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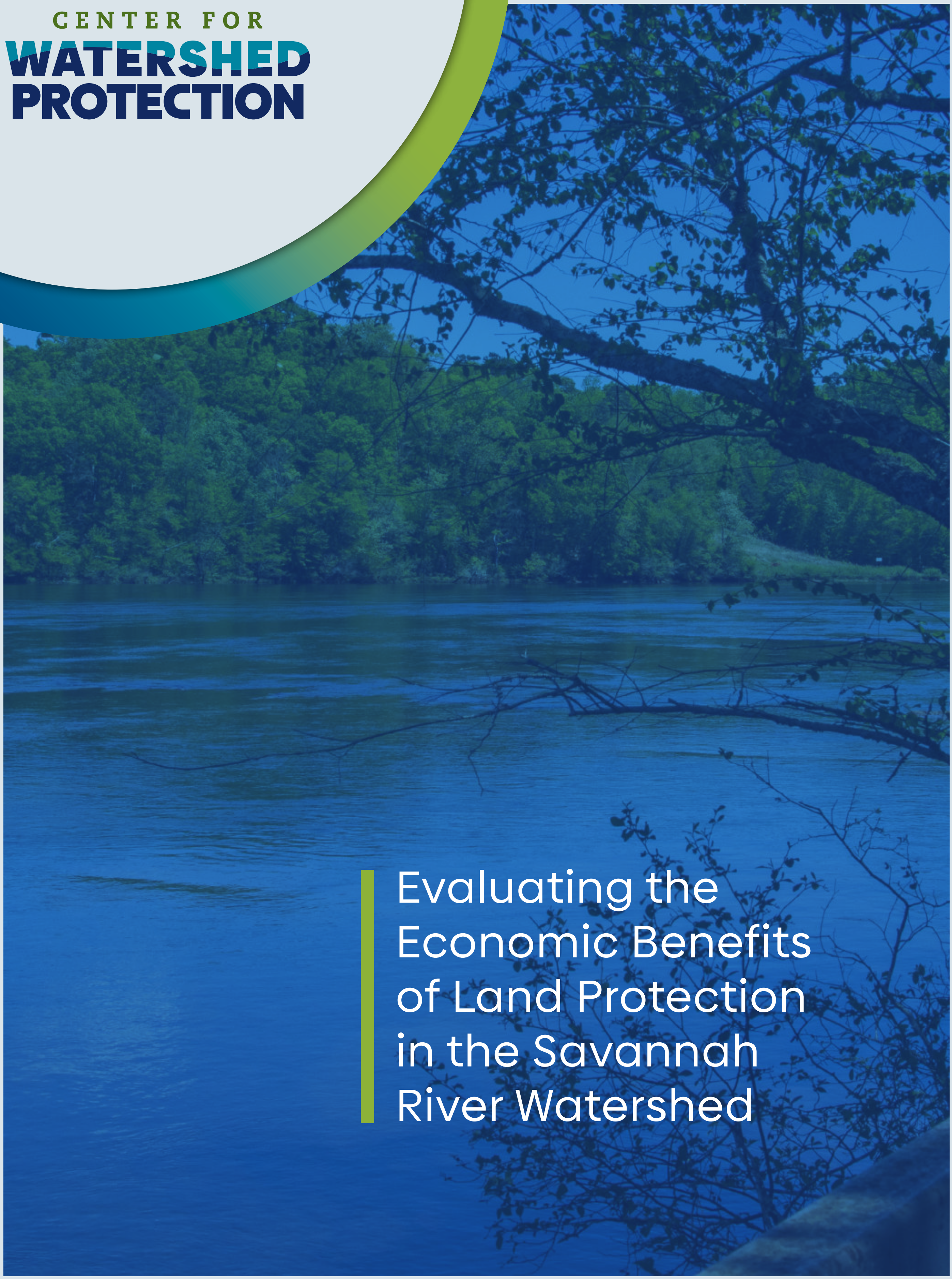

Evaluating the Economic Benefits of Land Protection in the Savannah River Watershed

Prepared by

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Project Overview

The mission of the Savannah River Clean Water Fund is to protect and restore forests in the Savannah River Basin to help provide safe, reliable, and affordable drinking water for the communities and businesses in the region. The goal of this study was to evaluate the relationships between upstream land uses—such as forests, cities, or farms—and downstream water quality and drinking water treatment costs using examples from the Savannah River Basin (Figure 1).

Land use and water quality data from the Middle Savannah River Watershed (i.e., "upstream") were compiled and evaluated, along with water quality data and treatment costs at the Beaufort-Jasper Water and Sewer Authority's Chelsea Water Treatment Plant in the Lower Savannah River Watershed (i.e., "downstream"). A review of relevant studies from outside the Savannah River Basin supplemented this analysis.

Figure 1. *Relationship between watershed land cover and drinking water treatment costs.*

Conserving upstream forests in the Savannah River Basin can reduce downstream pollution, which can save utilities money by reducing the treatment costs to address contaminants that affect the taste-and-odor of drinking water.

Key Findings

Finding #1: Upstream Land Use Affects Downstream Pollution

More forests upstream are linked to lower amounts of pollution delivered to the Savannah River, while more developed land upstream is linked to higher amounts of pollution delivered to the Savannah River.

Finding #2: Pollutants from Upstream Land Use Affect Levels of Compounds that Make Drinking Water Unpalatable

While data from the Savannah River Basin was insufficient to identify specific relationships, studies from outside the Basin show a link between pollutants from upstream land use and the formation of drinking water contaminants that affect taste and odor.

Finding #3: Levels of Compounds Affecting the Taste and Odor of Drinking Water Influence Treatment Costs

Sufficient data to determine predictive relationships between upstream land cover change and downstream water treatment costs were not available in the Savannah River Basin. However, based on a literature review and an analysis of water quality data at the Beaufort-Jasper Water and Sewer Authority's Chelsea Water Treatment Plant, nutrient reductions from forest conservation would likely reduce amounts of taste-and-odor compounds requiring the most expensive treatment.

Key Recommendations

The findings from this study support the Savannah River Clean Water Fund's mission to conserve and protect forests to improve water quality for communities and businesses in the Savannah River Basin. A key recommendation is to **conserve upstream forest land and manage these lands in a way that considers and prioritizes the relationship between land use and water quality**, which would help minimize drinking water treatment costs. Although there is a clear relationship between healthy, well-managed forests and water quality, forest conservation is one of many important strategies used by water utilities to ensure high-quality drinking water. There are multiple other effective management strategies that could be used alongside forest conservation to protect water quality, including but not limited to prescribed fire in floodplain forests and stormwater practices in upstream areas. It is also important to acknowledge that quantifying the water quality benefits provided by specific forest conservation projects is difficult. Decomposition of leaves and other organic matter in forests also increases total organic carbon, which must be treated. Water utilities must balance many factors when implementing their programs.

Additionally, **the Fund, water utilities, and other partners should continue investing in research (e.g., water quality monitoring and modeling studies) to shed additional light on the complex relationship between land use and water quality** in the Savannah River Basin, which will continue to change as development in the region continues.

Pollutants and Their Impact on Water Quality

Nutrients such as **nitrogen** and **phosphorus** are chemical compounds found in the environment that are important for plant and animal growth. However, excess nutrients in waterways contribute to algal growth, low dissolved oxygen, and even fish kills. Major sources of nutrient pollution include fertilizers, manure, wastewater treatment plants, and urban runoff.

From a drinking water treatment perspective, "taste-and-odor compounds," which make drinking water unpalatable for users, are often the most expensive to treat. One of these compounds is **geosmin**, an odorous but harmless chemical produced by cyanobacteria, which is a type of algae. Excess nutrients contribute to algal growth, which increases amounts of geosmin.

Sediment is one of the most common water pollutants and enters waterways through erosion on farm fields, construction sites, and stream banks during storms. Sediment pollution affects stream organisms, degrades aquatic habitat, and reduces water clarity. Toxic contaminants also often attach to sediment, making its pollution even more harmful. High amounts of sediment require treatment from drinking water treatment plants.

Another important taste-and-odor compound is **total organic carbon**, a type of organic pollutant that contributes to a swampy, earthy, or musty taste in drinking water. High runoff flows and discharges from wastewater treatment plants—both of which are associated with land development—can lead to increases in this compound. Total organic carbon has also been linked to organic matter decomposition associated with wooded or shrub/scrub wetlands.

I. Introduction

The mission of the Savannah River Clean Water Fund is to protect and restore forests in the Savannah River Basin to help provide safe, reliable, and affordable drinking water for generations to come. While the connection between upstream land cover and downstream water quality is widely acknowledged, water utilities and other investors in land conservation would benefit from information on the economic benefits of forest protection that is specific to the Savannah River Basin. The Center for Watershed Protection, Inc. (CWP) compiled and analyzed data from the Savannah River Basin to quantify specific elements of the complex relationship between land protection and drinking water treatment costs (Figure 1).

Figure 1. *Relationship between watershed land cover and drinking water treatment costs.*

II. Evaluating Relationships Between Land Cover and Water Quality

CWP gathered land cover data for 44 subwatersheds in the Middle Savannah River Watershed (i.e., upstream of the drinking water utilities) and evaluated the relationships between land cover and subwatershed pollutant levels using the U.S. Geological Survey's SPARROW model (SPAtially Referenced Regressions on Watershed attributes). SPARROW correlates state and federal water quality monitoring data and spatial datasets of watershed characteristics to quantify the long-distance transport and delivery of contaminants to important downstream locations like drinking water intakes, which is the water source for drinking water utilities.

The watershed pollutants modeled by SPARROW are Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), and Flow. TN and TP are nutrients that contribute to the formation of compounds that affect taste and odor. Flow is a measure of runoff volume that is linked to increased amounts of taste and odor compounds, and TSS is a measure of sediment pollution.

A statistical analysis of 2019 land cover and SPARROW model results showed the following relationships in the Middle Savannah River Watershed:

Forest cover decreases loads of TN in a statistically significant way, even after accounting for the effects of developed cover. Forest cover also decreases loads of TP, TSS, and Flow, but those impacts were not statistically significant.

Developed/urban cover significantly increases loads of all evaluated watershed pollutants: TN, TP, TSS, and Flow. Consequently, **conserving forest cover to reduce the amount of developed/urban cover would meaningfully reduce the loads of all evaluated watershed pollutants.**

Wetland cover reduces loads of both TSS and Flow, and it has no significant impact on loads of TN or TP.

Agricultural cover did not statistically impact loads of any evaluated watershed pollutant, possibly because so few of the subwatersheds in the Middle Savannah are dominated by agricultural uses.

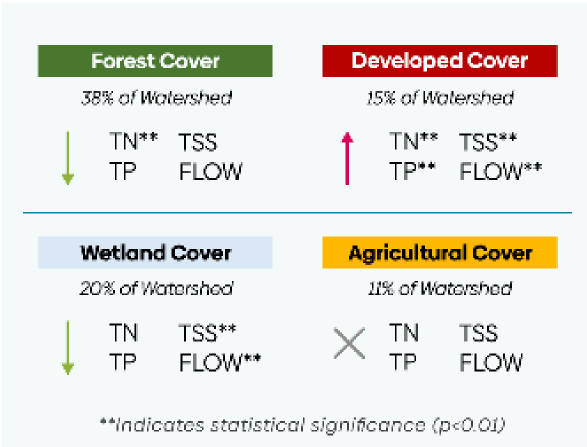

Figure 2. *Graphic representation of the statistical significance of relationships between each land cover category and each water quality pollutant load in the Middle Savannah River Watershed. Pollutant parameters without asterisks were not significant at the 0.01 or 0.05 level.*

III. The Relationship Between Watershed Pollutant Loads and Intake Water Quality

Elevated amounts of taste-and-odor (T&O) compounds in drinking water affect palatability. They can cause water to be odorous and to have a swampy, earthy, or musty taste. Drinking water can be treated to reduce the levels of T&O compounds, but it is expensive for utilities to do so.

CWP used water quality data from the untreated, raw water at the Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea Water Treatment Plant (i.e., the downstream part of the Basin) to evaluate the relationship between TN loads (from the SPARROW model) and T&O compounds. Two of the most expensive T&O compounds to treat are geosmin and total organic carbon. The goal of this analysis was to evaluate the connection between TN loads—which are reduced by forest cover and increased by developed cover—and levels of these two compounds. However, in the raw water monitoring data at the intake, there were no statistically significant relationships between TN and geosmin, total organic carbon, or three other T&O compounds. This was likely because there were so few instances where both TN and the T&O compounds were measured at the same time at the BJWSA Chelsea Plant's intake and overlapping data points were needed to identify a statistically significant relationship.

To further evaluate the relationship between watershed pollutant loads and amounts of geosmin (a type of cyanobacteria/algae) and total organic carbon (a type of organic pollutant), a literature review was conducted. This review identified well-documented connections between upstream land cover and amounts of total organic carbon and cyanobacteria. Due to the variability among studies (in terms of geography and study design), it is difficult to apply quantifications from those studies to the Savannah River Basin. However, **the qualitative relationships between upstream land cover and downstream water quality are applicable in the Savannah River Basin.** Nutrients, such as nitrogen and phosphorus, from upstream sources are linked to cyanobacteria and algal growth, which increases amounts of geosmin. Watershed characteristics associated with developed land cover—such as flow/runoff volume and effluent from wastewater treatment plants—are linked to organic compounds like total organic carbon (and disinfection byproducts, which are another kind of drinking water contaminant regulated by the Safe Drinking Water Act). **Land management that considers and prioritizes these land cover influences would likely minimize loads of T&O compounds and reduce drinking water treatment costs.**

IV. The Relationship Between Intake Water Quality and Drinking Water Treatment Costs

CWP used untreated, raw water quality data and information on treatment processes, materials, and costs from the Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea Water Treatment Plant to quantify the effects of elevated T&O concentrations on drinking water treatment costs.

As an example, from January 2021 through June 2021, additional treatment thresholds for total organic carbon (a type of organic pollutant) and geosmin (a type of cyanobacteria/algae) in raw water at the BJWSA Chelsea Plant were exceeded seven (7) and six (6) times, respectively. The exceedance of these additional treatment thresholds indicates an added, preventable treatment need for those compounds. The total cost of additional (i.e., preventable) treatment for **total organic carbon** in this time frame was $7,815, ranging from $90/day to $2,525/day, depending on how much the threshold was surpassed. Since there is no base (i.e., un-preventable) dose treatment for geosmin, all treatment costs are preventable. The total cost of treatment for **geosmin** in this time frame was $60,246, ranging from $864/day to $40,572/day. The total cost of preventable treatment for **both total organic carbon and geosmin** in this time frame was $68,061. It is important to note that is a snapshot of the costs associated with these compounds, and further analysis would be necessary to determine whether these exceedances and costs are typical of water utilities in the region.

Based on a literature review, **it is likely that additional treatment costs could be reduced through upstream land management and by conserving forest cover.** However, these costs depend heavily on the type of pollutant in question and how much the pollutant concentrations exceed the treatment thresholds. Additionally, these costs would need to be compared to the costs of preventative actions like upstream land management and forest conservation. Therefore, the additional treatment costs identified in this study are difficult to use in estimating potential future treatment costs given the lack of a predictive relationship between concentrations of TN and T&O compounds in untreated water at the plant intake.

V. Recommendations

Drinking water treatment plants in the Savannah River Basin can likely reduce costs by encouraging forest conservation. Forest cover can reduce loads of watershed pollutants, including those that increase taste-and-odor (T&O) compounds, which are expensive to treat. However, forest conservation itself can be expensive, so water utilities must balance many factors when protecting source water and treating drinking water.

CWP's analysis identified a number of recommendations for stakeholders concerned with forest preservation, water quality, and drinking water treatment in the Middle Savannah River Basin.

1) CONSERVE FORESTS UPSTREAM TO PROTECT DRINKING WATER QUALITY DOWNSTREAM

This study showed land use upstream has a direct effect on downstream pollution. Reducing urban development and conserving forests in upstream areas can meaningfully reduce watershed pollutants. With less pollutants, water will be less expensive to treat. Managing these lands in a way that considers and prioritizes the relationship between land use and water quality will help reduce drinking water treatment costs. This **supports the Savannah River Clean Water Fund's mission** to conserve and protect forests to protect water quality for communities and business in the Savannah River Basin. Recognizing the complexities of treating water, utilities should consider forest conservation as one component of a broader strategy. This study's findings provide forest conservation and management stakeholders with another compelling reason for their mission: improving water quality to reduce drinking water treatment costs.

2) CONTINUE TO INVEST IN RESEARCH TO BETTER UNDERSTAND THE RELATIONSHIPS BETWEEN LAND USE AND WATER QUALITY IN THE SAVANNAH RIVER BASIN

Pursue modeling efforts to quantify the costs and benefits of conserving and managing forests upstream relative to water quality treatment downstream. Such an effort must consider the broader benefits of forest conservation to communities and businesses in the Basin in addition to avoided treatment cost potential. It should also integrate Basin-specific data on which forests are most important to water quality, vulnerability to future change, and landowner willingness to engage in conservation activities. The results will help water utilities balance investments in upstream and downstream water quality strategies.

Develop a Watershed Implementation Plan for the Middle Savannah Watershed. The Middle Savannah watershed spans from Clarks Hill Lake, just north of Augusta, down to the confluence of Beaverdam Creek and the Savannah River, just east of Sylvania. Characterizing this area is important to inform the future land development and conservation of forests within the watershed. As with the City of Savannah's Source Water Protection Plan, the goal of a plan for the Middle Savannah would be to prepare the area for potential threats to the water supply (including reviewing and quantifying threats from land use-related activities and from contaminants of emerging concern) and to consolidate information. This information can then be shared with the area's stakeholders.

Continue to invest in water quality monitoring, particularly for total organic carbon, cyanobacteria (including geosmin), chlorophyll-a, and algae. This monitoring should occur both in the raw, untreated water at the intake and upstream in the watershed. This will help provide more quantitative support between watershed land cover and concentrations of T&O compounds specific to the Savannah River Basin. Additionally, water quality datasets should be updated consistently. Whenever possible, importing datasets from multiple organizations into one consolidated dataset would be most valuable and would accelerate collaborative insights.

Initiate research on emerging contaminants associated with developed/urban land uses, like per- and polyfluoroalkyl substances (PFAS), which may become regulated under the Safe Drinking Water Act. Forest conservation to minimize developed area would not only reduce costs associated with treating drinking water for T&O compounds, but it would also likely reduce costs to reduce and treat other contaminants from developed/urban areas, such as PFAS.

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