Economic Effects of Special Protection Stream Designations in the Pocono Mountains Region

July 2022

Prepared for Our Pocono Waters by: KEY-LOG ECONOMICS

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About

Key-Log Economics is an independent ecological economic research and consulting firm that works with clients to develop the facts and arguments that make for a competent understanding of today's conservation, environmental, and sustainability challenges.

Our Pocono Waters is a partnership of clean water and conservation advocates, businesses, community and faith leaders, and outdoor recreation enthusiasts working together to protect Exceptional Value (EV) streams and raise awareness of the role of EV streams for the resiliency and future success of the communities and economy of the Pocono Mountains region of Pennsylvania.

Our Pocono Waters, working together with Citizens for Pennsylvania's Future (PennFuture) and through support of the William Penn Foundation, has commissioned this study to develop information about the economic effects of enhanced stream protection in the Poconos region. *The opinions expressed in this report are those of the authors and do not necessarily reflect the views of the William Penn Foundation.*

Photos courtesy of Todd Burns, Donna Kohut, Abby Jones, and Geoff Rogalsky

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SUMMARY

Exceptional Value (EV) is the highest water quality use designation in Pennsylvania and requires that water quality must be maintained at the existing level (i.e., quality cannot be lowered) (25 Pa. Code § 93.4a(d)). A stream designated as High Quality (HQ) may be subject to reductions in water quality if "discharge is the result of necessary social or economic development, water quality criteria are met, and existing uses of stream are protected" (25 Pa. Code § 39.4c(b)(1)(iii)). EV and HQ comprise the "special protection water" uses under Pennsylvania's Clean Streams Law, the highest and most protective water quality uses in the Commonwealth.

The Pennsylvania Department of Environmental Protection (DEP) identifies both an existing use and a designated use for a waterbody; existing uses are uses attained within the stream (e.g., cold water fishes), while designated uses are those uses that are recognized by regulation (25 Pa. Code § 93.1). These water quality uses include water supply, recreation and fish consumption, special protection waters, and navigation (25 Pa. Code § 93.3). These water quality uses (whether existing or designated) determine the standards necessary to maintain a stream's water quality and the standards on specific sources of pollution (e.g., treatment, effluent limit, etc.) which can change abatement costs for polluters. Ideally, existing uses align with designated uses, and when higher existing uses are identified, a stream's designation (and accompanying regulatory standards) is subject to change. This redesignation occurs either when DEP identifies bodies that need redesignation or from a lawmaking petition to the Environmental Quality Board from agencies/public; part of the redesignation process includes a 30-day public comment period.

In most cases, EV and HQ designations affect development through (1) antidegradation review and stringent standards for new discharges and through (2) requirement for individual permit rather than a general permit (Royer et al., 2007). Under HQ designation, water quality reductions are permitted only if the "applicant" or development-interested party can demonstrate that the reduction is needed for significant social or economic development; this exception is called a "social or economic justification" (SEJ) exception and is not available for EV watersheds (Royer et al., 2007). EV designation does not require currently discharging parties to stop their discharge nor does it require the government to abate pollution under an existing permit. HQ and EV designation do not impact infrastructure (i.e., road) maintenance, on-site sewage, or agricultural activities (i.e., pesticides, plowing, tilling) (Royer et al., 2007).

More than 99% of streams and rivers are affected by human activities (van Meter et al., 2016). For example, streams suffer from degradation due to land conversion for agriculture, urbanization, and the use of harsh chemicals, such as fertilizers and pesticides. Worsened stream systems have negative implications for ecological and human communities. While there is increased commitment and interest in restoring stream systems, some streams are degraded to such an extent that full restoration is likely unachievable. These cases demonstrate the need to protect streams prior to degradation (van Meter et al., 2016).

Economic and societal benefits of watershed and stream protection include improved water quality and supply, nutrient retention, carbon storage, fish and wildlife habitat, and recreational opportunities. Within the seven-county study region, EV designated stream buffers retain 80-100% natural land cover. Applying ecosystem service values for nutrient retention, sediment control, recreation, and carbon sequestration along natural riparian buffers from the Delaware River Basin to the Poconos suggests the natural riparian buffers along designated streams in the region provide an annual $2.1 billion in benefit. More than $1.5 billion of this total is attributed to social benefits from carbon storage, and another $500 million in benefit can be attributed to cost-savings from improved nutrient retention along waterways.

HQ and EV Streams provide $2.1 billion in annual eco-system service value and increased tourism could result in $245 million to $982 million in visitor spending and 1,845 to 7,380 more jobs, with wage earnings increasing $61 million to $246 million.

Our statistical analyses of the relationship between economic indicators and stream quality in the Pocono Mountains (or Poconos) study region finds that residential and commercial land value increases for properties closer to an EV or HQ stream, when compared to otherwise similar properties farther away. This reflects landowners' willingness to pay for aesthetic quality, recreational opportunity (including for hunting and fishing), and other ecosystem services that are likely to be better or more available due to the stream protection.

Land value does not, however, seem to be affected one way or another by the presence of an EV or HQ stream on the property itself. We interpret this result, as others have, as an indication that such designations are viewed as a "mixed bag" by property purchasers — they convey some benefits, but they do bring more responsibilities.

There is a positive relationship between the combined HQ and EV designated stream density in a county and all three measures of economic prosperity: personal income, earnings, and employment. Further, there is no evidence to support the claim that combined HQ and EV stream designation harms counties' economic development prospects.

In addition, improvements in water quality may lead to increases in outdoor recreation expenditures and/or trips. Our economic impact analysis suggests that a 2% to 8% increase in visitor spending could result in a $245 million to $982 million (2021 $) increase in total regional output (sales) and 1,845 to 7,380 additional jobs, with wage earnings increasing $61 million to $246 million.

Finally, results of a comparison of economic impact multipliers for the Poconos study region and a region with similar EV and HQ stream density characteristics indicate that EV/HQ stream density and quality do not limit economic growth (sales, earnings, and jobs), as measured by input-output modeling.

All totaled, there is little cause for concern that enhanced stream protection will harm the Poconos region economy, and there is important evidence that such protection actually improves the region's economy.

Our analyses of the relationship between economic indicators and stream quality in the Poconos study region begins with a description of some of the economic benefits associated with stream protection, such as water quality, recreation, and carbon storage. This is followed by statistical analyses of the economic effects of Exceptional Value and High Quality streams in terms of land value, income, and employment. We then estimate the economic impacts of increases in visitor spending that could result from stream quality improvements.

ECONOMIC BENEFITS OF STREAM PROTECTION

Stream systems are integrated with larger river networks and waterbodies; the management and regulation of these systems affects the chemical and biological compositions of downstream networks, surface waters, and watersheds (Creed et al., 2017). Maintaining and preserving watershed ecosystems has both social and economic benefits for human communities, especially through their provision of ecosystem services — the benefits that people get from natural systems and which include water purification, air filtration, carbon storage, nutrient cycling, soil formation, erosion control, food, and recreational value[1] (U.S. Environmental Protection Agency, 2012). On average in the Northern Appalachian region, headwater streams provide about $39,446 per acrein annual ecosystem services (2021 $[2]) (i.e., water supply, water purification, and climate regulation) (Hill et al., 2014). Protecting these water systems is critical to maintaining sustainable and functional surface water bodies (Creed et al., 2017).

Riparian buffers — undeveloped land surrounding water bodies — are also important for their provision of ecosystem services. These buffers mitigate the negative impact of surrounding land uses and provide ecosystem services to surrounding communities. Buffers trap sediment and other pollutants that might otherwise reach streams and make streams less valuable for recreation or as sources of drinking water. They slow down water runoff during storms, thus limiting flooding downstream. They are also valuable habitat for wildlife, which is good for hunters, birders, and other wildlife watchers. A study focused on the Delaware River Basin, which includes a portion of Pennsylvania, estimates that riparian buffers provide more than $10,800 per acre per year in monetized benefits in addition to non-monetized benefits (2021 $) (Rempel & Buckley, 2018). Riparian buffers improve conditions that can lead to more recreational enjoyment and economic opportunity in both the local stream/water systems and the entire watershed.

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Water Quality

Stream and riparian buffer ecosystems support wildlife communities, complex stream ecologies, and the provision of ecosystem services. Jones et al. (2006) studied the effect of forest stream buffers on stream quality in Georgia and found that streams with reduced buffers (50-foot) had higher peak temperatures and more fine sediments as compared to 100-foot buffered streams (Jones et al., 2006). Streams with 50-foot riparian buffers experienced a 66% to 97% reduction of young trout populations; researchers concluded that such changes would eventually result in the significant decline or complete elimination of trout populations in Georgia streams (Jones et al., 2006; Rempel & Buckley, 2018).

Nutrient Retention

Stream and riparian protection improves water quality and functionality through nutrient retention and pollution filtration. Evaluating the effect of stream restoration on stream water quality, Thompson et al. (2018) found that stream restoration was associated with reducing 45% of phosphates, 46% of phosphorus, 26% of nitrate, 48% of ammonium, 50% of nitrogen, and 74% of total suspended sediments.[3] Similarly, Lowrance et al. (1997) found that each acre of riparian buffer in Georgia and Maryland retain between 23 and 65 pounds of nitrogen and 1.1 to 2.6 pounds of phosphorus annually. Valuing the nutrient retention removal services as the cost of removal and/or the prevention of the nutrients (i.e., $4.30 to $62.60 per pound nitrogen and $26 to $431 per pound phosphorus) (2021 $), Rempel & Buckley (2018) estimate that riparian buffers save between $94 and $5,172 in nutrient capture services and between $3 and $23 in sediment control services per acre per year (2021 $).

[1] Another helpful definition of ecosystem services is "the effects on human well-being of the flow of benefits from ecosystems to people over given extents of space and time" (Johnson, Bagstad, Snapp, & Villa, 2010).

[2] Values from the literature were converted to 2021 dollars using the Consumer Price Index.

[3] Percentages have been rounded.

Water Supply

In 2012, the U.S. Environmental Protection Agency released a report concluding the watershed and forest buffer protection is associated with reduced costs of water supply treatment, reduced damage expenses from flooding and erosion, reduced runoff pollution, and decreased stress on infrastructure (U.S. Environmental Protection Agency [EPA], 2012). Drawing on case studies in New York City and the Chesapeake Bay, they found that watershed and forest buffer protection provides a more cost effective means of wastewater treatment as compared to built filtration plants (EPA, 2012). Specifically, they report that watershed conservation was at least $6.5 billion cheaper than a new water filtration plant for drinking water in New York, and that forest buffers reduced nitrogen concentrations in the Chesapeake Bay for $4.15 per pound abated compared to $11.47 per pound abated (2021 $)using a wastewater treatment plant (EPA, 2012; Hanson et al., 2011).

Carbon Storage

Forests and other types of land cover, capture, and store carbon in vegetation and soils, thus contributing to global climate regulation. While riparian forests and natural land cover are known for protecting stream and river quality and preventing erosion, they can provide substantial co-benefits in the form of carbon sequestration and storage. A global meta-analysis of 117 studies and datasets on riparian biomass and soil properties determined that restored riparian forest can hold 168 to 290 Mg C/acre in biomass once the forest reaches maturity (Dybala et al., 2019). Other land uses store less carbon: rangeland stores 32 metric tons/acre, agricultural land stores 28 metric tons/acre, and developed land stores only 16 tons/acre (total of above ground, below ground, and soil carbon) (Rempel & Buckley, 2018). When forestlands are converted to other uses, stored carbon is released as greenhouse gasses. For every acre of forestland developed as commercial property, 53 to 66 metric tons of carbon would be released; the loss of carbon storage from the land conversion is valued at $7,520 to $9,409/acre[4] (2021 $) (Rempel & Buckley, 2018). For example, a typical distribution warehouse can be 250,000 square feet, which corresponds with $43,200 to $54,000 in carbon storage value lost annually. The development of commercial shopping centers with 800,000 square feet of leasable space on forested land results in a $138,000 to $173,000 loss in carbon storage value.

In the Delaware River Basin, riparian buffers provide an estimated $5,286 to $9,409 (2021 $) in carbon storage benefits per acre annually (Rempel & Buckley, 2018). These carbon storage benefits can play a significant role in offsetting the state's total annual emissions, which have decreased steadily since the early 2000's but still remain high at more than 219 million metric tons of CO2 in 2019 (U.S. EIA, 2019). Considering the social cost of carbon currently sits around $50 per metric ton, Pennsylvania's annual carbon emissions contribute to $10.95 billion in damages from the social cost of carbon alone. A million acres in natural riparian buffer around the state could offset around 70% of the damage in annual emissions in perpetuity, without accounting for the other ecosystem service benefits delivered from natural riparian buffers.

Increased recreational opportunities may result in increased tourism and trip- and recreation-related spending, which benefits the local economies.

Recreation

Headwater pollution contributes to reduced water quality in downstream ecosystems and is one the primary drivers of aquatic species extinction, which threatens valuable recreational ecosystem services (Colvin et al., 2019). The bog turtle, for example, has been listed as a "threatened species" under the federal Endangered Species Act, with loss of habitat and water pollution being major factors causing the species' decline (PennState Extension, 2021). Conversely, improved water quality can lead to increased recreational opportunities and experience quality, such as fishing, swimming, kayaking, etc. Increased recreational opportunities may result in increased tourism and trip- and recreation-related spending, which benefits the local economies. Research demonstrates that outdoor recreationists are willing to pay for stream water quality improvements; Farber and Griner (2000) found that households in Western

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[4] Based on an estimate of the social cost of carbon in the atmosphere ($31 per ton of CO_2 in $2010, or $127 per metric ton of CO_2 equivalent in $2017). The social cost of carbon estimates the present value of the stream of annual costs and damages expected to result from the emission of one metric ton of CO_2 (Rempel & Buckley, 2018).

Pennsylvania were willing to pay between $62 and $89 annually for five years (2021 $) to improve stream quality from moderately polluted levels to unpolluted; the same survey showed that respondents were willing to pay $151 to $194 annually for five years (2021 $) to improve stream quality from severely polluted levels to unpolluted (Farber and Griner, 2000; Johnston and Thomassin, 2010). Similarly, a survey in New England found that lake, river, and coastal recreationists had an average annual willingness to pay for improved water quality ranging from $15.10 for boating and fishing, $57.55 for viewing, and $128.96 for swimming uses (2021 $) (Parsons, Helm, & Bondelid, 2003).

By improving environmental conditions and water quality, riparian stream buffers can also lead to increased recreational and economic opportunities in both the local stream system and in the greater watershed (e.g., downstream, increased water quality, etc.). Studying the economic benefits of the Conservation Reserve Program in Pennsylvania (from wildlife viewing and freshwater fishing), the U.S. Department of Agriculture found that each acre of conserved riparian buffer provides an estimated $96.51 (2021 $) in annual recreational benefits, predominantly from wildlife viewing (Hansen et al., 1999). Rempel & Buckley (2018) estimates that each acre of natural riparian land lost for other uses in the Delaware River Basin is associated with a $67.82 loss (2021 $) in recreational value (from lost wildlife viewing, pheasant hunting, freshwater recreation, and recreational fishing).

Land Value

Healthy watersheds and high water quality support recreation and tourism industries, improve community health, and are associated with higher regional property values (U.S. Environmental Protection Agency, 2012). Nicholls & Crompton (2018) provide evidence that clean water has a positive effect on property values. In a review of 43 studies (most in the U.S.), all but two analyses demonstrated a statistically significant relationship between water quality and property price (Nicholls & Crompton, 2018). Waterfront businesses tend to have higher property values when they are in close proximity to clean waters (U.S. Environmental Protection Agency, 2012).

A study on water quality and property values in Maryland found a 1 milligram per liter change in total suspended solids is associated with $1,596 change in property value and the same reduction in dissolved inorganic nitrogen is associated with a $25,934 change in property value (2021 $) (Poor et al., 2007). Increased water quality is linked specifically to increased housing values as well. Water clarity (as measured by Secchi disk depths) is often used as a proxy for observed or perceived water quality, and Guignet et al. (2020) found that on average, a 1% increase in Secchi disk depth results in a 0.13% and 0.08% increase in home values for waterfront and non-waterfront homes respectively. Clearer water corresponds with a 0.05% increase in waterfront home value relative to non-waterfront homes, and homes on existing clear waterfronts that experience improved clarity see an additional 0.02% increase in home value (i.e., the "pristine premium"). Finally, data from the U.S. Northeast indicates a 1% increase in water clarity is associated with a 0.36% and 0.32% increase in value for waterfront and non-waterfront homes respectively (Guignet et al., 2020). Thus, a waterfront home valued at $275,000 would increase in value by almost $1,000 from a 1% increase in water clarity.

Riparian buffers are shown to increase residential price premiums between 1% and 26% (Young, 2016). Bin et al. (2009) examined the effect of mandatory riparian buffer rules on property values in the Neuse River Basin in North Carolina. These rules restrict land uses near streams and waterways and despite the restrictions on land use, they found no evidence that the mandatory buffer rule had a significant effect on riparian property values (Bin et al., 2009). The authors hypothesize that any negative effect due to restrictions on use is offset by a positive effect due to beneficial effects on water quality and improved aesthetics, both of which are associated with increased property values (Bin et al., 2009). They found that land with riparian buffers had 26% higher property values than those without buffers (Bin et al., 2009).

Riparian buffers — undeveloped land surrounding water bodies — are also important for their provision of ecosystem services.

Other studies do indicate that people prefer – and are willing to pay more for – homes that are closer to protected streams. Kenwick et al. (2009) found that suburban residents had a 90% preference for riparian tree buffers compared to no buffers. Young (2016) found that residential properties including or adjacent to riparian buffer areas tend to be more valuable — by as much as 26% — than otherwise similar properties lacking protected streams on them or nearby.

In the context here (potential restrictions on land use due to existing use determinations), our statistical analysis reveals that the presence of an EV or HQ stream on a residential property does not affect the property's assessed value, but the assessed value does increase by 1.9% with with each kilometer (km) closer to an EV or HQ stream the parcel lies. For the commercial properties examined[5], we see the same pattern, except that properties 1 km closer to an EV or HQ stream are 2.7% more valuable, on average, than similar parcels 1 km farther away from such streams.

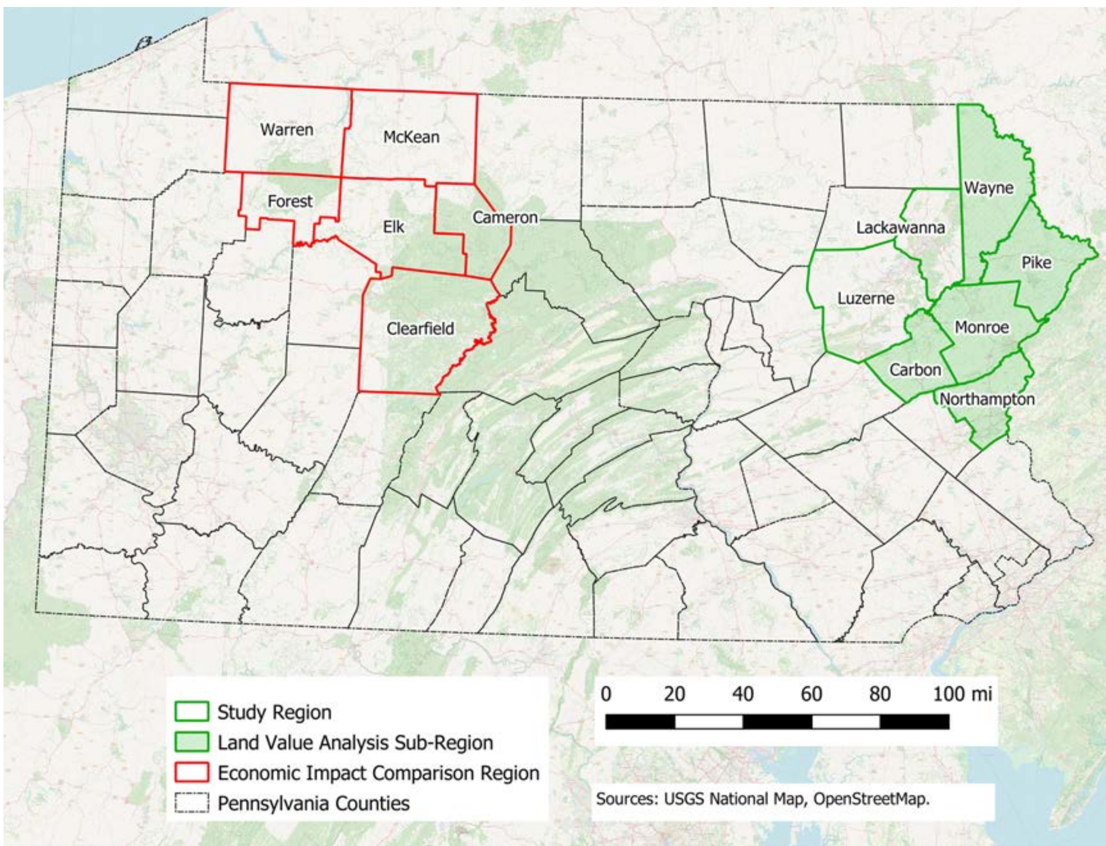
Interestingly, proximity to streams in general — that is without regard for the stream's designated use — does not confer any statistically significant benefit to landowners. From this, we can infer that it is either the protected status per se that bestows the added value or that the aesthetic, recreational, water quality, and other values that protected streams support that adds to the value of residential and commercial properties. (See Effects on Land Prices, below for details.)

[5] We included commercial properties used in recreation/tourism industries, as housing developments, as farms, and without a designated purpose in the analysis.

STUDY & COMPARISON REGIONS

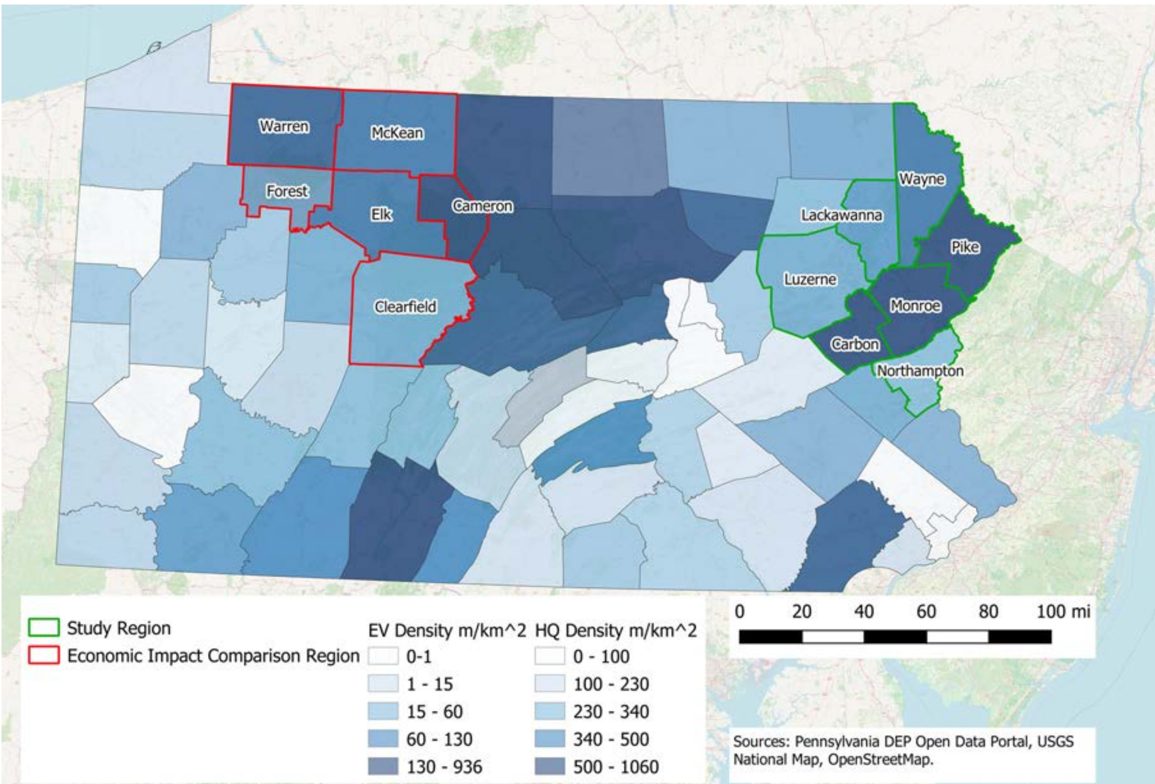
Our primary study region for the economic analyses comprises the Poconos region counties drained, ultimately, by the Delaware River. These are Wayne, Pike, Monroe, Carbon, Northampton, and portions of Lackawanna and Luzerne counties. For the economic impact comparisons, we selected a six-county region based on a comparison of the density of EV- and HQ-designated streams in each county in the Commonwealth. We calculated EV and HQ density as meters per square kilometer (m/km^2) and as the percentage of all streams (in m) in the county that are EV and HQ (Pennsylvania Department of Environmental Protection, 2021). The counties most similar to the primary study region lie within the Pennsylvania Wilds region (defined by Pennsylvania Department of Community and Economic Development), and from those, we selected the six contiguous counties that, overall, looked most like the study region by these measures. The counties are Warren, McKean, Elk, Cameron, Forest, and Clearfield. (See Figures 1 and 2, below.)

Figure 1. Study Regions for Three Economic Analyses



For the hedonic price analysis, and to minimize data acquisition costs, we excluded properties in Lackawanna and Luzerne counties, where only a small fraction of the land area lies within the Delaware basin. For other analyses, particularly those for which data are available only at the county level, these two counties are included.

Figure 2. Density of Streams with Designated or Existing uses of Exceptional Value or High Quality, by County (meters/km^2) *(Note that the two layers (for EV and HQ) are rendered in this map with 50% opacity. Overlaying these layers indicated the unweighted combination of the two densities.)*



ECOSYSTEM SERVICE VALUES OF POCONO NATURAL RIPARIAN BUFFERS

Natural land adjacent to waterways–such as forest, grassland, shrub and wetlands–allow for a cascade of benefits from improved ecosystem service delivery downstream, including water filtration, nutrient retention, and sediment control. Greater buffer protections accompany higher stream designations, allowing for this improved ecosystem service delivery.

Figure 3a shows the percentage of natural land cover within 150 feet from EV-designated streams in the seven-county study region; each county has more than 80% natural land cover in the 150-foot riparian zone, with Luzerne County providing near complete buffer coverage at 98% natural land cover. Figure 3b indicates the proportion of natural land cover in the same 150-foot riparian zone for all stream designations, including exceptional value (EV), high quality (HQ), warm water fisheries (WWF), cold water fisheries (CWF), and trout-stocked fishing (TSF). Nearly all counties have around three-quarters of the riparian zone preserved, but this level is notably lower than the county averages for EV stream buffer zones. Northampton County riparian buffer coverage is significantly lower than the rest of the region, with less than 60% natural buffer in the 150-feet riparian zone along designated streams. This difference may be attributed to the lower proportion of EV streams relative to all designations in Northampton County; EV designations make up only 2.8% of all stream designations in the county, with cold water fisheries making up half of the designated stream miles. Of 6,718 miles of streams in the study region, 806 miles are designated as EV and 3,844 miles are HQ streams, based on either the existing or designated use[6].

The natural land cover adjacent to Poconos streams and rivers produce an array of ecosystem service benefits both on-site and downstream. Local nonmarket benefits include aesthetic value, recreational value, habitat and sediment control, while nutrient retention may primarily benefit downstream communities and carbon storage provides global benefits.

Figure 3a. Percentage Natural Land Cover in EV-Designated 150-feet Stream Buffers[7]

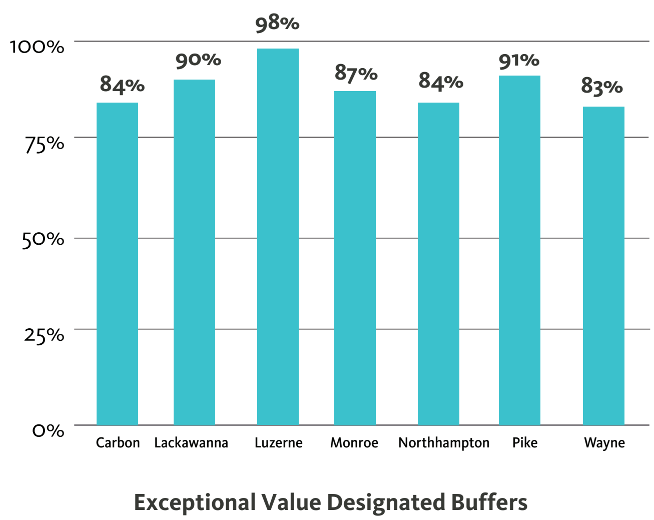
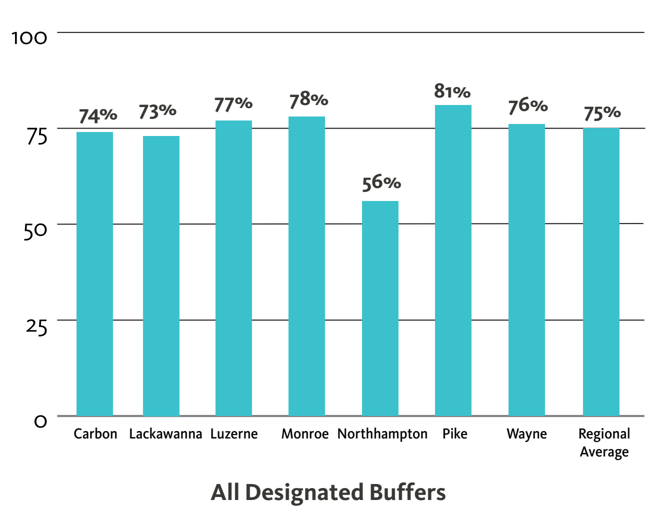


Figure 3b. Average Percentage of Natural Land Cover in All Designated 150-feet Stream Buffers



6 All EV streams, whether by virtue of their existing or designated use determination are assigned to the EV stream category. Of the remaining streams, all HQ Streams (whether EU or DU) are assigned to the HQ category.

7 Natural land cover is characterized here as the following land cover types from the National Land Cover Database: deciduous forest, evergreen forest, mixed forest, shrub/scrub, grassland, woody wetlands, and emergent herbaceous wetlands.

Table 1 describes the nonmarket benefits provided by natural stream buffers in the Poconos using annual per acre ecosystem service values applied in the Northeastern Appalachian Mountains and the nearby Delaware River Basin (Rempel & Buckley, 2018; see Appendix D for more details). Nutrient retention and carbon storage account for a vast majority of the nonmarket benefit quantified from natural stream buffers, and the stream buffers along protected waters in the seven-county region are estimated to produce more than $2.1 billion annually in bundled ecosystem service benefits.

All natural buffer acres are valued equally in this exercise, whether they be natural buffer acres around exceptional value streams or warm water fishery stream designations. However, exceptional value stream designations imply greater acreage of forest, shrub, and wetland in the accompanying riparian zones, which in turn provide more ecosystem service benefit to both the Poconos and downstream communities.

Table 1. Ecosystem Service Values from Designated Stream Natural Buffers in the Poconos

County	Designation Type	Natural Buffer Acres	Ecosystem Service Benefits ($ 2021/year)				
			Nutrient Retention	Sediment Control	Recreational Value	Carbon Storage	Total (Bundled)
Carbon	EV	4,570	$12,031,896	$59,405	$310,736	$33,573,239	$45,975,277
	HQ	9,484	24,970,268	123,287	644,883	69,675,868	95,414,306
	All Other	3,724	9,804,938	48,410	253,223	27,359,241	37,465,812
	Total	**17,777**	**$46,807,102**	**$231,102**	**$1,208,843**	**$130,608,348**	**$178,855,395**
Lackawanna	EV	3,724	9,806,109	48,416	253,253	27,362,509	37,470,287
	HQ	8,614	22,681,825	111,988	585,782	63,290,302	86,669,897
	All Other	11,877	31,273,443	154,407	807,670	87,263,951	119,499,471
	Total	**24,216**	**$63,761,377**	**$314,811**	**$1,646,705**	**$177,916,762**	**$243,639,655**
Luzerne	EV	938	2,468,802	12,189	63,759	6,888,829	9,433,580
	HQ	20,057	52,809,289	260,737	1,363,856	147,356,569	201,790,451
	All Other	22,277	58,655,126	289,600	1,514,830	163,668,519	224,128,076
	Total	**43,271**	**$113,933,217**	**$562,526**	**$2,942,445**	**$317,913,918**	**$435,352,107**
Monroe	EV	9,812	25,834,583	127,554	667,205	72,087,612	98,716,954
	HQ	19,557	51,493,493	254,241	1,329,874	143,685,032	196,762,639
	All Other	3,546	9,335,304	46,092	241,094	26,048,794	35,671,284
	Total	**32,914**	**$86,663,379**	**$427,886**	**$2,238,173**	**$241,821,439**	**$331,150,877**
Northampton	EV	498	1,312,283	6,479	33,891	3,661,733	5,014,386
	HQ	3,341	8,797,742	43,437	227,211	24,548,807	33,617,198
	All Other	7,544	19,863,432	98,072	512,994	55,425,991	75,900,490
	Total	**11,384**	**$29,973,457**	**$147,989**	**$774,096**	**$83,636,532**	**$114,532,074**
Pike	EV	5,699	15,006,638	74,093	387,562	41,873,821	57,342,114
	HQ	26,728	70,376,079	347,470	1,817,536	196,374,119	268,915,205
	All Other	100	262,339	1,295	6,775	732,020	1,002,430
	Total	**32,528**	**$85,645,057**	**$422,858**	**$2,211,874**	**$238,979,960**	**$327,259,749**
Wayne	EV	4,817	12,683,060	62,621	327,553	35,390,217	48,463,451
	HQ	41,113	108,249,585	534,464	2,795,660	302,054,578	413,634,287
	All Other	1,601	4,216,170	20,817	108,887	11,764,604	16,110,478
	Total	**47,531**	**$125,148,815**	**$617,901**	**$3,232,100**	**$349,209,399**	**$478,208,216**
Grand Total		**210,204**	**$553,466,622**	**$2,732,649**	**$14,293,859**	**$1,544,367,366**	**$2,114,860,496**

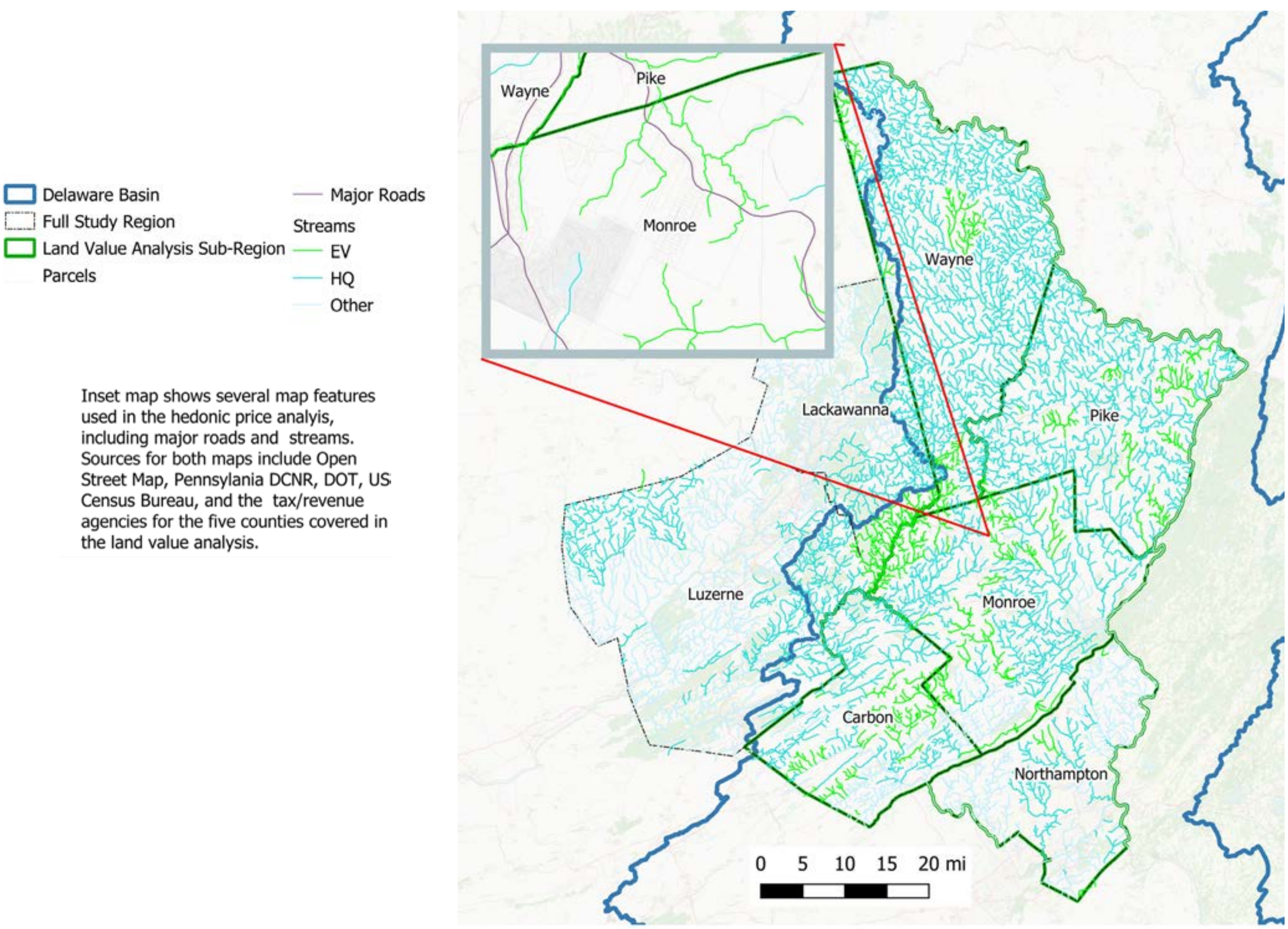
ECONOMIC EFFECTS OF HIGH QUALITY AND EXCEPTIONAL VALUE STREAMS

Effects on Land Prices

As noted, land protection in general, and land protection focused on improved water quality in particular, can affect property values. To determine whether and to what extent stream designations affect land value in the Pocono study region, we have completed a “hedonic price analysis” to analyze more than 240,000 residential properties, and more than 5,000 commercial properties in a five-county region comprising Carbon, Monroe, Northampton, Pike, and Wayne counties. These are the Poconos region counties that contain the vast majority of the region’s Delaware River drainage (see Figure 4, below). The analysis is designed to determine if the presence of an HQ or EV stream affects property value, once other factors are taken into account.

Hedonic price analysis, also known as the hedonic price method, is based on the idea that the price of a “composite good” like a piece of real estate, can be broken down, or decomposed, into the “shadow prices” of the various attributes of the good. In the case of real property, those attributes include the size of the parcel, the type, size, age, and condition of any improvements on the parcel, and, of course “location, location, and location”. The locational attributes include the population density and affluence of the community in which the parcel sits, the local property tax rate, proximity to roads, and whether the parcel is near amenities like protected streams or far from “locally undesirable land uses” like polluting facilities. In this study we have been able to find data on several important attributes (see Tables 2a & 2b, below, and Appendix A) including whether or not a parcel is crossed by a stream with a designated use or existing use of EV or HQ, and the distance to any stream, including such EV and HQ streams.

Figure 4. Sub-region for Land Value Analysis



We analyzed residential and commercial properties listed in the current property tax data of the five counties. Of necessity, we extracted only those parcel attributes that were common to each county's data, namely assessed land value, and certain broad land use categories, including residential, residential with or without a dwelling or other structure(s) for residential properties, and the industry in which commercial properties are used. We only examined commercial properties used in farming, for housing, in tourism (includes resorts, campgrounds, lodging, eating and drinking places, etc.), and which are bare land without a use yet identified. These are the land uses that seem to be most relevant for this examination of the effect of amenities and/or regulatory restrictions associated with stream protection. We included parcels in the analysis if their assessed land value is greater than or equal to $100 per acre and if they are more than 0.1 acre in size.

We obtained additional spatial data from the U.S. Census Bureau, and several Pennsylvania state agencies (roads, stream designations, municipal tax rates). Using geographic information system (GIS) processing, we connected parcels to these additional data sets and assigned such attributes as distance to the nearest EV or HQ (or any) stream, distance to a road, local property tax rate, population density, and median household income. We also used the GIS to generate consistent estimates of the size of each parcel.

Finally, we included binary variables to indicate the county in which each property lies[8]. These variables capture a portion of in-region variation in things like perceptions of educational quality, provision of local government services (parks, policing, road maintenance) and others that homebuyers might consider when deciding where to live and how much to pay for a home.

With these data in hand, we ran several versions of the models whose results we summarize here. Using the first two models, which we'll call the stream *proximity* models, we examine the question of whether being nearer to an EV or HQ stream affects property value. With the third, which we call the stream *presence* model. In this third model, we consider the question of whether having an EV or HQ stream cross a property affects the value of that property.

Our results are consistent with what one would predict from economic theory — namely that **per-acre** property value gets smaller as properties get larger, and that land value is greater for improved properties, for properties on major roads, and of particular interest here, with proximity to a stream designated as EV or HQ. (Note that proximity is measured as "distance from", so the sign on the coefficient estimate for stream distance will be negative: the price per acre goes down as you get farther away from the protected stream.)

By comparing this statistically significant result to the first version of the proximity model, in which we used distance to *any* stream, as opposed to those streams designated as EV or HQ, we may infer that it is stream *protection* (and the improved habitat, aesthetics, recreational opportunities and other benefits that protection affords) that affects land value. This inference is possible because there is no statistically significant relationship between per-acre land value and proximity to an undifferentiated stream.

We also found that property value drops with higher property tax rates. This reflects the likelihood that home buyers account for the property tax rate when they make their home buying decision. But it also reflects the fact that counties, boroughs, and schools balance their budgets by setting tax rates that produce the right amount of revenue from the assessed property value.

Interestingly, but also consistent with the results reported in Bin et al. (2009), we find no statistically significant relationship between per-acre land value and the simple presence of an EV- or HQ-designated stream right on the property itself. They concluded, and we concur, that it is most likely that buyers see pros and cons of owning properties including protected streams. On the one hand, such

Our results are consistent with what one would predict from economic theory — namely that per-acre property value gets smaller as properties get larger, and that land value is greater for improved properties, for properties on major roads, and of particular interest here, with proximity to a stream designated as EV or HQ.

8 For example, the Wayne County variable equals 1 for all observations in Wayne County, and equals 0 for all properties in Northampton, Carbon, Monroe, and Pike counties. We exclude the binary for Northampton County from the statistical model because to include it would be to provide redundant information. Northampton's binary is 1 minus the sum of the other four counties, so the county is still represented, but only once.

streams and the buffer strip that protect them provide the landowner with valuable ecosystem services, like recreational opportunities, aesthetic quality, and soil retention. Landowners would therefore be willing to pay more for such parcels. On the other hand, the stream protection measures mean that the property owner may not be able to use the land near the stream in any way they choose, and the owners might therefore discount that added ecosystem service value. The bottom line, however, is that one cannot say, with any statistical confidence, that the presence of a protected EV or HQ stream on a property either enhances or detracts from the market (or assessed) value of the property.

Table 2a. Relationships Between Streams and Residential Property Value. These equations were estimated using data for 240,155 parcels. Shades of colors indicate the direction of influence of each explanatory value on per-acre land value and the strength of the statistical relationship.

+++	++	+	none	–	– –	– – –

Explanatory (Independent) Variables(a) [with all-parcel average]		Stream Proximity Measure(b,c): Distance to Nearest Stream [472 m]	Distance to Nearest EV or HQ Stream [1,040 m]	Parcel Includes EV or HQ Stream [0.037 or 3.7% of properties]
	Intercept	9.70400	9.76800	9.70600
Parcel Size	Natural Log (ln) of Parcel Acreage (d) [1.86 ac, ln = 0.621]	-0.75520	-0.75510	-0.75460
Stream Proximity Measure (c) [see column headings]		0.00000	-0.000019	-0.01206
Parcel lies in...	Carbon County [0.931]	-0.91770	-0.95060	-0.91800
	Monroe County [0.264]	0.38930	0.35530	0.39020
	Pike County [0.135]	-1.60600	-1.64000	-1.60700
	Wayne County [0.172]	0.24620	0.20280	0.24600
Census Block Group Statistics	Population Density (persons/km^2) [399]	0.00009	0.00009	0.00009
	Median Household Income (block group) [70,616]	0.0000024	0.0000022	0.0000024
Structure(s) present	Dwelling [0.568]	0.06503	0.06593	0.06610

Table 2a. Continued on next page

Table 2a. Continued

+++	++	+	none	–	– –	– – –

Explanatory (Independent) Variables(a) [with all-parcel average]		Stream Proximity Measure(b,c)		
		Distance to Nearest Stream [472 m]	Distance to Nearest EV or HQ Stream [1,040 m]	Parcel Includes EV or HQ Stream [0.037 or 3.7% of properties]
	Apartment [0.005]	0.08144	0.08167	0.08261
	Vacation/Seasonal [0.005]	0.09418	0.09414	0.09595
	Townhome [0.001]	0.12960	0.13230	0.13090
Structure(s) present (continued)	Home and Commercial [0.0004]	0.33660	0.33510	0.33720
	Mobile Home [0.017]	-0.18130	-0.17890	-0.18030
	Multi-Family [0.01]	0.06475	0.06312	0.06559
	None [0.134]	-0.99600	-0.99440	-0.99490
Other Variables	Parcel near road [0.079]	0.03357	0.03203	0.03358
	Municipal Tax Rate (Total, per $1,000) [63.43]	0.00067	0.00062	0.00067
Model Diagnostics	R-Squared (adjusted)	0.7912	0.7915	0.7912
	F-Statistic	0.00055 p-value: < 2.2e-16	0.00051 p-value: < 2.2e-16	0.00055 p-value: < 2.2e-16

Notes:

(a) For MOST of the independent variables, the coefficient estimates in the colored cells can be interpreted as the percentage change in land value per acre for a **UNIT change** in the explanatory variable.

(b) For each model, the dependent variable is the natural log (ln) of assessed land value per acre.

(c) The model summarized in each column utilizes a different measure of proximity to EV/HQ or ANY stream.

(d) For the parcel size, the coefficient estimate can be interpreted as the percentage change in per-acre land value for a **one-percent change** in parcel size.

Table 2b. Relationships Between Streams and Commercial Property Value. These equations were estimated using data for 5,359 parcels. Shades of colors indicate the direction of influence of each explanatory value on per-acre land value and the strength of the statistical relationship.

+++	++	+	none	–	– –	– – –

Explanatory (Independent) Variables(a) [with all-parcel average]		Stream Proximity Measure (b,c)		
		Distance to Nearest Stream [421 m]	Distance to Nearest EV or HQ Stream [1,033 m]	Parcel Includes EV or HQ Stream [0.071 or 7.1% of parcels]
	Intercept	8.89400	9.00200	8.91981
Parcel size	Natural Log (ln) of Parcel Acreage (d) [5.03 ac, ln=1.614]	-0.58890	-0.58810	-0.58476
Stream Proximity Measure (c) [see column headings]		0.00004	-0.000027	-0.07548
Parcel lies in...	Carbon County [0.049]	-0.80020	-0.83890	-0.80810
	Monroe County [0.45]	0.79970	0.74630	0.79752
	Pike County [0.018]	-2.43700	-2.46800	-2.45082
	Wayne County [0.154]	1.14000	1.06700	1.13582
Commercial Land Use	Farm [0.003]	-0.74450	-0.74960	-0.74950
	Housing [0.653]	0.23720	0.23250	0.23531
	Land Only [0.103]	-1.11300	-1.12300	-1.11776
	Recreation/Tourism [0.233]	0.92640	0.91710	0.92559
Other Variables	Parcel near road [0.288]	0.26440	0.25940	0.26410
	Municipal Tax Rate (Total) [50.76]	0.01518	0.01488	0.01524
Model Diagnostics	R-Squared (adjusted)	0.6278	0.6282	0.6278
	F-Statistic	751.5 p-value: < 2.2e-16	753.0 p-value: < 2.2e-16	751.6 p-value: < 2.2e-16

Notes:

(a) For MOST of the independent variables, the coefficient estimates in the colored cells can be interpreted as the percentage change in land value per acre for a **UNIT change** in the explanatory variable.

(b) For each model, the dependent variable is the natural log (ln) of assessed land value per acre.

(c) The model summarized in each column utilizes a different measure of proximity to EV/HQ or ANY stream.

(d) For the parcel size, the coefficient estimate can be interpreted as the percentage change in per-acre land value for a **one-percent change** in parcel size.

Effects on Income and Employment

EV and HQ stream designations may affect development through (1) an antidegradation review for new discharges and (2) individual permit requirements (Royer et al., 2007). Additional regulations may delay, change, or disincentivize certain development processes. Under an HQ stream designation, a reduction in water quality is permitted only if the developer can demonstrate its necessity for significant development to move forward, known as an SEJ exception (Royer et al., 2007). EV stream designation does not allow for such exceptions for new development, but does not require existing parties to stop activity that may be affecting water quality.

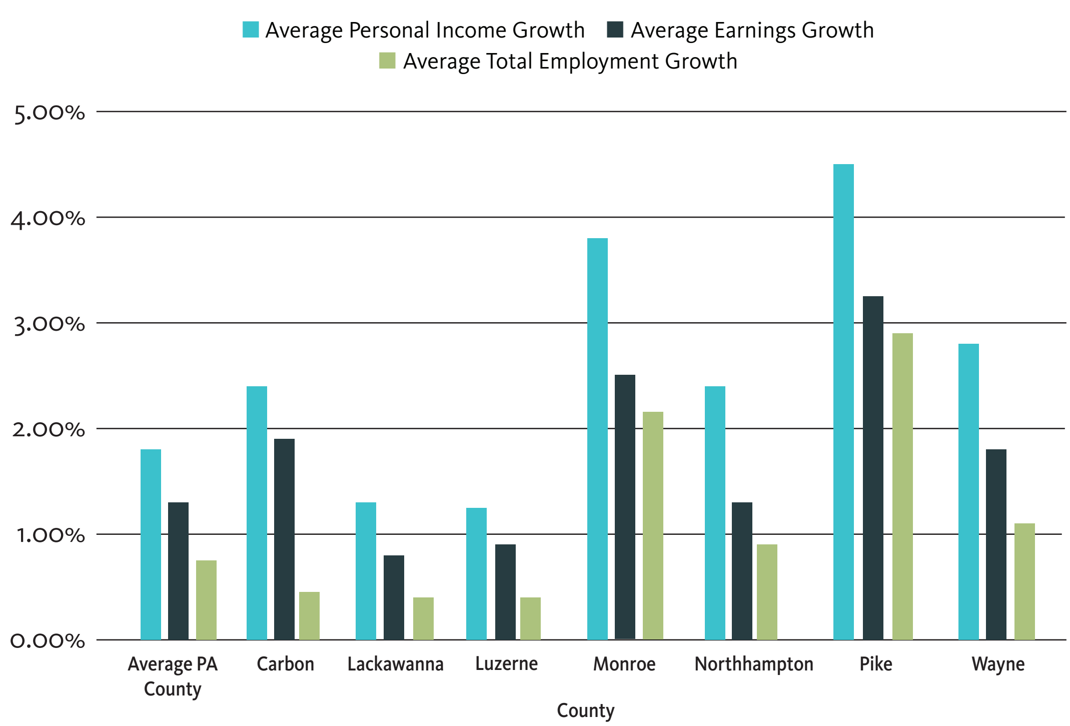
Here, we examine to what extent EV and HQ stream designations may affect typical economic performance indicators – personal and labor income, employment – and hypothesize that the presence of the stream designations (measured in density as meters of stream designation per square kilometer) does not have a meaningful relationship with the average historical county-level growth rates of personal income, wages and earnings, and total employment from 1971 to the present.

Data

Personal income, wages and earnings, and employment are affected by countless factors, including the population and demographic characteristics of a region along with events such as global supply shocks, natural disasters or unexpected policy changes. Industry types and local, regional, or state-level regulations can also drive variation in economic performance across counties.

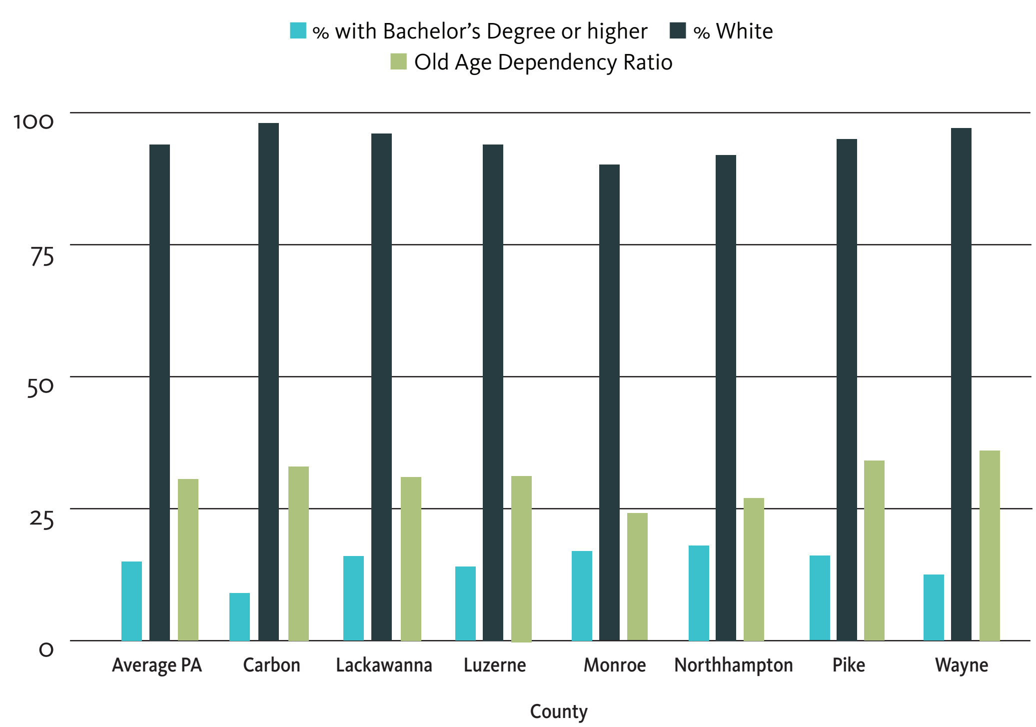
We collected county-level data on the general economic indicators from the U.S. Bureau of Economic Analysis (BEA) for 1971-2020, which represents the time frame between the adoption of Chapter 93 water quality standards and the present (U.S. Bureau of Economic Analysis, 2021). We determine the average annual county-level percent changes over the time period for the three economic performance indicators. To isolate the effect of whether or not HQ and EV streams impact the general economic performance of a county and to control for variations among counties, we include common control variables such as manufacturing employment, educational attainment, race, and age (Yu, 2010).

Figure 5. County-Level Economic Indicators, 1971-2020



We obtained county-level manufacturing employment data from BEA for 1971 to 2020 and characterized the variable as the average annual percent change over the time period (Bureau of Economic Analysis, 2021). Race data is from the U.S. Census Bureau and represents the average proportion of the population that is white between 1971 and 2020 (U.S. Census Bureau, 2020a; U.S. Census Bureau, 2021). Educational attainment is expressed as the average proportion of the population that completed four years of college or more from 1970 to 2019 (U.S. Department of Agriculture, Economic Research Service, 2021). We account for the relative "age" of the county by including average county-level old age dependency ratio data from 2010 to 2020, defined by the number of 65+ year-olds per hundred 18-64 year-olds. This is an estimate for the ratio of retirees to eligible labor force participants (U.S. Census Bureau, 2020b). (See Figures 5, above, and 6, below.)

Figure 6. Persistent County-Level Characteristics



Tables B1 and B2 in Appendix B provide further detail on the descriptive statistics at the state level and study region level for key variables in this analysis.

Results Overview

Based on the collective results analyzing the relationship of stream designation with personal income, earnings, and employment, we emphasize some takeaways:

While statistically significant, the relationship between HQ and EV stream designations and economic vitality is very weak (low magnitude). Thus stream designation alone is not a strategy for fueling economic growth.

That said, the statistically significant relationships between stream designation and the economic indicators are positive, not negative. There is no evidence in the analysis to support the claim that combined HQ and EV stream designations harm counties' economic development prospects.

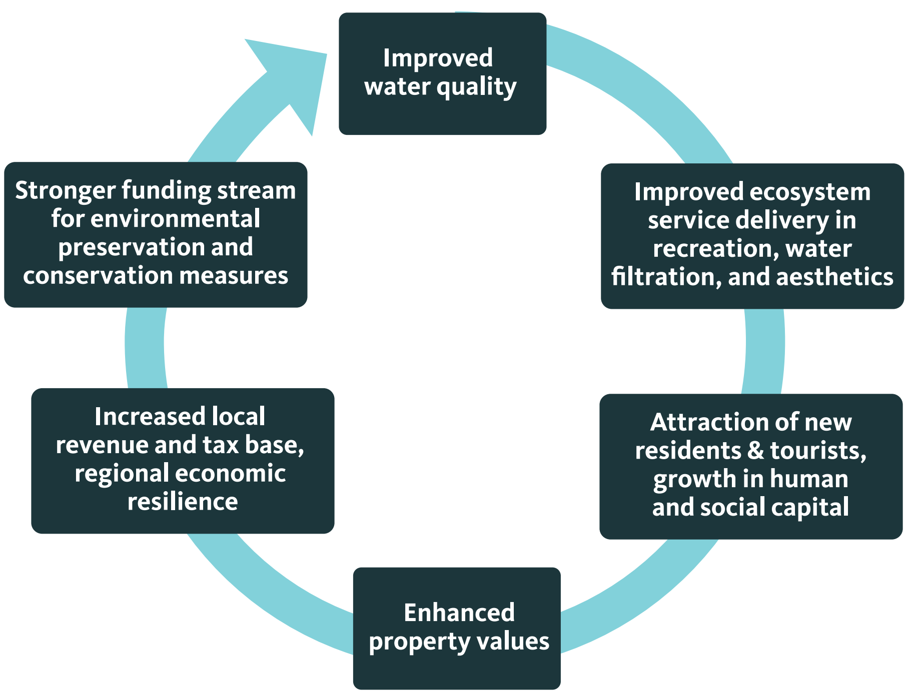
Bear in mind too that this analysis does not establish the direction of causality. For example, it could be the case that stream protection is a "normal good" — that is, demand for stream protection increases with affluence. It could also be the case that stream protection attracts and retains relatively affluent people who can choose where to live and who promote job and income growth among their fellow county residents.

There is a positive relationship between the combined HQ and EV designated stream density in a county and all three measures of economic prosperity.

By the logic of those who argue that stream protection harms economic development, this last point would seem counterintuitive. Such persons would expect that the more restrictive EV designations would be associated with lower economic economic growth while HQ designation would have a neutral, at best, relationship with growth.

By our reading of the literature on this topic, however, such logic is unsupported. Protecting natural amenities like stream quality can easily coexist with strong economic performance. Figure 7 demonstrates how nonmarket benefits from natural capital–such as water quality, recreation, and aesthetic value–can bolster the conventional measures of health in an economy by attracting new human and social capital, leading to a positive, self-supporting feedback loop for regional economic sustainability.

Figure 7. Cycle of Support for Natural, Social, Human, Built, and Financial Capital



By our empirical analysis here, we show that coexistence of stream quality and economic resilience is indeed the norm in Pennsylvania. Table 3 below provides a visual overview of the estimated relationships in the multiple regression analysis. The colors indicate whether the estimated relationship is positive or negative, and darker shades indicate the statistical strength of the estimated relationship.

Table 3. Estimated Economic Indicator and HQ/EV Stream Relationships. Shades of colors indicate the direction of influence of each explanatory value on per-acre land value and the strength of the statistical relationship.

+++	++	+	none	–	– –	– – –

Variables [PA County Averages]	Average Personal Income Growth (%)	Average Earnings Growth (%)	Average Total Employment Growth (%)
EV/HQ Stream Density (# of HQ and EV stream meters per square km) [376.29]	$5.8e^{-06}$	$8.7e^{-06}$	$4.78e^{-06}$
Education Level [0.14 - 14% with college degree]	0.03	0.08	0.05
Race [0.95 - 95% white]	0.01	-0.01	0.04
Old Age Dependency Ratio [30.74- ~31 60 yo+ persons per 100 working age]	$-3.7e^{-04}$	$-3.5e^{-05}$	$-7.3e^{-04}$
Manufacturing Employment Growth [-0.01]	0.20	0.37	

Note: The numbers presented in the table represent the magnitude relationship between the variables and measures of economic prosperity. For example, the 0.07 in the middle column indicates that for the average county, an additional 1% of the population with a Bachelor's degree or higher is associated with a 7% increase in average earnings growth. Pennsylvania county averages are provided in [] for reference of scale.

Personal Income Growth

Average personal income growth is defined by the average percentage change in income that Pennsylvania county residents receive from wages and salaries, government benefits, dividends and interest, and business ownership. Results suggest differences in average personal income growth across Pennsylvania counties is explained most by differences in education levels, manufacturing employment, and the ratio of retirees to workers in a county ("old age dependency ratio"). The racial makeup of the county did not have any significant effect in the model.

Results indicate that a 1% increase in county-level population with a Bachelor's degree or higher relates to a 2.5% increase in personal income growth, and a 1% increase in manufacturing employment growth relates to a 20% increase in personal income growth. The old age dependency – defined by the number of 65+ year-olds in a population relative to every hundred 18-64 year-olds – also meaningfully affects personal income growth among counties: each additional retiree relates to a 0.04% decline in personal income growth.

County-level combined EV and HQ stream designation density has a moderate, positive statistical relationship with personal income growth: each meter of designated stream per square kilometer in a county relates to less than a 0.00058% increase in personal income growth. If we use kilometers instead, this means each designated stream kilometer is associated with a 0.58% higher personal income growth than for otherwise similar Pennsylvania counties. While the relationship is positive and statistically significant, it is a very small effect.

Labor Income Growth

Earnings by place of work is a component of county-level personal income that, as the name implies, is closely tied to employment. For each county, we calculate the average annual percent change in these labor earnings. We find that most of the difference in labor income growth among counties is explained by educational levels and the relative importance of the manufacturing sector. County-level racial composition and the retiree-to-worker ratio do not have a meaningful relationship to labor income growth in Pennsylvania counties over the time frame analyzed.

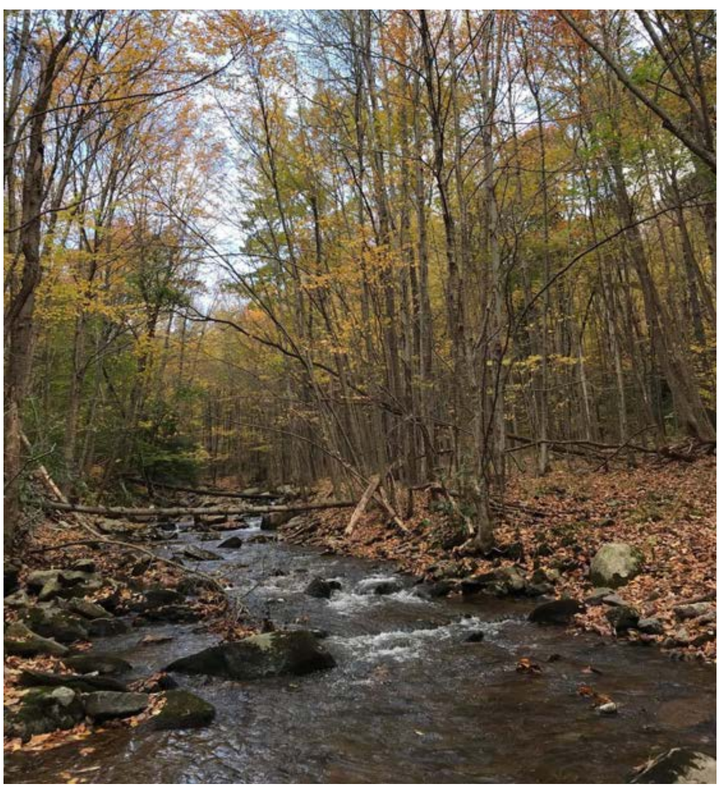
As is the case for personal income growth, the combined density of HQ and EV stream designation has a positive, meaningful but small relationship with labor income: each meter of designated stream per square kilometer in a county relates to a 0.00087% increase in labor income growth. In kilometers, each designated stream kilometer is associated with a 0.87% higher labor income growth.

Total Employment Growth

Average annual percent change in total employment is the third economic indicator we examine, which can help address the question of whether the regulatory measures in stream designations may influence the ability of counties to attract and retain workers and growing businesses. We find that stream designation density, education, race, and retiree to worker levels are all significant predictors of county-to-county differences in average employment growth from 1971 to 2020.

A 1% increase in the percentage of persons with a Bachelor's degree or higher is associated with a 5% higher rate of employment growth. Similarly, a 1% higher share of the county population that is white corresponds to a 4% increase in the rate of employment growth, and each additional retiree per 100 labor force participants relates to a 0.73% slower employment growth.

The relationship between EV and HQ stream designation density and total employment growth is slightly weaker than that of personal income growth; each designated stream kilometer is associated with a 0.48% increase in county-level total employment growth.



Economic Impacts

Economic impact analysis uses input-output multipliers to assess the potential impacts of economic activities on regional economies. These multipliers measure the effect of economic changes on industry output, household earnings, and employment in a region. They represent the total impact of new spending: the "direct effect" of new spending within the regions, and "ripple effects" when money re-circulates through the economy causing "indirect" and "induced" effects. The "indirect effect" is the sum of all impacts associated with inter-industry purchases. The "induced effect" is the sum of all impacts associated with household purchases.

We obtained final-demand[9] multipliers from the Bureau of Economic Analysis' (2022c) Regional Input-Output Modeling System (RIMS II) for two analyses: (1) a comparison of the multipliers for the Poconos study and a second region, and (2) estimation of the economic impact of an increase in visitor spending in the study region (Appendix C).

Comparison of Regional Multipliers

We compare economic impact multipliers for the Poconos study region with those for 6 contiguous counties within the Pennsylvania Wilds region (defined by Pennsylvania Department of Community and Economic Development): Cameron, Clearfield, Elk, Forest, McKean, and Warren counties. The range of EV and HQ stream density (m/km2) and the percentage of all streams that are EV or HQ in the comparison region are similar to those of the Poconos study region.

The two regions are similar in natural amenities, as ranked by the natural amenities scale measuring the physical characteristics that enhance the location as a place to live (U.S. Department of Agriculture, 1999). The scale is used to construct a ranking from 1 to 7 (low to high amenities) for each county in the lower 48 United States. Most of the counties in the Poconos study region have a rank of 4; Northampton County is ranked 3. In the Wilds comparison region, half of the counties rank 4 (Cameron, Clearfield, and Elk Counties) for natural amenities, and half rank 3 (Forest, McKean, and Warren Counties). It should be noted that virtually all Pennsylvania counties rank either 3 or 4; Mercer & Potter Counties rank 2.

In both regions the health care and social assistance, retail trade, accommodation and food services, manufacturing, and transportation and warehousing industries are the top 5 employers, accounting for over half of all full- and part-time jobs (U.S. Bureau of Economic Analysis, 2022a). In the Wilds comparison region, however, the portion of jobs in manufacturing is twice that in the Poconos region (18.5% vs. 9.1% of total employment, respectively). Accommodation and food services employment is slightly less (6.7%) in the comparison region than in the Poconos study region (9.6%).

The size of establishments (in terms of the number of employees) is somewhat similar, with 72% of establishments in both regions having less than 10 employees (U.S. Census Bureau, 2022). However, in the comparison region there are no establishments with 500 or more employees while in the Poconos study region there are 69 businesses with 500 or more employees.

The regions have similar distribution of personal income components (U.S. Bureau of Economic Analysis, 2022b):

- Earnings by place of work as percent of personal income (57% Poconos/58% Wilds comparison)
- Proprietors' income as percent of earnings by place of work (13% in both)
- Dividends, interest and rent as percent of personal income (16% Poconos/15% Wilds)
- Retirement and other transfer payments percent of personal income (21% Poconos/25% Wilds)
- Non-labor (retirement and other transfer payments plus dividends, interest and rent) as percent of personal income (38% Poconos study region/41% Wilds)

[9] Final-demand multipliers are used with purchases or investments by final users to reflect the economic impact of those changes.

There are, however, differences in aggregate socio-economic characteristics between the two regions, with population, total personal income, employment, and tourism spending substantially greater in the Poconos study region than in the Wilds comparison region. And, the geographic area of the comparison region is larger than that of the Poconos study regions.

Poconos study region counties are considered more metropolitan than those in the Wilds region based on the Rural-Urban Continuum Code, a classification scheme that distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area (U.S. Department of Agriculture, 2013). With the exception of Wayne County, all counties in the study region are classified as metropolitan, while all counties in the Wilds comparison region are classified as nonmetropolitan.[10] Pittsburgh is the closest (~130 miles) major city to the Wilds comparison region, with a 2020 population of 302,971 (U.S. Census Bureau, 2020c). In contrast, the Poconos study region is within 100 miles of New York City and Philadelphia, with populations totaling over 10 million.

Multiplier Comparison Results

Poconos study region output, earnings, and employment multipliers (Type II final-demand) were greater than those for the Wilds comparison region for most industries[11] (Table 4) (U.S. Bureau of Economic Analysis, 2022d and 2022e):

- farming
- mining
- construction
- wholesale and retail trade
- information
- finance, insurance, real estate, rental, and leasing
- professional, scientific, and technical services;
- educational services, health care, and social assistance
- arts, entertainment, recreation, accommodation and food services

This suggests that each additional dollar spent in these Poconos businesses would result in the creation of greater output (sales), earnings, and jobs than if spent in the Wilds comparison region.

[10] The 2013 Rural-Urban Continuum Codes are based on 2010 population and an update is planned for 2023 (U.S. Department of Agriculture, 2013).

[11] Only the employment multiplier for the Utilities industry is slightly higher for the Poconos region than the comparison region, and for the recreation sector slightly higher for the comparison region.

Table 4. Economic Impact Multiplier Comparison

INDUSTRY	POCONOS STUDY REGION	COMPARISON REGION
Agriculture, Forestry, and Fishing:		
Farms	•	
Forestry, fishing, and related activities		•
Mining, Quarrying, and Oil and Gas Extraction:		
Oil and gas extraction		•
Mining and support activities	•	
Utilities (a)		•
Construction	•	
Durable Goods Manufacturing		•
Nondurable Goods Manufacturing:		
Textile mills and products, apparel and leather products, paper, printing, plastics and rubber products	•	
Food and beverage and tobacco products, petroleum and coal products, chemical		•
Wholesale Trade	•	
Retail Trade	•	
Transportation and Warehousing:		
Rail, water pipeline transportation; warehousing and storage	•	
Air, truck, and transit and ground passenger transportation; other transportation and support		•
Information	•	
Finance, Insurance, Real Estate, Rental, and Leasing	•	
Professional, Scientific and Technical Services	•	
Educational Services, Health Care, and Social Assistance	•	
Arts, Entertainment, Recreation, Accommodation, and Food Services (b)	•	
Other Services (except government)	•	

(a) The final-demand employment multiplier for the Utilities industry is slightly higher for the Poconos region than the comparison region.
(b) The final-demand employment multiplier for the amusement, gambling, and recreation sector is slightly higher for the Wilds comparison region than the Poconos Region.

For the Wilds comparison region, multipliers were greater for forestry and fishing, oil and gas extraction,[12] utilities, and most durable goods manufacturing sectors. Within the nondurable goods manufacturing and transportation and warehousing industries, in some sectors the Poconos region had higher multipliers and in others the Wilds region multipliers were greater.

Discussion

The size of economic impact multipliers varies by industry and by region. Generally, the larger the area or more self-sufficient, the larger the multiplier (Coppedge, 2011). In addition, regions that serve as central places for the surrounding area will also have higher multipliers than more isolated areas (van Leeuwen et al., 2005). The larger multipliers for the Poconos study region may therefore be, in part, due to the fact that the Poconos is a more metropolitan region and may be more economically diverse than the Wilds comparison region.

Given that both regions have similar EV and HQ stream densities characteristics, results indicate EV/HQ stream density and quality do not limit economic growth (sales, earnings, and jobs), as measured by input-output model the multiplier effects of spending. Further examination of the economic structure and trade patterns of both regions (which is outside of the scope of this report) would be needed to assess additional possible reasons for multiplier differences.

Impact of Increased Visitor Spending

Improvements in water quality have been linked to increases in outdoor recreation expenditures, as noted in the Overview section. In an assessment of the relationship between water quality and water-based recreation in North Carolina, Phaneuf (2002) estimated users' willingness to pay for watershed, river basin, and state-wide improvements in water quality. (Water quality was measured by levels of ammonia, acidity (pH), phosphorus and dissolved oxygen.) He found a significant relationship between watershed-level water quality and recreation trips, with recreationists willing to pay between 2% and 6% more per trip for improved water quality in three river basins.

A study of the potential effects of an increase in water quality in New York's Peconic Estuary System found improvements in total nitrogen, coliform bacteria, brown tide cell counts, and water clarity (measured by Secchi disk depth) could result in an increase in swimming and fishing trips (Opaluch et al., 1999). A 10% improvement in all indicators is estimated to increase the number of swimming trips by 11%; an assumed policy that increases fishing catch rate 10% could result in 2% more fishing trips (Opaluch et al., 1999).

Improved water quality can result in increases in recreation-related spending when participants spend more money per trip and/or take more trips. Based on visitor expenditures in the study region (Tourism Economics, 2019[13]), we estimate the potential increase in spending based on the studies above, using a range of 2% to 8%. The minimum of 2% is based on the lowest estimate of recreationists' increased willingness to pay per trip found by Phaneuf (2002) and the increase in fishing trips by Opaluch (1999). The 8% maximum is based on the increase in swimming trips with a 10% increase in all water quality indicators except brown tide cell counts reported by Opaluch et al. (1999) because brown tides are typically not found in the study region (Maryland Department of Natural Resources, 2022).

The economic impact of a 2% to 8% increase is calculated using the Regional Input-Output Modeling System (RIMS II) (see Appendix D). Multiplying the estimated increase in spending due to improved water quality – represented by EV and HQ streams – by the RIMS II multiplier for each category of visitor spending results in an increase in total output (sales) of $245 million to $982 million ($2021), and 1,845 to 7,380 additional jobs, with wage earnings increasing $61 million to $246 million.

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[12] In 2021 the Delaware River Basin Commission prohibited hydraulic fracturing (or fracking) within the Delaware River Basin, an area which includes the Poconos study region counties, following an unofficial moratorium the previous 10 years (Rubright, 2021a).

[13] 2019 data was used because of the dramatic decline in 2020 visitation (28%) and spending (37%) in the state of Pennsylvania related to COVID-19 (Tourism Economics, 2020). Although Rubright (2021b) reports that the number of visits to the Poconos increased during the pandemic, visitor spending in the region declined between 2019 and of visits to the Poconos increased during the pandemic, visitor spending in the region declined between 2019 and 2020 (Tourism Economics, 2020).

SUMMARY & CONCLUSIONS

Economic and societal benefits of watershed and stream protection include improved water quality and supply, nutrient retention, carbon storage, fish and wildlife habitat, and recreational opportunities. Natural riparian buffers along designated streams in the Poconos are estimated to produce $2.1 billion annually in ecosystem service value from nutrient retention, sediment control, recreation, and carbon sequestration. Our statistical analyses of the relationship between economic indicators and stream quality in the Poconos study region finds that:

Residential and commercial land value increases for properties closer to an EV or HQ stream, when compared to otherwise similar properties farther away. This reflects landowners' willingness to pay for aesthetic quality, recreational opportunity (including for hunting and fishing), and other ecosystem services that are likely to be better or more available due to the stream protection.

Land value does not, however, seem to be affected one way or another by the presence of an EV or HQ stream on the property itself. We interpret this result, as others have, as an indication that such designations are viewed as a "mixed bag" by property purchasers — they convey some benefits, but they do bring more responsibilities.

Our economic impact analysis suggests that a 2% to 8% increase in visitor spending could result in a $245 million to $982 million ($2021) increase in total regional output.

There is no evidence to support the claim that combined HQ and EV stream designation harms counties' economic development prospects.

There is a positive relationship between the combined HQ and EV designated stream density in a county and all three measures of economic prosperity: personal income, earnings, and employment.

In addition, improvements in water quality may lead to increases in outdoor recreation expenditures and/or trips. Our economic impact analysis suggests that a 2% to 8% increase in visitor spending could result in a $245 million to $982 million ($2021) increase in total regional output (sales) and 1,845 to 7,380 additional jobs, with wage earnings increasing $61 million to $246 million.

Finally, results of a comparison of economic impact multipliers for the Poconos study region and a region with similar EV and HQ stream density characteristics indicate that EV/HQ stream density and quality do not limit economic growth (sales, earnings, and jobs), as measured by input-output modeling.

All totaled, there is little cause for concern that enhanced stream protection will harm the Poconos region economy, and there is important evidence that such protection actually improves the region's economy.

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Data

Table A1. Data definition and sources for the land value analysis.

Variable Name	Definition	Source(s)
lnlvac	Natural log (ln) of the per-acre assessed value (lvac) of the LAND associated with the parcel. We included all parcels with a computed per-acre assessed land value of $100 or more.	Counties of Carbon, Monroe, Northampton, Pike, and Wayne (County Parcel Data 2021)
lnac	Natural Log (ln) of the parcel size (ac), in acres. For completeness and consistency, we computed this acreage using the QGIS $area function rather than using the acreage included in the counties parcel GIS layers. We included all parcels greater tha 0.1 acre in area.	Calculated using GIS
DistANY	Distance (m) from the parcel centroid (the geographic center of the parcel) to the nearest stream, regardless of the stream's designation.	Calculated using GIS from county-supplied parcel data and Chapter 93 Existing Use & Designated Use Stream data (County Parcel Data, 2021; Pennsylvania Department of Environmental Protection, 2022)
DistEVorHQ	Distance (m) from the parcel centroid to the nearest stream with a designated or existing use of EV or HQ1.	Calculated using GIS from county-supplied parcel data and Chapter 93 Existing Use & Designated Use Stream data (County Parcel Data, 2021; Pennsylvania Department of Environmental Protection, 2022)
EVorHQ	Binary (0/1): 1 if the parcel intersects any stream with a designated or existing use of EV or HQ1, 0 other-wise.	Calculated using GIS from county-supplied parcel data and Chapter 93 Existing Use & Designated Use Stream data (County Parcel Data, 2021; Pennsylvania Department of Environmental Protection, 2022)
County Binaries (Carbon, Monroe, Northampton, Pike and Wayne)	Binary (0/1): 1 if the parcel lies in the indicated county, 0 otherwise.	Derived from county-supplied parcel data (County Parcel Data, 2021).
PopDens	Persons per square kilometer, in 2019, for the Census Block Group that contains the parcel's centroid (its geographic center)	GIS analysis (spatial join) of parcels (County Parcel Data, 2021) with American Community Survey data (U.S. Census Bureau, 2021)
MedHshldInc	Median Household Income, 2019, for the Census Block Group that contains the parcel's centroid (the geographic center) of the the parcel.	GIS analysis (spatial join) of parcels (County Parcel Data, 2021) with American Community Survey data (U.S. Census Bureau, 2021)
LUC_R_Dwell	Binary (0/1): 1 if the residential includes a dwelling, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_Apt	Binary (0/1): 1 if the residential includes an apartment, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_Vaco	Binary (0/1): 1 if the residential includes a vacation home, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)

Table A1. Continued on next page

Table A1. Data definition and sources for the land value analysis, cont.

Variable Name	Definition	Source(s)
LUC_R_Town	Binary (0/1): 1 if the residential includes a townhome, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_PlusCom	Binary (0/1): 1 if the residential includes a structure used for commercial purposes, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_Mobile	Binary (0/1): 1 if the residential includes a mobile home, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_Multi	Binary (0/1): 1 if the residential includes a multi-family dwelling, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_R_NoBldg	Binary (0/1): 1 if the residential includes no building at all, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_C_Farm	Binary (0/1): 1 if the commercial parcel includes buildings for farm use, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_C_Housing	Binary (0/1): 1 if the commercial parcel includes buildings for housing uses, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_C_Land	Binary (0/1): 1 if the commercial parcel includes no buildings at all, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
LUC_C_Tour	Binary (0/1): 1 if the commercial parcel includes buildings for tourism uses, 0 otherwise.	County-supplied parcel data and land use code lists (County Parcel Data, 2021)
RoadProx	Binary (0/1): 1 if there is a major road within 20m of the parcel's boundary, 0 otherwise. (The 20m threshold was chosen to account for the gap between road centerlines in the GIS and the edges of parcel boundaries.)	County-supplied parcel data (County Parcel Data, 2021)
TaxRate	Property tax rate (millage) for the municipality that contains the parcel's centroid.	County-supplied parcel data (County Parcel Data, 2021), and Municipal Tax Rates (2021)

Notes:

1. All EV streams, whether by virtue of their existing or designated use determination are assigned to the EV stream category. Of the remaining streams, all HQ Streams (whether EU or DU) are assigned to the HQ category. Further, any stream witn EV or an HQ designation were assigned to the "EVorHQ" category.

   We used the combined "EVorHQ" attribute of each stream segment when determining presence of or distance to a protected stream because the distribution of EV and HQ designations is not even throughout the study region (see Figure 4).

Methods

Mathematically and following Rosen (1974), the hedonic price of a parcel of land may be represented by a price function:

$p(z) = p(z1, z2, \ldots zm)$ A.1

where z1 through zm represent the presence or quantity of m attributes of the parcel. The price of each attribute would then be the first derivative of this function with respect to that attribute:

$pi(z) = dp(z)/dzi$ A.2

In words, this means that the price of one unit of the ith attribute of the parcel is equal to the change in total parcel prices as the the amount of that attribute.

To estimate the prices of parcel attributes, and following both theoretical and previous empirical guidance, we assume that the relationship between land prices and parcel attributes in the study region follows the transcendental functional form (Alsonso 1964; Chicoine 1981; and Hushak and Sadr 1979; Turner, Newton and Dennis 1991; and Phillips 2004). With this assumption, the implicit price equation becomes

$$lvac = \beta_0 ac^{\beta_1} exp\left(\sum_{i=2}^{m} \beta_i Z_i\right)$$

A.3

where lvac is the assessed value of the land in the parcel and ac is is the total size (in acres) of the parcel and the Zis are the other parcel and location attributes. The s are the estimated coefficients. The marginal price of an attribute, as in equation A.2, above, is the first derivative of this implicit price equation, or

$$\frac{\partial lvac}{\partial X_i} = \beta_i \beta_0 ac^{\beta_1} exp\left(\sum_{i=2}^{i=n} \beta_i X_i\right)$$

A.4

This form accommodates both the likelihood that per-acre price varies inversely with the size of the parcel (bigger parcels have lower per-acre prices) and that the marginal value of each attribute, expressed as equation A.4, depends on the levels of other attributes.

Converting equation A.3 to logarithmic form allows estimation using ordinary least squares. Thus the estimated model is

$$lnlvac = \alpha + \beta_1 lnac + \left(\sum_{i=2}^{i=n} \beta_i X_i\right) + \mu$$

A.5

where is the unexplained error.

The results of the estimation of the six versions of this model (for residential and commercial properties and for each of the three indicators of proximity to streams (DistANY, DistEVorHQ, and EVorHQ)) are presented in the body of the report.

Limitations

There are two potentially important limitations to these data and methods that are common to many hedonic price studies. The first is that our measure of land value is the assessed value rather than market value of each parcel. As good as the procedures and practices of assessors might be, it is possible, even likey, that the collective decisions of land buyers and land sellers in the marketplace are incorporating information about the value of parcels for sale that are not captured in the assessed value. These can include expectations about future price trends, individual variation in willingness to pay for a parcel, and a host of other information that would not be available to the assessor. Data on actual market prices was available for only one of the five counties, however, so we had to make do with assessed value, which was available for all parcels.

The second limitation is that, like county assessors, we do not know everything we would like to know about each parcel included in the study. For example, while we know broadly whether the parcel has a dwelling, a mobile home, farm buildings, or buildings used for tourism on the property, we do not know the age, condition, style, or other important attributes of the structures. Some of these attributes might have been taken into account by the assessor, others could have been beyond the scope of the assessment.

Despite these limititations, the models explain 79% of the variation in per-acre residential land price and 63% of the variation in per-acre commercial land prices (based on the reported R-squared statistics). In addition the overall “goodness of fit” for these models is strong and significant (based on teh F statistic). This does not mean that versions of our models that accounted for a wider array of parcel attributes could not be better. Rather, it means that our models are already fairly strong and robust for the data we do have available.

Summary Statistics

Table B1 and B2 provide descriptive statistics for the variables used in the multiple linear regression analysis, for the entire dataset of Pennsylvania's 67 counties and for the Poconos study region, respectively. Pike is one of 7 Pennsylvania counties with nonpublic manufacturing employment data, leaving the summary statistics for manufacturing employment growth to n=6.

Table B1. Pennsylvania Counties Summary Statistics

	N	Mean	Std. Dev.	min	max	skewness
Average Personal Income Growth	67	.019	0.007	0.005	0.044	0.873
Average Earnings Growth	67	0.013	0.009	-0.006	0.037	0.435
Average Employment Growth	67	0.008	0.007	-0.009	0.029	0.462
Average Proprietor's Income Growth	67	0.019	0.024	-0.119	0.121	-1.608
EV Stream Density (m/km2)	67	91.72	159.12	0	935.92	3.26
HQ Stream Density (m/km2)	67	312.181	229.46	0	1,053.96	.89
Average % Bachelor's or higher	67	0.145	0.058	0.065	0.347	1.711
Manufacturing employment growth	60	-0.013	0.012	-0.048	0.045	1.338
% White	67	0.945	0.066	0.51	0.99	-4.59
Average Old Age Dependency	67	30.743	4.573	17.8	44.3	0.049

Table B2. Poconos Study Region: Summary Statistics

	N	Mean	Std. Dev.	min	max	skewness
Average Personal Income Growth	7	0.026	0.012	0.013	0.044	0.375
Average Earnings Growth	7	0.018	0.009	0.008	0.033	0.554
Average Employment Growth	7	0.012	0.010	0.004	0.029	0.846
Average Proprietor's Income Growth	7	0.026	0.019	0.001	0.058	0.402
EV Stream Density (m/km2)	7	129.86	92.70	15.73	265.57	.127
HQ Stream Density (m/km2)	7	587.34	301.72	246.07	1,053.96	0.405
Average % Bachelor's or higher	7	0.146	0.029	0.097	0.177	-0.602
Manufacturing employment growth	6	-0.02	0.011	-0.03	0.003	1.523
% White	7	0.95	0.029	0.9	0.99	-0.449
Average Old Age Dependency	7	30.95	3.743	24.2	35.55	-0.682

The Poconos' counties have higher than average HQ and EV stream densities and higher than average growth rates of personal income, earnings, employment and proprietors' income. The other variables described for the Poconos' counties are relatively representative of the average Pennsylvania county.

Methods

We use multiple linear regression analysis to estimate the relationship between EV and HQ stream designation and several key economic measures, including income and employment growth. The variables used in the analysis are either time-constant or averaged over the time frame, reducing the variation to a cross-sectional analysis among Pennsylvania's 67 counties. Based on existing literature, data availability, and established general macroeconomic relationships, the control variables we include in the analysis are education, retirement/labor force ratio, race, and manufacturing employment.

The general framework used in multiple linear regression analysis is as follows:

$$Y_i = f(X_i B) + \varepsilon_i$$

Where i represents an individual county, Y_i represents the outcome variable (personal income growth, earnings growth, and total employment growth), X_i represents the vector of explanatory (predictor) variables used to describe the outcome variable, B represents the vector of true (unobserved) parameters describing relationship between the indicator variables and the outcome variable, and ε_i represents the error term, capturing any unexplained variation between the observed outcome variable Y_i and the predictor variables in the model.

For example, the estimated equation for average personal income growth is

$$\Delta per\widehat{sonalinco}me_i = \hat{\beta}_0 + \hat{\beta}_1 EV streamdensity_i + \hat{\beta}_2 HQstreamdensity_i + \hat{\beta}_3 education_i + \hat{\beta}_4 white_i + \hat{\beta}_5 manufacturing_i + \hat{\beta}_6 agedependency_i + \hat{\beta}_7 outliers_i$$

Where (Δpersonalincome)̂ is the predicted average personal income growth for a Pennsylvania county given the explanatory data at the county-level. The ε̂ parameters are estimated by minimizing the residual error between the predicted average personal income growth and the observed average personal income growth. The εoutliersε_i variable accounts for several counties with average personal income growth rates that deviated extremely (more than three standard deviations away) from the mean Pennsylvania county. We use similar estimated equations for average earnings growth and average employment growth, accounting for any influential outlier counties in the model. Because manufacturing employment is a component of total employment, it is excluded from the model on average total employment growth.

Our hypotheses on the estimated parametrized relationships between the explanatory variables and personal income growth are consistent for earnings and employment growth:

<u>Hypothesis 1:</u> Stream designation densities do not have a significant effect on average personal income growth.

$$H_0 : \hat{\beta}_1, \hat{\beta}_2 = 0; H_a : \hat{\beta}_1, \hat{\beta}_2 \neq 0$$

<u>Hypothesis 2:</u> Education, racial composition, and manufacturing employment have a significant, positive relationship with personal income growth.

$$H_0 : \hat{\beta}_3, \hat{\beta}_4, \hat{\beta}_5 = 0; H_a : \hat{\beta}_3, \hat{\beta}_4, \hat{\beta}_5 > 0$$

<u>Hypothesis 3:</u> Old age dependency ratio has a significant, negative relationship with personal income growth.

$$H_0 : \hat{\beta}_6 = 0; H_a : \hat{\beta}_6 > 0$$

In this analysis, any temporal trends in economic measures are eliminated by averaging data across time, with a focus on comparing persistent characteristics and differences among counties. To ensure the statistical validity of using multiple linear regression analysis with the data on hand, several assumptions must be satisfied:

1. The relationship between the explanatory variables and the outcome variables is linear in nature
2. The error term is independent of (not correlated with) the explanatory variables
3. There is no multicollinearity or perfect collinearity among the explanatory variables
4. The error terms are homoskedastic (the error term variance is constant)
5. The error terms are normally distributed

We test these assumptions for the multiple linear regression analysis and find them to be reasonable. Further details on the assumptions and limitations of the analysis follow.

Regression Diagnostics

We conduct the multiple linear regressions and associated analysis in STATA, performing several regression diagnostic tests to justify the use of multiple linear regression analysis to explain the data and variable relationships. The tests include:

1. Residual plot analysis to identify nonlinear patterns and observation outliers
2. Variation inflation factor tests for multicollinearity
3. STATA's "linktest" to ensure proper model specification
4. Breusch-Pagan test for possible heteroskedasticity in the residual errors
5. Kernel-density plots to verify normality in data distributions

Residual plot analysis revealed several outlier counties that we control for in the regressions to ensure those data points are not overly influential in the analysis. We perform variation inflation factor (VIF) tests in each regression and find no sign of substantial multicollinearity among explanatory variables. The "linktest" for model specification helps to identify whether any irrelevant variables included in the regression may be harming the model, or whether relevant variables may be omitted. Test results indicate that each regression is specified well. Heteroskedasticity is not detected for the Breusch-Pagan tests on patterns in residual error terms, and kernel-density plots reveal the key variables in the analysis follow a relatively normal distribution.

Results

Table B3 provides the multiple regression output for the model described in the body of the report, in which EV and HQ stream designation density is combined into a single variable at the county-level. The three multiple linear regressions have reasonable goodness-of-fit measures for cross-sectional data, with about 50% of the variance in our outcome variables explained by the predictors in the models. We include fixed-effect dummy variables to account for significant outliers (more than three standard deviations away from the mean) in county-level data on personal income growth, earnings growth, and employment growth.

Table B3. Combined HQ + EV Stream Density Multiple Regression Output

	(1) Personal Income Growth	(2) Earnings Growth	(3) Employment Growth
HQ + EV Stream Density	5.8e-06** (2.7e-06)	8.7e-06** (3.4e-06)	4.8e-06* (2.6e-06)
Education	0.03* (0.015)	0.08*** (0.019)	0.05*** (0.016)
White	0.01 (0.013)	-0.01 (0.017)	0.04*** (0.012)
Manufacturing Employment	0.204*** (0.06)	0.369*** (0.08)	
Old Age Dependency Ratio	-3.74e-04 (0.00023)	-3.49e-06 (0.0003)	-7.31e-04*** (0.0002)
PI County Outliers (FE)	0.009** (0.004)		
Employment County Outliers (FE)			0.004 (0.004)
Intercept	0.017 (0.012)	0.014 (0.015)	-0.02* (0.01)
N	60	60	67
R2	0.54	0.52	0.49

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

We also provide the multiple regression output for a model with EV and HQ stream designation density as individual predictor variables, detailed in Table B4. In this model, EV and HQ stream designation density are defined separately as meters of stream designation per square kilometer. Neither EV nor HQ stream density at the county-level have strong, statistically significant relationships with the economic measures. Thus we cannot reject Hypothesis 1, meaning that one cannot conclude that the stream designations affect county-level economic performance in this model.

Detailed further below, the strongest positive predictors across the three main macroeconomic measures include educational attainment levels and manufacturing growth, largely verifying Hypothesis 2. The only significant negative predictor in the analysis is old age dependency ratio ("age" of the county), supporting Hypothesis 3. Table B4 provides the multiple linear regression estimates for average personal income growth, earnings growth, and employment growth at the county level. Table B3 presents the parameter estimates for each explanatory variable, along with the standard error estimates in parentheses.[14] A handful of observations (counties) are dropped in the personal income growth and earnings growth analysis because manufacturing employment data was not reported due to confidentiality (Bureau of Economic Analysis, 2021).

Limitations

As discussed in the Data and Methods sections, the dataset used in the multiple linear regression analysis is cross-sectional: varying at the county-level but time-constant. In order to assess the changes in county-level economic measures due to the designation of streams as EV or HQ, we would need extensive time-series data that can capture general economic temporal trends and before and after and lag effects of stream designations at the county-level. Therefore, this analysis can estimate the relationship between variation in stream designation densities and economic outcomes across the state, but cannot characterize or predict the effect of additional EV and HQ designation on economic outcomes over time.

While the economic variable data at the county-level reflects average annual growth rates from 1971-2020, other variables included in the analysis represent historical averages only from the last one to two decades due to data availability (i.e., racial composition and educational attainment levels). Because the variables with data only from the last twenty years are relatively fixed over time and vary more by county than year, we assume the discrepancy in the time frames for the purpose of the cross-sectional analysis is reasonable.

[14] The standard error (SE) is a measure of how close the coefficient estimated for a given set of data is to the (unknown) true coefficient. Smaller standard errors relative to the coefficient estimate mean we can have more confidence in the coefficient estimate, and coefficients that are about 2 times the size of their SEs are generally said to be "significant" in explaining variation in the dependent variable.

Table B4. EV and HQ Stream Density Multiple Regression Output

	(1) Average Personal Income Growth	(2) Average Earnings Growth	(3) Average Employment Growth
EV Stream Density	2.68e-06 (7.66e-06)	1.33e-05 (1.01e-05)	-2.88e-06 (5.40e-06)
HQ Stream Density	6.12e-06 (3.85e-06)	5.65e-06 (5.04e-06)	6.96e-06* (3.67e-06)
Education	0.027* (0.015)	0.075*** (0.019)	0.054*** (0.016)
White	0.0102 (0.0128)	-0.00916 (0.0170)	0.0407*** (0.0118)
Manufacturing Employment	0.205*** (0.0606)	0.363*** (0.0792)	
Old Age Dependency	-3.72e-04 (2.29e-04)	-2.73e-05 (3.04e-04)	-6.29e-04*** (2.32e-04)
PI County Outliers (FE)	9.60e-03** (4.01e-03)		
Employment County Outliers (FE)			3.61e-03 (3.74e-03)
Intercept	0.016 (0.012)	0.014 (0.015)	-0.021* (0.012)
N	60	60	67
R2	0.54	0.52	0.49

Standard errors in parentheses
* p < .10, ** p < .05, *** p < .01

APPENDIX C: Economic Impacts

Improvements in water quality have been linked to increases in outdoor recreation spending, as noted in the Overview section. In an assessment of the relationship between water quality and water-based recreation in North Carolina, Phaneuf (2002) estimated users' willingness to pay for watershed, river basin, and statewide improvements in water quality. (Water quality was measured by levels of ammonia, acidity (pH), phosphorous and dissolved oxygen.) He found a significant relationship between watershed-level water quality and recreation trips, with recreationists willing to pay between 2% and 6% more per trip for improved water quality in three river basins (Table C1).

Table C1. Increase in Willingness to Pay for Water Quality Improvements in North Carolina

River Basin	Mean Trip Price	Willingness to Pay for Water Quality improvements (per trip)	Increase in Willingness to Pay
Tar-Pamlico	$ 132	$ 2.67	2.0%
Neuse	114	4.03	3.4%
Cape Fear	108	6.29	5.5%

Source: Phaneuf, 2002; assumed 2002 dollars.

A study of the potential effects of an increase in water quality in New York's Peconic Estuary System found improvements in total nitrogen, coliform bacteria, brown tide cell counts, and water clarity (measured by Secchi disk depth) could result in an increase in swimming and fishing trips (Opaluch et al., 1999). A 10% improvement in all indicators increases the number of swimming trips by 11%, with the largest increase in trips (6%) associated with water clarity (Table C2).

Table C2. Swimming Trips with 10% Improvement in Water Quality Indicators

Increased Trips with Improvement in:	Nitrogen	Coliform	Brown Tide Cell Count	Secchi Disk Depth	Total Trips
Number	17,156	9,387	37,175	87,581	151,299
Percent	1.2%	0.67%	2.6%	6.2%	10.7%

Source: Opaluch et al., 1999
Number of trips at baseline (existing) water quality = 1,409,970.

Fishing catch rates have been used as a proxy for water quality conditions, with higher rates assumed to be partly a result of better water quality (Massey, Newbold & Gentner, 2006). Simulating the effects of an assumed policy that increases catch rate 10% results in 2% more fishing trips (Opaluch et al., 1999).

In an estimation of the value of water quality changes for the Atlantic Coast summer flounder fishery, catch rates and harvest levels are predicted to increase by approximately 20% if water quality is improved in all bays and estuaries throughout the range of the species (Massey, Newbold & Gentner, 2006). Simulated water quality improvements in the study area alone (Maryland coastal bays) are predicted to increase catch rates by approximately 2% in the study area.

Data

Improved water quality can result in increases in recreation-related spending when participants spend more money per trip and/or take more trips. Based on visitor expenditures in the study region, we estimate the potential increase in spending based on the study results above, using a range of 2% to 8%. The minimum of 2% is based on the lowest estimate of recreationists' increased willingness to pay per trip found by Phaneuf (2002) and the increase in fishing trips by Opaluch (1999). The 8% maximum is based on the increase in swimming trips with a 10% increase in all water quality indicators except brown tide cell counts reported by Opaluch et al. (1999) because brown tide blooms are restricted to shallow estuaries (Maryland Department of Natural Resources, 2022). The economic impact of this 2% to 8% increase is then calculated using the Regional Input-Output Modeling System (RIMS II).

Visitor Spending

Spending by visitors in the Poconos study region is obtained from Economic Impact of Travel & Tourism in Pennsylvania, 2019 (Tourism Economics) (Table C3). The study region is composed of Carbon, Lackawanna, Luzerne, Monroe, Northampton, Pike, and Wayne counties.

Table C3. Visitor Spending in Poconos Study Region, 2019

	Spending (millions)	Percent of Total
Lodging (a)	$ 996.3	14.2%
Food and beverages	1,501.9	21.4
Retail	1,131.1	16.1
Transportation (b)	1,888.3	27.0
Recreation	1,487.3	21.2
Total	$ 7,004.9	

Source: Tourism Economics, 2019. Carbon, Lackawanna, Luzerne, Monroe, Northampton, Pike, and Wayne counties.

(a) Lodging costs include second home rentals.

(b) Transportation costs within the region include the purchase of gasoline and bus tickets, as well as parking, tolls, and car repairs while traveling.

Methods

The economic impact of increased visitor spending is calculated using the Regional Input-Output Modeling System (RIMS II). RIMS II is a regional economic model used to estimate the potential economic impact of projects. The model provides multipliers estimating the impact of changes in final demand (changes in the purchases of goods or services by final users) on one or more regional industries in terms of output, employment, and labor earnings. That is, the total change that occurs in all industries for each additional dollar delivered to final demand by a specific industry. Multipliers are available for all industries in a region (any state, county, or combination of states or counties defined by the user) and for specific industries.

RIMS was developed and is maintained by the U.S. Bureau of Economic Analysis. The most recent RIMS II multipliers (2019) are based on 2012 national benchmark input-output data and 2017 regional data. RIMS provides both Type I and Type II multipliers: Type I multipliers account for both the direct and indirect (interindustry) impacts of a final-demand change; Type II multipliers also account for induced impacts (household spending). For example, the direct employment impact of an increase in spending on kayak rentals would be more jobs for people in kayak rental establishments. An indirect impact would be more jobs for kayak manufacturers, because the rental establishments would buy additional kayaks from the manufacturers. And an induced impact would be more jobs in the grocery stores where kayak rental and manufacturers buy their food.

The broader Type II employment multipliers represent the total change in the number of jobs that occurs in all industries for each additional $1 million of spending. Note that "jobs" include full-time, part-time, and seasonal jobs, and are not full-time equivalents. There is no explicit time dimension to these jobs: if spending occurs over 5 years, for example, the job estimate would be divided by 5 and the resulting number represents the average number of jobs supported each year. (It would be correct to say that those jobs would be "created" only in the first year.)

Calculations

We first identify the industries in RIMS II that correspond to the visitor spending categories (Table D4). (These industries are based on the North American Industry Classification System[1] (NAICS)). Because there are several industries (and thus multipliers) for all but 1 spending category, we use the lowest industry multiplier in each category in the economic impact calculations as a conservative estimate.

Table C4. Visitor Spending Categories and RIMS II Industries

Spending Category	RIMS II/NAICS Industries
Lodging	Accommodations (hotels, motels, B&B inns, RV parks, campgrounds)
Food and beverages	Full-service restaurants Limited-service restaurants All other food and drinking places (includes bars)
Retail	Food and beverage stores General merchandise stores Health and personal care stores Clothing and clothing accessories stores All other retail (includes sporting goods stores)
Transportation (a)	Gasoline stations
Recreation	Scenic and sightseeing transportation and support activities for transportation Travel arrangement and reservation services General and consumer goods rental (includes recreational goods rental) Other amusement and recreation industries (includes golf courses & country clubs, skiing facilities, marinas, fishing & tourist guide services, outdoor adventure operations (e.g., whitewater rafting))

(a) Transportation expenditures are assumed to be gasoline spending because there are no airports or passenger rail stations in the study region.

Results

Multiplying the estimated increase in spending due to improved water quality by the RIMS II multiplier for each category results in economic impacts shown in Tables C5 and C6: an increase in total output (sales) of $245 million to $982 million ($2021). An additional 1,845 to 7,380 jobs could result, with wage earnings increasing $61 million to $246 million.

Table C5. Economic Impact of 2% Increase in Visitor Spending ($ millions)

	Increased Spending (2%)	Economic Impacts: Output (Sales)	Earnings	Jobs
Lodging	$19.9	$32	$8	246
Food and beverages	30.0	50	11	462
Retail	22.6	36	9	301
Transportation	37.8	65	18	601
Recreation	29.7	48	11	236
Total (2019 $)	$140.1	$232	$58	1,845
Total (2021 $)	$148.5	$245	61	

Source: U.S. Bureau of Economic Analysis, 2022.

Table C6. Economic Impact of 8% Increase in Visitor Spending ($ millions)

	Increased Spending (8%)	Economic Impacts: Output (Sales)	Earnings	Jobs
Lodging	$ 79.7	$ 126	$ 32	982
Food and beverages	120.2	202	44	1,846
Retail	90.5	146	36	1,205
Transportation	151.1	261	74	2 405
Recreation	119.0	192	46	943
Total (2019 $)	$ 560.4	$ 926	$ 232	7,380
Total (2021 $)	$ 594.0	$ 982	$ 246	

Source: U.S. Bureau of Economic Analysis, 2022.

APPENDIX D: Summary of Relevant Ecosystem Service Valuation Studies

Reference	Value Estimate for Riparian Buffers ($2021/acre/year)	Ecosystem Service Benefit	Valuation Method	Primary Site/ Location	Applicability to Poconos Region
Hill et al., 2014	$39,446	Total Bundled Ecosystem Services	Production function approach	North Appalachian headwaters	High, covers Poconos region
	$1,206	Water Supply	Commodity price		
	$738	Climate Regulation	Market value (Social cost)		
	$21,396	N sequestration	Cost avoidance		
	$9,400	P sequestration	Cost avoidance		
	$6,708	Denitrification	Cost avoidance		
Rempel & Buckley, 2018	**$10,800**	**Total Bundled Ecosystem Services**		**Delaware River Basin**	**Medium-high, valuation within region**
	$94- $5,172	Nutrient retention	Cost Avoidance		
	$3- $23	Sediment Control	Cost Avoidance		
	$68	Recreational value	Stated preference survey- benefit transfer	(Northeastern U.S.)	
	$5,286 - $9,409	Carbon storage	Market value		

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