ECONOMIC COSTS OF THE PENNEAST PIPELINE:

EFFECTS ON ECOSYSTEM SERVICES, PROPERTY VALUE, AND THE SOCIAL COST OF CARBON IN PENNSYLVANIA AND NEW JERSEY

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EXECUTIVE SUMMARY

The PennEast Pipeline (PE), a proposed 36-inch diameter high-pressure natural gas pipeline, would transport 1.1 million dekatherms/Mcf, per day of natural gas from the Marcellus Shale region approximately 118 miles through four counties in Pennsylvania and two counties in New Jersey. PennEast Pipeline LLC (PE LLC), a joint venture of AGL Resources, NJR Pipeline Company, PSEG Power, SJI Midstream, Spectra Energy Partners, and UGI Energy Services, would be in charge of constructing and operating the pipeline.

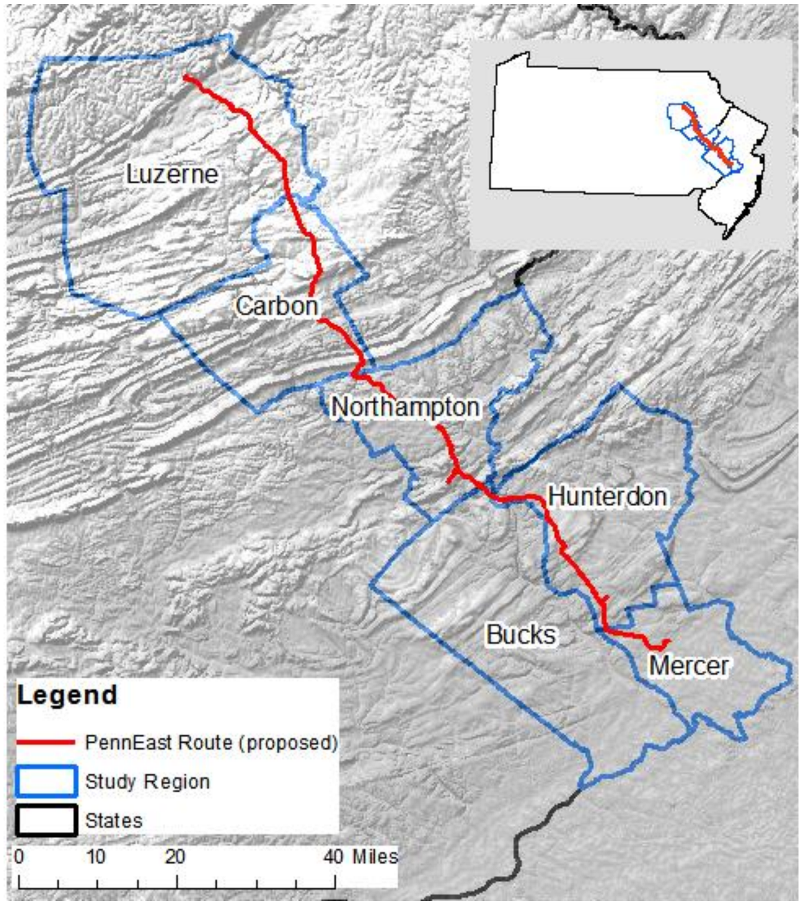

FIGURE 1: PennEast Pipeline (Proposed)

Sources: PennEast route obtained from the Delaware Riverkeeper Network; Study Region (counties), federal lands, and hill shade from USGS (U.S. Department of Interior & U.S. Geological Survey, 2015).

The Federal Energy Regulatory Commission (FERC) is the federal agency responsible for reviewing PE LLC's proposal and either approving or rejecting the project. Under its own policy and the more comprehensive requirements of the National Environmental Policy Act (NEPA), FERC's review must look at the economic benefits, but also consider the full range of environmental effects of the proposed project. These costs include, but are not limited to, the different ways in which the environmental effects from the pipeline would result in changes in human well-being—including economic benefits and costs.

PE LLC promotes the project based on its own estimates of economic benefits, including job creation during the construction period and operation of the pipeline in the long term. FERC, however, concludes that the PennEast pipeline would have "minor" and "minor to moderate" positive effects in the form of jobs, payroll taxes, workers' expenditures, and local governments' tax revenues (Federal Energy Regulatory Commission, 2016b, p. ES-12). While even these minor benefits may be overstated, [1] the major problem over the public consideration of the PennEast Pipeline is that there are also important costs that, to date, PE LLC and FERC have discounted or ignored. The information provided by PE LLC and by FERC in the Draft Environmental Impact Statement falls severely short of systematically considering the potential negative economic effects, or more simply, the economic costs of the PE project.

[1] See Phillips, [Spencer], (2016, September 9), Comment on Draft Environmental Impact Statement, FERC Docket No. CP15-558-000; PennEast Pipeline Company, LLC, FERC/EIS-0271D, for explanation.

Delaware Riverkeeper Network commissioned this report to fill that information gap and provide research into some of the key economic and environmental costs that will certainly occur if the PE pipeline is approved. In this report, we provide quantitative estimates of several types of costs and consider other important costs FERC should evaluate before rendering its decision on the proposed pipeline.

The construction, operation, and presence of the pipeline would 1) Diminish ecosystem service value, 2) Reduce property value along the pipeline, and 3) Create economic damages associated with increases in carbon dioxide emissions (the social cost of carbon) (U.S. EPA, Climate Change Division, 2016). The construction of the pipeline corridor, as well as the establishment of a permanent easement, would alter existing land use/land cover and diminish ecosystem services, causing a loss of between $6.3 and $22.1 million during construction and an annual loss between $2.4 and $9.0 million during operation. Affected properties, those touched by the 50 foot right-of-way (ROW), the 1.2-mile-wide evacuation zone, and within half a mile of the proposed Kidder Compressor Station, could lose between a total of between $159.7 and $177.3 million in property value. The pipeline could also undermine scenic and quality of life amenities contributing to decreases in visitation, in-migration, tourism, and small business development. (See "At a Glance," page iv for details.)

The estimated one-time costs for the study region range from $166.0 to $199.4 million. These one-time costs are comprised of diminished ecosystem services and property value lost during the construction period. Annual costs, costs that would begin following the construction period and recur each year for as long as the PE ROW exists, total between $5.3 and $12.8 million for lower ecosystem service productivity in the pipeline ROW, and lower property tax revenue due to the initial drop in property value. There is also an annual cost associated with the social cost of carbon, varying with the year in which the emissions would occur and the assumed rate at which future costs are discounted. Using a 5% discount rate, the social cost of carbon ranges from $291.9 to $608.1 million per year between 2019 and 2048. With a 2.5% discount rate, the annual social cost of carbon ranges from $1.5 to $2.3 billion.

Putting the streams of annual costs into present value terms[2] and adding the one-time costs, the total estimated economic cost of the PE pipeline in the study region is between $13.3 and $56.6 billion. Contrasting, and as we explain more thoroughly in this report, the costs are several times larger than the proposed benefits.

For reasons explained in the body of this report, these are conservative estimates of the external costs for the proposed PennEast Pipeline. One reason is simply that categories of impacts exist that are beyond the scope of this study. One example includes changes to sites or landscapes that possess historical or cultural significance. Like lost aesthetic quality or a decrease in the capacity of the landscape to retain soil, filter water, or sequester carbon (examples of ecosystem service values that the estimates DO include), historical and cultural impacts matter to humans and, therefore, could be expressed in monetary terms.

Further, and due to data limitations, we did not quantify public health costs to residents that may experience negative health impacts from compressor stations. We also did not estimate increased costs to communities

[2] The present value of a perpetual stream of costs is the one-year cost divided by the real discount rate recommended by the Office of Management and Budget for cost-benefit and cost-effectiveness analysis of public projects and decisions (Office of Management and Budget, 2015). For our analysis, we used the recommended real discount rate for each year the project is expected to be in operation—i.e., for up to 30 years, or until 2048. These discount rates were applied to the estimated annual loss in tax revenue and ecosystem service value in each of those years. The social cost of carbon calculations have discounting built in. The total present discounted value for all costs is then the one-time costs, plus the social cost of carbon for 30 years, plus the separately discounted costs due to lost property taxes and ecosystem services.

from potential increases in demand for emergency services, more road maintenance and repair, and potential impacts on public or private water supplies, or other costs that may accompany construction.

Another important category of cost not counted here is "passive use value." Passive use value includes the value to people of simply knowing an unspoiled natural area exists and the value of keeping those places unspoiled for the sake of some future direct or active use. In light of this, it is important to consider the estimates of economic costs provided here as a fraction of the total economic value put at risk by the proposed PennEast Pipeline.

Finally, while this report covers some of the costs that *will* occur if the PennEast Pipeline is constructed and operating, it does not include an assessment of natural resource damage and other effects that *might* occur during construction and operation. For example, there is a probability that erosion of steep slopes and resulting sedimentation of streams and rivers will occur during construction. There is also the likelihood that a leak or explosion could occur somewhere along the length of the pipeline during its lifetime. If, when, and where these events occur, there will be cleanup and remediation costs, costs of fighting fires and reconstructing homes, businesses, and infrastructure, the cost of lost timber, wildlife habitat, and other ecosystem services, and most tragically, the cost of lost human life and health.[3]

The magnitude of these damages, multiplied by the probability of occurrence, yields additional "expected costs" which add even more to the certain costs estimated in this study. To be clear, the costs estimated here—the effect on ecosystem services from clearing land for the pipeline corridor, the impact on land values resulting from buyers' concerns about the pipeline, and the social cost of carbon—will occur with or without any discreet or extreme events like landslides or explosions ever happening. These impacts and their monetary equivalents are simply part of what will happen in Pennsylvania and New Jersey if the PennEast Pipeline is approved, built, and operates without incident.

[3] While no one was killed in the incident, the recent explosion of Spectra Energy's Texas Eastern gas transmission line in Pennsylvania is an example of these impacts. See, for example, "PA Pipeline Explosion: Evidence of Corrosion Found" (Phillips [Susan], 2016).

At a Glance:

The PennEast Pipeline in Pennsylvania and New Jersey

Bucks, Carbon, Luzerne, and Northampton Counties in PA and Hunterdon and Mercer Counties in NJ

- **Miles of pipeline:** 118
- **Impacted acres (area converted temporarily or permanently from its existing use or cover):**
  - In the permanent right-of-way (ROW): 717.3
  - In the construction zone (the construction corridor, new temporary roads, pipeyards, and temporary aboveground infrastructure): 1,852.7
  - In new permanent access roads and aboveground infrastructure: 55.8
  - The most heavily affected land cover types: forest (386.8 acres) and cropland (147.0 acres) (ROW only)
- **Parcels:**
  - In the ROW: 730
  - In the 1.2-mile-wide evacuation zone: 18,097
  - Within half a mile of the compressor station: 40
- **Residents and housing units in the evacuation zone:** 54,579 people, 23,293 homes
- **Lost ecosystem service value, such as for water and air purification, aesthetics, and recreation:**
  - Over the one-year construction period (a one-time cost): $6.3 to $22.1 million
  - In the ROW and in other permanent infrastructure (annual): $2.6 to $9.8 million
- **Property value:**
  - Baseline—that is, in a "no pipeline" scenario—property value at risk (and the expected one-time cost due to the pipeline in the following parentheses):
    - In the ROW: $200.5 million ($8.4 to $26.1 million)
    - In the 1.2-mile-wide evacuation zone: $3.9 billion ($149.9 million)
    - Within half a mile of the compressor station: $5.6 million ($1.4 million)
  - Total property value lost (a one-time cost): $159.7 to $177.3 million
  - Resulting loss in property tax revenue (annual): $2.7 to $3.0 million
- **The social cost of carbon:**
  - The project would contribute to an equivalent of 21.3 million metric tons of carbon dioxide a year. Using a 5% discount rate, the social cost of carbon ranges from $291.9 to $608.1 million per year between 2019 and 2048. Using a 2.5% discount rate for the same time period, the social cost of carbon ranges between $1.5 and $2.3 billion per year.
- **Other impacts for consideration:**
  - Visual impacts:
    - The ROW for the pipeline and laterals can potentially be seen from approximately 35% of the study region. At least 1 km (0.62 miles) of pipeline ROW is visible from roughly 20% of the study region. (While these visual impacts have financial implications, we do not estimate these strictly in property value terms. Instead, the economic cost of impaired views for homeowners, as well as losses experienced by recreational visitors, and others would be captured as part of the "lost ecosystem service value")
  - Economic activity that depends on the region's scenic, recreational, and quality-of-life: (We consider scenarios in which visitor spending declines by 10% from current levels, and the rate of growth in retirement and proprietor's income slows by 10%)
    - Annual loss of recreation tourism expenditures of $448.0 million that would otherwise support 4,090 jobs and generate $38.8 million in state and local tax receipts
    - Annual loss of personal income of $55.6 million due to slower growth in the number of retirees
    - Annual loss of personal income of $16.3 million due to slower growth in sole proprietorships
- **Total estimated costs:**
  - One-time costs (lost property value plus lost ecosystem service value during construction) would total between $166.0 and $199.4 million
  - Annual costs (costs that recur year after year) would range from $5.3 to $12.8 million PLUS the social cost of carbon, which varies by year, and ranges between $291.9 million and $2.3 billion per year
    - Present discounted value of all future annual costs (including the social cost of carbon): $13.1 to $56.4 billion
  - One-time costs plus the discounted value of all future annual costs: $13.3 to $56.6 billion

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Abbreviations and Terms

BTM: Benefit Transfer Method, a method for estimating the value of ecosystem services in a study region based on values estimated for similar resources in other places

Construction Zone: Refers to the construction corridor, new temporary roads, pipeyards, and temporary aboveground infrastructure

EIS: Environmental Impact Statement, a document prepared under the National Environmental Policy Act analyzing the full range of environmental effects, including on the economy, of proposed federal actions, which in this case would be the approval of the PennEast Pipeline (Related DEIS and FEIS for Draft and Final EIS, respectively)

ESV: Ecosystem Service Value, the effects on human well-being of the flow of benefits from an ecosystem endpoint to a human endpoint at a given extent of space and time, or more briefly, the value of nature's benefits to people

FERC or the Commission: Federal Energy Regulatory Commission, the agency responsible for preparing the EIS and deciding whether to grant a certificate of public convenience and necessity (i.e., whether to permit the pipeline)

HCA: High Consequence Area, the area within which both the extent of property damage and the chance of serious or fatal injury would be expected to be significant in the event of a rupture failure

PE: PennEast Pipeline, which in this report generally refers to the pipeline corridor itself

PE LLC: PennEast Pipeline Company, LLC, a joint venture of AGL Resources, NJR Pipeline Company, PSEG Power, SJI Midstream, Spectra Energy Partners, and UGI Energy Services

NEPA: National Environmental Policy Act of 1970, which requires the environmental review of proposed federal actions, preparation of an EIS, and, for actions taken, appropriate mitigation measures

ROW: Right-of-Way, the permanent easement in which the pipeline is buried

AUTHORS' NOTE

Delaware Riverkeeper Network commissioned this report to help ensure that the likely costs of the PennEast Pipeline project are not left out of the public debate. Delaware Riverkeeper Network has been working throughout the Delaware River Watershed for over 25 years. Using independent advocacy, and backed by accurate facts, science, and law, Delaware Riverkeeper Network champions the rights of communities to a Delaware River and tributary streams that are free flowing, clean, healthy, and abundant with a diversity of life. Please visit www.delawareriverkeeper.org to learn more about their work.

Key-Log Economics is an independent consultancy that brings more than 50 years of combined experience analyzing the economic features of land and resource use and related policy. We are grateful for the assistance of Delaware Riverkeeper Network in identifying local information sources and making contacts in the study region.

Key-Log Economics remains solely responsible for the content of this report, the underlying research methods, and the conclusions drawn. We used the best available data and employed appropriate and feasible estimation methods but nevertheless make no claim regarding the extent to which these estimates will match the actual magnitude of economic effects that will be realized if the PennEast Pipeline is approved.

Cover Photo from Carla Kelly-Mackey, Hunterdon County, New Jersey.

BACKGROUND

According to documents filed by PennEast Pipeline LLC (PE LLC), the proposed PennEast Pipeline (PE) would be 36-inches in diameter over most of its 118-mile length. PE LLC intends on transporting up to 1.1 million dekatherms/Mcf per day of natural gas from the Marcellus Shale region in northern Pennsylvania to New Jersey, eastern and southern Pennsylvania, and via connection to existing pipelines (PennEast Pipeline Company, LLC, 2015a). The project would start in Luzerne County, Pennsylvania and travel through Carbon, Northampton, and Bucks Counties in Pennsylvania, then enter Hunterdon, New Jersey, and end in Mercer County, New Jersey. Proponents of the project tout the project as necessary to meet market demand for natural gas in Pennsylvania and New Jersey (PennEast Pipeline Company, LLC, 2015a), however, reports in response to the Draft Environmental Impact Statement (DEIS) (2016) and to the proposal conclude there is in fact no need for the pipeline (Berman, 2015; New Jersey Division of Rate Counsel, 2016). For example, the New Jersey Division of Rate Counsel (2016) found that “forecasted demands of the LDCs that PennEast is designed to supply are already being met by existing gas supply arrangements and available transportation capacity” (p. 8).

The route would cross important waterways such as the Delaware—the longest undammed river east of the Mississippi—, Lehigh, and Susquehanna rivers, pristine streams, the Appalachian Trail, wetlands, forests, and established public and private conservation lands. The D&R Greenway Land Trust estimates that the proposed route in New Jersey “will touch lands that have been preserved over time with public funding totaling over $37 million” (D&R Greenway Land Trust, 2015). In addition, the project would potentially harm the habitat of several federally listed endangered species (Federal Energy Regulatory Commission, 2016b).

The permanent right-of-way (ROW), the temporary construction corridor of the pipeline—50 and 100 feet wide, respectively—, and the proposed 47,700 horsepower (hp) compressor station in Kidder Township would impose additional external costs on local residents and businesses, including costs that accrue due to safety concerns. Pipeline leaks and explosions are expensive, cause substantial physical damage (Table 1), and occur more frequently than in the past (Pipeline Safety Trust, 2015). According to an analysis conducted by the Pipeline Safety Trust (2015), more incidents associated with gas transmission pipelines occur for pipelines installed after 2010. Larger magnitude incidents require evacuation of wide swaths (up to 1.2 miles across for the PE), disrupting tens of thousands of homes, farms, and businesses. Still wider, but more difficult to gauge and estimate, are the zones within which the construction, operation, and presence of the pipeline would affect human well-being by changing the availability of ecosystem services such as clean air, water supply, and

TABLE 1. Pipeline Incidents, Impacts, and Costs, 1996 to 2015. Includes gas distribution, gas gathering, gas transmission, hazardous liquid, and LNG lines.

Source: Pipeline and Hazardous Materials Safety Administration (2016).

Place	Incidents	Fatalities	Injuries	Total Cost
U.S.	11,198	360	1,377	$6.9 Billion
Pennsylvania	297	20	73	$114.9 Million
New Jersey	177	5	34	$49.7 Million

recreational opportunities. This would occur as the pipeline creates an unnatural linear feature on a landscape that otherwise remains largely natural or pastoral and dampens the attractiveness of the affected region as a place to live, visit, retire, or do business.

To date, these negative effects and estimates of their attendant economic costs have not received much attention in the otherwise vigorous public debate surrounding the proposed PE. This report is both an attempt to understand the nature and potential magnitude of the economic costs of the PE in the six-county region, as well as to provide an example for FERC as it proceeds with its process of analyzing and weighing the full effects of the proposed PE along its entire length.

Policy Context

Before construction can begin, the PE must be approved by the Federal Energy Regulatory Commission (FERC). That approval, while historically granted to pipeline projects, depends on FERC's judgment that the pipeline would meet a public purpose and need. Because the approval would be a federal action, FERC must also comply with the procedural and analytical requirements of the National Environmental Policy Act (NEPA). These include requirements for arranging public participation, conducting environmental impact analysis, and writing an Environmental Impact Statement (EIS) that evaluates all of the relevant effects. Of particular interest here, such relevant effects include direct, indirect, and cumulative effects on or mediated through the economy. As the NEPA regulations state,

> Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), <u>aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative</u>. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial (emphasis added, 36 CFR 1508.b).

It is important to note NEPA does not require that federal actions—which in this case would be the approval or denial of PennEast LLC's application—necessarily balance or even compare benefits and costs. NEPA is not a decision-making law, but rather a law requiring decisions be supported by an as full as possible accounting of the reasonably foreseeable effects of federal actions on the natural and human environment. It also requires that citizens have opportunities to engage in the process of analyzing and weighing those effects. NEPA therefore requires that decision-making agencies (i.e., FERC) develop or obtain and then consider information about the costs associated with the decisions they make.

Moreover, FERC's own policy regarding the certification of new interstate pipeline facilities (88 FERC, para. 61,227) requires adverse effects of new pipelines on "economic interests of landowners and communities affected by the route of the new pipeline" be weighed against "evidence of public benefits to be achieved [by the pipeline]" (88 FERC, para. 61,227; Hoecker, Breathitt, & He'bert Jr., 1999, pp. 18–19). Further, "…construction projects that would have residual adverse effects would be approved only where the public benefits to be achieved from the project can be found to outweigh the adverse effects" (p. 23).

In principle, this policy—what FERC calls an "economic test"—is in line with the argument, on economic efficiency grounds, that the benefits of a project or decision should be at least equal to its cost, including external costs. However, the policy's guidance regarding what adverse effects must be considered and how they are measured is deeply flawed. The policy states, for example, "if project sponsors…are able to acquire all or substantially all, of the necessary right-of-way by negotiation prior to filing the application…it would not adversely affect any of the three interests," which are pipeline customers, competing pipelines, and

"landowners and communities affected by the route of the new pipeline" (Hoecker et al., 1999, pp. 18, 26). FERC's policy contends the only adverse effects that matter are those affecting owners of properties in the right-of-way. Even for a policy adopted in 1999, this contention is completely out of step with long-established understanding that development that alters the natural environment has negative economic effects.

A further weakness of the FERC policy is that it relies on applicants to provide information about benefits and costs. The policy's stated objective "is for the applicant to develop whatever record is necessary, and for the Commission to impose whatever conditions are necessary, for the Commission to be able to find that the benefits to the public from the project outweigh the adverse impact on the relevant interests" (Hoecker et al., 1999, p. 26). The applicant therefore has an incentive to be generous in counting benefits[4] and parsimonious in counting the costs of its proposal. Under these circumstances, it seems unlikely that the Commission's policy will prevent the construction of pipelines for which the full costs are greater than the public benefits they would actually provide. Indeed, until March 2016, FERC had never rejected a pipeline proposal (Woodall, 2016). (For the rejection, the Jordan Cove energy project (Federal Energy Regulatory Commission, 2016a) failed to demonstrate demand for the gas that would have been transported—that is, there would be no public or private benefits.)

Due to these weaknesses and as evidenced by FERC's track record, the "economic test" does not provide a robust evaluation of the public merits of natural gas transmission projects.[5] It is a "test" in which difficult questions (such as ones about external costs involving all stakeholders) are not asked, and where those taking the test (the applicants) provide the answer key. In the case of the PennEast proposal, PE LLC has failed to acquire a sufficient portion of the right-of-way, so by FERC's policy (and due to the interests of other federal agencies in how the PE would affect resources under their stewardship), FERC prepared an EIS (Federal Energy Regulatory Commission, 2016b). The process began with a series of scoping meetings where members of the public could express their general thoughts on the pipeline as well as what effects should fall under the scope of the EIS. Interested parties also had the opportunity to submit comments online and through the mail.

Much of what FERC heard from citizens echoed and expanded upon the list of potential environmental effects listed in its Notice of Intent to prepare an EIS (Federal Energy Regulatory Commission, 2015). In a review of comments collected through the DEIS, 99.4% of people who mentioned recreation and tourism businesses, 100% of commenters mentioning health (either related to the pipeline or the compressor station), and 93.3% of people mentioning the environment believed the PE would have a negative effect. In the DEIS, which came out in July 2016, FERC recognized that common topics mentioned during the scoping period include loss of property value, added responsibility for small emergency response teams, limited evacuation routes for local residents, human health and environmental impacts from compressor stations, and forest fragmentation (Federal Energy Regulatory Commission, 2016b). These effects can take the form of economic costs external to PE LLC that would be borne by individuals, businesses, and communities throughout the landscape the PE would traverse.

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[4] PE LLC has published estimates of economic benefits in the form of employment and income stemming from the construction and operation of the PE (PennEast Pipeline Company, LLC, 2015b). These studies suffer from errors in the choice and application of methods and in assumptions made regarding the long-run economic stimulus represented by the PE. Most significantly, the studies make no mention of likely economic costs, and their projections of long-term benefits extend far beyond the time period (of a year or so) within which economic impact analysis is either useful or appropriate. See Phillips, [Spencer], (2016, September 9), Comment on Draft Environmental Impact Statement, FERC Docket No. CP15-558-000; PennEast Pipeline Company, LLC, FERC/EIS-0271D, for explanation.

[5] See, for example, FERC's Draft and/or Final Environmental Impact Statements the Constitution Pipeline (CP13-499), Mountain Valley Pipeline (CP16-10), Atlantic Coast Pipeline (CP15-554) and PennEast Pipeline (CP-15-558).

Study Objectives

Given the policy setting and what may be profound effects of the proposed PennEast Pipeline on the people and communities of Pennsylvania and New Jersey, we have undertaken this study to provide information of two types:

1. An example of the scope and type of analyses that FERC could, and should, undertake as part of its assessment of the environmental (including economic) effects of the PE.
2. An estimate of the potential magnitude of economic effects in this region where the PE's environmental effects will be felt.

The estimates presented below, however, represent less than the total of all potential costs that would attend the construction, operation, and presence of the pipeline. The reason is that there are several categories of cost for which the scope of the project or the availability of data preclude direct quantification of those costs. These categories are:

- "Passive use value," including the value of preserving the landscape without a pipeline for future direct use.
- Probabilistic damages to natural resources, property, and human health and lives in the event of mishaps during construction and leaks/explosions during operation.
- Increases in the costs of community service like road maintenance and emergency response.[6] We discuss these costs under the heading of "Community Service Costs" (page 36), but we do not have sufficient data on which to base numeric estimates of these costs.

Our overall estimates, therefore, should be understood to be conservative, lower-bound estimates of the true total cost of the PE in the region.

PASSIVE USE VALUE

Passive use values include *option* value, or the value of preserving a resource unimpaired for one's potential future use; *bequest* value, which is the value to oneself of preserving the resource for the use of others, particularly future generations; and *existence* value, which is the value to individuals of simply knowing that the resource exists, absent any expectation of future use by oneself or anyone else. In the case of the PE, people who have not visited the Poconos or otherwise spent vacation time and dollars in the region, are better off knowing that the setting for their planned activities is a beautiful aesthetically pleasing landscape. What future visitors would be willing to pay to maintain that possibility would be part of the "option value" of a PE-free landscape.

Current Economic Conditions in the Study Region

Our geographic focus is the six-county region the PennEast Pipeline is proposed to cross. This study region encompasses Bucks, Carbon, Luzerne, and Northampton counties in Pennsylvania, as well as Hunterdon and Mercer counties in New Jersey. This 2,961-square-mile region supports diverse land uses, including the Delaware, Lehigh, and Susquehanna Rivers, thriving cities and townships, wetlands, and parks. These natural, cultural, and economic assets are among the reasons more than 1.8 million people call this six-county region home and an even larger number visit each year for hiking, fishing, festivals, kayaking, horseback riding, weddings, and other events.

[6] Similar to communities impacted by the shale gas boom, communities along the pipeline can expect spikes in crime as transient workers come and go, more damage to roads under the strain of heavy equipment, increases in physical and mental illnesses including asthma, depression, anxiety, and others triggered by exposure to airborne pollutants, to noise, and to emotional, economic, and other stress. See, for example, Ferrar et al. (2013), Healy (2013), Fuller (2007), Campoy, (2012), and Mufson (2012).

Statistics from the Center for the Study of Rural America, part of the Federal Reserve Bank of Kansas City, highlight the extent to which the region possesses the right conditions for resilience and economic success in the long run (Low, 2004). These data show that the study region has a higher human amenity index (based on scenic amenities, recreational resources, and access to health care), and strong entrepreneurship relative to the average for Pennsylvania and New Jersey counties.[7]

More traditional measures of economic performance suggest the counties are generally strong and resilient, though there are some differences among the Pennsylvania and New Jersey counties.
From 2000 through 2014, for example:[8]

- Population in the study region grew by 5.2%, compared to a 4.9% increase for Pennsylvania and New Jersey overall.
    - Population in the Pennsylvania section of the study region grew by 5.3%, compared to a 4.1% increase for the state of Pennsylvania.
    - Population in the New Jersey section of the study region grew by 5.0%, compared to a 6.0% increase for the state of New Jersey.
- Employment in the study region grew by 12.6%, compared to an 8.0% increase for Pennsylvania and New Jersey overall.
    - Employment in the Pennsylvania section of the study region grew by 12.7%, compared to a 7.3% increase for the state of Pennsylvania.
    - Employment in the New Jersey section of the study region grew by 12.3%, compared to a 9.0% increase for state of New Jersey.
- Personal income in the study region grew by 16.9%, compared to a 16.1% increase in personal income for Pennsylvania and New Jersey overall.
    - Personal income in the Pennsylvania section of the study region grew by 19.7%, compared to an 18.4% increase for the state of Pennsylvania.
    - Personal income in the New Jersey section of the study region grew by 11.5%, compared to a 19.7% increase for the state of New Jersey.
- On average, earnings per job in the study region are lower, by about $3,500/year, than the average for Pennsylvania and New Jersey overall.[9]
    - Earnings per job in the Pennsylvania section of the study region are lower, by about $7,000/year, than the average for the state of Pennsylvania.
    - Earnings per job in the New Jersey section of the study are higher, by about $5,600/year than the average for the state of New Jersey.
- Per capita income, by contrast, is higher in the study region, by $3,600/year, than the average for Pennsylvania and New Jersey overall.[10]
    - Per capita income in the Pennsylvania section of the study region is higher, by about $4,200/year, than the average for the state of Pennsylvania.
    - Per capita income in the New Jersey section of the study region is higher, by about $6,800/year, than the average for the state of New Jersey.

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[7] Note that the Kansas City Fed's statistics have not been updated since 2004-2006, and conditions in and outside the study region have undoubtedly changed. Some of these relative rankings may no longer hold.

[8] These data are from the U.S. Department of Commerce (2015a) as reported in Headwaters Economics' Economic Profile System.

[9] It is not uncommon for wages to be lower in high-amenity areas, as workers can view amenities as a "second paycheck." See, for example, Roback (1988) and Niemi and Whitelaw (1999).

[10] Per capita income reflects non-labor income, such as from investments and social security, in addition to the wages and salaries included in earnings per job.

- The unemployment rate in the study region is 5.8%, compared to 6.2% for Pennsylvania and New Jersey overall.
    - The unemployment rate in the Pennsylvania section of the study region is 5.9%, compared to an unemployment rate of 5.8% for the state of Pennsylvania.
    - The unemployment rate in the New Jersey section of the study region is 5.5%, compared to an unemployment rate of 6.6% for the state of New Jersey.

In addition, several trends suggest entrepreneurs and retirees are moving to (or staying in) this region, bringing their income, expertise, and job-creating energy with them. Namely,

- The region's population growth has been primarily due to in-migration,
- The proportion of the population 65 years and older has increased from 14.3% to 15.8%,
- Proprietors' employment is up by 47.7%, and
- Non-labor income (primarily investment returns and age-related transfer payments like Social Security) is up by 26.7%.

Temporary residents—tourists and recreationists attracted to the natural amenities of the region—and the businesses that serve them are also important parts of the region's economy. Tourists spent about $4.5 billion in the study region in 2015. The companies that directly served those tourists employed 40,896 people, or 5.7% of total private employment in the region (Tourism Economics, 2015 & 2016).

"I wouldn't have the opportunity to have my animal farm for income and it would also devastate the bucolic landscape that has driven the tourism that supports my town, bike riding and fundraisers (5k runs, cycling and others). It would also take away a safe place for my children to play and have a childhood. I would have no other choice than to leave and it would be a life without a home we own, without our farm animals and the money we made from them. Without a studio for me to earn another source of income. How could PennEast possibly mitigate this for me and my community?"

-Jacqueline Evans, Landowner
Hunterdon, NJ

It is in this context the potential economic impacts of the PE must be weighed and the apprehension of the region's residents understood. Many believe the construction and operation of the pipeline will kill, or at least dampen, the productivity of the proverbial goose that lays its golden eggs in the region. This could result in a slower rate of growth in the region and worse economic outcomes. More dire is the prospect that businesses will not be able to maintain their current levels of employment. Just as retirees and many businesses can choose where to locate, visitors and potential visitors have practically unlimited choices for places to spend their vacation time and expendable income. If the study region loses its amenity edge, other things being equal, people will go elsewhere, and this region could contract.

Instead of a "virtuous circle" with amenities and quality of life attracting/retaining residents and visitors, who improve the quality of life, which then attracts more residents and visitors, the PE could tip the region into a downward spiral. In that scenario, loss of amenity and risk to physical safety would translate into a diminution or

outright loss of the use and enjoyment of homes, farms, and recreational and cultural experiences. Some potential in-migrants would choose other locations and some long-time residents would move away, draining the region of some of its most productive citizens. Homeowners would lose equity as housing prices follow a stagnating economy. With fewer people to create economic opportunity, fewer jobs and less income will be generated. Communities could become hollowed out, triggering a second wave of amenity loss, out-migration, and further economic stagnation.

> ***"This pipeline would directly impact our spring fed farm, our physical safety, farming yield, and overall proposes environmental harm to flora, fauna, water, and soil."***
>
> *-Rosemary Litschauer, Landowner*
> *Rieglesville, PA*

Environmental-Economic Effects and Where They Would Occur

In the remainder of this report, we follow this potential cycle and consider four distinct types of economic consequences.

1. **Effects on Ecosystem Service Value:** Corresponding to the direct biophysical impacts of the proposed pipeline are effects on ecosystem services–the benefits nature provides to people for free, like purified water or recreational opportunities, that will become less available and/or less valuable due to the PE's construction and operation.
2. **Effects on Property Value:** Estimating the loss of private property value as owners and would-be owners choose properties farther from the pipeline's right-of-way, evacuation zone, compressor station, and viewshed.
3. **The Social Cost of Carbon:** The economic cost of harm associated with the emission of carbon.
4. **Effects on Economic Development:** More general economic effects caused by a dampening of future growth prospects or even a reversal of fortune for some industries.
5. **Other Impacts Not Quantified:** We examine the impacts to public health due to the operation of the pipeline and compressor station, the potential impact of pipeline construction and operation on municipal and county community services, and provide an overview of how the pipeline's visual impact may decrease property value.

We begin with an exploration of the geographic area over which these various effects will most likely be felt.

Impact Zones within the Study Region

Right-of-Way and Construction Corridor

Construction of the pipeline corridor itself would require clearing an area at least 100 feet (30.5 m) wide. After construction, the permanent right-of-way would be 50 feet (15.2 m) wide along the entire length of the pipeline.

High Consequence Area

Operated at its intended pressure and due to the inherent risk of leaks and explosions, the pipeline would present the possibility of having significant human and ecological consequences within a large High Consequence Area (HCA). A High Consequence Area is "the area within which both the extent of property damage and the chance of serious or fatal injury would be expected to be significant in the event of a rupture failure" (Stephens, 2000, p. 3). Using Stephens' formula, the HCA for this pipeline would have a radius of 949 feet (289.26 m).

Evacuation Zone

The evacuation zone is defined by the distance beyond which an unprotected human could escape burn injury in the event of the ignition or explosion of leaking gas (Pipeline Association for Public Awareness, 2007, p. 29). There would be a potential evacuation zone with a radius of at least 3,157 feet (962.48 m).[11] (See map, Figure 2, for a close-up of these zones in part of the study region.)

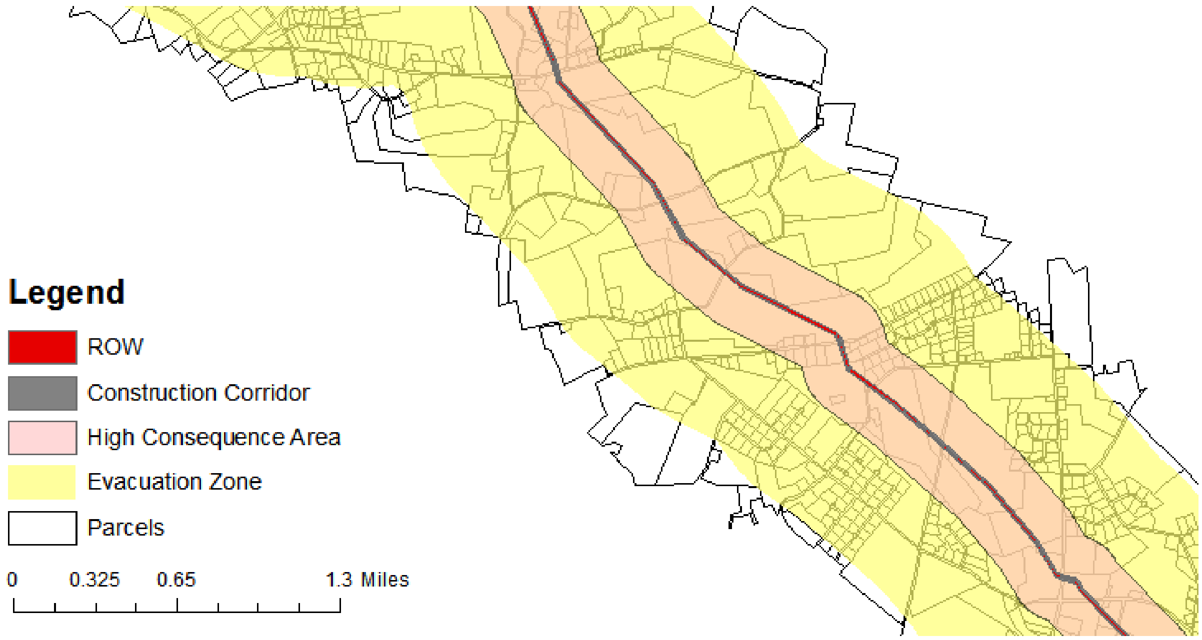

FIGURE 2: Right-of-Way, Construction Corridor, High Consequence, and Evacuation Areas for a Section in Northampton, PA.

Note that the overlay of the HCA (in pink) and the evacuation zone (in yellow) shows up as the salmon band in the map. The ROW covers much of the construction corridor, leaving a thin band of red/grey visible. Also, we only had data for parcels as far out as the edge of the evacuation zone for a few counties.

Sources: PE route obtained from the Delaware Riverkeeper Network; Counties from USGS (U.S. Department of Interior & U.S. Geological Survey, 2015); Parcels from Northampton obtained from the Northampton County GIS Department.

Within the construction corridor and right-of-way is where the greatest disruption of ecosystem processes will occur, so these corridors are where reductions in ecosystem service value (ESV) emanate. Because we estimate ecosystem service values at their point of origin, we focus on the ROW, the construction zone (the construction corridor, new temporary roads,[12] pipeyards, and temporary aboveground infrastructure), new permanent access roads,[12] and permanent aboveground infrastructure. An explosion would undoubtedly affect ecosystem processes within the HCA and possibly the evacuation zone, but given the probability of an explosion at a

[11] The maximum operating pressure proposed for the PE is 1,480 PSIG, but the source data for the evacuation distance is a table with pressure in 100 PSIG increments. The full evacuation distance would be between 3,071 feet and 3,179 feet, the distances recommended for a 36” pipeline operated at 1,400 and 1,500 PSIG. The exact evacuation distance is determined by subtracting the 1500 PSI 36” distance value from the 1400 PSI 36” value, taking 80% of that value, and adding it to the 1400 value to determine the appropriate evacuation distance for a 1480 PSI 36” pipeline. The upshot for this study is a slightly more conservative estimate of the effect of the PE on property value.

[12] We estimate lost ESV only for *new* temporary and permanent access roads because it is for these roads that other land uses (forest, cropland, etc.) will be converted to road surfaces. Where existing roads will be used for access, even if improved by paving, we assume there is no change in their function as sources of ecosystem service value and, therefore, there would be no decrease in that value due to their use related to the PE.

particular point along the pipeline at a given time is small, we do not include the additional effects *on ecosystem service value* due to explosion in the cost estimates.

Effects on land value are another matter, and it is reasonable to consider land value impacts within the evacuation zone. As Kielisch (2015) stresses, the value of land is determined by human perception, and property owners and would-be owners have ample reason to perceive risk to property near high-pressure natural gas transmission pipelines. Traditional and new media reports attest to the occurrence and consequences of pipeline leaks and explosions, which are even more prevalent for newer pipelines than for those installed decades ago (Smith, 2015). Information about pipeline risks translates instantly into buyers' perceptions and their willingness to pay for properties exposed to those risks. For would-be sellers, this dynamic reduces the price they could expect to receive for their homes and makes it harder to find a buyer in the first place. Property owners who do not wish to move would experience a loss of economic value due to diminished enjoyment of their homes (Freybote & Fruits, 2015).

Compressor Station

The proposed compressor station is likely to have separate effects on property value and on human health. Based on the experience of homeowners near a compressor station in Hancock, New York, we consider the possibility of a property value effect within one half mile of the proposed compressor station in Kidder Township, Carbon County (Catskill Citizens for Safe Energy, 2015). This zone overlaps the ROW and the evacuation zone, and because we assume that the more acute and ever present effect of proximity to the compressor station would dominate all other effects, we ignore the ROW and evacuation zone effects for these particular properties.

Compressor stations have also been associated with various human health effects at distances up to two miles away from compressor stations (Subra, 2009, 2015). Further epidemiological research would allow estimation of the costs of those effects for the proposed station in Kidder Township, however, without such research, we do not include the potential public health costs in the present study.

Viewshed

Beyond the areas where the proposed pipeline would alter land use and present the risk of physical danger, the pipeline would change the aesthetic qualities of the region. Residents and visitors will see the pipeline corridor as a break in a once completely forested hillside, and the lower aesthetic quality would translate into further loss of value for properties from which the corridor is visible. In this study, that effect is captured as lost aesthetic value under the heading of ecosystem services. Therefore, while we do map the areas from which the pipeline could be visible, we do not separately estimate impacts on properties at those locations. The cost, in other words, is estimated from the pipeline corridor where the aesthetic quality is impaired, not the points at which the diminished aesthetic quality is experienced.

Boroughs, Townships, Cities, and Counties

If PE is built, there will likely be increases in the costs of community service, such as for traffic control and extra law enforcement capacity needed during construction and for emergency preparedness/emergency services during operation. As borough, township, city, and county governments, as well as volunteer fire companies meet these needs, costs for services would increase. In the DEIS, FERC states that they do not expect a change in the level of services provided by law enforcement and fire protection during pipeline construction and that PennEast will work to coordinate local community service departments in case of an emergency response situation (Federal Energy Regulatory Commission, 2016b). Neither PE LLC nor FERC have confirmed in Resource Reports or the DEIS that they interviewed officials responsible for such services. Based on comment letters

submitted to FERC from local emergency service groups raising questions and concerns over the proposed project, however, it does not seem likely PE LLC reached out. From that assumption, FERC's statement appears to be based entirely on PennEast's assurance and not on any real data, which should be rectified before the final decision regarding the pipeline.

Region-Wide Effects

Beyond the loss of ecosystem services stemming from the conversion of land in the ROW, the loss of property value resulting from the chance of biophysical impacts (leaks and explosions), or the certainty of impacts on aesthetics, the proposed PE would also diminish physical ecosystem services, scenic amenity, and passive use value that are realized or enjoyed beyond the evacuation zone and out of sight of the pipeline corridor. The people affected include residents, businesses, and landowners throughout the study region, as well as past, current, and future visitors to the region. The impacts on human well-being would be reflected in economic decisions such as whether to stay in or migrate to the study region, whether to choose the region as a place to do business, and whether to spend scarce vacation time and dollars near the PE instead of in some other place.

TABLE 2: Geographic Scope of Effects

A check mark indicates the zones/effects for which estimates are included in this study. The "?s" indicate cost categories for future study and for which quantitative estimates are not included in this report.

Values/Effects	ROW & Construction Zone	HCA & Evacuation Zone	Near the Compressor Station	Pipeline Viewshed	Entire Study Region	Beyond the Study Region
Ecosystem Services	✓	a,b	✓	a,b	?[a,b]	?
Human Health and Safety	?	?	✓	?	?	?
Land/Property Value	✓[c]	✓[d]	✓[d]	✓[e]	?	?
Community Services	?	?	?	?	?	?
Economic Development	f	f	f	f	✓	?

Notes:

a. Changes in ecosystem services felt beyond the ROW and construction zone may be key drivers of "Economic Development Effects," but they are not separately estimated to avoid double counting.

b. With the exception of the impact on visual quality, we do not estimate the spillover effects associated with altering the ecosystem within the ROW on the productivity of adjacent areas. The ROW, for example, provides a travel corridor for invasive species that could reduce the integrity and ecosystem productivity of areas that without the PE would remain core ecological areas, interior forest habitat, etc.

c. We estimate land value effects for the ROW but not for the construction zone.

d. Properties in the HCA are treated as though there is no additional impact on property value relative to the impact of being in the evacuation zone. Also, we exclude properties in the compressor station zone from estimates of impacts related to the ROW and the evacuation zone because while the compressor station's effects on land value may be similar (driven by health and safety concerns and possible loss of use), they are both more acute and certain. (Noise and air emissions from the compressor stations will be routine, while the probability of a leak occurring at a given time from the pipeline is rare.) We assume that the ongoing effects of the compressor station on use and enjoyment of properties nearby would overshadow or dominate the possibility of a high-consequence event or the need to evacuate.

e. To avoid double-counting, changes in property value due to an altered view from the property are considered to be part of lost aesthetic value under the "Effects on Ecosystem Service Value" section.

f. Economic development effects related to these subsets of the study region are included in estimates for the study region.

To the extent the PE causes such decisions to favor other areas, less spending and slower economic growth in the study region would be the result. A secondary effect of slower growth would be further reductions in land value, but in this study we consider the primary effects in terms of slower population, employment, and income growth in key sectors. Table 2, above, summarizes the types of economic values considered in this study and the zones in which they are estimated.

EFFECTS ON ECOSYSTEM SERVICE VALUE

The idea that people receive benefits from nature is not at all new, but "ecosystem services" as a term describing the phenomenon is more recent, emerging in the 1960s (Millennium Ecosystem Assessment, 2003). "Benefits people obtain from ecosystems" is perhaps the simplest and most commonly heard definition of ecosystem services (Reid et al., 2005).

"Ecosystem services" is sometimes lengthened to "ecosystem goods and services" to make it explicit that some are tangible, like physical quantities of food, water for drinking, and raw materials, while others are truly services, like cleaning the air and providing a place with a set of attributes that are conducive to recreational experiences or aesthetic enjoyment. We use the simpler "ecosystem services" here. Table 3, lists the provisioning, regulating, and cultural ecosystem services included in this study.

TABLE 3: Ecosystem Services Included in Estimates

Provisioning Services[a]
Food Production: The harvest of agricultural produce, including crops, livestock, and livestock by-products; the food value of hunting, fishing, etc. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Forest
Raw Materials: Fuel, fiber, fertilizer, minerals, and energy. **Associated land uses[b]:** Forest, Wetland
Water Supply: Filtering, retention, storage, and delivery of fresh water—both quality and quantity—for drinking, watering livestock, irrigation, industrial processes, hydroelectric generation, and other uses. **Associated land uses[b]:** Forest, Water, Wetland
Regulating Services[a]
Air Quality: Removing impurities from the air to provide healthy, breathable air for people. **Associated land uses[b]:** Shrub/Scrub, Forest, Wetland, Urban Open Space
Biological Control: Inter- and intra-specific interactions resulting in reduced abundance of species that are pests, vectors of disease, or invasive in a particular ecosystem. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Forest
Climate Regulation: Storing atmospheric carbon in biomass and soil as an aid to the mitigation of climate change, and/or keeping regional/local climate (temperature, humidity, rainfall, etc.) within comfortable ranges. **Associated land uses[b]:** Pasture/Forage, Grassland, Shrub/Scrub, Forest, Wetland, Urban Open Space, Urban Other
Erosion Control: Retaining arable land, stabilizing slopes, shorelines, riverbanks, etc. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Shrub/Scrub, Forest

Regulating Services Continued
Pollination: Contribution of insects, birds, bats, and other organisms to pollen transport resulting in the production of fruit and seeds. May also include seed and fruit dispersal. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Shrub/Scrub, Forest
Protection from Extreme Events: Preventing and mitigating impacts on human life, health, and property by attenuating the force of winds, extreme weather events, floods, etc. **Associated land uses[b]:** Forests, Wetland, Urban Open Space
Soil Fertility: Creation of soil, inducing changes in depth, structure, and fertility, including through nutrient cycling. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Forest
Waste Treatment: Improving soil and water quality through the breakdown and/or immobilization of pollution. **Associated land uses[b]:** Cropland, Pasture/Forage, Grassland, Shrub/Scrub, Forest, Water, Wetland
Water Flows: Regulation by land cover of the timing of runoff and river discharge, resulting in less severe drought, flooding, and other consequences of too much or too little water available at the wrong time or place. **Associated land uses[b]:** Cropland, Pasture/Forage, Forests, Wetland, Urban Open Space, Urban Other
Cultural Services[a]
Aesthetic Value: The role that beautiful, healthy natural areas play in attracting people to live, work, and recreate in a region. **Associated land uses[b]:** Cropland, Pasture/Forage, Forest, Wetland, Urban Open Space
Recreation: The availability of a variety of safe and pleasant landscapes—such as clean water and healthy shorelines—that encourage ecotourism, outdoor sports, fishing, wildlife watching, hunting, etc. **Associated land uses[b]:** Cropland, Shrub/Scrub, Forest, Water, Wetland, Urban Open Space, Urban Other

Notes:

a. Descriptions follow Balmford (2010, 2013), Costanza et al. (1997), Reid et al. (2005), and Van der Ploeg, et al. (2010).

b. “Associated land uses” are limited to those for which per-unit-area values are available in this study.

Different ecosystems (forest, wetland, cropland, urban areas, for example) produce different arrays of ecosystem services, and/or produce similar services to greater or lesser degrees. This is true for the simple reason that some ecosystems or land uses produce a higher flow of benefits than others.

At a conceptual level, we estimate the potential effects of the PE on ecosystem service values by identifying the extent to which the pipeline’s construction would affect, and how its long-term existence would perpetuate, a change in land cover or land use, which in turn results in a change in ecosystem service productivity. Lower productivity, expressed in dollars of value per acre per year, means fewer dollars’ worth of ecosystem service value produced each year.

Permanent easement of Tennessee Gas Pipeline Company’s 300 line in Pike County, Pennsylvania.
(Photo Credit: Wendy Selepouchin)

Construction will strip bear the 100-foot-wide construction corridor and the rest of the construction zone. Once construction is complete and after some period of recovery, much of the 50-foot-wide right-of-way will be occupied by a different set of ecosystems (land cover types) than were present before

construction. By applying per-acre ecosystem service productivity estimates (denominated in dollars) to the various arrays of ecosystem services, we can estimate ecosystem service values produced per year in the periods before, during, and after construction. The difference between annual ecosystem service value *during* construction and the value *before* construction is the annual loss in ecosystem service value *of* construction. The difference between the annual ecosystem service value during ongoing operations (i.e., the value produced in the ROW) and the before-construction baseline (no pipeline) is the annual ecosystem service cost that will be experienced indefinitely.

In addition to the ROW and construction corridor, the PE would require the construction of various temporary and permanent access roads,[13] pipeyards,[14] and aboveground infrastructure.[15] These additional features are treated as though they are part of the construction zone. Permanent roads and permanent aboveground infrastructure are treated separately.[13,16] This overall process is illustrated in Figure 3 and the details of our methods, assumptions, and calculations are described in the following two subsections.

Ecosystem Service Estimation Methods

Economists have developed widely used methods to estimate the monetary value of ecosystem services and/or natural capital. The most commonly known example is a study by Costanza et al. (1997) that valued the natural capital of the entire world. That paper and many others employ the benefit transfer method (BTM) to establish a value for the ecosystem services produced or harbored from a particular place.[17] According to the Organization for Economic Cooperation and Development, BTM is "the bedrock of practical policy analysis," particularly in cases such as this when collecting new primary data is not feasible (OECD, 2006).

BTM takes a rate of ecosystem benefit delivery calculated for one or more "source areas" and applies that rate to conditions in the "study area." As Batker et al. (2010) state, the method is very much like a real estate appraiser using comparable properties to estimate the market value of the subject property. It is also similar to using an existing or established market or regulated price, such as the price of a gallon of water, to estimate the value of some number of gallons of water supplied in some period of time. The key is selecting "comps" (data from source areas) that match the circumstances of the study area as closely as possible.

[13] As noted above, we only consider the ecosystem service conversion of *new* temporary and permanent access roads, not partially existing roads. Resource Report 1 (PennEast Pipeline Company, LLC, 2015a) provides the length and width of each road as well as the existing land condition, such as "grass" or "grass and trees." We used this land condition as a proxy for the baseline land cover. For the "with PE" scenario, all of these areas would, for ecosystem services estimation purposes, be converted to the barren land category.

[14] Resource Report 1 (PennEast Pipeline Company, LLC, 2015a) gives the coordinates and total acreage disturbed by the construction of pipeyards, but it does not report their exact shape. To evaluate the land uses converted to barren land for pipeyards, we centered a circle of the corresponding area at the coordinate for each pipeyard and then estimated the acreage in the various land uses within that circle. To avoid double counting, we excluded any portions of these circles that overlapped with the construction corridor.

[15] As with pipeyards, Resource Report 1 (PennEast Pipeline Company, LLC, 2015a) gives the coordinates and amount of temporary acreage disturbed for aboveground infrastructure facilities, but it does not report their exact shape. For temporary aboveground infrastructure, we assumed a circular footprint for each facility and, after excluding any overlap with the construction corridor, we estimate the acreage in the various pre-construction land uses.

[16] As with pipeyards and temporary infrastructure, Resource Report 1 (PennEast Pipeline Company, LLC, 2015a) gives the coordinates and amount of permanent acreage disturbed on and off the ROW for aboveground infrastructure facilities, but not the exact footprint of the areas. For these facilities, we again assume a circular footprint of a size corresponding to each area and estimate the acreage of each land use disturbed within those circles. This estimation excludes any area of overlap with the ROW.

[17] See also Esposito et al. (2011), Flores et al. (2013), and Phillips and McGee (2014) for more recent examples.

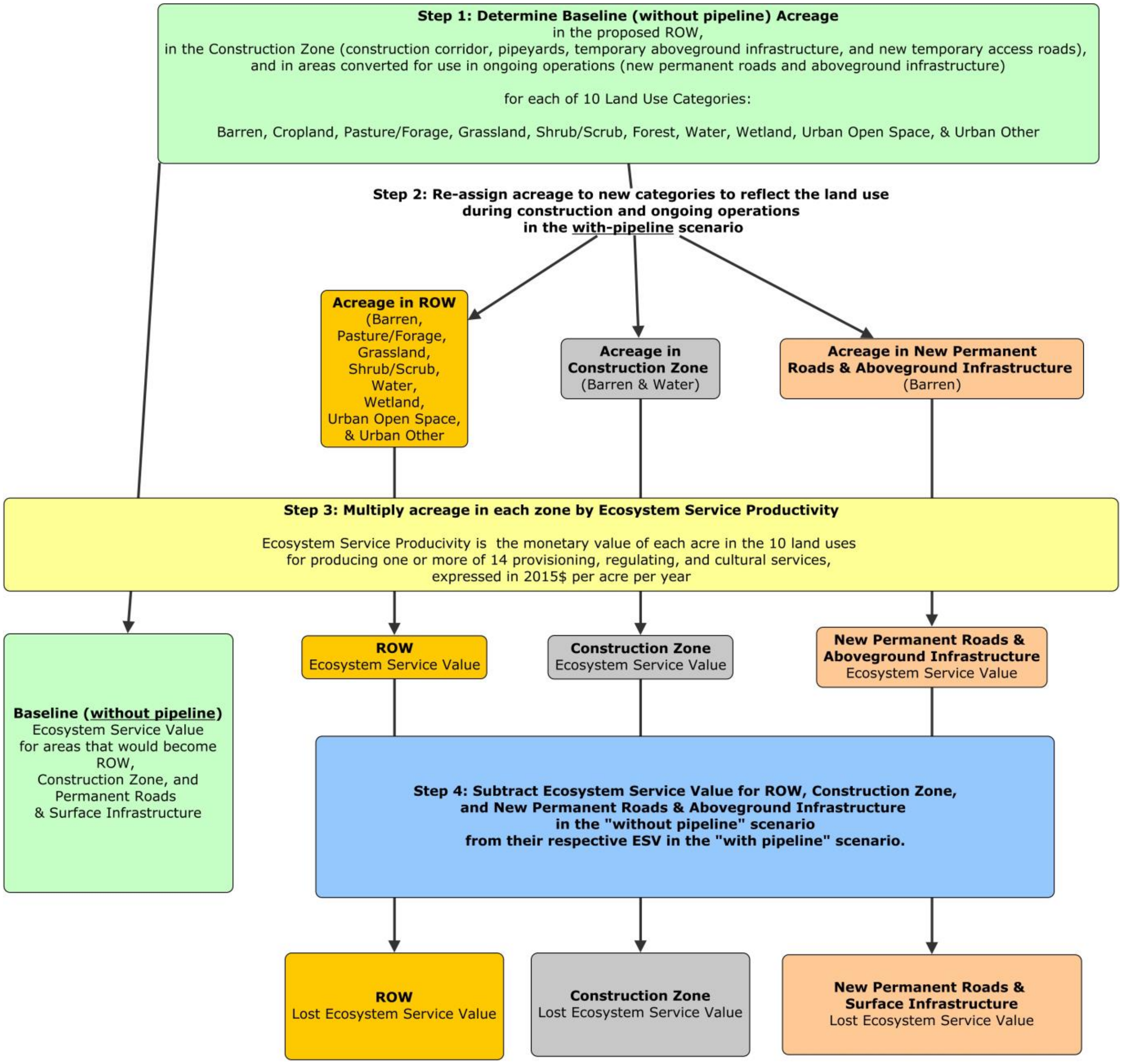

FIGURE 3: Ecosystem Service Valuation Process

Typically, values are drawn from previous studies that estimate the value of various ecosystem services from similar land cover/biome types. Also, it is benefit (in dollars) per-unit-area-per-year in the source area that is transferred and applied to the number of hectares or acres in the same land cover/biome in the study area. For example, data for the source area may include the value of forestland for recreation. In that case, apply the per-acre value of recreation from the source area's forestland to the number of acres of forestland in the study area. Multiply that value by the number of acres of forestland in the study area to produce the estimate of the value of the study area's forests to recreational users. Furthermore, it is important to use source studies that are from regions with similar underlying economic, social, and other conditions to the study area.

Following these principles and techniques developed by Esposito et al. (2011), Esposito (2009), and Phillips and McGee (2014, 2016), and as illustrated in Figure 3, we employ a four-step process to evaluate the short-term and long-term effects of the PE on ecosystem service value in the study region.

The steps in summary:

1. Assign land and water in the study to one of 10 land uses based on remotely sensed (satellite) data in the National Land Cover Dataset (NLCD) (Fry et al., 2011). This provides the array of land uses for estimating baseline or "without PE" ecosystem service value.
2. Re-assign or re-classify land and water to what the land cover would most likely be during construction and during ongoing operation.
3. Multiply acreage by per-acre ecosystem service productivity (the "comps") (in dollars per acre per year) to obtain estimates of annual aggregate ecosystem service value under the baseline/no PE scenario, for the construction zone (and period) and for the ROW during ongoing operation.

   For simplicity and given the 7-month construction period (Kornick, 2016a), we assume the construction zone will remain barren for at least 5 months after construction is completed (a one year construction period). We recognize revegetation will occur soon after the trench is closed and fill and soil are returned, but it will still be some time until something resembling a functioning ecosystem is restored.
4. Subtract baseline (no pipeline) ESV from ESV (with pipeline) for the construction period (in the construction zone) and from ESV during ongoing operations (in the ROW) to obtain estimates of the ecosystem service costs imposed annually during the construction and operations period, respectively.

Step 1: Assign Land to Ecosystem Types or Land Uses

The first step in the process is to determine the area in the 10 land use groups in the study region. This determination is made using remotely sensed data from the National Land Cover Database (NLCD) (Fry et al., 2011). Satellite data provides an image of land in one of up to 21 land cover types at the 30-meter level of resolution;[18] 15 of these land cover types are present in the study region (Figure 4).

Looking forward to the final step, we will use land use categories to match per-acre ecosystem value estimates from source areas to the six-county study region. Unfortunately, value estimates are not available for all of the detailed land use categories present in the region. We therefore simplify the NLCD classification by combining a number of classifications into larger categories for which per-acre values are more available. Specifically, low-, medium-, and high-intensity development are grouped as "urban other," and deciduous, evergreen, and mixed forest are grouped as "forest." In addition, we add land in the NLCD category of "woody wetlands" to the "forest" category for two reasons. First, these wetlands would normally become forest in the study region (Johnston, 2014; Phillips & McGee, 2016). Second, wetlands possess some of the highest per-acre values for several ecosystem services. To avoid overestimating the ecosystem services contribution of "woody wetlands," we count them as "forest" instead of "wetland."

In the end, for baseline (no pipeline) conditions, we have land in 10 land uses (Figure 4 and Table 4). The total area that would be disturbed in the construction corridor, new temporary access roads, pipeyards, and temporary aboveground infrastructure is 1,852.7 acres, of which 715.0 acres would be occupied by the permanent right-of-way. An additional 55.8 acres would be devoted to new permanent access roads and permanent aboveground infrastructure. Figure 5 shows the distribution of acreage in the ROW, construction zone, and in land needed for permanent surface infrastructure pre-PE, or baseline land use.

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[18] Because 30 meters is wider than the right-of-way and not much narrower than the 100-foot construction corridor, we resample the NLCD data to 10m pixels, which breaks each 30m-by-30m pixel into 9 10m-by-10m pixels. This allows for a closer approximation of the type and area of land cover in the proposed ROW and construction corridor.

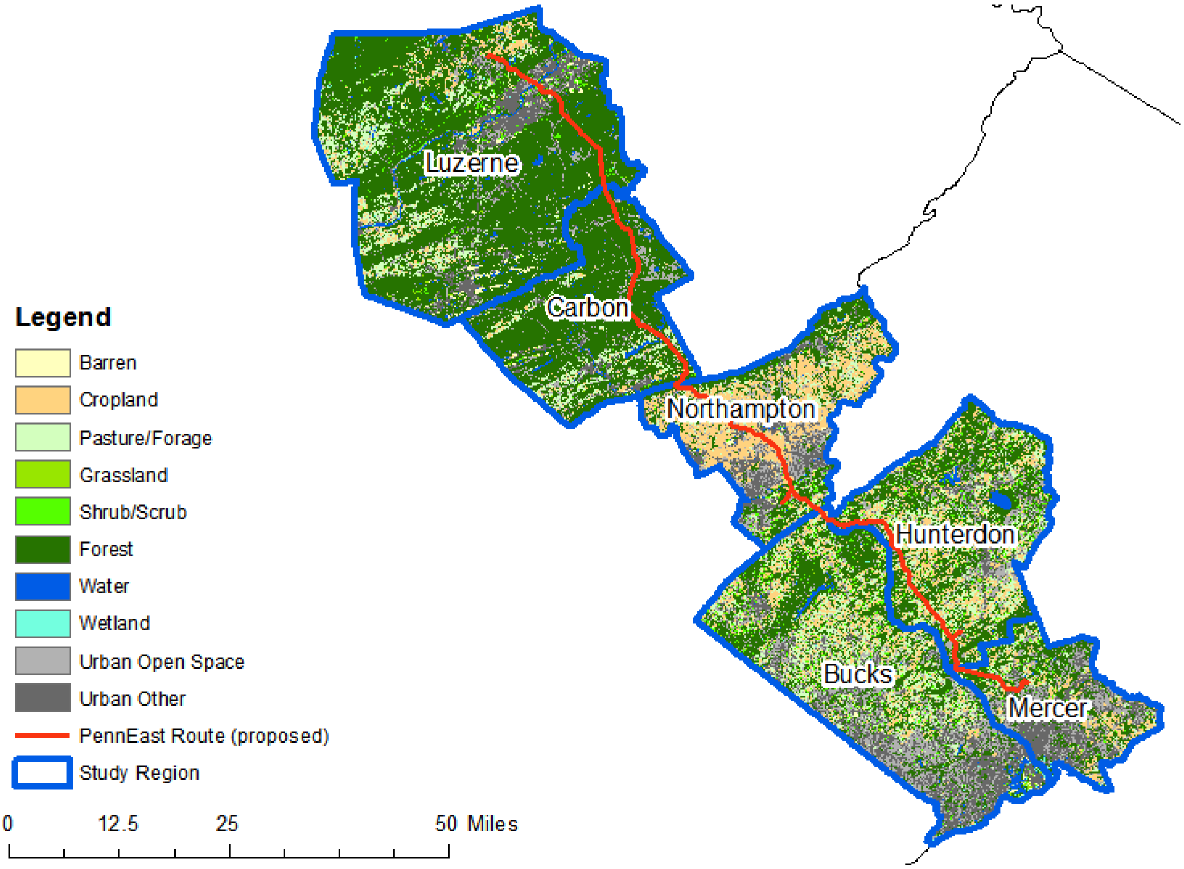


FIGURE 4: Land Use in the Study Region, as Classified for Ecosystem Service Valuation
Land cover for the entire study region is shown to display the overall range and pattern of land use. The ecosystem service valuation only covers portions of the study region occupied by the PE right-of-way and construction zone.
Sources: Land Cover from National Land Cover Database (Fry, et al. 2011); PE route obtained from the Delaware Riverkeeper Network; Counties from USGS (U.S. Department of Interior & U.S. Geological Survey, 2015).

TABLE 4: Land Area Affected By PE, Study Region Total (See Also Figure 5)

Land Use	Baseline acreage in ROW	Baseline acreage in the construction zone	Baseline acreage in permanent surface infrastructure and access roads
Barren	4.4	52.1	0
Cropland	147.0	401.8	9.5
Pasture/Forage	77.6	164.0	4.4
Grassland	7.2	17.1	3.0
Shrub/Scrub	31.8	106.6	2.3
Forest	386.8	887.7	33.0
Water	3.5	6.3	0
Wetland	0.7	1.1	0
Urban Open Space	39.6	99.9	2.4
Urban Other	16.4	116.2	1.1
Total	**715.0**	**1,852.7**	**55.8**

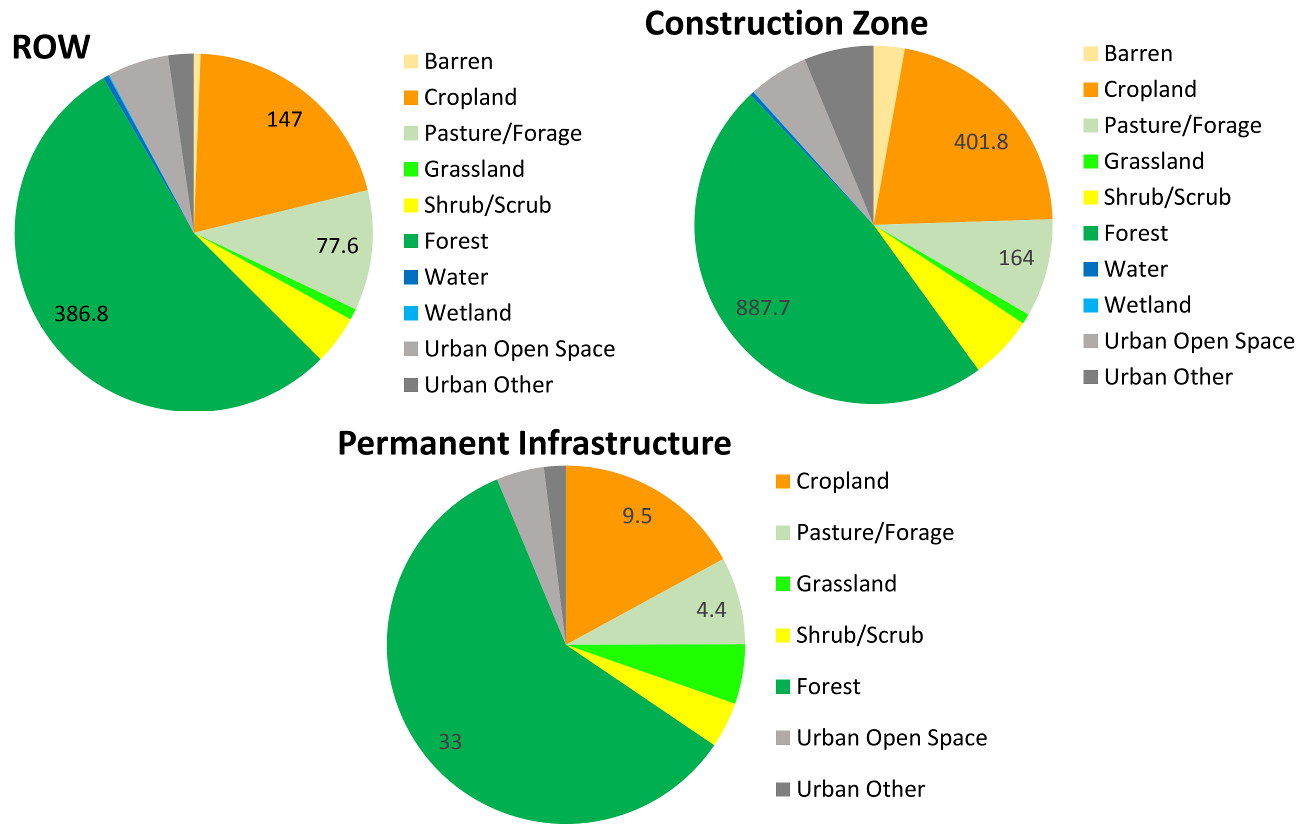


FIGURE 5: Baseline (Pre-PE) Land Use in the ROW, Construction Zone, and Permanent Access Roads and Aboveground Infrastructure (Acres) (See also Table 4)

Step 2: Re-assign Acreage to New Land Cover Types for the Construction and Operation Periods

We assume all land in the construction corridor will be "barren" or at least possess the same ecosystem service productivity profile as naturally-occurring barren land for the duration of the construction period. Water will remain water during construction. Table 5 lists the reassignment assumptions in detail.

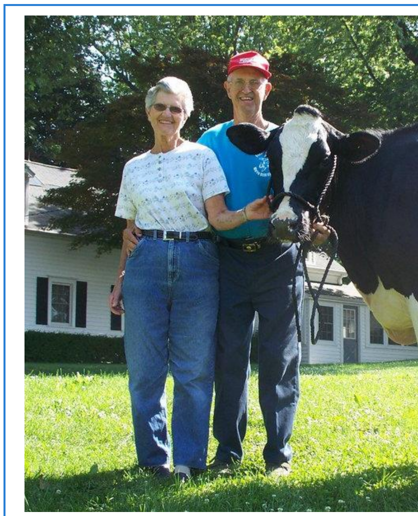
TABLE 5: Land Cover Reclassification

NLCD Category	Reclassification for Baseline	Reclassification for Construction	Reclassification for Ongoing Operation in the ROW	Reclassification for Ongoing Operation Roads and Aboveground Infrastructure
Barren Land	Barren	Barren	Barren	Barren
Cultivated Crops	Cropland	Barren	Pasture/Forage	Barren
Pasture/Hay	Pasture/Forage	Barren	Pasture/Forage	Barren
Grassland/Herbaceous	Grassland	Barren	Grassland	Barren
Shrub/Scrub	Shrub/Scrub	Barren	Shrub/Scrub	Barren
Deciduous Forest	Forest	Barren	Shrub/Scrub	Barren
Evergreen Forest	Forest	Barren	Shrub/Scrub	Barren
Mixed Forest	Forest	Barren	Shrub/Scrub	Barren

Table 5 Continued				
Woody Wetlands	Forest	Barren	Shrub/Scrub	Barren
Open Water	Water	Water	Water	Barren
Emergent Herbaceous Wetlands	Wetland	Barren	Wetland	Barren
Developed, Open Space	Urban Open Space	Barren	Urban Open Space	Barren
Developed, Low Intensity	Urban Other	Barren	Urban Other	Barren
Developed, Medium Intensity	Urban Other	Barren	Urban Other	Barren
Developed, High Intensity	Urban Other	Barren	Urban Other	Barren

Within the ROW, and for the indefinite period following construction—during ongoing operations—we assume pre-PE forestland converts to shrub/scrub, and cropland converts to pasture/forage. We recognize that cropland in the ROW could potentially revert back to cropland, but if there are restrictions on the weight of vehicles that can be operated on top of the buried pipeline easement, it may turn out to be the case that cropland reverts, at best, to pastureland. These include limits on the weight of equipment that could cross the corridor at any given point and difficulty using best soil conservation practices, such as tilling along a contour, which may be perpendicular to the pipeline corridor. (This would require extra time and fuel use that could render some fields too expensive to till, plant, or harvest.) Reclassifying cropland as pasture/forage (which is a generally less productive ecosystem service) recognizes these effects while also recognizing some sort of future agricultural production in the ROW (grazing and possibly haying) could be possible.

An additional effect not captured in our methods is long-standing harm to agricultural productivity due to soil compaction, soil temperature changes, and alteration of drainage patterns due to pipeline construction. Rob Fulper, a farmer in West Amwell, Hunterdon County, New Jersey, noticed that corn planted over two existing pipelines buried on his 100-year-old family farm during World War II that now transport natural gas produce lower yields (Colaneri, 2015). Separately, agronomist Richard Fitzgerald (2015) concludes, “it is my professional opinion that the productivity for row crops and alfalfa will never be regenerated to its existing present ‘healthy’ and productive condition [after installation of a pipeline]." Thus, the true loss in food and other ecosystem service value from pasture/forage acreage would be larger than our estimates reflect.



Bob and Sally Fulper at the Fulper Family Farmstead.
(Photo Credit: Breanna ‘Fulper’ Lundy)

Permanent access roads and sites for mainline valves are assumed, post construction, to remain in the “barren” land use and produce the corresponding level of ecosystem services.

Step 3: Multiply Acreage by Per-Acre Value to Obtain ESV

After obtaining acreage by land use in the construction zone and the ROW, we are ready to multiply those acres times per-acre-per-year ecosystem service productivity (in dollar terms) to obtain total ecosystem service value in each area and for with- and without-pipeline scenarios. Per-acre ecosystem service values are obtained primarily from a database of more than 1,300 estimates compiled as part of a global study known as "The Economics of Ecosystems and Biodiversity" or "the TEEB" (Van der Ploeg et al., 2010).[19] The TEEB database allows the user to select the most relevant per-unit-area values, based on the land use/land cover profile of the study region, comparison of general economic conditions in the source and study areas, and the general "fit" or appropriateness of the source study for use in the study area at hand. After eliminating estimates from lower-income countries and estimates from the U.S. that came from circumstances vastly different from Pennsylvania and New Jersey, we identified 91 per-acre estimates in the TEEB that adequately provide approximations of ecosystem service value in our study region.[20]

After selecting the best candidate studies and estimates in the TEEB database, we still had some key land use/ecosystem services values (such as food from cropland) without value estimates. To fill some of the most critical gaps, we turned to other studies that examined ecosystem service value in this general region (Phillips, 2015; Phillips & McGee, 2016) and to specific data on cropland and pasture/hayland value from the National Agricultural Statistics Service (USDA National Agricultural Statistics Service, 2016).

For several land cover-ecosystem service combinations, either multiple source studies were available or the authors of those studies reported a range of dollar-per-acre ecosystem service values. We are therefore able to report both a low and a high estimate based on the bottom and top end of the range of available estimates.

In the end, we have 165 separate estimates from 61 unique source studies covering 67 combinations of land uses and ecosystem services. (See Appendix A to this report for a full list of the values and sources that yielded these estimates.) This is still a fairly sparse coverage given there are 140 possible combinations of the 10 land uses and 14 services. Therefore, we know our aggregate estimates will be lower than they would be if dollar-per-acre values for all 14 services were available to transfer to each of the 10 land use categories in the study region. It is possible to live with that known underestimation, or it is possible to assign per-acre values from a study of one land-use-and-service combination to other combinations. Doing so would introduce unknown over- or perhaps under-estimation of aggregate values. We prefer to take the first course, knowing our estimates are low/conservative and urge readers to bear this in mind when interpreting this information for use in weighing the costs of the proposed PE.

After calculating acreage and per-acre ecosystem service values, we now calculate ecosystem service value-per-year for each of the four area/scenario combinations. To repeat, these annual values are:

- Baseline (no pipeline) ecosystem service value in the proposed construction zone
- Ecosystem service value in the construction zone during construction

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[19] Led by former Deutsche Bank economist, Pavan Sukhdev, the TEEB is designed to "[make] nature's values visible" in order to "mainstream the values of biodiversity and ecosystem services into decision-making at all levels" ("TEEB - The Initiative," n.d.). It is also an excellent example of the application of the benefit transfer method.

[20] Among those U.S. studies included in the TEEB database that we deemed inappropriate for use here were a study from Cambridge Massachusetts that reported extraordinarily high values for aesthetic and recreational value and the lead author's own research on the Tongass and Chugach National Forests in Alaska. The latter was excluded due to the vast differences in land use, land tenure, climate, and other factors between the source area and the current study region.

- Baseline (no pipeline) ecosystem service value in the proposed right-of-way
- Ecosystem service value in the right-of-way during the (indefinite) period of ongoing operations[21]

Value calculations are accomplished according to the formula:

$$\text{ESV} = \Sigma_{i,}[(Acres_j)\times(\$/acre/year)_{i,j}]$$

Where:

$Acres_j$	is the number of acres in land use (j)
$(\$/acre/year)_{i,j}$	is the dollar value of each ecosystem service (i) provided from each land use (j) each year. These values are drawn from the TEEB database and other sources listed in Appendix A.

Step 4: Subtract Baseline "without PE" ESV from ESV in "with PE" Scenario

With steps 1-3 complete, we now estimate the cost in ecosystem service value of moving from the baseline (no pipeline) or status quo to a scenario in which the PE is built and operating. The cost of construction is the ESV from the construction zone during construction, minus the baseline ESV for the construction zone. PennEast, LLC estimates an approximate 7-month construction period (Kornick, 2016a). Our estimate of a one-year construction period assumes that the land disturbed during construction will remain barren for at least the next 5 months after construction. The ecosystem service cost of ongoing operations is ESV from the ROW in the "with PE" scenario minus the baseline ESV for the ROW. This will be an annual cost borne every year in perpetuity.

Ecosystem Service Value Estimates

Ecosystem service value in the construction zone will be lost for one year and total between $6.3 and $22.1 million. Those one-time losses will be followed by annual losses in the ROW of between $2.4 and $9.0 million and annual losses from other permanent surface infrastructure of between $218,186 and $789,362. Most of this annual loss is due to the long-term conversion of more productive to less productive land uses in the ROW. The remainder is due to the displacement of natural land cover and functioning ecosystems by surface infrastructure and new permanent roads. By discounting the perpetual stream of annual losses we compute the present discounted value of all future losses to be between $72.6 and $272.4 million. Combined with the one-time loss during construction this puts the total loss of ecosystem service value due to the proposed PennEast Pipeline at $78.9 to $294.6 million.

In the baseline or "no pipeline" scenario, the land in the construction zone (including the construction corridor, new temporary roads, pipeyards, and temporary aboveground infrastructure) produces between $6.3 and $22.1 million per year in ecosystem service value. The largest contributors to this total (at the high end) are aesthetics, water, and pollination. Under a "with PE" scenario, and not surprisingly given the temporary conversion to bare/barren land, these figures drop to near zero, or between a total of $640 and $5,044 during the one year long construction period. Taking the difference as described in step 4, estimated per-year ecosystem service cost of the PE's construction would be between $6.3 and $22.1 million (Table 6).

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[21] Note that while the ROW and construction corridors overlap in space, they do not overlap in time, at least not from an ecosystem services production standpoint. During construction, the land cover that would eventually characterize the ROW will not exist in the construction corridor. Thus, there is no double counting of ecosystem service values or of costs from their diminution as a result of either construction or ongoing operations.

TABLE 6: Ecosystem Service Value Lost to the Construction Corridor, New Temporary Roads, Pipeyards, and Temporary Aboveground Infrastructure, Relative to Baseline, by Ecosystem Service

Ecosystem Service	Study Region			
	Baseline (low) (2015$)	*Loss (low) (2015$)*	*Baseline (high) (2015$)*	*Loss (high) (2015$)*
Aesthetic Value	4,074,427	(4,074,427)	16,294,264	(16,294,264)
Air Quality	338,034	(338,034)	354,037	(354,037)
Biological Control	10,782	(10,782)	93,016	(93,016)
Climate Regulation	214,188	(214,188)	223,733	(223,733)
Erosion Control	19,310	(19,310)	98,867	(98,867)
Protection from Extreme Events	739,748	(739,748)	775,744	(775,744)
Food Production	30,692	(30,692)	30,692	(30,692)
Pollination	187,254	(187,254)	982,539	(982,539)
Raw Materials	21,827	(21,827)	148,140	(148,140)
Recreation	313,753	(312,823)	775,837	(770,123)
Soil Formation	8,970	(8,970)	64,670	(64,670)
Waste Treatment	62,009	(61,942)	347,929	(347,862)
Water Supply	42,231	(42,087)	1,152,907	(1,149,702)
Water Flows	210,333	(210,333)	732,789	(732,789)
Total	**$6,273,559**	**($6,272,418)**	**$22,075,164**	**($22,066,177)**

The ecosystem service costs for the ROW are predictably smaller on a per-year basis, but because they will persist indefinitely, the cumulative effect is much higher. In the baseline or "no pipeline" scenario, the land in the ROW produces between $2.6 and $9.4 million per year in ecosystem service value. Under the "with PE" scenario, using minimum values, the annual ecosystem service value from the ROW falls from $2.6 million to about $227,900 for an annual loss of over $2.4 million. At the high end of the range, the ecosystem service value of the ROW falls from $9.4 million to about $454,400 for an annual loss of $9.0 million in the study region (Table 7).

TABLE 7: Ecosystem Service Value Lost Each Year Post Construction in Right-Of-Way, Relative to Baseline, by Ecosystem Service

Ecosystem Service	Study Region			
	Baseline (low) (2015$)	*Loss (low) (2015$)*	*Baseline (high) (2015$)*	*Loss (high) (2015$)*
Aesthetic Value	1,770,919	(1,707,351)	7,092,570	(7,013,190)
Air Quality	146,631	(129,697)	152,973	(129,697)
Biological Control	4,386	(858)	34,868	(31,340)
Climate Regulation	74,333	(18,670)	78,531	(22,756)
Erosion Control	7,419	6,159	41,118	(15,759)

Table 7 Continued				
Protection from Extreme Events	321,090	(308,529)	337,532	(308,529)
Food Production	11,780	(6,330)	11,780	(6,330)
Pollination	81,381	(77,026)	372,309	(365,572)
Raw Materials	9,523	(9,487)	64,559	(64,523)
Recreation	45,399	709	247,900	(196,163)
Soil Formation	3,725	(2,902)	24,965	(24,142)
Waste Treatment	23,357	(21,891)	146,293	12,247
Water Supply	18,423	(18,329)	503,337	(499,826)
Water Flows	92,316	(88,592)	319,393	(308,156)
Total	**$2,610,683**	**($2,382,794)**	**$9,428,127**	**($8,973,736)**

Most of this loss is due to the conversion of forestland to shrub/scrub. Shrub/scrub naturally increases its share of overall ecosystem service value in the "with pipeline" scenario. Those ecosystem service value gains are dwarfed, however, by the loss of much more productive forests. Similarly, the ecosystem service value of cropland falls due to its assumed transition to pasture/forage. While there is some gain in the pasture/forage category, there is a net loss of ecosystem service value from the two agricultural land uses of between $15,300 and $348,900 per year.[22]

"With this pipeline construction through my property, the disruption of my spring is only one of my concerns. We do not have air conditioning and rely on the mature trees to provide shade to keep the house cool in the summer months. Many of these trees will be taken down if this project is approved."

-Jeremy Hayes, Landowner
Bath, PA

Finally, the establishment of new permanent access roads and other aboveground infrastructure will entail the conversion of land from various uses to what, from an ecosystem services perspective, will function as barren land. These areas amount to a total of 55.8 acres across the study region, so the effect on ecosystem service values are correspondingly small, at least when compared to the impact of the construction zone and ROW. As with the ROW, however, these effects would occur year after year for as long as the PE exists. The annual loss of ecosystem service value from these areas under a "with PE" scenario would range from $218,186 to $789,362.

[22] Note that due to differences in the range of dollars-per-acre estimates available for the various combinations of land use and ecosystem service, there are some instances where an apparent gain at the low end turns into a loss at the high end. For example, and based on the estimates available from the literature, the minimum value for erosion control from shrub/scrub acres is higher than the minimum for forests. Because we assume that forests return to shrub/scrub after the pipeline is in operation, this translates into a net increase in erosion regulation. At the high end, however, available estimates show a higher erosion control value for forests than for shrub/scrub. Thus, the high estimate shows a net loss of erosion control benefits. It is important, therefore, to keep in mind that these estimates are sensitive to the availability of underlying per-acre estimates.

TABLE 8: Ecosystem Service Value Lost Each Year Post Construction in Permanent Infrastructure, Relative to Baseline, by Ecosystem Service

Ecosystem Service	Study Region			
	Baseline (low) (2015$)	*Loss (low) (2015$)*	*Baseline (high) (2015$)*	*Loss (high) (2015$)*
Aesthetic Value	150,016	(150,016)	603,428	(603,428)
Air Quality	12,456	(12,456)	12,847	(12,847)
Biological Control	333	(333)	2,347	(2,347)
Climate Regulation	5,173	(5,173)	5,522	(5,522)
Erosion Control	543	(543)	3,290	(3,290)
Protection from Extreme Events	27,085	(27,085)	27,774	(27,774)
Food Production	672	(672)	672	(672)
Pollination	6,913	(6,913)	25,644	(25,644)
Raw Materials	809	(809)	5,503	(5,503)
Recreation	3,108	(3,108)	19,848	(19,848)
Soil Formation	296	(296)	1,776	(1,776)
Waste Treatment	1,582	(1,582)	11,282	(11,282)
Water Supply	1,563	(1,563)	42,629	(42,629)
Water Flows	7,636	(7,636)	26,800	(26,800)
Total	**$218,186**	**($218,186)**	**$789,362**	**($789,362)**

It bears repeating that the BTM as applied here is useful for producing first-approximation estimates of ecosystem services. For several reasons, we believe this approximation of the effect of the PE's construction and operation on ecosystem service values is too low rather than too high. These reasons include:

- The estimates only include the loss of value that would otherwise emanate from the ROW, construction zone, and aboveground infrastructure. The estimates do not account for the extent to which the construction and long-term presence of the PE could damage the ecosystem service productivity of *adjacent* land. During construction, the construction zone could be a source of air and water pollution potentially compromising the ability of surrounding or downstream areas from delivering their own ecosystem services. For example, if construction contributes to sedimentation of surface waters, those streams and rivers may lose some ability to provide clean water, food (fish), recreation, and other valuable services. This reduced productivity may persist after construction is complete.
- Over the long term, the ROW could serve as a pathway for invasive species or wildfire to more quickly penetrate areas of interior forest habitat, thereby reducing the natural productivity of those areas and imposing direct costs on communities and landowners in the form of fire suppression costs, lost property, and the costs of controlling invasive species.
- Finally, these estimates only reflect changes in natural benefits occurring due to changes in conditions on the lands surface. Activities during construction could alter existing underground waterways and disrupt water supply. There is also a risk that sediment and other contaminants could reach surface water or groundwater supplies if sinkholes form near the pipeline during construction or afterwards.

Effects on Property Value

Land Price Effects

To say the impacts and potential impacts of the PennEast Pipeline on private property value are important to people along its proposed route would be an extreme understatement. Key-Log Economics and Delaware Riverkeeper Network are conducting an analysis of all comments submitted through the closing of the DEIS comment period on September 12, 2016. Of 1977 total comments reviewed thus far (a sample), 99.8% of comments mentioning property value believed the PE would have a negative impact.

Landowners and Realtors along the proposed route of the Mountain Valley Pipeline, a 42" high-pressure natural gas pipeline designated to transport gas from fracked wells in the Marcellus through West Virginia and Virginia, report abandoned building plans, lower than expected appraisals, and buyers walking away from properties potentially affected by the construction (Adams, 2016). At least one ROW landowner was told by insurance agencies that their rates would likely increase if coverage remains available at all (Roston, 2015).

> ***"Real estate brokers have indicated that the value of our farm with the pipeline running across it would see an 80%-100% drop in value relative to its value absent the pipeline—if the property is sellable at all."***
>
> *-Richard Kohler, Owner of Cedar Lane Farm, Inc. Hunterdon, NJ*

While it is impossible to know precisely how large an effect the specter of the PE has already had on land prices, there is strong evidence from other regions that the effect would be negative. In a systematic review, Kielisch (2015) presents evidence from surveys of Realtors, home buyers, and appraisers demonstrating natural gas pipelines negatively affect property values for a number of reasons. Among his key findings relevant to the PE:

- 68% of Realtors believe the presence of a pipeline would decrease residential property value.
- Of these Realtors, 56% believe the decrease in value would be between 5% and 10%. (Kielisch does not report the magnitude of the price decrease expected by the other 44%.)
- 70% of Realtors believe a pipeline would cause an increase in the time it takes to sell a home. This is not merely an inconvenience, but a true economic and financial cost to the seller.
- More than three quarters of the Realtors view pipelines as a safety risk.
- In a survey of buyers presented with the prospect of buying an otherwise desirable home with a 36-inch diameter gas transmission line on the property, 62.2% stated that they would no longer buy the property at any price. Of the remainder, half (18.9%) stated that they would still buy the property, but only at a price 21%, on average, below what would otherwise be the market price. The other 18.9% said the pipeline would have no effect on the price they would offer.

  Not incidentally, the survey participants were informed that the risks of "accidental explosions, terrorist threats, tampering, and the inability to detect leaks" were "extremely rare" (2015, p. 7). The survey participants had, in other words, realistic information about the probability of pipeline accidents and were not responding out of overblown fears.

Considering only those buyers who are still willing to purchase the property, the expected loss in market value would be 10.5%.[23] This loss in value provides the mid-level impact in our estimates. A much greater loss (and higher estimates) would occur if one were to consider the fact that 62% of buyers are effectively reducing their offer prices by 100%, making the average reduction in offer price for all potential buyers 66.2%.[24] In our estimates, however, we have used the smaller effect (-10.5%) based on the assumption that sellers will eventually find one of the buyers still willing to buy the pipeline-easement-encumbered property.

- Based on five "impact studies" in which appraisals of smaller properties with and without pipelines were compared, "the average impact [on value] due to the presence of a gas transmission pipeline is -11.6%" (Kielisch, 2015, p. 11). The average rises to a range of -12% to -14% if larger parcels are considered, possibly due to the loss of subdivision capability.

These findings are consistent with economic theory about the behavior of generally risk-averse people. While would-be landowners who are informed about pipeline risks and nevertheless decide to buy property near the proposed PE corridor could be said to be "coming to the nuisance," one would expect them to offer less for the pipeline-impacted property than they would offer for a property with no known risks.

Kielisch's findings demonstrate that properties on natural gas pipeline rights-of-way suffer a loss in property value. Boxall, Chan, and McMillan (2005), meanwhile, show that pipelines also decrease the value of properties lying at greater distances. In their study of property values near oil and gas wells, pipelines, and related infrastructure, the authors found that properties within the "emergency plan response zone" (EPZs) of sour gas[25] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

"I am entering retirement and am also deeply concerned about my future and what the property value of my only nest egg will be when it comes time for me to sell it. Local realtors tell me that properties along the proposed route are already not selling and sitting on the market. Realtors also tell me that I will have to sell my house for much less than I would without the pipeline."

-Janice Hofreiter, Landowner
Mercer, NJ

The risks posed by the PE would be different—it would not be carrying sour gas, for example—but there are similarities between the PE scenario and the situation in the study that makes their finding particularly relevant. The emergency plan response zones, for example, are defined by the health and safety risks posed by the gas operations and infrastructure. Also, in contrast to PE-cited studies showing no price effects (see "Claims that pipelines have no effect on property value may be invalid," below), the Boxall study examines prices of properties for which landowners must inform prospective buyers when one or more EPZs intersect the property.

The PE has both a high consequence area and an evacuation zone radiating from both sides of the pipeline defined by health and safety risks. Whether disclosed or not by sellers, prospective buyers are likely to become informed regarding location of the property relative to the PE's HCA and evacuation zones or, at a minimum, regarding the presence of the PE in the study region.

[23] Half of the buyers would offer 21% less, and the other half would offer 0% less; therefore the expected loss is 0.5(-21%) + 0.5(0%) = -10.5%.
[24] This is the expected value calculated as 0.622*(-100%) + 0.189*(-21%) + 0.189*(0%).
[25] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.

The compressor station proposed for Kidder Township in Carbon County would likely cause its own more severe reduction in the value of nearby properties. We apply the percentage reduction awarded in the Hancock, New York case (25%) to properties that are (as the properties were in that case) within half a mile of the proposed compressor station ("Proximity of Compressor Station Devalues Homes by as much as 50%," 2015). The stations can also be noisy, with low-frequency noise cited as a constant nuisance ("Proximity of Compressor Station Devalues Homes by as much as 50%," 2015). These issues led some homeowners to pull-up stakes and move away and to reduced property value assessments for others (Cohen, 2015; "Proximity of Compressor Station Devalues Homes by as much as 50%," 2015).

Existing studies suggest negative impacts on land value from various types of nuisances that impose noise, light, air, and water pollution, life safety risks, and lesser human health risks on nearby residents (Sun, 2013; Bolton & Sick, 1999; Boxall et al., 2005). In addition to the emerging body of evidence demonstrating a negative relationship between natural gas infrastructure and property value, well established analyses strongly reveal the opposite analog. Namely, amenities such as scenic vistas, access to recreational resources, proximity to protected areas, cleaner water, and others convey positive value to property.[26] The bottom line is that people derive greater value from, and are willing to pay more for, properties that are closer to positive amenities and farther from negative influences, including health and safety risks.

Claims That Pipelines Have No Effect on Property Value Are Invalid

The DEIS (Federal Energy Regulatory Commission, 2016b) and PE LLC cite studies purporting to show that natural gas pipelines (and in one case a liquid petroleum pipeline) have at most an ambiguous and non-permanent effect on property values (Allen, Williford & Seale Inc., 2001; Fruits, 2008; Palmer, 2008; Diskin et al. 2011). While the studies differ in methods, they are similar in that they fail to take into account two factors potentially voiding their conclusions entirely.

First, the studies fail consider that the property price data employed in the studies do not reflect buyers' true willingness to pay for properties closer to or farther from natural gas pipelines. For prices to reflect willingness to pay (and therefore true economic value), buyers would need to have full information about the subject properties, including whether the properties are near a pipeline. Second, the studies that find no difference in prices for properties closer to or farther away from pipelines are not actually comparing prices for properties that are "nearer" or "farther" by any meaningful measure.[27] The studies compare similar properties and, not surprisingly, find that they have similar prices. Their conclusions are neither interesting nor relevant to the important question of how large an economic effect the proposed pipeline would have.

When the pre-conditions for a functioning market are not met, observed property prices do not (and cannot) indicate the true economic value of the property

Economic theory holds that for an observed market price to be considered an accurate gauge of the economic value of a good, all parties to the transaction must have full information about the good. If, on the other hand, buyers lack important information about a good, in this case whether a property is near a potential hazard, they cannot bring their health and safety concerns to bear on their decision about how much to offer for the

[26] Phillips (2004) is an example of a study that includes an extensive review of the literature on the topic.
[27] This is based on a best estimate of the location of the pipelines derived from descriptions of the pipelines location provided in the study (only sometimes shown on the neighborhood maps) and an approximation of the evacuation zone based on pipeline diameter and operating pressure (Pipeline Association for Public Awareness, 2007).

property. As a result, buyers' offering prices will be higher than both what they would offer if they had full information and, most importantly, the true economic value of the property to the buyer.

As Albright (2011) notes in response to the article by Disken, Friedman, Peppas, & Peppas (2011):

> "The use of the paired-sales analysis makes the assumption of a knowing purchaser, but I believe this analysis is not meaningful unless it can be determined that the purchaser had true, accurate and appropriate information concerning the nature and impact of the gas pipeline on, near or across their property… I believe that the authors' failure to confirm that the purchasers in any of the paired sales transactions had full and complete knowledge of the details concerning the gas transmission line totally undercut the authors' work product and the conclusions set forth in the article" (p. 5).

Of the remaining studies, only Palmer (2008) gives any indication that any buyers were aware of the presence of a pipeline on or near the subject properties. For Palmer's conclusion that the pipeline has no effect on property value to be valid, however, it must be true that **all** buyers have full information, and this was not the case.

In some cases, however, the location and hazards of petroleum pipelines become starkly and tragically known. For example, a 1999 liquid petroleum pipeline exploded in Bellingham, Washington, killing three, injuring eight, and causing damage to property and the environment. In that case and as Hansen, Benson, and Hagen (2006) found, property values fell after the explosion, which is to say, once would-be buyers became aware of the pipeline in the neighborhood. The authors also found that the negative effect on prices diminished over time. This makes perfect sense if, as is likely, information about the explosion dissipated once the explosion and its aftermath left the evening news and the physical damage from the explosion had been repaired.

Today's market is quite different. In contrast to Bellingham homebuyers in the months and years after the 1999 explosion, today's homebuyers can query Zillow to see the history of land prices near the pipeline and explore online maps to see what locally undesirable land uses exist near homes they might consider buying. They also have YouTube and repeated opportunities to find and view news reports, landowners' videos, and other media describing and depicting such explosions and their aftermath. Whether the pre-explosion prices reflected the presence of the pipeline or not, it is hard to imagine that a more recent event and the evident dangers of living near a fossil fuel pipeline would be forgotten so quickly by today's would-be homebuyers.

In Resource Report 5 (2015b), PE LLC claims that "it has never been commonplace for consumers to identify the presence of natural gas pipelines as part of their real estate transaction diligence and therefore, it can be argued the presence of natural gas pipelines is not a significant determinant to the value for real estate transactions" (p. 5-23). This is grossly misleading and plainly illogical. It is wrong to conclude a lack of a negative effect from the fact that home sellers do not typically—and against their own self-interest—disclose information that could induce a drop in the sale price. There are many attributes of homes offered for sale that are not typically included in the information displayed on real estate marketing sites. Drafty windows or unpleasant neighbors are but two examples of things home sellers do not typically include in their description of a home on the market. They are nevertheless two attributes of a home that would diminish the value to prospective buyers and, once known by those buyers, would also diminish the price offered.

PE LLC would instead have FERC believe that all persons selling real estate always disclose any and all features of their property that could possibly reduce the offers they may receive. If that were true, there would be no need for the laws that require homeowners to disclose, for example, whether the basement is damp or if the property is included in a homeowners association. Either PE LLC does not understand rational buyer/seller behavior, or they expect that FERC and the public do not.

What Zillow.com or other sites do accomplish is lowering the effort required for homebuyers to visualize the location of properties relative to other land uses, including pipeline rights-of-way. Combined with other information, such as maps of pipeline routes and other searchable online information, real estate marketing tools make it more likely that prospective buyers will gain information about the hazard they could be buying into.

With more vocal/visible opposition to large, high-pressure natural gas pipelines, it also seems likely that prospective home buyers will not have to wait for an incident involving the PennEast Pipeline to learn of it and, therefore, for the pipeline to affect their willingness to pay (and actual offer prices) for properties nearby. A drive down the street and a quick online search for information about a community one is considering a move to would likely reveal “no pipeline” signs, municipal ordinances opposing the pipeline, and Facebook groups created by local community members formed to raise awareness about the pipeline. Anyone with an eye toward buying property near the proposed PennEast corridor could quickly learn that the property is in fact near the corridor, that there is a danger the property could be adversely affected by the still-pending project approval, and that fossil fuel pipelines and related infrastructure have an alarming history of negative health, safety, and environmental effects.

When people possess more complete information about a property, they are able to express their willingness to pay when it comes time to make an offer. Accordingly, the prices buyers offer for homes near the PennEast Pipeline will be lower than the prices offered for other homes farther away or in another community or region.

Due to fundamental flaws, studies concluding that proximity to pipelines do not result in different property values are not actually comparing prices for properties that are different

While the studies cited in Resource Report 5 and the DEIS purport to compare the price of properties near a pipeline to properties not near a pipeline, many or in some cases all, of the properties counted as “not near” the pipelines are, in fact, near enough to have health and safety concerns that could influence prices. In both studies written by the Interstate Natural Gas Association of America (INGAA) the authors compare prices for properties directly on a pipeline right-of-way to prices of properties off the right-of-way (Allen, Williford & Seale Inc., 2001; Integra Realty Resources, 2016). However, in almost all of the case studies the geographic scope of the analysis was small enough where most or all of the properties not on the right-of-way were still within the pipelines’ respective evacuation zones (Allen, Williford & Seale Inc., 2001; Integra Realty Resources, 2016).[28]

INGAA analyzed six case studies in the 2016 study. In four of the case studies where an exact distance between the property and the pipeline was given, an average of 72.5% of the “off” properties were actually within the evacuation zone and, like the “on” properties, are likely to suffer a loss in property value relative to properties farther away.[29]

For the other two case studies analyzed in the 2016 INGAA study, the study reported a simple “yes” or “no” to indicate whether the property abutted the pipeline in question. For these two case studies, we assume the

[28] Proximity of properties to pipelines is based on best estimate of the location of the pipelines derived from descriptions of the pipelines’ locations provided in the studies and an approximation of the evacuation zone based on pipeline diameter and operating pressure (Pipeline Association for Public Awareness, 2007).

[29] We estimated the evacuation zone based on available information about the pipeline diameter and operating pressure (Pipeline Association for Public Awareness, 2007).

"PennEast can trumpet the study and try to convince landowners how beneficial their pipeline would be for everyone concerned, but the truth of the matter, based on my own personal experience, is that nobody wants a property with a pipeline."

-Joyce Sherman, Resident
Stockton, NJ

author's methods, while flawed, are at least consistent from one case study to the next meaning it is likely at least 50% or more of the comparison properties (the "off" properties) are in fact within the evacuation zone.

To adequately compare the price of properties with and without a particular feature, there needs to be certainty that properties either have or do not have said feature. The feature of interest in this case is the presence of a nearby risk to health and safety. INGAA instead relied upon case studies with little to no variation in the feature of interest (i.e., the majority of properties are within the evacuation zone), and found, unsurprisingly, that there was no systematic variation in the subsequent price of properties. This is a situation where comparing apples and oranges is not only reasonable, but also essential. The INGAA case studies are only looking at and comparing all "apples." By comparing apples to apples rather than comparing apples to oranges, the INGAA studies reach the obvious and not very interesting conclusion that properties that are similar in size, condition, and other features including their location within the evacuation zone of a natural gas pipeline have similar prices.

To varying degrees, the other studies cited by FERC and PE LLC suffer from the same problem. Fruits (2008), who analyzes properties within one mile of a pipeline with a 0.8-mile-wide-evacuation zone (0.4 miles on either side), offers the best chance that a sizable portion of subject properties are in fact "not near" the pipeline from a health and safety standpoint. He finds that the distance from the pipeline does not exert a statistically significant influence on the property values, but he does not examine the question of whether properties within the evacuation zone differ in price from comparable properties outside that zone. A slightly different version of Fruits' model, in other words, could possibly have detected such a threshold effect. (Such an effect would show up only if the buyers of the properties included in the study had been aware of their new property's proximity to the pipeline.)

In short, the conclusion that pipelines do not negatively affect property values cannot be drawn from these flawed studies. To evaluate the effects of the proposed PennEast Pipeline on property value, FERC and others must look to studies (including those summarized in this report) in which buyers' willingness to pay is fully informed about the presence of nearby pipelines and in which the properties examined are truly different in terms of their exposure to pipeline-related risks.

Land Value Effects of Compressor Stations

Compressor stations like the three-unit, 47,700 hp station proposed for Kidder Township can cause decreases in home values and have even forced some homeowners to move away from the noise, smells, and illnesses associated with living near stations. In one case from Minisink, New York, a family of six moved to escape the effects of a much smaller (12,600 hp) compressor station operated by Millennium Pipeline, L.L.C. After two years of headaches, eye irritation, and lethargy among the children and even lost vigor in their fruit trees, the couple, unable to find a buyer for their home, moved away, leaving their $250,000 investment in the property on the table with their bank holding the balance of the mortgage (Cohen, 2015).

In Hancock, another New York town with a relatively small (15,000 hp) compressor station, three homeowners have had their property assessments reduced, two by 25% and one by 50%, due to the impact of truck traffic, noise, odors, and poor air quality associated with the compressor station ("Proximity of Compressor Station Devalues Homes by as Much as 50%", 2015). The larger of these reductions was for a home very close to the station and reflected physical damage that led to an increase in radon concentrations above safe levels. The two properties devalued by 25% were approximately one half mile away (Ferguson, 2015).

As of this writing, there are no statistical studies demonstrating the relationship between a property's value and its proximity to a compressor station. The mounting anecdotal information, however, suggests there is a negative relationship and depending on the particular circumstances, the effect can be large–up to the 100% loss sustained by the family in Minisink (minus whatever the bank might be able to recover at auction). FERC must therefore count the potential loss of property value associated with the compressor station proposed for location in Kidder Township.

For our estimates, we follow the example of the Hancock, New York case and assume that properties within one half mile of the Kidder Township compressor station would lose 25% of their value if the station is built.[30] We believe this assumption provides a conservative estimate in part because the Kidder compressor station would be more than three times the horsepower of the Hancock station. It is therefore likely that its noise, odor events, and other physical effects would be experienced at a greater distance and/or with greater intensity than in the New York case.

Parcel Values

We obtained parcel data in electronic form from the Geographic Information System (GIS) departments from each of the six counties impacted by the proposed route. These included GIS layers for, at minimum, those parcels touched by the evacuation zone, as well as valuation/assessment data for those parcels. Because publicly owned conservation lands (parks, etc.[31]) are unlikely to be sold, they do not have any market value. To avoid overestimating property value effects, we set the value of any publicly owned parcels equal to zero.

Using the GIS data, we identified the five different types of parcels for which the pipeline would have an effect. In order of increasing distance from the pipeline itself, these are:[32]

1. Parcels crossed by the right-of-way
   (730 parcels, with total baseline value (without PE) of $200.5 million)
2. Parcels crossed by the construction corridor
   (842 parcels, with total baseline value (without PE) of $228.0 million)
3. Parcels at least partially within the high consequence area (HCA)
   (4,619 parcels, with total baseline value (without PE) of $1.0 billion)
4. Parcels at least partially within the evacuation zone
   (18,097 parcels, with total baseline value (without PE) of $3.9 billion)

[30] For land value analysis of the compressor station, we buffered a half mile radius around the parcel containing the station.
[31] We used the "Protected Areas Database" from the National Gap Analysis Program to identify fee-owned conservation properties (Conservation Biology Institute, 2012).
[32] Ideally, one would also want to identify the parcels from which views would be impaired by the presence of the pipeline ROW. Such an analysis would require parcel maps for the entire study region. Our maps (GIS layers) for some counties, however, cover only the evacuation zone, making a parcel-by-parcel analysis of viewshed impacts impossible. See the section titled "Visual Effects" for a general analysis of the PE's potential impact on viewsheds across the study region.

5. Parcels with their geographic center (centroid) within one-half mile of the parcel containing the compressor station
   (40 parcels, with total baseline value (without PE) of $5.6 million)

Note there is overlap among the zones. All ROW parcels are within the construction corridor, the HCA, and the evacuation zone. All construction corridor parcels are within the HCA and the evacuation zone. And HCA parcels are within the evacuation zone. To avoid double counting parcel values, only one land value effect is applied to a given parcel.

For estimates of the ROW, we assume that the health and safety concerns associated with the compressor station dominate the effects within the ROW and the evacuation zone. Estimates of the impact of the ROW and evacuation zone exclude the compressor zone parcels, and we estimate a separate effect of the compressor station. ROW parcels are also assumed to suffer no further reduction in value due to their location within the evacuation zone.

We do not consider the construction corridor separately for the land value analysis. Even though the additional 112 parcels and $27.5 million in value (relative to parcels in the ROW) are not trivial, we do not have a basis for estimating a change in value that is separate from, or in addition to, the change due to these parcels' proximity to the ROW or their location within the evacuation zone.

Furthermore, we treat parcels in the HCA and in the evacuation zone the same by applying a single land value change to all parcels in the evacuation zone. Arguably, there should be a larger effect on parcels in the HCA than those only in the evacuation zone. Living with the possibility of having to evacuate at any time day or night should have a smaller effect on property value than living with the possibility of not surviving a "high consequence" event and, therefore, not having the chance to evacuate at all. We do not have data or other study results that allow us to draw this distinction. We therefore apply the lower evacuation zone effect to all HCA and evacuation zone parcels (beyond the ROW).

To summarize, Table 9 repeats a portion of Table 2, but with the property value effects in place of check marks.

TABLE 9: Summary of Marginal Property Value Effects

Values/ Effects	Right-of-Way (Low, Medium, & High Effects)	High Consequence Area	Evacuation Zone	Compressor Station Zone	Pipeline Viewshed
Land/ Property Value	-4.2%[a] -10.5%[b] -13.0%[c]	-3.8%[d]		-25%[e]	Impact included with Ecosystem Services

Notes:

a. Kielisch, Realtor survey in which 56% of respondents expected an effect of between -5% and -10% (0.56*-7.5% = -4.2%).

b. Kielisch, buyer survey in which half of buyers still in the market would reduce their offer on a property with a pipeline by 21% (0.50*-0.21 = -10.5%).

c. Kielisch, appraisal/impact studies showing an average loss of between -12% and -14% (-13% is the midpoint).

d. Boxall, study in which overlap with an emergency planning zone drives, on average, a 3.8% reduction in price. We apply this reduction ONLY to those parcels in the evacuation zone that are not also in the ROW or within one half mile of the compressor station.

e. Based on examples from the town of Hancock, New York.

Estimated Land Value Effects

Following the procedures outlined in the previous section, our conservative estimate for costs of the proposed PE would include between $159.7 million and $177.3 million in diminished property value. Some of the most intense effects will be felt by the owners of 730 parcels in the path of the right-of-way, who collectively would lose between $8.4 million and $26.0 million in property value. Some 18,097 additional parcels lie outside the ROW but are within or touching the evacuation zone. These parcels' owners would lose an estimated $149.9 million (Table 10). Finally, the compressor station proposed for Kidder Township in Carbon County, Pennsylvania would reduce the value of 40 properties by a total of $1.4 million.

Table 10: Summary of Land Value Effects, by Zone and County

	Effects in Right-of-Way (2015$)			Effects in Evacuation Zone (2015$)
Area	**Realtor Survey (4.2%)**	**Buyer Survey (10.5%)[a]**	**Impact Studies (13.0%)**	**Boxall Study (3.8%)**
Study Region	**-8,420,100**	**-21,050,250**	**-26,062,214**	**-149,890,650**
Pennsylvania Portion	-4,400,237	-11,000,593	-13,619,782	-77,656,828
Bucks	-24,305	-60,761	75,228	-334,798
Carbon	-411,78	-1,029,459	-1,274,568	-3,690,122
Luzerne	-2,709,525	-6,773,812	-8,386,625	-36,044,026
Northampton	-1,254,624	-3,136,560	-3,883,360	-37,587,882
New Jersey Portion	-4,019,863	-10,049,657	-12,442,433	-72,233,822
Hunterdon	-2,326,511	-5,816,278	-7,201,106	-30,734,752
Mercer	-1,693,352	-4,233,380	- 5,241,327	-41,499,070

Table 10: Continued

	Effects Near Compressor (2015$)	Total of ROW, Compressor Station, and Evacuation Zone Effects (2015$)		
Area	**Hancock, NY Finding (25%)**	**Low**	**Medium**	**High**
Study Region		**-159,698,484**	**-172,328,634**	**-177,340,598**
Pennsylvania Portion	-1,387,734	-83,444,799	-90,045,155	-92,664,344
Bucks	n/a	-359,103	-395,560	-410,027
Carbon	-1,387,734	-5,489,639	-6,107,315	-6,352,424
Luzerne	n/a	-38,753,551	-42,817,838	-44,430,651
Northampton	n/a	-38,842,506	-40,724,442	-41,471,242
New Jersey Portion	n/a	-76,253,685	-82,283,479	-84,676,255
Hunterdon	n/a	-33,061,263	-36,551,029	-37,935,857
Mercer	n/a	-43,192,422	-45,732,450	-46,740,397

Based on median property tax rates in each county, these one-time reductions in property value would result in reductions in property tax revenue of between $2.7 and $3.0 million per year (Table 11). The present value of this stream of lost revenue over the 2018-2048 operating period would be $75.9 and $84.2 million. To keep their budgets balanced in the face of this decline in revenue, counties would need to increase tax rates, cut back on services, or both. The loss in revenue would be compounded by the likelihood that the need for local public

services, such as road maintenance, water quality monitoring, law enforcement, and emergency preparedness/emergency response could increase. Thus, the PE could drive up expenses while driving down the counties' most reliable revenue stream. (See also "Community Service Costs", below.)

Table 11: Effects on Local Property Tax Revenue

Source: Property Taxes by State (propertytax101.org, 2016).

Area	Median Tax Rate (% of Home Value)[a]	Lost Property Tax Revenue (2015$)		
		Low	Medium	High
Study Region		**-2,719,343**	**-2,932,534**	**-3,017,134**
Pennsylvania Portion		-1,215,386	-1,310,614	-1,348,403
Bucks	1.27%	-4,561	-5,024	-5,207
Carbon	1.56%	-85,638	-95,274	-99,098
Luzerne	1.40%	-542,550	-599,450	-622,029
Northampton	1.50%	-582,638	-610,867	-622,069
New Jersey Portion		-1,503,95	-1,621,920	-1,668,731
Hunterdon	1.91%	-631,470	-698,125	-724,575
Mercer	2.02%	-872,487	-923,795	-944,156

The Social Cost of Carbon: An Additional Cost of Methane Transport

The social cost of carbon (SCC) is a comprehensive estimate of the economic cost of harm associated with the emission of carbon. The SCC is important for regulation because it helps agencies more accurately weigh the costs and benefits of a new rule or regulation. In April 2016, a federal court upheld the legitimacy of using the social cost of carbon as a viable statistic in climate change regulations (Brooks, 2016). In August 2016, The Council on Environmental Quality (CEQ) issued its final guidance for federal agencies to consider climate change when evaluating proposed Federal actions (Council on Environmental Quality, 2016). The CEQ states "agencies should consider applying this guidance to projects in the EIS preparation stage if this would inform the consideration of differences between alternatives or address comments raised through the public comment process with sufficient scientific basis that suggest the environmental analysis would be incomplete without application of the guidance, and the additional time and resources needed would be proportionate to the value of the information included" (Council on Environmental Quality, 2016).

EPA has also challenged FERC's failure to consider climate change implications in a similar application process (Westlake, 2016). Citing the CEQ guidance, EPA notes that the Final EIS for the Leach Xpress, Columbia Gulf Transmission LLC-Rayne Xpress Expansion project "perpetuates the significant omission...with respect to a proper climate change analysis to inform the decision making process" and recommends that GHG emissions from end product combustion be counted among the environmental effects of each alternative" (p. 2).

PennEast, LLC estimates the pipeline would transport 401,500,000 dekatherms annually, contributing to an equivalent of 21.3 million metric tons of CO_2 emitted per year (U.S. EPA, 2016a). Because the SCC assumes a ton of carbon emitted in the future will have more dire impacts than a ton emitted in the present, we estimate the cost of carbon annually until 2048.[33] Using U.S. EPA estimates based on the average of impacts from three

[33] We assumed that if the PE were to be approved, construction would occur in 2018 and the first year of operation, or the first year the project would produce associated emissions, would be 2019. Based off of an email correspondence with a PennEast representative, "PennEast fully anticipates the PennEast Pipeline safely will transport enough natural gas for

assessment models and discount rates of 5% and 2.5% (U.S. EPA, Climate Change Division, 2016), the cost to society of the carbon transmitted through the PennEast Pipeline would total between $12.9 and $56.0 billion over 30 years. FERC must count this significant cost among the effects of the proposed pipeline.

Other Impacts For Consideration

Public Health Effects

Natural gas transmission releases toxins, smog forming pollutants, and greenhouse gases that have a negative impact on public health (Fleischman, McCabe, & Graham, 2016). Emissions from the natural gas industry have been tied to a myriad of health concerns, however, more concrete epidemiological studies are needed to determine the extent to which natural gas transmission causes public health concerns.

More recent emerging literature is beginning to quantify just how large of an effect the industry can have on public health. For example, a study by the Clean Air Task Force (2016) estimated that in 2025, increases in ozone levels due to pollution from the oil and gas industry will cause 750,000 additional asthma attacks in children under the age of 18, add an additional 2,000 asthma-related emergency room visits and 600 respiratory related hospital admissions, cause children to miss 500,000 days of school annually, and cause adults to deal with 1.5 million days of forced rest or reduced activity due to ozone smog.

Air Pollution from the Proposed Compressor Station

The PennEast Pipeline impacts air quality by converting forests, which remove normal levels of impurities from the air, to other land uses. There is also concern for impacts that would occur due to the dumping of excess impurities into the air in the first place. While there is a chance leaks could occur at any place along the proposed route, leaks and major releases of gas and other substances (lubricants, etc.) would certainly occur at the 47,700 hp compressor station proposed for Kidder Township, Carbon County, Pennsylvania. Leaks in seals on the moving parts of natural gas compressors produce a significant amount of VOC emissions (Fleischman, McCabe, & Graham, 2016).

The negative effects of the compressor station include noise and air pollution from everyday operations plus periodic "blowdowns," or venting of gas in the system to reduce pressure. As a recent study by the New York Department of Environmental Conservation indicates, pollution around compressor stations is common and severe (Lucas, 2015). The five-state study found that "more than 40% of the air samples from compressor stations exceeded federal regulations for certain chemicals like methane, benzene, and hydrogen sulfide" (Lucas, 2015). The study also found high rates of illnesses such as nosebleeds and respiratory difficulties among people living near the stations.

While more definitive epidemiological studies are needed to determine the extent to which natural gas compressor stations add to background rates of various illnesses, these stations are implicated as contributing to a long list of maladies. According to Subra (2015), individuals living within 2 miles of compressor stations and metering stations experience respiratory impacts (71% of residents), sinus problems (58%), throat irritation (55%), eye irritation (52%), nasal irritation (48%), breathing difficulties (42%), vision impairment (42%), sleep disturbances (39%), and severe headaches (39%). In addition, some 90% of individuals living within 2 miles of these facilities also reported experiencing odor events (Southwest Pennsylvania Environmental Health Project,

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several decades" (Kornick, 2016b). For our analysis, we interpreted "several decades" as thirty years after the first year of construction.

2015). Odors associated with compressor stations include sulfur smell, odorized natural gas, ozone, and burnt butter (Subra, 2009). Furthermore, compressors emit constant low-frequency noise, which can cause negative physical and mental health effects (Luckett, Buppert, & Margolis, 2015).

In Carbon County, 560 people live within 2 miles of the proposed compressor station (U.S. Census Bureau, 2015). Translating the findings from Subra (2015), 504 people would experience odor events, 398 people would experience respiratory impacts, 325 people would experience sinus problems, and 218 people would experience sleep disturbances and/or severe headaches. In addition to the health impacts discussed above, this pollution can cause damage to agriculture and infrastructure. One study found that shale gas air pollution damages in Pennsylvania already amount to between $7.2 and $30 million, with compressor stations responsible for 60-75% of this total (Walker & Koplinka-Loehr, 2014). Using the low estimate of 60%, that is between $4.32 and $18 million in damages associated with compressor stations.

Visual Effects

Information about how the visual effects of natural gas transmission pipelines are reflected in property values is scarcer than information related to health and safety effects. On one hand, we know better views increase property value. Conversely, utility corridors from which power lines are visible decrease property values (by 6.3% in one study) (Bolton & Sick, 1999). This suggests that a pipeline corridor reduces property value either by impairing a good view or, like power lines, by simply being unattractive. It is reasonable to conclude that the proposed PE would have effects on property value due to the visual effects, but the literature to date does not offer clear guidance on how large or strong the effects may be. We therefore did not include separate estimates of the impact of the PE on property value in the viewshed. Moreover, we do not wish to double-count a portion of the impact of the PE on “Aesthetics,” which is already included among the ecosystem service value effects.

However, it is important to know the places where the pipeline would be visible in the study region that might suffer a portion of lost aesthetic value. To determine the potential visibility, a GIS-based analysis provides an estimate of how many points along the pipeline could potentially be seen from each 30m-by-30m spot in the study region (Figure 6). To keep the computing needs manageable, we analyzed a sample of points placed at 100m intervals along the proposed PE route.

Because weather, smog, and other conditions may limit the distance of extended unobstructed views in Pennsylvania and New Jersey, we restricted the scope of analysis for any given point on the pipeline to spots in the study region that lie within a 25-mile radius or within the counties’ boundaries.

By tallying the number of points on the pipeline corridor that can be seen from each spot in the study region, we obtain an estimate for the amount of pipeline visible. In Figure 6, yellow spots on the map are points where between 1 and 10 points on the pipeline are visible, whereas red spots have a view of up to 300 points. Since each point represents 100 meters of pipeline, this analysis shows that there are places in the study region where 30 km, or 18.6 miles, of the pipeline corridor could be visible. One limitation is that this is a *potential* view of the pipeline because other visual obstructions, such as trees or buildings, are not taken into account.

Based on this GIS analysis, it would be possible to see at least one point (representing 100m) along the ROW from 36% of the six-county study region. For this 36% of the region, an average of 1.8 km (1.1 miles) of the PE ROW would be visible. For 20% of the study region, seeing 10 or more points, or 1 km (0.62 miles) of the ROW is possible. Note that what would be visible is not the pipeline itself, but rather the gap or break in otherwise intact forests, farm fields, or other more natural features through which the ROW passes.

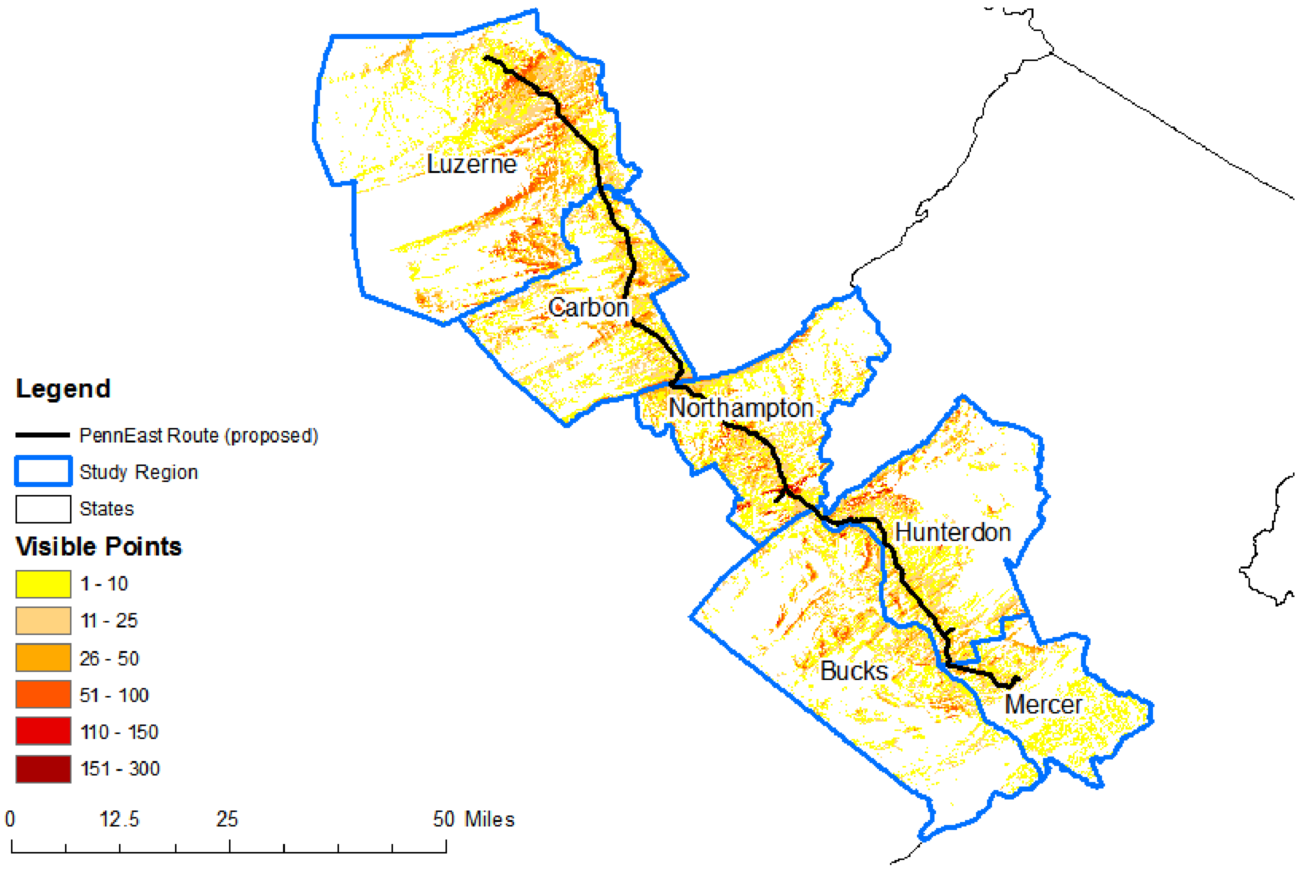


FIGURE 6: Visibility of the Proposed PennEast Pipeline

The color of each point on the map indicates the number of waypoints, spaced 100m apart, along the PE route and within 25 miles that could be seen from each point. Note that the analysis is based on elevation only and does not take into account the extent to which buildings or trees may mask views of the pipeline corridor.

Sources: PE route obtained from the Delaware Riverkeeper Network; Counties from USGS (U.S. Department of Interior & U.S. Geological Survey,

Community Service Costs

The construction and operation of the PennEast Pipeline is likely to impose various costs on local governments and, by extension, local taxpayers. The main categories of community services that the PE could affect are 1) Provision of Public and Private Water, 2) Roads and Traffic, 3) Emergency Services (Fire, Rescue, and EMS), and 4) Law Enforcement. For this report, we do not have a complete basis for providing estimates of the costs of community service for the counties and municipalities affected by the pipeline. However, we explain them below to provide a more complete picture of public services at stake and an example of indirect costs FERC should be further investigating and considering.

Provision of Public and Private Water

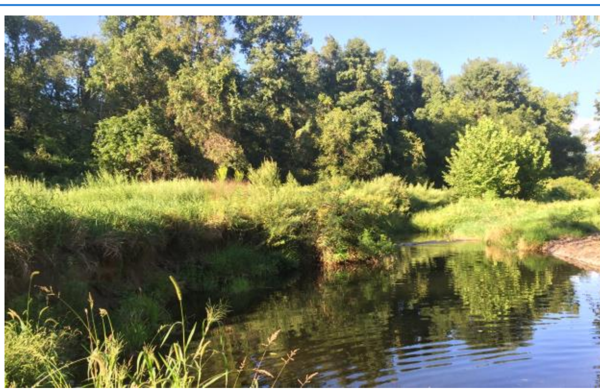
Landowners all over the Marcellus region are increasingly worried about the potential degradation of water quality associated with the construction and operation of pipelines (Wheeler, 2014; Adams, 2015a). The construction of natural gas infrastructure causes erosion, sedimentation, and contamination of local waterways from runoff (Union of Concerned Scientists, n.d.). In an example from just earlier this year, the state of New York rejected the Constitution Pipeline because the project failed to address significant water resource impacts (New York State Department of Environmental Conservation, 2016).

The PennEast Pipeline would cross, at least, four principal bedrock aquifer systems, multiple surficial unconsolidated aquifers, two EPA-designated sole source aquifers, and three wellhead protection areas (Federal Energy Regulatory Commission, 2016b). The PennEast Pipeline would also cross the Delaware River, a major drinking water source for communities in NJ and PA.

To mitigate potential impacts to water quality, PennEast prepared a Well Monitoring Plan stating that the company will conduct pre- and post-construction water quality monitoring within 150 feet of the construction corridor. If PennEast deems the water supply quantity or quality is affected, they are prepared to provide alternate water supply sources or reparations to the landowner for a new, analogous well (Federal Energy Regulatory Commission, 2016b). The 150 feet buffer, however, does not protect all potentially impacted landowners. In response to the buffer identified by PE LLC and listed in the DEIS, the New Jersey Department of Environmental Protection commented that a monitoring distance of 150 feet of the pipeline is inadequate, suggesting a 1,000 feet monitoring radius instead (New Jersey Department of Environmental Protection, 2015).

The Environmental Protection Agency also submitted a comment letter outlining drinking water concerns and inadequacies in information noting that the DEIS fails to identify Source Water Protection Areas which are determined by contaminant time-of-travel and include areas more than 3 miles upstream of potable source water intakes (U.S. EPA, 2016b). Only three Wellhead Protection Areas (WHPAs) are identified in the DEIS, however, the EPA's comment letter notes 122 WHPAs within 5 miles of the pipeline's proposed path. To more thoroughly account for potential drinking water contamination, the EPA (2016b) suggests PE LLC work directly with state water agencies to locate the intersections between source water protection areas and WHPAs.

In New Jersey, two public supply wells in Alexandria Township in Hunterdon County are within 150 feet of the construction corridor (Federal Energy Regulatory Commission, 2016b). PE LLC has not currently identified the number or location of private wells in New Jersey but states that it will identify affected private wells using public records and interviews with landowners. Dozens of communities along the proposed route are already passing official resolutions against the pipeline. Many of them, for example Kingwood Township, a rural municipality located in Hunterdon County, New Jersey, strongly oppose the PE because of the potential impacts on landowners that predominantly rely on private water supplies (Township Committee of the Township of Kingwood, 2014).



Proposed PE crossing along the Alexauken Creek in New Jersey, a C1 stream.
(Photo Credit: Faith Zerbe)

According to the DEIS, "based on review of the Pennsylvania Department of Conservation and Natural Resource (PA DCNR) Pennsylvania Groundwater Information System, no public and/or private water supply wells or springs are located within 150 feet of the pipeline construction workspace in Pennsylvania" (Federal Energy Regulatory Commission, 2016b). However, Delaware Riverkeeper Network found that community members and volunteer monitors have identified additional potential freshwater wells and springs within 150 feet of the route (Zerbe, 2016). In Pennsylvania, more than a million people rely on private wells, with 20,000 new wells drilled each year (PennState Extension, 2016), however, because the state of Pennsylvania does not regulate private well use, testing for contamination falls on the homeowner. These well testing costs would be yet another external cost of the PE that would fall on landowners.

> ***"If your well is dry or poisoned, your family's well-being is at risk, and your property has become worthless, it won't matter how much PennEast is paying in taxes."***
>
> *-Mayor Susan Lockwood of Delaware Township, Mayor Kevin Kuchinski of Hopewell Township, Mayor Zach Rich of West Amwell Township, Mayor Richard Dodds of Kingwood Township, and Mayor Ray Krov of Holland Township*

Roads and Traffic

Although no current literature exists that provides estimates of the extent to which natural gas pipeline construction and operation would increase wear and tear on local roads, snarl traffic, or increase the rate of motor vehicle accidents, it is reasonable to assume some of these effects will occur based on documented instances in areas where unconventional natural gas drilling. The increase in traffic volume from fracking produces a strain on existing transportation infrastructure because damage to roads and bridges increases exponentially with vehicle weight (Abramzon et. al, 2014). Heavy vehicle traffic associated with fracking in the Barnett shale in Texas has already run up a repair bill of $40 million, and New York State estimates potential fracking would require road and bridge upgrades of upwards of hundreds of millions to prepare for the punishment associated with increased vehicle volume and traffic (Efstathiou, 2012).

Damaged or worn-out roads, an increase in traffic volume involving those heavy vehicles, and an influx of out-of-area workers unfamiliar with local roads are also associated with increases in motor vehicle accidents (Muehlenbachs & Krupnick, 2014). Motor vehicle accidents impose a range of costs, from emergency response, medical care, time off of work, premature death, property damage, and the cost of time lost to traffic jams at accident scenes (National Highway Traffic Safety Administration, 2015).

Another reason to expect that PE's external costs would include transportation impacts is that PennEast LLC has stated that it will pay to restore local roads damaged during construction to their original or better condition (Federal Energy Regulatory Commission, 2016b). To help ensure that this does in fact happen, at least one Pennsylvania Township is taking steps and spending public funds to document current road conditions so that officials know how much PennEast-related damage would need to be repaired. According to Upper Nazareth Township zoning Officer John Soloe, "Our road system could be dramatically impacted" (Best, 2016). Since PennEast has pledged only to pay for the damage to roads, the costs of such surveys would be borne by municipalities. Similarly, PennEast would not be paying for the costs of time lost to traffic congestion, traffic accidents, or excess wear and tear on vehicles traversing damaged roads before they are repaired. By paying just a portion of the external transportation-related costs of the PE, the project would leave many costs unmitigated.

Emergency Services (Fire, Rescue, and Emergency Medical Services)

With pipeline incidents becoming more and more frequent (Kelso, 2013), fire and rescue teams must devote additional time and resources for planning, training, and response. In Allentown, Pennsylvania, roughly 15 miles west of the proposed PennEast Pipeline, the process for responding to a natural gas incident is intensive and burdens the community (Kutz, 2012). When the fire station receives a pipeline related call it must dispatch a battalion chief, one truck company, and three engines with 13-15 firefighters in all. When the first units arrive on the scene, they close roads to all traffic for one square block, take samples, and wait for the utility company to arrive (Kutz, 2012). Fire departments that do not already have the requisite level of staffing, training, and equipment will need to invest to increase their capacity to serve their communities in the face of new risks.

Although incidents with larger transmission lines, such as PennEast, occur with lower frequency, potential accidents still require preparatory training and warrant concern. According to Tim Butters, former deputy administrator of the Pipeline and Hazardous Materials Safety Administration, emergency responders are often overwhelmed with the amount of information on various hazards and priorities in their jurisdiction, which may impact their ability to properly respond to an incident involving a larger transmission pipeline (Armstrong, Hall, & Butters, 2011). An investigation into a pipeline rupture in California that killed eight people, injured over 60, destroyed 38 homes, and damaged 70 others, for example, revealed that local responders were not prepared to handle the emergency (Armstrong, Hall, & Butters, 2011).

PennEast states that it does not expect construction to have an adverse impact on local and regional medical services (Federal Energy Regulatory Commission, 2016b). However, PennEast fails to answer critical questions in their filings relevant for emergency medical services (EMS). The chief of the Kingwood Rescue Squad raises concerns on whether or not rescue vehicles may drive or park over the pipeline, whether a helicopter would be able to land on site, how PennEast would address downed power lines near the PE, and what protective gear would be necessary for first responders to possess and be trained to use (Ponter, 2015).

Law Enforcement

The increased cost to law enforcement stems from additional time and potential personnel needed to handle increased motor vehicle accidents and crime associated with temporary workers as demonstrated by the experience of communities where temporary workers are a regular presence due to shale gas operations. Pennsylvania localities have experienced a 46% increase in 911 call activity, even with their population declining (Detrow, 2011). The majority of 911 calls stem from heavy trucks jamming traffic on local roads and accidents involving heavy rigs, trucks, tractor-trailers, dump trucks, and trailers hauling hazardous materials, all of which will be present during pipeline construction.

Furthermore, a multi-state analysis found that counties with high drilling had statistically significant increases in violent crime and property crime (Multi-State Shale Research Collaborative, 2014). Temporary out-of-state workers have been associated with increased arrests, traffic violations, protection-from-abuse orders, and warrants for people failing to appear in court (Associated Press, 2011). In Bradford County, Pennsylvania, for example, DUI arrests rose 60%; the number of sentences handed for criminal offenses rose 35%; warrants for criminal activity such as protection-from-abuse rose 25% as well (Associated Press, 2011).

PennEast expects 60% of their 2,400 person workforce to consist of non-local, temporary hires (Federal Energy Regulatory Commission, 2016b). While pipeline construction jobs will come and go more quickly than gas field jobs, it is reasonable to assume, prepare for, and expect higher costs for additional law enforcement needs.

Effects on Economic Development

Impacts to public health, scenery, and community services could affect the economic development of the counties crossed by the pipeline's route. Across the study region, county-level economic development plans recognize the importance of a high quality of life, a clean environment, and scenic and recreational amenities to the economic future of people and communities. According to the Comprehensive Economic Development Strategy Five-Year Plan for Northeastern Pennsylvania, which encompasses Carbon and Luzerne Counties, "the Northeastern Pennsylvania region will continue to be an attractive place to live because of its excellent quality of life, which is supported by a strong and diversified economic base that brings prosperity to its residents...the

Pasture in Hunterdon County that would be impacted by the PennEast Pipeline.
(Photo Credit: Carla Kelly-Mackey)

region will maintain a balance between the preservation of its rural environment with open space and an expanded economic base with industrial, commercial and retail centers for its residents" (Northeastern Pennsylvania Alliance, 2013, p. 23).

In New Jersey, Hunterdon County's Comprehensive Economic Development Strategy notes the County's melding of old and new economy businesses (farming and nationally recognized healthcare, for example) and recognizes that the "beautiful rural landscape comprised of rolling hills, working farms, and attractive historical hamlets…provides an attractive location for a young, highly-skilled workforce that is heavily vested in an active outdoor lifestyle" (Hunterdon County Board of Chosen Freeholders, CEDS Governing Committee, Hunterdon County Planning Board Staff, & North Jersey Transportation Planning Authority, 2014, p. 102).

These intentions mirror common trends in other amenity-rich locales around the country. For example, Niemi and Whitelaw state "as in the rest of the Nation, natural-resource amenities exert an influence on the location, structure, and rate of economic growth.... This influence occurs through the so-called people-first-then-jobs mechanism, in which households move to (or stay in) an area because they want to live there, thereby triggering the development of businesses seeking to take advantage of the households' labor supply and consumptive demand" (1999, p. 54). They note that decisions affecting the supply of amenities "have ripple effects throughout local and regional economies" (p. 54). Similarly, Johnson and Rasker (1995) found that quality of life is important to business owners deciding where to locate a new facility or enterprise and whether to stay in a location already chosen. This is not surprising. Business owners value safety, scenery, recreational opportunities, and quality of life factors as much as residents, vacationers, and retirees.

Part of what makes tourism an important part of the region's economy is the high aesthetic quality and environmental amenities available in the study region. In 2012, a visitor report about the Pocono Mountains (partially located in Carbon County) reported $1.3 billion in total spending resulting from overnight visits, with an estimated 25 million total person-trips consisting of 9.1 million in overnight trips and 15.9 million day trips during 2012 (Northeastern Pennsylvania Alliance, 2013).

Wildlife-related recreational activities related to tourism are also important. In 2011, hunters, anglers, and wildlife watchers spent $2.7 billion in Pennsylvania and another $2.2 billion in New Jersey (U.S. Fish & Wildlife Service, 2011b, 2011a).

The PE could dampen these economic activities and undermine the progress toward economic development goals. A loss of scenic and recreational amenities, the perception and the reality of physical danger, and environmental and property damage resulting from the PE could discourage people from visiting, relocating to, or staying in the region. Workers, businesses, and retirees who might otherwise choose to locate along the PE's proposed route will instead pick locations that have retained their character, their productive and healthy landscapes, and their promise for a higher quality of life.

This is already occurring in the region. With the possibility of the PE looming, business plans are stalling and the real estate market is slowing. For example, Movant, Kay Trio, LLC, a land development company, had plans to

develop 105 total acres for single family homes in Nazareth, Pennsylvania. The proposed pipeline, however, would cross the "Trio Fields" development and "aside from destroying numerous lots and any profits associated therewith, will likely affect sales, interest, operation and the overall success of the development as a whole" (Avrigian, Jr. & Martosella, III, 2015). Natasha Jiovino, an owner of property in Holland Township, New Jersey, has been pursuing a development project since 1999 that has incurred development costs of over $2.8 million to date. Among other impacts, the PE would jeopardize the construction of 132 townhouses and other units that would help the township reach its affordable housing requirements (Jiovino, 2015).

> ***"Our customers will not tolerate less than pristine environmental conditions for their prized champion mares and their foals. Construction of the pipeline will result in the immediate loss of our customers and the closure of our business, resulting in the loss of the primary source of income for my wife and me."***
>
> *-Richard Kohler, Owner of Cedar Lane Farm Inc. Hunterdon, NJ*

Many of the region's residents believe the PE will harm the travel and tourism industry. For example, officials from the City of Lambertville in Hunterdon County, New Jersey believe the pipeline and associated construction will disrupt local tourism and recreation businesses (City of Lambertville & PennEast Pipeline Committee of the City of Lambertville, 2016).

It is difficult to predict just how large an effect the PE would have on decisions about visiting, locating to, or staying in the study region. Even so, based on information provided by business owners to FERC and as part of this research, we can consider scenarios for how the PE might affect key portions of the region's overall economy, such as tourism and recreation, retirement, and entrepreneurship.

If, for example, the PE were to cause a 10% drop in recreation and tourism spending from 2015 baselines, the PE could mean $448.0 million less in travel expenditures each year (Tourism Economics, 2015, 2016).[34] Those missing revenues would otherwise support roughly $38.8 million in state and local tax revenue and 4,090 jobs in the six-county region.[35] In the short run, these changes multiply through the broader economy as recreation and tourism businesses buy less from local suppliers and fewer employees spend their paychecks in the local economy. As with the reduction in local property taxes, lost tax revenue from a reduction in visitation and visitor spending would squeeze local governments trying to meet existing public service needs as well as additional demands created by the PE.

Along similar lines, retirement income is an important economic engine that could be adversely affected by the PE. In county-level statistics from the U.S. Department of Commerce, retirement income shows up in investment income and as age-related transfer payments, including Social Security and Medicare payments. In the study region, investment income grew by 0.6% per year from 2000 through 2014, and age-related transfer payments grew by 4.1% per year. During roughly the same time period (through 2013), the number of residents age 65 and older grew by 15.8% (1.2% per year), and this age cohort now represents 15.8% of the total population (U.S. Department of Commerce, 2015a; U.S. Department of Commerce, 2015b).

[34] Baseline tourism data for Pennsylvania was given for 2014 and adjusted for inflation to 2015$.

[35] This reduction in economic activity would be in addition to the lost recreation benefits (the value to the visitors themselves over and above their expenditures on recreational activity) that are included under the heading of lost ecosystem services.

It is difficult to precisely quantify the effect of the PE on retirement income, but given the expression of concern from residents about changes in quality of life, safety, and other factors influencing retirees' location decisions, it is important to consider that some change is likely. Here, we consider what a *10% reduction of the growth rate* might entail. A 10% growth reduction scenario would mean an annual decrease in investment income and age-related transfer payments of approximately $55.6 million. That loss would ripple through the economy as the missing income is not spent on groceries, health care, and other services such as restaurant meals, home and auto repairs, etc.

"As a business owner, I provide employment for ten heads of households in a rural area where few job opportunities exist. I also provide critical youth employment on a part time basis for many of our local teenagers. Part of the draw of my restaurant, Milford Oyster House, is the pristine natural environment in which it exists. Travelers come from all over to visit our beautiful area."

-Amy Coss, Owner of Milford Oyster House
Milford, NJ

The same phenomenon also applies to people starting new businesses or moving existing businesses to communities in the study region. This may be particularly true of sole proprietorships and other small businesses who are most able to choose where to locate. As noted, sole proprietors account for a large and growing share of jobs in the region. If proprietors' enthusiasm for starting businesses in the study region were dampened to the same degree as retirees' enthusiasm for moving there, the 10% reduction in the rate of growth would mean 791 fewer jobs and $16.3 million less in personal income.

For "bottom line" reasons (e.g., cost of insurance) or due to owners' own personal concerns, businesses in addition to sole proprietorships might choose locations where the pipeline is not an issue. If so, further opportunities for local job and income growth will be missed.

These are simple scenarios and the actual magnitude of these impacts of the PE will not be known unless the pipeline is built. Even so, and especially because the pipeline is promoted by its supporters for its jobs and potential other economic benefits to the region, it is important to consider the potential for loss.

CONCLUSIONS

The full costs of the proposed PennEast Pipeline to people and communities in the six-county study region and beyond are wide-ranging. The costs include one-time costs like reductions in property value and lost ecosystem services during pipeline construction. These one-time costs, according to our conservative estimates, would be between $166.0 and $199.4 million. There are also ongoing costs like diminished ecosystem service value, lost property tax revenue, and the cost of increased carbon emissions that recur year after year for the life of the pipeline (assumed to be 30 years). Lost ecosystem service value and diminished property tax revenues would total between $5.3 and $12.8 million per year. The majority of these costs would be borne by the residents, businesses, and institutions in Bucks, Carbon, Luzerne, Northampton, Hunterdon, and Mercer counties.

Beyond the immediate region, the PennEast Pipeline would also impose a cost on people worldwide, due to the addition to the combustion of natural gas transported through the pipeline. The social cost of carbon is an annual cost that varies by year and with the rate at which future costs are discounted. It would total between $291.9 million and $2.3 billion, raising the total annual external costs to between $297.2 million and $2.3 billion.

Adding up all one-time recurring costs, and discounting those future costs to 2017, we estimate the total external costs of PennEast Pipeline to be between $13.3 and $56.6 billion.

By contrast, the pipeline would in the words of FERC's DEIS provide only "minor" benefits in the form of economic impact during construction and operation of the pipeline. Using PennEast LLC's own estimates (Econsult Solutions & Drexel University School of Economics, 2015) and applying the same methods to calculate the present value of all future benefits, the pipeline promises a total of $2.3 billion in economic impact over 30 years of operation. This means for every dollar of benefit promised, the PennEast Pipeline would impose between $5.85 and $24.97 in costs.

While the decision to approve or not approve the PE does not hinge on a simple comparison of estimated benefits versus estimated costs, the huge difference between the external economic costs presented in this report and the potential payments to local and state governments as well as citizens suggests that, from an economic perspective, the proposed PE is grossly inefficient. The scope and magnitude of the costs outlined here reflect an important component of the full extent of the PE's likely environmental effects that must be considered when making the certification decision. Impacts on human well-being, including but not limited to those that can be expressed in dollars-and-cents, must be taken into account by the Federal Energy Regulatory Commission and others weighing the societal value of the PennEast Pipeline.

If these considerations and FERC's overall review result in selection of the "no-action" alternative and the PennEast Pipeline is never built, most of the costs outlined in this report will be avoided. It is *most*, not *all,* costs because the cost of delayed business plans, houses languishing on the market, and the cost to individuals of the stress, time, and energy diverted to concern about the pipeline rather than what would normally (and more productively) fill their lives has already occurred.

Another possible scenario is that FERC, considering the impacts of the PE *as currently proposed* on ecosystem services, property values, and economic development, conducts a thorough analysis of all possible alternatives. Those alternatives may include using alternative energy technologies for meeting the energy needs of the region, using existing gas transmission infrastructure (with or without capacity upgrades), routing new gas transmission lines along existing utility and transportation rights-of-way, and/or scaling down permitted new pipeline capacity to match regional gas transmission needs. In this case, estimates of these impacts should inform the choice of a preferred alternative that minimizes environmental damage and, thereby, minimizes the economic costs to individuals, businesses, and the public at large.

Note that consideration regional energy and natural gas transmission needs would most appropriately be made in the course of preparing a Programmatic Environmental Impact Statement, or PEIS, that considers the multiple pipeline proposals now on FERC's docket as well as others that FERC could reasonably foresee as likely to be proposed to transport gas from the Marcellus Shale to regional, national and international markets. FERC has unfortunately, and possibly in direct violation of NEPA, so far refused to do PEISs (Adams, 2015b). FERC's reason is in part that it has not done PEIS's before. FERC also maintains that it can adequately address such concerns as part of its analysis of the cumulative effects of any individual pipeline.

In the case of the Mountain Valley Pipeline, for example, FERC stated in a 2015 letter that its DEIS "will analyze both the project-specific impacts of the Mountain Valley Pipeline and the cumulative impacts of other actions affecting the environment in the region, including other proposed natural gas pipelines (FERC Chairman Norman Bay, quoted in Adams, 2015b)." That DEIS was released in the fall of 2016 and, as it turns out, FERC failed to adequately assess cumulative impacts of the proposed project. The U.S. Environmental Protection Agency (which has responsibility to review the quality of other agencies' compliance with NEPA) critiqued FERC's DEIS,

saying FERC "uses a narrow geographic and temporal scope," EPA said the Commission defined the scope of analysis of cumulative effects is too narrow. EPA recommended "that FERC describe the inter-related network of existing and proposed pipelines and associated impacts...to provide a more comprehensive consideration of impacts from natural gas production, transmission and use" (U.S. EPA Office of Environmental Programs, 2016, p.4).[36]

Unfortunately, and as demonstrated in the case of the Mountain Valley Pipeline and several other pipeline proposals in the Marcellus Shale region, the outlook for an adequate environmental review by FERC and, subsequently, an economically efficient outcome is not good. FERC routinely discounts or ignores important economic costs and turns a blind eye to energy supply and transmission options that could reduce the waste of land, natural resources, and financial wealth.

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APPENDIX A: CANDIDATE PER-ACRE VALUES FOR LAND-USE AND ECOSYSTEM SERVICE COMBINATIONS

As explained under "Effects on Ecosystem Service Value," the benefit transfer method applies estimates of ecosystem service value from existing studies of "source areas" to the "study area," which in this case is the proposed PE corridor. This application is done on a land-use-by-land-use basis. So, for example, values of various ecosystem services associated with forests in the source area are applied to forests in the study area. The table below lists all of the values from source area studies considered for our calculations.

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/acre/year	Source Study
Cropland	Aesthetic	35.01	89.23	(Bergstrom, Dillman, & Stoll, 1985)
	Biological Control	15.21	15.21	(Brenner Guillermo, 2007) *
	Biological Control	14.38	204.95	(Cleveland et al., 2006)
	Erosion	27.31	72.55	(Pimentel et al., 2003) *
	Food	33.25	33.25	(Lex & Groover, 2015)
	Pollination	10.14	10.14	(Brenner Guillermo, 2007) *
	Pollination	13.89	13.89	(Robinson, Nowogrodzki, & Morse, 1989)
	Pollination	47.43	1,987.97	(Winfree, Gross, & Kremen, 2011)
	Recreation	18.77	18.77	(Brenner Guillermo, 2007) *
	Recreation	2.16	5.02	(Knoche & Lupi, 2007)
	Soil Fertility	7.28	7.28	(Pimentel, 1998) *
	Soil Fertility	115.23	115.23	(Pimentel et al., 2003)
	Waste	132.26	132.26	(Perrot-Maître & Davis, 2001) *
Grasslands	Aesthetic	102.38	116.61	(Ready, Berger, & Blomquist, 1997)
	Biological Control	15.21	15.21	(Brenner Guillermo, 2007) *
	Climate	3.55	3.55	(Brenner Guillermo, 2007) *
	Erosion	17.48	17.48	(Barrow, 1991) *
	Erosion	68.28	68.28	(Sala & Paruelo, 1997) *
	Food	15.50	15.50	(Lex & Groover, 2015) *
	Pollination	16.23	16.23	(Brenner Guillermo, 2007) *
	Soil Fertility	3.55	3.55	(Brenner Guillermo, 2007) *
	Waste	55.28	55.28	(Brenner Guillermo, 2007) *
	Waste	5.88	64.40	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Water Flows	2.54	2.54	(Brenner Guillermo, 2007) *
Pasture	Aesthetic	102.38	116.61	(Ready et al., 1997)
	Biological Control	15.21	15.21	(Brenner Guillermo, 2007) *
	Climate	3.55	3.55	(Brenner Guillermo, 2007) *
	Erosion	17.48	17.48	(Barrow, 1991) *
	Erosion	68.28	68.28	(Sala & Paruelo, 1997) *
	Food	15.50	15.50	(Lex & Groover, 2015)
	Pollination	16.23	16.23	(Brenner Guillermo, 2007) *
	Soil Fertility	3.55	3.55	(Brenner Guillermo, 2007) *
	Waste	55.28	55.28	(Brenner Guillermo, 2007) *

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/acre/year	Source Study
	Waste	5.88	64.40	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Water Flows	2.54	2.54	(Brenner Guillermo, 2007) *
Shrub/Scrub	Air Quality	37.26	37.26	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Climate	7.27	7.27	(Croitoru, 2007) *
	Erosion	22.75	22.75	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Pollination	1.41	7.10	(Robert Costanza, Wilson, et al., 2006)
	Recreation	3.95	3.95	(Haener & Adamowicz, 2000)
	Waste	46.35	46.35	(Croitoru, 2007) *
	Waste	0.10	324.35	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
Forest	Aesthetic	4,439.71	18,141.99	(Nowak, Crane, Dwyer, & others, 2002)
	Air Quality	372.57	372.57	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Biological Control	8.91	8.91	(Wilson, 2005) *
	Biological Control	2.54	2.54	(Brenner Guillermo, 2007) *
	Climate	67.45	67.45	(Brenner Guillermo, 2007) *
	Climate	56.89	56.89	(Robert Costanza, d’Arge, et al., 2006)
	Erosion	61.87	61.87	(Brenner Guillermo, 2007) *
	Erosion	3.09	36.09	(Zhou, Al-Kaisi, & Helmers, 2009)
	Extreme Events	797.66	797.66	(Weber, 2007)
	Food	0.13	0.13	(Wilson, 2005) *
	Pollination	202.87	202.87	(Brenner Guillermo, 2007) *
	Raw Materials	24.53	24.53	(Wilson, 2005) *
	Raw Materials	166.82	166.82	(Weber, 2007)
	Recreation	152.66	152.66	(Brenner Guillermo, 2007) *
	Recreation	1.29	4.55	(Cruz & Benedicto, 2009) *
	Recreation	1.56	1.56	(Kniivila, Ovaskainen, & Saastamoinen, 2002) *
	Recreation	37.13	45.50	(Prince & Ahmed, 1989)
	Recreation	2.79	503.97	(Shafer, Carline, Guldin, & Cordell, 1993)
	Soil Fertility	6.09	6.09	(Brenner Guillermo, 2007) *
	Soil Fertility	19.97	19.97	(Weber, 2007)
	Waste	55.28	55.28	(Brenner Guillermo, 2007) *
	Waste	8.66	8.66	(Cruz & Benedicto, 2009) *
	Waste	265.79	266.89	(Lui, 2006)
	Water	204.39	204.39	(Brenner Guillermo, 2007) *
	Water	47.39	47.39	(Cruz & Benedicto, 2009) *
	Water	1,292.23	1,292.23	(Weber, 2007)
	Water Flows	230.01	230.01	(Mates, 2007)
	Water Flows	797.66	797.66	(Weber, 2007)
Water	Recreation	446.31	446.31	(Brenner Guillermo, 2007) *

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/acre/year	Source Study
	Recreation	155.36	914.10	(Cordell & Bergstrom, 1993)
	Recreation	304.18	437.19	(Mullen & Menz, 1985)
	Recreation	148.68	148.68	(Postel & Carpenter, 1977)
	Waste	10.72	10.72	(Gibbons, 1986) *
	Water	512.74	512.74	(Brenner Guillermo, 2007) *
	Water	22.98	22.98	(Gibbons, 1986) *
Wetland	Aesthetic	38.46	38.46	(Amacher & Brazee, 1989) *
	Air Quality	75.50	98.02	(Jenkins, Murray, Kramer, & Faulkner, 2010)
	Climate	1.84	1.84	(Wilson, 2005) *
	Climate	157.73	157.73	(Brenner Guillermo, 2007) *
	Extreme Events	228.06	369.85	(Wilson, 2005) *
	Extreme Events	110.06	4,583.26	(Brenner Guillermo, 2007) *
	Extreme Events	304.18	304.18	(Robert Costanza, Farber, & Maxwell, 1989)
	Extreme Events	278.77	278.77	(Robert Costanza & Farley, 2007)
	Extreme Events	1,645.59	7,513.98	(Leschine, Wellman, & Green, 1997)
	Raw Materials	50.16	50.16	(Everard, Great Britain, & Environment Agency, 2009)
	Recreation	80.71	80.71	(Bergstrom, Stoll, Titre, & Wright, 1990)
	Recreation	1,716.76	1,761.89	(Brenner Guillermo, 2007) *
	Recreation	109.30	429.97	(Robert Costanza et al., 1989)
	Recreation	1,041.04	1,041.04	(Creel & Loomis, 1992)
	Recreation	88.06	994.50	(Gren & Söderqvist, 1994) *
	Recreation	71.11	71.11	(Gren, Groth, & Sylven, 1995) *
	Recreation	208.01	208.01	(Kreutzwiser, 1981)
	Recreation	209.51	209.51	(Lant & Roberts, 1990) *
	Recreation	648.57	4,203.82	(Whitehead, 1990)
	Waste	141.56	141.56	(Wilson, 2005) *
	Waste	67.02	67.02	(Breaux, Farber, & Day, 1995)
	Waste	1,050.34	1,050.34	(Brenner Guillermo, 2007) *
	Waste	170.05	170.05	(Gren & Söderqvist, 1994) *
	Waste	35.20	35.20	(Gren et al., 1995) *
	Waste	551.02	551.02	(Jenkins et al., 2010)
	Waste	209.51	209.51	(Lant & Roberts, 1990) *
	Waste	5,027.28	5,027.28	(Meyerhoff & Dehnhardt, 2004) *
	Waste	10,881.15	10,881.15	(Lui, 2006)
	Water	1,934.84	2,407.52	(Brenner Guillermo, 2007) *
	Water	622.77	622.77	(Creel & Loomis, 1992)
	Water	18.19	18.19	(Folke & Kaberger, 1991) *
	Water Flows	3,741.87	3,741.87	(Brenner Guillermo, 2007) *
	Water Flows	3,920.69	3,920.69	(Leschine et al., 1997)
	Water Flows	4,329.70	4,329.70	(UK Environment Agency, 1999)
Urban Open Space	Aesthetic	1,006.06	1,322.31	(Qiu, Prato, & Boehrn, 2006)
	Air Quality	32.46	32.46	(G. McPherson, Scott, & Simpson, 1998)
	Air Quality	192.35	192.35	(G. E. McPherson, 1992)

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/acre/year	Source Study
	Climate	1,134.38	1,134.38	(G. E. McPherson, 1992)
	Extreme Events	315.52	597.01	(Streiner & Loomis, 1995)
	Water Flows	8.32	8.32	(G. E. McPherson, 1992)
	Water Flows	138.22	187.58	(The Trust for Public Land, 2010)
Urban Other	Climate	420.95	420.95	(Brenner Guillermo, 2007) *
	Recreation	2,670.74	2,670.74	(Brenner Guillermo, 2007) *
	Water Flows	7.61	7.61	(Brenner Guillermo, 2007)

All values are adjusted for inflation to 2015 dollars.

* Indicates source is from the TEEB database.