas and are sparsely distributed in rural areas.

These developed lands are crucial for our communities, serving as integral parts of our economy. However, status quo development practices can have substantial negative impacts to the Hill Country landscape that are both ecologically and economically costly.

For this metric we used the National Land Cover Database (NLCD). The NLCD looks across the country at 5-year intervals to characterize the way land is being used. Categories include urban development, suburban development, cropland, wetland, open water, forest, scrubland and grassland, among others. We isolated the categories associated with development to identify how much of the Hill Country has been dedicated to urban, suburban, industrial and commercial uses. Additionally, the infrastructure that connects those uses together is also assessed.

Based on these criteria, 828,066 acres, or 7% of the Hill Country have been developed as of 2016 (the most recent available data).

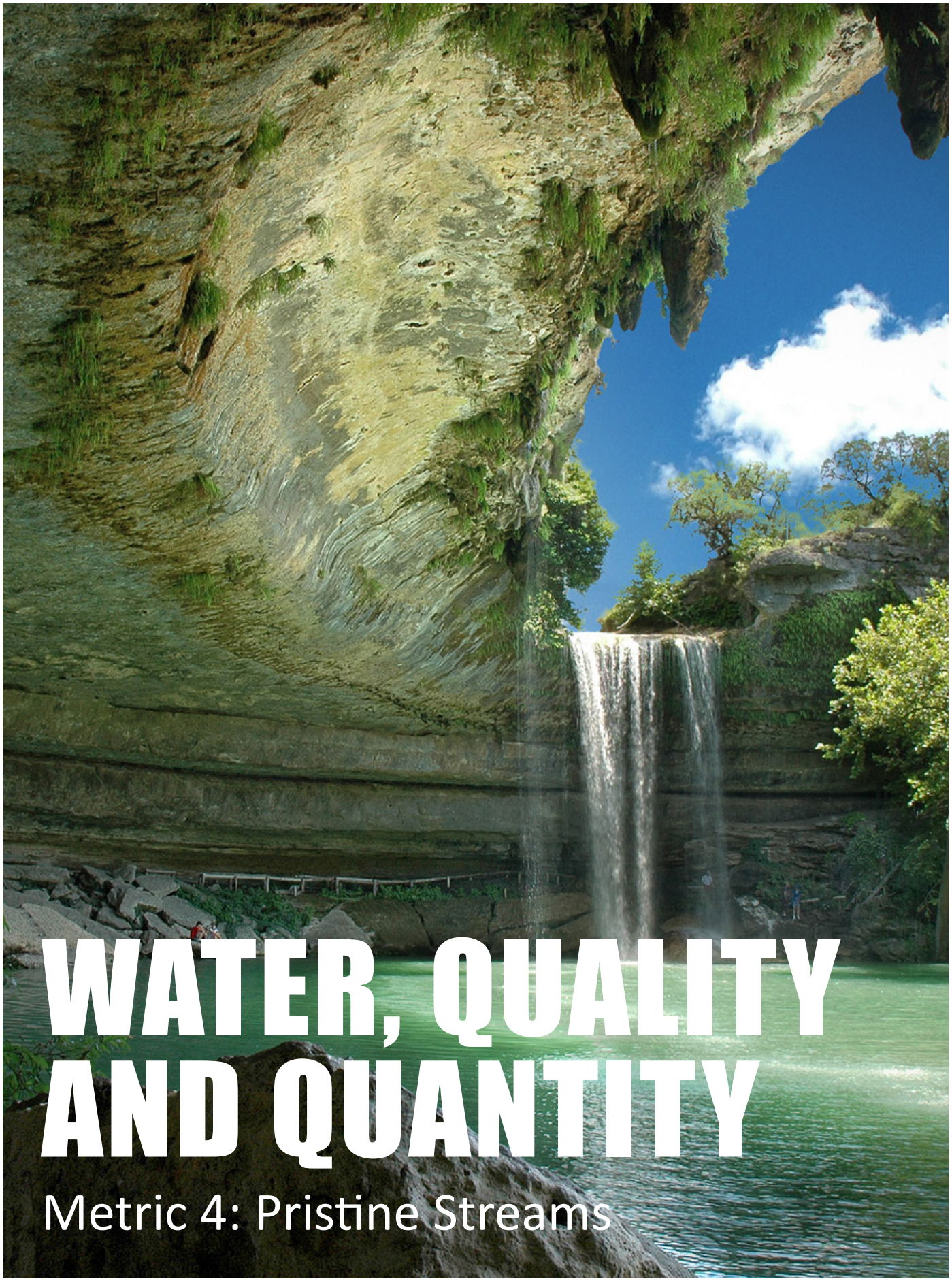
Dividing the developed area data into counties, the "Conserved Lands vs. Developed Lands" graphic shows that many of the western counties have low levels of development. The eastern counties along the I-35 corridor have higher levels of development; Travis and Bexar are substantially higher than other counties.

Of particular note is the accelerating development in Comal, Hays, Medina and Kendall counties. This substantial shift has numerous implications. In a broad sense, it can alter the aesthetic experience of the landscape from traditional Hill Country views that have been valued for generations.

From a community perspective, development means that small Hill Country towns with limited services are growing at an exponential rate. This growth — and the expanded roads, schools, and emergency services that it entails — often outpace the ability of communities to provide infrastructure (see Metric 1).

We can determine how to use the landscape more effectively, just as municipalities are figuring out how to use water more effectively (see Metric 5). By using these areas more effectively, we can reduce our infrastructure, our environmental impacts and our overall costs for development. We can incorporate techniques that allow ecological services to function for communities.

Reducing impervious cover per person, integrating storm water solutions and rainwater collection, incorporating open space and nature into design are all potential methods of reducing the impact of developed land.



WATER, QUALITY AND QUANTITY

Metric 4: Pristine Streams

METRIC BASELINE:

Pristine Stream Miles 2020:

1,142

The Texas Hill Country is known for the many clear, spring-fed creeks and flowing rivers that crisscross the verdant belly of the state.

Hill Country streams offer countless recreational opportunities for residents and visitors, from paddling the Llano to floating the Frio, from fishing in the Guadalupe to bird watching on the Pedernales, from swimming at Barton Springs to standing under Gorman Falls on the Colorado. "Taking in the waters" is a regional pastime and the most refreshing way to beat the heat of a Texas summer.

However, the importance of this resource goes far beyond our visceral pleasure or recreational amusement.

These streams and the aquifers to which they are intimately linked provide drinking water to nearly all the region's 3.8 million people and the abundant, diverse wildlife that live here. (A small but growing number of people in our region rely on rainwater as their sole source of potable water at home.)

The Hill Country is extremely fragile because of its unique karst geology; dissolved limestone provides fissures, caves and sinkholes that route water back down to the aquifer (carrying along any pollutants). Preserving the cleanliness of the water — the **water quality** — is paramount to the continued viability of the Hill Country as both a functioning ecosystem and a desirable place to live.

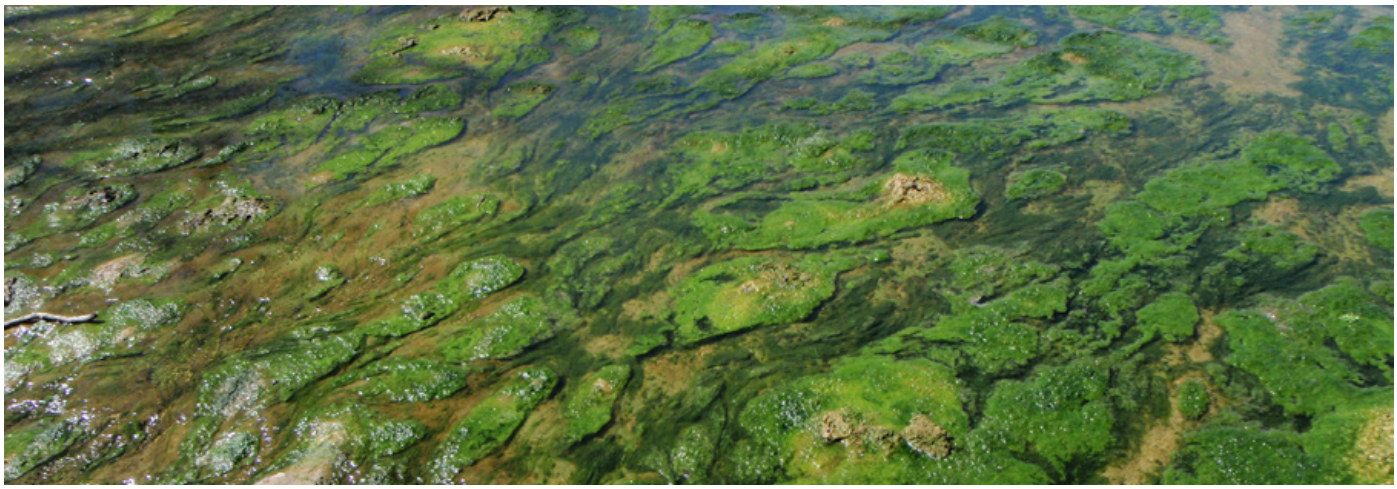
Why aren't all waterways pristine?

The 12 rivers with headwaters in this region roll through some of the fastest-growing counties in the country, all the way to the Gulf of Mexico.

As growth comes to our region, we see more applications to discharge treated wastewater into those rivers and their tributaries. As of 2018, there were permit applications to dump more than 2.1 billion gallons of treated wastewater per year into the pristine waters of the Hill Country. Even when treated to the highest standards, treated wastewater includes levels of phosphorus higher than the base levels in those receiving creeks and rivers. Those discharge permits present an immediate threat to the health of those ecosystems and the economies that depend on them. State water quality standards require that the treated wastewater discharged into rivers is relatively clean, but any level of discharge degrades the existing water quality.

"Water is the driving force of all nature."

—Leonardo da Vinci



Stream suffering from an influx of too many nutrients, likely due to direct discharge of waste water, fertilizer runoff, or both.

What's Impairing Hill Country Streams?

Wastewater effluent dumping
from treatment plants

Impervious surface runoff
Including roads and parking lots

Airborn pollutant emissions
from vehicles and power plants

Agricultural runoff
from farming operations

Ever wonder why our streams are crystal-clear and teeming with life? Treated wastewater does not sustain these waterways. Groundwater-dependent springs do. Hill Country streams create glorious swimming holes that grace postcards and drive tourists to our area.

Treated wastewater contains high amounts of phosphorus, which clouds water and causes algal blooms. The upper segments of streams and rivers fed solely by groundwater — like the Nueces, the Frio and the Devils — contain little to no phosphorus, a component of wastewater. If we discharge treated wastewater into these streams, we run the risk of polluting groundwater because groundwater and surface water are connected across the Edwards Plateau.

Other causes of water quality impairment include excessive fertilizer use that also can lead to algal blooms in local creeks, as well as airborne pollutants that land on large lakes. These problems are compounded where impervious surface cover is extensive, as rainfall will carry more pollutants over these surfaces and directly into waterways.

What makes a stream pristine?

Only about 40 of more than 2,000 streams across Texas are considered pristine — the majority are in the Hill Country — because they have no detectable phosphorus, a component of wastewater. Included, for example, is the beloved Upper Frio River (which flows through the popular and crowded Garner State Park), the Upper San Marcos River (a very short portion of the stream fed by the largest spring in the state) and the iconic and wild Devils River.

In addition to very low levels of chemical indicators like phosphorus, other factors contributing to a stream's quality include physical factors like whether the riparian area (the area between the water and floodplain) is healthy and well-functioning, and how abundant and diverse wildlife, including invertebrates, are. While more difficult to measure than chemical indicators, these physical and biological indicators also play a key role in the health of a waterway. While we are using the word pristine to describe Hill Country waterways with 0.06 mg/l or less of phosphorus, it's important to note that all streams and waterways in the Hill Country have been impacted by human activity and have been degraded from their natural state.

For this metric, Texas Commission on Environmental Quality (TCEQ) Clean Rivers Program data from January 2011- January 2021 was used to calculate which stream segments had 0.06 mg/l or less of phosphorus 90% of the time. Water quality in the Hill Country is monitored primarily by river authorities — the Lower Colorado River Authority, the Upper Guadalupe Blanco River Authority, the San Antonio River Authority, the Bandera County River Authority and Groundwater District and the Nueces River Authority — and by certain municipal

Pristine Stream Miles by Watershed, 2020

Pristine stream

Monitored stream

Watershed boundary

66% of Texas' Pristine Streams lie within Hill Country Counties.

Treated Wastewater Discharge Points (SBCA), 2017-2020

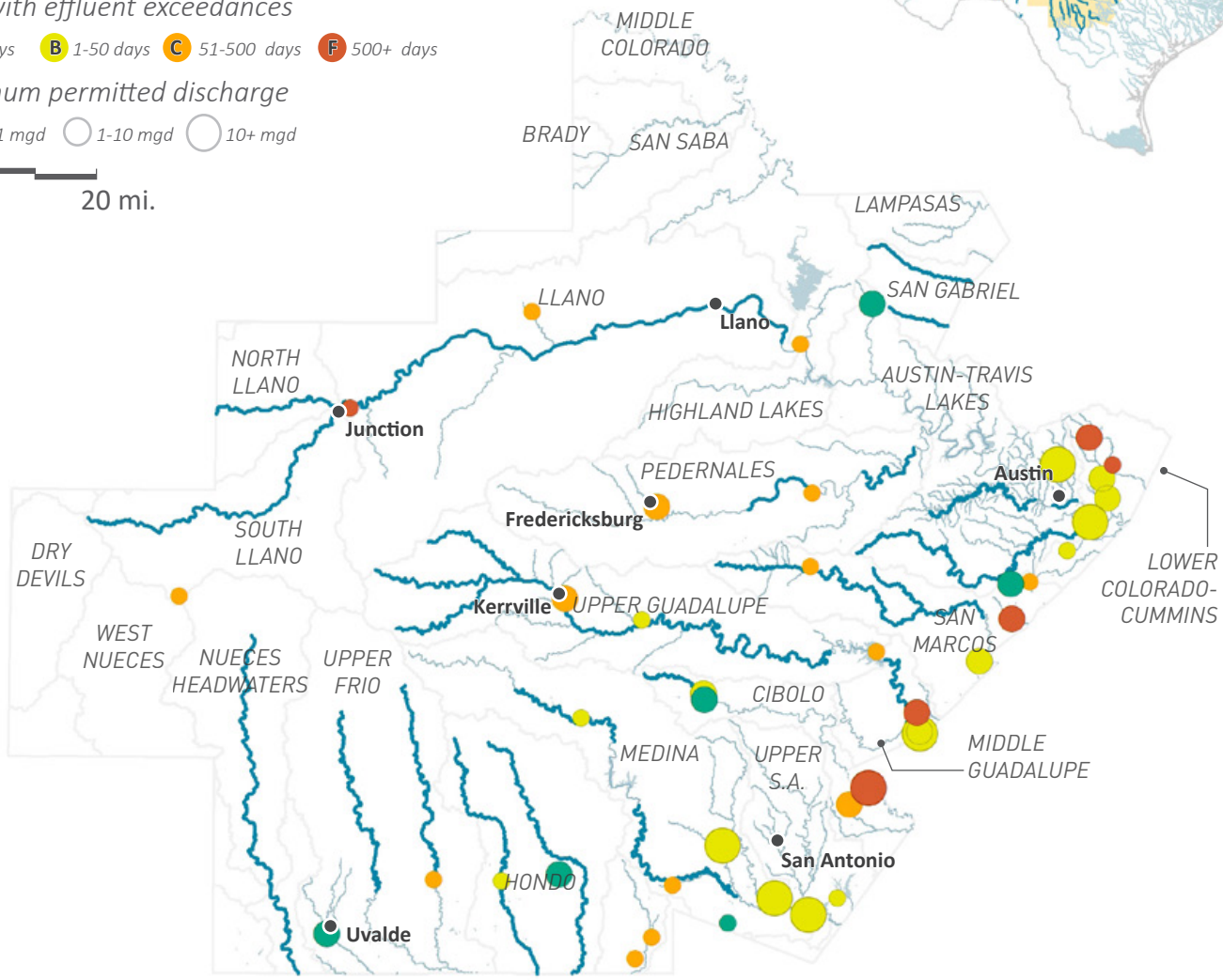
Days with effluent exceedances

A *0 days* B *1-50 days* C *51-500 days* F *500+ days*

Maximum permitted discharge

0.1-1 mgd *1-10 mgd* *10+ mgd*

0 20 mi.



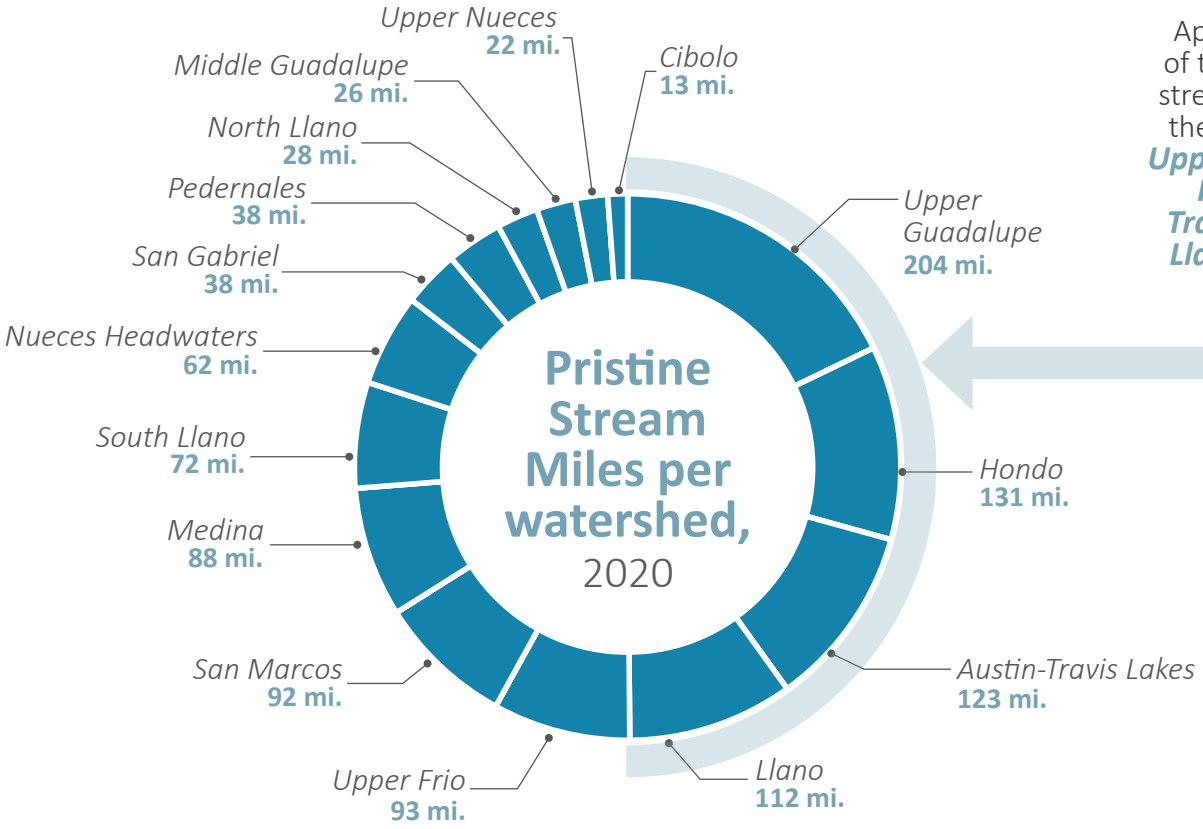
governments. The data is compiled continuously by the TCEQ. [11]

As of 2020, there are 1,142 miles of pristine streams in the Hill Country.

Addressing water quality in the Hill Country

Improving and preserving water quality in the Hill Country is a multi-faceted effort, with important roles for governmental agencies and elected policy makers, landowners and residents, developers and municipal utilities to play.

Legislatively, Senate Bill 1747 was introduced by Senator Judith Zaffirini in the 2021 Texas Session to restrict permits authorizing direct discharge of waste or pollutants into water in certain stream segments. The bill reached the Senate's Water, Agriculture & Rural Affairs committee but did not



progress. An identical companion bill, HB 4146 by Representative Tracy O. King, passed in the House but died without approval of its Senate companion bill.

These bills would have protected waterways containing only very low levels of phosphorus. Instead of allowing phosphorus-laden wastewater into these streams, applicants would be directed to use a Texas Land Application Permit for safe, beneficial use of that discharge.

A Watershed Protection Plan (WPP) is a useful way to organize water quality protection and restoration strategies in Texas and in the Hill Country. WPPs are created and implemented by diverse groups of local partners within a watershed. Typically funded by government grants, they address all sources and causes of water quality impairments and threats, building in a process for ongoing monitoring and adaptive management. In Texas, WPPs may be sponsored by the TCEQ or the Texas State Soil and Water Conservation Board, within guidelines defined by the Environmental Protection Agency (EPA). [12]

In the Hill Country, eight watersheds have WPPs:

- Cypress Creek in Hays County
- Dry Comal Creek and Comal River
- Cibolo Creek
- Plum Creek
- Shoal Creek
- Upper Llano River
- Upper San Antonio River
- Upper San Marcos River [13]

Although each WPP differs in its specifics, all emphasize the importance of outreach and education, best management practices and smart public policy to achieve water quality goals.

In recent years, new infrastructure and building techniques have emerged (or, in some cases, traditional concepts have re-emerged) with an eye toward maintaining water quality and conserving water resources in the Hill Country. The umbrella term for these techniques is Low Impact

Development (LID). According to the EPA, LID refers to "systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of storm water in order to protect water quality and associated aquatic habitat." [14] In essence, LIDs reduce impervious surface cover and allow storm water to infiltrate the earth near where it falls, minimizing runoff into nearby streams.

Increasingly, Hill Country communities are returning to this traditional idea of letting the rain find its way to the dirt.

In rural areas of our region, management practices employed by ranchers and farmers can have an impact on the health of creeks and rivers. The U.S. Department of Agriculture and other government agencies offer programs to help ranchers and farmers adopt practices that minimize pollution in local waterways.

In 2018 the USDA's Natural Resources Conservation Service (NRCS) selected the Texas Hill Country Conservation Network as a partner for its Regional Conservation Partnership Program, pledging $5.15 million to help private landowners in our region adopt best management practices that will protect water resources. These grant funds are being distributed directly to landowners to fund stewardship activity or cover costs related to conservation easements. [15]

The Hill Country's creeks and rivers are generally still healthy and, in many cases, nearly pristine. However, as population and industry increase, the risk of impairment grows as well. Hill Country waterways are unique in Texas, needing special protections since current statewide rules don't sufficiently provide for their protection. Without stewardship, we can lose these truly invaluable, irreplaceable resources and with them, the high quality of life and rich natural environment that makes this region a desirable place to live.

Image courtesy of Lisa Woods Photography.

METRIC BASELINE:

Max GPCD 2018:	Average GPCD 2018:
783 (Travis County MUD 4)	191

When we turn on our faucets, our access to water feels endless. No matter how long the tap is open, a clean and uninterrupted flow of water is available to most Hill Country residents. The consistency of service at our taps disguises water's scarcity. The continued availability of water for us to drink, wash with, cook with, irrigate with, generate electricity with, or use in manufacturing ultimately depends on the rain we get in the Hill Country, our ability to protect and preserve it while it flows through the region's aquifers, rivers, reservoirs, pipes and treatment plants, and on our collective ability to reduce our water consumption through conservation.

The way that each of us manages our water has a huge impact on our downstream neighbors, communities, wildlife and plants. The environment of the Hill Country has the potential to provide high-quality water, but variability of climate — drought — and local utilization could limit access to this finite resource.

As new residents continue to make the Hill Country their home and communities become further removed from the resources that sustain them, the understanding of water as a finite resource is lost. As we move into the future, it is of paramount importance that people rediscover water's significant role in the success of the region and the potential threat of reaching the limit of that resource if we don't make changes to our collective patterns of consumption.

How is water consumption measured?

This metric analyzes water consumption in the region by looking at the total volume of water that water providers process and distribute, then dividing that volume by the number of people within the service district, to create a gallons-per-capita-per-day (GPCD) figure. Water usage typically varies seasonally with the highest usage in the summer and lowest in the winter. GPCD numbers average out those highs and lows.

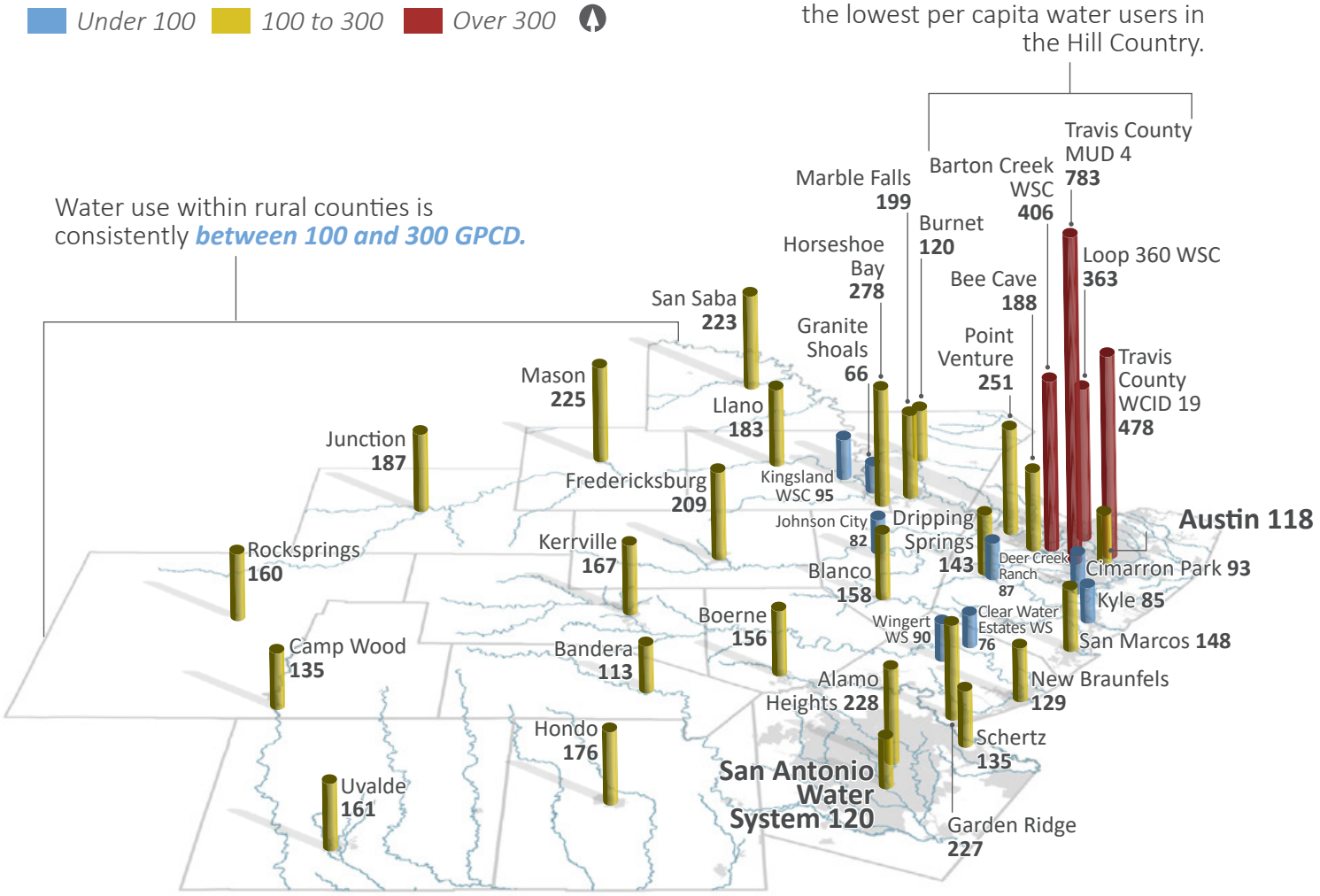
Water use across the Hill Country

Data from 2018 shows that the average per capita use of water in the Hill Country ranges from 66 gallons per day in Granite Shoals to 783 gallons per day in Travis County Municipal Utility District 4. This is an enormous spread that suggests there is a substantial disparity in how we view the limits of clean water as a resource.

To put it another way, that's a difference between a little less than a bathtub of water used per day (Granite Shoals) and more than 11 bathtubs per day (Travis County MUD 4).

With the prospect of future population expansion, the current over-allocation of water rights and the need to keep creeks and rivers flowing, we need to figure out how more of the Hill Country can meet the standards of cities as varied as Granite Shoals, Kyle and San Antonio.

Gallons per Capita per Day by Water User Group 2018



For example, the City of San Antonio has been able to reduce daily per capitawater use from 144 gallons per day in 2001 to 118 in 2018. Successful conservation strategies have included: updating infrastructure by fixing old pipes and updating fixtures, creating climate-appropriate landscapes with native vegetation, replacing wasteful fixtures (pipes, toilets, washing machines) and reducing the duration and timing of water-use activities.

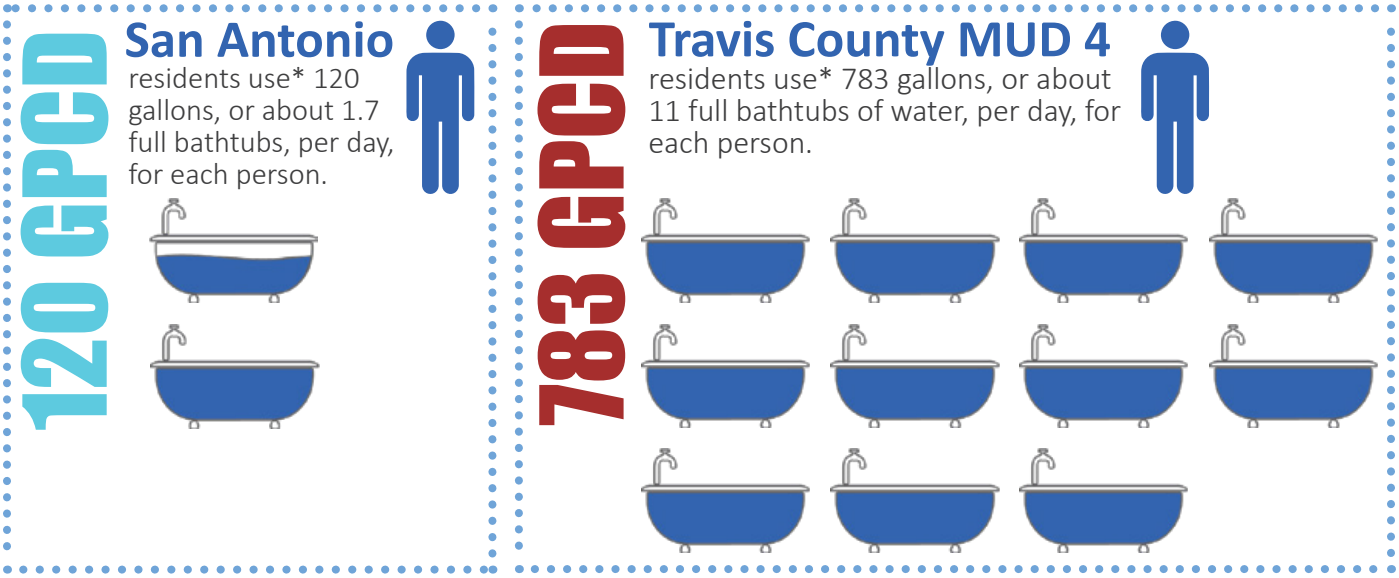
Acknowledging the importance of water conservation, Texas recently adopted the 2022 State Water Plan that contemplates big investments in conservation in the coming years. These strategies are meant to include methods that reduce everyday water consumption and increase water use efficiency, allowing more to be done with the same amount of water.

In the 2022 State Water Plan conservation strategies make up approximately 29% of all water management strategy recommended for 2070. These strategies will yield 2.2 million acre-feet of water savings across Texas.

Finding balance

The lesson to be learned from places like San Antonio, Granite Shoals and Kyle is that we can live in better balance between how much water is available and how much is used. We need to educate Hill Country residents and businesses on

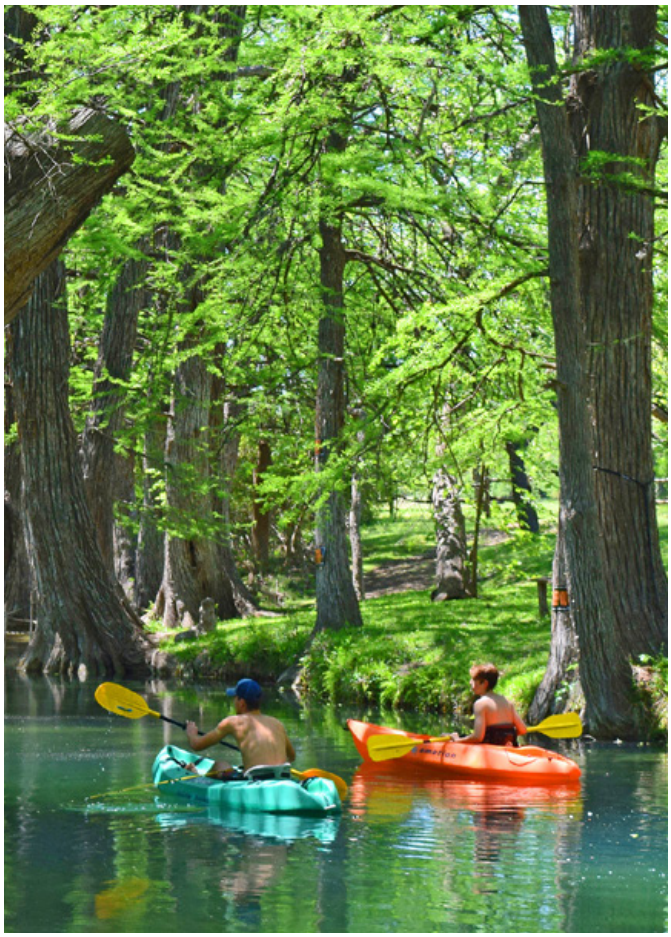
Who's Using the Water?
Gallons per Capita per Day



**The current measure of GPCD does not separate out indoor vs. outdoor water use. There is currently no tracked data that tells this story, but it is important to understand that outdoor irrigation is a significant factor driving water consumption.*

how to reduce water consumption. We need to ask policymakers to support sound water policies encouraging water conservation and smart water reuse, such as implementing One Water practices in both urban and rural settings.

Reducing individual water use means that there is more of this vital resource to share among our communities and to support healthy creek and river systems. Tracking this metric helps cities, residents and conservation partners understand regional and seasonal trends. It also helps pinpoint where the implementation of particular conservation programs has been effective. The economic and environmental future of the Hill Country, along with the livelihood of millions of Texans, is dependent on the continued monitoring and conservation of this finite resource.



WATER

Metric 6: Spring Flow

Image courtesy of Carl Griffin.

METRIC BASELINE:

COMAL SPRINGS	SAN MARCOS SPRINGS	BARTON SPRINGS	JACOB'S WELL
307 CFS	179 CFS	71 CFS	3.4 CFS

(Median spring flow 2000-2020 for all springs)

Groundwater, wells, springs and streams are strongly connected in the Hill Country, and spring flow is a measurable indicator of the overall health of the region's water supply. The limestone hills and valleys have been faulted and eroded through time, so rainfall rapidly infiltrates through the fragile soils (degraded through decades of clearcutting and poor land management), faults and karst features (like caves and sinkholes) to replenish the Trinity and Edwards Aquifers.

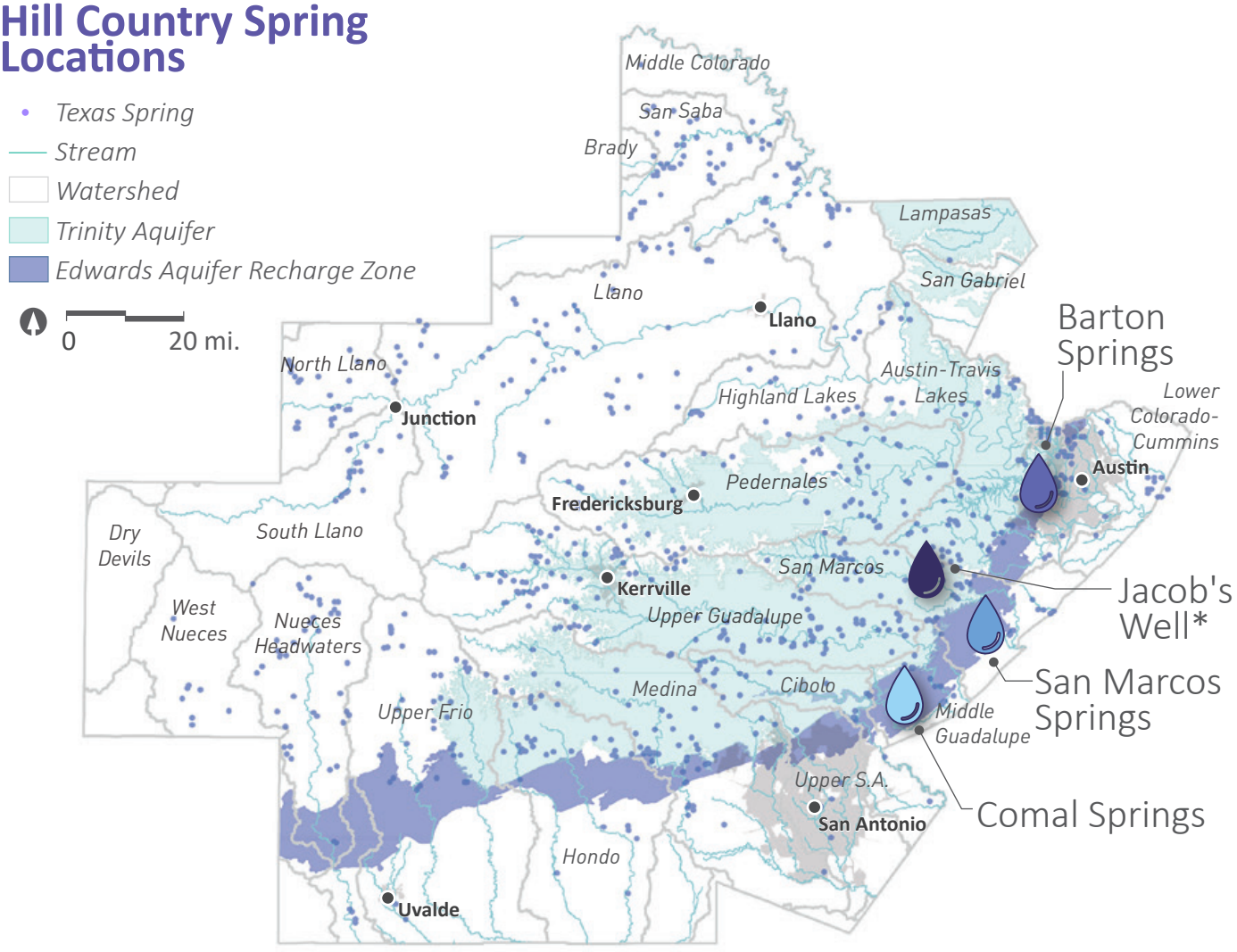
Springs provide essential baseflow to iconic Hill Country creeks, streams and rivers. As water travels downstream, karst features in streambeds can funnel it back into the groundwater system. Ideally, the process repeats itself endlessly as intended — a well-connected, circular water cycle.

A tale of two aquifers

Trinity Aquifer springs tend to be smaller and more distributed than *Edwards Aquifer* springs, but due to their location in the upstream sections of Hill Country watersheds, they play a critical role. Trinity springs provide vital baseflow for headwater reaches of rivers, including the Pedernales, Blanco, Guadalupe, Medina, Frio and Nueces rivers.

Jacob's Well and Pleasant Valley Springs are the largest of the Trinity springs and have flows ranging from 0 to 70 cubic feet per second (cfs). Some notable Trinity springs with flows generally below 5 cfs include West Cave, Klepac, Rebecca, Coal and Honey Creek Springs.

Hill Country Spring Locations



**Jacob's Well draws from the Trinity Aquifer, while Barton, San Marcos, and Comal Springs draw from the Edwards Aquifer.*

Edwards Aquifer springs are well-known. In fact, five of the top 10 largest springs in Texas come from water in the Edwards Aquifer (Comal, San Marcos, Barton, Las Moras and Hueco Springs). Flows at San Marcos and Comal springs typically range from 80 to 450 cfs; Barton Springs ranges from 14 to 120 cfs.

Different geologies

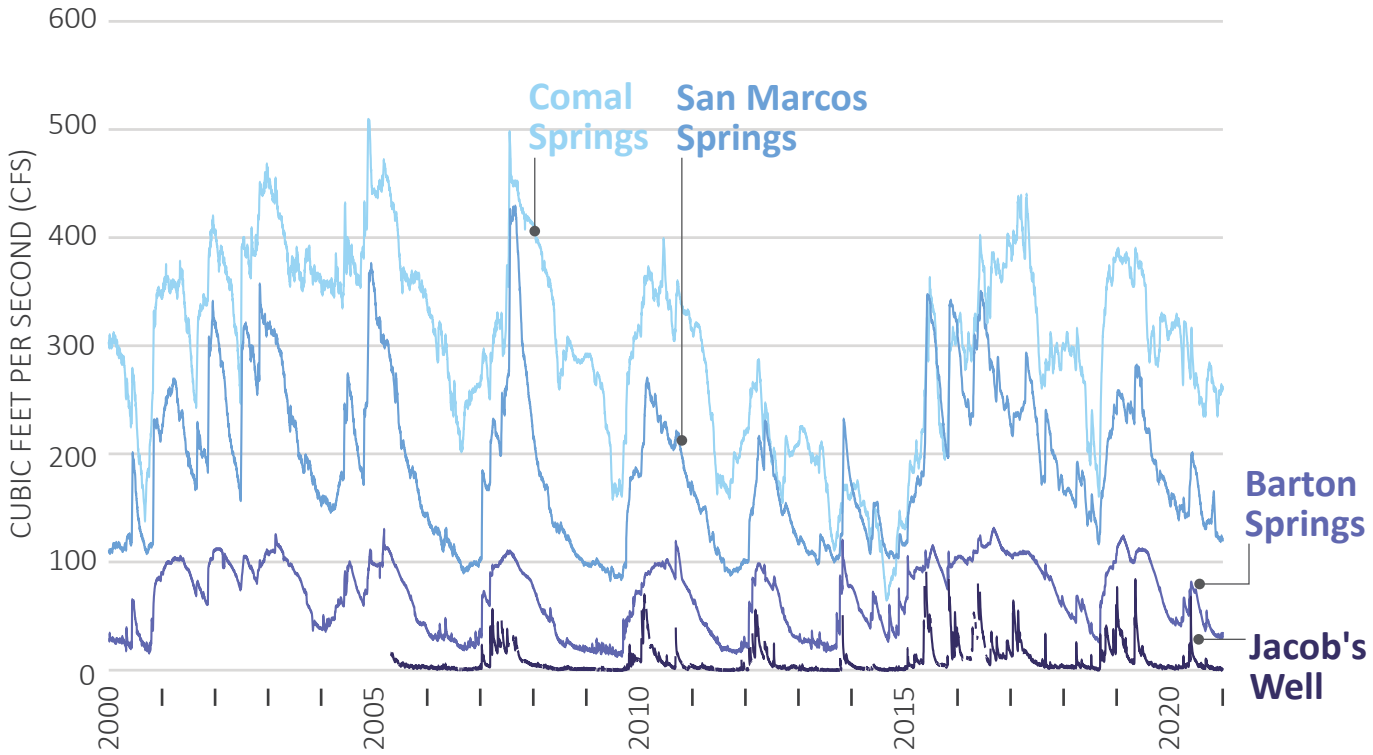
The Trinity and Edwards aquifer systems are both dominated by karstified limestone, but their rock layers were deposited during different time periods, and consequently have different characteristics.

The Trinity system has a diverse set of rock layers including the upper and lower Glen Rose limestones, Hensel sandstone, Cow Creek limestone and the Sligo and Hosston conglomerates. Because of the highly variable properties of the rock layers, the Trinity Aquifer is separated into three aquifer subsystems: Upper, Middle and Lower Trinity.

Trinity rock layers are at the surface or just under fragile soils in the western areas of the Hill Country where the rocks that form the Edwards Aquifer have been eroded away through uplift and weathering. Rainfall on the surface — particularly where Middle Trinity rock layers are exposed — recharges the Trinity Aquifer quickly.

The Edwards Aquifer rock layers are not as variable as those of the Trinity and allow for more developed karst conduits over a larger area. The

Mean Daily Spring Flow 2000-2020



Edwards benefits from a larger contributing zone and baseflow provided by the upstream Trinity. The larger volume of water entering the system has increased dissolution of karst features, created rapid groundwater flow rates and generated larger springs.

Long-term flow records are essential to better understand how climate and population impact spring flow and streamflow in the Hill Country.

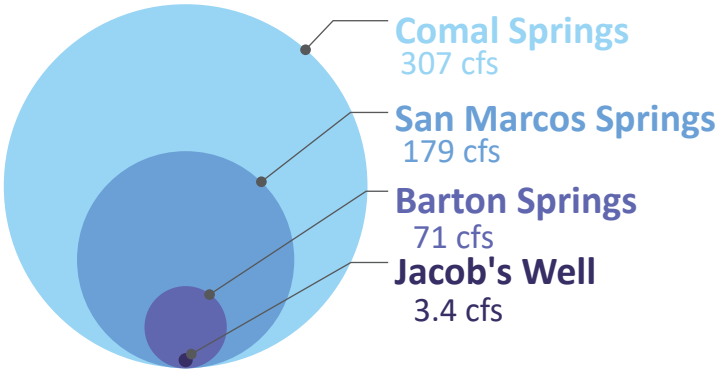
Spring flows have been measured since the early 1900s; continuous monitoring is becoming more widespread. Central Texas' frequent floods and droughts are reflected in the highly variable spring flow rates.

Edwards Aquifer spring flow has long served to set drought conditions and trigger restrictions. Establishment of Trinity Aquifer spring records has begun and will be an important tool to inform sustainable groundwater management.

Life in the Hill Country is dependent on groundwater from the Trinity and Edwards aquifers. Fish and wildlife (including numerous endangered

Median Spring Flow 2000-2020

Comal Springs' median discharge is about ***32 times*** the volume of Jacob's Well.



species) rely on springs to keep rivers flowing when rainfall is scarce. The Texas Water Development Board (TWDB) estimates that 30 percent of all surface water flows in Texas originate from groundwater, and "groundwater contributions to surface water are greatest … around major springs in the Hill Country." (16)

Rural residents rely heavily on wells for drinking water. Groundwater levels in wells and flow at springs reflect the amount of groundwater stored in source aquifers; higher water levels and spring flow are measured during wet periods, and lower water levels and low to no spring flow during droughts.

Large pumping centers and localized heavy groundwater use can lower groundwater levels, causing measurable drawdowns that can impact spring flow. Monitor wells, particularly in the Trinity Aquifer, show substantial drawdown near dense groundwater-dependent population centers.

Who's in charge?

Even though springs provide a significant source of flow to rivers in the Hill Country, groundwater and surface water are managed separately in Texas. Surface water is the property of the state; groundwater is considered private property.

The Rule of Capture, adopted a century ago, allowed landowners to pump unlimited groundwater from beneath their property, but in a series of decisions (most recently, EAA v Day) the Texas Supreme Court deemed that the rule is not absolute and gave authority to the Legislature to regulate groundwater.

The Texas Legislature has established **groundwater conservation districts** (GCDs), each with its own distinct set of rules, management strategies and goals governed at the local level. Although GCDs have the authority to manage groundwater resources sustainably to ensure that spring flow is sustained, they are not required to. Most GCDs lack incentives to do so either because of a lack of science, funding, or political will. The districts are left with policies based not on sustainability but on depletion, just trying to keep the aquifer from being drained faster than rainfall can replenish it.

In 2005, the Legislature set up **groundwater management areas** (GMAs) so groundwater districts could work together to set desirable future conditions (DFCs). GMA 9 covers most of the Hill Country, and in 2010 set a DFC that allows a 30-foot groundwater drawdown across the region through 2060. Experts worry about the impact on Jacob's Well and point out the prudence of decreasing this proposed drawdown to a more conservative level to sustain water supply and spring flows.

Across Texas, the flow of rivers is being diminished by groundwater pumping (including the San Saba, Rio Grande, Brazos, Nueces and more) as well as iconic Texas springs, such as Jacob's Well and San Solomon Springs. This adversely affects landowners' property interests in the groundwater they own in place and the public's interest in surface water, which the state holds in trust for the people of Texas.

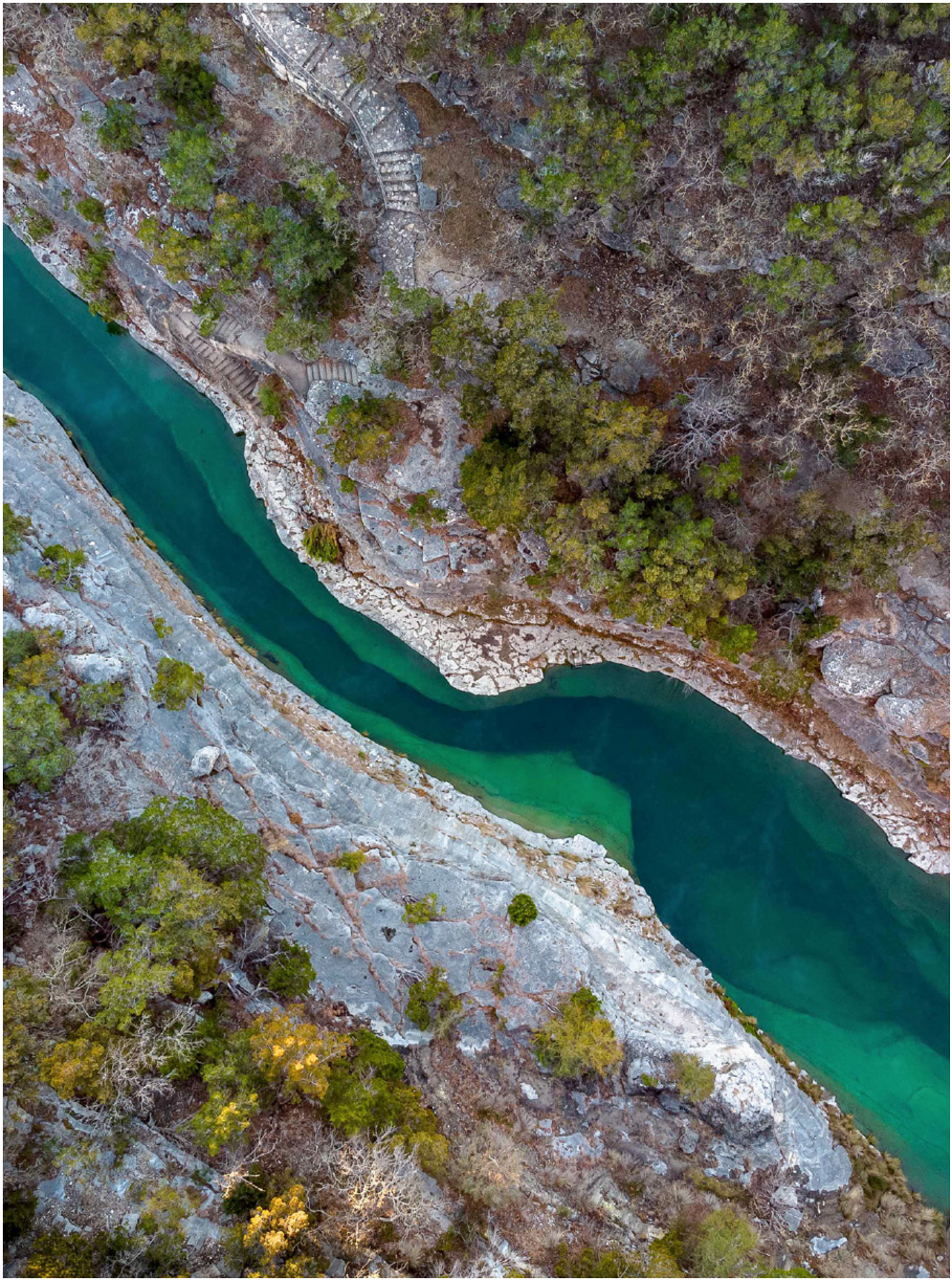
Feeling the impact

Drought, rainfall and pumping affect groundwater in the Hill Country. Spring flow records clearly demonstrate seasonal, climatic and pumping-induced fluctuations in flow in both the Trinity and Edwards springs. Owing to the comparatively thin nature and smaller contributing zone for the Trinity Aquifer, the impact of water level and spring flow fluctuations are more pronounced than those observed in the Edwards Aquifer.

How do we safeguard groundwater, wells, springs and streams in the Hill Country?

- encourage alternative supplies
- enhance reuse and water conservation
- strengthen coordinated drought management
- expand land conservation in critical recharge areas

Spring flow is a measurable way to track effective policies and practices. Maintaining healthy, flowing springs in the Hill Country benefits all residents and visitors, both human and wildlife alike.



DARK SKIES FOR STARGAZING

Metric 7: Night Skies

METRIC BASELINE:

Excellent night sky, 2015:
62%

Good night sky, 2015:
24%

Poor night sky, 2015:
14%

For those visiting the Hill Country for the first time and for those whose families have lived here for generations, the star-filled sky is a striking presence on any clear night – one that inspires, soothes and sets the stage for memorable conversations or quiet contemplations by the campfire.

Naturally dark skies are vital for the region's wildlife as well. From tiny fireflies to majestic whitetail bucks, the Hill Country's flora and fauna and the ecosystems they comprise are healthiest when their days are broken by dark nights, free from the intrusion of errant light.

There are economic benefits to preserving dark nights in the Hill Country, including reduced energy costs and increased tourism. An estimated $250 million in Texas is wasted annually on light shining where it is not intended, about one-third of the total energy cost for outdoor lighting. [17]

Increasingly, tourists include the potential for stargazing among their considerations when choosing a travel destination. **Astro-tourism**, as it is called, is a growing part of ecotourism, the fastest-growing tourism sector and a vital piece of Hill Country economies. Due to artificial skyglow, four out of five Americans cannot see the Milky Way from where they live, including more than 4 million people just an hour's drive from the rural Hill Country. For these people, an overnight trip to the Hill Country, which allows for stargazing, is often worth the added expenditures of hotels and meals in restaurants, which means more revenue for rural Hill Country communities.

Unfortunately, starry skies in the Hill Country are at risk due to increased conventional commercial, residential and industrial development. Indeed, the skies have already lost much or all their striking brilliance in some parts of the region. Thankfully, not only can we protect the high-quality skies that remain, but with time and effort, we can recover our lost view of the stars. It's as simple as shining lights down where they are needed and only having them on when they are needed.

Darkness Rating

The Night Skies metric evaluates the region's skies in three simple ratings: Excellent, Good and Poor. The Light Pollution Science and Technology Institute produced the underlying data [18] to develop the New World Atlas of Artificial Night Sky Brightness; ratings reflect the state of the sky in 2014.

Excellent: naturally dark night skies and skies that are only slightly — almost imperceptibly — impacted by light pollution in the region (typically from a medium-sized city over the horizon). This category roughly corresponds to a Bortle rating of one, two or three (see below for information about the Bortle rating). In these places, the Milky Way is not only visible, but it also looks like veined marble. Faint stars can be seen. Sixty-two percent of Hill Country skies are in this category.

Good: high-quality night skies that are noticeably impacted by their proximity to large and medium-sized cities, especially along the horizon. This category roughly corresponds to a Bortle rating of four or five. The Milky Way is visible in much of the sky in these places, though most of its detail is lost. Nearly a quarter of the region's skies are in this category.

"The stars at night are big and bright, deep in the heart of Texas."
— Deep in the Heart of Texas (song)

What is the Bortle Dark-Sky Scale?

John E. Bortle created the scale in 2001 as a way to help amateur astronomers measure the quality (brightness) of the night sky for a particular location. It uses practical celestial observations to estimate the overall brightness of the sky. There are nine levels; Class 9 indicates the most extreme amount of light pollution, as in the inner city. Big Bend Ranch State Park, an isolated expanse in West Texas, is Class 1. Many Hill Country parks are Class 3; a few are even darker.

Poor: skies that are significantly impacted by light pollution. This category roughly corresponds to a Bortle rating of six, seven, eight or nine. In the best case, a small piece of the Milky Way may be visible, but typically it is not visible at all; in fact, very few stars are. Fourteen percent of the region's skies are in this category.

Preserving the Night Sky

Without a concerted effort by communities of all sizes, the darkness of Hill Country night skies will be lost as the region grows over the coming decades. The good news is that many Hill Country communities are taking important actions today that will have lasting impacts.

More than two dozen municipalities across 11 Hill Country counties have adopted an outdoor lighting ordinance to address the issue. Many of these ordinances have been quite effective at stemming the spread of light pollution, even as new development occurs. In some places, the ordinance on the books is weak or unenforced, but in most cases, city officials, staff and volunteers are working on improvements.

Although counties in Texas cannot, with a few exceptions, adopt similar ordinances for their unincorporated areas, 14 Hill Country counties have adopted resolutions indicating their support for night sky preservation. While these resolutions are not protective themselves, the supportive stance these counties have taken reflects a growing appreciation for the value of our region's skies and a dedication across the region to their preservation.

Whether in a city with a strong ordinance, a community that has not yet considered an ordinance, or an unincorporated area where adopting an ordinance is not legally an option, education and partnerships are the most important and most common means for preserving the night sky. All across the Hill Country, volunteers, educators, astronomy enthusiasts, parks personnel, and others organize star parties, night hikes, public presentations, and other educational events, year-round. Chambers of Commerce are partnering with the Hill Country Alliance to create Night Sky Friendly Business recognition programs, and developers are opting to put dark sky provisions into the Homeowner Association rules they create to establish Night Sky Friendly Neighborhoods.

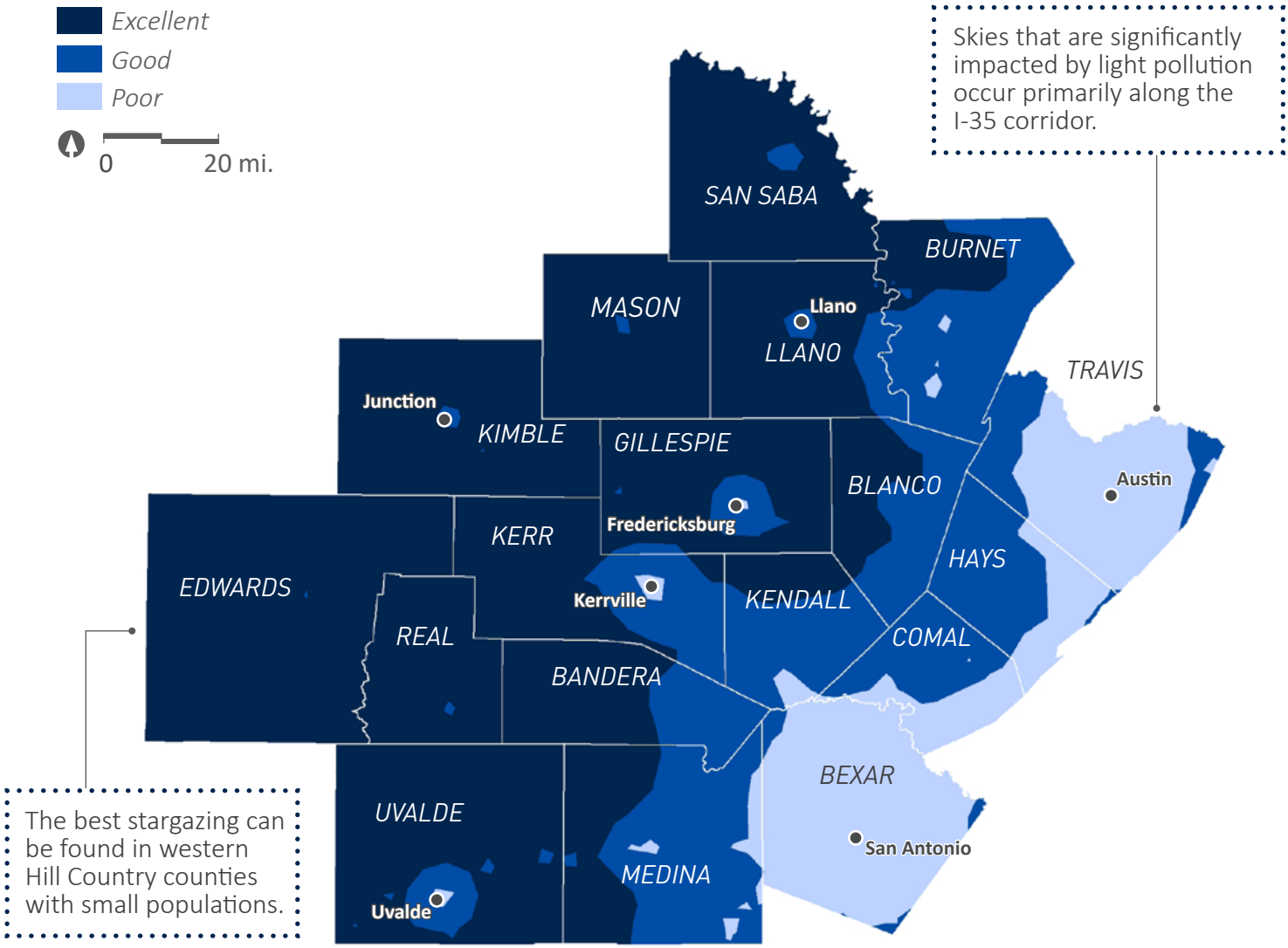
These kinds of educational activities and collaborative relationships, paired with strong lighting policies, are the most effective strategy for preserving a place's night skies. Together, they can qualify a community, park or subdivision to become recognized as an International Dark-Sky Place by the International Dark-Sky Association (IDA).

In fact, the Hill Country is home to

- International Dark-Sky Communities: Dripping Springs, Horseshoe Bay, the Wimberley Valley and Fredericksburg
- Dark-Sky Parks: Enchanted Rock State Natural Area, South Llano River State Park, LBJ National Historical Park, Milton Reimers Ranch Park and UBarU Camp and Retreat Center
- Dark-Sky Friendly Developments of Distinction: Lost Creek and River Hills, both in Travis County

Night Sky Visibility

2015



The region's enthusiasm grows, and more applications are currently pending or under development around our region.

"The Texas Hill Country is home to more dark sky preservation activity than any other similarly-sized region in the world," the IDA says. [19]

"Friends of the Night Sky" groups in Bandera, Blanco, Comal, Hays, Kendall, Kerr, Llano and Travis counties are forming to drive local preservation efforts. These groups will be instrumental to achieving the long-term goal of restoring sky quality across the region; more friends groups will come online in the coming years.

Naturally dark nights and star-filled skies are invaluable treasures for Hill Country communities, a draw for tourists from across the state and beyond and an essential part of the quality habitat for our region's wildlife. Although conventional development techniques jeopardize this vital asset, night sky-friendly development practices are easy and affordable to implement.

Working together, our region can recover and preserve our dark skies for future generations.

INVESTMENT

Metric 8: Public Investment

METRIC BASELINE:

Total Conservation Funds Passed, 1992-2020

$1,220,247,967

The story of public investment in conservation in the Hill Country is one of measured success.

San Antonio and Austin have led the region (and, in some ways, the nation) with innovative, successful, voter-approved programs. Other communities — Bee Cave, Buda and San Marcos, as well as Bexar, Hays, Kendall and Travis counties — have also put public dollars to work conserving land.

Conserved land is used for a range of purposes, from preserving water quality and wildlife habitat to offering recreational opportunities.

As a region, there is still considerable work to do to achieve the level of investment that proper stewardship of the landscape requires today and into the future. Every community, especially those experiencing unprecedented growth, needs to find ways to preserve open space.

A history of successful ballot measures

Voters in our region have passed 33 of 34 ballot measures for public investment in land conservation.

Austin voters were the first to do so, approving $42 million in general obligation bonds to preserve endangered species habitat and water quality protection in 1992. The following year, Travis County voters rejected a $48.9 million proposition, the only defeat.

Since then, every single proposition in our region has passed, with an average of 64% of voters in favor.

The total sum approved by Hill Country voters to date is just over $1 billion.

More than half of that sum ($558 million) was approved by voters in the City of San Antonio; more than one-fifth ($265 million) was approved by voters in the City of Austin; one-fifth ($244 million) by Travis County voters; and the remainder by voters in Hays County ($108.5 million), Kendall County ($5 million), Bexar County ($3.7 million), Bee Cave ($3.5 million) San Marcos ($2 million) and Buda ($1.1 million). [20]

How's the money raised?

By and large, these investments are general obligation bonds, repaid by taxpayers through property taxes and other forms of government revenue.

San Antonio's conservation expenditures are the exception. The bulk of these — $515 million, or about 90% of the city's overall conservation investment to date — have been funded by a $0.00125 (one-eighth of one cent) **sales tax** on

"To those devoid of imagination, a blank place on the map is a useless waste; to others, the most valuable part."

— Aldo Leopold

every taxable dollar spent in San Antonio.

This funding strategy has worked very well for the City of San Antonio, whose voters have reapproved it three times since 2000. This strategy, however, is difficult to pursue for most jurisdictions in our region because state law sets a two percent cap for combined municipal and county sales taxes. Most municipalities and counties are already collecting — and have already allocated — this maximum.

For these communities, a conservation funding strategy based on the sales tax would require taking funds away from their current uses or an increase on the cap itself, which would require action by the Texas Legislature. (See the Edwards Aquifer Protection Program case study on page 50 of this report for more information about San Antonio's successful sales tax-funded program.)

Conservation Funds Passed by Hill Country Voters

1992-2020

Total funds passed: **$1,220,247,967**

How's the money spent?

In our region, public investment in land conservation has been directed towards a range of objectives:

- creation of parks and expansion of recreational opportunities
- preservation of endangered species habitats
- attenuation of urban flooding
- preservation of healthy watersheds to maintain water quality in aquifers, streams and rivers

Typically, some public funds are put towards purchasing land outright and some towards purchasing conservation easements, which leaves the land itself in private ownership.

Often, local governments are able to extend the reach of their investments in land conservation by pulling in matching funds from the state or federal governments, or from conservation organizations and foundations.

What's the return on investment for public conservation?

Communities in our region have found that land conservation is a common-sense approach for addressing the inevitable challenges of rapid growth and development.

According to a 2019 study from the Texas A&M University Natural Resources Institute (TAMU NRI), the average acre of conserved land in the Hill Country provides $1,279 per year in water supply

Putting Conservation on the Ballot

1992-2020

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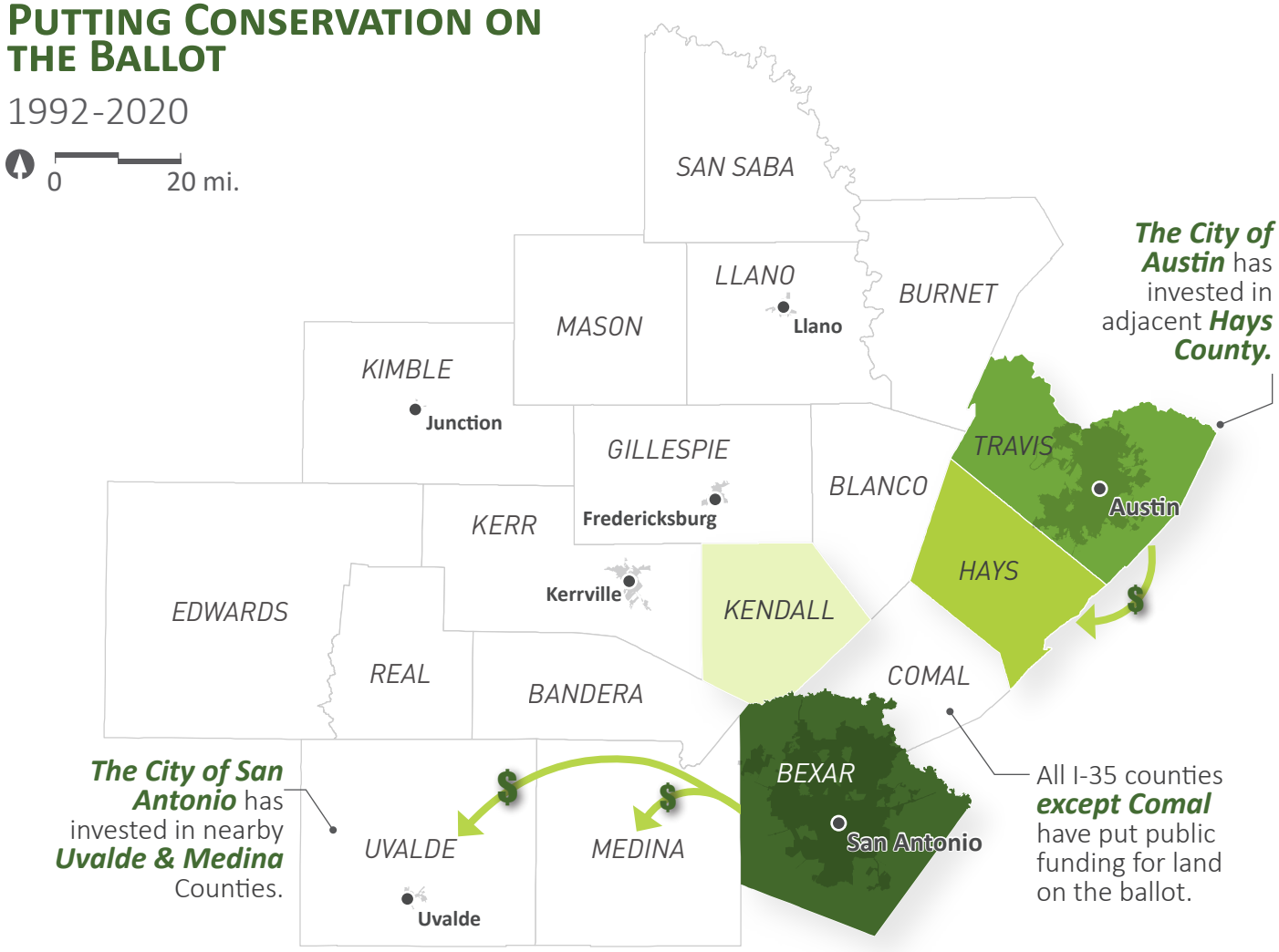
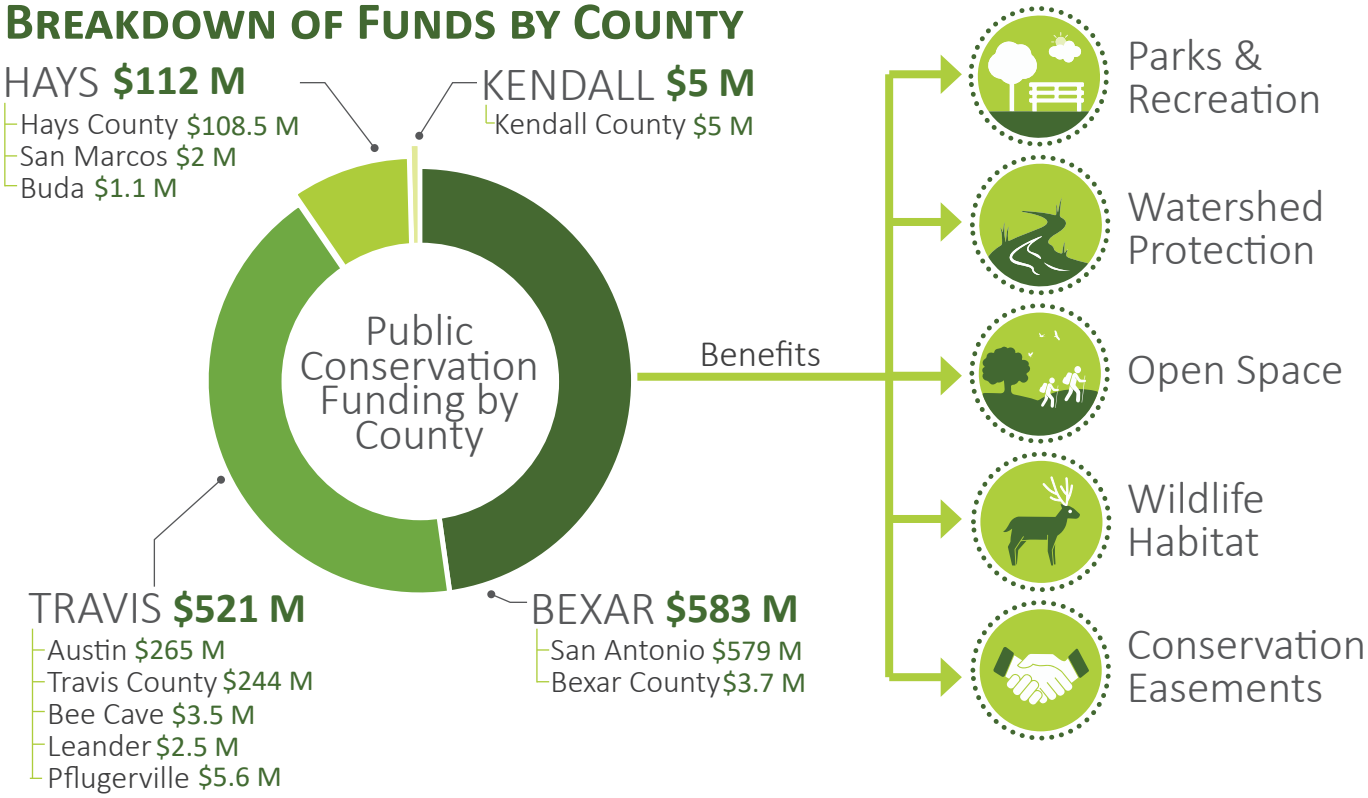


Breakdown of Funds by County



Purchasing Power

The market value of potential parklands has ***more than tripled since 1998***. Therefore, a conservation dollar today can only purchase less than one third of what it could then. These lands will be even more expensive to conserve in the future.

services like aquifer recharge. [21] A 2016 TAMU NRI study found that, on average, **$1 invested in land conservation today results in $6 savings on drinking water infrastructure in the future.**[22]

Conserved lands may include endangered species habitat which must be protected to allow for development elsewhere. Floodplains may be used as parkland that increases neighboring property values. Scenic vistas and outdoor recreation draw in tourists while improving the quality of life for locals.

Although public expenditures for land conservation have proven to be good investments for the communities that make them, they are becoming increasingly difficult to make, due to the rapidly increasing costs of undeveloped land in our region. The City of Austin, for instance, has found that the cost of a typical acre of desirable conservation land near the edge of the city has grown from $19,558 in 1998 to $66,666 in 2018, more than a three-fold increase. [23]

This trend will almost certainly not reverse in the foreseeable future, so investments made today will always go further than those put off until tomorrow.

Can't keep pace with the region's growth

Conservation investments in our region have not kept up with regional growth.

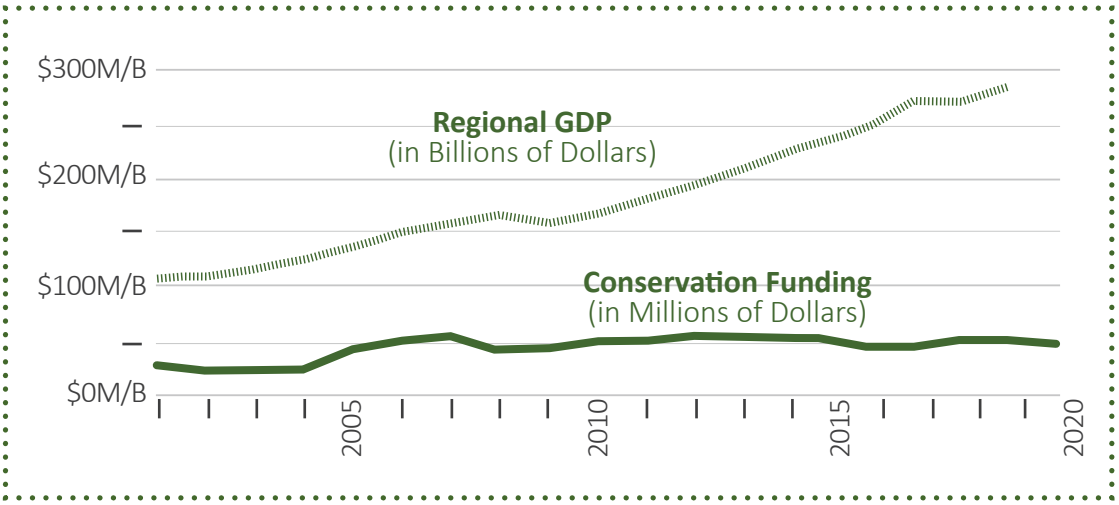
In 2001, a decade after the first ballot measure for land conservation in our region (Austin's $42 million investment), the average annual investment (years 1992 through 2001) was $28.2 million. Five years later, in 2006, the 10-year annual average (1997 through 2006) for the region was $50.1 million, roughly where it has stayed since.

Let's look at the regional Gross Domestic Product (GDP) over this same period. Combining the GDPs for the Austin-Round Rock and San Antonio-New Braunfels Metropolitan Statistical Areas, we find that the Hill Country's economy has grown tremendously. In 2001, the regional GDP was $107.8 billion. In 2019, the regional GDP was $288.8 billion, more than 2.5 times greater. [24, 25]

On average, the regional GDP has grown by 5.7% annually over this period. Average annual public investment in land conservation has only grown by 4.2% each year over the same period. Our region invested 0.025% of our GDP into land conservation in 2001; today, in 2019, it only invested 0.018% into land conservation. We need to increase the proportional investment in conservation substantially in order to effectively preserve vital natural resources and ecosystem function.

10 Year Average Conservation Funding vs. Regional GDP

2001-2020



Looking ahead, bold ideas

What would it look like for our region to invest a very small, albeit consistent, portion of our regional economic activity into public land conservation each year?

A study from the University of Texas School of Architecture described the concept in a 2015 report, "Towards a Regional Plan for the Texas Hill Country." The report proposes the creation of an ongoing regional funding stream — a Hill Country Endowment — that would generate money for the region's conservation needs.

The funding stream would draw from sources that grow with the economy. Examples might include utilities fees and tax increment reinvestment zones. [26]

If the regional economy continues to grow as it has over the last 20 years, a small 0.025% annual investment — roughly what our region invested in land conservation during the 1990s — would yield $2.9 billion for conservation over the next 20 years. Matched with federal, state and private dollars, these funds could conceivably compensate landowners for the development rights of several hundred thousand acres.

It is an ambitious but worthy goal. There's a serious need for more conserved lands, while the region's rapid growth is causing development pressures that make land conservation increasingly difficult. Thankfully, the region's history of successful bond measures demonstrates that the public is willing to pay for strategic land conservation in some of the region's fastest-growing areas.

Growing investment

There's also evidence that non-investing communities would be willing to do so, if the question were put to the voters. A "Conservation Finance Feasibility Study" authored by the Trust for Public Land (in partnership with the Hill Country Alliance and the Texas Land Trust Council) found that there is substantial capacity and willingness to pass bond measures for conservation lands in Hill Country counties, especially Comal, Kerr and Burnet counties. [27]

The expanded use of existing tools like general obligation bonds will be critical to keeping up with the economic growth and land development of the region. Exploring innovative funding methods, like those described by the Hill Country Endowment concept, would enable our region to meet its long-term needs.

CASE STUDY:

San Antonio Edwards Aquifer Protection Program

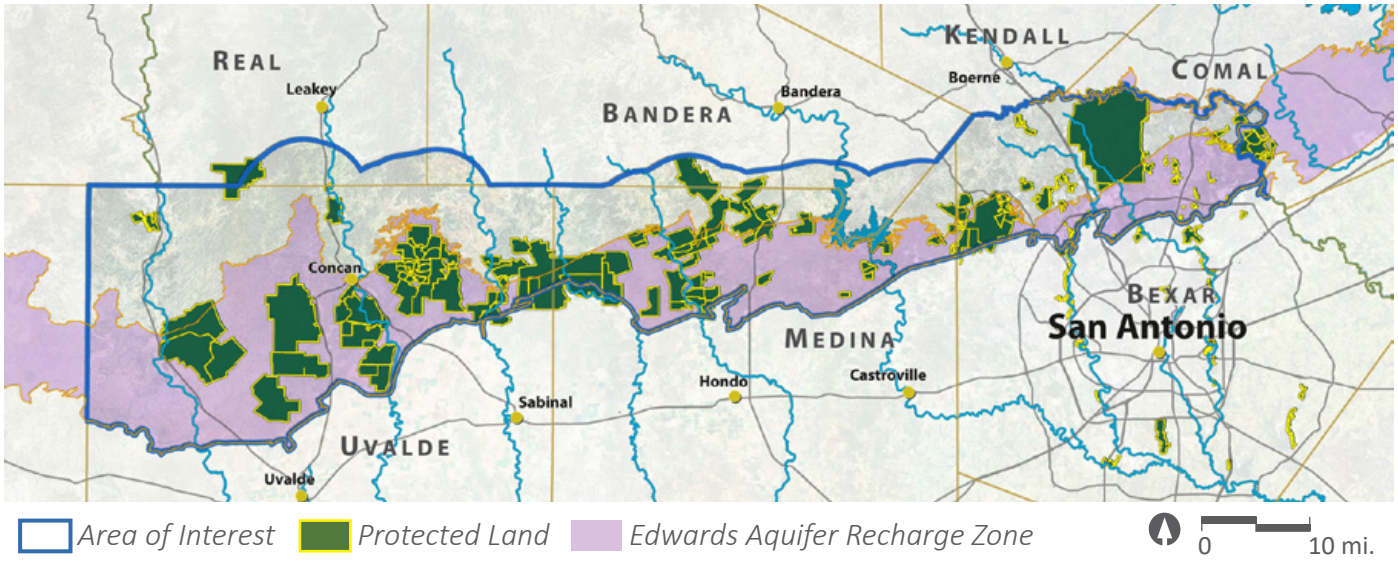
San Antonio is the 7th largest city in the country, and remarkably, one of the largest in the world where drinking water comes primarily from groundwater (aquifers). With most surface water from lakes and rivers in Texas already claimed by other entities, San Antonio currently relies on — and will continue to rely on — groundwater to meet this demand.

The city's main groundwater source is the San Antonio segment of the Edwards Aquifer, an underground karst formation that stretches across millions of acres and several counties in Central Texas. As rainfall enters the aquifer through fractures, caves and sinkholes, the water level of the aquifer is replenished.

However, rapid growth and development across the Hill Country threaten this resource as demand for water increases. As development spreads, so do impervious surfaces that diminish the ability of water to soak into the ground, resulting in increased flash flooding and runoff in our waterways and across the landscape. This reduces opportunities for water to filter into the ground, flow into the recharge area and fill the aquifer.

Recognizing the drastic patterns of population growth and the need to steward this vital resource, San Antonio decided to protect the aquifer through the conservation of lands in the recharge and contributing zones.

Edwards Aquifer Protection Program Protected Lands



Proposition 3: Sales tax funds Government Canyon State Natural Area purchase

In 2000, voters approved a ballot measure, Proposition 3, to allocate a one-eighth cent addition to the local sales tax to generate revenue for the **San Antonio Edwards Aquifer Protection Program** (SEAPP). This measure raised $45 million for the acquisition of land and development rights through the purchase of conservation easements on private property in Bexar County.

Through the initial funding, approximately 6,500 acres of land were conserved to support the protection of San Antonio's water supply. Many of these properties were ranches and estates, ranging from 50 to more than 1,100 acres in size. A significant portion of this land was converted into natural areas for hiking and recreation, including land associated with what is now Government Canyon State Natural Area.

Expanding to nearby counties

Although Proposition 3 managed to protect numerous acres in Bexar County, approximately 70% of the Edwards Aquifer's San Antonio section recharge zone lies west of Bexar. Water that arrives in San Antonio homes may enter the ground as far as 100 miles west of the city.

However, in 2000 the Texas Local Government Code (TLGC) only allowed cities to expend sales tax funds for land acquisition in their county to create parks. In a wonderful example of the state of Texas giving local communities the tools they need to provide for their constituents, the TLGC was amended in 2004 to create the option for sales tax funds to be used for the purposes of land acquisition for watershed protection. Suddenly, sales tax funds allocated to the SAEAPP could be used to purchase conservation easements or fee-simple land acquisition in critical recharge areas in counties to the west of Bexar County.

The program was expanded across the aquifer to include Medina and Uvalde counties as well as southern portions of Bandera and Real counties. In 2005, voters again approved allocating sales tax revenue to the program, resulting in an additional $90 million for the purchase of sensitive properties.

Aquifer experts used a geospatial analysis to prioritize land selection, then reached out to landowners in those preferred areas. Where interests aligned, willing landowners were paid for the development rights to their property and a conservation easement was put in place to ensure that the property would protect the water supply forever. This process was renewed in 2010 and 2015 when voters overwhelmingly approved the continuation of the sales tax.

The program's expansion into neighboring counties was at first met with skepticism by some landowners who were uncertain if they wanted San Antonio getting involved with local affairs. Today, however, the SEAPP is a strong example of how rural and urban interests can come together to preserve our water resources and accommodate a growing population.

Many once-skeptical landowners now see the conservation easement as a source of support and reimbursement for the important improvements their properties provide to water quality and quantity. While protecting the aquifer, landowners stay on their property, continuing traditions such as ranching and hunting while keeping family lands intact and protecting the working heritage of our region.

The project has invested over $220 million in conservation lands to date; about $80 million remains to be invested. The partnership between landowners and SAEAPP has successfully protected over 150,000 acres.

Along with partner organizations, that means that more than 240,000 acres of land has been preserved for the protection of San Antonio's water supply in less than two decades.

While elected officials and residents discuss changes to the program that will likely affect how it functions in the future, the San Antonio Edwards Aquifer Protection Program and its partners are currently the brightest success story for conservation in Texas and the nation.

CASE STUDY:
Jacob's Well Groundwater Management

Jacob's Well is a well-known karst spring that flows from the Middle Trinity Aquifer through more than a mile of cave passage before rising to the surface as one of the Hill Country's most iconic swimming holes. It is the headwaters of Cypress Creek and provides baseflow, which in turn provides ecological, hydrological and financial benefits to the Wimberley region. The Middle Trinity Aquifer is also the primary water supply in the region.

The flow record at Jacob's Well shows that groundwater storage and spring flow are influenced by rainfall, drought and groundwater pumping. Drought conditions exacerbated by increased groundwater use has caused Jacob's Well to stop flowing several times within the last decade. Persistent low- and no-flow periods impact water quality, jeopardize aquatic habitat, threaten local water supplies and affect the local economy. The story of private stewardship, scientific research and monitoring, coordinated groundwater management and public conservation efforts make the history of Jacob's Well an instructive case study.

Private stewardship

Jacob's Well and Cypress Creek have been important Hill Country landmarks throughout history. Cypress Creek's water flow has served as an economic driver from the time of the historic mills (in service from 1850–1925) to present-day tourism and commerce. With consistent, perennial flow — even through the 1950s drought — Cypress Creek provides high-quality habitat to wildlife and aquatic species. The natural beauty and cool waters make the Wimberley Valley an attractive home and tourist destination for swimmers, hikers and nature-lovers.

With about 95% of land in Texas privately owned, stewardship efforts often start with motivated landowners. In the case of Jacob's Well, David Baker and his family joined those ranks in 1988 when he moved to one of the 100 parcels with access to the well. At that time, there were over 3,600 platted lots above the well in the nearby neighborhood, with more development proposals on the way (including a mobile home park and condos on top of the well and a plan for a golf course development, using water from the aquifer to water the course). In 1991, the Baker family, with partner investments, purchased 25 acres and half of the parcels with access to Jacob's Well.

Stress from increased development, increased demand on the groundwater supply and Texas' drought-prone climate became apparent in 1996 when Jacob's Well and Cypress Creek almost stopped flowing. This cumulative impact on water resources inspired a team of local landowners to form the Wimberley Valley Watershed Association (WVWA), a 501c3 nonprofit, to protect Jacob's Well and Cypress Creek and address the critical water issues of the region. With Baker as the Executive Director, the WVWA began acquiring key parcels, pursuing conservation easements and encouraging science research and monitoring.

Research and monitoring

In 2000, a Science Dive Program was established at Jacob's Well to conduct scientific research by mapping the caverns, collecting water quality samples and documenting flora and fauna. To date, the project has surveyed and mapped all areas that are currently accessible and documented approximately 6,000 feet of passages in two principal conduits. The detailed map indicates the cave is completed in the Middle Trinity Aquifer with most of the passage in the highly productive Cow Creek formation. The Cow Creek formation is known for good water quality and high porosity and permeability, and is often targeted for drinking-water wells in the region.

In 2000, after prolonged drought, Cypress Creek made the U.S. Environmental Protection Agency (EPA) impaired stream segment list (also known as the 303(d) list) because of a quantity of dissolved oxygen lower than needed to support aquatic life. Dissolved oxygen levels and suitable aquatic habitat correlate with flow. The degraded water quality correlated with the creek's recorded low flow of 0.33 cubic feet per second (cfs) in July of 2000.

In 2001, The Texas Stream Team (a citizen-science monitoring program led by the Meadows Center for Water and the Environment) began monitoring water quality and qualitatively measuring flow. In 2003, WVWA joined the Texas Clean Rivers Program in partnership with the Guadalupe Blanco River Authority (GBRA) and the Village of Wimberley, initiating a water quality monitoring program at seven sites along Cypress Creek and the Blanco River to establish baseline data.

In 2005, the U.S. Geological Survey (USGS) continuous flow gauge at Jacob's Well was established. Initial funding was through WVWA and the USGS Coop program, then in 2008, GBRA incorporated the Jacob's Well gauge into their USGS contract. The continuous spring flow record is currently used as a drought trigger for area water suppliers.

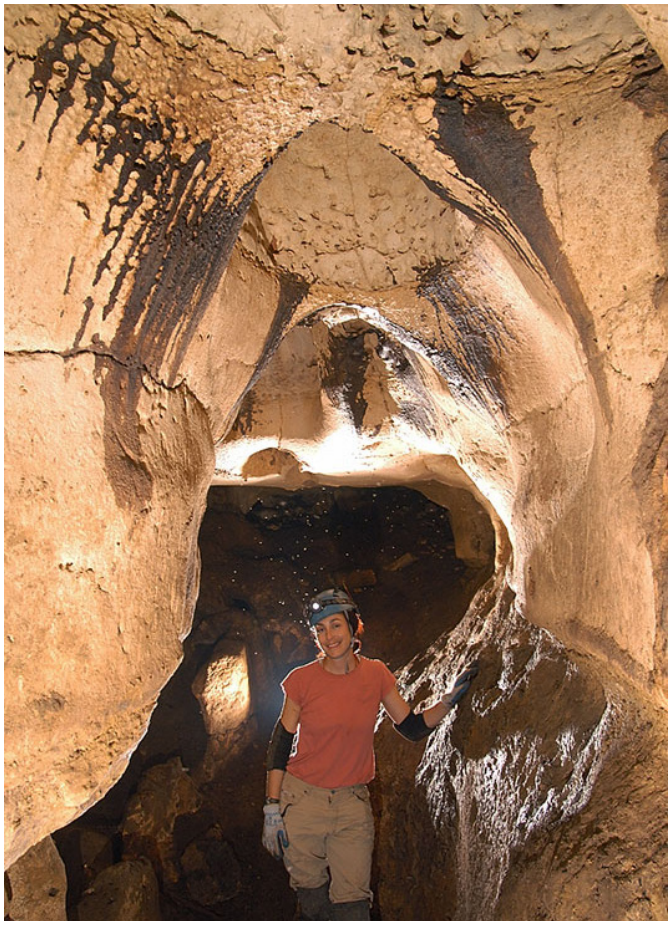


Image courtesy of Dr. Jean K. Krejca, Zara Environmental LLC

Coordinated management

In 1990, the Texas Commission on Environmental Quality (TCEQ) determined that the Trinity Aquifer in the Texas Hill Country was a limited supply suffering severe groundwater declines where projected demand for groundwater in the region would exceed availability. Consequently, TCEQ created the Hill Country Priority Groundwater Management Area (PGMA) and recommended that the Texas Legislature create groundwater conservation districts in the PGMA to manage and conserve groundwater resources.

About a decade later after prolonged drought, the Texas Legislature subsequently created the Hays Trinity Groundwater Conservation District in the western half of Hays County in 2001 and voters confirmed the district in 2003.

In 2008, through a grant from the TCEQ and the EPA, partners led by WVWA and the Meadows Center for Water and the Environment formalized the Cypress Creek Project and began characterization of the watershed and development of a protection plan. As the first voluntary, proactive plan to incorporate groundwater conservation and water quality protection, the Cypress Creek Watershed Protection Plan was approved by TCEQ in 2014. Implementation of the plan, funded through two phases of Clean Water Act 319(h funding from the EPA and TCEQ, has boosted education, facilitated installation of green infrastructure and alternate water supplies and helped inform policy and monitor water quality.

In March 2020, after a lengthy stakeholder process (informed by a scientific technical committee, the Hays Trinity Groundwater Conservation District established the Jacob's Well Groundwater Management Zone to coordinate water use within the springshed to protect groundwater availability and spring flow. However, in May 2020, Cypress Creek was again listed on the 303d list for impaired stream segments because low flows at Jacob's Well and Cypress Creek caused low dissolved oxygen levels and poor aquatic habitat.

Public conservation

Hays County, the City of Wimberley and the City of Woodcreek — all members of the Cypress Creek Project — recognize the importance of land and water conservation. Working together, they have invested in parks, preserves and green infrastructure.

Hays County has passed three major bonds to fund parks and open space acquisition, a $3.5 million bond package in 2001, a $30 million bond package in 2007 and a $75 million bond package in 2020. The bond funds are leveraged and multiplied by matching grants and funds, so the impact across the county is even greater than promised. The 85 acres that formed the Jacob's Well Natural Area were purchased with the 2007 bond. Coleman's Canyon Preserve is a 117-acre land conservation and restoration project contiguous to Jacob's Well

Natural Area that was identified as the highest-priority project to fund with the 2020 bond.

These properties contain significant karst features that recharge Jacob's Well including the iconic Wimberley Bat Cave and more than 100 acres of golden-cheeked warbler habitat. Preserving and enhancing this land helps protect groundwater supplies, water quality, Jacob's Well spring flow and Cypress Creek flow.

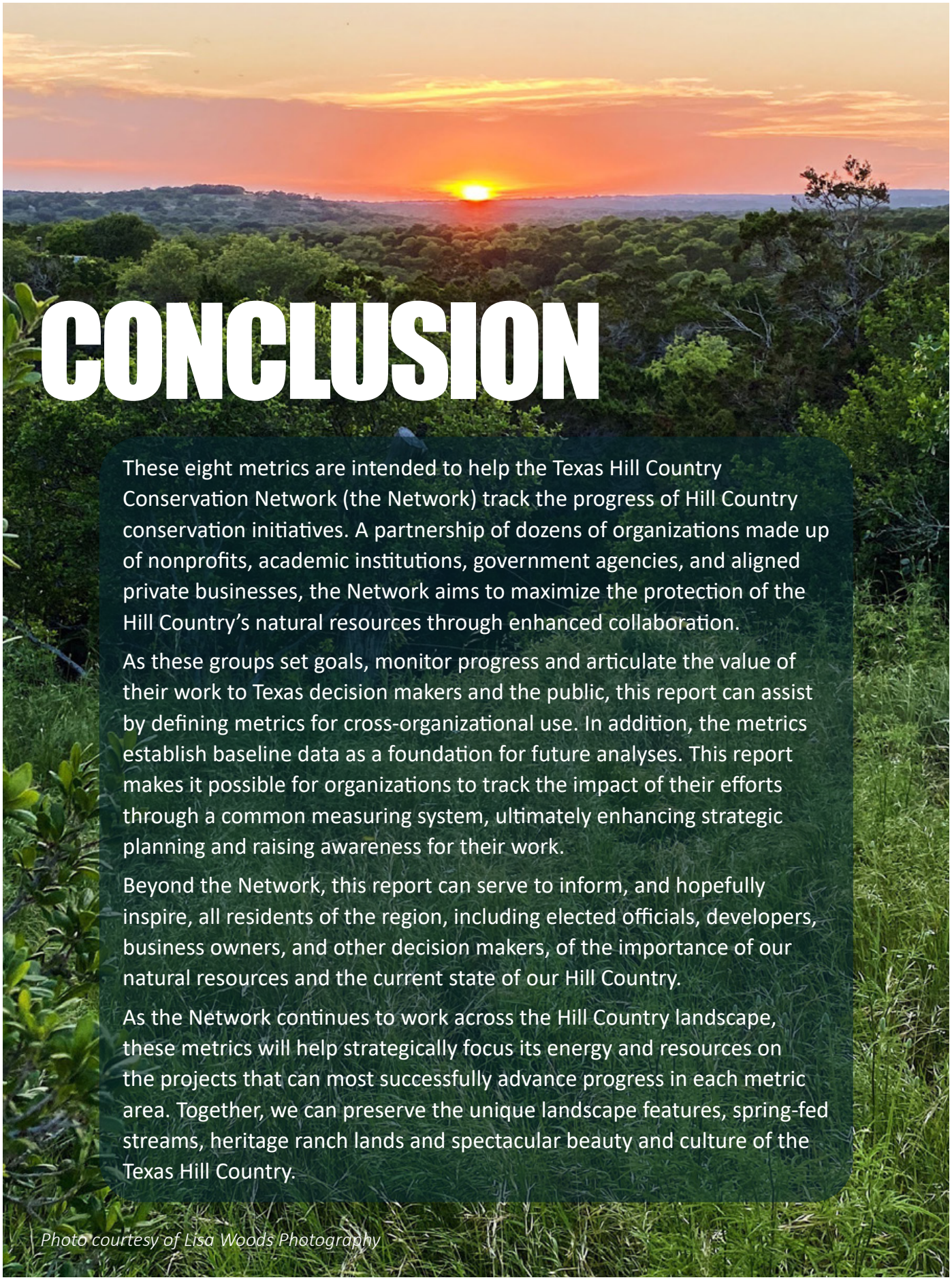
The City of Wimberley manages approximately 140 acres that includes two parks, a nature preserve and a bird refuge. One Water design, reuse and water catchment at the Blue Hole Regional Park minimizes water use and increases beneficial recharge potential. A conservation easement on the Cypress Creek Nature Trail and Preserve optimizes management to protect sensitive riparian habitat. Habitat enhancements, rainwater harvesting and stormwater control at the Patsy Glenn Refuge encourages bird habitat and slows down runoff. The City of Woodcreek has incorporated green stormwater controls through raingardens at August Park and the Veterans' Memorial.

Whether through voter support or volunteer efforts, the community support for land and water conservation demonstrates the importance of natural resource conservation. This commitment to conserve land and preserve irreplaceable natural resources will serve many generations and provide for outdoor recreation and better health.

Future

Maintaining spring flow levels during drought is the key indicator of the health of both the Trinity and Edwards aquifers. Economic studies show significant benefits of maintaining spring flow as it relates to tourism, sales tax revenues and property values. The interconnected nature of groundwater and surface water in the karst region of the Texas Hill Country calls for integrated water management considerations. Groundwater and surface water are intimately related and should be managed with awareness and protection of critical recharge zones. Active and effective groundwater management, land management optimized for recharge, green infrastructure, and use of alternate water supplies are crucial to protecting flow and water quality.

Private citizens alone cannot adequately protect shared natural resources in the Hill Country. A multi-tiered approach that builds policy based on science, incorporates robust public conservation programs, and effective tools to coordinate water use and development is the only way to maintain spring flow, protect water quality and safeguard economic values associated with clean, clear, flowing springs and rivers in the Hill Country.



CONCLUSION

These eight metrics are intended to help the Texas Hill Country Conservation Network (the Network) track the progress of Hill Country conservation initiatives. A partnership of dozens of organizations made up of nonprofits, academic institutions, government agencies, and aligned private businesses, the Network aims to maximize the protection of the Hill Country's natural resources through enhanced collaboration.

As these groups set goals, monitor progress and articulate the value of their work to Texas decision makers and the public, this report can assist by defining metrics for cross-organizational use. In addition, the metrics establish baseline data as a foundation for future analyses. This report makes it possible for organizations to track the impact of their efforts through a common measuring system, ultimately enhancing strategic planning and raising awareness for their work.

Beyond the Network, this report can serve to inform, and hopefully inspire, all residents of the region, including elected officials, developers, business owners, and other decision makers, of the importance of our natural resources and the current state of our Hill Country.

As the Network continues to work across the Hill Country landscape, these metrics will help strategically focus its energy and resources on the projects that can most successfully advance progress in each metric area. Together, we can preserve the unique landscape features, spring-fed streams, heritage ranch lands and spectacular beauty and culture of the Texas Hill Country.

Photo courtesy of Lisa Woods Photography

REFERENCES

1 US Census Bureau. (2018). American Fact Finder [Data file]. Available from US Census Bureau Website: https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml Population figures are taken from the US Bureau of Labor Statistics, either from the decadal census (1990, 2000 or 2010) or the annual estimate. Figures labeled "current" refer to the 2020 annual estimate.

2 Texas Water Development Board. (2016). Population Projections [Data file]. Retrieved from: http://www.twdb.texas.gov/waterplanning/data/projections/2017/popproj.asp

3 American Farmland Trust. (2003). Cost of Community Services. Finding the balance: Ranching and rapid growth in Bandera County, Texas. Farmland Information Center. Viewed February 2019: https://www.farmlandinfo.org/sites/default/files/COCS_BanderaCounty_Texas_1.pdf

4 American Farmland Trust. (2003). Cost of Community Services. The value of farmland and open space in Bexar County, Texas. Farmland Information Center. Viewed February 2019: https://www.farmlandinfo.org/sites/default/files/Bexar_COCS_4C_final_1.pdf

5 American Farmland Trust. (2003). Cost of Community Services. The value of farm and ranch land in Hays County, Texas. Farmland Information Center. Viewed February 2019: https://www.farmlandinfo.org/sites/default/files/COCS_HaysCounty_Texas_1.pdf

6 American Farmland Trust. (2016). Cost of Community Service Studies. Farmland Information Center. Viewed March 2019: https://www.farmlandinfo.org/sites/default/files/Cost_of_Community_Services_Studies_AFT_FIC_201609.pdf

7 Dinerstein, E. et al. (2019). A Global Deal For Nature: Guiding principles, milestones, and targets. Retrieved from https://www.science.org/doi/10.1126/sciadv.aaw2869

8 Center for Watershed Protection. Impacts of Watershed Protection Research Monograph No. 1: Impacts of Impervious Cover on Aquatic Systems (March 2003). Retrieved from https://owl.cwp.org/mdocs-posts/impacts-of-impervious-cover-on-aquatic-systems-2003/

9 Texas Land Trust Council. Conservation Lands Inventory. https://texaslandtrustcouncil.org/what-we-do/conservation-lands-inventory/

10 Texas Demographic Center. (2018). Texas Population Estimates Program [Data file]. Available

from Texas Demographic Center Website: http://txsdc.utsa.edu/Data/TPEPP/Estimates/

11 Texas Commission on Environmental Quality. (2006). Preserving and Improving Water Quality. Retrieved from https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/08twqi/pollution_control.pdf

12 Texas State Soil and Water Conservation Board. Watershed Protection Plan Program. Accessed on April 22, 2019: https://www.tsswcb.texas.gov/programs/texas-nonpoint-source-management-program/watershed-protection-plan-program

13 Texas Commission on Environmental Quality. (2018). Texas Nonpoint Source Program Nine-Element Watershed Protection Plans [Map]. Retrieved from https://www.tceq.texas.gov/assets/public/waterquality/nps/watersheds/WBP_MapForWeb.pdf

14 US Environmental Protection Agency. Urban Runoff: Low Impact Development. Retrieved on April 22, 2019: https://www.epa.gov/nps/urban-runoff-low-impact-development

REFERENCES

15 Hill Country Conservancy. Hill Country Headwaters Conservation Initiative. https://hillcountryconservancy.org/land-projects/land-projects-hchci/

16 The Geological Society of America. Regional Groundwater Management: Considering Flows to Springs And Streams (2017) https://gsa.confex.com/gsa/2017SC/webprogram/Paper289120.html

17 Dr. John Barentine, Program Manager for the International Dark-Sky Association (IDA), at the Hill Country Dark Sky Conference in Fredericksburg (May 19, 2017). https://www.hillcountryalliance.org/wp-content/uploads/2014/06/5.31.17_17-Hill-Country-Communities-Represented-at-Regional-Dark-Sky-Conference-in-Fredericksburg.pdf

18 Falchi, Fabio; Cinzano, Pierantonio; Duriscoe, Dan; Kyba, Christopher C.M.;Elvidge, Christopher D.; Baugh, Kimberly; Portnov, Boris; Rybnikova, Nataliya A,; Furgoni, Riccardo (2016); Supplement to: The New World Atlas of Artificial Night Sky Brightness. GFZ Data Services. http://doi.org/10.5880/GFZ.1.4.2016.001

19 Dr. John Barentine, Program Manager for the International Dark-Sky Association (IDA), at the Hill Country Dark Sky Conference in Fredericksburg (May 19, 2017). https://www.hillcountryalliance.org/wp-content/uploads/2014/06/5.31.17_17-Hill-Country-Communities-Represented-at-Regional-Dark-Sky-Conference-in-Fredericksburg.pdf

20 The Trust for Public Land. (2018). Almanacs Land Vote Data, 2018, Conservation Almanac: A resource of the Trust for Public Land, viewed Jan 2019. Retrieved from: http://www.conservationalmanac.org/secure/almanac/southwest/tx/lvdata.html.

21 Texas A&M Natural Resources Institute (TAMU NRI). (2019). Texas Land Trends: Conservation Easements in Texas. Texas A&M Natural Resources Institute (TAMU NRI). Retrieved from: http://txlandtrends.org/media/1027/conservationeasementsintexasreport.pdf.

22 Texas A&M University Institute of Renewable Natural Resources (TAMU IRNR). (2016). Texas Farm and Ranch Lands Conservation Program: Evaluation Report [White paper]. Texas A&M Institute of Renewable Natural Resources. Retrieved from: https://nri.tamu.edu/media/1090/tfrlcp-eval-report-20170222_final.pdf.

23 Water Quality Protection Lands Program. (2018, February). Open Space Working Group Report and Possible Action on Items. Presented to the Bond Election Advisory Task Force, Austin, TX.

24 Federal Reserve Bank of St. Louis. (2019). FRED Economic Research, Total Gross Domestic Product for Austin-Round Rock, TX (MSA). Retrieved from: https://fred.stlouisfed.org/series/NGMP12420

25 Federal Reserve Bank of St. Louis. (2019). FRED Economic Research, Total Gross Domestic Product for San Antonio-New Braunfels, TX (MSA). Retrieved from: https://fred.stlouisfed.org/series/NGMP41700

26 The University of Texas at Austin. (2016). Toward a Regional Plan for the Texas Hill Country. Retrieved from: http://www.hillcountryalliance.org/wp-content/uploads/2016/01/Toward-a-Regional-Plan-for-the-Texas-Hill-Country.pdf

27 The Trust for Public Land (2012). Hill Country, Texas: Conservation Finance Feasibility Study. The Trust for Public Land.

Appendix A

Data Sources & Analysis Methods

COMMUNITY

Metric 1: Unincorporated Population

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
City boundaries	.shp	TXDOT	2018	may require update
County boundaries	.shp	TXDOT	2018	should not require update
City population estimates (1990)	table	TX Demographer	1990	N/A (historical data)
County population estimates (1990)	table	TX Demographer	1990	N/A (historical data)
City population estimates (2020)	table	US Census Vintage Estimates	2020	Annual

*See "Source Links" for more information

Methods

Data Acquisition Notes

- Download: Historical data comes from TX Demographer and most up to date comes from US Census Vintage Estimates - which are estimates based on the 2010 census.
- Data release: Vintage Census Estimates are updated annually. It is recommended to update to actual 2020 Census when available.

Analysis performed using Microsoft Excel and ArcGIS

1. 1990 data:
   - Join city population spreadsheet with city boundary shapefile. Use city name as join field
   - Join county population spreadsheet with county boundary shapefile. Use county name as join field.
   - Intersect city boundary with county boundaries
   - Remove portions of city limits that fall outside of county boundaries. Recalculate city population using the proportion of the city that falls within the county.
   - Sum city populations by county.
   - Subtract the sum of city population from the county population. The result is the "Unincorporated Population".
2. 2020 data:
   - No need to follow the process for 1990 data. Vintage estimate data for "cities" includes a "Balance of XX County" row that is effectively the "unincorporated population" for each county. Find rows for HCA counties and that work is done!

Source Links

Texas Demographer: http://txsdc.utsa.edu/Data/TPEPP/Estimates/

US Census Vintage Estimates: https://www.census.gov/programs-surveys/popest/technical-documentation/research/evaluation-estimates.html

TXDOT: http://gis-txdot.opendata.arcgis.com/datasets?t=Boundaries&sort=-updatedAt

LAND

Metric 2: Conserved Land

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Conserved Lands Inventory	.shp	TLTC/Siglo Group	2021	on request
County Boundaries	.shp	TXDOT	2018	should not require update

*See "Source Links" for more information

Methods

Data Acquisition Notes:

- Download: Inquire with Siglo Group for most recent version of spatial data.
- Data release: On request.

Analysis performed using Microsoft Excel and ArcGIS

1. Clip 2021 data set to HCA counties.
2. Intersect Conserved Lands Inventory with counties- calculate acres conserved per county.
3. NOTE: *Conserved Land and Developed Land metrics were assessed together. When calculating acreage, conserved land was given priority over developed. i.e. All conserved land was counted while only developed land that did not overlap with conserved land was counted.*

Sources Links

Conserved Lands Inventory (combination of the following):

- TLTC Lands Inventory: http://www.texaslandtrustcouncil.org/index.php/what-we-do/cli (Inquire with Siglo Group for most recent version of spatial data).
- Parcel Data by County & institutional knowledge about conserved lands: (see individual county assessor site for parcels)
- TPWD Statewide Inventory: https://tpwd.maps.arcgis.com/apps/webappviewer/index.html?id=85c175c2155e4345a206bf312d5d46a2

TXDOT: http://gis-txdot.opendata.arcgis.com/datasets?t=Boundaries&sort=-updatedAt

LAND

Metric 3: Developed Land

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
National Land Cover Dataset (NLCD)	raster	MRLC	2016	5 years
County Boundaries	.shp	TXDOT	2018	should not require update

*See "Source Links" for more information

Methods

Data Acquisition Notes:

- Download: Download NLCD from Multi-Resolution Land Characteristics Consortium
- Data release: Released every 5 years with a 2-3 year lag. 2016 data was released in 2019.

Analysis performed using Microsoft Excel and ArcGIS

1. Clip NLCD to HCA counties.
2. Extract all developed classes (4) from NLCD. This includes classes 21 (Developed, Open Space), 22 (Developed, Low Intensity), 23 (Developed, Medium Intensity), 24 (Developed, High Intensity).
3. Intersect developed classes with counties- calculate acres developed per county that do not intersect with conserved land.
4. NOTE: *Conserved Land and Developed Land metrics were assessed together. When calculating acreage, conserved land was given priority over developed. i.e. All conserved land was counted while only developed land that did not overlap with conserved land was counted.*

Sources Links

National Land Cover Dataset: https://www.mrlc.gov/data

TXDOT: http://gis-txdot.opendata.arcgis.com/datasets?t=Boundaries&sort=-updatedAt

WATER

Metric 4: Pristine Streams

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Phosphorus stream data	table	TCEQ	Jan 2011- Jan 2021	continuous
TCEQ segments & assessment units	.shp	TCEQ	2021	as needed
Watershed Boundaries	.shp	USGS	2010	should not require update
Treated Wastewater Discharge Points	table	SBCA	October 2020	contact SBCA

*See "Source Links" for more information

Methods- Pristine Streams

Data Acquisition Notes:

- Download: Data was downloaded and processed outside of the scope of this report. A general outline of how it was done is decribed here. Contact Sky Lewey for more information -slewey@nueces-ra.org
- Data release: Data is continuously collected.

Analysis outline:

1. Filter CRP data for #665 Phosphorus
2. Pristine streams read <.06 at least 90% of the time
3. Join data to assessment units- "Look first at segments to see if a classified segment would qualify. If it does not, then look at assessment units with those segments to see if a particular unit would qualify. This becomes important on rivers like the San Marcos where the upper segment contains discharge and does not qualify as whole, but that segment includes a high profile assessment unit at its uppermost reach that does qualify."- Sky Lewey

Sources Links

Phosphorus stream data: https://www80.tceq.texas.gov/SwqmisWeb/public/crpweb.faces

TCEQ segments & assessment units: https://gis-tceq.opendata.arcgis.com/search?categories=water

Methods- Treated Wastewater Discharge Points

Data Acquisition Notes:

- Download: Data was downloaded and processed outside of the scope of this report. Contact SBCA for more information - info@nodumpingsewage.org
- Data release: October 2020

Sources Links

Treated Wastewater Discharge Points (table): Save Barton Creek Association (SBCA). (2020) Pristine to Polluted; Sewage Problems & Solutions in the Texas Hill Country. Table with data from page 4 supplied July 2021.

WATER

Metric 5: Water Consumption

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Water User Group (WUG) Utility GPCD	table	TWDB	2018	annual
WUG Counties	table	TWDB	2016	should not require update

*See "Source Links" for more information

Methods

Data Acquisition Notes

- Download: Click on the "Summary Estimates, 2016 and Later" link under "Regional Water Planning Water User Group (WUG) Utility GPCD. Click desired year, view report, and then export data to desired format. The WUG counties table was provided through inquiry with TWDB. Likely the same one can be used year to year.
- Data release: There is usually a two year delay in new data release.
- Caveat: Methodology for data collection changed in 2016. Do not include pre-2016 in analysis.

Analysis performed using Microsoft Excel and ArcGIS

1. Join WUG Utility GPCD table with WUG counties table to extract data from only HCA counties.
2. Select counties that were analyzed within 2016 data. Calculate change between previous and current years.
3. In general WUGs that represent large populations, >400 GPCD and <100 GPCD were shown with guidance from HCA. In the future, WUGs displayed could vary depending on new outliers.

Source Links

TWDB: http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/index.asp

TWDB (Direct to download): https://www3.twdb.texas.gov/apps/reports/WU/SumFinal_UtilityWUGSum

WATER

Metric 6: Spring Flow

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Spring Flow	table	USGS National Water Information System	2000-2020	continuous

*See "Source Links" for more information

Methods

Data Acquisition Notes:

- Download: Navigate to USGS water data mapper. Click "Springs" on "Sites" tab. Check "active sites" and uncheck everything else. Zoom to HCA extent, find spring, click on marker then "Access Data". Click "Daily Data" and check the box next to "Discharge". Click "Tab-separated" and enter date range then click "Go". This will lead to results for the selected gage showing mean discharge in cfs, per day for the period of record.
- Data release: Data is updated continuously.

Analysis performed using Microsoft Excel

1. Combine mean data from all analyzed gages in Excel. Use to create charts and calculate statistics.
2. The years 2000-2020 were analyzed in this report, in order to show contemporary spring discharge trends.

Sources Links

USGS National Water Information System: https://maps.waterdata.usgs.gov/mapper/index.html

NIGHT SKY

Metric 7: Dark Skies for Stargazing

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Dark sky quality	.shp	Starry Sky Austin	2015	contact Amy Jackson

*See "Source Links" for more information

Methods

- Data and analysis were supplied by Amy Jackson with Starry Sky Austin. Contact her for data updates and methods. amy@starryskyaustin.com

Source Links

https://arcg.is/1XWSnX

INVESTMENT

Metric 8: Public Investment in Land Conservation

Data Sources

DATA	TYPE	SOURCE*	REPORT DATA DATES	NEW DATA RELEASE
Land Conservation $	table	HCA	1992-2020	annual
Annual GPD	table	FRED Economic	2001-2019	annual

*See "Source Links" for more information

Methods

Data Acquisition Notes

- Conservation dollar data for this report was provided by HCA from a recent research effort.
- Research and local knowledge can be used to updated this spreadsheet annually

Analysis performed using Microsoft Excel

1. Evaluate all counties for conservation funding:
   - Total funding per year
   - Sum county dollars since 1992- show break-down of funding per county
2. Conservation funding vs. Regional GDP :
   - Sum of regional GDP for Austin/Round Rock MSA and San Antonio-New Braunfels MSA. Chart as line.
   - Conservation funding line is the 10 year moving average of total funding per year. Chart as line.

Source Links

FRED- Austin/Round Rock MSA: https://fred.stlouisfed.org/series/NGMP12420

Appendix B

Metrics Summary Table

Metrics by County

	Year/Timeframe	TOTAL	Bandera	Bexar	Blanco	Burnet	Comal	Edwards	Gillespie	Hays	Kendall	Kerr	Kimble	Llano	Mason	Medina	Real	San Saba	Travis	Uvalde
County Acreages	N/A	**12,093,264**	510,109	804,048	456,500	652,668	367,819	1,356,649	678,787	434,066	423,972	708,103	799,459	618,058	597,063	855,078	447,659	727,717	655,609	999,900
METRIC 1: COMMUNITY																				
Unincorporated Population	2020	**864,336**	22,954	289,350	7,742	24,948	73,568	795	15,441	91,351	27,000	27,167	1,962	14,363	1,997	31,248	2,260	2,588	220,513	9,089
Unincorporated Population % Change	1990-2020	**103%**	137%	81%	104%	109%	176%	-14%	50%	195%	176%	55%	34%	76%	45%	166%	24%	-7%	98%	29%
METRIC 2: LAND																				
Conserved Land Acres	2021	**546,301**	22,611	68,441	24,954	22,874	13,618	8,362	8,174	37,283	10,712	19,892	4,047	3,476	7,830	61,248	17,084	4,786	93,470	117,439
METRIC 3: LAND																				
Developed Land Acres	2016	**828,066**	16,414	307,872	11,300	27,356	48,913	10,949	20,604	40,566	16,940	29,068	12,805	19,138	9,550	28,702	5,733	14,242	186,473	21,441
METRIC 5: WATER																				
MAX Gallons per day per person	2018	**783 (Travis County MUD 4)**	113	228	158	199	2260	160	209	278	156	167	187	278	225	176	135	223	783	161
Average Gallons per day per person	2018	**191**	113	167	120	136	319	160	209	144	156	167	187	153	225	176	135	223	221	161
METRIC 7: NIGHT SKIES																				
Excellent Acres	2015	**1,649,715**	-	776,333	-	9,173	142,918	-	2,469	142,821	20,009	11,488	-	-	-	45,674	-	-	493,081	5,750
Good Acres	2015	**2,910,837**	162,910	28,299	252,530	460,726	225,147	350	85,239	291,497	291,819	227,466	8,136	86,629	4,135	518,799	2,002	15,173	162,822	87,157
Poor Acres	2015	**7,540,732**	347,595	-	204,296	183,098	-	1,356,831	591,616	-	112,473	469,688	791,850	531,906	593,393	291,278	445,944	713,117	-	907,647
METRIC 8: INVESTMENT																				
Total Investment	1992-2020	**$ 1,220,247,967**	$ -	$582,841,739	$ -	$ -	$ -	$ -	$ -	$ 111,600,000	$5,000,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$520,806,228	$ -

Metrics by Watershed*

	Year/Timeframe	TOTAL	Austin-Travis Lakes	Cibolo	Hondo	Llano	Medina	Middle Guadalupe	North Llano	Nueces Headwaters	Pedernales	San Gabriel	San Marcos	South Llano	Upper Frio	Upper Guadalupe	Upper Nueces
METRIC 4: WATER																	
Pristine Stream Miles	2020	**1,142**	123	13	131	112	88	26	28	62	38	38	92	72	93	204	22
METRIC 6: WATER																	
Spring Flow - 20 Year Median (cfs)	2020	**N/A**	Barton Springs - 71	-	-	-	-	Comal - 307	-	-	-	-	San Marcos - 179 Jacob's Well - 3.4	-	-	-	-

**Watersheds that intersect the study area that do not have pristine streams or springs within HCA Counties include: Atascosa, Brady, Buchanan-Lyndon B, Dry Devils, Elm-Sycamore, Lampasas, Lower Colorado-Cummins, Lower San Antonio, Middle Colorado, San Miguel, San Saba, Turkey, Upper Devils, Upper San Antonio, and West Nueces.*

texas hill country
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