TEXAS ECOSYSTEM SERVICES:
A STATEWIDE ASSESSMENT

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REPORT CONTRIBUTORS

SUGGESTED CITATION

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What Are Ecosystem Services?

The diverse landscapes in Texas are comprised of many ecosystems providing vital goods, services, and public benefits. These commodities of nature, defined as ecosystem services, are the set of functions or products benefitting human wellbeing, encompassing many life-sustaining products such as climate regulation, air purification, and pollination.[1] Many ecosystem services are traditionally considered free to society. For example, everyone enjoys clean air, clean water, and flood control provided by healthy forests, rangelands, and wetland ecosystems.[1] Although an important component of natural landscapes, ecosystem services typically lack formal market structures, and their associated benefits are difficult to quantify or appropriately value. As a result, the contributions and importance of ecosystem services are often overlooked by the general public, government leaders, and those involved in land use decision-making. With an increasing global demand for natural resources, the Millennium Ecosystem Assessment (MEA), initiated in 2001 by the United Nations, assessed the consequences of ecosystem disruption and the associated goods and services they provided to communities. The MEA report categorized ecosystem services into four groups defined as provisioning, regulating, cultural, and supporting services.[2]

> **The environment is where we all meet, where we all have a mutual interest; it is the one thing all of us share...**
>
> **-Claudia "Lady Bird" Johnson**

Ecosystem Service Categories

Promoting the long-term sustainability and stewardship of natural resources begins with a basic understanding of ecosystem services and their public benefits—and, ideally, the ability to assign monetary value can illustrate the importance of contributions to society. This information can serve to support land conservation strategies and policies to promote the conservation of open spaces and natural resources. In this report, we describe open spaces as *working lands*, or privately-owned farms, ranches, and forests that produce food and fiber, support rural economies, and provide wildlife habitat, clean air and water, and recreational opportunities. These lands constitute the majority of the undeveloped, rural land mass in Texas.

Provisioning services— Tangible goods that society extracts from nature, such as food, fuel, fiber, and biomass, and serve as vital contributors to local and regional economies. These services often possess well-developed markets and valuation systems.

Regulating services— Benefits obtained from the regulation of ecosystem processes to include the improvement of water quality, air pollution removal, flood mitigation, and erosion control. Regulating services are much harder to value, as they are less tangible and difficult to quantify or measure.

Cultural services— These services are difficult to quantify and assign market values, and typically include non-material benefits obtained from nature such as recreation, spiritual enrichment, tourism, and aesthetic experiences. This category of services emphasizes the significance and importance of nature to human well-being and experiences.[3]

Supporting services— Important ecological functions such as soil formation, nutrient cycling, and photosynthesis, which collectively form the foundation for provisioning, regulating, and cultural services.[3]

Valuing Texas Working Lands

Texas has a rich history of land stewardship across generations that contributes to the ongoing production and conservation of ecosystem goods and services for the 30+ million citizens within the state. While 82% of the state's entire land area is classified as privately-owned rural land, or working land (i.e., 141 million acres of farms, ranches, and forests), Texas is also home to seven of the top 15 most rapidly growing cities in the nation.[4] Rapid population growth, suburbanization, and rural development have increased the demand for working lands and their associated benefits.[4] Working land loss across the state over the last 20 years has garnered attention for increased efforts to protect the vital natural resources and land infrastructure of Texas, however, not without considerable challenge. The total economic value of Texas working lands is difficult to define. Thus, the objectives of this report are to *(1)* provide examples of broad ecosystem services, and *(2)* estimate their relative economic value or level of current investments.

Approach

We identified 11 ecosystem services through extensive literature review on approaches to estimating ecosystem services at state or region-wide scales.[5, 6, 7, 8] Traditionally, a benefits transfer method is used to estimate ecosystem service values by transferring available information or values from original, similar studies. Applying a benefits transfer approach for this study was not possible for all selected metrics due to data limitations and/or lack of availability. Instead, we used *market-based estimates* from the Texas Comptroller of Public Accounts and the Texas Water Development Board (TWDB) where appropriate, and *willingness-to-pay estimates* from established federal field-scale or operation level conservation programs through the Natural Resources Conservation Service (Table 1).

Table 1. Eleven Texas ecosystem services by category, data source and valuation method.

	ECOSYSTEM METRIC	CATEGORY	SOURCE
Market-based	Food and Fiber Production	Provisioning	Texas Comptroller of Public Accounts
	Water Quantity (Replacement)	Supporting	Texas Water Development Board
	Recreation (Consumptive-Hunting)	Cultural	Texas Comptroller of Public Accounts
Willingness-to-pay	Water Quantity (Improvement)	Supporting	Natural Resources Conservation Service
	Water Quality	Supporting	Natural Resources Conservation Service
	Wildlife Habitat and Biodiversity	Supporting	Natural Resources Conservation Service
	Erosion Control	Regulating	Natural Resources Conservation Service
	Flood Mitigation	Regulating	Natural Resources Conservation Service
	Air Quality and Air Pollution Removal	Regulating	Natural Resources Conservation Service
	Carbon Storage and Sequestration	Regulating	Natural Resources Conservation Service
	Recreation (Non-Consumptive)	Cultural	Natural Resources Conservation Service

Approach (continued)

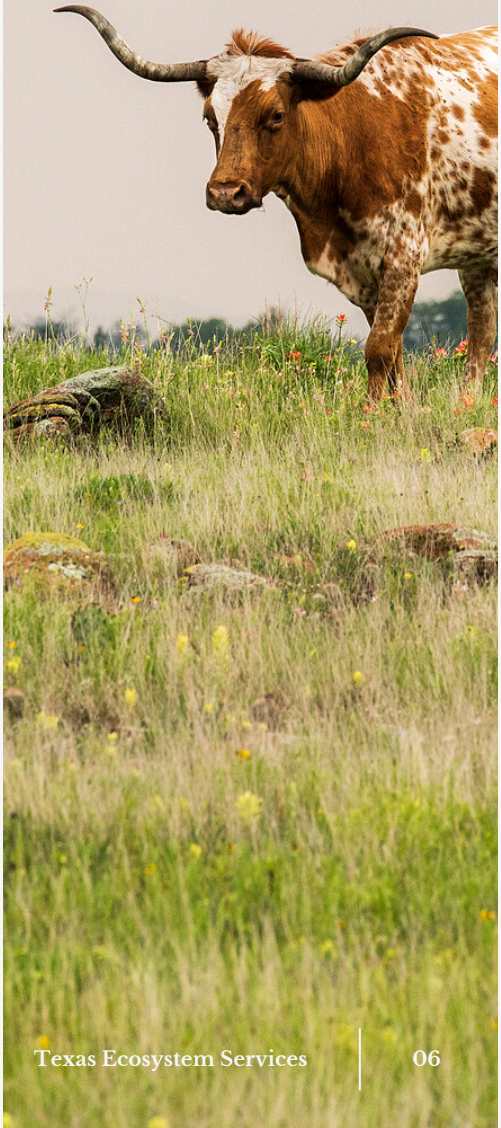
Market-based estimates utilize current financial mechanisms to calculate the market value of an ecosystem service. For example, food and fiber production are tangible products that are already included in a traditional market system where people regularly come to buy and sell these goods and services. Existing data can tell us how much a crop is worth and what it contributes to our market economy. Market-based estimates utilize this existing data—what we know we already pay—to assign values to ecosystem services.

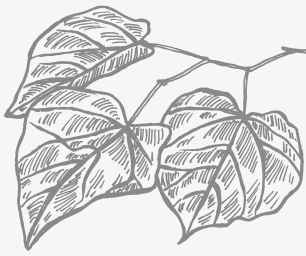
In contrast, a *willingness-to-pay* model utilizes the maximum value a consumer is willing to pay for a given good or service.[9, 10, 11] For the purposes of this study, we used government payments to federal landowner incentive programs to determine the level of investment of federal government programs to conserve or protect previously identified ecosystem services in Texas.

MARKET-BASED ESTIMATES

Food and Fiber Production— Food and fiber production as a provisioning service are the goods provided by Texas working lands that already have accessible economic value. These are simple services that many Texans are already very familiar with—foods such as crops and livestock, and fibers such as cotton, timber, and wool/mohair. They are the tangible products we use from working lands that can be readily extrapolated to show their economic value and benefit to our state.

The Texas Comptroller of Public Accounts maintains yearly estimates of market and production values ($/acre) for all open space lands classified as 1-D and 1-D-1 agricultural land use appraisal. County appraisers account for only those factors associated with the land's capacity to produce marketable agricultural products in their productivity value assessments. This process requires a modified income approach that converts an estimate of the property's income into an estimate of the property's value using net income divided by a standard capitalization rate.





Food and Fiber Production (continued)— Net incomes are based on a five-year period preceding the year before the year of appraisal. For example, an appraisal in 2018 was based on income from 2016 (two years before the appraisal), 2015, 2014, 2013, and 2012 (five-year period preceding). A similar approach, including average annual timber prices, growth, and costs, is used for timber land productivity values. Through using this dataset, we can capture the value of food and fiber production ($/acre/year) as a representative measure for the most common and productive provisioning services on working lands in Texas.

Water Quantity (Replacement)— Texas working lands provide undeveloped, permeable surfaces to capture rainfall, reduce water runoff, and increase groundwater recharge. With current population projections, the latest Texas State Water Plan (2022) by the Texas Water Development Board (TWDB) emphasizes that the state will be in a nearly 6.9M acre-feet water deficit by 2070.[12] To address this shortage, $80B in water management strategies have been proposed and developed by the TWDB.[12] We used these estimates to calculate the cost of replacing potential captured water on 1 acre of working land by Texas county. We summarized average annual rainfall by county and used a 50% water infiltration rate to calculate potential water capture on 1 acre of working land. We then calculated the relative replacement cost of those water resources if that acre were to be developed, according to the 2022 Texas State Water Plan. We divided the cost of implementing targeted water management strategies for a given region ($) by the projected yield for those strategies (acre-feet). The resulting value ($/acre-feet) was multiplied by the potential captured water (Ac-Ft) to determine the final water replacement cost ($/acre/year) of captured water on 1 acre of working land.

Recreation (Consumptive-Hunting)— Recreational hunting and wildlife management play an important role in both the state's economy and ecological well-being.[13] Access to hunting opportunities in the state are market-based, varying by region and species hunted. The Texas Comptroller maintains data on hunting lease prices across the state (2014-2018). We used the geometric mean of hunting lease prices ($/acre) across the latest five years for each county in Texas. For counties without any lease data, we used the 2018 Texas Parks and Wildlife district average. This dataset provides a market-based estimate of the value ($/acre/year) of hunting for each county in Texas.

WILLINGNESS-TO-PAY ESTIMATES

Willingness-to-pay estimates were derived from the USDA Natural Resources Conservation Service's (NRCS) expenditures on landowner incentive programs including the Conservation Stewardship Program (CSP), Environmental Quality Incentives Program (EQIP), and the Regional Conservation Partnership Program (RCPP) from funding years 2014 and 2018. The database maintained by NRCS includes contract payments (made from 2015-2020) for 94 different conservation and land management practices to maintain, enhance, or conserve valuable ecosystem services. Leaders from NRCS regional offices weighted each conservation practice according to its relative benefit to our eight selected ecosystem services (Table 1). Conservation practice payments were divided by either the acreage it was applied to or the entire contract acreage ($/acre), depending on data availability. This value was then multiplied by the NRCS provided weight per ecosystem service to represent the value of federal program dollars spent on improving or maintaining a given ecosystem service. The final calculations included an average $/acre/year value for each county for each of the eight ecosystem services listed in Table 1.

Results

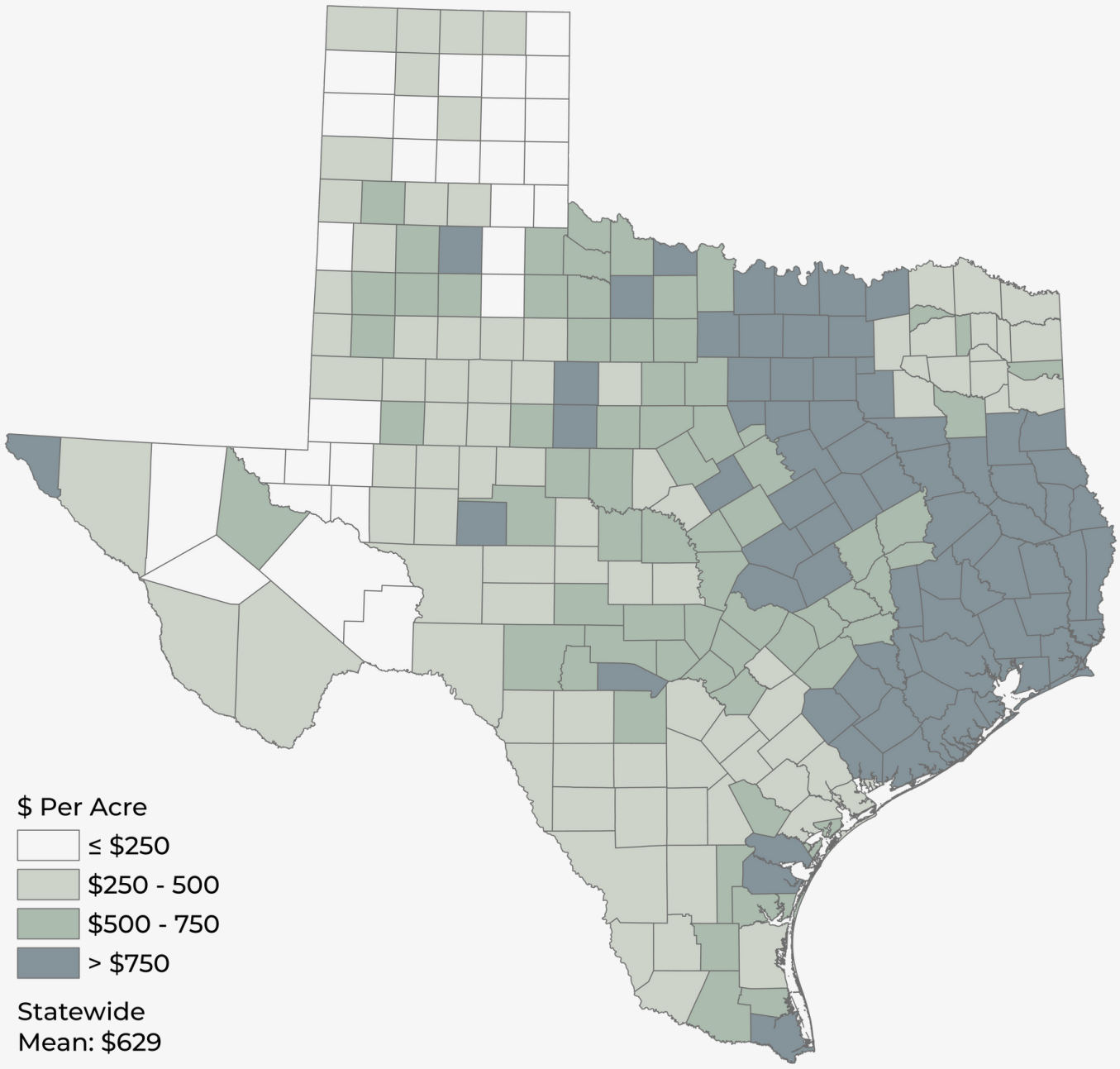
Statewide averages for each ecosystem service and category (provisioning, cultural, regulating, and supporting) are presented in Table 2. We summarized all calculated ecosystem service values to get one total ecosystem service value for Texas. The following maps depict results for Texas counties for each ecosystem service calculation.

Table 2. Statewide averages for each ecosystem service and category on an annual per acre basis.

	ECOSYSTEM SERVICE	STATEWIDE AVERAGE ($/ACRE/YEAR)
Provisioning Total: $103	Food and Fiber Production	$103
Regulating Total: $81	Erosion Control	$27
	Flood Mitigation	$22
	Air Quality and Air Pollution Removal	$19
	Carbon Storage and Sequestration	$13
Cultural Total: $22	Recreation (Consumptive Hunting)	$9
	Recreation (Non-Consumptive)	$12
Supporting Total: $423	Water Quantity (Replacement)	$348
	Water Quantity (Improvement)	$29
	Water Quality	$30
	Wildlife Habitat and Biodiversity	$16
	Total Ecosystem Services Value	**$629/acre/year**

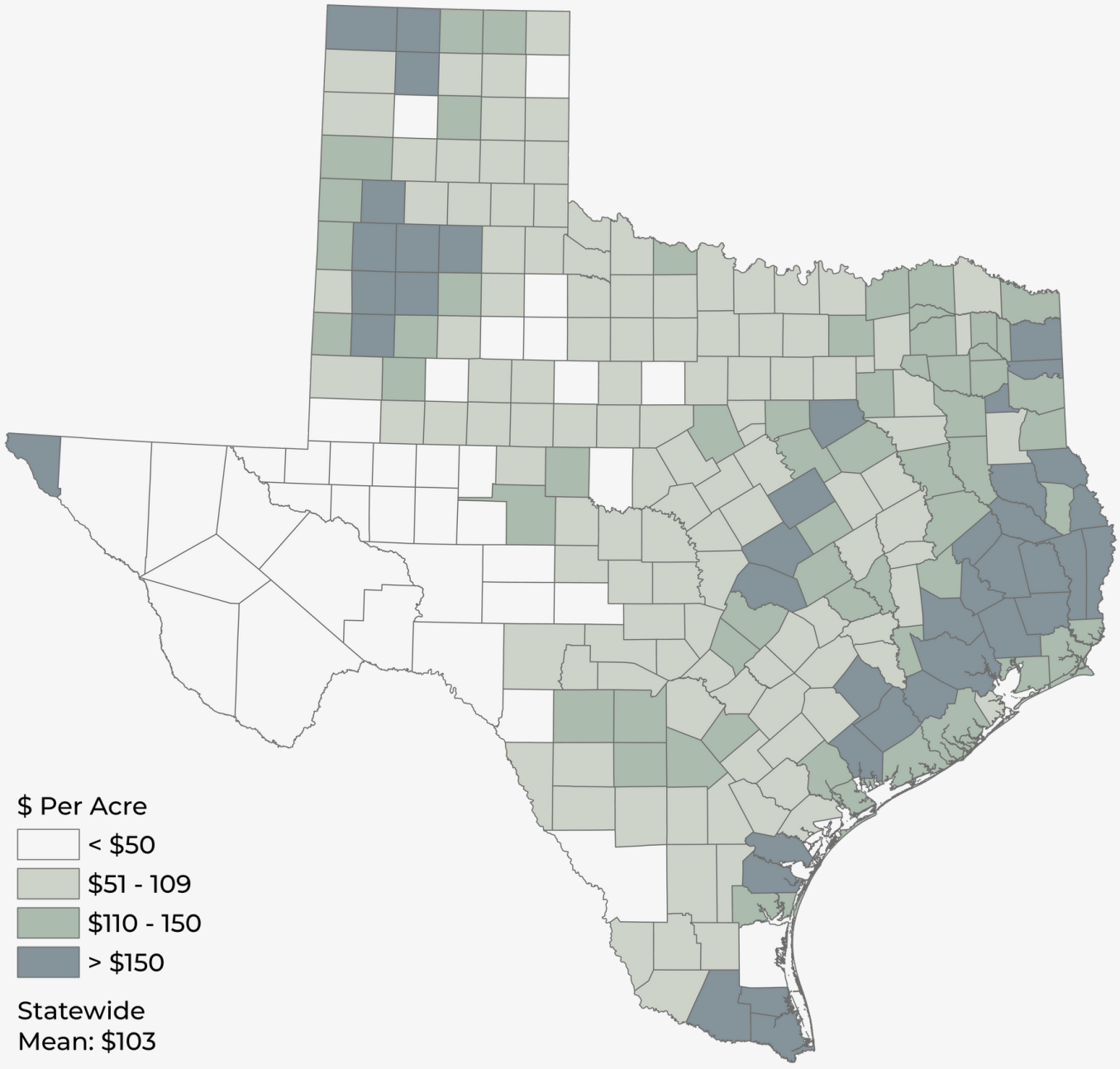
TOTAL ECOSYSTEM SERVICES VALUE

Total annual ecosystem service value ($/acre/year) by Texas county.



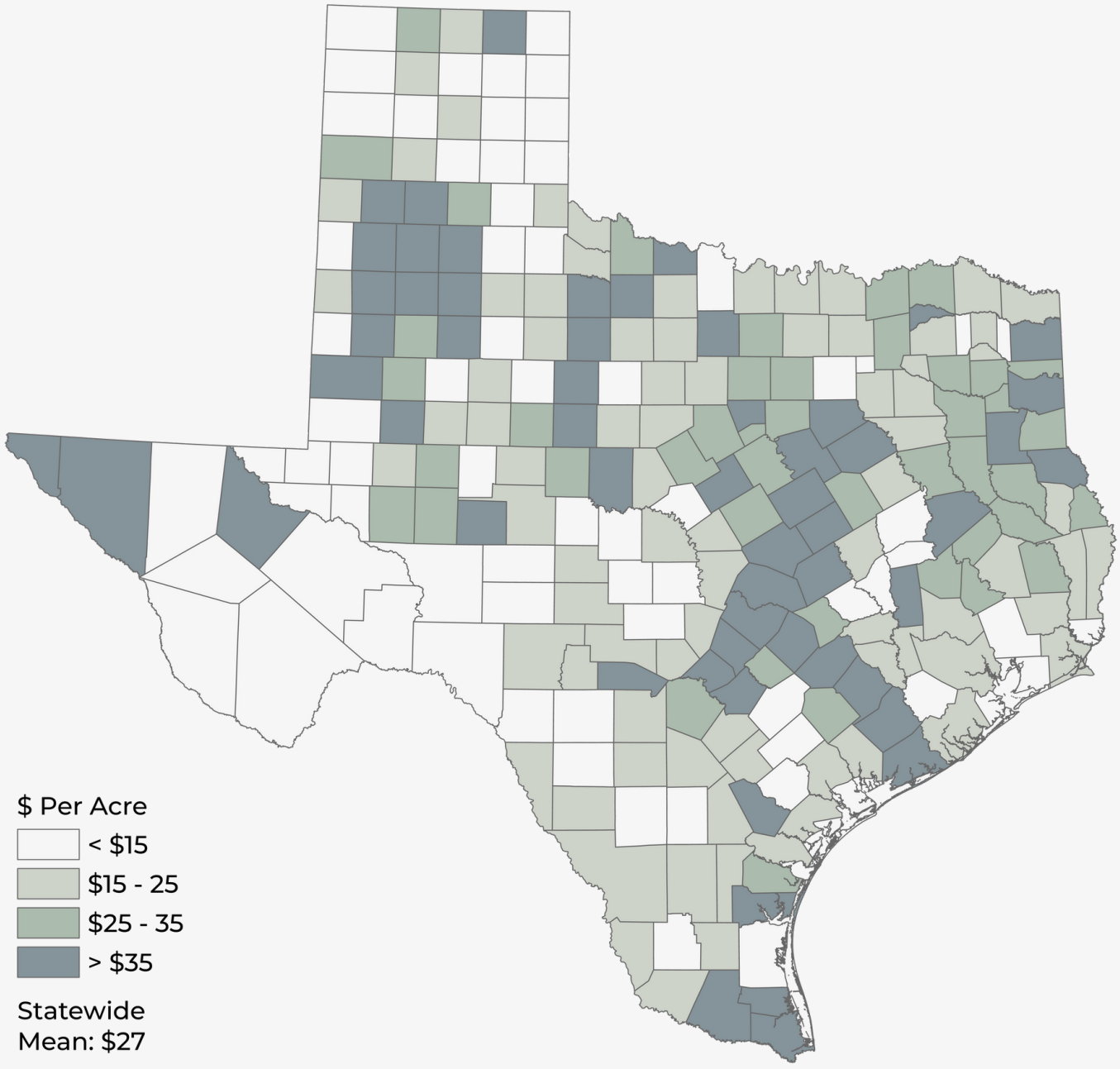
FOOD AND FIBER PRODUCTION

Average annual agricultural productivity value ($/acre/year) for food and fiber production by Texas county, 2017.



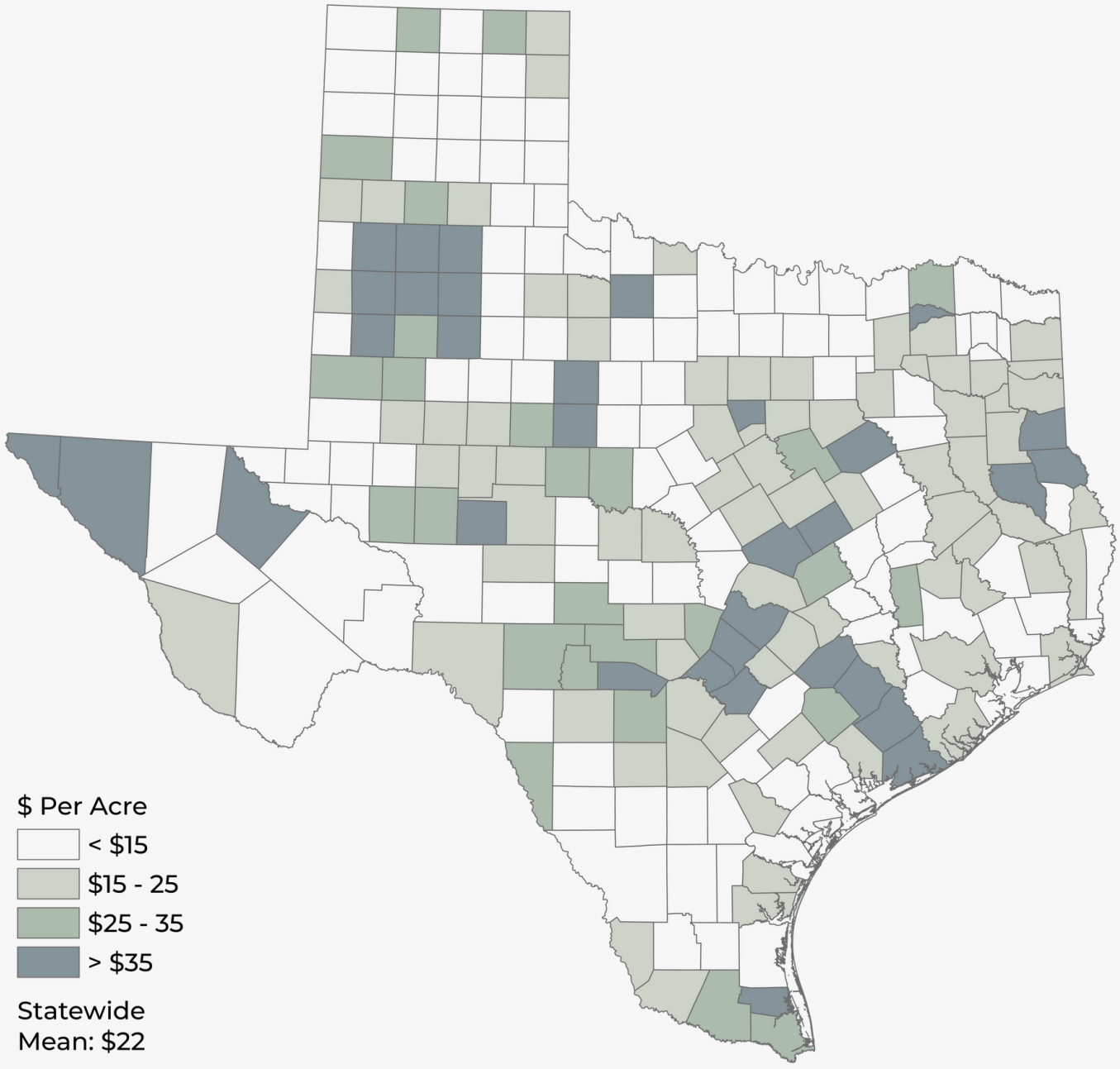
EROSION CONTROL

Average annual payments ($/acre/year) made to improve, maintain, or conserve erosion control measures from NRCS conservation practices implemented in Texas from 2015 to 2020.



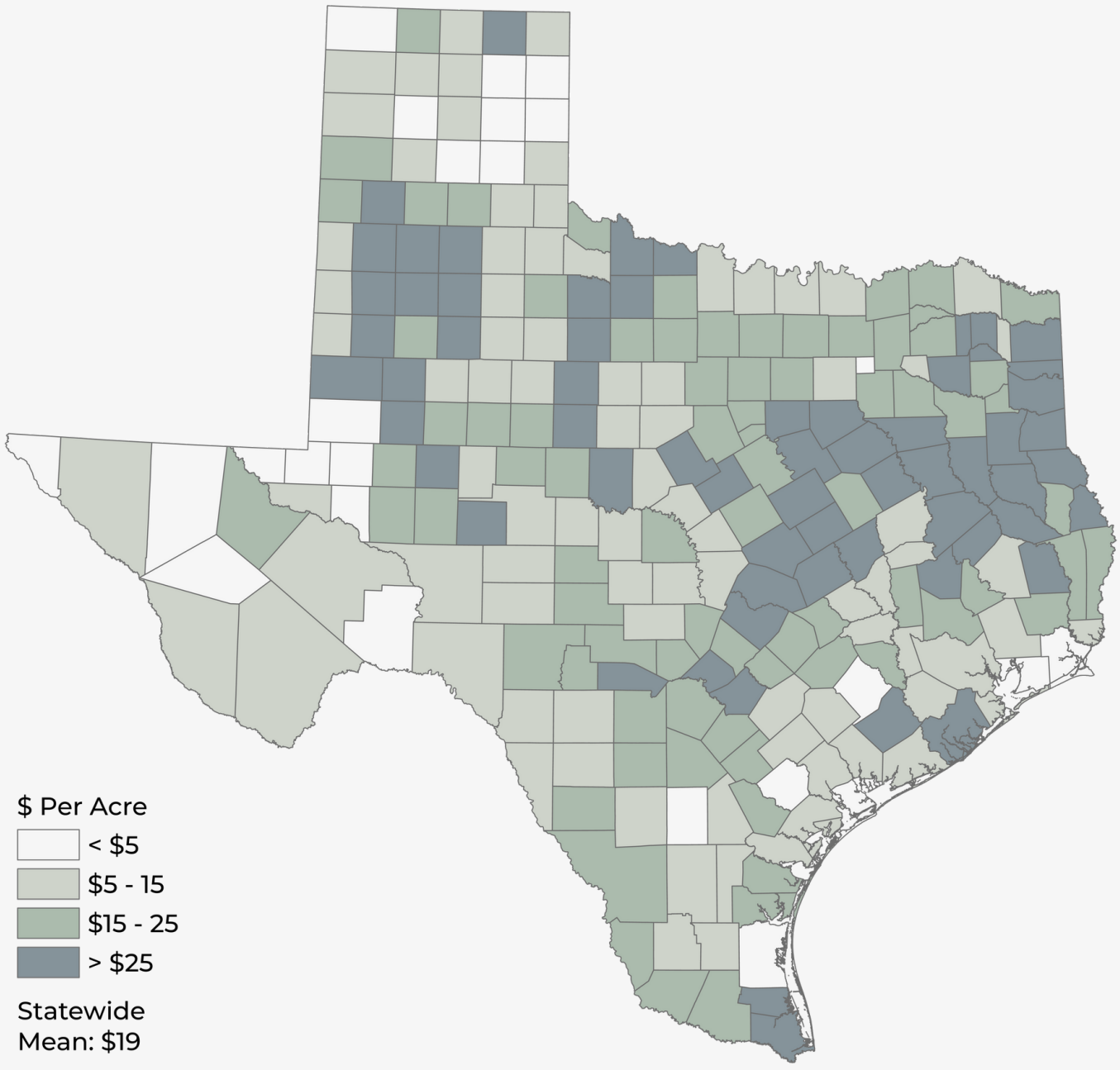
FLOOD MITIGATION

Average annual payments ($/acre/year) made to improve, maintain, or conserve flood mitigation efforts from NRCS conservation practices implemented in Texas from 2015 to 2020.



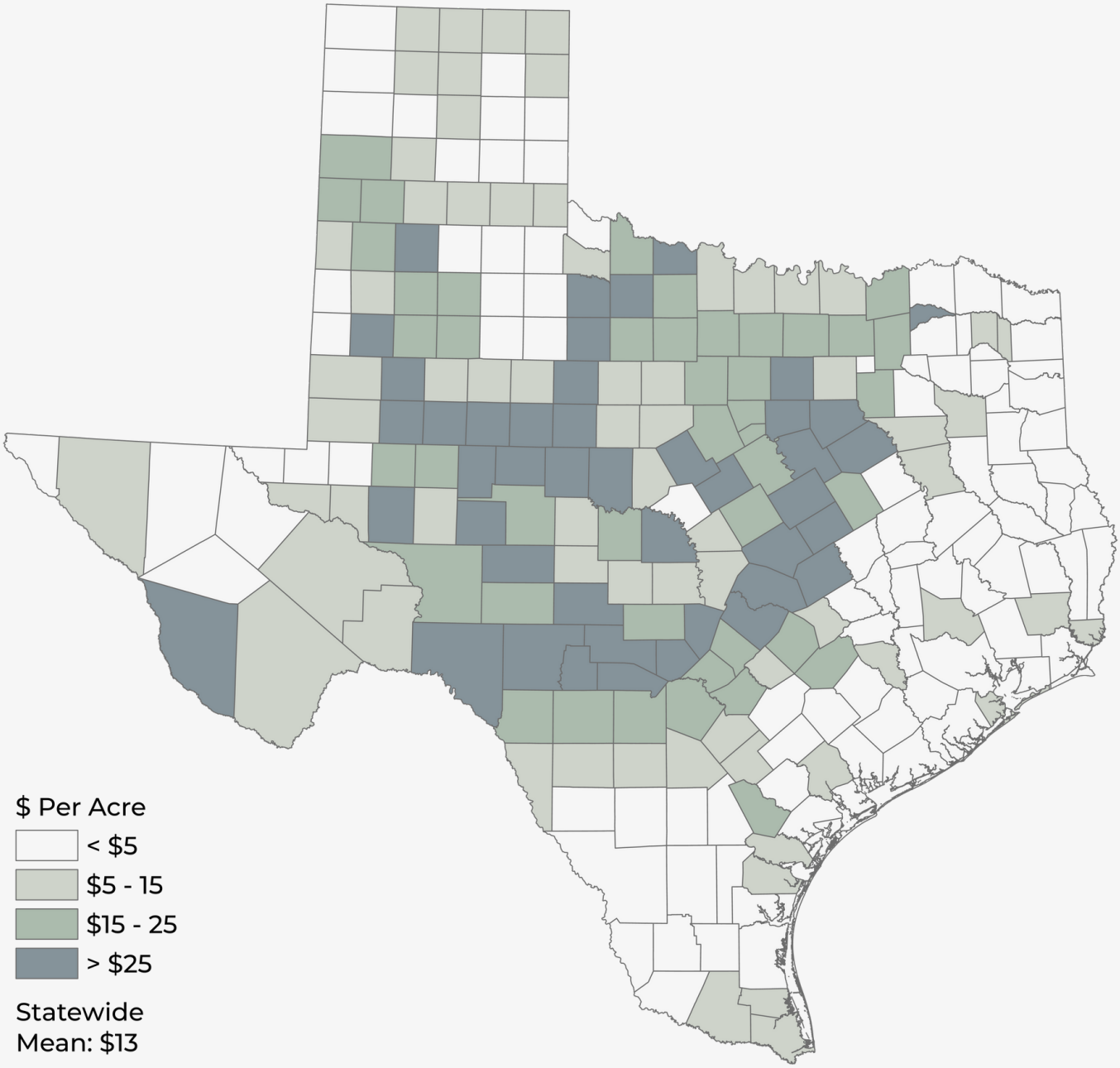
AIR QUALITY AND AIR POLLUTION REMOVAL

Average annual payments ($/acre/year) made to improve, maintain, or conserve air quality and air pollution removal from NRCS conservation practices implemented in Texas from 2015 to 2020.



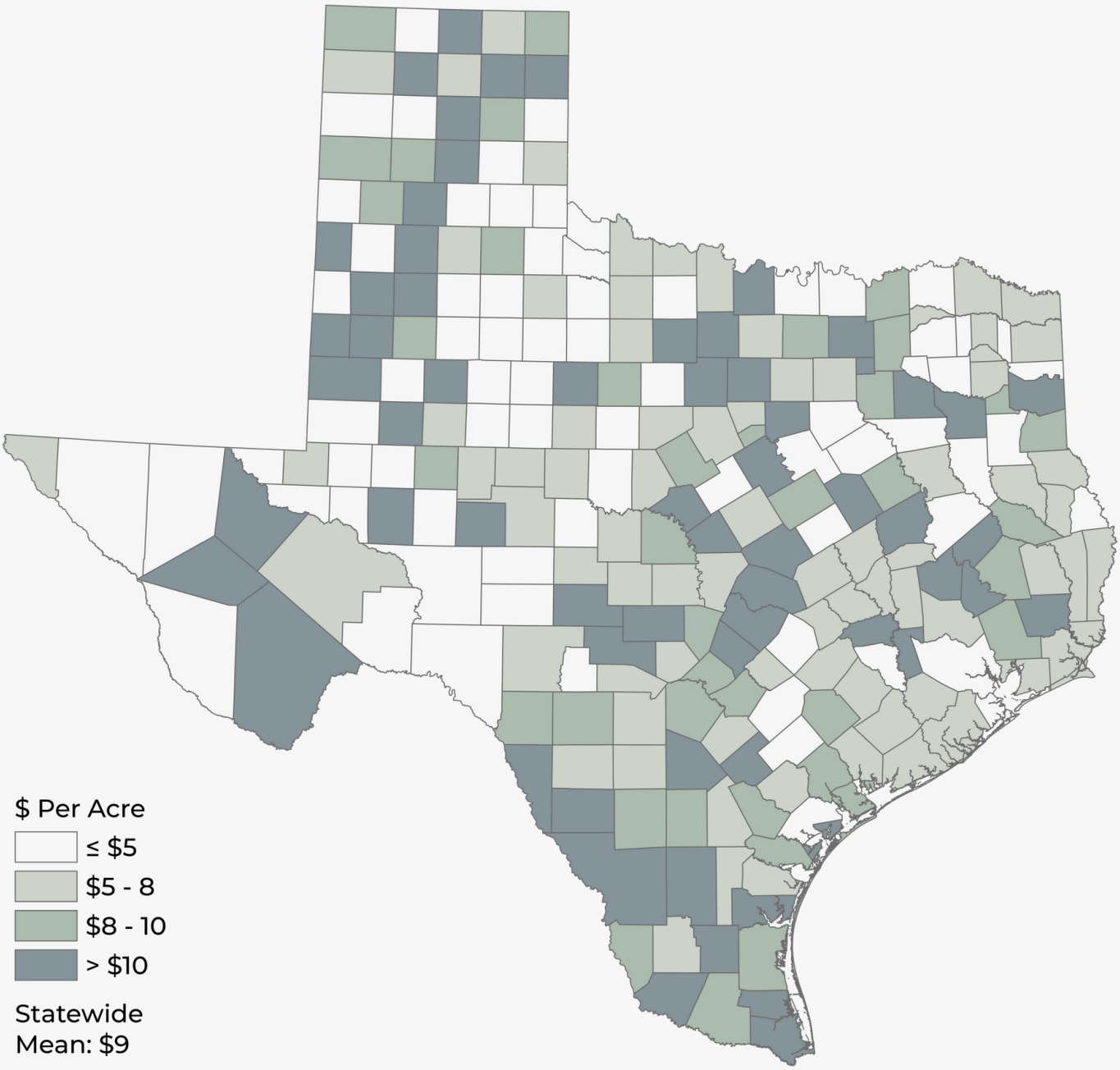
CARBON STORAGE AND SEQUESTRATION

Average annual payments ($/acre/year) made to improve, maintain, or conserve carbon storage and sequestration from NRCS conservation practices implemented in Texas from 2015 to 2020.



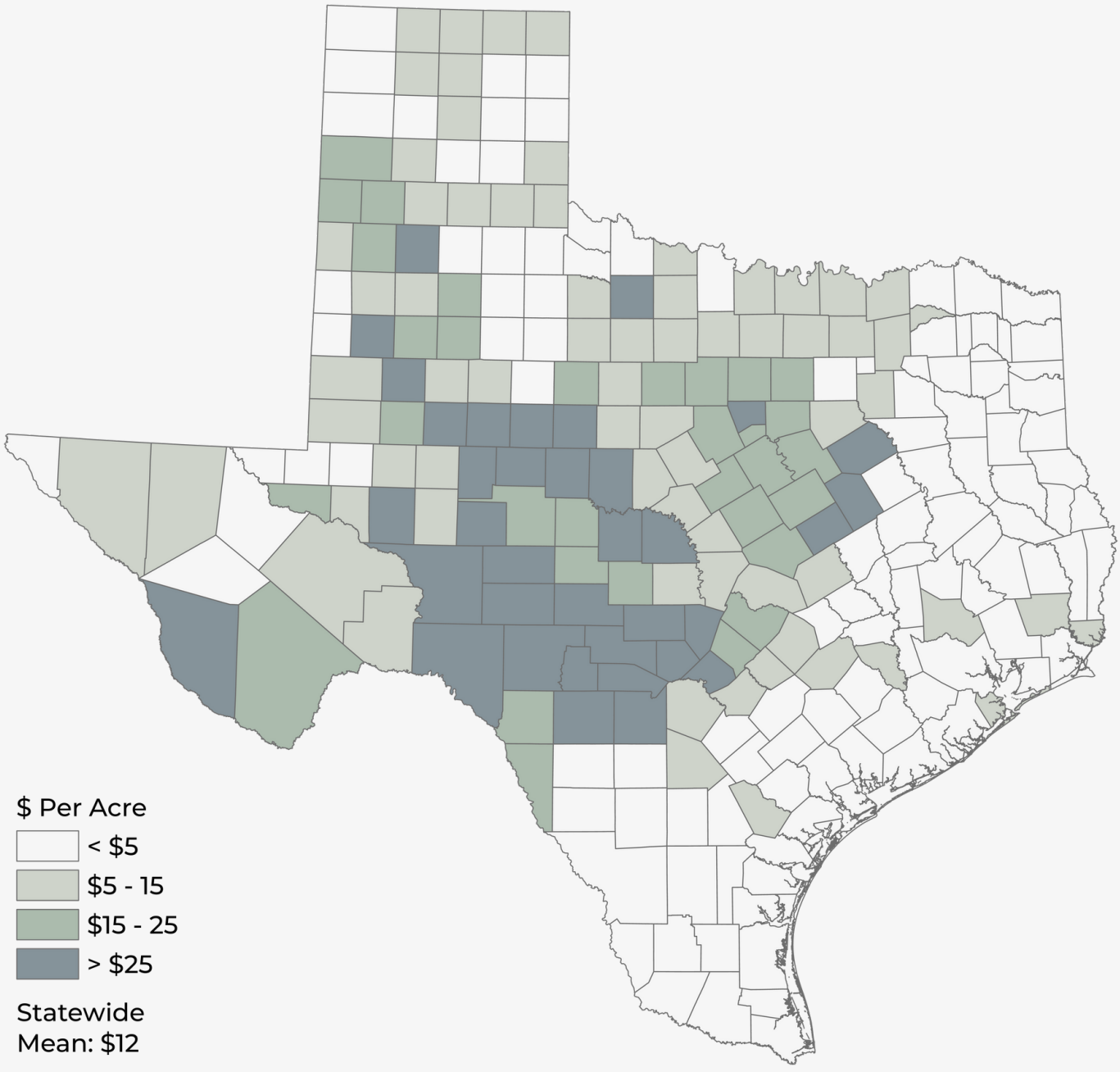
RECREATION (CONSUMPTIVE HUNTING)

Average (geometric mean) annual hunting lease price ($/acre/year) by Texas county from 2014 to 2018.



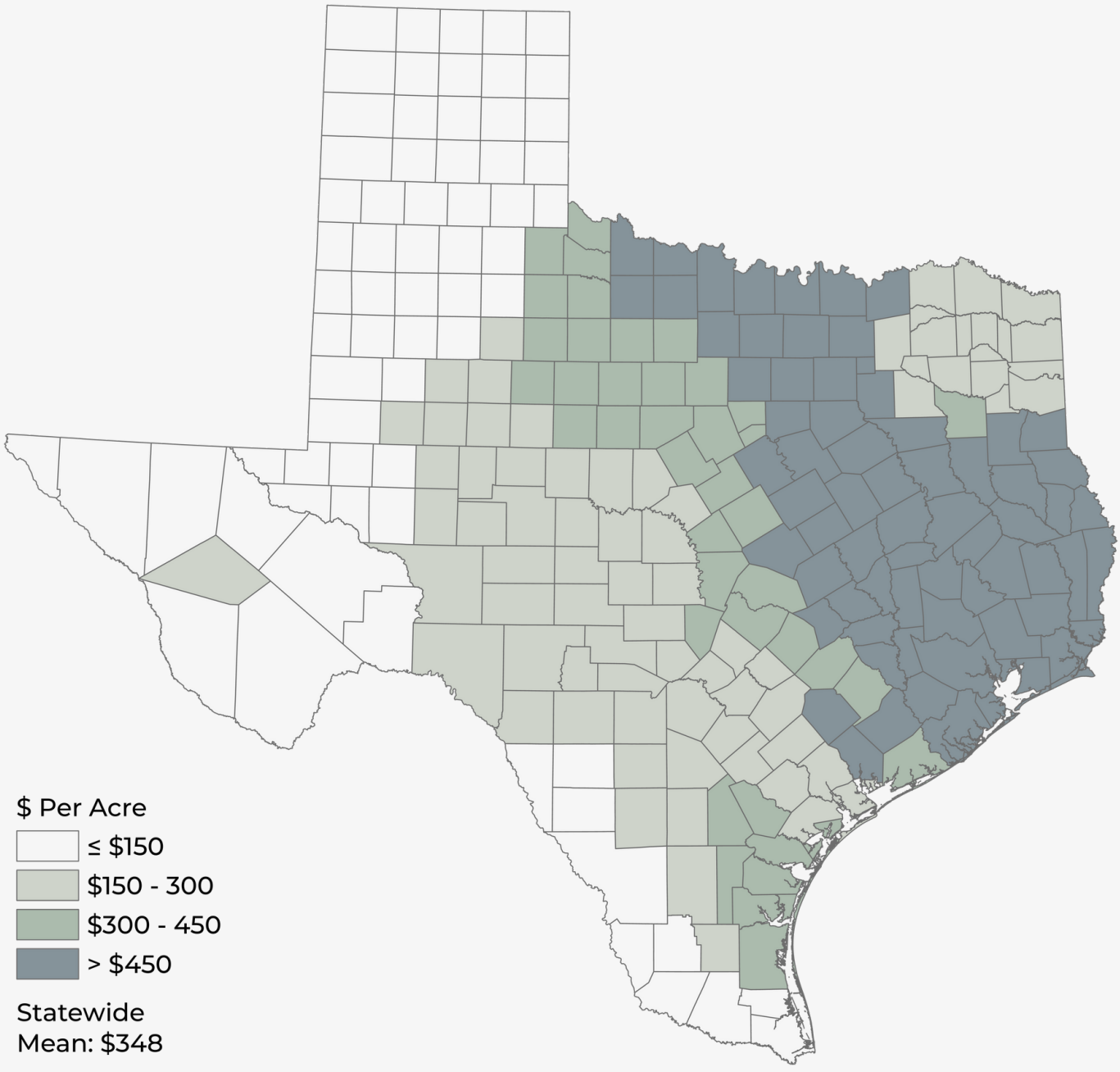
RECREATION (NON-CONSUMPTIVE)

Average annual payments ($/acre/year) made to improve, maintain, or conserve non-consumptive recreation from NRCS conservation practices implemented in Texas from 2015 to 2020.



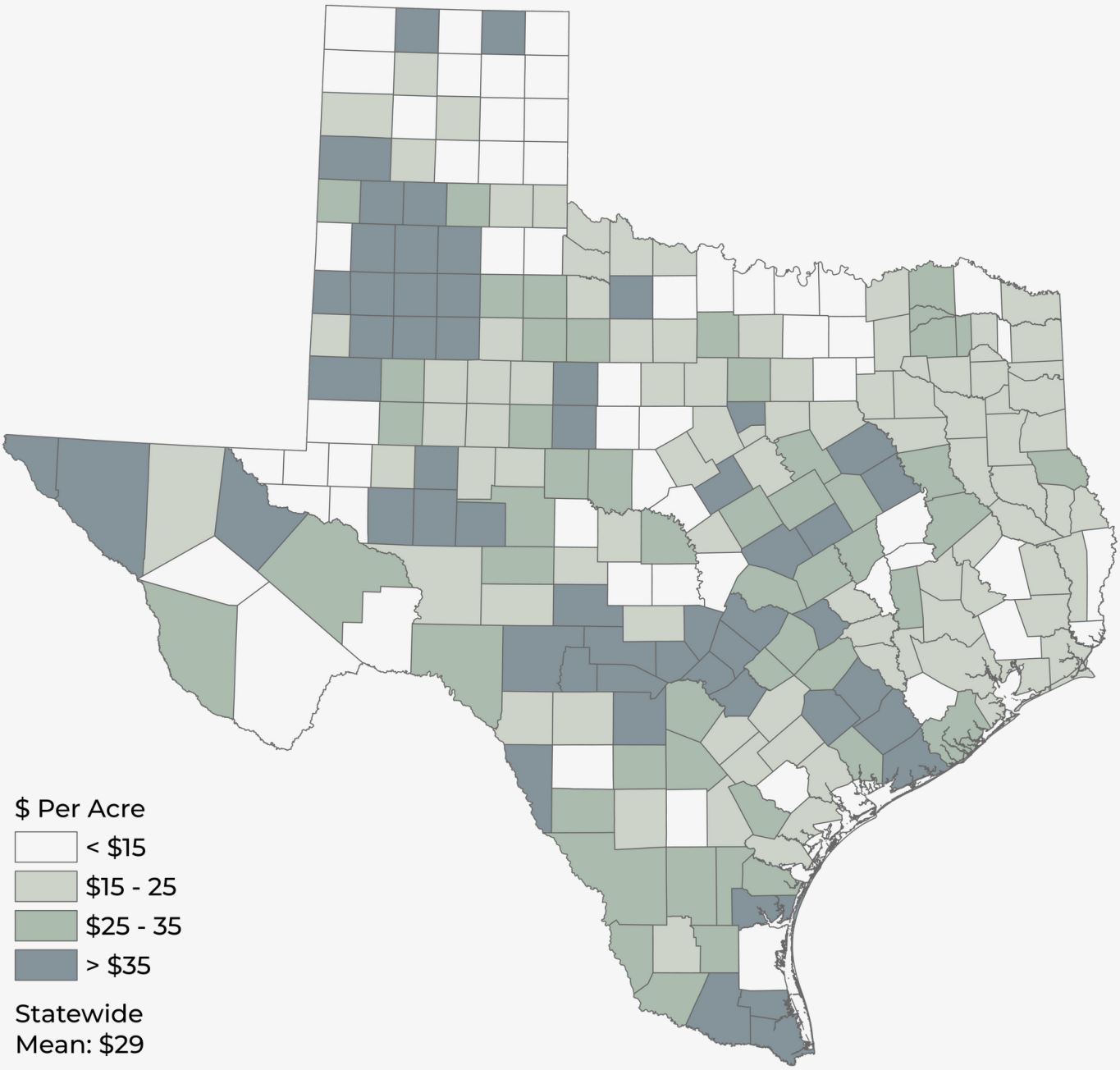
WATER QUANTITY (REPLACEMENT)

Annual replacement cost ($/acre/year) of captured water on 1 acre of working land by Texas county based on the Texas Water Development Board's Texas State Water Plan, 2022.



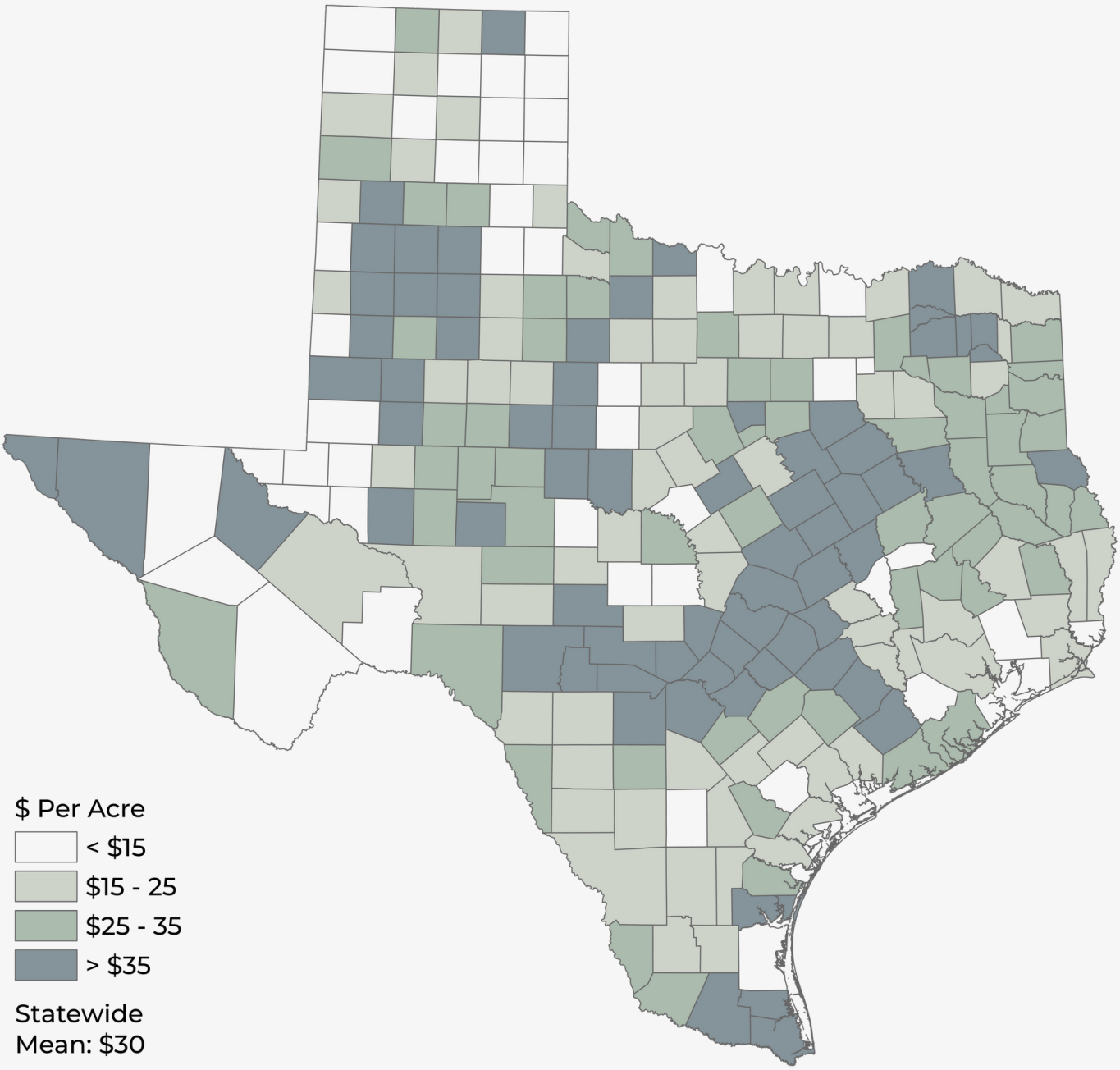
WATER QUANTITY (IMPROVEMENT)

Average annual payments ($/acre/year) made to improve, maintain, or conserve water quantity from NRCS conservation practices implemented in Texas from 2015 to 2020.



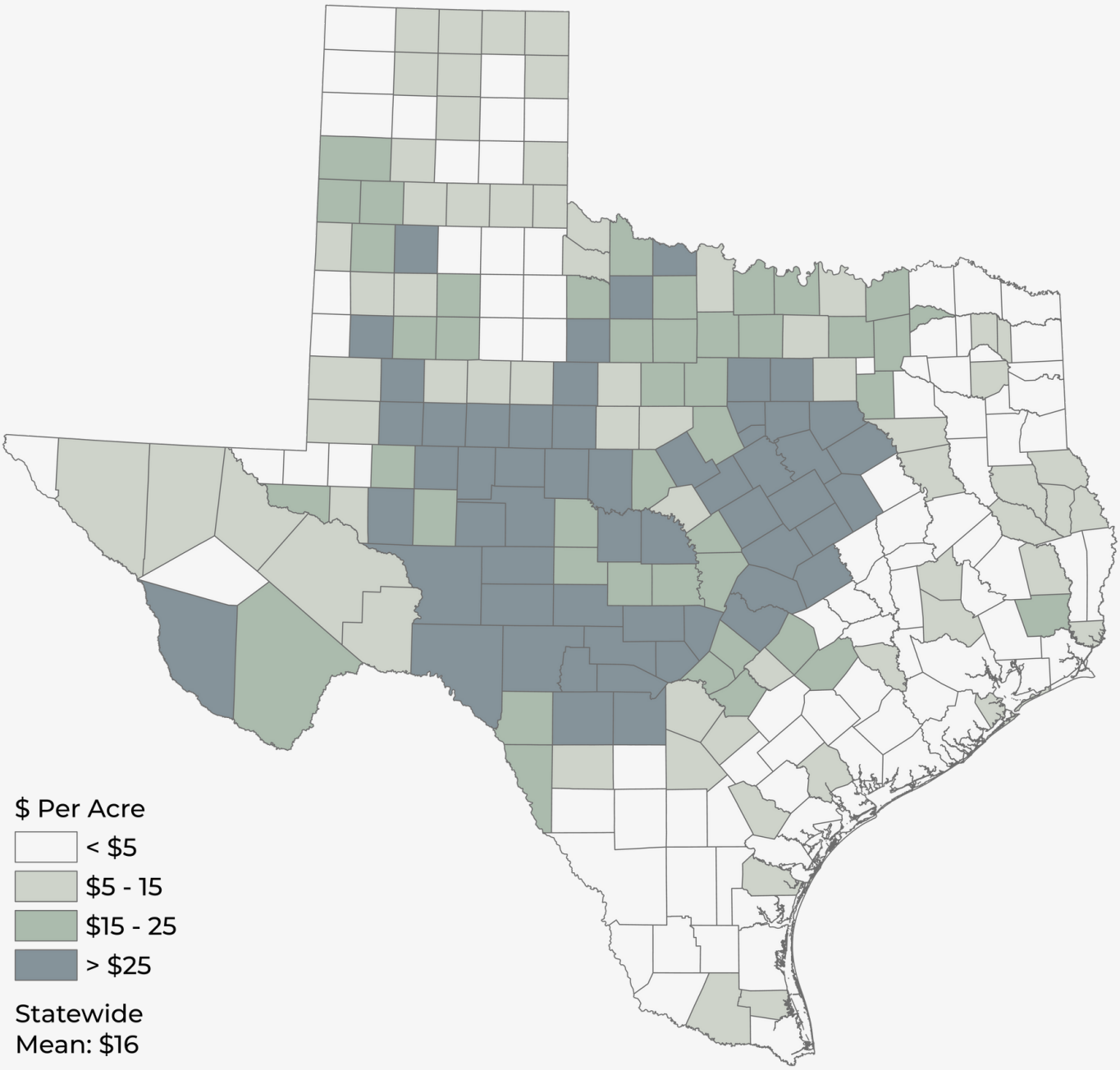
WATER QUALITY

Average annual payments ($/acre/year) made to improve, maintain, or conserve water quality from NRCS conservation practices implemented in Texas from 2015 to 2020.

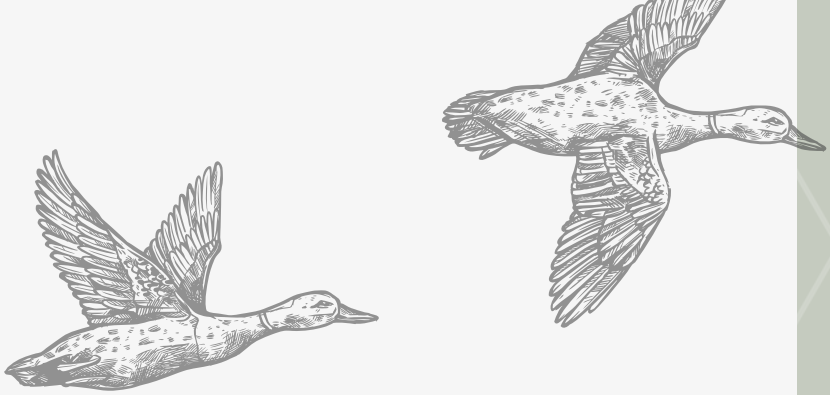


WILDLIFE HABITAT AND BIODIVERSITY

Average annual payments ($/acre/year) made to improve, maintain, or conserve wildlife habitat and biodiversity from NRCS conservation practices implemented in Texas from 2015 to 2020.



Summary



Texas working lands provide various ecosystem services benefiting not only our state and local economies, but also supporting critical ecological functions that protect and enhance communities. We identified 11 ecosystem services in this assessment, some of which have been historically overlooked and not readily recognized by the public for their societal benefits or values. Using a benefits transfer methodology was not feasible, as data were not widely available for Texas ecosystems and products. Instead, we approached our report using both market-based and willingness-to-pay models to calculate general estimates for ecosystem services across the state. A better understanding of these services, and a more thorough method for measuring their benefits will further refine the efforts in this study, and ultimately, result in better integration with our current market-based financial mechanisms.

It is important to note that our willingness-to-pay estimates are a measure of federal program investments spent across Texas on supporting or enhancing rural working lands at a field-based or operation level for a number of conservation goals. These estimates may not reflect the full or complete value for each ecosystem service, but instead serve to illustrate a portion of dollars already spent in restoration or conservation practices of current working lands.

Values presented here are likely conservative and, in many cases, underestimated for some services. Many landowner programs, such as those offered by NRCS, require a cost share that, for example, is not captured in this study. Furthermore, these estimates are limited in scope as they only account for participants in NRCS landowner programs and exclude values for non-participating rural lands. We used the willingness-to-pay model as a proxy to ecosystem service value and provide, at a minimum, an average and conservative estimate of investments made in ecosystem services. Additional research in this area should continue to better capture and quantify the value of ecosystem services.

Our results illustrate a wide diversity in ecosystem services and their values, mirroring the diversity found across Texas landscapes. To summarize these findings for the state as a whole, our working lands provide roughly $629/acre/year in ecosystem services. Assuming an average of $629/acre, the annual ecosystem services across our 141M acres of working lands in the state would total a conservative estimate of over $89B annually. These estimates provide some insight to serve policy makers, conservation organizations, and land managers with a better grasp of the full economic and ecological benefit Texas receives from these vital lands.

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