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RETURN ON ENVIRONMENT (ROE) STUDY

GREATER BONNE FEMME WATERSHED (GBFW)

Prepared for

Boone County, Missouri
5551 S. Tom Bass Road Room 205
Columbia, Missouri 65201

Prepared by

Geosyntec Consultants, Inc.
250 S. Marquette Ave.
Minneapolis, MN 55104

Project Number: MN2686

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Geosyntec consultants

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ACRONYMS AND ABBREVIATIONS

%	percent
ACS	American Community Survey
AFT	American Farmland Trust
BMP	best management practice
CDC	Center for Disease Control and Prevention
COCS	cost of community services
CPI	Consumer Price Index
CPI-M	Consumer Price Index for Medical Care
FEMA	Federal Emergency Management Agency
FRM	flood risk management
FY	fiscal year
GBFW	Greater Bonne Femme Watershed
GBFWI	Greater Bonne Femme Watershed Initiative
HAZUS	Hazards United States
IMPLAN	Impact Analysis for Planning
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
LULC	land use and land cover
MCDA	multicriteria decision analysis
MDT	Missouri Division of Tourism
MoDNR	Missouri Department of Natural Resources
NAICS	North American Industry Classification System
NatCap	Natural Capital Project
NIH	National Institute of Health
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NRPA	National Recreation and Park Association
OSHA	Occupational Safety and Health Administration
ROE	return on environment
RUVD	Recreation Use Values Database
U.S.	United States

USACE	United States Army Corps of Engineers
USD	United States Dollars
USEPA	United States Environmental Protection Agency
WBP	watershed-based plan

EXECUTIVE SUMMARY

Boone County, Missouri has experienced significant growth. The associated land development across the Greater Bonne Femme Watershed (GBFW) has detrimentally impacted water resources, with elevated E. coli levels being the primary water quality issue. To combat this and other present and future water quality challenges in GBFW's waterways, Boone County and its partners launched the Greater Bonne Femme Watershed Initiative (GBFWI) to develop a non-regulatory watershed plan for managing the GBFW.

The plan's overarching goal is to foster watershed management that invests in the environment and allows communities and their economies to grow and thrive. The GBFWI plan has been organized into "four pillars" of work corresponding to implementation of agricultural best management practices (BMPs), wildlife habitat restoration, outreach and communication, and contribution of healthy soil and water to the quality of life for people (water quality connections).

Successful development and implementation of the plan requires input, support, and action from a diverse group of stakeholders. To enhance communication with stakeholders and inform future water quality connection efforts, Boone County commissioned a return on environment (ROE) study within this plan's Outreach and Communication pillar. The natural capital contained in the GBFW directly contributes to economic activity within Boone County, particularly in terms of industries that support outdoor recreation and tourism. This ROE Study describes the GBFW's regional contributions and assets (benefits) in economic terms.

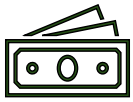
This ROE study highlights the importance of preserving, restoring, and protecting natural resources and capital by quantifying the current economic value (in USD) of ecosystem services and natural resources and by illustrating their societal benefits to community well-being and economic stability.

This Return on Environment Study estimates the current value of ecosystem services and natural resources within the Greater Bonne Femme Watershed. Our economic analysis of five benefit categories: 1) direct use benefits, 2) environmental (indirect use) benefits, 3) economic activity, 4) property value benefits, and 5) community cost savings identified the following economic value and benefits to the community:

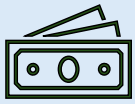
$363M to $548M
in annual recreation benefits

$460M to $1B+
in avoided healthcare and workplace costs (e.g., physical activity related to recreation)

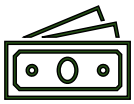
$765M
in prevented flood damage via stormwater retention



$11M
of annual economic tourism spending supported by activities in the GBFW



$2M
in annual tax revenues captured by tourism-related spending



100+ jobs
supported by tourism-related activities in the watershed

$20,000 +
in added property value for structures located near open spaces

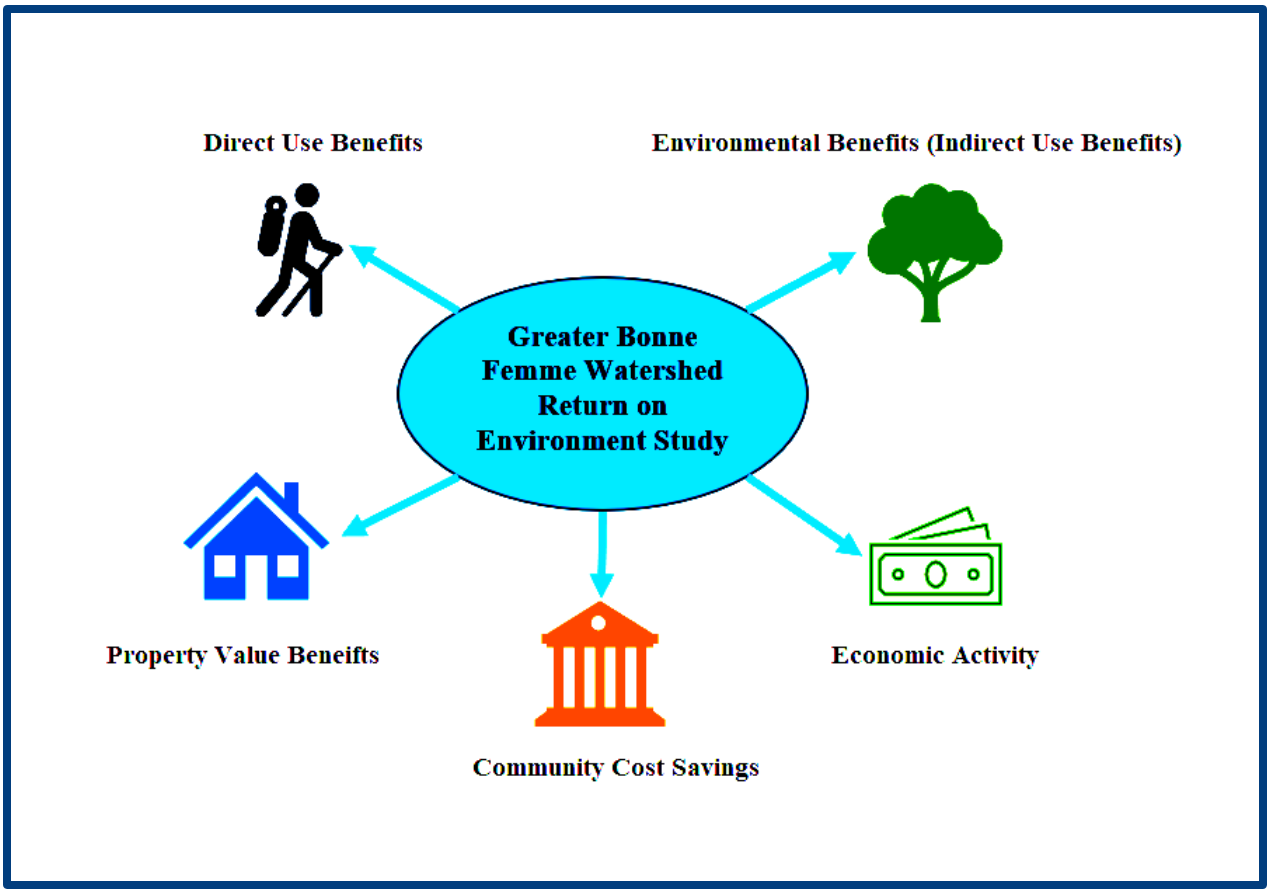


Figure ES-1: Conceptual Overview of Benefit Categories

Direct Use Benefits

The GBFW offers essential recreational benefits that enhance the well-being of residents and visitors, contributing to individual and community health. It provides diverse outdoor activities like hiking, fishing, kayaking, and birdwatching, supported by its rich natural capital, including protected forests, streams, and open spaces. These resources and activities improve physical and mental health and foster a deeper connection to nature. This ROE study highlights the substantial direct use benefits of recreating, and the costs avoided from related physical activity. The lasting community benefits shown below are attributable to preservation of open spaces:

Recreational benefits are estimated between $363 million and $548 million annually from various outdoor activities within the watershed.

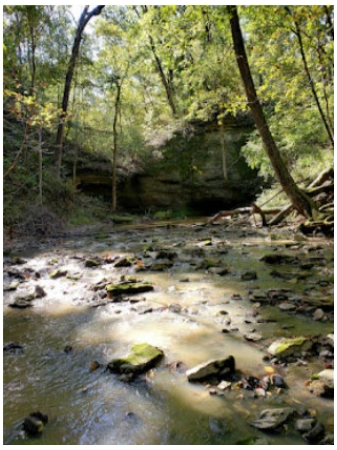
Physical activity associated with recreation in the watershed yields measurable cost savings by helping prevent chronic diseases and helping reduce the need for medical interventions. These healthcare cost savings amount to an estimated $49 million to $155 million annually in addition to preventing between approximately $148 million to $465 million in indirect medical costs.

Approximately $980,000 to $3 million is expected to be saved by businesses (collectively) each year from avoided workers' compensation claims in addition to an estimated $1 million to $13 million of costs avoided related to indirect workers' compensation costs.

Increased physical activity helps businesses (collectively) avoid between $261 million and $510 million annually in lost productivity costs due to reduced absenteeism and presenteeism.

Direct Benefits: Who Benefits?		
Private Citizens	**Businesses**	**Government**

Environmental Benefits (Indirect Use Benefits)



Environmental benefits are commonly defined as natural processes, resources, and assets that provide benefits to ecological health and water quality within a watershed. In the GBFW these natural resources and features offer benefits like water filtration, flood risk reduction, carbon dioxide storage, soil stabilization (erosion prevention), and pollinator habitats. All these aspects enhance public health and reduce infrastructure costs, highlighting the connection between nature and human well-being. Implementing best management practices (BMPs) to enhance these natural resources can also generate additional environmental benefits, which often translates into economic value for the community. This ROE study evaluates the quantitative and qualitative benefits of management actions like reducing nutrient, sediment, pesticide, and E. coli loads in streams, in addition to how natural vegetation provides flood protection. Key findings from the analysis are shown below:

- Reducing nitrogen and phosphorus loads, which is estimated to save anywhere from $4,000 to $5 million annually by avoiding cost of removal of these nutrients.
- Preventing 1 million to 4 million pounds of sediment from entering waterways, which will save approximately $38,000 to $2 million in water treatment costs.
- Mitigating flood risks through stormwater retention, which will avert approximately $765 million in potential infrastructure damages that could occur during a 100-year storm.
- Reducing pesticide use in the watershed has the potential to result in approximately $364,000 to $884,000 in annual benefits by reducing the human health and environmental risks associated with pesticide exposure.
- Reducing *E. coli* loads in the watershed has the potential to enhance recreational opportunities, reduce water treatment and infrastructure costs, and enhance public health.

Environmental Benefits: Who Benefits?		
Private Citizens	**Businesses**	**Government**

Economic Activity

The natural resources within the GBFW significantly boost Boone County's economy, especially through tourism and outdoor recreation. Columbia, Missouri, a popular destination for overnight visitors, benefits greatly with nearly 25% of travelers citing outdoor recreation as a reason for their visit. This ROE study estimates the economic impact of tourism spending related to activities in the GBFW, along with annual tax revenue from this spending.

The communities in and around the GBFW realize an estimated $11 million in economic benefits from tourism spending related to activities in the watershed, which supports over 100 jobs.

Approximately $2 million in tax revenues is collected each year from tourism spending.

The GBFW is a vital component of Boone County's environmental, economic, and social fabric. Its contributions to tourism, business attraction, and employee attraction highlight the interconnected nature of economic and environmental benefits.

Economic Activity: Who Benefits?		
Private Citizens	**Businesses**	**Government**

Property Value Benefits

The presence of open spaces within the GBFW enhances surrounding property values, reflecting both economic and lifestyle benefits for homeowners. Research confirms that proximity to open spaces, particularly in planned communities with greenways or recreational areas, significantly boosts property values. This ROE study estimated property value premiums for homes located near open spaces and found:

- Homes near open spaces in the GBFW have an average property value premium of approximately $23,000 to $30,000.
- Property value premiums increase homeowner equity, offering greater borrowing power and improved resale potential, and reflect the heightened desirability of properties near open space.
- Housing preference surveys also indicate a communal desire to reside close to parks and walkable areas, reinforcing the demand for properties near open spaces.

Property Value Benefits: Who Benefits?

Private Citizens

Community Cost Savings

Within this part of the ROE study, we explore community cost savings by comparing county tax revenue generated through various land uses to community service expenditures. Because each type of land use can generate different levels of tax revenue, we can evaluate whether the tax revenue generated in each land use category is greater than or lesser than the cost of public services. Key findings from this ROE study show:

Residential Land Use: for every $1 of revenue generated, the cost of public services is $1.02 to $1.67.

Commercial and Industrial Land Use: for every $1 of revenue generated, the cost of public services is $0.17 to $1.04.

Working and Open Lands: for every $1 of revenue generated, the cost of public services is $0.05 to $0.77.

Balanced land use planning is essential to help prevent fiscal imbalances.

Community Cost Savings: Who Benefits?

Government

Prioritized Recommendations

Stakeholder engagement feedback from focus groups and a public survey were used in evaluation of ROE benefit categories and provided guidance on prioritizing the below recommendations.

Table ES-1: Prioritized Recommendations

Rank	Measures	Examples
1	Restore wildlife habitat and advocate for water quality connections*	• Pursue conservation efforts that preserve or restore open space on public land. • Encourage regenerative agriculture practices that improve environmental and community health.
2	Improve water quality, implement BMPs, and conduct education and outreach	• Establish or enhance stream buffer corridors along streams to manage and protect waterways. • Conduct demonstration projects and tours to showcase BMPs in action. • Hold community events, distribute educational materials, begin incentive programs, and keep up-to-date with media marketing.
3	Pursue efforts related to long-term water quality goals and conduct community engagement and encourage participation	• Annually review programs that support adopting agricultural and residential BMPs. • Promote parks and recreational areas within the watershed.
*Water quality connections focus on how water quality intersects with human health, environmental health and animal and plant health in the watershed, incorporating a variety of concepts from regenerative agriculture to increasing health benefits from recreation in the GBFW (Boone County Resource Management 2024b).		

1. INTRODUCTION

1.1 Study Background

Boone County and its project partners launched the Greater Bonne Femme Watershed Initiative (GBFWI), which takes a broad approach to restoring and protecting water quality in the Greater Bonne Femme Watershed (GBFW). The overall goal of the GBFWI is to create a watershed management plan that Boone County and the Cities of Columbia and Ashland will adopt.

Before the GBFWI's development began, Boone County and its partners developed a nine-element watershed-based plan (WBP) in collaboration with the Missouri Department of Natural Resources and the United States Environmental Protection Agency (USEPA). On June 12, 2023, USEPA approved the WBP for Section 319 funding as an alternative restoration plan in lieu of total maximum daily loads. This status is valid for 5 years from the date of plan approval, at which time the WBP will need to be updated. The WBP outlines a path forward to restore and protect the streams in the GBFW. Modeling results indicated that installing agricultural best management practices (BMPs) would reduce *Escherichia coli* (*E. coli*) loading into streams (restoration) and simultaneously reduce nitrogen, phosphorus, and sediment loading (protection). The time frame for implementation of the WBP is 21 years.

In developing initial strategies for implementing the WBP, Boone County and its project partners determined that reliance on the agricultural BMPs would potentially be insufficient to restore and protect the streams in the GBFW. Boone County is now working with partners to develop the GBFWI, which will result in a watershed management plan that will integrate four conceptual pillars:

- **Pillar One, Implementation of the WBP:** This involves the voluntary installation of BMPs, such as cover crops, by agricultural landowners in the watershed and installation of demonstration projects. BMPs will increase the amount of living vegetation on the ground to slow, spread, and infiltrate runoff. Demonstration projects will allow the public to view the BMPs in action.
- **Pillar Two, Creation of a Watershed-Wide Wildlife Habitat Restoration Project:** The County will collaborate with agency partners, including the Missouri Department of Conservation and private wildlife groups, to work with landowners in the watershed to improve wildlife habitat on their property. Wildlife habitat restoration is projected to have similar water quality benefits to the installation of agricultural BMPs.
- **Pillar Three, Outreach and Communication:** The County will coordinate with key project partners to implement the GBFWI Outreach and Communication Plan to increase awareness about watershed and water quality issues, strengthen understanding among stakeholders of how land use activities are connected to water quality, and encourage BMP implementation for the protection and improvement of water quality in the GBFW.
- **Pillar Four, Water Quality Connections:** Healthy water and soil for humans, wildlife, and the ecosystem will be the focus of this element, incorporating a variety of concepts from regenerative agriculture to increased health benefits from recreation in the GBFW.

1.2 Study Purpose and Scope of Services

This return on environment (ROE) study analyzes the current value of natural resources, ecosystem services, and community sentiment through an economic lens and then translates this value into qualitative and quantitative (United States dollars [USD]) community benefits and impact. The ROE study was conducted to identify and measure the environmental, societal, and economic benefits of water resources and ecosystems within the GBFW. This ROE study does not attempt to replace the intrinsic values held by many but rather attempts to connect nature to a community's quality of life and wellbeing while quantifying the significant benefits that nature offers in a universal language (i.e., monetary values for natural system services) that more people can understand and support. This ROE study conveys to stakeholder groups the importance of restoring, maintaining, and protecting the health of the GBFW waters and ecosystem by quantifying and illustrating the watershed's environmental, societal, and economic benefits. This information is useful in guiding stakeholder decisions concerning land use, infrastructure, economic development, recreation, and tourism by providing a way to assess the value of nature and the widespread benefits it provides today's society. Five ecosystem service benefit categories were quantitatively evaluated within the GBFW, and qualitative discussion related to other ecosystem system benefits has been provided throughout.

1.3 Report Organization

The remainder of this report is organized into sections as follows:

- Section 2, The Greater Bonne Femme Watershed, provides background on the GBFW and a brief overview of existing watershed conditions.
- Section 3, Key findings, summarizes the ROE study along with key conclusions from the analyses.
- Section 4, Direct Use Benefits, discusses direct use benefits of the ecological end products within the GBFW in terms of recreation, health benefits, and cost savings related to healthcare and the workplace.
- Section 5, Environmental Benefits (Indirect Use), highlights the indirect use benefits from ecosystem services related to nutrient load reduction, sediment load reduction, urban flood risk management (FRM), and pesticide and *E. coli* load reduction.
- Section 6, Economic Activity, provides estimates of economic activity related to tourism spending. Benefits related to business and employee attraction and support for working farms and forests are also discussed.
- Section 7, Property Value Benefits, discusses the relationship between open space and increased property values.
- Section 8, Community Cost Savings, discusses the fiscal impacts of different land uses and highlights the potential for community cost savings provided by open spaces.
- Section 9, Prioritized Recommendations, identifies recommendations based on the set of analyses and stakeholder engagement.
- Section 10, References, identifies the sources cited herein.

1.4 Approach

This ROE study employs a multimethod approach to evaluate the monetary value of the environmental, societal, and economic benefits provided by the ecosystem services within the GBFW. A multimethod approach was chosen because the metrics contained within each benefit category require different analysis techniques to translate the ecosystem services into a benefit that is expressed in terms of monetary units. For example, to evaluate direct use benefits related to recreation, a net willingness-to-pay, also known as consumer surplus, approach was used to develop monetary estimations of the value of participating in recreational activities within the watershed. In contrast, to evaluate the economic and fiscal effects of tourism-related spending, benefits were estimated based on existing analysis published by the Missouri Division of Tourism (MDT) using Impact Analysis for Planning (IMPLAN).

In other cases, the Value Transfer Method was used to apply quantitative estimates from other studies or academic literature to the GBFW. The Value Transfer Method draws upon existing research to estimate economic values and cost savings by applying quantitative estimates for ecosystem services from existing studies to another similar context. The values from existing studies, also known as the source case, are transferred to the target case, which is the GBFW in this ROE study, and are used for benefit estimation purposes. The Value Transfer Method does not necessarily apply one specific method but rather applies a variety of methods based on the available data. Application of Value Transfer Method follows the steps outlined in Figure 1.

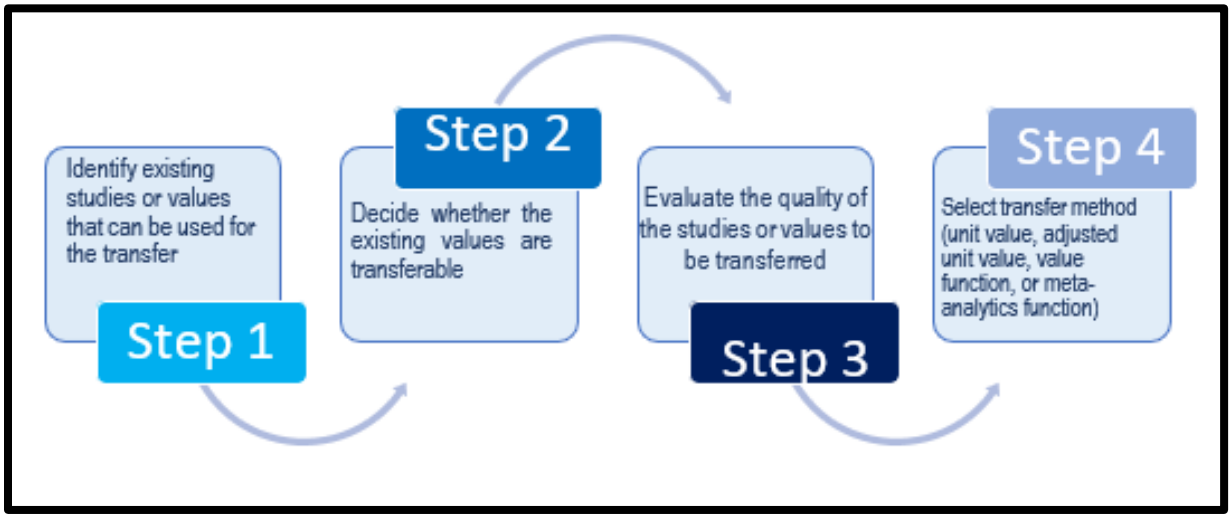


Figure 1: Conceptual Overview of the Value Transfer Method

A summary of the four different transfer methods noted in Step 4 of the figure above are as follows (Brander 2013):

- **Unit value transfer:** Value estimates are assumed to be correct on average and transferred without any form of adjustment.
- **Adjusted unit value transfer**: Value estimates are transferred with simple adjustments, typically for differences in income and price levels between the source and target cases.
- **Value function transfer:** The value function estimated is used for an individual source case in conjunction with information on target case characteristics to calculate the unit

value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service.

- **Meta-analytic function transfer:** This method is like the value function transfer method, but the value function is generated from the results of many valuation source cases instead of a single source case. The method assumes that similar preferences apply across all the study sites.

Additionally, Geosyntec adopted a process validation framework when deciding whether the Value Transfer Method is appropriate to quantify the benefits identified in this ROE study (Rolfe and Bennett 2006). Within this framework, there are five key requirements that need to be met for Value Transfer Method process validation. A summary of the five key requirements is provided below:

- The biophysical conditions in the source case must be similar to those in the target case.
- The environmental scale in the source case must approximate the target case.
- The socioeconomic characteristics of the population investigated in the source population must approach those of the target population.
- The frame or setting in which the valuation was made at the source must be close to the target's.
- The source study must have been conducted in a technically satisfactory fashion. For example, peer-reviewed studies and studies from authoritative sources are considered to have been conducted in a technically satisfactory fashion for the purposes of this study.

Section 4 through Section 8 contain the analysis for each benefit category that was evaluated as a part of this ROE study. Each section highlights the methods used to evaluate each benefit category and the corresponding results. In instances where ecosystem service benefits were not quantified, a qualitative discussion is provided that integrates observations and findings from reputable sources, such as academic research. Additionally, a survey was developed and distributed to stakeholders to better understand community perceptions on the value of healthy waterways, ecosystems, and greenspace. This survey included questions related to stakeholder engagement with the GBFW. A copy of the survey questions can be found in Appendix A. Survey results are incorporated throughout the ROE study to highlight the connection between the valuation of ecosystem services and stakeholder perceptions.

2 THE GREATER BONNE FEMME WATERSHED (GBFW)

2.1 Background

The GBFW lies in southern Boone County between the cities of Columbia and Ashland and includes the Bonne Femme and Little Bonne Femme watersheds. The Bonne Femme and Little Bonne Femme watersheds are collectively referred to as the GBFW. The GBFW tributaries include Bass Creek, Turkey Creek, Fox Hollow Branch, Smith Branch, Devil's Icebox Branch, Gans Creek, Clear Creek, and Mayhan Creek. The geographic area comprises 92.4 square miles, which is approximately 13 percent (%) of the land area within Boone County. Major land uses include row cropping, livestock grazing, residential development, and recreation. Most of the land along the stream segments in the GBFW is owned by private landowners (Boone County Resource Management and Project Partners 2023). Figure 2 displays a map of the GBFW.

The watershed is an attractive area near the rapidly growing cities of Columbia and Ashland. Population growth over the last 10 years has increased at a rate of 40%, which is above the 34% population growth for all of Boone County from 2000 to 2021. Growth rates in Boone County are anticipated to continue to rise over the next few decades.

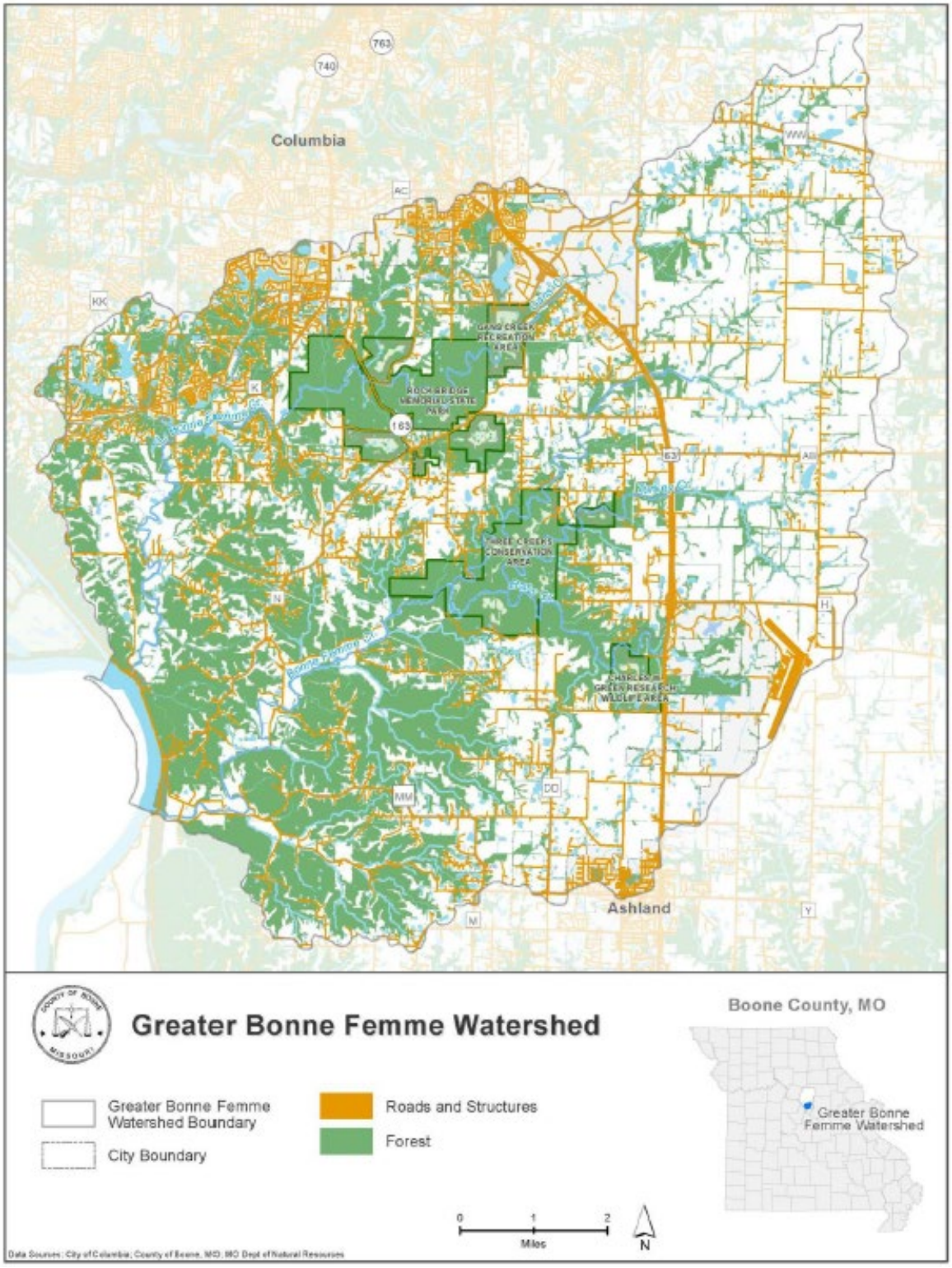


Figure 2: Greater Bonne Femme Watershed Aerial Map (Boone County Resource Management and Project Partners 2023)

2.2 Existing Watershed Conditions and Land Use

2.2.1 Land Use and Land Cover

Land use and land cover (LULC) within the GBFW exhibit a diverse composition, though agricultural activities remain predominant in the watershed. However, given recent growth rates, several large tracts of land previously used for agricultural purposes have been repurposed into planned residential developments or single-family homes situated on parcels ranging from 2.5 to 10 acres. Table 1 shows the breakdown of existing land cover in the GBFW (Boone County Resource Management and Project Partners 2023). A LULC map for the GBFW is depicted in Figure 3.

Table 1: GBFW Existing Land Cover

Land Use	Percent Land Use
Forest	43%
Pasture/Hay	33%
Cultivated Crops	13%
Urban	9%
Other	2%

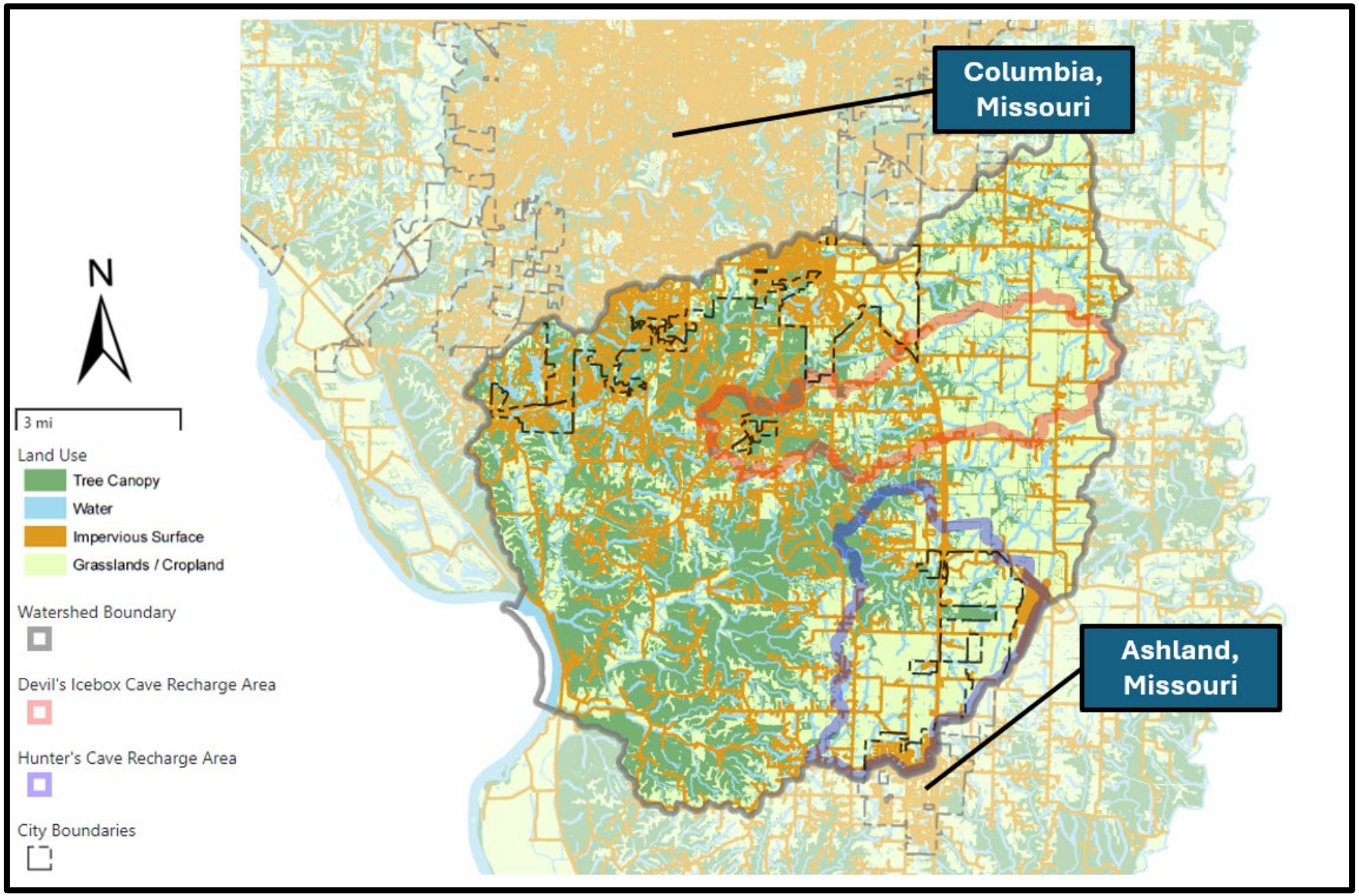


Figure 3: GBFW Land Use/Land Cover Map (Boone County Resource Management 2024a)

2.2.2 Watershed Conditions

The watershed contains sensitive karst[1] habitats and Outstanding State Resource Waters[2] that are vulnerable to water quality degradation. Due to the watershed's karst features, the pollution in surface water has a high impact on groundwater within the watershed. Consequently, land use and management practices have significant impacts on these unique ecosystems. Threats to these ecosystems include riparian area deforestation, failing on-site sewage systems, nutrients, pesticides, sediment in stormwater runoff from commercial and residential sites, and animal waste. Water quality concerns are currently present within that watershed and include elevated levels of *E. coli*, nutrients, and total suspended solids (Boone County Resource Management and Project Partners 2022).

2.2.3 Public Spaces

Figure 4 identifies primary public recreation areas in the GBFW. These open spaces are primary areas where many of the ecosystem service benefits are expected to be realized. Recreation sites in Figure 4 can be identified as follows: (A) Ashland City Park, (B) Ashland Ridge City Park, (C) Cascades Park, (D) Cosmo-Bethel Park, (E) Gans Creek Recreation Area, (F) Gates Park, (G) Nifong Park, (H) Philips Park, (I) Rock Bridge Memorial State Park, (J) Rock Quarry Park, (K) Three Creeks Conservation Area.

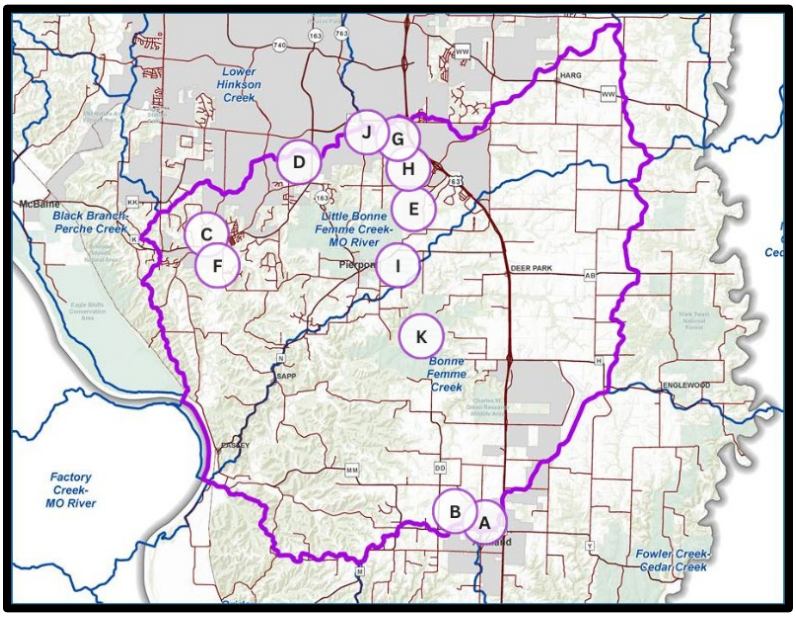


Figure 4: Key Public Recreation Areas in the GBFW

[1]According to the National Park Service (2025), *"Karst is a type of landscape where the dissolving of the bedrock has created sinkholes, sinking streams, caves, springs, and other characteristic features."*

[2] High quality waters with a significant aesthetic, recreational, or scientific value that are specifically designated as such by the Clean Water Commission (Cornell Law School 2025).

2.2.4 Watershed Benefits

Open space in the GBFW provides numerous benefits through ecosystem services. The following sections identify and quantify environmental, societal, and economic benefits in the GBFW for the following five benefit categories: direct use benefits, environmental benefits (indirect use), economic activity benefits, property value benefits, and community cost savings.

3 KEY FINDINGS

This section summarizes the findings of the five benefit categories evaluated in this ROE study. Details for each benefit category are provided in Sections 4 through 8.

3.1 Direct Use Benefits

Key findings related to the analysis of direct benefits within the GBFW include the following:

- An estimated $363 million to $548 million in direct use benefits are accrued annually by residents who participate in recreational activities in the GBFW. This translates into approximately $4,700 to $7,000 per household in Boone County, Missouri.
- Numerous physical and mental health benefits are linked to recreation and physical activity, such as increased life expectancy and better cognitive function. Open spaces in the GBFW provide an opportunity for individuals to realize these health benefits.
- Physical activity associated with recreation in the watershed contributes to an estimated $49 million to $155 million in avoided healthcare costs annually by preventing chronic diseases and reducing the need for medical interventions in addition to an estimated $148 million to $465 million of indirect medical costs avoided.
- Increased physical activity in the GBFW is estimated to save businesses approximately $980,000 to $3 million each year from direct costs avoided for workers' compensation claims in addition to an estimated $1 million to $13 million of costs avoided related to indirect workers' compensation costs.
- Physical activity helps businesses (collectively) avoid approximately $261 million to $510 million annually in lost productivity costs due to reduced absenteeism and presenteeism.

3.2 Environmental Benefits (Indirect Use)

Key findings related to the analysis of environmental benefits, or indirect benefits, within the GBFW include the following:

- Implementing BMPs to reduce nitrogen and phosphorus loads results in estimated annual cost savings of approximately $4,000 to $5 million annually.
- Implementing BMPs is expected to prevent 1 million to 4 million pounds of sediment from entering waterways, avoiding an estimated $37,000 to $2 million in avoided water treatment costs annually.
- Retaining stormwater by natural infrastructure (e.g., forests, riparian buffers, and vegetation) mitigates flood risks, averting approximately $765 million in potential infrastructure damages at the 100-year rainfall event, in 2024 dollars.
- It is estimated that consumers and farmers in the GBFW would be collectively willing to pay between $364,000 and $884,000 per year to reduce or avoid the human and environmental health risks associated with pesticide use.
- Reducing *E. coli* and pesticide loads enhances water quality. Improved water quality supports recreational opportunities, minimizes water treatment costs, and safeguards public health by decreasing the potential for waterborne diseases.

3.3 Economic Activity

Key findings related to the analysis of economic activity within the GBFW include the following:

- Approximately $11 million of economic activity is estimated to be generated each year from spending related to tourism and recreation, with over 100 jobs supported.
- The fiscal (tax) contributions, amounting to approximately $2 million in tax revenues across the federal, state, and local levels, underscore the watershed's value in contributing to public finances.
- The GBFW enhances business and employee attraction by offering quality-of-life improvements. Open spaces like those within the watershed support physical and mental well-being, fostering a healthier and more productive workforce. Three primary quality-of-life benefits identified are improved cognitive function, increased instances of happiness and lower instances of depression, and a reduction of adverse outcomes for vulnerable populations. Health benefits such as these have the potential to attract businesses and employees alike, especially from areas that lack access to open spaces or natural environments. Consequently, these quality-of-life improvements have the potential to help drive local economic activity by either attracting new businesses and employees or preventing existing businesses and employees from leaving.
- Businesses benefit from the attractive environment provided by open spaces, which can be ideal for locating new or expanding existing operations. Furthermore, the watershed creates vibrant settings that stimulate commerce by increasing foot traffic, consumer spending, and overall economic activity.

3.4 Property Value Benefits

The following is a key finding related to the analysis of property values within the GBFW:

- Most homes near open spaces benefit from a property value premium estimated to be between approximately $23,000 and $30,000. This premium reflects increased equity, enhanced market desirability, and greater long-term investment stability for homeowners.

3.5 Community Cost Savings

Key findings related to the analysis of community cost savings within the GBFW include the following:

- Conversion of open space to residential development often leads to a negative fiscal impact on municipalities and school districts because residential land often generates insufficient tax revenue to cover associated public service costs.
- Estimates reflect that for every dollar of tax revenue generated by residential buildings, between $1.02 and $1.67 in public service costs are incurred. For every dollar of tax revenue businesses generate, between $0.17 and $1.04 of public service costs are incurred. Finally, for every dollar of tax revenue generated by agriculture, between $0.05 and $0.77 of public service costs are incurred.

4 DIRECT USE BENEFITS

4.1 Introduction to Direct Use Benefits

The GBFW offers significant recreational benefits that are vital to the well-being of its residents and visitors, contributing to both individual and community health. The GBFW provides diverse opportunities for outdoor activities such as hiking, fishing, kayaking, and birdwatching; all of which are supported by GBFW's rich natural capital, including protected forests, streams, and open spaces. These recreational opportunities enhance physical and mental health and foster a deeper connection to nature. Assessing the recreation and health benefits within the watershed highlights the importance of natural capital within the watershed and how preserving natural capital generates lasting returns through the ecosystem services provided.

This section focuses on the direct use benefits of ecological end products in the GBFW. Ecological end products are the relevant biophysical components of nature that are directly used or appreciated by humans; for example, natural elements like plants, animals, water quality, and landscapes are directly used or valued by humans and represent ecosystem benefits (USEPA 2024a). Direct use of an ecological end-product means that the user or beneficiary directly extracts the ecological end-product, directly interacts with the ecological end-product, or physically senses the ecological end-product in the environment. The direct use value (i.e., or direct use benefit) is the value received by individuals which are derived from direct contact with, use of, or enjoyment from the goods or services. This is the value people hold for a service that they use in any tangible way. These include consumptive uses, such as catch-and-keep fishing, and nonconsumptive uses, such as bird-watching (USEPA 2024a). The subsections below provide an analysis related to some of the direct use benefits of the GBFW.

4.2 Recreation Benefits

4.2.1 Method of Estimating Recreation Benefits

The economic value of recreation in the GBFW was estimated using community survey data and the Value Transfer Method for published net willingness-to-pay values. Willingness-to-pay represents the maximum price a customer is willing to pay for a product or service (Stobierski 2020). For estimating recreation benefits, willingness-to-pay is based on nonmarket values, which means that willingness-to-pay values are not derived from a market price that estimates a monetary value (Endalew et al. 2018). Therefore, willingness-to-pay values should not be interpreted as a monetary transfer but as a reflection of the nonmarket benefits provided by recreational opportunities provided in the GBFW. In other words, the willingness-to-pay values do not reflect real transactions; instead, they represent the estimated amount of money that the average consumer would be willing to spend on a service or activity if it were not freely available through the natural resources in the GBFW. Therefore, the values presented in this section should not be interpreted as income or revenue, but rather as the benefits derived from the free access to recreational opportunities within the watershed.

To estimate recreation benefits in the GBFW, Geosyntec applied willingness-to-pay values from the Recreation Use Value Database (RUVD). The 2016 update of the RUVD (Rosenberger 2016) contains 421 documents of economic valuation studies that estimated the use value of recreation activities in the United States (U.S.) and Canada from 1958 to 2015, totaling 3,192 estimates in per person per activity day units. These recreational use value estimates are measures of net

willingness-to-pay, or consumer surplus, for recreational access to specific sites or for certain activities at broad geographic scales (e.g., state or province, national). The RUVD does not contain information on marginal values for changes in site quality or condition (Rosenberger 2016). Given that RUVD use values are in 2016 price levels, the *Consumer Price Index for All Urban Consumers: All Items in U.S. City Average* (U.S. Bureau of Labor Statistics 2024a) was used to adjust recreational benefits from 2016 to 2024 price levels.

The recreation use values were then applied to the GBFW based on community survey data regarding recreation use and population estimates. A survey was developed by Geosyntec and distributed to the local community by Boone County to better understand community perceptions on the value of healthy waterways, ecosystems, and green space. The survey included questions pertaining to recreation in the GBFW and helped provide information related to the frequency of recreational use in the watershed. Specific recreation sites, also depicted in Figure 4, that were asked about in the survey are listed below:

- Ashland City Park
- Ashland Ridge City Park
- Cascades Park
- Cosmo-Bethel Park
- Gans Creek Recreation Area
- Gates Park
- Nifong Park
- Philips Park
- Rock Bridge Memorial State Park
- Rock Quarry Park
- Three Creeks Conservation Area

The survey was hosted on the Microsoft Forms platform, and Boone County advertised the survey through various methods, including email distribution lists, advertisements in various communal public spaces, and social media posts. Over a 46-day period, Boone County collected 190 anonymous survey responses. Survey questions and responses can be found in Appendix A. Although the number of responses is limited compared to the population that may recreate within the watershed, the results provide a useful starting point to gain insight related to community perceptions and engagement in recreational activities within the GBFW.

Survey responses indicate that 77% of respondents recreate in forests and conservation areas within the watershed once per month or more, with the most popular activities being walking, hiking/backpacking, wildlife watching, and birding/birdwatching. The recreational sites that respondents most frequently used were Rock Bridge Memorial State Park, Gans Creek Recreation Area, and Three Creeks Conservation Area. A total of 71% of respondents indicated that recreational activity is very important to them, and 21% of respondents indicated that it is important to them. Only 2% of respondents indicated that recreational activities in the above recreational areas are not important to them. Figure 5 depicts survey responses that reflect the perceived importance of recreational activities at key locations within the GBFW. Figure 6 displays responses related to the frequency of participation in recreational activities in key areas throughout the watershed. Figure 7 depicts the survey results where most respondents indicate that they recreate in forests and conservation areas within the GBFW once per month or more. Figure 8 shows the types of recreational activities that respondents prefer to engage in within the GBFW. A copy of the full list of survey questions and responses is available in Appendix A.

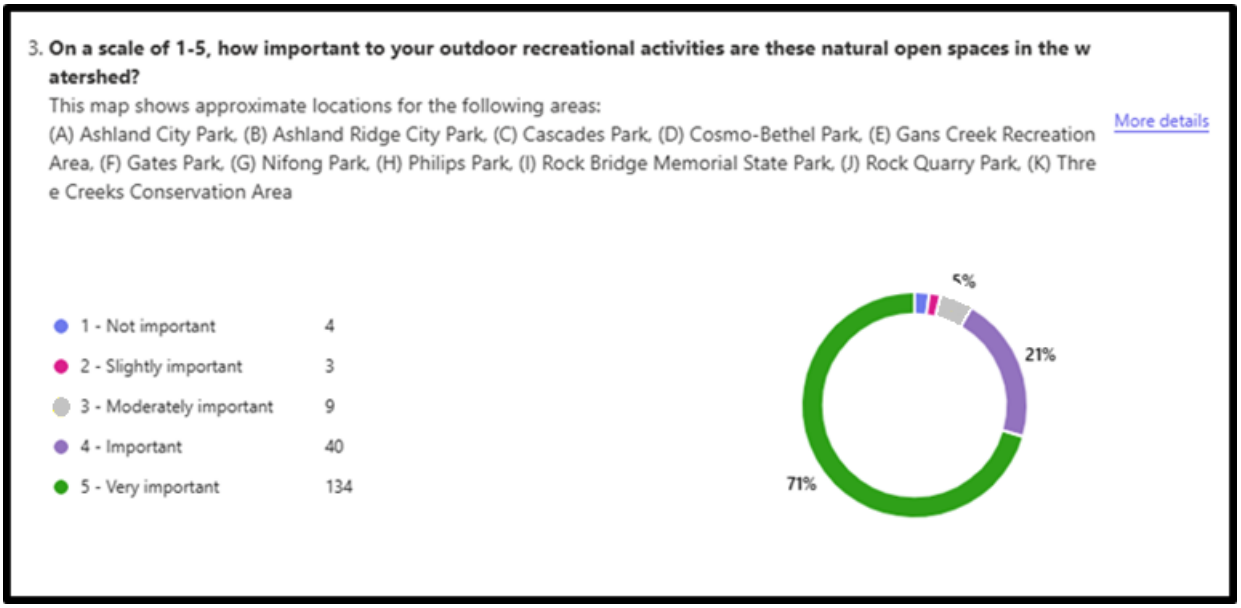


Figure 5: Survey Results: Importance of Recreational Activities in the GBFW

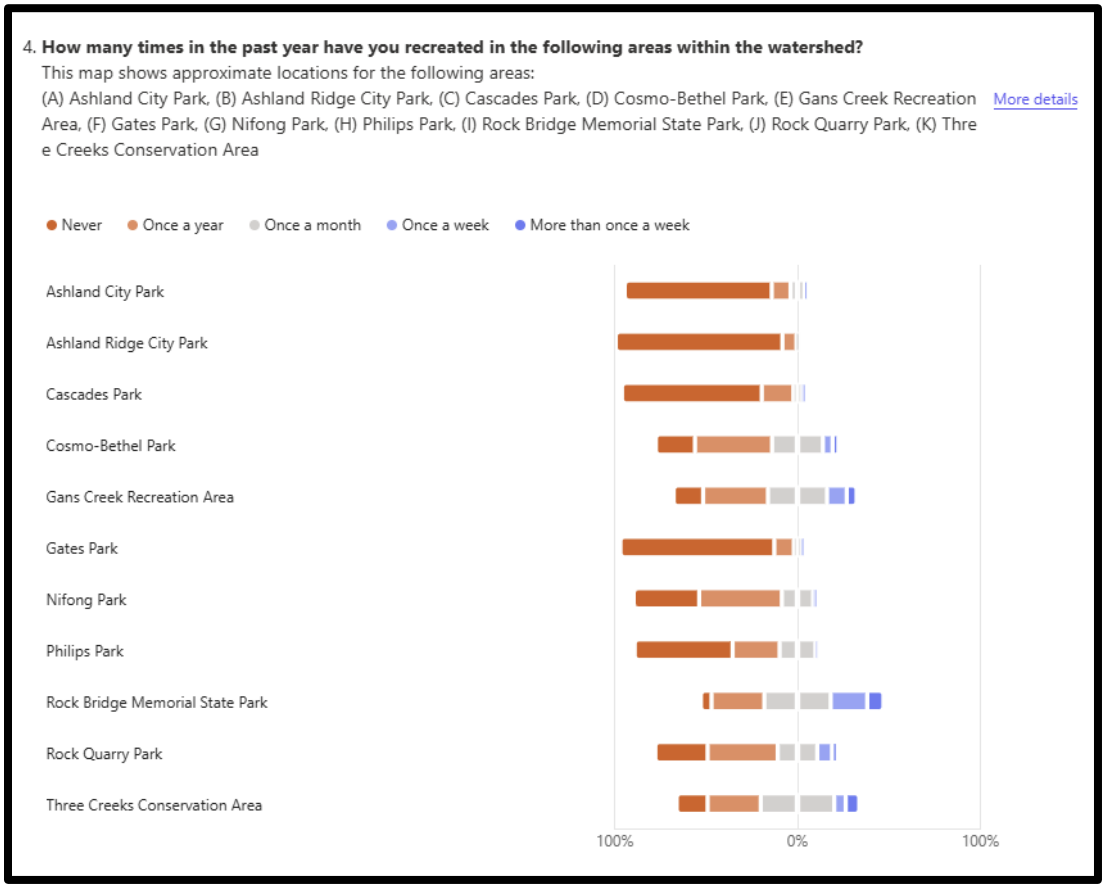


Figure 6: Survey Results: Frequency of Recreation at Key Locations in the GBFW

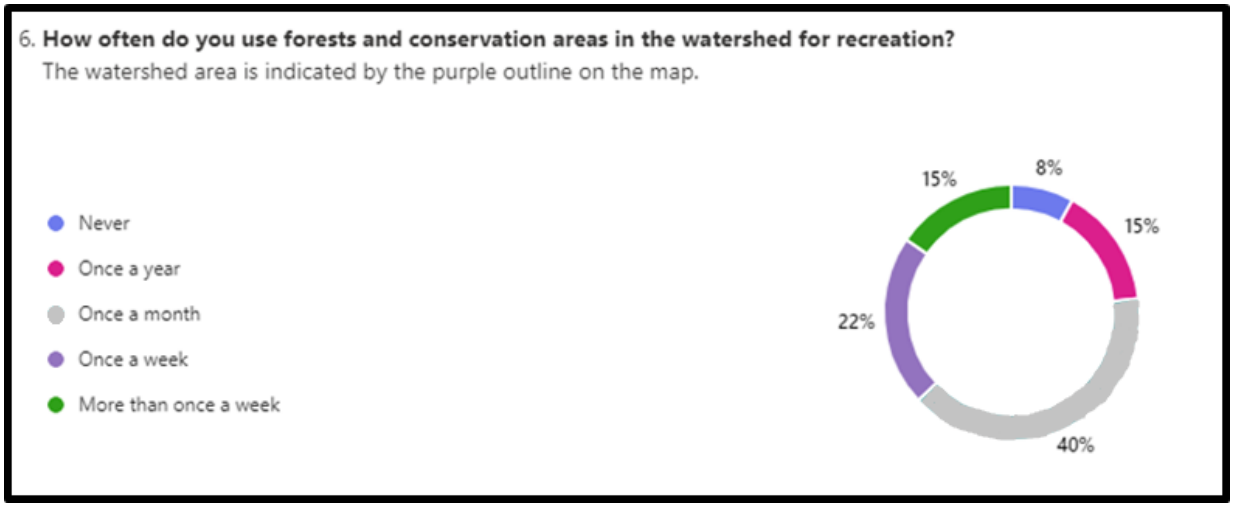


Figure 7: Survey Results: Frequency of Forests and Conservation Area Use for Recreation in the GBFW

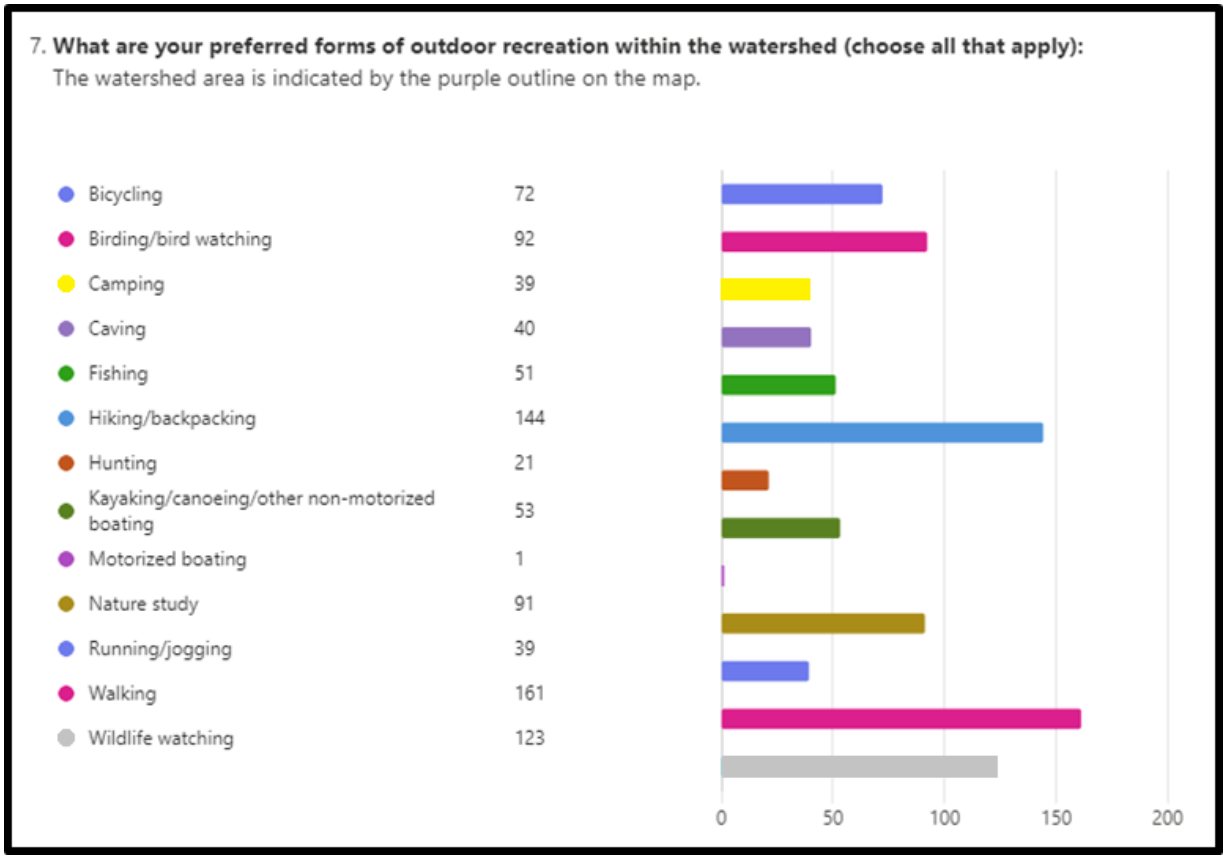


Figure 8: Survey Results: Outdoor Recreation Activity Preference in GBFW

Below are some observations based on the survey results:

- Activities such as walking, hiking/backpacking, and wildlife watching highlight a strong preference for environmentally low-impact, nature-oriented activities.
- Nature-focused activities (e.g., nature study, birding) show a strong appreciation for intact ecosystems.
- There is a low preference for motorized boating and hunting, which reflects limited demand for environmentally high-impact, nature-oriented activities.

These survey results indicate that respondents who recreate within the watershed value activities that require intact and healthy ecosystems, which aligns with Pillar Four of the GBFWI.

Geosyntec compared findings in the GBFW Community Survey with similar recreation surveys. The following are some examples of the constancies observed between the GBFW Community Survey and other nationwide surveys—one survey conducted by the Outdoor Foundation in 2024 (Outdoor Foundation 2024) and one survey conducted by the National Recreation and Park Association (NRPA) in 2024 (NRPA 2024):

- Walking, bicycling, and running and jogging were identified as top activities among all three surveys.
- Respondents in the NRPA survey and the GBFW Community Survey emphasized the importance of ease of access to green space and how it relates to well-being.
- A relatively high proportion of respondents in the Outdoor Foundation survey and GBFW Community Survey indicated a preference for hiking as an activity.

Conversely, the following inconsistencies were observed among the three surveys:

- The NPRA obtained responses from 1,000 U.S. adults (i.e., 18 years or older). In comparison, the GBFW Community Survey received 190 anonymous responses. The number of respondents in the Outdoor Foundation survey is not stated.
- When accounting for individuals who participate in outdoor recreation in open spaces once per year or more, the overall participation rate was lower in the Outdoor Foundation Study (57.1%) and NRPA study (82%) than in the GBFW Community Survey (92%). Additionally, the Missouri Department of Natural Resources (MoDNR) states that approximately 61% of Missouri residents participate in outdoor recreation each year (MoDNR 2025).
- The Outdoor Foundation study showed that the percentage of respondents who engage in bicycling, camping, running, fishing, and hiking were substantially higher than respondents in the GBFW Community Survey.
- The Outdoor Foundation study indicated that the average number of outdoor outings per year was approximately 62.5 per person, which averages to approximately 5 outings per person per month. In contrast, the GBFW Community Survey indicated an average of 32 outdoor outings per year per person in forests and conservation areas, which averages out to about 2 to 3 outings per person per month.

Given the inconsistencies between the GBFW Community Survey and other outdoor recreation studies and the relatively small sample size of 190 participants in the GBFW Community Survey, a level of uncertainty is introduced when applying the survey data to the population of Boone County, particularly as it pertains to the frequency of participation in outdoor recreation. To adjust for the uncertainty in the frequency of participation, Geosyntec calculated a range of recreation benefits. The upper bound of the range does not adjust the survey responses in the benefit calculation, but the lower bound of the range adjusts the survey responses related to recreational frequency using an iterative proportional fitting, or raking, method (Pew Research Center 2018). This raking method includes taking a value that is known about the population and applying it to the survey response data. Next a scaling factor, or weight, is calculated to adjust the remaining survey responses proportionally. More detailed descriptions of how the upper and lower bounds of recreation benefits were calculated are described below.

4.2.1.1 Upper Bound Calculation

For calculation of the upper bound of recreation benefits, the recreational frequency indicated in the GBFW Community Survey was applied to the 2023 American Community Survey (ACS) population data estimates for Boone County, Missouri, (U.S. Census Bureau 2023) to develop the estimated number of individuals in Boone County who recreate within the GBFW at least once per year in forests and conservation areas. The population of Boone County was used as a proxy for estimating how many individuals recreate within the watershed based on survey participation rates and Boone County population data. The limitations of this approach include that it does not account for any substitution effects, where residents of Boone County may choose to recreate in similar areas outside of the GBFW. It also does not account for the recreation benefits realized by those who live outside of Boone County and recreate within the GBFW.

As an example of how survey results were applied to Boone County population data, survey results show that 40% of respondents recreate in forests and conservation areas at least once per month. Applying this same participation rate to the population data for Boone County, approximately 75,000 individuals who reside in Boone County are estimated to recreate in forests and conservation areas within the GBFW once per month. Conversely, 8% of respondents indicated that they never recreate in forests and conservation areas within the watershed. We therefore estimate that approximately 15,000 Boone County residents are not expected to participate in recreational activities in these areas and thus were factored out of recreational benefit estimates.

The annual number of recreational occurrences in the GBFW was determined by how many times an individual is expected to recreate within the watershed in a year based on the frequency indicated in survey responses. For example, if someone recreates within the watershed once per year, the value for recreational occurrences is 1, and if someone recreates within the watershed once per month, the value for recreational occurrences is 12.

A unit value transfer was applied to derive the mean recreation value of $69.05, which represents the average net willingness-to-pay in the U.S. and Canada for recreational activities contained in the RUVD (Rosenberger 2016). Using a standard error of 1.3 contained in the RUVD for the mean recreation use value, a 95% confidence interval was calculated to further understand the extent of the range. At a 95% level of confidence, the range falls between $66.50 and $71.60 for recreation use values for the U.S. and Canada, which indicates low variability in recreation use values and less potential for extreme values, as most of the statistical distribution is captured by this range.

The number of recreational occurrences was then multiplied by the mean recreation use value for the U.S. and Canada to estimate an aggregated economic value for recreation. The mean recreation value across the U.S. and Canada was used because although data for a smaller geographic area in the Midwest was available, it contains a relatively low sample size and a relatively high standard error compared to other regions. The result was divided by the number of households in Boone County (U.S. Census Bureau 2023) to estimate the recreation benefit per year per household in Boone County, Missouri.

4.2.1.2 Lower Bound Calculation

Calculation of the lower bound of recreation benefits follows the same process as calculation of the upper bound, but a raking method was applied to the participation rates shown in Figure 7 to adjust the values to be more reflective of the frequency of participation in outdoor recreation in Missouri. In the GBFW Community Survey, 8% of respondents indicated that they never recreate in forests and conservation areas within the GBFW. This value was adjusted to 39% based on MoDNR (2025) stating that 61% of Missouri residents participate in outdoor recreation. A scaling factor of 0.663 was developed so that the survey responses related to the frequency of recreation in the remaining groups of recreationalists would still retain their weight relative to each other when calculating recreational benefits. The scaling factor was calculated by taking the new percentage of the total number of individuals expected to participate in outdoor recreational activities (61%) and dividing it by the same total from the survey results (92%). Given an adjusted value of 39% of residents never participating in outdoor recreation, the scaling factor was multiplied by the frequency of recreation indicated by respondents in the GBFW Community Survey to get an adjusted percentage for each category. The adjusted values for recreation frequency results are shown in Table 2. The adjusted percentages were then used to calculate lower bound recreation benefit estimates using the same process outlined in the upper bound calculation.

Table 2: Adjusted Values for Frequency of Recreation in the GBFW

Frequency of Recreation	Percent of Total Respondents	Scaling Factor	Adjusted Percentages
Never	8%	N/A	39%
Once per year	15%	0.663	10%
Once per month	40%		26%
Once per week	22%		14%
More than once per week	15%		10%
Total	**100%**		**100%**

4.2.2 Results of Recreation Benefits Analysis

This analysis estimates that residents are willing to pay between $363 million and $548 million to participate in recreational activities in the GBFW. Given 2023 ACS data estimating 76,762 households in Boone County (U.S. Census Bureau 2023), the annual value of between $363 million and $548 million is approximately equivalent to between $4,700 and $7,000 per household in Boone County, Missouri, which is the estimated annual value of net willingness-to-pay, or consumer surplus, by each household every year by having the ability to recreate for free in the GBFW.

Table 3 outlines pertinent survey results, ACS population data for Boone County, RUVD use values, and Consumer Price Index (CPI) data along with recreational benefit estimates. Table 4 shows the same, but with adjusted values for the frequency of recreation.

Table 3: GBFW Recreation Benefit Estimate (Upper Bound)

Frequency of Recreation	Percent of Total Respondents[1]	Recreational Interactions per Year for a Single Individual by Frequency[2]	Total Number of Residents by Recreational Frequency[3]	Total Interactions per Year	General Recreation Use Value[4]	Recreation Benefit[5]	CPI Adjustment Factor[6]	Recreation Benefit[7]
Never	8%	0	15,037	0	$69.05	$0	1.303	$0
Once per year	15%	1	29,071	29,071		$2,007,353		$2,616,000
Once per month	40%	12	75,184	902,208		$62,297,462		$81,180,000
Once per week	22%	52	41,100	2,137,200		$147,573,660		$192,304,000
More than once per week	15%	104	29,071	3,023,384		$208,764,665		$272,042,000
Total	**100%**	**N/A**	**189,463**	**6,091,863**		**$420,643,140**		**$548,141,000**

[1] Results based on responses from the GBFW Community Survey (Appendix A).

[2] For respondents who indicated that they recreate in the GBFW more than once per week, it was assumed that they recreate twice per week, totaling to 104 recreational interactions in the GBFW per year. This assumption was made because the survey responses are not detailed enough to inform the exact number of days that these individuals recreate in the watershed. This might lead to an underestimation of participation, and consequently, an underestimation of recreation benefits for this group of recreators.

[3] The total population estimate is based on 2023 American Community Survey (ACS) Data from the U.S. Census Bureau for Boone County, Missouri. The total population estimate was stratified based on the recreational frequency indicated in survey responses.

[4] General recreation use values are derived from the Recreation Use Values database (Rosenberger 2016).

[5] Dollar values are in 2016 price levels and rounded to the nearest thousands ($1,000's).

[6] The Consumer Price Index (CPI) adjustment factor was calculated using the *Consumer Price Index for All Urban Consumers: All Items in U.S. City Average* (U.S. Bureau of Labor Statistics 2024a).

[7] Dollar values are in 2024 price levels and rounded to the nearest thousands ($1,000's).

Table 4: GBFW Recreation Benefit Estimate (Lower Bound)

Frequency of Recreation	Percent of Total Respondents[1]	Recreational Interactions per Year for a Single Individual by Frequency[2]	Total Number of Residents by Recreational Frequency[3]	Total Interactions per Year	General Recreation Use Value[4]	Recreation Benefit[5]	CPI Adjustment Factor[6]	Recreation Benefit[7]
Never	39%	0	73,891	0	$69.05	$0	1.303	$0
Once per year	10%	1	19,275	19,275		$1,330,939		$1,734,350
Once per month	26%	12	49,850	598,200		$41,305,710		$53,825,589
Once per week	14%	52	27,251	1,417,052		$97,847,441		$127,505,279
More than once per week	10%	104	19,275	2,004,600		$138,417,630		$180,372,409
Total	**100%**	**N/A**	**189,542**	**4,039,127**		**$278,901,719**		**$363,437,627**

[1] Results based on adjusted responses from the GBFW Community Survey (Appendix A).

[2] For respondents who indicated that they recreate in the GBFW more than once per week, it was assumed that they recreate twice per week, totaling to 104 recreational interactions in the GBFW per year. This assumption was made because the survey responses are not detailed enough to inform the exact number of days that these individuals recreate in the watershed. This might lead to an underestimation of participation, and consequently, an underestimation of recreation benefits for this group of recreators.

[3] The total population estimate is based on 2023 American Community Survey (ACS) Data from the U.S. Census Bureau for Boone County, Missouri. The total population estimate was stratified based on the recreational frequency indicated in survey responses.

[4] General recreation use values are derived from the Recreation Use Values database (Rosenberger 2016).

[5] Dollar values are in 2016 price levels and rounded to the nearest thousands ($1,000's).

[6] The Consumer Price Index (CPI) adjustment factor was calculated using the *Consumer Price Index for All Urban Consumers: All Items in U.S. City Average* (U.S. Bureau of Labor Statistics 2024a).

[7] Dollar values are in 2024 price levels and rounded to the nearest thousands ($1,000's).

4.3 Health Benefits and Healthcare and Workplace Cost Savings

4.3.1 Method of Estimating Health Benefits

Health benefits are mainly discussed qualitatively in this section using the USEPA EnviroAtlas Eco-Health Relationship Browser (USEPA 2024b) and several academic papers that are related to recreation and physical activity. The Eco-Health Relationship Browser was used to highlight the linkages between forests and agro-ecosystems, recreation and physical activity, and various health benefits to help qualitatively describe the health benefits that conservation areas and open spaces provide in the GBFW. Examples of specific health benefits related to recreation and physical exercise are also highlighted in the discussion of health benefits.

In addition to the qualitative discussion related to health benefits, estimations of healthcare and lost productivity cost savings due to the recreation and physical activity that occurs within the GBFW were developed. The Value Transfer Method was used to transfer values from an ROE study conducted for several counties in Southeastern Pennsylvania (Delaware Valley Regional Planning Commission 2011a) to estimate healthcare and lost productivity cost savings. For purposes of applying the Value Transfer Method, Southeastern Pennsylvania is the source case and Boone County, Missouri, is the target case. The following counties in Pennsylvania were included in the source case: Bucks County, Chester County, Delaware County, Montgomery County, and Philadelphia County. These counties were chosen as the source case because the following requirements were met from the process validation framework discussed in Section 1.4:

- The biophysical conditions in Southeastern Pennsylvania are similar to those in Boone County. Both sites have sensitive karst areas and are prone to sinkholes (Boone County Government 2024, Commonwealth of Pennsylvania 2024). Both sites have somewhat comparable levels of forest coverage with similar forest characteristics, such as the relative distribution of various deciduous trees, management activities, growth, removal, and mortality rates (U.S. Forest Service 2024). Additionally, both sites boast a variety of ecosystems, including forests, rivers, and wetlands (Boone County Resource Management 2024b, Montgomery County 2024).
- The socioeconomic characteristics of the population in Southeastern Pennsylvania are similar to the socioeconomic characteristics of the population in Boone County. For example, both sites have similar levels of educational attainment, with 49.7% of Boone County residents having a bachelor's degree or higher and 56.1%, 43.3%, and 51.4% for Chester, Bucks, and Montgomery Counties, respectively, in Pennsylvania (National Institute for Health 2024). Both sites have a comparable percentage of the population in the workforce with Boone County having approximately 66% and other counties in Southeast Pennsylvania having very similar rates. Bucks County, Chester County, Delaware County, Montgomery County, and Philadelphia County have 63.4%, 67.9%, 65.8%, 68.1%, and 66.2% of the population in the workforce, respectively. Boone County and Southeastern Pennsylvania also have diverse populations, with a comparable mix of racial and ethnic groups (U.S. Census Bureau 2025).
- The source case is framed in the context of an ROE study, which matches the frame of the target case.
- The source case appears to have been conducted in a technically satisfactory manner.

A unit transfer method was applied to obtain a range of per capita physical activity cost savings for direct medical care costs, indirect medical care costs, workers' compensation costs, and lost productivity. Low and high estimates were transferred from the source case to estimate these costs. A per capita cost was calculated for each category by dividing the total physical activity cost savings by the total active population in the source case. Indirect workers' compensation cost estimates were derived from the Occupational Safety and Health Administration's (OSHA's) Individual Injury Estimator. OSHA states the indirect workers' compensation costs can vary from 1.1 to 4.5 times direct workers' compensation costs (OSHA 2025). For lower-end estimates of indirect workers' compensation costs, direct workers' compensation costs were multiplied by 1.1, and for a high-end estimate, they we were multiplied by 4.5. Transferred unit values are presented in Table 5.

Table 5: Transferred Physical Activity Cost Savings Values[1]

Categories[2,3]	Low	High
Direct Medical Cost Savings	$302	$629
Indirect Medical Cost Savings	$906	$1,887
Direct Workers' Compensation Savings	$6	$12
Indirect Workers' Compensation Savings	$7	$54
Lost Productivity	$1,597	$2,070

[1] Dollar values are in 2011 price levels and reflect per capita physical activity cost savings.

[2] Direct medical care costs, indirect medical care costs, direct workers' compensation costs, and lost productivity were transferred from the source case (Delaware Valley Regional Planning Commission 2011b).

[3] Indirect workers' compensation cost savings were estimated by applying a multiplier of 1.1 to lower-bound estimates for direct workers' compensation savings and a multiplier of 4.5 for upper-bound estimates for direct workers' compensation savings (OSHA 2025).

The transferred unit values were applied to the population of Boone County by developing estimations related to the number of active individuals in the county. Given that there is uncertainty surrounding the number of active individuals, estimates are provided in a range, with an estimated lower bound and upper bound. The lower bound was estimated from a study from MoDNR (2025) finding that 61% of residents in Missouri participate in outdoor recreation. A factor of 0.61 was multiplied by the 2023 ACS population estimate for Boone County (U.S. Census Bureau 2023) to develop a lower-bound estimate of 115,572 active residents in Boone County. In the GBFW Community Survey, 92% of respondents indicated that they participate in outdoor recreation activities at least once per year. The upper bound was estimated by multiplying a factor of 0.92 by the population estimate for Boone County to produce a value of 174,306 active residents in Boone County. The results of this process are shown in Table 6. A limitation of this method is that it assumes that all active individuals recreate outdoors in the GBFW, which might overestimate healthcare and workplace cost savings benefits attributed to recreational activities in the GBFW.

Table 6: Estimation of People Who Participate in Outdoor Recreation in Boone County

Population[1]	Minimum	Maximum
189,463	115,572	174,306

[1] Population estimates for Boone County were gathered from the 2023 1-Year American Community Survey (U.S. Census Bureau 2023).

The minimum and maximum estimates of active individuals were multiplied by the per capita unit values in Table 5 to produce a range of estimates related to healthcare and workplace cost savings attributed to physical activity within the GBFW. Monetary values were adjusted from 2011 price levels to 2024 price levels using the Consumer Price Index for Medical Care (CPI-M) (U.S. Bureau of Labor Statistics 2024b).

4.3.2 Health Benefits Results

Engaging in regular physical activity is a cornerstone of a healthy lifestyle. Natural outdoor environments encourage diverse activities and offer opportunities for recreation, as discussed in the previous subsection. While indoor alternatives, such as fitness centers, provide opportunities for recreation and physical activity, these facilities can be costly in terms of time and money and might not be accessible to all individuals. Research indicates that many individuals prefer outdoor exercise, which has been shown to yield greater physical and mental health benefits than indoor alternatives (USEPA 2024b). The availability of outdoor green spaces enhances opportunities for recreation and physical activity, promoting both planned exercise and incidental physical activity, such as walking or cycling. Together, these forms of activity can contribute significantly to overall health and well-being. Furthermore, in the GBFW Community Survey, 96% of respondents indicated that they believe they are mentally and physically healthier when the natural environment is healthy, indicating that the community perception is that the health of the GBFW is directly linked to individual health and well-being.

The forests, public green spaces, and agro-ecosystems within the GBFW provide numerous health benefits for individuals that directly engage with them. The USEPA has developed the EnviroAtlas Eco-Health Relationship Browser which illustrates scientific evidence for links between human health and ecosystem services (USEPA 2024b). Figure 9 displays the links between recreation and physical activity, healthy ecosystems, and health benefits. Linkages between certain types of ecosystems and recreation and physical activity are shown with yellow arrows. Linkages between recreation and physical activity and human health are shown by the blue arrows; these linkages demonstrate that recreation and physical activity can reduce or prevent adverse health effects while also promoting physical and mental well-being. Academic literature and studies related to all linkages can be viewed through the EnviroAtlas Eco-Health Relationship Browser by clicking the information icon (*"i"*) between each linkage (USEPA 2024b).

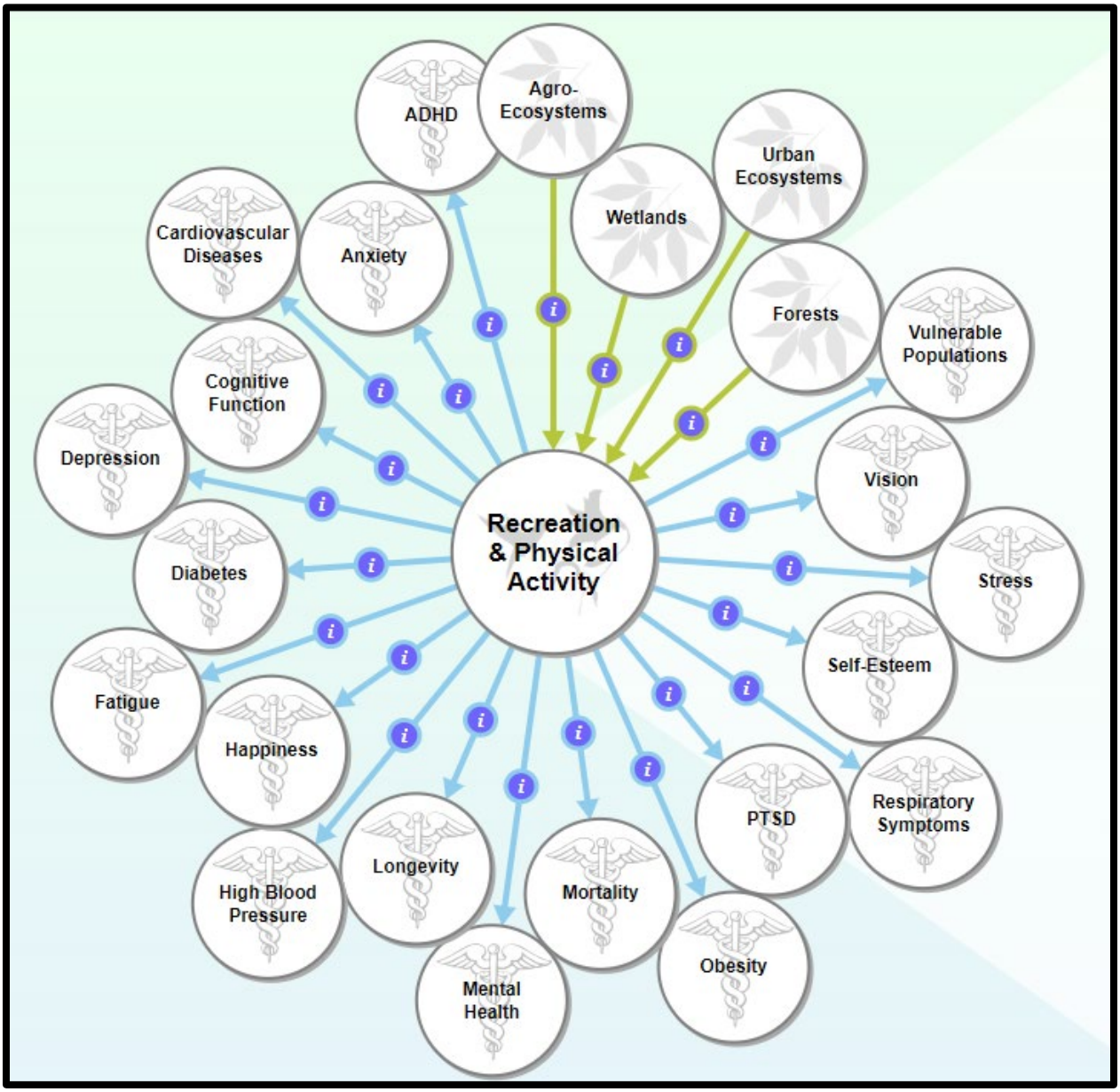


Figure 9: Linkages Between Public Health and the Recreation and Physical Activity Ecosystem Service (USEPA 2024b)

Figure 9 demonstrates that forests, wetlands, urban ecosystems, and agro-ecosystems, which are a substantial proportion of the GBFW, support recreation and physical activity resulting in a variety of public health benefits. The following are some high-level examples from a literature review of relevant research:

- Eight studies found that separation from nature via modern living is detrimental to human development, health, and wellbeing and that regular contact with nature, such as provided by parks, is required for mental health (Sallis and Spoon 2015).
- Diabetic individuals taking 30-minute walks in a forest experienced lowered blood glucose levels far more than the same amount of time spent doing physical activity in other settings.

The 30-minute forest walks resulted in larger drops in blood glucose than 3 hours of cycling. (Sallis and Spoon 2015)

- Males living in the greenest urban wards in the United Kingdom had a 5% lower risk of cardiovascular disease mortality and an 11% lower risk of respiratory disease mortality than those males living in the least green wards. (Sallis and Spoon 2015)

4.3.3 Healthcare Costs and Workplace Costs Avoided Results

Beyond improving or maintaining personal health, engaging in regular physical activity also leads to significant reductions in healthcare costs by preventing chronic diseases, reducing healthcare costs, and minimizing the need for medical interventions (Center for Disease Control and Prevention [CDC] 2024). The results below outline the quantitative healthcare and workplace cost savings from recreation and physical activity within the GBFW to Boone County residents only. However, this cost savings is likely an underestimation of overall cost savings given that the GBFW receives numerous visitors every year from outside of Boone County, and these same cost savings benefits would most likely extend to visitors to some degree as well, especially if they visit the GBFW frequently. For example, data from Missouri Division of Tourism (MDT) shows that Missouri's tourism is primarily regional with 34.6% of visitors coming from within the state (MDT 2023a).

The healthcare and workplace cost savings are partitioned into three main categories: medical cost savings, workers' compensation cost savings, and lost productivity cost savings. Each of these categories are described in more detail below.

4.3.3.1 Medical Cost Savings

Direct medical costs refer to the expenditures associated with the treatment of illnesses or medical conditions that are caused by or exacerbated by physical inactivity. Using inflation-adjusted estimates of average per-capita annual savings in direct medical costs, we estimate that Boone County residents avoid between $49 million and $155 million per year in direct medical costs (Table 7).

Indirect medical costs represent the economic impact of adverse health conditions associated with physical inactivity on an individual's quality of life. These costs quantify the monetary value of pain and suffering, diminished quality of life, and reduced life expectancy linked to physical inactivity. Research suggests that indirect medical costs are approximately three times higher than direct medical costs, with a commonly cited ratio of 3:1 (Chenoweth 2005). Based on this ratio, the estimated annual savings in indirect medical costs are approximately between $148 million and $465 million.

Together, avoided direct and indirect medical costs produce a savings of approximately $197 million to $620 million per year.

4.3.3.2 Workers' Compensation Cost Savings

Studies suggest that physical inactivity increases the risk of injury and extends the recovery time. Workplace injuries linked to physical inactivity may render individuals eligible for workers' compensation benefits. Research estimates the average per-worker cost of workers' compensation claims attributable to physical inactivity range from $6 to $12.53 (Chenoweth 2005). More broadly, a separate study found that the estimated financial burden that includes direct medical care, workers' compensation, and lost productivity costs across several states is $93.32 billion for

physical inactivity (Chenoweth 2006). And further work by Feltner 2001, showed that moderately physically active employees had fewer injuries over time than those employees who reported no regular activity, in a generally linear relationship ranging from 6.53 claims per 100 full-time equivalent employees for sedentary persons to 4.53 claims per 100 full-time equivalent employees who exercise 4 to 5 days per week.

It is estimated that workers who engage in physical activity on protected open spaces contribute to between $980,000 and $2.96 million in avoided direct workers' compensation costs annually. Since employers typically pay private insurers to provide workers' compensation coverage, these insurers are likely the primary beneficiaries of reduced claims, with employers benefiting indirectly by avoiding potential premium rate increases (Marsh McLennan Agency 2024, Forgeron 2024).

Indirect costs associated with workers' compensation refer to the administrative expenses borne by employers because of workers' compensation claims. The source case suggests that these indirect costs are approximately four times greater than the direct costs, establishing a 4 to 1 ratio (Delaware Valley Regional Planning Commission 2011b). However, due to the uncertainty is this ratio, as outlined in Section 4.3.1, a ratio of between 1.1 to 1 and 4.5 to 1 was used to estimate indirect costs for workers' compensation claims. Based on these ratios, it is estimated that employers in Boone County avoid approximately between $1 million and $13 million in indirect workers' compensation costs annually due to the physical activities their employees engage in on protected open spaces.

4.3.3.3 Lost Productivity Cost Savings

The direct costs incurred by businesses due to lost productivity represent a substantial component of the overall economic burden associated with physical inactivity. Research identifies lost productivity as manifesting in two primary forms: absenteeism, defined as "*the absence of a worker due to illness (either a personal illness or as a caretaker for a sick dependent*," and presenteeism, described as "*employees who are legitimately ill but continue to come to work*" (Howard et al. 2012).

It is projected that businesses in Boone County avoid approximately between $261 million and $510 million in costs annually because of employee physical activity within the GBFW. This estimate encompasses the combined value of costs averted due to reductions in both absenteeism and presenteeism attributable to physical activity.

Table 7 and Table 8 show a summary of low and high estimates of healthcare and workplace costs avoided due to physical activity.

Table 7: Healthcare and Workplace Cost Saving Estimates (Low)

Category	Medical Costs Avoided (Lower)[1]	Medical Costs Avoided (Upper)[1]	CPI Adjustment Factor[2]	Adjusted Medical Costs Avoided (Lower)[3]	Adjusted Medical Costs Avoided (Upper)[3]
Direct Medical Cost Savings	$34.90	$72.70	1.413	$49.32	$102.72
Indirect Medical Cost Savings	$104.71	$218.09		$147.95	$308.15
Direct Workers' Comp Savings	$0.69	$1.39		$0.98	$1.96
Indirect Workers' Comp Savings	$0.76	$6.24		$1.08	$8.82
Lost Productivity	$184.57	$239.23		$260.79	$338.03
Total	**$325.64**	**$537.64**		**$460.11**	**$759.67**

[1] Dollar values are in millions (USD) per year and 2011 price levels.
[2] CPI Adjustment Factor was calculated using the Consumer Price Index for Medical Care (CPI-M; U.S. Bureau of Labor Statistics 2024b).
[3] Dollar values are in millions (USD) per year and 2024 price levels.

Table 8: Healthcare and Workplace Cost Saving Estimates (High)

Category	Medical Costs Avoided (Lower)[1]	Medical Costs Avoided (Upper)[1]	CPI Adjustment Factor[2]	Adjusted Medical Costs Avoided (Lower)[3]	Adjusted Medical Costs Avoided (Upper)[3]
Direct Medical Cost Savings	$52.64	$109.64	1.413	$74.38	$154.92
Indirect Medical Cost Savings	$157.92	$328.92		$223.14	$464.75
Direct Workers' Comp Savings	$1.05	$2.09		$1.48	$2.96
Indirect Workers' Comp Savings	$1.15	$9.41		$1.63	$13.30
Lost Productivity	$278.37	$360.81		$393.32	$509.82
Total	**$491.12**	**$810.87**		**$693.94**	**$1,145.73**

[1] Dollar values are in millions (USD) per year and 2011 price levels.
[2] CPI Adjustment Factor was calculated using the Consumer Price Index for Medical Care (CPI-M; U.S. Bureau of Labor Statistics 2024b).
[3] Dollar values are in millions (USD) per year and 2024 price levels.

4.3.4 Direct Use Benefits Summary

The GBFW offers significant direct use benefits through its diverse recreational opportunities, which enhance the quality of life for Boone County residents. Activities such as hiking, fishing, kayaking, and birdwatching allow individuals to directly interact with the natural environment, fostering physical and mental well-being. These activities yield substantial economic value, with an estimated annual benefit of between $363 million and $548 million, equating to approximately between $4,700 and $7,000 in value per household per year. This amount reflects the costs savings or the amount that they are willing to pay and quality-of-life enhancements provided by free access to outdoor recreational opportunities in the GBFW.

In addition to the numerous health benefits provided through direct use of the natural resources contained within the GBFW, recreational opportunities result in measurable healthcare cost and workplace savings for the community. Physical activity associated with recreation in the watershed contributes to an estimated $49 million to $155 million in direct healthcare costs avoided annually by helping prevent chronic diseases and helping reduce the need for medical interventions in addition to an estimated $148 million to $465 million of indirect medical costs avoided. Approximately between $980,000 to $3 million is expected to be saved by businesses each year from avoided workers' compensation claims in addition to an estimated $1 million to $13 million of costs avoided related to indirect workers' compensation costs. Furthermore, the increased physical activity helps businesses avoid approximately between $261 million and $510 million annually in lost productivity costs due to reduced absenteeism and presenteeism. These savings underscore the broader economic value of the GBFW, which extends beyond personal enjoyment to include significant public health and workplace benefits.

These findings emphasize the critical economic and social value of the GBFW as a natural resource that supports community health and economics. By quantifying the benefits in monetary terms, the analysis in this section underscores the importance of conserving and sustainably managing the watershed to maintain its role as a key provider of ecosystem services. Such values advocate for continued investment in the protection of natural spaces to ensure the longevity of these benefits for current and future generations.

5 ENVIRONMENTAL BENEFITS (INDIRECT USE)

5.1 Introduction to Environmental Benefits

Indirect use benefits represent a critical dimension of ecosystem service valuation, reflecting the advantages derived from ecosystem functions that support human well-being and economic productivity without being directly consumed or experienced. These benefits are typically associated with ecosystem processes, such as filtering water, capturing and storing carbon dioxide, stabilizing soil (i.e., erosion control), reducing pollutant loads, managing flood risk, and facilitating pollination, which operate in the background to sustain environmental health and economic activities. By enabling and enhancing the functioning of natural and human systems, indirect use benefits contribute to a wide array of societal and economic outcomes, including improved public health, reduced infrastructure costs, and enhanced agricultural productivity (Markandya 2019). Incorporating the analysis of indirect use benefits provides a more comprehensive understanding of the value ecosystems generate, ensuring that the full range of their contributions is recognized. This is integral to a holistic approach that underscores the interconnectedness of natural systems and human welfare, reinforcing the imperative to conserve and sustainably manage natural resources (Chan et al. 2011). The following sections discuss the indirect use benefits of the natural resources within the GBFW in the context of analyzing the benefits of reducing pollutant load related to nutrients, sediment, and *E. coli*. In addition to environmental benefits, there is the potential for social costs to be incurred by residents within the watershed related to pesticide use. The implementation of BMPs, such as regenerative agriculture practices, might be able to reduce these social costs.

5.2 Nutrient Load Reduction

Nutrient load reduction refers to the process of decreasing the levels of nutrients, particularly nitrogen and phosphorus, in streams to improve water quality and ecosystem health. In the context of the GBFW, nutrient reduction plays a crucial role in mitigating water pollution and enhancing the overall environmental quality. The WBP (Boone County Resource Management and Project Partners 2023) emphasizes the critical importance of nutrient reduction to maintain and improve water quality within the watershed. The WBP outlines strategies to mitigate nutrient loading, including the implementation of BMPs in agricultural areas, such as cover cropping, riparian buffer establishment, and nutrient management plans, to reduce nutrients in stormwater runoff and enhance nutrient uptake by vegetation. By reducing nutrient loads, the watershed can experience significant indirect use benefits, such as improved recreational opportunities, enhanced biodiversity, and improved water quality for downstream users. These benefits not only support the ecological integrity of the watershed but also contribute to the well-being and economic prosperity of the surrounding communities.

5.2.1 Method of Estimating Nutrient Load Reduction Benefits

This analysis is intended to reflect the value of nutrient load reduction from future implementation of BMPs throughout the watershed. The estimation of the nutrient load reduction benefits for the GBFW was based on the nutrient load reduction values from the WBP (Boone County Resource Management and Project Partners 2023) for future implementation of BMPs throughout the watershed at various phases (30%, 60%, 90%) and over various lengths of time (7 years, 14 years, 21 years). Based on the WBP, some examples of BMP measures that could be implemented are as follows:

- **Cover Crops:** Cover crops are short-term crops grown after the main cropping season and are used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity, and reduce pollutants of concern migrating into streams in stormwater runoff from the farm fields or adjacent areas.
- **Nutrient Management:** Nutrient management helps the producer maximize profits by balancing crop yields and nutrient inputs. Using a nutrient management plan, producers can optimize the economic returns from nutrients used in production, minimize nutrient loss, and improve water quality at the same time.
- **Manure Management:** Manure management or animal waste management systems involve manure storage, transportation off-site, and improvements in manure recoverability. This practice reduces the source of nutrients and bacteria in stormwater runoff.
- **Fencing:** Fencing of streams and other water bodies is designed to prevent livestock from entering the water body. This prevents livestock from depositing manure directly into the waterway and from damaging streambanks.
- **Livestock Exclusion and Alternative Sources of Water:** Livestock exclusion involves fencing off streams and other water bodies to prevent livestock from entering the water body and is coupled with providing alternative sources of water.

A full list of BMPs can be found in the WBP (Boone County Resource Management and Project Partners 2023).

Absent BMP implementation, nutrients are expected to continue loading into the streams. The analysis in this section explores the costs of nutrient removal through BMP implementation at various phases during a 21-year period of implementation against the cost of nutrient removal utilizing other methods or technologies. The cost savings from BMP implementation is characterized as the economic benefit, or costs avoided.

To estimate costs related to nutrient removal, Geosyntec gathered unit cost data expressed in 2001 price levels from the USEPA (2002) related to the cost of phosphorus and nitrogen removal, measured in dollars per pound. According to the USEPA,

> *"EPA uses cost-effectiveness calculations to compare the efficiencies of regulatory options for removing priority and nonconventional pollutants. Although not required by the Clean Water Act, a cost-effectiveness (C-E) analysis offers a useful metric to compare the efficiency of alternative regulatory options in removing pollutants and to compare the proposed technology option with other regulatory alternatives that EPA considered" (USEPA 2002).*

Unit cost values from the USEPA (2002) for phosphorus and nitrogen removal were provided in a range as minimum and maximum values and varied depending on the treatment type. The minimum values for phosphorus removal ($0.36 per pound) and nitrogen removal ($0.09 per pound) were selected because they reflect the lowest estimated cost of treating nutrient pollution at the source through agricultural land applications. The maximum values for phosphorus removal ($135 per pound) and nitrogen removal ($9.53) were chosen because they exclude unit cost estimates that involve treatment types that include large wastewater treatment plants and similar

municipal facilities, which are currently deemed as unfeasible nutrient pollution treatment options within the watershed. Therefore, the maximum costs reflect agricultural lagoons as the treatment type given that they reflect the maximum unit cost value of nutrient removal factoring out the cost of large wastewater treatment plants and municipal facilities. The USEPA based the chosen unit costs on several studies that assess the cost-effectiveness of various state-level programs to reduce nutrients. Treatment types that include nutrient removal at agricultural sources using various methods are reflected in the selected unit costs and are presented in Table 9, before adjusting for inflation (USEPA 2002). It is important to note that these unit costs are used as a proxy to estimate the cost of nutrient removal; the development of site-specific treatment types and costs would reduce the level of uncertainty in this analysis.

An estimation of the economic benefits from avoiding the costs of nutrient removal was calculated using nutrient load reduction values provided in the WBP and unit cost data.

The results of this analysis can be interpreted as an upper-end estimate of costs avoided because it represents an estimate of the maximum costs that would be incurred for nutrient removal if all the phosphorus and nitrogen loads were to be removed. However, there may be constraints that prevent full removal of nutrients, such as costs; therefore, it is possible for costs avoided from nutrient load reduction to be lower than what is reflected in the results of this analysis. In other words, the implementation of BMPs incur a cost at various phases, but their implementation might prevent costs of implementing nutrient-reduction measures using other methods or technologies, which would cost more than implementing BMPs. The results of this analysis are presented in the following subsection.

5.2.2 Results of Nutrient Load Reduction Cost Analysis

USEPA (2002) provided a range of nutrient removal costs for both phosphorus and nitrogen removal (Table 9). The range was based on different measures to remove nutrients. Given that there is uncertainty related to which measures may be used for nutrient removal absent the implementation of BMPs, the low values in Table 9 were chosen based on the minimum costs for phosphorus and nitrogen removal, and the high values were chosen based on the maximum costs.

Table 9: Cost of Nutrient Removal

Cost of Removal ($ per pound, 2001 Price Level)			
Phosphorus		Nitrogen	
Low	High	Low	High
$0.36	$135	$0.09	$9.53

[1] Nutrient removal costs are sourced from the Appendix E of the USEPA's *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (USEPA 2002).

Unit cost data was adjusted from 2001 price levels to 2024 price levels using the *Consumer Price Index for All Urban Consumers: Water and Sewer and Trash Collection Services in U.S. City Average* (U.S. Bureau of Labor Statistics 2024c). This index was used because changes in the price of water and wastewater treatment are included in this index. Many of the unit costs provided by the USEPA (2002) include water treatment measures and escalating unit costs, thus using this index accounts for related price changes over time. Adjusted unit costs of nutrient removal are depicted in Table 10.

Table 10: Adjusted Unit Cost of Nutrient Removal

Cost of Removal Adjusted for Inflation ($ per pound, 2024 Price Level)			
Phosphorus		Nitrogen	
Low	High	Low	High
$0.99	$186	$0.25	$26.16

[1] Nutrient removal costs are sourced from the Appendix E of the USEPA's *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (USEPA 2002).
[2] The *Consumer Price Index for All Urban Consumers: Water and Sewer and Trash Collection Services in U.S. City Average* was used to adjusted unit cost data from 2001 to 2024 price levels.

For each BMP implementation phase, low and high unit costs for nutrient removal were multiplied by the amount of phosphorus and nitrogen removed each year to provide an upper-end estimation of costs avoided. The results are shown Table 11. The estimation of costs avoided represents an estimation of maximum additional costs for treating nutrient loads. The following annual costs avoided, or annual benefits, were estimated at each BMP implementation phase:

- 30% Implementation Scenario: $4,428 to $1.59 million
- 60% Implementation Scenario: $8,825 to $3.17 million,
- 90% Implementation Scenario: $13,284 to $4.78 million

It is currently unknown which measures, or treatment types, may be taken to reduce nutrient loads in the watershed absent BMP implementation. Unit cost data from the USEPA is also presented in a range for each measure which indicates variation in costs for different treatment types. Given these uncertainties, costs avoided represent a wide range of costs related to various measures outlined by the USEPA. For example, the USEPA estimates unit costs for phosphorus reduction related to agricultural land applications ranges between $0.36 and $34.27 per pound of removal. In contrast, unit costs for utilizing agricultural lagoons to reduce phosphorus are estimated between $2.72 and $135.17 per pound of removal (USEPA 2002).

A most likely value was calculated by taking the average of the low and high total costs avoided. A benefit-cost analysis was conducted to compare the most likely costs avoided, framed as the benefits in this case, against the estimated costs of implementing BMPs from the WBP. BMP implementation costs gathered from the WBP were provided as total costs for each implementation phase. The costs for each phase were averaged over a 7-year period to estimate average annual costs to compare against average annual benefits. The results of the benefit-cost analysis are contained in Table 12. The high benefit-to-cost ratio indicates that implementing BMPs is likely to yield benefits from reducing nutrient loads that substantially outweigh the costs of implementation.

Table 11: Costs Avoided for Nutrient Removal

Cost Avoided for Nutrient Removal[1]									
BMP Load Reduction Scenario	Phosphorus			Nitrogen			Total Costs Avoided ($/yr)		
	Reduction (lb/yr)	Costs Avoided (Low)	Costs Avoided (High)	Reduction (lb/yr)	Costs Avoided (Low)	Costs Avoided (High)	Costs Avoided (Low)	Costs Avoided (Most Likely)	Costs Avoided (High)
30% Implementation Scenario	4,216	$4,166	$1,564,098	1,061	$262	$27,752	$4,428	$798,139	$1,591,850
60% Implementation Scenario	8,401	$8,301	$3,116,695	2,124	$525	$55,556	$8,825	$1,590,538	$3,172,251
90% Implementation Scenario	12,647	$12,496	$4,691,923	3,188	$787	$83,386	$13,284	$2,394,297	$4,775,309

[1] Dollars are in 2024 price levels and expressed in annual costs avoided. Costs avoided are expressed in $ per year.

Table 12: Benefit-Cost Analysis for Nutrient Removal

Benefit-Cost Analysis for Nutrient Removal[1]				
BMP Load Reduction Scenario	Average Annual Costs Avoided (Benefits)	Average Annual Cost of BMP Implementation (Costs)[2]	Average Annual Net Benefits	Benefit to Cost Ratio (BCR)
30% Implementation Scenario	$798,139	$57,424	$740,715	13.90
60% Implementation Scenario	$1,590,538	$67,381	$1,523,158	23.61
90% Implementation Scenario	$2,394,297	$53,052	$2,341,244	45.13

[1] Dollars are in 2024 price levels and expressed in annual costs avoided.
[2] BMP implementation costs were obtained from the WBP (Boone County Resource Management and Project Partners 2023), which provides total costs for each implementation phase. The costs for each phase were averaged over a 7-year period to estimate average annual costs to compare against average annual benefits.

5.3 Sediment Load Reduction

Sediment load reduction is a critical ecosystem service that provides tangible environmental, social, and economic benefits. Excess sedimentation in waterways is often associated with erosion, agricultural runoff, and deforestation and can lead to the degradation of aquatic habitats, reduced storage, and increased costs for water treatment and dredging (Ongley 1995, USEPA 2005). Natural and managed ecosystems, which mitigate sediment transport, reduce these negative impacts, yielding measurable cost savings and economic returns. Additionally, sediment reduction enhances biodiversity, supports recreational opportunities, and improves public health by maintaining clean water systems (USEPA 2006, 2024c).

5.3.1 Method of Estimating Sediment Load Reduction Benefits

To estimate the sediment reduction benefits for the GBFW, Geosyntec obtained sediment load reduction values from the WBP. These sediment load reduction values are reflective of the future implementation of BMPs throughout the watershed at various phases (30%, 60%, 90%) and over various lengths of time (7 years, 14 years, 21 years). Examples of specific BMP measures are discussed in Section 5.2.1, and a full list can be found in the WBP (Boone County Resource Management and Project Partners 2023).

Absent BMP implementation, sediment loading is expected to continue in streams. The analysis in this section explores the costs of sediment removal through BMP implementation at various phases during a 21-year period of implementation against the cost of sediment removal using other methods or technologies. The cost savings from BMP implementation are characterized as economic benefit, or costs avoided.

Like the approach in Section 5.2.1, unit cost data expressed in 2001 price levels was gathered related to the cost of sediment removal and was measured in dollars per pound. Unit cost values from USEPA (2002) for sediment removal were provided in a range as minimum and maximum values and varied depending on the treatment type. The minimum value ($0.01 per pound) and maximum value ($0.18 per pound) for sediment removal were chosen to capture the full range of unit costs across different treatment types and used as the basis for estimating sediment removal costs before adjusting for inflation, as shown in Table 13. The true maximum ($4.61 per pound) was excluded from this range because it represents the unit cost for a large municipal facility to remove sediment, which is currently deemed unfeasible in the GBFW.

USEPA based the applied minimum unit cost on the Northeast Wisconsin Water for Tomorrow studies that were conducted to compare the cost-effectiveness of point and nonpoint source controls across 41 sub-watersheds in the Fox-Wolf watershed. The Northeast Wisconsin Water for Tomorrow studies estimated the cost of reducing total suspended solid loads from municipal treatment facilities and agricultural sources and estimated an average cost of $0.008 cents per pound (rounded to $0.01) to remove total suspended solid loads from rural land. USEPA based the applied maximum unit cost on the benchmark measures that estimate the average cost per pound to remove total suspended solids through stormwater controls (USEPA 2002).

An estimation of the economic benefits of avoiding the costs of sediment removal was calculated using sediment load reduction values provided in the WBP and unit cost data from USEPA.

As in Section 5.2.1, the results of this analysis can be interpreted as an upper--end estimate of costs avoided. An upper--end value was chosen because it represents an estimate of the maximum costs

that would be incurred for sediment removal if all sediment loads were to be removed from the stream.

5.3.2 Results of Sediment Load Reduction Cost Analysis

Table 13 depicts the unit cost data gathered from the USEPA (2002) to estimate the cost of sediment removal. The cost of sediment removal varied depending on the method, thus low and high values for sediment removal are presented in Table 13.

Table 13: Cost of Sediment Removal

Cost of Sediment Removal ($ per pound, 2001 Price Level)	
Low	High
$0.01	$0.18
[1] Sediment removal costs are sourced from the Appendix E of the USEPA's *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (USEPA 2002).	

Unit cost data was adjusted from 2001 price levels to 2024 price levels using the *Consumer Price Index for All Urban Consumers: Water and Sewer and Trash Collection Services in U.S. City Average* (U.S. Bureau of Labor Statistics 2024c). Adjusted unit costs of sediment removal are depicted in Table 14.

Table 14: Adjusted Unit Cost of Sediment Removal

Cost of Sediment Removal ($ per pound, 2024 Price Level)	
Low	High
$0.03	$0.49
[1] Sediment removal costs are sourced from the Appendix E of the USEPA's *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (USEPA 2002). [2] The *Consumer Price Index for All Urban Consumers: Water and Sewer and Trash Collection Services in U.S. City Average* (U.S. Bureau of Labor Statistics 2024c) was used to adjusted unit cost data from 2001 to 2024 price levels.	

For each BMP implementation phase, unit costs for sediment removal were multiplied by the amount of sediment removed each year to provide an upper-end estimation of costs avoided. The results are shown in Table 15. It is estimated that approximately $37,541 to $2.82 million of costs will be avoided each year with the implementation of BMPs. The most likely value was calculated by taking the average of the low and high total costs avoided. A benefit-cost analysis was conducted to compare costs avoided, framed as the benefits in this case, against the estimated costs of BMP implementation from the WBP (Boone County Resource Management and Project Partners 2023). BMP implementation costs gathered from the WBP were provided as total costs for each implementation phase. The costs for each phase were averaged over a 7-year period to estimate average annual costs compared against average annual benefits. The results of the benefit-cost analysis are contained in Table 16. The high benefit-to-cost ratio indicates that implementing BMPs is likely to yield benefits from reducing nutrient load that substantially outweigh the costs of implementation.

Table 15: Costs Avoided for Sediment Removal

Cost Avoided for Sediment Removal[1]				
BMP Load Reduction Scenario	**Reduction (lb/yr)**	**Total Costs Avoided (Low)**	**Total Costs Avoided (Most Likely)**	**Total Costs Avoided (High)**
30% Implementation Scenario	1,367,784	$37,541	$356,635	$675,730
60% Implementation Scenario	2,733,563	$75,026	$712,748	$1,350,469
90% Implementation Scenario	4,103,345	$112,621	$1,069,904	$2,027,186

[1] Dollars are in 2024 price levels and expressed in annual costs avoided.

Table 16: Benefit-Cost Analysis for Sediment Removal

Benefit-Cost Analysis for Sediment Removal[1]				
BMP Load Reduction Scenario	**Most Likely Total Costs Avoided (Benefits)**	**Cost of BMP Implementation (Costs)**	**Net Benefits**	**Benefit-to-Cost Ratio (BCR)**
30% Implementation Scenario	$356,635	$57,424	$299,212	6.21
60% Implementation Scenario	$712,748	$67,381	$645,367	10.58
90% Implementation Scenario	$1,069,904	$53,052	$1,016,852	20.17

[1] Dollars are in 2024 price levels and expressed in annual costs avoided.
[2] BMP implementation costs were obtained from the WBP (Boone County Resource Management and Project Partners 2023), which provides total costs for each implementation phase. The costs for each phase were averaged over a 7-year period to estimate average annual costs to compare against average annual benefits.

5.4 Costs Avoided to Infrastructure

Stormwater retention is a vital ecosystem service that plays a significant role in reducing damage to infrastructure. Effective stormwater retention mitigates runoff volumes during heavy rainfall, alleviating stress on urban drainage systems, preventing road washouts, and reducing flood-induced damage to buildings and critical infrastructure. The avoided damages translate into significant cost savings for municipalities, businesses, and homeowners. Additionally, stormwater retention can deliver additional benefits, such as improved water quality and enhanced aesthetic and recreational value (Serra-Llobet et al. 2022). The quantification of the economic benefits of avoided infrastructure damages highlights the financial efficiency and sustainability of natural and nature-based solutions and offers valuable insights for policymakers, urban planners, and stakeholders seeking to balance environmental conservation with economic development. Given that most of the land area in the GBFW consists of either forested or agricultural land (Boone County Resource Management and Project Partners 2023), the natural infrastructure within the watershed plays a critical role in retaining significant volumes of water during storms by reducing runoff, slowing surface flows, and creating storage capacity for excess water. This process not only minimizes the reliance on engineered flood risk management (FRM) solutions but also delivers economic benefits by preventing damage to infrastructure caused by stormwater flooding. By naturally mitigating flood risks, these systems offer a cost-effective and sustainable approach to water management, providing a solution that is both ecologically and economically advantageous for stakeholders who are directly impacted by runoff and surface flow dynamics.

5.4.1 Method of Estimating Costs Avoided to Infrastructure

To estimate the costs avoided to infrastructure, Geosyntec used the InVEST Urban FRM (Natural Capital Project [NatCap] 2024) model. This model uses a Natural Resources Conservation Service (NRCS; formerly known as the Soil Conservation Service) curve number approach and calculates runoff reduction and potential economic damage by overlaying information related to flood extent potential and built infrastructure. Economic benefits are estimated in the context of damages avoided to infrastructure due to the stormwater retention offered by the natural infrastructure within the GBFW.

The following inputs were gathered to run the InVEST Urban FRM model for the GBFW:

- Polygon shapefile representative of the GBFW extents: Hydrologic Unit Code 12 data for Bonne Femme Creek and Little Bonne Femme Creek was downloaded from the Missouri Spatial Data Information Service (2024) to generate a polygon shapefile representative of the GBFW extents.
- Built infrastructure: Microsoft Footprint (Microsoft Corporation 2024) data was overlayed with the United States Army Corps of Engineers' (USACE) National Structure Inventory data (USACE 2024) to estimate the location of residential, commercial, and industrial buildings.
- Rainfall Depth: National Oceanic and Atmospheric Administration's (NOAA's) Atlas 14 Point Precipitation Frequency Estimates were gathered for the Columbia, Missouri, station (NOAA 2024). A depth value of 187.706 millimeters was chosen, which corresponds with the design storm of interest. This allows for the analysis to reflect the effectiveness of natural infrastructure in retaining runoff volumes in a way that is comparable to the

engineered stormwater infrastructure in the watershed. The Boone County Stormwater Ordinance states,

> *"overland flood routing paths shall be used to convey stormwater runoff from the 100-year storm event to an adequate receiving water resource or stormwater BMP such that the runoff is contained within the drainage easement for the flood routing path and does not cause flooding of buildings or related structures. The peak 100-year water surface elevation along flood routing paths shall be at least one foot below the finished grade elevation at the structure."* (Boone County Government 2010).

Given this information, a depth value for the 0.01 annual exceedance probability event (i.e., the 100-year event) was chosen from the NOAA Atlas 14 Point Precipitation Frequency Estimates as the rainfall depth input for this model.

- LULC Data: 2023 National Land Cover Data was gathered from the Multi-Resolution Land Characteristics Consortium (2023).
- Soil Hydrologic Group Data: Raster data of soil type and locations were processed internally at Geosyntec from the WBP (Boone County Resource Management and Project Partners 2023).

Other numeric inputs were required to run the Urban FRM model, and the default values that are recommended by NatCap were used, shown in Table 17 (NatCap 2024). Table 17 depicts the biophysical table that was used as an input into the Urban FRM model. The biophysical table contains NRCS curve number data for each LULC class, represented by Curve A, Curve B, Curve C, and Curve D in Table 17. Each curve number category represents different hydrologic soil groups. Summarized definitions of hydrologic soil groups are contained below (NRCS 2007):

- Curve A: These soils have low runoff potential when thoroughly wet. Soils that typically have less than 10% clay and more than 90% sand or gravel.
- Curve B: These soils have moderate runoff potential when thoroughly wet. These soils typically have between 10% and 20% clay and 50% to 90% sand or sandy loam textures.
- Curve C: Soils in this group have moderately high runoff potential when thoroughly wet. Soils typically have between 20% and 40% clay and less than 50% sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures.
- Curve D: Soils in this group have high runoff potential when thoroughly wet. Soils typically have greater than greater than 40% clay, less than 50% sand, and have clayey textures.

Each curve category represents a hydrologic soil group based on land use type and is assigned a value from 0 to 100, with a lower value indicating that more rainfall infiltrates the soil and a higher value indicating that less rainfall infiltrates the soil. In the InVEST Urban FRM model, raster data representing soil hydrologic data is overlayed with LULC raster data on a pixelated grid. Each grid cell has a corresponding value for the soil hydrologic group and the LULC class; the ability for rainfall infiltration into the soil at each grid cell is determined in the model by overlaying these two values to determine a value between 0 to 100. For example, if a grid cell is determined to be a deciduous forest and assigned soil hydrologic A (Curve Number A), the biophysical table inputs

a value of 36 into the model for that grid, indicating that grid cell is likely to have high rainfall infiltration in the soil. Ultimately, these values are translated into equations as inputs during model processing to determine runoff retention at each grid cell. More information related to these equations and how the InVEST Urban FRM model works can be found in the user manual (NatCap 2024). Default curve number data from the InVEST Urban FRM model was used for each LULC class.

Table 18 contains potential damage loss estimates for each building type. The damage estimates for each building type were developed using North American depth-damage functions, which are based on the Federal Emergency Management Agency (FEMA) Hazards United States (HAZUS) data and include damages related to structures and their contents (European Commission's Joint Research Centre 2017). HAZUS depth-damage data was cross-referenced with the model input for rainfall depth to obtain an estimated damage value for residential, commercial, and industrial structures. Original depth-damage estimates were in 2017 price levels and expressed in units of Euros per square meter. Euros were converted to USD 2017 price levels using exchange rates provided by the European Central Bank (2024). Price levels were subsequently updated to 2024 price levels using the *Producer Price Index by Commodity: Final Demand Construction* (U.S. Bureau of Labor Statistics 2024d). The final demand construction index tracks price change for new construction and maintenance and repair construction sold to final demand (U.S. Bureau of Labor Statistics 2025). The result of both calculations is a damage estimate for residential, commercial, and industrial buildings expressed in dollars per square meter, which is the unit of measurement required for the InVEST Urban FRM model. As an example, it is estimated that, on average, for every square foot that a residential unit is flooded, approximately $33 in damage occurs when a depth of 187.706 millimeters of flooding is applied. This value is representative of the average repair and replacement costs attributed to flooded residential units.

Table 18 also contains a column that converts the dollars per square meter to dollars per square foot for comparison purposes only. The dollars per square foot value was not used as model input.

Table 17: InVEST Urban FRM Biophysical Table Inputs

LULC	Curve Number A	Curve Number B	Curve Number C	Curve Number D
Open Water	1	1	1	1
Developed Open Space	49	69	79	84
Low Intensity Developed	51	68	79	84
Medium Intensity Developed	61	75	83	87
High Intensity Developed	89	92	94	95
Barren	77	86	91	94
Deciduous Forest	36	60	73	79
Evergreen Forest	36	60	73	79
Mixed Forest	36	60	73	79
Grassland/Herbaceous	49	69	79	84
Pasture/Hay	49	69	79	84
Cultivated Crops	63	75	83	87
Woody Wetlands	1	1	1	1
Emergent Herbaceous Wetlands	1	1	1	1

[1] Curve number data presented in the table is default curve number data that is recommended by the Natural Capital Project (NatCap 2025).

Table 18: Damage Loss Table for InVEST Urban FRM Model

Type (Identifier for Model to Interpret Building Type)	Building Type	Damage ($/m^2) (USD)	Damage ($/ft^2) (USD)
0	Residential	$353	$32.81
1	Commercial	$517	$48.02
2	Industrial	$798	$74.14

[1] Damage estimates for each building type were developed using North American depth-damage functions, which are based on the Federal Emergency Management Agency (FEMA) Hazards United States (HAZUS) data and include damages related to structures and their contents (European Commission's Joint Research Centre 2017).
$/F^2: dollars per square foot
$/m^2: dollars per square meter

5.4.2 Results of Costs Avoided to Infrastructure Analysis

The output from the InVEST Urban FRM model is displayed in Table 19. The results estimate that of the total runoff volume of 975,959,167 cubic feet, and 495,705,582 cubic feet is expected to be retained at the 100-year event. An average runoff retention rate of 0.32 is estimated across the watershed; this value can be interpreted as an estimated 32% of rainfall is absorbed or detained by the landscape within the watershed, thereby reducing the volume of surface runoff. This is

indicative that the open spaces within the GBFW provide a flood-risk-reduction benefit by preventing stormwater from flooding existing structures within the watershed. The model results indicate that given a 100-year rainfall event, stormwater retention from natural infrastructure within the GBFW potentially prevents approximately $765 million in economic damages. Given that the current built infrastructure inventory estimates over 7,000 total structures within the GBFW, this translates into an estimated value of approximately $98,000 in repair and replacement costs avoided per structure. Given that the model uses a simple approach, this estimated $765 million in economic damages prevented should be considered as a maximum value of economic damages prevented. The InVEST Urban FRM model does not have the capability to produce inundation maps and confirm exposed infrastructure. The valuation approach for damages prevented in this model is expressed as potential damages avoided for built infrastructure, and a limitation of this model is that it applies the damage values, contained in Table 18, to the built infrastructure regardless of the depth of flooding and does not consider flood severity (NatCap 2024).

Given the results of this modeling approach, it is expected that if more development were to occur within the watershed, there will likely be potential for less runoff volume to be contained by natural infrastructure and potential damages would also likely increase due to a larger number of structures in the watershed.

Table 19: InVEST Urban FRM Model Results

Average Runoff Retention[1]	Total Runoff Retention Volumes (cubic feet)	Runoff Volume (cubic feet)	Maximum Damages Avoided[2]
0.32	475,705,582	975,959,167	$764,996,141

[1] Values for runoff retention and runoff volume are calculated in the model on a pixelated grid system that is overlayed on the GBFW. Each pixel has different runoff and retention volumes. Average runoff retention output is representative of the average runoff retention for all pixels across the entire watershed.

[2] Dollar values are in USD 2024 price levels and rounded to the nearest thousands.

These benefits are enjoyed by property owners who avoid incurring repair and replacement costs due to flood damage. Municipalities may also rely on the stormwater retention of natural infrastructure, to some degree, which reduces the need to build and maintain engineered stormwater systems that would be needed should this ecosystem service not be available. As mentioned earlier, natural infrastructure might also assist with improving water quality and providing opportunities for recreation and tourism, which are ancillary benefits to reducing flood risk.

5.5 Social Costs of Pesticide Use and Pesticide Reduction

5.5.1 Method of Estimating Social Costs of Pesticide Use

Social cost represents the total cost to society from an activity, including both private and external costs. Pesticide use can result in both acute and chronic risks to human health, including cancer, particularly when high concentrations are involved. Research indicates that farmers may be exposed to harmful concentrations in the field, while the public can be exposed through drinking

water and food products. Pesticides have also been found to impact the ecological status of water and soil and to affect wildlife and biodiversity negatively (Rufo et al. 2024).

To estimate the benefits of reducing pesticide use, Geosyntec collected data from a study that reviewed 30 years of research on how much consumers and farmers are willing to pay to lower the social costs of pesticides. The meta-analysis focuses on the negative externalities of pesticide use and factors in the risk to human health and environmental health. The risks of pesticide use as they relate to human health included risks to both farmers and consumers and factored in cancer and both acute and chronic effects. The risks of pesticide use as they relate to environmental health include biodiversity loss, surface water pollution, and groundwater pollution. Social costs of pesticide use are measured as a proxy from empirical nonmarket valuation approaches to assess the willingness-to-pay of food consumers and farmers to reduce or prevent the risks associated with pesticide use. In other words, the social cost of pesticide use can be estimated by understanding what people are willing to pay to reduce the risk of pesticide use. The meta-analysis concluded that the estimated average global social cost of pesticide use is $51 per person per year and a median global cost of $21 per person per year, with no significant differences between consumers and farmers or between risk eliminations and partial risk reductions. (Rufo et al. 2024).

The following are some examples of social costs that the meta-analysis did not include:

- Public Health Expenditures: The financial burden due to pesticide-related illnesses. For instance, the use of organophosphate pesticides in the U.S. has been estimated to lead to health costs of up to $44.7 billion per year (Centner 2021).
- Pesticide Resistance and Increased Chemical Dependence: Dependence on chemical pesticides can lead to the development of resistance among pests, necessitating the use of higher doses or more-potent chemicals. This cycle increases production costs and environmental contamination (Hu 2020).

Using the built infrastructure inventory used in the InVEST Urban FRM model, Geosyntec estimates that there are 7,437 residential housing units in the GBFW. Given that the estimated social costs are presented in dollars per person per year, 2023 ACS data for Boone County (U.S. Census Bureau 2023) was used to estimate an average household size of 2.33, and that number was multiplied by the number of residential units to estimate the number of residents within the GBFW. Estimates were rounded to the nearest whole number.

The median willingness-to-pay value was used to estimate the lower-bound estimate of the annual social cost of pesticide use in the GBFW, and the mean willingness-to-pay value was used to estimate the upper-bound estimate. Mean and median willingness-to-pay values were multiplied by the estimated number of residents within the GBFW to estimate a range of social costs. Results are presented in Table 20.

5.5.2 Results of Social Costs of Pesticide Use Analysis

Social costs related to pesticide use in the GBFW are estimated to be between $363,888 and $883,728 per year for residents in the GBFW (Table 20). This range of monetary values represents an aggregate estimate of how much residents are willing to pay each year to prevent the risk associated with pesticide use as they pertain to human and environmental health.

Table 20: Pesticide Load Reduction Benefits

Social Cost of Pesticide Use (Median)[1]	Social Cost of Pesticide Use (Mean)[1]	Number of Residential Housing Units[2]	Average Household Size[3]	Estimation of Residents within the GBFW	Annual Social Cost of Pesticide Use in the GBFW (Lower Bound)	Annual Social Cost of Pesticide Use in the GBFW (Upper Bound)
$21	$51	7,437	2.33	17,328	$363,888	$883,728

[1] Social costs were gathered from *The social costs of pesticides: a meta-analysis of the experimental and stated preference literature* (Rufo et al. 2024).
[2] The number of units was estimated using Microsoft Footprint data (Microsoft Corporation 2024) and USACE NSI data (USACE 2024).
[3] Average household size was estimated using 2023 ACS data for Boone County (U.S. Census Bureau 2023).

One method that can be used is regenerative agriculture, which is reducing the need for pesticide use or eliminating pesticides completely (Karas 2025). The WBP emphasizes the adoption of regenerative agriculture as one of the key strategies in the WBP's endorsement of conservation agriculture practices to enhance water quality and promote environmental sustainability within the watershed (Boone County Resource Management and Project Partners 2023). Conservation agriculture is defined in the WBP appendices as,

> "*A holistic approach focusing on practices that minimize soil disturbance, maintain soil coverage, increase plant diversity, keep living roots in the soil, and integrate animals into farming systems. Specific practices include diverse crop rotations, multi-species cover crops, no-till or low-till farming, soil management, prairie strips, and rotational grazing" (Boone County Resource Management and Project Partners 2022).*

Regenerative agriculture practices would help reduce the use of pesticides, and thus, reduce the human and environmental health risks from the exposure to pesticides.

5.6 *E. coli* Load Reduction

5.6.1 Qualitative Benefits of *E. Coli* Load Reduction

Reducing *E. coli* loads in the GBFW could provide significant indirect benefits, supporting both environmental quality and socioeconomic resilience. In the WBP, *E. coli* contamination is identified as a specific concern. Elevated levels of *E. coli* have been detected in several streams, leading to their inclusion on Missouri's Clean Water Act Section 303(d) list of impaired waters. Specifically, six stream segments—Bass Creek, Bonne Femme Creek (upper and lower segments),

Gans Creek, Little Bonne Femme Creek, and Turkey Creek—have been listed due to *E. coli* concentrations exceeding the state's water quality standards for whole-body contact recreation.

The WBP attributes these impairments to multiple factors, including the following:

- Microbial contamination from on-site wastewater systems: Failing or improperly maintained on-site wastewater systems can release untreated or partially treated sewage into the watershed, introducing pathogens such as *E. coli* into water bodies.
- Animal waste runoff from pastures: Livestock grazing near streams contributes to fecal matter being directly deposited into waterways or being transported via stormwater runoff, elevating *E. coli* levels.
- Animal waste from wild animals contributes to the "natural" background levels of *E. coli*
- Stormwater runoff from residential, commercial, and industrial areas: Urban development increases impervious surfaces, leading to greater stormwater runoff that can carry pollutants, including *E. coli*, into streams.

These sources collectively contribute to *E. coli* loading, posing risks to public health and the ecological integrity of the watershed. The WBP emphasizes the need for targeted interventions, such as improving on-site wastewater system management, implementing BMPs in agriculture to reduce runoff, and enhancing stormwater management in urban areas to mitigate *E. coli* contamination and restore the designated uses of the impaired streams.

Addressing this contamination would deliver a wide range of indirect benefits that enhance community well-being and environmental sustainability. Some examples of these benefits are outlined below.

5.6.1.1 Recreational Opportunities

The GBFW is a valuable natural resource that supports recreational activities, such as swimming, fishing, and kayaking, and *E. coli* contamination often results in reducing access to these activities. Cleaner waterways would enhance recreational opportunities, attracting visitors and boosting local economies. According to a study by USEPA, water quality improvements can increase recreational activity participation and generate economic benefits, particularly in areas reliant on tourism and outdoor recreation (USEPA 2024c).

5.6.1.2 Reduced Water Treatment and Infrastructure Costs

High *E. coli* levels can necessitate costly treatment processes for municipalities and private water systems to ensure the safety of drinking water. For example, to demonstrate the potential magnitude for treatment costs, Missouri American Water invested more than $450 million to improve water and wastewater treatment and pipeline systems in 2022 (Missouri American Water 2023). Although these investments were not exclusive to only treating *E. coli*, it highlights the scale of financial commitments involved in maintaining water quality. By reducing *E. coli* loads at the source, communities in the watershed can lower treatment costs, leading to long-term savings.

Forests and other vegetated areas act as natural filters. As water passes through these areas, vegetation and soil can trap and absorb pollutants, including *E. coli*, thereby preventing them from reaching waterways (Gould 2021). According to USEPA, natural landscapes filter pollutants and protect water quality. A review of treatment costs and watershed characteristics for 27 drinking

water utilities found that for every 10% increase in forest cover of the source water area, chemical and treatment costs decrease by 20% (USEPA 2024c). In a separate case, New York City found it significantly more cost-effective to protect the watershed's natural land cover and forests to provide natural filtration than to install a multi-billion-dollar water treatment facility (USEPA 2024c).

5.6.1.3 Public Health Benefits

High *E. coli* levels in water can lead to waterborne diseases, posing significant risks to human health. Reducing contamination would decrease the incidence of gastrointestinal illnesses and related healthcare costs. The National Institute of Health (NIH) emphasizes that certain strains of *E. coli* tend to have a high prevalence for transmitting waterborne diseases and that addressing microbial pollution is essential for protecting public health, reducing healthcare burdens and enhancing water security (NIH 2021). Additionally, *E. coli* is an indicator organism, and its presence suggests that there could be other disease-causing organisms present as well. Health impacts related to illnesses linked to *E. coli* can have both direct and indirect impacts on residents. For example, a study estimated that patients incurred between $7,476.84 and $8,048.68 in direct medical costs to bloodstream infections related to *E. coli* (Wang et al. 2020). Adjusted to 2024 price levels using the *Consumer Price Index for All Urban Consumers: Medical Care in U.S. City Average* (U.S. Bureau of Labor Statistics 2024b), direct medical costs are estimated to be between $8,133.37 and $8,755.42 for patients with bloodstream infections related to *E. coli.* Furthermore, when indirect impacts are considered, it is estimated that patients lost an average of 2.15 years of full health, measured in disability-adjusted life years, as well (Wang et al. 2020).

There is uncertainty surrounding how health costs such as these relating to *E coli* would translate into a benefit, due to lack of publicly available data. Data such as local hospitalization rates would help provide a quantitative benefit estimate. Nevertheless, if reducing *E. coli* loads leads to a reduced instances of *E. coli*-related illnesses, there is expected to be a direct benefit to individuals in the watershed from direct medical costs avoided and an indirect benefit from the potential to avoid a reduction in the number of years of full health, or disability-adjusted life years.

Efforts to reduce the *E. coli* contamination that might affect the water quality in GBFW would create a ripple effect of indirect benefits. These include economic growth through tourism, reduced costs for water treatment and healthcare, enhanced ecosystem services, and increased community satisfaction and quality of life.

5.7 Environmental Benefits Summary

The analysis of indirect use benefits within the GBFW underscores the significant environmental and economic advantages provided by ecosystem services. Reducing nitrogen and phosphorus loads through BMP implementation results in an annual cost savings of approximately $4,000 to $5 million, contingent upon the implementation of BMPs at various phases. Similarly, implementation of sediment load reduction BMPs is estimated to prevent between 1 million and 4 million pounds of sediment from entering waterways annually, translating into roughly avoiding between $37,000 and $2 million of costs for soil replacement. Additionally, BMP implementation has the potential to achieve a multitude of benefits simultaneously. For example, the enhancement of riparian corridors has the potential to reduce nutrients, sediment, and *E. coli* loads.

Stormwater retention by natural infrastructure mitigates flood risks, averting approximately $765 million in potential infrastructure damages. Collectively, it is estimated the residents in the GBFW

would be willing to pay between $364,000 and $884,000 annually to avoid the human and environmental health risks associated with pesticide use.

Qualitatively, these benefits extend beyond mere cost savings to encompass improvements in community well-being, environmental sustainability, and public health. Reducing *E. coli* loads has the potential to enhance water quality and therefore supports recreational opportunities, minimizes water treatment costs, and safeguards public health by decreasing the prevalence of waterborne diseases. Additionally, these indirect use benefits foster socioeconomic resilience, help promote tourism and enhance the overall quality of life for residents.

Additionally, survey results from the GBFW Community Survey indicate the following, which demonstrates community support for measures that promote environmental benefits:

- 90% of respondents are likely to adopt conservation practices on their property if it improves the community's environmental health.
- 95% of respondents agree that pollution in local streams harms the environment.
- 96% of respondents agree that it is important to consider the environmental impacts of residential and commercial development.

The findings emphasize the interconnectedness of ecological health and economic prosperity, reinforcing the importance of integrating natural capital preservation into policy and planning. The value of indirect use benefits highlights the compelling case for sustained conservation efforts to secure both environmental and economic sustainability.

6 ECONOMIC ACTIVITY BENEFITS

6.1 Introduction to Economic Activity Benefits

The natural capital contained in the GBFW directly contributes to economic activity within Boone County, particularly in terms of industries that support outdoor recreation and tourism. To help emphasize the importance of tourism and outdoor recreation, there are some statistics that are worth mentioning. MDT discovered that almost 25% of travelers identified outdoor recreation as one reason for visiting Missouri in fiscal year (FY) 2021 (Extension University of Missouri 2022). MDT also discovered that Columbia, Missouri, was one of the top destinations of overnight visitors in Missouri in 2023 (MDT 2023b). Furthermore, some research has found that 75% of travelers state that outdoor activities are essential to their travels (WiT 2024). The natural capital within the GBFW also bolsters economic activity by offering appealing benefits to both employers and workers and contributing to the tax base of the County and local municipalities. This section focuses on estimating the economic and fiscal impacts that can be attributed to natural capital in addition to recognizing additional ancillary benefits for businesses and employees.

6.2 Economic and Fiscal Impacts

The economic impact analysis estimates the direct, indirect, and induced economic activity from estimated tourism spending related to activities within the GBFW. Tourism spending is estimated using MDT's North American Industry Classification System (NAICS) spending estimates for FY2023 in Boone County, which is $545,793,404 (MDT 2023b). MDT's NAICS spending estimates are based on 45 tourism-related NAICS codes (MDT 2023b). Given that NAICS spending data is given at the county level, a ratio of the urban land area within the GBFW and the land area of Boone County was used to estimate a proportional NAICS spending value within the GBFW. The results of this calculation are provided in Table 21. A limitation of this approach is that it could overestimate economic activity and fiscal impact benefits given that the NAICS spending categories used by MDT (2023b) include visitor spending on activities that may not be pertinent to or limited within the GBFW. It also assumes that spending occurs proportionally across Boone County.

Table 21: NAICS Spending Estimate for the GBFW

Land Area of Boone County (mi^2)	Land Area of GBFW (mi^2)	Proportional Land Area (Urban Area in GBFW to Boone County)	NAICS Spending (Boone County, MO)	Proportional NAICS Spending
691.12	92.4	0.012	$545,793,404	$6,549,521
[1] NAICS spending data was gathered from the FY2023 report for MDT (MDT 2023b).				

MDT used the IMPLAN input-output model to trace the flow of visitor-related expenditures through the state's economy. This model was included in a study that was done by Tourism Economics, an Oxford Economics company, for MDT. The IMPLAN input-output model traces the flow of visitor-related expenditures through the state's economy and estimates their impact on employment, wages, and taxes while also looking at impacts to suppliers and income. Tourism Economics cross-checked model outputs (impacts) with employment and wage data for each sector

to ensure estimated impacts fall within reasonable ranges. According to MDT, their Tourism Economics model calculates three levels of impact which include (MDT 2023c):

- **Direct Impact:** Impacts (business sales, jobs, income, and taxes) created directly from spending by visitors to a destination within a discreet group of tourism-related sectors (e.g., recreation, transportation, accommodations).
- **Indirect Impact:** Impacts created from purchase of goods and services used as inputs (e.g., food wholesalers, utilities, business services) into production by the directly affected tourism-related sectors (i.e., economic effects stemming from business-to-business purchases in the supply chain).
- **Induced Impact:** Impacts created from spending in the local economy by employees whose wages are generated either directly or indirectly by visitor spending.

Direct impacts of visitor spending related to activities within the GBFW were estimated using the calculated NAICS spending value for the GBFW presented in Table 21. Indirect and induced impacts were estimated by comparing the direct, indirect, and induced impacts from MDT's IMPLAN outputs and taking a ratio of indirect impacts compared to direct impacts and a ratio of induced impacts compared to direct impacts. These calculations are presented in Table 22. These ratios were multiplied by the estimated proportional spending, or direct impacts, for the GBFW to estimate both indirect and induced impacts for the GBFW; the results are presented in Table 23. Dollar values in Table 23 were adjusted from 2023 price levels to 2024 price levels using a CPI factor of 1.0311, calculated from the *Consumer Price Index for All Urban Consumers: All Items* (U.S. Bureau of Labor Statistics 2024a).

Table 22: Economic Impact of Tourism Spending in Missouri

	Direct	Indirect	Induced	Total
Economic Impacts of Tourism-Driven Business Sales (Missouri)	$11.90	$4.10	$4.00	$19.90
Proportion of Direct Spending (Missouri)	N/A	0.34	0.34	N/A

[1] Dollars are expressed in billions and 2023 price levels.

[2] Economic impact data was gathered from MDT's report titled, *Economic Impact of Visitors in Missouri FY2023* (MDT 2023c).

Table 23: Estimation of Economic Impacts from Tourism Spending in the GBFW

	Direct	Indirect	Induced	Total
2023 Price Level	$6,549,521	$2,256,558	$2,201,520	$11,007,598
2024 Price Level	$6,752,948	$2,326,646	$2,269,898	$11,349,492

[1] Indirect and induced impacts are estimated by multiplying a weight against direct impacts. Weights were calculated from the results of the IMPLAN analysis used to estimate economic impacts contained in MDT's report titled, *Economic Impact of Visitors in Missouri FY2023* (MDT 2023c).

The fiscal (tax) impacts of visitor spending related to activities within the GBFW were estimated using a similar method as above. MDT (2023c) provides estimates for industry employment and fiscal impacts related to visitor spending (Table 24). Like Table 22, Table 24 displays proportional values of tax revenues collected at the federal, state, and local levels compared to total economic impacts represented by the sum of direct, indirect, and induced impacts. Fiscal impacts of visitor spending related to activities within the GBFW were estimated by multiplying the total impact value contained in Table 23 by the proportional values at each level of government, represented in Table 24; the result of these calculations are contained in Table 25 and represent an estimation of fiscal impacts at the federal, state, and local levels. Dollar values in Table 25 were adjusted from 2023 price levels using a CPI factor of 1.0311, calculated from the *Consumer Price Index for All Urban Consumers: All Items* (U.S. Bureau of Labor Statistics 2024a).

Table 24: Fiscal Impact Estimates of Tourism Spending in Missouri

	Federal	State	Local	Total
Fiscal (Tax) Impacts in Missouri from Visitor Spending	$1.1469	$0.6116	$0.9347	$2.6927
Proportion of Total Spending (Missouri)	0.06	0.03	0.05	0.14

[1] Dollars are expressed in billions and 2023 price levels.

[2] Fiscal impact data was gathered from MDT's report titled, *Economic Impact of Visitors in Missouri FY2023* (MDT 2023c).

Table 25: Estimation of Fiscal Impacts from Tourism Spending in the GBFW

	Federal	State	Local	Total
2023 Price Level	$634,403	$338,304	$517,025	$1,489,732
2024 Price Level	$654,107	$348,812	$533,084	$1,536,003

[1] Fiscal impact is estimated by multiplying a weight for each category against total spending. Weights were calculated from the results of the IMPLAN analysis used to estimate economic impacts contained in MDT's report, *Economic Impact of Visitors in Missouri FY2023* (MDT 2023c).

MDT estimated that NAICS spending in FY2023 supported 11,612 tourism-related jobs in Boone County (MDT 2023c). On average, this approximates to one job supported for every $47,000 in spending. Given that NAICS spending is estimated at approximately $6.55 million for activities related to tourism within the GBFW (Table 21), it is estimated the visitor spending supports approximately 139 jobs, as shown in Table 26.

Table 26: Estimation of Employment from Tourism

NAICS Spending (Boone County)	Number of Tourism-Related Jobs Supported in Boone County	Expenditures Needed per Job in Boone County	NAICS Spending (GBFW)	Estimate of Tourism-Related Jobs Supported in the GBFW
$545,793,404	11,612	$47,003	$6,549,521	139
[1] NAICS spending and employment data was gathered from the FY2023 report for MDT (2023b).				

6.3 Business and Employee Attraction

Open spaces are an important component in driving economic vitality by attracting businesses and employees. Open spaces provide quality-of-life improvements and create vibrant environments that draw businesses seeking to establish or expand operations. Moreover, open spaces enhance workforce productivity and reduce healthcare costs by promoting physical and mental well-being, making regions with abundant natural environments more appealing for business relocation and expansion. For employees, open spaces can support mental health, reduce stress, and foster happiness; these factors are increasingly valued in the modern job market. These benefits are particularly significant for attracting skilled professionals and improving work-life balance. Additionally, open spaces stimulate local economies by increasing foot traffic and consumer spending, and equitable access to these areas mitigates health disparities and enhances community inclusivity. The following subsections focus on a qualitative discussion related to business and employee attraction and how they relate to the GBFW.

6.3.1 Business Attraction

Open spaces have a profound impact on a community's economic vitality and attractiveness to businesses. Open spaces such as parks, forests, and green infrastructure contribute to a healthier workforce and an improved quality of life; both are factors that draw businesses. According to the Trust for Public Land, the presence of parks and community green spaces not only attracts and retains businesses but also fosters economic development by generating tax revenues and supporting tourism (Trust for Public Land 2024); this was also indicated by many of the economic results in previous sections. These spaces create a vibrant environment that encourages commerce and enhances the overall appeal of a community for investors and businesses alike.

The correlation between green spaces and workforce health is another critical driver of economic value. Research published in the International Journal of Environmental Research and Public Health demonstrates that urban green spaces promote physical and mental well-being, which increases workforce productivity and reduces healthcare costs for employers (Wilson and Xiao 2023). A healthier and more productive workforce becomes an asset to businesses, making locations that offer ample green space attractive for relocation and expansion.

6.3.2 Employee Attraction

The GBFW represents a significant asset to Boone County, not only for its ecological contributions but also for its potential influence on employee attraction and retention. The following subsections examine how the presence of open spaces within the GBFW can enhance Boone County's capacity to attract and retain a skilled workforce, thereby contributing to broader economic and social vitality.

6.3.2.1 Cognitive Function

Exposure to green outdoor environments has been shown to facilitate recovery from mental fatigue and enhance an individual's capacity for directed attention. Experimental studies indicate that views of natural landscapes support creativity and improve performance in attention-intensive tasks. Additionally, the presence of greener surroundings near homes or educational institutions has been associated with cognitive benefits throughout various stages of life. Some examples include the following:

- A study found that children 4 to 8 years old had higher attention scores following a nature walk than following an urban walk (Schutte et al. 2017).
- For adults aged 45 to 68 at baseline, more greenery around the home was associated with slower cognitive decline over 10 years as measured by tests of reasoning and verbal fluency (de Keijzer et al. 2018).
- Odds of Alzheimer's disease were lower among seniors (65 years and older) not living in nursing homes who lived in greener neighborhoods than for those who lived in less green neighborhoods (Brown et al. 2018).

6.3.2.2 Happiness and Depression

Engaging in activities such as walking or spending time in natural, green environments rather than developed or urban settings has been linked to elevated levels of positive emotional states. Similar effects have been observed when individuals view images depicting natural landscapes. Furthermore, residents living in areas with greater green space have reported higher levels of happiness and well-being. Some examples include the following:

- Walking in a rural versus an urban setting had a positive effect on mood, including stress and happiness; this effect was larger in the group with poor mental health (Roe and Aspinall 2011).
- A meta-analysis found that study subjects who had various short-term exposures to nature stimuli reported improved positive affect on happiness (McMahan and Estes 2015).

Furthermore, exposure to green spaces, whether through participation in outdoor activities or proximity to vegetated areas, has been associated with a reduction in depressive symptoms. These benefits can manifest with as little as 10% green space coverage or a minimum of 30 minutes of exposure. Conversely, residing in environmentally degraded areas with minimal vegetative cover has been correlated with an increased risk of depression (USEPA 2024b). Some examples of this include the following:

- A study found that green space was significantly associated with decreased depression regardless of an area's social economic status (Groenewegen et al. 2018).
- Study subjects who perceived the absence of greenery and other public assets (places to sit or walk, or safe places for children to play) in their neighborhoods were 90% more likely to feel depressed or sad (Ellaway et al. 2009).

6.4 Economic Activity Benefits Summary

The economic activity analysis contained in this section demonstrates that the watershed contributes directly to Boone County's economic vitality, particularly through tourism and outdoor recreation. With an estimated $11 million in total economic impacts from visitor spending and

support for over 100 tourism-related jobs, the ecosystem services within the GBFW prove to be essential to fostering economic activity. Moreover, the fiscal contributions, amounting to about $2 million in tax revenues across the federal, state, and local levels, further underscore the watershed's value in contributing to public finances.

Beyond quantitative metrics, the GBFW enhances business and employee attraction by offering significant quality-of-life improvements. Open spaces, such as those within the watershed, support physical and mental well-being, fostering a healthier and more productive workforce. Businesses benefit from reduced healthcare costs and an attractive environment for relocating or expanding operations. Furthermore, the watershed creates vibrant settings that stimulate commerce by increasing foot traffic, consumer spending, and overall economic activity. The qualitative findings also point to the importance of these natural spaces in reducing stress, improving cognitive function, and mitigating mental health challenges, which can be beneficial for businesses who are seeking to attract and retain skilled professionals.

The GBFW is a vital component of Boone County's environmental, economic, and social fabric. Its contributions to tourism, business attraction, workforce productivity, and community health highlight the interconnected nature of economic and environmental sustainability. As pressures on natural resources continue to grow, prioritizing investments in open spaces, like those within the GBFW, will be essential for ensuring long-term economic prosperity and resilience in the region.

7 PROPERTY VALUE BENEFITS

7.1 Introduction to Property Value Benefits

The relationship between property values and the presence of open spaces has garnered significant attention in recent years, driven by the growing recognition of the multifaceted benefits that such spaces offer to communities. This section investigates the economic advantages offered by open spaces on surrounding property values.

7.1.1 Method of Estimating Property Value Benefits

A simplified approach was applied to estimate property value premiums provided to residents owning homes located near open spaces. The first step of the process involved gathering home value data from the *Boone County and the City of Columbia Housing Study* (Boston et al. 2024) as the basis for valuing residential properties. Ranges of property values were assigned to 13 groups as shown in Table 27.

Table 27: Grouped Property Value Ranges

Group	Property Value Range[1,2]
1	< $50,000
2	$50,000–$99,999
3	$100,000–$149,999
4	$150,000–$199,999
5	$200,000–$249,000
6	$250,000–$299,999
7	$300,000–$399,999
8	$400,000–$499,999
9	$500,000–$749,999
10	$750,000–$999,999
11	$1,000,000–$1,499,999
12	$1,500,000–$1,999,999
13	> $2,000,000

[1] Dollar values are expressed in 2024 price levels.

[2] Property value data was gathered from *the Boone County and the City of Columbia Housing Study* (Boston et al. 2024).

Second, the range of property value premiums were estimated based on results from a study that reviewed 33 studies and found a premium of 8% to 10% on properties adjacent to a passive park (Crompton and Nicholls 2020). Finally, a range of property value premiums for each group was calculated for each group of property values. The lower-bound estimate was calculated by multiplying the lowest property value in a group by 8%. The upper-bound estimate was calculated by multiplying the highest property value in a group by 10%. A lower-bound estimate for home values in Group 1 is not provided, and an upper-bound estimate for home values in Group 13 is not provided. This is due to how the *Boone County and the City of Columbia Housing Study*

(Boston et al. 2024) categorized home value data, as shown in Table 27. A range of property value premiums were estimated for Group 1 and Group 13 by multiplying a single home value by the estimated low and high estimated premium percentages. Results are shown in Table 28. Additional qualitative discussion is also contained in Section 7.2.

7.1.2 Results of Property Value Benefits Analysis

Given the simplified method, the average property value premium for structures in Boone County located next to open spaces, including those located next to open spaces within the GBFW, ranges substantially depending on the property value of the home, between $4,000 and $200,000. Given an estimated median home value of $296,787 (Boston et al. 2024), most homes located near open spaces are estimated to receive a home value premium of approximately between $23,743 and $29,679.

Table 28: Property Value Premium for Structures Near Open Spaces[1, 2, 3]

Home Value Group	Home Value (Low)	Home Value (High)	Estimated Premium (%, Low)	Estimated Premium ($, Low)	Estimated Premium (%, High)	Estimated Premium ($, High)
1	N/A	$49,999	8%	$4,000	10%	$5,000
2	$50,000	$99,999	8%	$6,000	10%	$7,500
3	$100,000	$149,999	8%	$10,000	10%	$12,500
4	$150,000	$199,999	8%	$14,000	10%	$17,500
5	$200,000	$249,000	8%	$17,960	10%	$22,450
6	$250,000	$299,999	8%	$22,000	10%	$27,500
7	$300,000	$399,999	8%	$28,000	10%	$35,000
8	$400,000	$499,999	8%	$36,000	10%	$45,000
9	$500,000	$749,999	8%	$50,000	10%	$62,500
10	$750,000	$999,999	8%	$70,000	10%	$87,500
11	$1,000,000	$1,499,999	8%	$100,000	10%	$125,000
12	$1,500,000	$1,999,999	8%	$140,000	10%	$175,000
13	$2,000,000	N/A	8%	$160,000	10%	$200,000+

[1] Dollar values are expressed in 2024 price levels.

[2] Property value data was gathered from the *Boone County and the City of Columbia Housing Study* (Boston et al. 2024), and estimations for property value premiums were gathered from *Impact on property values of distance to parks and open spaces: An update of U.S. studies in the new millennium* (Crompton and Nicholls 2020).

[3] A lower-bound estimate for home values in Group 1 is not provided, and an upper-bound estimate for home values in Group 13 is not provided. This is due to how the *Boone County and the City of Columbia Housing Study* (Boston et al. 2024) categorized home value data. A range of property value premiums were estimated for Group 1 and Group 13 by multiplying a single home value by the estimated low and high estimated premium percentages.

This premium is a benefit to homeowners for a multitude of reasons:

Increased Home Equity

- The premium directly increases the market value of the property, boosting the homeowner's equity. This higher value can result in the following:
    - Greater borrowing power: Higher equity can be leveraged for loans or lines of credit (Corradin and Popov 2015).
    - Improved resale potential: Homeowners may demand a higher price if they decide to sell, leading to a better return on investment (Scisco 2024).

Desirability and Demand

- Surrounding parks and open spaces have a statistically significant impact on residential property values inferring relatively higher desirability and demand (Lei 2020).
- Research indicates that the greatest premium occurs in planned communities where homes with a view of green spaces are located close to large, passive recreational greenways (Kim and Peiser 2018).
- More than 30 studies have shown that people are willing to pay more for a property located close to an urban open space than for a house that does not offer this amenity (University of Washington 2024).

In addition to the findings in academic literature, the GBFW Community Survey indicated the following:

- 94% of respondents agree that maintaining natural open spaces for public access increases property values.
- 90% of respondents agree that environmental contamination affects property values.

These results indicate that it is likely that community perceptions in the GBFW and findings in academic literature align well, which supports the notion that properties in the GBFW that are located proximal to open spaces do realize a premium in their value. Furthermore, as part of a housing study conducted for Boone County and the City of Columbia (Boston et al. 2024), a survey was conducted to learn more about the housing needs, preferences, and challenges in Boone County. In that survey, respondents were asked to state factors that are important considerations when moving to a new home. Most respondents indicated that proximity to parks or playgrounds and the walkability of the surrounding area were important to them. This reflects a communal desire for properties located near open spaces and serves as supporting evidence to suggest that this demand may play a role in property value premiums for these properties.

7.2 Property Value Benefits Summary

The estimated property value premium approximately between $23,000 and $30,000 for most homes near open spaces highlights the economic and lifestyle benefits provided by such amenities. The full range of estimates for property value premiums is wide, ranging from $4,000 to $200,000 or more, and the estimated property value benefit is expected to rise in tandem with the value of the home. This premium reflects increased equity and enhanced market desirability for homeowners. As urbanization continues to limit access to open spaces, the value of properties near

these areas is likely to grow, underscoring the importance of preserving and integrating open spaces into community planning.

8 COMMUNITY COST SAVINGS

8.1 Introduction to Community Cost Savings

Residential development often imposes a disproportionate fiscal burden on municipalities and school districts. As an example, and unlike some land uses, residential property development generates demand for educational services by adding students to local schools, which can lead to increased expenditures that are not fully offset by school-related tax revenues. This fiscal imbalance can place strain on local government budgets or necessitate higher taxes to cover the shortfall (Kotval and Mullin 2006).

In contrast, protected open spaces, such as farmland and undeveloped land, provide economic and community benefits that contribute to the financial stability of municipalities and school districts. A cost of community services (COCS) study uses a case-study method to assess the fiscal impact of various local land uses on municipal budgets. Positioned within the broader domain of fiscal analysis, COCS studies have gained recognition as a cost-effective and dependable approach for quantifying the direct financial relationships between land uses and public expenditures. These studies are particularly valuable for providing an equitable assessment of working and open lands alongside residential, commercial, and industrial land uses, ensuring that all land categories are evaluated on comparable terms (Farmland Information Center 2016). Initially developed by the American Farmland Trust (AFT) in New England, this method has been successfully applied across various states to inform land-use planning and fiscal policy decisions. For Boone County, Missouri, and particularly the GBFW, this section highlights the importance of maintaining open spaces to protect local economic interests through community cost savings.

8.2 Background and Method

In a COCS study, researchers analyze financial records to allocate municipal service costs across major land use categories, including residential, commercial, industrial, and working or open lands. The process begins with consultations between researchers and local sponsors to define the study's scope and identify relevant land use classifications. For instance, working lands may encompass farms, forests, and ranches, while residential development includes all forms of housing, such as rentals. In cases involving a migrant agricultural workforce, temporary housing for these workers is classified under agricultural land use. In rural settings, commercial and industrial land uses are often combined for analysis.

COCS findings are presented as ratios comparing annual revenues to annual expenditures for a community's specific land use mix. The method follows three fundamental steps:

1. Collect local revenue and expenditure data.
2. Categorize and allocate revenues and expenditures to major land use categories.
3. Analyze the data to calculate revenue-to-expenditure ratios for each category.

Ensuring accurate and reliable results requires local oversight. The most complex aspect involves interpreting existing financial records to align with the COCS land use categories. This allocation demands extensive research, including detailed interviews with financial officers and public administrators.

The AFT pioneered COCS studies in the mid-1980s as a cost-effective tool for communities to assess the fiscal contributions of agricultural lands. According to the Farmland Information Center (2016), since then, over 151 COCS studies have been conducted across the U.S.

The COCS method evaluates the public service costs incurred for every dollar of revenue generated by different land uses. These land uses are categorized as follows:

- Residential: Housing developments, apartments, and similar properties
- Commercial and Industrial: Businesses, factories, and warehouses
- Working and Open Land: Protected lands, parks, forests, and agricultural areas

By comparing revenues and expenditures for each category, the COCS study produces ratios that quantify the net fiscal impact of various land uses, providing communities with a valuable tool for informed land-use planning and financial decision-making.

A range of results from these studies was used to estimate the community cost savings benefits within the GBFW. The range was developed by taking the minimum and maximum COCS ratios from COCS studies that were conducted in states located in the Midwest according to the U.S. Census Bureau (2021). Midwest states that had COCS ratio data available are Michigan, Minnesota, Ohio, and Wisconsin. Ultimately, data from 19 COCS studies was incorporated into the analysis (Farmland Information Center 2016).

8.3 Results of Community Cost Savings Analysis

A range of COCS ratios are presented in Table 29. These represent the estimated range of community cost savings within the GBFW. A median COCS ratio for each land use category is also provided in Table 29.

Table 29: Estimation of Community Cost Savings

Land Use	COCS Ratio ($) Minimum	COCS Ratio ($) Median	COCS Ratio ($) Maximum
Residential	1:1.02	1:1.15	1:1.67
Commercial and Industrial	1:0.17	1:0.31	1:1.04
Working and Open Land	1:0.05	1:0.30	1:0.77
[1] COCS ratios were source from 19 COCS studies conducted in the Midwest (Farmland Information Center 2016)			

These results indicate that for every dollar of revenue generated by residential buildings, between $1.02 and $1.67 in public service costs are incurred. For every dollar of revenue generated for commercial and industrial, between $0.17 and $1.04 of public service costs are incurred. Finally, for every dollar of revenue generated for working and open land, between $0.05 and $0.77 of public service costs are incurred.

Some key conclusions highlighted by the Farmland Information Center (2016) that could also be applicable to the GBFW include that communities pay a high price for unplanned growth, and scattered development frequently causes traffic congestion, air and water pollution, loss of open space and increased demand for costly public services. This is why it is important for citizens and

local leaders to understand the relationships among residential and commercial growth, agricultural land use, conservation, and their community's bottom line. According to the Farmland Information Center (2016), COCS studies help address three misperceptions that are commonly made in rural or suburban communities facing growth pressures:

- Open lands, including productive farms and forests, are an interim land use that should be developed to their "*highest and best use.*" The findings show that, on average, working and open lands generate substantially more tax revenue than they require in public services. The results also indicate that if the open lands were to be developed into residential structures, the public services those residents would require would likely cost more than the revenue generated from property taxes.
- Agricultural land gets an unfair tax break when it is assessed at its current use value for farming or ranching instead of at its potential use value for residential or commercial development. Agricultural lands, which are included in the working and open land category, are estimated to cost between $0.05 and $0.77 in public services for every $1 of tax revenue they generate. This indicates that tax breaks might not be unfair, as agricultural lands generate more tax revenue than they require in public service costs.
- Residential development will lower property taxes by increasing the tax base. The results of COCS studies indicate that residential land use is the only land use category that consistently costs more in public services than it provides in tax revenue. The one exception is that the upper-bound COCS ratio for commercial and industrial land uses estimates that $1.04 of public service costs are incurred for every $1 of tax revenue generated. However, out of the 19 studies that were included in the estimates provided in Table 29, only 1 study estimated that the cost of public services for commercial and industrial land uses would exceed the tax revenue generated. Given that other land use types typically provide a fiscal surplus, it is likely that they compensate for the fiscal imbalance related to residential structures. It is also likely that highly developed areas with many residential structures could experience property tax raises given there are no commercial, industrial, open lands, or working lands to help offset the fiscal imbalance.

Given these findings, it is important for the community to balance residential land use with commercial and agricultural land use given that residential land use costs more to maintain in terms of public services provided than the tax revenue that it generates. For example, if open and working lands were developed into residential buildings, the public service costs would be estimated to increase by $0.90 to $0.97 per dollar of tax revenue generated.

8.4 Community Cost Savings Summary

COCS studies are a widely used fiscal analysis tool to assess the fiscal impacts of different land uses, such as residential, commercial and industrial, and working and open lands on municipal budgets. These studies reveal that residential development often imposes a fiscal imbalance, with service costs exceeding tax revenues, while commercial and industrial and working and open lands often generate fiscal surpluses. The COCS ratio results show that for every $1 of revenue generated, residential properties cost between $1.02 and $1.67 in public services, compared to between $0.17 and $1.04 for commercial and industrial land use and between $0.05 and $0.77 for working and open lands. A key takeaway from this analysis is the need for balanced land-use planning to minimize fiscal strain and optimize municipal resources.

9 PRIORITIZED RECOMMENDATIONS

This section presents a set of prioritized recommendations. Prioritized recommendations were developed using a combination of stakeholder input (including community members, environmental experts, and local organizations), key findings in this ROE study, and related case studies or instances that were found of similar efforts that are either ongoing or have been implemented in the past. We developed a Theory of Change Framework for the County to demonstrate how conservation actions can lead to long-term impacts, which was also incorporated into these recommendations. Additionally, we created a Stakeholder Network Analysis Map for the County, outlining other organizations, agencies, and institutions in the area working on similar initiatives. This map supports the County in identifying partnership opportunities when planning for the recommendations below. To help ensure the long-term health and sustainability of the GBFW, Geosyntec has identified a series of conservation practices that are crucial to implement because they either preserve or enhance the benefits that the watershed provides, protect existing natural resources, and promote ecological balance in the watershed. Based on this, the following measures have been identified.

Improve Water Quality

- Promote conservation practices:
    - Encourage property owners to adopt conservation practices, such as planting native plants rather than manicured lawns and using rain barrels to collect rainwater to improve environmental health.
    - Encourage developers to implement environmentally friendly practices and support conservation subdivisions and transfer of development rights.
    - Establish or enhance stream buffer corridors along streams to manage and protect waterways.
    - Restore areas along the banks of streams and rivers with native vegetation to stabilize banks, filter pollutants, and provide habitat for wildlife.
    - Promote conservation easements to help facilitate conservation practices.
- Conduct outreach and communication with homeowners about on-site wastewater systems:
    - Develop and implement educational programs to inform homeowners about the types of on-site wastewater systems they have, the importance of regular maintenance, and the benefits of using advanced technologies like drip irrigation systems and pretreatment septic tanks.
    - Advocate for regulatory updates that require disclosure and inspection of on-site wastewater systems during real estate transactions to ensure new homeowners are aware of their systems and their maintenance needs.
    - Partner with real estate agents to educate new homeowners about their on-site wastewater systems and emphasize the importance of proper maintenance and the availability of better technologies to prevent contamination.

Implement BMPs

- Implement BMPs:
  - Encourage voluntary installation of agricultural BMPs by agricultural landowners, such as cover crops, intensive rotational grazing, and riparian corridor restoration to protect soil, improve soil and water health, and reduce sediment runoff.
  - Promote the benefits to both cattle and water health by keeping cattle out of streams.
  - Encourage a reduction in fertilizer and pesticide use by residential landowners.
  - Implementing incentive programs, such as the Stormwater Champions Program, Water Friendly Recognition Program, and SepticSmart Wastewater Program, to drive adoption of BMPs.
  - Conduct demonstration projects and tours to showcase BMPs in action.
  - Develop and distribute educational materials on agricultural BMPs.
  - Track voluntary adoption of BMPs and monitor water quality improvements over time to gauge effectiveness of BMP implementation.

Restore Wildlife Habitat

- Support existing wildlife habitat restoration partners and projects:
  - Work with agency partners and private wildlife groups to improve wildlife habitat on private properties.
  - Pursue conservation efforts that preserve or restore open space on public lands.
  - Carry out projects that have similar water quality benefits to agricultural BMPs.

Conduct Outreach and Communication

- Identify target audiences:
  - Create a directory of contacts for key project partners (name, affiliation, role, email, phone number).
  - Discuss with key project partners any audience organizations/individuals, or event/signage locations that warrant targeted outreach and communication effort.
- Develop outreach and communication programs for each audience:
  - Develop appropriate materials and deliverables specific to each program.
  - Create a database of audience contact info to distribute information.
- Implement outreach and communication programs for each audience:
  - Hold community events, distribute educational materials, begin incentive programs, and keep up to date with media marketing.
  - Create a master repository for information and events accessible to the public.
- Develop methods/metrics for gauging plan efficacy:

    - Develop appropriate methods and metrics for gauging plan efficacy by goal type and target audience, as applicable.
- Evaluate plan efficacy:
    - Monitor water quality for improvement over time.
    - Survey the various target audiences annually.
    - Track email interaction frequency and quality using email marketing software or digital community engagement platform.
    - Track changes in state/federal conservation reporting for the County (Natural Resources Conservation Service, National Institute of Food and Agriculture, etc.).
    - Maintain attendance metrics for public events, lectures, and tabling events.
    - Track outreach and communication program efforts according to Appendix K of the WBP.
- Grow and improve programs via adaptive management frameworks:
    - Evaluate and adjust the education and outreach plan annually to maintain efficacy and accuracy.

Advocate for Water Quality Connections

- Advocate for water quality connections:
    - Encourage regenerative agriculture practices that improve environmental and community health.
    - Emphasize the connection between a healthy natural environment and mental and physical health.
    - Focus on healthy water and soil for humans, wildlife, and the ecosystem.
    - Promote the health benefits of recreation in the GBFW.

Pursue Efforts Related to Long-Term Water Quality Goals

- Maintain the implementation of BMPs:
    - Review programs that support the adoption of agricultural and residential BMPs on an annual basis.
    - Allocate resources to programs that show success and work with stakeholders to adjust programs that are not resulting in increased adoption of BMPs.
- Refresh the economic and environmental analysis:
    - Review the economic and environmental analyses and adjust as trends within the County change.

Conduct Community Engagement and Encourage Participation

- Replace manicured lawns in County-owned spaces with native plants and use rain barrels for rainwater harvesting.
- Engage with the public in various spaces and formats:
    - Educate the community about the term "watershed" and the boundaries of the GBFW.
    - Promote parks and recreational areas within the watershed.
    - Provide education on conservation and restoration practices, such as maintaining waste management systems, using regenerative agriculture practices, and applying agricultural BMPs.
    - Engage in stream teams, water quality monitoring, and habitat restoration efforts.
    - Attend field days, watershed tours, and environmental festivals to learn and spread awareness.

To assist the County and stakeholders in identifying where effort and resources should be directed during implementation, we analyzed our ROE findings to compile a list of prioritized recommendations to maintain or improve the health of the watershed. Geosyntec considered stakeholder input, the results of this ROE study, and case studies or similar instances of implementation and incorporated these factors into a multicriteria decision analysis (MCDA) approach to rank the previously listed measures into a set of prioritized recommendations. Stakeholder feedback and the findings of the ROE analysis were equally weighted in the MCDA analysis. Case studies related to each measure were also examined to determine whether the recommended measures have either been assessed or implemented in areas outside of the GBFW. For the purposes of this MCDA, if a case study was found related to the measure or an instance was found of similar efforts that are either ongoing or have been implemented in the past, Geosyntec assigned a score of 1; otherwise, we assigned a score of 0. The scores of all three criteria were added together for a total score and each measure was ranked based on total scores. These rankings formed the basis of prioritizing recommendations. Measures that received the same ranking can be interpreted as having the same level of priority.

All the measures have a level of stakeholder support based on stakeholder feedback that was received early in the ROE study. However, it is currently unknown how stakeholders will prioritize these measures and value them relative to each other. Given this information, a value of 5 was assigned for all measures under the stakeholder support criteria. To assign scores for ROE benefits, we ranked benefit categories on their overall contribution to the estimated total annual benefits. Figure 10 provides a summary of benefit estimations.

The estimated total annual benefits for all benefit categories evaluated is approximately $883 million to $1.93 billion. The rankings for each benefit category in Table 30 show that direct use benefits are the largest proportion of estimated total annual benefits. Community cost savings and property value benefits did not have annualized values contributing to the total annual benefit estimate. The community cost savings category was ranked above property value benefits because the community cost savings analysis reflected recurring fiscal impacts based on different land uses on a relative basis by comparing tax revenues generated to the cost of public services. In contrast,

property value benefits are considered as a one-time benefit given that these benefits are not realized on an annual or recurring basis but rather reflect a premium on home values. The scores in Table 30 were then applied to the MCDA analysis based on which benefit category is the most applicable to each measure. For example, improving water quality is most related to environmental benefits and a score of 3 was assigned to the ROE Analysis Results criteria in the MCDA for that measure. The results of the MCDA are shown in Table 31.

Table 30: ROE Analysis Benefit Ranking and Scores for MCDA

Ranking of ROE Benefits	Category	Score
1	Direct Use	5
2	Economic Activity	4
3	Environmental Benefits (Indirect Use)	3
4	Community Cost Savings	2
5	Property Value Benefits	1

Given the results of the MCDA, prioritized recommendations are given below:

1. Restore Wildlife Habitat and Advocate for Water Quality Connections.
2. Improve Water Quality, Implement BMPs, and Conduct Outreach and Communication.
3. Pursue Efforts Related to Long-Term Water Quality Goals and Conduct Community Engagement and Encourage Participation.

Specific actions related to each of these measures are outlined earlier in this section. It should be noted that although no measures that were directly tied to property value benefits or economic activity were explicitly incorporated into the MCDA matrix, the results of this ROE study indicate that pursuing many of the measures outlined in Table 31 would likely enhance these benefits as well. For example, one of the actions recommended related to restoring wildlife habitat is to pursue conservation efforts that preserve or restore open space on public lands. If conservation efforts lead to more open spaces, especially those where recreational activities can be enjoyed, economic activity related to tourism spending could increase as well. Additionally, homes located next to these open spaces could also realize a property value premium. In the case of this MCDA analysis, only the score for the primary benefit category was applied to the decision criteria related to the ROE analysis results. However, it is likely that all measures have co-benefits in other benefit categories as well.

Table 31: MCDA Analysis for Prioritized Recommendations

Measure	Stakeholder Support (1-5)	ROE Analysis Results (1-5)	Case Studies (0-1)	Total Score	Ranking	Case Study Source
Improve Water Quality	5	3	1	9	2	Chesapeake Bay Foundation 2025
Implement BMPs	5	3	1	9	2	Chesapeake Bay Foundation 2025
Restore Wildlife Habitat	5	5	1	11	1	Mather 2025
Conduct Outreach and Communication	5	3	1	9	2	Chesapeake Bay Program 2025
Advocate for Water Quality Connections	5	5	1	11	1	Iowa State University 2025
Pursue Efforts Related to Long-Term Water Quality Goals	5	2	1	8	3	South Florida Water Management District 1999
Conduct Community Engagement and Encourage Participation	5	2	1	8	3	Hibbard and Lurie 2007

Benefit/Cost Category	Subcategory	Benefit or Cost?[1]	Monetized Annual Benefit/Cost[2]	Non-Annualized Benefit[3]	Benefit/Cost Description	Beneficiaries/Cost Bearer[4]
Direct Use	Recreation	Benefit	$363M to $548M		Recreational use values, willingness to pay	Private Citizens
	Health	Benefit	Qualitative		Health Benefits related to recreation and physical activity	Private Citizens
	Health	Benefit	$197M to $620M		Healthcare Costs Avoided (Direct and Indirect)	Private Citizens
	Health	Benefit	$2M to $16M		Workers' Compensation Costs Avoided (Direct and Indirect)	Business and Government
	Health	Benefit	$261M to $510M		Lost Productivity Costs Avoided	Business
Environmental Benefits (Indirect Use)	Nutrient Load Reduction	Benefit	$4,000 to $5M		Nutrient load reductions through BMP implementation	All
	Sediment Load Reduction	Benefit	$38,000 to $2M		Sediment load reductions through BMP implementation	All
	Costs Avoided to Infrastructure	Benefit		$765M	Damages avoided to infrastructure at the 100-year rainfall event	Citizens/Business/Government
	Social Costs of Pesticide Use	Cost	$364,000 to $884,000		Willingness to pay to reduce risk of pesticide use	Private Citizens
	E. coli Load Reduction	Benefit	Qualitative		*E. coli* load reduction	All
Economic Activity	Tourism Spending	Benefit	$11M		Economic impact of tourism spending	Business
	Fiscal Impacts	Benefit	$2M		Fiscal impact of tourism spending	Government
	Business Attraction	Benefit	Qualitative		Open spaces' impact on revenue generation, business relocation and expansion	Business
	Employee Attraction	Benefit	Qualitative		Health and well-being	Employees
Property Value Benefits	Property Value Premiums	Benefit		$23,000 - $30,000	Increased property values near open space. This is a one-time/non-recurring benefit.	Private Citizens
		Benefit			Greater borrowing power	Private Citizens
		Benefit	Qualitative		Improved resale potential	Private Citizens
		Benefit	Qualitative		Increased desirability and demand	Private Citizens
		Benefit	Qualitative			
Property Value Benefits	Fiscal	Cost	Qualitative		Negative impact of converting open space to residential development	Government
		Cost			Residential -Every $1 in tax revenue generated, $1.02 to $1.67 in public service costs	Government
		Cost			Business - Every $1 in tax revenue generated, $0.17 to $1.04 in public service costs	Government
		Cost			Open/Working Land - Every $1 in tax revenue generated, $0.05 to $0.77 in public service costs	Government
		Total Annual Benefits	**$836M - $1.7B**			

[1] A cost related to each benefit category is considered a negative benefit and is not reflective of any costs required to implement measures or act, such as costs associated with implementing best management practices. For example, the social costs of pesticide use are considered a negative benefit because consumers, farmers, and the environment are exposed to health risks from the use of pesticides.

[2] Dollar values are in 2024 price levels.

[3] Non-annualized benefits are monetary benefits that are not incorporated in the total annual benefits. For example, it is estimated that natural infrastructure prevents approximately $765 million in flood damage from stormwater runoff. Given this is conditional on the 100-year rainfall event occurring, flood damages prevented are not presented as an annualized value. Additionally, property value benefits are considered a non-recurring, or one-time, benefit and do not reflect an annualized value.

[4] If the benefit subcategory is identified as a benefit, then groups who receive that benefit are identified as beneficiaries. Otherwise, if the benefit subcategory is identified as a cost, groups who realize that cost are considered cost bearers.

Figure 10: Summary of Benefits and Costs

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Appendix A

Survey Results of the Greater Bonne Femme Watershed Initiative Community Survey