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ENVIRONMENTAL FINANCE CENTER

THE Economic Value OF Riparian Buffers

MARCH 2016

About American Rivers

American Rivers protects wild rivers, restores damaged rivers, and conserves clean water for people and nature. Since 1973, American Rivers has protected and restored more than 150,000 miles of rivers through advocacy efforts, on-the-ground projects, and the annual America's Most Endangered Rivers® campaign. Headquartered in Washington, DC, American Rivers has offices across the country and more than 200,000 members, supporters, and volunteers.

Rivers connect us to each other, nature, and future generations.
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About the Environmental Finance Center

The Environmental Finance Center (EFC) at the University of Maryland is one of ten University-based centers across the country providing communities with the tools and information necessary to manage change for a healthy environment and an enhanced quality of life. EFC believes that environmental finance can be used to develop a shared community vision. Our focus is protecting natural resources and watersheds by strengthening the capacity of local decision-makers to analyze environmental problems, develop innovative and effective methods of financing environmental efforts and educate communities about the role of finance and economic development in the protection of the environment.

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Economic Terms

Amenity: The desirable aspect of a good or service. Examples of environmental amenities include landscapes and vista, treed areas, etc.

Valuation: Assigning a monetary value to a (environmental) good or service.

Willingness-To-Pay (WTP): A measure of an individual's willingness to exchange money for a good or service. It is a monetary measure of the value an individual assigns an environmental benefit.

Stated Preference: A valuation approach that uses surveys to elicit a respondent's direct or implied preferences and values for an (environmental) good or service. An example of a stated preference technique is contingent valuation.

Contingent Valuation (CV): A valuation approach that estimates the value of a good or service based on an individual's stated preference (measured as willingness-to-pay) between a baseline or status quo scenario and a hypothetical alternative scenario(s).

Revealed Preference: A valuation approach that infers values based on observed behavior and a related (environmental) attribute, like linking an observed behavior such as home sales with an environmental attribute like the home's proximity to a river. Hedonic price models are one type of revealed preference technique.

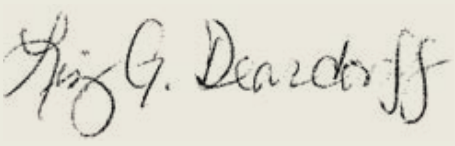
Hedonic Price Model (HPM): A valuation approach that uses statistical methods to measure the how much each attribute of a good contributes to its price. Hedonic property value studies measure how the individual characteristics of a property, such as number of rooms, lot size, and proximity to open space, contribute to it sales price.

Price Premium: The additional amount a consumer is willing to pay for a particular feature or characteristic of a good. For example, the amount proximity to a riparian buffer contributes to the price of a property.

Forward

Land disturbances in headwater and urbanizing areas are known to contribute to water quality degradation and poor stream health and habitat. As a result, there are an increasing number of 'best' land use practices and planning strategies to support stream health and water quality. One of these practices is riparian buffers—streamside areas in which natural vegetation provide hydrologic function. Recent science demonstrates that forested buffers of at least 100' in width excel at restoring and protecting streams, their habitats and the activities and uses streams support. However, planners and policy makers are challenged to advance riparian buffer protection and restoration especially in urbanized or developing areas where the values and benefits of riparian buffers is not well understood. American Rivers presents this report, *Economic Value of Riparian Buffers*, a summary of literature and research findings conducted by the Environmental Finance Center at the University of Maryland on the value and benefit of economic buffers to property and communities.

This report investigates the various means by which riparian buffers are valued, identifies specific challenges and gaps in current knowledge, and recommends opportunities for improved understanding of riparian buffer values. Two key findings are that the public has a willingness to pay for the restorative qualities associated with riparian buffers and that the values of streamside improvements can be projected to an entire community. The findings presented throughout *Economic Value of Riparian Buffers*, hand-in-hand with scientific evidence, support the use of riparian buffers as an effective economic and environmental protection tool.



Liz Deardorff, Director

Executive Summary

Riparian buffers deliver multiple benefits for rivers and people and can be an effective restoration, conservation and management practice generally appropriate for all land use types.

Riparian buffers deliver services supporting both land and water functions by enhancing or maintaining water quality, habitats, resilience, and amenities to the built environment. While riparian buffers deliver multiple benefits, the current state of research provides estimates for only two sources of economic value. The first is the impact on residential property values. The second is a more general community value.

The relationship between riparian buffers and property values is measured as a price premium on single-family, residential properties. These properties tend to be located in watersheds that have undergone extensive land development near urban centers. Evidence suggests that mandatory buffer requirements do not adversely affect property values. Quite the contrary, the price premium for properties adjacent to or within riparian zones is positive and potentially sizable, with some studies finding the premium to be upwards of 26%. The price premium generally increases as properties get closer to open space and streams.

The public values — or general community values — come from survey-based studies that ask individuals their willingness to pay for policies that promote watershed restoration and protection through riparian buffer strategies. These types of values range between $5 and $47 per household per year. In aggregate this value can be significant. For example, with a community of 100,000 households, this range of values estimates the annual willingness to pay for a riparian buffer program to be between $500,000 and $4.7 million.

The following summarizes our findings related to the economic value of riparian buffers.

- **Riparian buffers have a positive economic value** when measured in terms of private benefits and public benefits.
- **The economic value of riparian buffers generally increases with length and width**. However, the relationship between amenity values and buffer width is not fixed. The incremental gain in value of a property falls as the buffer becomes wider and may eventually turn negative.
- **Riparian buffers generate a price premium for residential homes.** Studies demonstrate the positive relationship between residential

Stream buffering is one of many green infrastructure practices Philadelphia Water Department is utilizing to reduce stormwater pollution and add community amenities.

property values and proximity to riparian buffers. Estimates of this price premium range between 1% and 26%. The magnitude of benefits depends on a range of factors including quality of established riparian buffers, baseline property values, and extent to which surrounding environmental amenities interact with individual parcel values.

- **The public generally supports riparian buffers and is willing to pay for watershed restoration through buffers**. This willingness to pay ranges from $5 to $47 per household, with some evidence suggesting that people tend to prefer complete restoration over piecemeal or partial efforts.

- **More research is needed to understand what attributes of riparian buffers drive how people value them**. Our understanding of how people assign value to riparian buffers is incomplete — particularly with respect to how values are impacted by different land uses (e.g., urban, commercial, agriculture), the health of the water way, and the quality, width and density of riparian buffers. Moreover, the general public may not be aware of existing buffer requirements or the quality of these buffers, suggesting that education and awareness play an important role in helping communities better understand how riparian buffer requirements and policy impact them. More research is needed to guide how we design and implement riparian buffers so that we maximize their environmental and social value.

Introduction

Riparian buffers are defined as land along a stream or waterbody that is managed to enhance or protect ecological health. Buffers play an essential role in our environment, providing protection against erosion and filtering pollutants conveyed in runoff from surrounding uplands. Given this protective function, increased attention has been given to protecting and restoring riparian buffers so that they keep sediment and excess nutrients from entering streams, protecting downstream water quality and generating a range of private and public benefits.

While the function and role of riparian buffers, especially forested buffers, in protecting and managing waterways is well established, their economic value is not fully understood. This white paper discusses the economic value of riparian buffers by mapping their functions to benefits and valuation methodology. The first section briefly examines some of the most commonly identified functions of riparian buffers. These functions — or services — are the basis for identifying and measuring benefits. The next section describes approaches to valuing riparian buffers. These valuation studies provide economic (monetary) estimates of public and private benefits associated with riparian buffers. Studies estimating public benefits focus on the value of water quality or watershed health achieved through riparian buffer restoration or protection. In contrast, studies of private benefits characterize how amenities associated with riparian buffers affect property values. This paper concludes with a summary of the key findings and how these findings can inform future efforts to value riparian buffers.

Riparian buffers help reduce stream bank erosion, minimize the down-cutting of stream beds, and restore aquatic ecosystems.

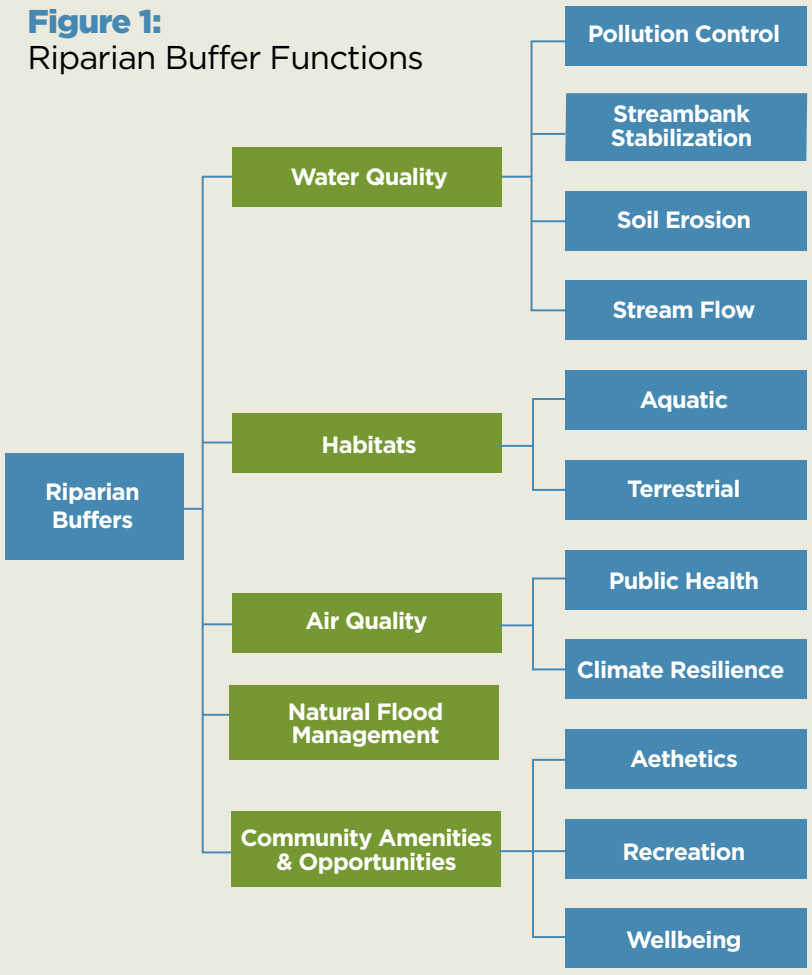
Functions of Riparian Buffers

Riparian buffers provide a wide range of services supporting both land and water functions by enhancing or maintaining water quality, habitats and resilience. The multiplicity of their benefits makes riparian buffers an appealing management practice that is generally appropriate for all land use types and relevant to both restoration and conservation objectives.

Beneficial functions of riparian buffers generally fall into one of five broad categories:

- water quality
- fish and wildlife habitat
- air quality
- natural flood management
- community amenity

Figure 1:
Riparian Buffer Functions



These functions lead to multiple benefits that support both the environment and people. (See Figure 1.) Riparian buffers address water quality through several avenues. They remove pollutants by trapping and removing sediment and nutrients (major contributors to eutrophication in aquatic ecosystems) and other contaminants such as pesticides. Riparian buffers also assist in stabilizing stream banks and reducing channel erosion. Buffers provide habitat and contiguous travel corridors for wildlife. They moderate water temperatures and provide woody debris for fish and other aquatic organisms. They function as a natural flood management system by providing an area to safely store and convey flood water, thereby decreasing damage to property. Buffers trap and filter atmospheric pollution and increase available oxygen through photosynthesis. They are also an amenity for property owners, enhancing the livability and aesthetics of developed parcels. For communities, riparian buffers can improve the aesthetics of stream corridors and create opportunities for recreation.

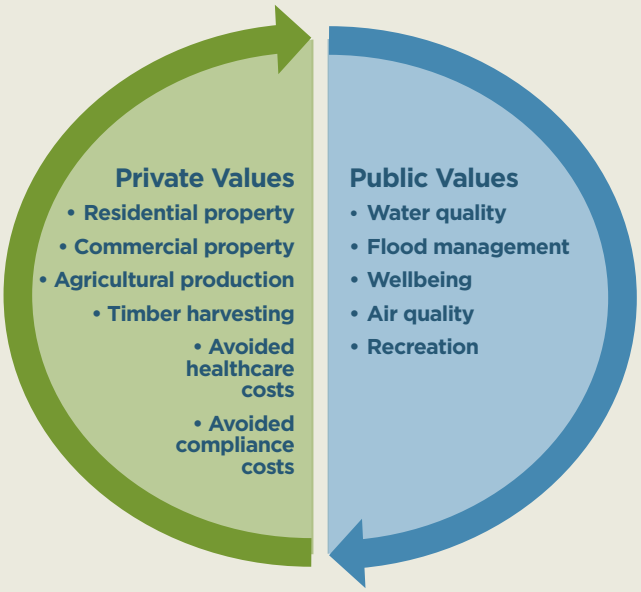
Approaches to Valuing Riparian Buffers

The scientific, economic and policy literature indicate that riparian buffers play a positive role in enhancing water quality and social values. However, the nature and scale of benefits from riparian buffers cannot be separated from their location (surrounding land uses, climate, region, etc.) and their attributes (vegetation, soil, width, etc.). Intuitively, the effectiveness and impact of riparian buffers should generally track with the scale of economic benefits they impart on individuals or society. However, the exact relationship between riparian buffer function and the associated economic benefits is not well established.

A wide range of private and public benefits can be identified based on our understanding of riparian buffer function in the natural and built environment. (See Figure 2.) Riparian buffers provide public benefits through functional improvements or services that communities and society as a whole enjoy. These services include riparian restoration, water quality improvements, improved air quality, natural flood management, and improvements in health risks and visual amenities. Often these benefits are difficult to value because of their diffuse nature and the complex causal relationships between changes in the state of riparian buffers and public outcomes. In contrast, the private benefits are more tangible but can be equally difficult to parse given how they are bundled in market transactions or production systems.

Regardless of the measurement challenges, several studies dating back to the 1980s have estimated the value of riparian buffers to people. Overwhelmingly, these studies affirm that riparian buffers have positive economic value generated by their environmental amenities regardless of estimation techniques.

Figure 2:
Private and Public Benefits of Riparian Buffers



Several factors play into how a buffer is valued:

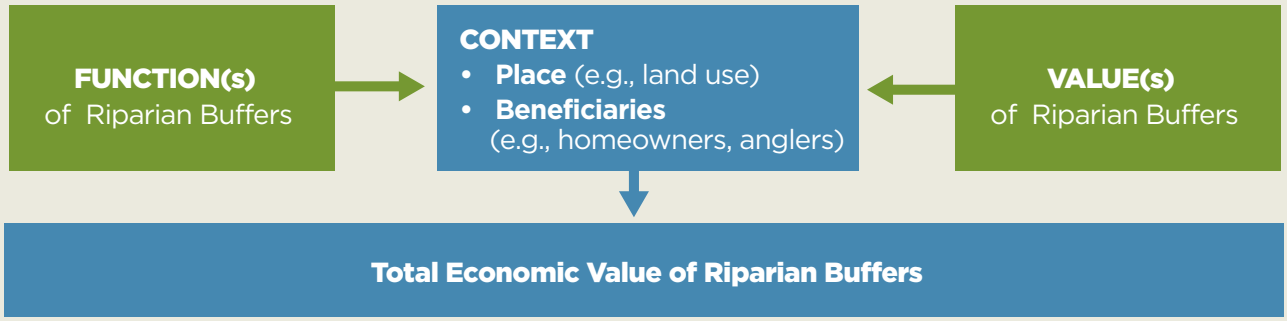
- **Scale** — People tend to place higher values on riparian buffers when they are part of a more holistic, rather than piecemeal, approach to watershed restoration.
- **Location** — Property along rivers and streams generally command a price premium.
- **Size** — Wider riparian buffers often add a premium to property prices up to a point, after which the effect can reverse itself, and buffers become a disamenity or drawback.
- **Access** — People generally prefer access to areas in or around the buffer.

The existing economic research mainly provides estimates for two types of benefits arising from riparian buffers: the impact on residential property values and a more general community value. The studies rely on two types of valuation techniques: stated preference and revealed preference. All of the reviewed stated preference studies use the contingent valuation (CV) method, which is survey-based. This method involves asking individuals their willingness to support and pay for policies that promote riparian restoration and/or protection. Notably, CV studies elicit values for a hypothetical policy or outcome. In contrast, revealed preference studies infer values from actual choices. In the case of riparian buffers, the revealed preference studies apply hedonic price models (HPM) to property values. Hedonic models build on the theory that from observed prices, implicit prices can be calculated for attributes that define the property.

Both valuation estimates (property premium and community willingness to pay (WTP)) are applicable to individuals and households where riparian buffers provide amenities to residential living. This paper does not include studies that consider the value of riparian buffers to adjacent lands used for productive purposes such as timber harvesting or agriculture; nor did the literature review identify studies that estimate amenity values of riparian buffers for commercial property and activity.

Using these property estimates and community willingness to pay estimates requires an understanding of the key function that a riparian buffer serves and who benefits. Each stream or river will offer its own unique set of recreational opportunities and amenities; this set of benefits differs not only because of the health of the waterbody but also its unique location and characteristics. For example, not all streams or rivers offer fishing and boating opportunities. Additionally, the type of fishing experience may differ based on how degraded or intact and well-functioning a waterbody is. With residential property values, the magnitude or scale of a price premium depends upon the base price of residential properties. Figure 3 illustrates how riparian functions and values align based on context — taking into account both the characteristics of the "place" (e.g., land use) and affected populations (e.g. residential property owners).

Figure 3: Process for Valuing the Impact of Riparian Buffers



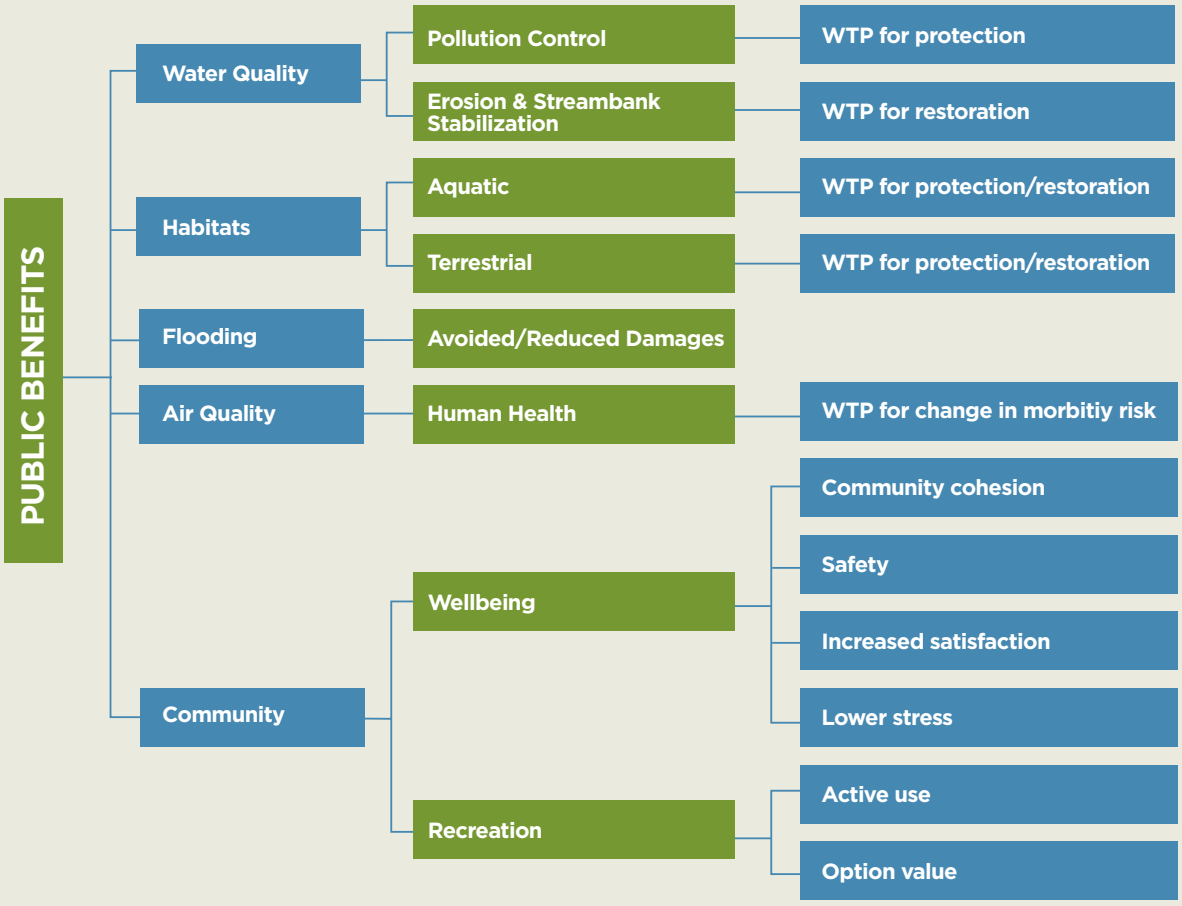
Value of Riparian Buffers as Public Good

Healthy and intact riparian buffers produce a wide range of ecosystem services (e.g., clean water, sustainable habitats) that in turn benefit people. (See Figure 4.) Increasingly the public has looked to the protection and/or restoration of these zones as a potentially effective strategy for enhancing watershed health. The public nature of the environmental amenities associated with riparian buffers makes them a good candidate for stated preference techniques (e.g., contingent valuation method).

While in many instances the benefits of watershed restoration and the benefits of riparian buffers are the same, not all watershed restoration values are necessarily applicable to riparian restoration. For example, economic estimates of the value of watershed restoration through forest conservation may emphasize road restoration and hunting benefits. In contrast, watershed restoration through riparian buffers may draw attention to stream shading and water quality outcomes.

Our review found one study that specifically considered valuing riparian ecosystem restoration.

Figure 4:
Sources of Public Benefits from Riparian Buffers



Riparian buffer restoration will improve water quality, reduce creek erosion, create bird and wildlife habitat and beautify parkland.

Holmes et al. (2004) conducted a valuation study in the Little Tennessee River (LTR) watershed, located in Macon County, North Carolina. The watershed had undergone strong development growth and nearly half of the watershed was privately owned. Both agricultural activity and commercial and residential development were adversely impacting water quality. The study focused on one portion of the watershed approximately 20 miles in length, with 8.5 miles along the river already restored. The study surveyed watershed residents, presenting them with four potential programs, each with a unique combination of environmental outcomes. The four programs were: a base program mandating best management practices (BMPs) along tributaries of the LTR with no new river restoration or with some new river restoration of three varying lengths. To characterize the benefits of riparian restoration associated with each potential program, the study identified five indicators of ecosystem services: presence of game fish, water clarity, wildlife habitats in the riparian buffer, recreational opportunities, and ecosystem integrity. The level of service for each indicator varied from low to high across the programs. Once presented with the program description, respondents had to first vote if they were willing to accept the program and then indicate how much they were willing to pay to support it. The payment vehicle for the programs involved a county-level sales tax that would be implemented over ten years.

The study found that WTP for riparian restoration was scale dependent. The option for complete restoration had a larger increase in marginal benefit over partial and piecemeal restoration. Annual household WTP for a baseline program that mandated best management practices on tributaries with no restoration ranged from $5 to $12. Annual household WTP for initiatives that involved only partial restoration was considerably lower (between $0.95 and $6.10). In contrast, WTP for the baseline program plus full restoration was substantially higher, ranging from $37 to $47. Benefits per mile of full river restoration were calculated to be $6.20 per household per mile restored.

Applying Public Benefits Estimates

Unlike the revealed preference studies, values derived from the stated preference technique can be applied to the general population. Figure 4 identifies the variety of benefits and where estimates are available for valuation. While the figure illustrates the diversity of benefits, it does not capture the interrelated and connected nature of these benefits. This complexity gives rise to challenges in valuation. A piecemeal approach could be taken to valuing leading components of the benefits package. However, that approach has potential for double counting. This piecemeal approach also requires information about the frequency and use of each benefit in the community of interest.

In contrast, Holmes et al. provide an estimate that reflects a bundled set of benefits. This bundled value gives up the specificity of a piecemeal approach but in turn can be more widely applied at the community level. For example, a six-mile restoration project in a county with around 180,000 households would generate $6.7 million in benefits (based on each household paying $6.20 per mile restored or $37 for the restoration effort). The extent to which this estimate over- or understates the total value of public benefits is unknown. This uncertainty should be acknowledged and discussed specifically in the context of how particular benefits may play a more or less important role in the motivation for undertaking riparian buffer protection or rehabilitation.

Value of Riparian Buffers and Residential Property Values

The body of work that values riparian buffers based on their impact on property values is larger. Nearly all of these economic studies consider property values only for single-family residential homes. By looking at the differences in property characteristics, these hedonic studies uncover the impact of environmental amenities, like a waterfront view, or liabilities, such as risk of flooding. Most of the

Figure 5:
Components of Property Premium

study areas are in suburban and urban watersheds where the amenities from riparian buffers account for open space, treed space, water frontage, and/or water views. (See Figure 5.)

While often responding to the same policy or regulatory drivers that address riparian buffers, this body of work differs from the stated preference studies (e.g., contingent valuation method) in several ways. Stated preference studies build upon hypothetical scenarios. In contrast, revealed preference studies, such as hedonic price methods, rely on actual observed behavior. The "what if" nature of stated preference studies open the door to concerns about hypothetical bias and the extent to which respondents are making fully informed decisions. While the values for particular property characteristics are not directly observed, hedonic studies allow them to be inferred based on price variation. This distinction from stated preference studies makes hedonic values generally more widely accepted. Moreover, hedonic price estimates are more akin to private values. This emphasis on private values means that they can provide insight into the merits and strength of arguments that buffer requirements diminish property values by restricting property rights.

The hedonic studies provide estimates of the price premium for properties that contain a riparian zone or are adjacent to one. These studies generally conclude:

- Riparian properties have a significant price premium.
- Proximity to open space and streams increase property values.
- Mandatory buffer requirements may not adversely affect property prices — especially in light of the positive amenities these zones generate, even in the absence of recreational opportunities.

Qui et al. (2006) explores the relationship between proximity and access to riparian buffers and house values in a suburban watershed. The study area focused on a watershed outside of St. Louis, Missouri that had undergone significant urban development over two decades. In response, the county passed an ordinance that required riparian buffers along both sides of main streams and tributaries flowing through residential and other nonagricultural land uses. The study found that property prices fall as a property gets farther from a stream. At the sample mean, the sale price fell by nearly $16 for every meter away from the stream.

Notably, the authors found proximity to a stream could also lower prices if the parcel was within a Federal Emergency Management Agency (FEMA) flood zone. The threat of flooding lowered home values between 4.7% and 5.6%. Qui et al. noted that other studies found properties in a floodplain tended to have 4% to 12% lower prices. The adverse price impact from being in a floodplain and the positive price impact from riparian buffer protection highlights the complex relationship between property prices and proximity to streams and rivers.

The relationship between property values and proximity to streams was relatively consistent with a survey of the area's residents. With a decreasing rate at which property values fall with respect to distance from a stream, it is not surprising that Qui et al. found that around two-thirds of the respondents (65%) stated that the creek had no impact on their property, while 28% reported the creek adding value. Assuming a riparian buffer resulted in a home being 100 feet further back from a stream, the loss in value would be about $1,580. However, it would be difficult for some to discern the impacts of proximity to a stream and other property characteristics (e.g., lot size, amount of open space, etc). The potential for proximity to be a disamenity is also consistent with respondent perceptions. Nearly 8% stated the creek reduced their property value due to flooding, bank erosion and child safety concerns.

Another hedonic study from the same year found riparian properties to have a much stronger effect on real estate prices. Bin et al. (2009) conducted a hedonic study comparing sales data for riparian and non-riparian land parcels adjacent to the Neuse River. They estimate that riparian properties experience a 26% premium over an otherwise equivalent property.

In addition to assessing the riparian price premium, the authors examined the data to determine if a recently passed mandatory buffer rule had an impact. The rule not only limited a property owner's ability to develop in the buffer area but also to cull riparian trees. The study found the buffer rule did not have a significant impact on riparian properties. The authors postulate that the rule's lack of impact on prices is because it did not change how property owners would have used or managed the land in the absence of the rule. They note that the buffer rule has two countervailing effects. The first is a negative effect as a result of restrictions on the use of private property. At the same time, the rule enhances environmental amenities (aesthetics and water

Through tree planting activity, riparian buffer projects engage community members in stream restoration.

quality) in the area surrounding a parcel affected by the buffer restrictions. This general aesthetic improvement while public in nature could enhance property values to the point where it more than offsets any loss of value associated with the property use restriction. Alternatively, the rule may not actually have a material effect on land use behavior, so there is no "appreciable" effect to be measured. The authors also suggest that property values may not fully reflect water quality and aquatic habitat improvements that arise from riparian buffers.

A hedonic study by Bark et al. (2011) investigates the role of green space as a bundled amenity — including adjacency to a riparian corridor. The authors suggest being adjacent to these areas includes view of or access to the corridor and possibly incorporates wildlife viewing and privacy (due to development restrictions); this study also considered being close by, but not adjacent to the riparian corridor. Homebuyers have consistent preferences for green space, and neighborhood level greenery has the largest marginal effect on prices. Riparian restoration programs likely generate positive externalities for nearby residents by raising property values. The premium for living near a riparian corridor was around $16,500.

In contrast to the above studies that consider proximity to riparian buffers, Mooney and Eisgruber (2001) explore the effect of riparian buffer width on property prices in the Mohawk River watershed in Oregon. In the study area, local policy was encouraging property owners to plant riparian buffers (as opposed to preserve or enhance). Consistent with other studies, the authors find stream frontage increases property values (by 7%). However, property values follow an inverted u-shape with respect to the width of a riparian buffer. On average, a one-foot increase in width results in a 0.06% decrease in price. The magnitude of the price change appears to be dependent upon the existing buffer width. The mean riparian buffer width for properties in the study was 30 feet, and the authors use this mean to

illustrate how the relationship between property values and buffer width changes. For properties with an existing buffer width of 30 feet or greater, the study found each additional foot of riparian buffer lowers property values by 0.07%. In contrast, the fall in price is greater for properties with riparian buffers of 30 feet or less; property values fall by 0.33% for every additional foot of riparian buffer.

It is worth noting that the Mohawk River and its tributaries have limited recreational opportunities. They are not known for boating or fishing. The authors postulate that this negative effect may be related to wider buffers obscuring a resident's view of the stream. This explanation is consistent with Benson et al. (1998) that find obstructed views lower prices for oceanfront property.

Applying Residential Benefits to New Areas

As noted earlier, the price premium on residential properties reflects a bundle of amenities. The price premium most likely has its origins in the aesthetic and passive wellbeing benefits of riparian buffers. Depending upon its location and availability of access, it may also include some recreational values.

The presence and quality of riparian buffers enhance property values by less than 1% to upwards of 26%. This premium should be applied only to properties adjacent to or containing riparian zones. To estimate the total value to a community, the premium can be applied to the median house price and scaled up by the number of affected homes. Importantly, this premium will already be reflected in house prices if the riparian buffers are established. In the context of a regulation or ordinance that preserves riparian buffers, this premium can be used to "backout" the benefits of riparian buffers. The calculated value then reflects an upper bound on the opportunity cost were the riparian buffers not protected.

Applicability of Open Space and Trees to Valuing Riparian Buffers

For urban communities, riparian buffers are just one type of open space or treed space planning, making the benefits of riparian buffers analogous to those of open space. For example, riparian buffers and open space can offer similar environmental amenities such as recreational opportunities, water quality improvements, wildlife and aquatic habitats, and public health improvements.

This section briefly reviews key findings from the open space literature with respect to two types of benefits (residential property price premiums and wellbeing benefits) and discusses their applicability to valuing riparian buffers.

Property Price Premiums

Not surprisingly, property value's relationship to riparian buffers is similar to its relationship with tree canopy and open space. Most studies find open space and trees to enhance property values (Kadish and Netusil, 2012; Donovan and Butry, 2010; Netusil, Chattopadhyay, and Kovacs, 2010; Anderson and Cordell, 1988; Mansfield, Pattanayak, McDow, McDonald and Halpin, 2005). This positive effect holds for trees both on the property, as well as in the neighborhood. In fact, Payton et al. (2008) find that neighborhood greenness impacts 'dominated' property level greenness impacts when valuing vegetation amenities (Payton et al., 2008). However, similar to riparian buffers, trees and vegetation can also have a negative effect especially if highly dense (Netusil et al., 2010).

These studies raise confidence in the claim that riparian buffers generate positive amenities that are, in turn, captured in property values. However given the potential differences in the bundle of services and amenities trees and open space generate compared to riparian buffers, it is difficult to use these studies for valuation purposes. Rather they support the view that the value of riparian buffers is not zero and most likely additive.

Using Wellbeing Improvements to Value Riparian Buffers

In some cases, urban greenspace involves riparian buffers. In these settings, it is possible that the wellbeing benefits of urban greenspace could be used as an approximation of the value of riparian buffers.

Many of the studies that quantify and value the wellbeing benefits of urban greenspace are European-based and respond to the concentration of people living in highly urbanized environments. The research generally confirms that greenspace and open space provide many positive impacts. They can be psychological and physical, with the experience being active or passive (recreating and observing, respectively). Psychological benefits include reduced stress, increased positive emotions, greater attention, etc. Physical benefits include increased longevity and physical activity levels. Open space is also found to enhance community wellbeing through stronger social cohesion, enhanced resilience to climate and other environmental challenges.

As found in the valuation studies, greenspaces can have negative impacts on people and communities — especially when not managed. These include raising safety concerns when spaces are not well lit, filled with debris, or have the presence of certain animals (Bertram and Rehdanz, 2015; and Brander and Koetse, 2011).

Applicability of Productive Land Use to Value Riparian Buffers

Riparian buffers reduce the amount of land available for 'consumptive' or revenue producing purposes such as timber harvesting or agriculture. Studies that consider these land use types tend to focus on the compensation needed to offset revenue losses from less land being available for production. Kline, Alig, Johnson (2000) illustrates the importance of the land use when considering compensation or welfare losses due to mandates for riparian buffers. The authors conduct a CV study of forest land owners that shows how the level of compensation required for riparian buffers depends on how the owner uses the land.

Forest land owners often did not require compensation if the land was being used primarily for recreation. In contrast, owners required greater compensation when productive use (e.g., timber harvesting) was impacted. Studies focused on forested lands and agricultural lands do not often address ancillary benefits of riparian buffers. In other words, they do not offer insight into how riparian buffers compare as a cost-effective alternative to other regulatory or policy options addressing water quality, flooding erosion or how buffers may enhance aspect of a working land's productivity.

Findings

The current state of research affirms the beneficial functions of riparian buffers and their positive economic value. Empirical evidence generally supports valuing two types of benefits — residential property premiums and public willingness to support riparian buffer programs. These values demonstrate the potentially significant economic value riparian buffers generate when aggregated across households and communities.

A review of the available studies providing estimates for valuing riparian buffers highlight the following:

- **The relationship between benefits and riparian buffers is positive.** The magnitude of benefits from riparian buffers increase with length and width. Some studies, however, suggest that the relationship between amenity benefits and buffer width is not fixed and that the incremental gain falls as the buffer becomes wider or even turns negative at some point. Further research is needed to understand what attributes of riparian buffers drive the potential disamenity and whether better riparian buffer design can alleviate this loss.
- **The positive relationship between residential property values and proximity to riparian buffers is relatively well-established.** The magnitude of benefits depends on a range of factors including quality of established riparian buffers, baseline property values, and extent to which surrounding environmental amenities interact with individual parcel values.
- **The public generally supports riparian buffers but prefers complete restoration over piecemeal or partial efforts.** At the same time, the general public may not be aware of existing buffer requirements or the health of these buffers, suggesting that education and awareness play an important role to helping communities better understand how riparian buffer requirements and policy impact them.
- **Values for riparian buffers are similar to open space and green space in terms of shape and impact.** However before transferring open space and green space values to riparian buffers, careful consideration should be given to where the bundled amenities differ.
- **The relationship between riparian buffers and productive land is different from residential and public good values.**

Photo courtesy of Alliance for the Chesapeake Bay

Planting wider buffers supports clean water downstream.

Recommendations

Additional research is necessary to better measure the economic value of riparian buffers and guide how we design and implement riparian buffers so that we maximize their environmental and social value.

To that end and as a result of the findings listed above, the following are specific recommendations for future work.

- Conduct further research into what conditions and attributes of riparian buffers allow valuation of riparian buffers to increase in line with their ecological functioning.
- Conduct further research focused on how people assign value to riparian buffers:
  - Identify what attributes of riparian buffers drive how people value them; and
  - Research how values are impacted by riparian buffer conditions and attributes such as different land uses, waterway health, and riparian buffer quality and density.
- Where studies assign values to green or open space, quantify the role and value of riparian buffers in those environments.
- For land uses other than single-family residential, research what elements of riparian buffers generate amenity benefits.
- Significantly expand public awareness and understanding of the policies and benefits related to riparian buffers to increase the ability to measure their societal value.

Planting streamside trees helps to grow sustainable habitat and community.

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Appendix A.

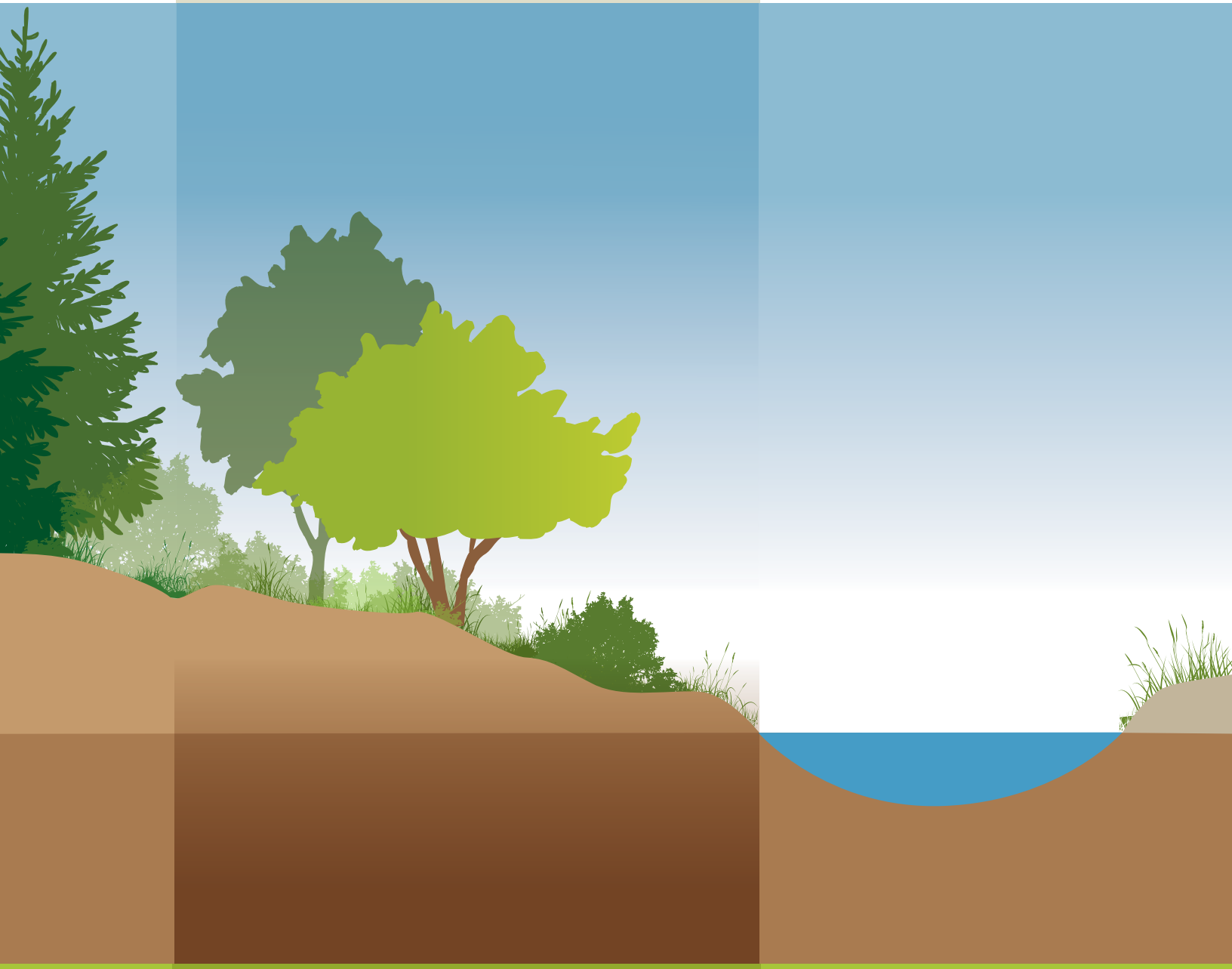
Private Benefits — Summary Table of Riparian Buffer Valuation

Author	Title	Study Year	Location	Description	Value (2015$)
Bark, Rosalind H., Daniel E. Osgood, Bonnie G. Colby and Eve B. Halper (2011)	How Do Home-buyers Value Different Types of Green Space?	1998-2003	Tucson, AZ North Central and NE	Hedonic Price premium for bundled environmental amenities	$16,520 premium for property near riparian zone
Bin, Okmyung, Craig E. Landry, and Gregory F. Meyer (2009)	Riparian Buffers and Hedonic Prices: A Quasi-Experimental Analysis of Residential Property Values in the Neuse River Basin	2002	Neuse River, NC Craven County, NC	Hedonic Price premium for riparian properties arising from imple-mentation of buffer rule	26% premium for riparian property
Kadish, Jonathan and Noelwah R. Netusil (2012)	Valuing Vegetation in an Urban Watershed	2005	Portland, OR Multnomah County	Hedonics Metro area of Price premium for various types of urban vegetation	0.049% price premium for high structure vegetation
Mooney, Sian and Ludwig M. Eisgru-ber (2001)	The Influence of Riparian Protec-tion Measures on Residential Property Values: The Case of the Oregon Plan for Salmon and Watersheds	1996	Oregon Mohawk watershed in western OR	Hedonics Relationship between width of riparian buffer and house values	Price drop of 0.006% with each additional foot of riparian buffer width
Qui, Zeyuan, Tony Prato, and Gerry Boehm (2006)	Economic Valuation of Riparian Buffer and Open Space in Suburban Watershed	2002	St. Louis, Missouri Dardeen Creek Watershed	CV and Hedonic Suburban watershed in St. Louis metro area Incremental addition-al amount in house price for access to riparian buffer Range depends on proximity to buffer	$1,943 – $9,038 increase in home purchase price

Appendix B.

Public Benefits — Summary Table of Riparian Buffer Valuation

Author	Title	Study Year	Location	Description	Value (2015$)
Blaine, T.W. and F.R. Lichtkoppler (2004)	Willingness to Pay for Green Space Preservation: A comparison of soil and water conservation district clientele and the general public using the contingent valuation method	2001	Cleveland, OH Cuyahoga County	CV WTP for conservation easements	$3.60 – $4.10 per month per household
Holmes, Thomas P., John C. Bergstrom, Eric Huszar, Susan B. Kask, and Fritz Orr III. (2004)	Contingent Valuation, net marginal benefits, and the scale of riparian ecosystem restoration.	2000	North Carolina Little Tennessee River in western NC	CV WTP for varying levels of restoration activity	$7.90 – $123/ft $0.95 – $74/ household



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