FERC Routinely Ignores the Economic Costs of Pipeline and Compressor Infrastructure Projects

FERC's section 7 duty to consider the public interest is broader than promoting a plentiful supply of cheap gas. (*See Fla. Gas Transmission Co. v. FERC,* 604 F.3d 636, 649 (D.C. Cir. 2010)). Rather, FERC must ensure "the [public] benefits of the proposal outweigh the adverse effects on other economic interests." *AES Ocean Express, LLC,* 103 F.E.R.C. ¶ 61,030 at ¶ 19.

Despite this clear mandate, FERC routinely ignores documented economic harms anticipated from proposed pipelines, while accepting at face value company claims of benefit. As Dr. Spencer Phillips, Ph.D. articulates, FERC's policy that guides its review of pipeline economics "is completely inadequate for evaluating the costs and benefits of proposed pipelines."[1]

- First, FERC's stated policy is for the applicant to provide information that supports FERC's approval. By asking only for information **supporting a foregone conclusio**n, FERC fails to subject pipeline applications to a full, rigorous, or economically adequate examination of the proposals.
- Second, FERC relies almost **exclusively on cost and benefit information supplied by applicants** and their consultants, who have – and act upon – their self-interest by presenting inflated estimates of benefits and greatly discounted estimates of costs. As most recently demonstrated by the Atlantic Coast Pipeline[2] (*FERC Docket No. CP15-554*), Mountain Valley Pipeline[3] (*FERC Docket No. CP16-13*), PennEast Pipeline[4] (*FERC Docket No. CP15-558*), Millennium Eastern System Upgrade Project[5] (*FERC Docket No. CP16-486*), Atlantic Sunrise pipeline[6] (*FERC Docket No. CP15-138*), and Adelphia Gateway Project (*FERC Docket Nos. CP18-46*)[7] FERC's NEPA review relies almost entirely on the information provided by the applicant and as a result, provides no serious consideration of the costs of pipeline construction, operation and maintenance.

Property Value Costs and Lost Tax Revenues Are Significant and Ignored

Some of the important costs that pipeline applicants and FERC fail to consider include:

- Reductions in private property values along the length of pipelines and extending

[1] Economic Harms Attachment 1, Testimony of Dr. Spencer Phillips, People's Hearing Investigating FERC Abuses of Law & Power, December 2, 2016.
[2] Economic Harms Attachment 2, Key-Log Economics, LLC, *Economic Costs of the Atlantic Coast Pipeline*, February 2016.
[3] Economic Harms Attachment 3, Key-Log Economics, LLC, *Economic Costs of the Mountain Valley Pipeline*, May 2016.
[4] Economic Harms Attachment 4, Key-Log Economics, LLC, *Economic Costs of the PennEast Pipeline*, January 2017.
[5] Economic Harms Attachment 5, Key-Log Economics, LLC, *Economic Costs At a Glance of the Millennium Eastern System Upgrade Project*, Publication of Full Report Pending.
[6] Economic Harms Attachment 7, Key-Log Economics, LLC, *FERC's Approval Based on Incomplete Picture of Economic Impacts*, March 2017
[7] Economic Harms Attachment 9, Key-Log Economics, LLC, *The Social Cost of Carbon of the Adelphia Gateway Project*, February 2019.

outward through the right-of-way, the "high consequence area," and the evacuation zone. These reductions in property value translate into a reduction in the property taxes collected by local governments. These property value reductions can be significant:

→ construction and operation of the Penneast Pipeline, for example, would result in a loss of property value of $159.7 to $177.3 million resulting in a $2.7 to $3.0 million loss in property tax revenue annually[8];

→ construction and operation of the Mountain Valley Pipeline would result in losses of $42.2 to $53.3 million in property value (resulting in losses ranging from $243,500 to $308,400 tax revenue annually).[9]

- Reductions in property value are not limited to pipelines; compressor stations were responsible for a 25-50% reduction of property assessments for homes in Hancock, NY.[10]

Credible, independent research shows that pipelines do in fact have significant negative effects on property values. See "Claims That Pipelines Do Not Harm Property Value Are Invalid" beginning on page 20 of Key-Log Economics' report on the Millennium Eastern System Upgrade project.[11] And yet, FERC routinely cites fundamentally flawed, industry-sponsored studies that claim there is no such property value effect, ignoring the independent data and real world experiences to the contrary.

Environmental, Business, Farming, and Other Economic Costs are Far Reaching, Staggering, and Ignored

Additional costs resulting from pipeline construction, operation, and maintenance that are ignored by FERC include:

- Loss of water purification, water storage, air quality benefits, flood protection, aesthetic quality and wildlife habitat, are among the costs that are ignored. These benefits are lost, minimized and/or significantly reduced when land uses/land covers like forests, wetlands, natural meadows, and natural open space that produce these benefits at a high rate are converted to pipeline associated industrial operations and/or shrub/scrub that produce far less, and frequently no, natural benefits.
- Economic harms such as reduced crop production for farmers, adverse impacts to businesses along or near the pipeline right of way, and adverse impacts to ecotourism and related businesses and jobs.
- Forgone economic development opportunity from recreationists, tourists, retirees, entrepreneurs, and workers who will choose safer, more environmentally healthy, and more aesthetically pleasing locations the ones associated with construction and operation of the proposed pipeline/compressor.
- Social Cost of Carbon resulting from upstream and downstream greenhouse gas emissions that are facilitated by additional natural gas transmission

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[8] Economic Harms Attachment 4, Key-Log Economics, LLC, *Economic Costs of the PennEast Pipeline*, January 2017.

[9] Economic Harms Attachment 3, Key-Log Economics, LLC, *Economic Costs of the Mountain Valley Pipeline*, May 2016.

[10] Economic Harms Attachment 6, Catskill Citizens, Press Release, *Proximity of Compressor Station Devalues Homes by as Much as 50%*, July 7, 2015.

[11] Economic Harms Attachment 5, Key-Log Economics, LLC, *Economic Costs of the Millennium Eastern System Upgrade Project*, April 2017.

These costs can be significant and staggering:[12]

Table 1: Summary of Cost Estimates for Several Proposed Interstate Natural Gas Transmission Projects.

Estimated impacts (costs)	Atlantic Coast Pipeline[a]	Mountain Valley Pipeline[b]	PennEast Pipeline[c]	Atlantic Sunrise Pipeline[d]	Millennium Eastern System Upgrade[e]
Lost Property Value (one-time cost)	$57.8 - 83.0 million	$43.7 - 55.2 million	$165.1 - 183.4 million	Not Estimated	$2.1 million
Lost Property Tax Revenue (Annual loss for the life of the project)	$0.29 - 0.42 million	$.25 - 0.32 million	$2.8 - 3.1 million	Not Estimated	$0.0376 million
Lost Ecosystem Service Value during Construction (one-time)	$17.5 - 63.2 million	$23.6 - 85.0 million	$6.5 - 22.8 million	$6.3 - 23.1 million	Not Estimated
Lost Ecosystem Service Value during Operation (annual)	$5.0 - 18.4 million	$4.2 - 15.3 million	$2.5 - 9.3 million	$3.0 - 11.4 million	Not Estimated
Forgone Economic Development[f] (annual)	$51.3 million 387 jobs	$136.9 million 1,164 jobs	$537.6 million 4,090 jobs	Not Estimated	$85.3 million 745 jobs
Social Cost of Carbon[g] (annual)	Not Estimated	Not Estimated	$301.8 - 2,339.0 million	$466.5 - 3,615.1 million	$51.8 - 434.5 million
Lifetime costs in Present Discounted Value	$9.5 - 11.8 billion	$23.7 - 25.8 billion	$14.5 - 60.3 billion[h]	$22.2 - 95.1 billion[h]	$4.9 - 19.5 billion

FERC Accepts Exaggerated Pipeline Benefits as the Basis for Decisionmaking

Pipeline companies seeking FERC approval typically claim that construction of their project will result in positive economic impacts, job creation, increases in personal income, and lower end-user energy costs for natural gas and/or for electricity generated in gas-fired power plants that will

[12] See table from Economic Harms Attachment 8, Key-Log Economics, LLC, Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines and FERC Docket No. PL18-1, *Economic Costs of the Atlantic Coast Pipeline*, July 23, 2018.

spur further economic development. However, independent expert analyses submitted to FERC consistently find these claims to be exaggerated or entirely false.

For example, in a thorough, retrospective, statistical analysis of the experience of the region affected by the Marcellus Shale-based boom in natural gas availability and natural gas pipeline construction since 2000, Key-Log Economics found that, despite claims that increased pipeline capacity drives down electricity prices, electricity prices have instead increased during the Marcellus Shale boom:[13]

> From 2001 through 2015—a period encompassing the beginning of the Marcellus Shale gas boom—the total natural gas transmission capacity available in the Marcellus region increased from 20,195 million cubic feet per day (Mmcfd) in 2001 to 1,098,894 Mmcfd. That is an increase of more than 5,300%. If the contentions that increased pipeline capacity drives down electricity prices were true, we would expect to see dramatically lower electricity prices during this same period. What we observe, however, is the opposite: total electricity prices (including residential, commercial, and industrial customers for utilities), have increased from an average of 69.62$/MWh in 2001 to 98.80$/MWh in 2015 (in inflation-adjusted 2017$)—a 42% increase. For residential customers, the price increase was 36%, from 86.65$/MWh in 2001 to 118.12 $/MWh in 2015 (in 2017 $). During the same time period, however, the average price of natural gas to end users (i.e. "distribution price") did fall from $9.04/Mcf to $4.80/Mcf (in 2017$).

Despite clear evidence dispelling pipeline companies' claims of economic benefits, FERC accepts their claims at face value as the basis for its public interest determination.

FERC Refuses to Consider the Social Cost of Carbon in Its Pipeline Analysis

FERC fails to use readily available tools to quantify the public costs of the projects it reviews in order to ensure "projects that 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" (88 FERC 61,227, p. 23). Among the most significant and calculable residual adverse effects resulting from fracked gas infrastructure projects are the incremental economic impacts of incremental greenhouse gas (GHG) emissions.

The United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit) in *Sierra Club, et al. v FERC*, 867 F.3d 1357, (D.C. Cir., Aug. 22, 2017), found that FERC is required to consider and quantify the downstream greenhouse gas ("GHG") emissions from the combustion of the natural gas transported by a project as part of their National Environmental Policy Act review. In light of the recent D.C. Circuit's decision, FERC must:

- quantify pipeline projects' emissions combined with past, present, and reasonably foreseeable future gas projects in the region;
- and adopt appropriate mitigation measures in recognition of the past, present, reasonably foreseeable future gas projects in the region to reduce the severity of cumulative impacts from the project.

[13] Economic Harms Attachment 8, Key-Log Economics, LLC, Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines and FERC Docket No. PL18-1, *Economic Costs of the Atlantic Coast Pipeline*, July 23, 2018.

The social cost of carbon (SCC), "a measure, in dollars, of the long-term damage done by a ton of carbon dioxide (CO2) emissions in a given year,"[14] is an available and appropriate tool that would allow FERC to measure economic impacts of climate change that would result from proposed pipelines as required by NEPA and the NGA.

Despite the fact that a federal court recently upheld the legitimacy of using the social cost of carbon as a viable statistic in climate change regulations,[15] and that the CEQ had recommended its use in its final guidance for federal agencies to consider climate change when evaluating proposed Federal actions,[16] the Commission continues to contend that it "'has not identified a suitable method' for determining the impact from the Projects' contribution to climate change and, absent such a method, it simply 'cannot make a finding whether a particular quantity of [GHG] emissions poses a significant impact on the environment and how that impact would contribute to climate change.'"[17]

However, as Commissioners Glick and LaFleur have pointed out in response to multiple recent certificate order decisions, FERC is incorrect in its claims that there is **"**no widely accepted standard to ascribe significance to a given rate or volume of GHG emissions"[18] and that "it cannot 'determine how a project's contribution to GHG emissions would translate into physical effects on the environment.'"[19]As Commissioner Glick explains[20]:

> "That is precisely what the Social Cost of Carbon provides. It translates the long-term damage done by a ton of carbon dioxide into a monetary value, thereby providing a meaningful and informative approach for satisfying an agency's obligation to consider how its actions contribute to the harm caused by climate change."[21]

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[14] EPA Fact Sheet, Social Cost of Carbon, December 2016, retrieved from: https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

[15] Susanne Brooks, Environmental Defense Fund, *In Win for Environment, Court Recognizes Social Cost of Carbon,* August 29, 2016.

[16] Final Guidance on Greenhouse Gases and Climate Change, Council on Environmental Quality, August 2016.

[17] Statement of Commissioner Richard Glick on Texas Eastern Transmission, LP, FERC Docket No. CP18-10, July 19, 2018.

[18] *Id.* P 27. *Florida Southeast Connection, LLC,* 162 FERC ¶ 61,233, at 2, 5–8 (2018) (Glick, Comm'r, dissenting).

[19] Statement of Commissioner Cheryl A. LaFleur on Texas Eastern's Texas Industrial Market Expansion Project, FERC Docket No. CP18-10, July 19, 2018 referencing Texas Eastern Certificate Order at P 33.

[20] Statement of Commissioner Richard Glick on Northwest Pipeline, LLC, FERC Docket Nos. CP17-441-000, CP17-441-001, July 19, 2018. See also Texas Eastern Transmission, LP, July 19, 2018, Docket No.: CP18-10-000; partial dissent on on Columbia Gas Transmission, L.L.C., July 19, 2018, Docket No.: CP17-80-000; July 19, 2018, Docket No.: CP17-80-000; partial dissent of the Northwest Pipeline certificate order.

[21] *Id.* at 5 (Glick, Comm'r, dissenting) (citing cases that discuss the Social Cost of Carbon when evaluating whether an agency complied with its obligation under NEPA to evaluate the climate change impacts of its decisions).

> "the Commission has the tools needed to evaluate the Projects' impacts on climate change. It simply refuses to use them."[22]

The SCC for pipeline projects, conservatively estimated, can run into tens of billions of dollars over their designed lifetime of a pipeline. Key-Log Economics recently calculated that the additional 325 million cubic feet of natural gas capacity per day created by the Adelphia Gateway Project translates to 6.3 million metric tons of CO_2 equivalent in GHG in each year of operation. Using a range of conservative discount rates, the SCC of the project over 30 years of operation ranges from $300 million to $40 billion.[23]

Key-Log Economics has also calculated staggering SCC estimates resulting from pipeline projects each year:

- The PennEast Pipeline would result in SCC costs of $301.8-2.3 billion annually.[24]
- The Atlantic Sunrise Pipeline would result in a SCC of $466.5 million to $3.6 billion each year.[25]
- The Millennium Eastern System Upgrade would impose $51.8 – 343.5 million in SCC annually.[26]

Despite the clear mandates from NEPA, the Natural Gas Act, and the Courts, FERC continues to illegally narrow its consideration of the adverse societal impacts of pipelines, compressors and related infrastructure in its decisionmaking.

FERC Lacks the Economic Expertise to Remedy Its Economic Failings

It is also important to note that FERC's reliance on pipeline applicants to provide information about the need for, as well as the benefits and costs of, their proposals is exacerbated by FERC's lack of capacity to review and filter the economic information they receive, let alone to conduct analyses of its own. The Office of Energy Projects (OEP), whose "mission…is to foster economic and environmental benefits for the nation through the approval and oversight of hydroelectric and natural gas pipeline energy projects that are in the public interest".[27] has no economists among its staff.[28] The Office of Energy Policy and Innovation, which otherwise collaborates with other FERC offices to evaluate industry proposals, does not support OEP by providing any economic review and analysis of pipeline certification projects.[29]

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[22] Statement of Commissioner Richard Glick on Mountain Valley Pipeline, LLC , FERC Docket Nos. CP16-10-000 and CP16-13-000, June 15, 2018.

[23] Economic Harms Attachment 9, Key-Log Economics, LLC, *The Social Cost of Carbon of the Adelphia Gateway Project*, February 2019.

[24] See Economic Harms Attachment 4, Key-Log Economics, LLC, *Economic Costs of the PennEast Pipeline*, January 2017.

[25] Economic Harms Attachment 7, Key-Log Economics, LLC, *FERC's Approval Based on Incomplete Picture of Economic Impacts*, March 2017

[26] Economic Harms Attachment 5, Key-Log Economics, LLC, *Economic Costs of the Millennium Eastern System Upgrade Project*, April 2017.

[27] FERC, Office of Energy Projects, Updated March 20, 2017, available at https://www.ferc.gov/about/offices/oep.asp

[28] 2017 FERC Employee Phone Directory, available at https://www.ferc.gov/contact-us/tel-num/phone.pdf

[29] Personal communication of Dr. Spencer Phillips (Key-Log Economics) with OEPI's Administrative Officer, March 17, 2017.

It does not seem plausible that an agency responsible for evaluating the economic merits of energy project proposals could do so without benefit of qualified economic expertise. Indeed, as we have noted above and as is detailed in the attachments listed below, FERC has not provided adequate review of the economic costs and benefits of pipelines. The predictable result will be too much pipeline capacity, too many environmental and other external costs, and a loss of economic vitality for American people and communities.

Attachments:

Economic Harms Attachment 1, Testimony of Dr. Spencer Phillips, People's Hearing Investigating FERC Abuses of Law & Power, December 2, 2016.

Economic Harms Attachment 2, Key-Log Economics, LLC, *Economic Costs of the Atlantic Coast Pipeline*, February 2016.

Economic Harms Attachment 3, Key-Log Economics, LLC, *Economic Costs of the Mountain Valley Pipeline*, May 2016.

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Complete People's Dossier: FERC's Abuses of Power and Law

available at http://bit.ly/DossierofFERCAbuse

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 1, Testimony of Dr. Spencer Phillips, People's Hearing Investigating FERC Abuses of Law & Power, December 2, 2016.

KEY-LOG. economics LLC

Research and strategy for the land community.

Statement of Spencer Phillips, Ph.D.

to the

People's Hearing Investigating FERC

Washington, DC
December 2, 2017

My name is Dr. Spencer Phillips, and I am a natural resource economist with more than 25 years' experience in the field. My colleagues and I have examined the economics of several proposed interstate natural gas pipelines as well as how well (or not) FERC has done its job to consider those economic effects. We have found that FERC's pipeline certification policy suffers from failures of design and execution that guarantee that the American people will be saddled with an economically inefficient and environmentally unsustainable excess of pipeline capacity.

Common sense and fundamental tenets of economics tell us that an action is worthwhile if and only if the benefits outweigh the cost. U.S. environmental policy requires that "cost" include the foreseeable negative consequences stemming from damage to ecosystems.

FERC's pipeline certification policy does make a nod in this direction; it requires pipeline companies to demonstrate that their proposals benefit the public without imposing uncompensated "residual adverse effects" on affected communities. Beyond that whiff of good intention, however, FERC's policy is completely inadequate for evaluating the costs and benefits of proposed pipelines. Here's why:

- First, FERC's process is plagued by confirmation bias. FERC's stated policy is for the applicant to provide information that supports FERC's approval. By asking only for information supporting a foregone conclusion, FERC fails to subject pipeline applications to a full, rigorous, or economically adequate examination of the proposals.
- Second, FERC relies almost exclusively on cost and benefit information supplied by applicants and their consultants, who have–and act upon–their self-interest by

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presenting inflated estimates of benefits and greatly discounted estimates of costs. In the cases we have reviewed (ACP, MVP, PennEast, Millennium ESU), the applicants provide no serious consideration of any costs at all.

Some of the important costs that pipeline applicants and, by extension, FERC fail to consider include:

- Reductions in private property value along the length of pipelines and extending outward through the right-of-way, the "high consequence area," and the evacuation zone. (Applicants and FERC cite fundamentally flawed, industry-sponsored studies that claim there is no such effect. Credible, independent research shows that pipelines do have significant negative effects on property values.)
- Lost natural benefits like water filtration, aesthetic quality, wildlife habitat, and food production.
- Forgone economic development opportunity as recreationists, tourists, retirees, entrepreneurs, and workers choose safer, more environmentally healthy, and more aesthetically pleasing locations.

These costs can be significant and staggering:

- For the Atlantic Coast Pipeline, where we estimated these costs for just a fifth of the ACP's proposed 500+ mile length, these costs total between $6.9 and $7.9 billion.
- For the Mountain Valley Pipeline, we looked at the region impacted by half the proposed 300-mile length and estimate between $8 and $8.9 billion in costs.
- And for the PennEast Pipeline, our examination of the whole length (118 miles) reveals external costs of approximately $38 billion.[1]

The results of FERC's flawed policy and subsequent failure to give serious consideration to benefits and costs is predictable, inefficient, and inequitable. There is already more than

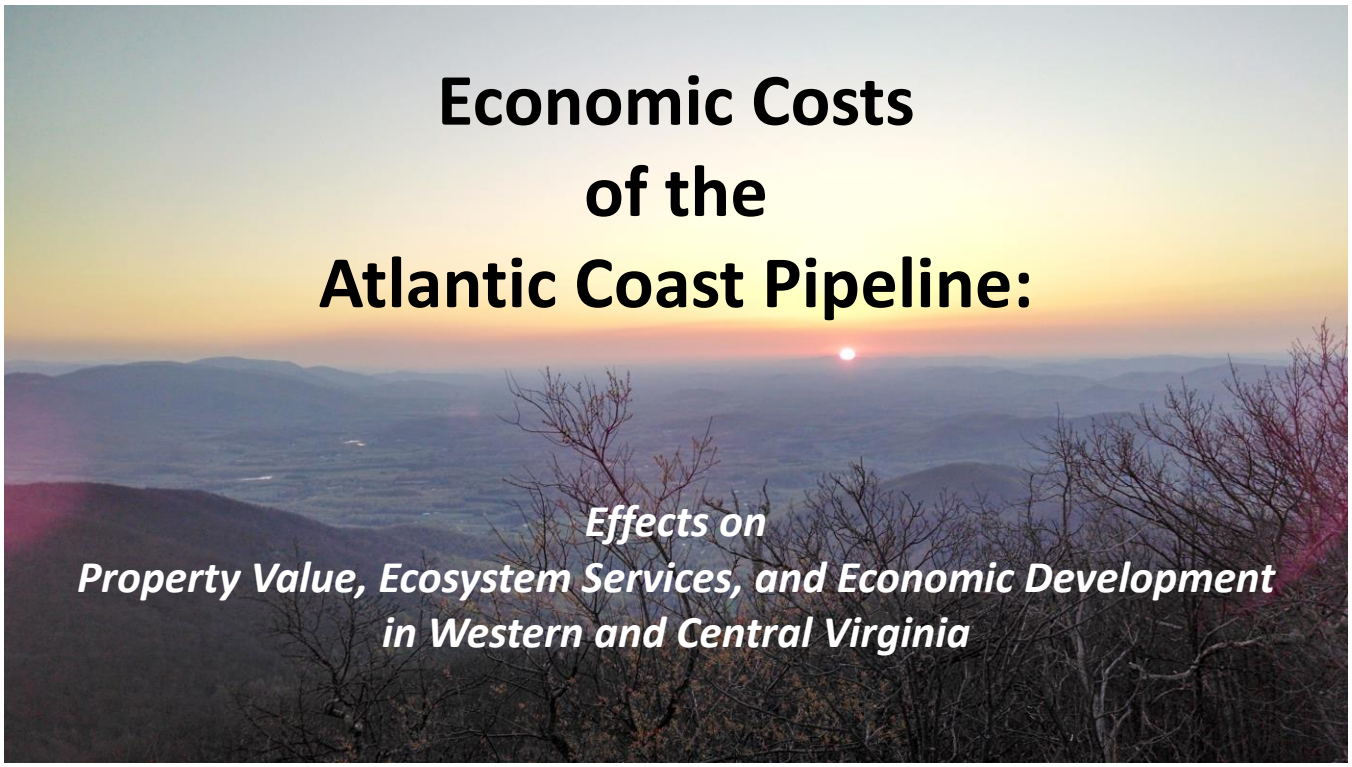
[1] Regional differences in land prices account for much of the difference between these examples. Eastern Pennsylvania and New Jersey are higher cost-of-living areas than rural Virginia and West Virginia.

enough pipeline capacity, and the addition of the PennEast or other pipelines awaiting FERC's foregone approval will only make matters worse. That's the inefficiency.

The outcome is inequitable because pipeline companies will profit as they pass the financial costs of these wasteful projects on to ratepayers while burdening landowners, residents, business owners, and visitors with massive external environmental costs for which there will be no offsetting benefit and little chance for just compensation.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 2, Key-Log Economics, LLC, Economic Costs of the Atlantic Coast Pipeline, February 2016.



Economic Costs of the Atlantic Coast Pipeline:

Effects on Property Value, Ecosystem Services, and Economic Development in Western and Central Virginia

FEBRUARY 2016

UPDATED MAY 2016

Highlanders for Responsible Development

Augusta County Alliance

Friends of Nelson County

Friends of Buckingham, Virginia

Yogaville Environmental Solutions

Prepared by:
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KEY-LOG. economics LLC

Research and strategy for the land community.

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EXECUTIVE SUMMARY*

The Atlantic Coast Pipeline (ACP) is proposed to carry natural gas from the Marcellus Shale through a 564-mile-long swath of West Virginia, Virginia, and North Carolina to markets in Virginia and North Carolina and, potentially, overseas. It has been represented as both environmentally safe and economically beneficial, providing economic opportunity for local communities along the proposed route.

Promised economic benefits, however, are only part of the impact the Federal Energy Regulatory Commission (FERC) must review before deciding whether to approve the construction and operation of the pipeline. Under the National Environmental Policy Act, FERC's review must consider the full range of environmental effects of the proposed pipeline. These include the various ways in which environmental effects would result in changes in human well-being—that is, in economic benefits and costs. While estimates of positive economic effects including construction jobs and local tax payments have been developed and promoted as reasons to move forward with the pipeline, no systematic consideration of the potential negative economic effects—economic costs—of the ACP has been completed.

To help fill the gap in current information, five community groups from a four-county region in central and western Virginia commissioned this independent research into key economic costs of the ACP. This region, comprised of Highland, Augusta, Nelson, and Buckingham Counties, would experience three types of economic costs due to the construction, operation, and presence of the ACP. First, the pipeline would impact property values along the 126 miles of pipeline proposed for the region. Affected properties are those touched by the 75-foot-wide right-of-way, within the 1.4-mile-wide evacuation zone, in proximity to the compressor station proposed for Buckingham County, and throughout the viewshed of the proposed pipeline. Second, construction and the ongoing operation of the pipeline would alter land use/land cover in ways that diminish ecosystem service values, such as aesthetics, water supply, and timber and food production. Third, and in part due to a loss of scenic and quality-of-life amenities, there would be decreases in visitation, in-migration, and small business development and a loss of jobs and personal income those activities would otherwise support.

Considering this four-county region alone, estimated one-time costs range from $72.7 to $141.2 million. These one-time costs comprise lost property value and the value of ecosystem services lost during construction. Annual costs following the construction period include lower ecosystem service productivity in the ACP's right-of-way, lower property tax revenue due to the initial losses in property value, and dampened economic development. These total between $54.8 and $67.8 million per year, and would persist forever. (See "At a Glance," below for details.) Putting the stream of costs into present value terms [1] and adding the one-time costs, the total estimated cost of the ACP in Highland, Augusta, Nelson, and Buckingham Counties is between $4.0 to $4.9 billion. For reasons explained in the body of this report, these are conservative estimates.

The costs represented by the estimates presented here are what economists call "externalities," or "external costs," because they would be imposed on parties other than (external to) the company proposing to build the pipeline. Unlike the private (or internal) costs of the pipeline, external costs borne by the public do not affect the company's bottom-line. From an economic perspective, the presence of externalities is what demands public involvement in decsions about the ACP. Without consideration of all of the costs of the project, too much pipeline (which may mean any pipeline at all) is the inevitable result. FERC must therefore consider the true bottom line and ensure that the full costs of the pipeline, especially those external costs imposed on the public, are rigorously examined and brought to bear on its decision about whether or not to permit the ACP project to proceed.

*This March 2016 update addresses a new report from the Interstate Natural Gas Association of America (INGAA) Foundation Inc., which purports to have found no property value impact from natural gas pipelines. See pages 32-35 of this report for a review of the INGAA study and similar studies.

[1] The present value of a perpetual stream cost is the one-year cost divided by the 1.4% real discount rate recommended by the Office of Management and Budget for cost-benefit and cost-effectiveness analysis of public projects and decisions (http://federalaccounting.org/2015/01/omb-updates-cost-benefit-analysis-discount-rates/).

At a Glance:
The Atlantic Coast Pipeline in Western and Central Virginia
~ Highland, Augusta, Nelson, & Buckingham Counties ~

- Miles of Pipeline: 125.5
- Acres in the construction corridor and permanent right-of-way (ROW): 1,901 and 1,140
- Most impacted land cover types (ROW only): forest (795 acres) and pasture (247 acres)
- Parcels touched by ROW: 521
- Parcels in the 1.4-mile-wide evacuation zone: 6,148
- Parcels within one half mile of the compressor station: 87
- Residents and housing units in the evacuation zone: 15,128 people and 8,762 homes
- Parcels from which the pipeline would be visible: 31,117, or 29% of all parcels in the four-county study region
- Baseline property value at risk (and expected one-time cost due to the ACP):
  - In the ROW: $277.1 million ($11.6 to $36.0 million)
  - In the evacuation zone: $1.13 billion ($43.0 million)
  - Near the compressor station: $4.9 million ($1.2 million)
  - In the viewshed: $7.44 billion (to avoid double counting with lost aesthetic value under ecosystem services, this impact is not separately estimated)
- Total property value lost: $55.8 to $80.2 million
- Resulting loss in property tax revenue (annual): $281,300 to $408,400
- Lost ecosystem service value, such as for water and air purification, recreational benefits, and others:
  - Over the two-year construction period: between $16.9 and $61.0 million (a one-time cost)
  - Annually for the life of the ACP: between $4.9 and $17.8 million
- Lost economic development opportunities due to the erosion of these Counties' comparative advantages as attractive places to visit, reside, and do business. Under the scenarios described below, these could include:
  - Annual loss of recreation tourism expenditures of $41.3 million that supports 387 jobs and $7.4 million in payroll and generates $1.8 million in state and $1.3 million in local taxes
  - Annual loss of personal income of $6.6 million due to slower growth in the number of retirees
  - Annual loss of personal income of $1.6 million due to slower growth in sole proprietorships
- One-time costs (property value and ecosystem services during construction) would total between $72.7 and $141.2 million
- Annual costs (all other costs above) would range from $54.8 to $67.8 million

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ABBREVIATIONS AND TERMS

ACP: Atlantic Coast Pipeline. For this report, this generally refers to the pipeline corridor itself as well as the compressor station proposed for Buckingham County.

ACP LLC: Atlantic Coast Pipeline, LLC, an entity formed by Dominion Resources, Inc., Duke Energy Corporation, Piedmont Natural Gas Co., Inc., and AGL Resources, Inc. to develop, own, and operate the proposed Atlantic Coast Pipeline (ACP)

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

DTI: Dominion Transmission, Inc., the entity that would build and operate the proposed ACP under contract to ACP LLC

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 Atlantic Coast Pipeline

FERC: 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)

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

AUTHORS' NOTE:

We are grateful for the assistance the sponsoring organizations (Highlanders for Responsible Development, Augusta County Alliance, Friends of Nelson County, Yogaville Environmental Solutions, and Friends of Buckingham Virginia) have provided in identifying local information sources and making contacts in the study region. Key-Log Economics however, remains solely responsible for the content of this report, the underlying research methods, and the conclusions we draw from them.

BACKGROUND

The proposed Atlantic Coast Pipeline (ACP) is a high-volume transmission pipeline intended, as described in filings with the Federal Energy Regulatory Commission (FERC), to transport 1.5 billion cubic feet (bcf) per day of natural gas from the Marcellus Shale region in West Virginia to power generation facilities, natural gas distributors, and commercial and industrial end users in Virginia and North Carolina (Natural Resource Group, 2015c).[2] Atlantic Coast Pipeline, LLC, would control the pipeline, while permit applications, construction, and operations would be managed by Dominion Transmission, Inc. (DTI).

The majority of the pipeline, and all of it in the four-county region considered in this study (Figure 1), would consist of 42-inch diameter pipe and would be operated at a pressure of 1,440 pounds per square inch gauge (PSIG). This pressure would be maintained by three compressor stations, including one proposed for Buckingham County, Virginia, which is part of the study region (Natural Resource Group, 2015c).

Along the way, the ACP would cross portions of the Monongahela and George Washington National Forests, Blue Ridge Parkway, the Appalachian Trail, and other public conservation, scenic, and natural areas. Its permanent right-of-way and temporary construction corridor—75 and 125 feet wide, respectively—would also cross thousands of private properties. Pipeline leaks and explosions could cause substantial physical damage and require evacuation of even wider swaths, affecting perhaps 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 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, such negative effects and estimates of their attendant economic costs have not received much attention in the otherwise vigorous public debate surrounding the ACP proposal. This report, commissioned jointly by five community groups[3] located in central and western Virginia is both an attempt to understand the nature and potential magnitude of the economic costs of the ACP in a particular four-county area, 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 ACP along its entire length and, by extension, throughout the region in which its effects will occur.

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[2] While pipeline backers maintain that the gas transported via the ACP would not be for export, the pipeline would add to overall national gas transmission capacity and thus would serve to free up more gas for export at Dominion Cove Point LNG LP's newly approved liquefied natural gas export facility in Calvert County, Maryland.

[3] These are, from west to east, Highlanders for Responsible Development, Augusta County Alliance, Friends of Nelson County, Yogaville Environmental Solutions, and Friends of Buckingham Virginia.

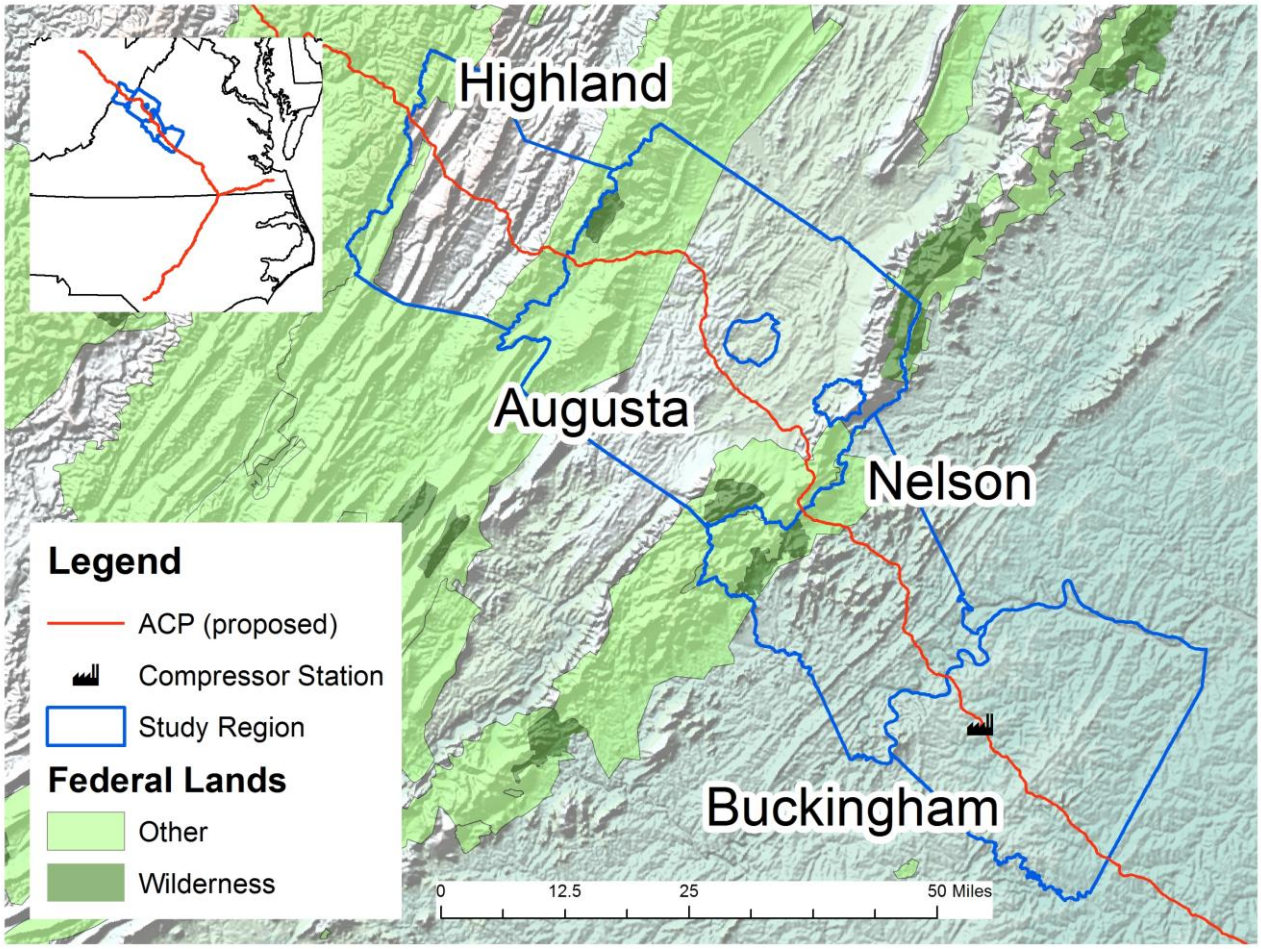

Figure 1: Four-County Study Region.

Note: Augusta County includes the independent cities of Staunton and Waynesboro

Sources: ACP route and compressor digitized from interactive map, Dominion Resources Inc. http://dom.maps.arcgis.com/, and Resource Report 1: Appendix A, Topographic Route Maps (Natural Resource Group 2015); Study Region (counties); federal lands, and hill shade from USGS and http://nationalmap.gov/small_scale/

Policy Context

Before construction can begin, the ACP must be approved by 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 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), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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 approval or not of the ACP – necessarily balance or even compare benefits and costs. NEPA is not a decision-making law, but rather a law that requires decisions be supported by as full as possible an 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.

In addition to the requirements of NEPA, FERC's own policy regarding the certification of new interstate pipeline facilities (Docket No. PL99-3-000) requires that 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]" (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 principal, this policy 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 total cost, including external costs. The policy's guidance regarding what adverse effects must be considered and how they are measured is deeply flawed, however. The policy states, for example, that "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," the third of which include communities through which the proposed pipeline would pass (Hoecker et al., 1999, p. 26). In effect, the Commission's policy contends that the only adverse effects that matter are those that affect owners of properties in the right-of-way. Even for a policy adopted in 1999, this contention is completely out of step with then current understanding of the economic effects of development that alters the natural environment.

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

[4] Dominion Resources and Dominion Transmission Inc. have published estimates of economic benefits in the form of employment and income stemming from the construction and operation of the ACP. As has been well documented elsewhere, both studies suffer from errors in the choice and application of methods and in assumptions made regarding the long-run economic stimulus represented by the ACP. 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 (2015b) and Stanton et al. (2015) for details on these shortcomings.

for which the full costs are greater than the public benefits they would actually provide. Indeed, FERC has never rejected a pipeline proposal (van Rossum, 2016).

With ACP LLC having failed to acquire a sufficient portion of the right-of-way and with the need for other federal agencies, including the US Forest Service, to evaluate how the ACP would affect resources under its stewardship, the Commission issued a Notice of Intent to prepare an EIS in February of 2015 (Federal Energy Regulatory Commission, 2015). The process began with a series of scoping meetings at which members of the public could express their thoughts on the pipeline in general 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. FERC received more than 1,600 individual comment letters, another 1,239 form letters, and several petitions bearing multiple signatures each.[5]

Much of what FERC heard from citizens echoed and expanded upon the list of potential environmental effects listed in its Notice of Intent. Of those, several are particularly important as the sort of environmental effects that resonate in the lives of people. These effects can take the form of external economic costs that would be borne by individuals, businesses, and communities throughout the landscape the ACP would traverse. Table 1 lists these key issues along with the number of scoping letters from residents of Highland, Augusta, Nelson, and Buckingham County who mentioned the issue.

FERC also received input about both the legal and economic importance of considering the economic consequences of these environmental effects along with recommendations of the type and scope of economic analysis that should be undertaken to quantify, to the extent possible, the magnitude of the economic costs (see Phillips, 2015, for example). DTI responded to this input in a letter to FERC arguing against such analysis, stating "because there is no commonly accepted methodology to weigh the economic benefits of the ACP against possible environmental, health, and safety risks using all possible positive and negative externalities, the economic impact assessment can only address tangible economic benefits of the ACP using known variables and economic modeling" (Woolard & Natural Resource Group, 2015, p. 58).

Contrary to DTI's claim, experts in the fields of natural resource, agricultural, environmental, and ecological economics have been developing, testing, and improving such methods since the 1960s (and the underlying economic models have been established for even longer). Textbooks such as *The Benefits of Environmental Improvement: Theory and Practice* (Freeman III, 1979) or *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment* (Kopp & Smith, 1993) plus many thousands of peer-reviewed papers and other resources provide ample documentation of the methods

[5] While the NEPA's scoping phase is intended to generate guidance for the lead agency (FERC) on how to conduct the EIS and is not intended as a referendum, FERC nevertheless has heard opinions in support of the pipeline, and, as it turns out, many more opinions in opposition to the pipeline. Pipeline opponents cite a variety of concerns, including those that are the subject of this report. Key-Log Economics is preparing a full analysis of content of the scoping comments. Using crowd-sourcing, Key-Log Economics has reviewed and coded the content of all 2,875 individual letters, form letters, and petitions submitted to FERC through, and somewhat beyond, its announced formal scoping period. A report summarizing that content as a measure of citizens' level of interest in the issues they have raised and, therefore, those they should most expect FERC to cover in the EIS process, will be released in early 2016.

by which one may estimate the negative externalities and other economic consequences of changes in environmental quality that projects like the proposed ACP would cause.

TABLE 1: Environmental Concerns Raised During FERC Scoping Process

Environmental Issue / Resource Value[a]	Mentions among 1,299 scoping comment letters[b,c]
Impacts on property values, tourism, and recreational resources	521 (property value) 630 (tourism) 381 (recreation)
Safety issues, such as construction and operation of the planned facilities near existing residences, schools, businesses, and military training facilities, and in karst and steep slope terrain	528 (risk of accidents) 467 (general safety) 420 (erosion)
Impacts on forested areas and other vegetation	739 (forested areas, vegetation, habitat, etc.)
Impacts on surface water resources including rivers springs, seeps, and wetlands	812 (waterways) 604 (water quality) 370 (water supply)
Impacts on groundwater resources and wells	370 (water supply)
Impacts on protected species and habitat	404 (wildlife)
Impacts on cultural resources including battlefields, cemeteries, and historic properties	489 (rural character) 240 (culture)
Concerns regarding construction and operational noise, especially related to compressor stations	334 (health) 517 (quality of life) 40 (compressor station)

Notes:

a. This is a partial list of "Currently Identified Environmental Issues" from FERC's Notice of Intent to prepare an Environmental Impact Statement regarding the ACP (Federal Energy Regulatory Commission, 2015, p. 12165).

b. The categories in parentheses are related to the "currently identified environmental issues" listed in the FERC Notice of Intent (Federal Energy Regulatory Commission, 2015, p. 12165).

c. These "mentions" are the number of comment letters written by or on behalf of residents of the study region (Highland, Augusta, Nelson, and Buckingham Counties) that noted or mentioned the listed issue. While detailed analysis of the full set of comments is ongoing, the vast majority of commenters from the study region expressed a belief that the ACP would have a negative impact on the resource/value listed in the first column.

Moreover, precedent from the Tellico Dam, to the Exxon Valdez settlement, to the national forest planning rule and recent guidance from the Council on Environmental Quality (with their emphases on ecosystem services) show that such methods do exist and are useful both for determining the costs of environmental damage and for guiding cost-effective environmental decision-making (Carson et al., 2003; Donovan, Goldfuss, & Holdren, 2015; Randall, 1987; USDA Forest Service, 2012).

The applicant's professed ignorance of established methods for estimating the economic costs of environmental damage perhaps serves "to develop whatever record is necessary" (Hoecker et al.,

1999), for FERC to permit the pipeline, but it does nothing to develop a proper assessment of costs and or to serve the public interest. To ensure an economically efficient use of public and private resources and to meet its obligations under NEPA, FERC must obtain credible estimates of public benefit (which has so far not been demonstrated), develop rigorous estimates of the full suite of costs, and bring both sets of information to bear on its decisions regarding the Atlantic Coast Pipeline.

Study Objectives

Given the policy setting and what may be profound effects of the ACP as proposed on the people and communities of central and western Virginia, 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 ACP.
2. An estimate of the potential magnitude of economic effects in this four-county subset of the landscape where the ACP's environmental and economic effects will be felt.

We do not claim the estimates below represent the total of all of the potential costs that would attend the construction, operation, and presence of the pipeline. Specifically, we have not estimated costs in two categories: "passive-use value,"[6] including the value of preserving the landscape, without a pipeline, for future direct use; and increases in the cost of community services like road maintenance and emergency response that may increase due to the construction and operation of the pipeline.[7]

Therefore, our figures should be understood to be conservative, lower-bound estimates of the true total cost of the ACP in that sub-region and, of course, they do not include costs for the remainder of the region proposed for the ACP. We do urge that the FERC augment the results of this study with its own similar analysis for the entire region and with additional research to determine the costs of community services and other relevant classes of costs not counted here.

[6] 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 ACP, people who have not yet, but who may intend, to travel the Blue Ridge Parkway or attend the Highland Maple festival are better off knowing that the setting for activities is a beautiful aesthetically pleasing landscape. What such visitors would be willing to pay to maintain that possibility would be part of the "option value" of an ACP-free landscape.

[7] As in communities impacted by the shale gas boom itself, 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).

Current Economic Conditions in the Study Region

Our geographic focus is a four-county region comprising Highland, Augusta,[8] Nelson, and Buckingham Counties in Virginia. This 2,480 square-mile region supports diverse land uses, from some of Virginia's wildest forests, the iconic Shenandoah Valley, the heart of Virginia's Blue Ridge traversed by both the Appalachian Trail and Blue Ridge Parkway, thriving cities, international retreat centers, historically and culturally significant human settlements, working farms, and extensive commercial timberland. These natural, cultural, and economic assets are among the reasons more than 150,000 people call this region home and an even larger number visit each year for skiing, sightseeing, music and maple festivals, spiritual retreats, weddings, wine tastings, brewery tours, and other pursuits.

Statistics from the Center for the Study of Rural America, part of the Federal Reserve Bank of Kansas City, further reveal the extent to which the region has 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), more financial wealth in the form of investment income per capita, and stronger entrepreneurship than most Virginia counties (Figure 2).[9]

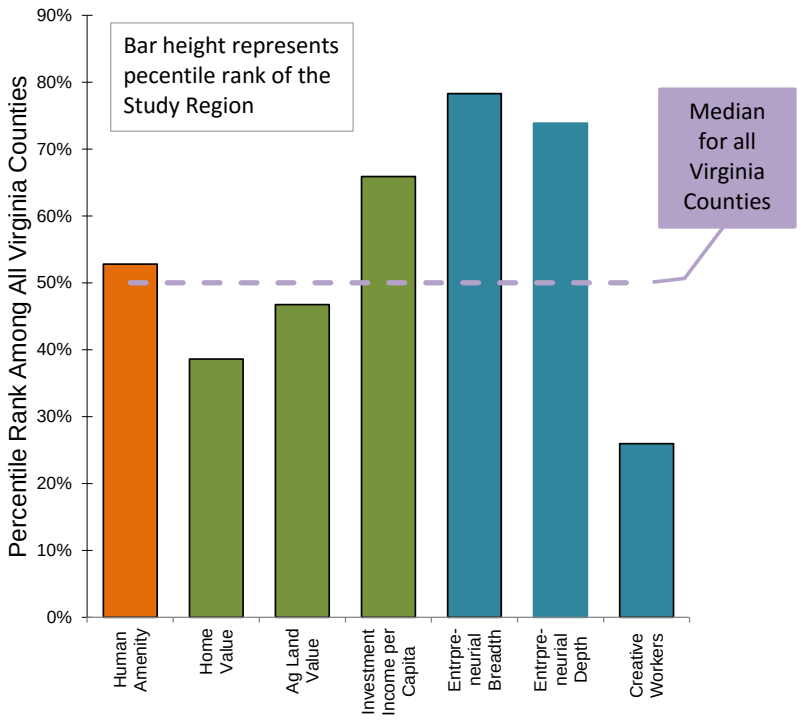

FIGURE 2: Regional Asset Indicators for the Study Region, Relative to All Virginia Counties (Source: Federal Reserve Bank of Kansas City)

More traditional measures of economic performance suggest the region is strong and resilient. From 2000 through 2014, for example:

- Population in the study region grew by 8.5%, compared to a 0.2% loss of population for non-metro Virginia[10]

[8] Two independent cities, Staunton and Waynesboro, lie within the geographic borders of Augusta County. In this report, subject to some limitations where noted, statistics, estimates, and other information labeled as "Augusta County" reflect totals for the County plus the two independent cities.

[9] Note that the 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.

[10] "Non-metro Virginia" comprises those counties that are not a part of a federally defined metropolitan statistical area (MSA). While Augusta is part of the Staunton-Waynesboro-Augusta MSA and Nelson and Buckingham are part of the

- Employment grew by 6.3%, compared to a drop of 6.7% for non-metro Virginia
- Personal income grew by 23.8%, compared to 13.1% for non-metro Virginia
- Earnings per job are higher, by about $2,400/year, than the average for non-metro Virginia
- Per capita income is higher, by $4,000/year, than the average for non-metro Virginia
- Unemployment grew by less and ended the period two points lower than the average for non-metro Virginia.[11]

These and other trends indicate not only that the region has been doing quite well, but also that it is doing well with, and perhaps because of, a relative absence of industrial development like the ACP. The region has what regional economists McGranahan and Wojan have called the "Rural Growth Trifecta" of outdoor amenities, a creative class of workers, and a strong "entrepreneurial context" (innovation-friendliness) (2010). Individual workers, retirees, and visitors are attracted to the natural beauty of the region while entrepreneurs are attracted by the quality of the environment, by the quality of the workforce, and by existing support from local government. Workers, for their part, are retained and nurtured by dynamic businesses that fit with the landscape and lifestyle that attracted them in the first place.

As four further indicators of this dynamic, consider since 2000:

- The region's population growth has been primarily due to in-migration
- The proportion of the population 65 years and older has increased from 15.0% to 17.6%
- Proprietors' employment is up by 28.1%
- Non-labor income (primarily investment returns and age-related transfer payments like Social Security) is up by 45.8%.[11]

These trends suggest that entrepreneurs and retirees are moving to (or staying in) this region. They bring their income, their expertise, and their job-creating energy with them.

Temporary residents – tourists and recreationists – are also an important part of the region's economy. Tourists spent more than $413 million in the study region in 2014. The companies that directly served those tourists employed 3,866 people, or 4.9% of all full- and part-time workers (Headwaters Economics, 2015; Virginia Tourism Corporation, 2015).

It is in this context the potential economic impacts of the ACP must be weighed and the apprehension of the region's residents understood. The region has been doing quite well on the strength of its amenities and quality of life. 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

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Charlottesville MSA, each of the study region counties are predominantly rural in landscape and character and are much more like other non-metro counties than they are like Northern Virginia or Tidewater. Therefore, we believe that averages for non-metro Virginia provide a more appropriate point of comparison than statistics that include the Commonwealth's more urban areas.

[11] These data are from Headwaters Economics (2015), US Bureau of Economic Analysis (2015), and US Bureau of the Census (2014, 2015).

result in a slower rate of growth, which would mean worse economic outcomes than would be expected with a continued absence of a pipeline. For example, if the pipeline is built, business groups Friends of Wintergreen and Nelson 151 identified $75 million in foregone investments and between 200 and 300 new employees who will not be hired (Theiss, 2015). These businesses, which depend on the scenic and other amenities noted above, would simply not have enough business in the form of visitors, diners, skiers, golfers, and others to justify their now-on-hold expansions and new developments.

More dire is the prospect that such businesses will not be able to maintain their current levels of employment. Just as retirees and many business 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.

> ***"Whether they are seeking a retirement home or a weekend retreat, people choose Highland county BECAUSE it doesn't have what people have in other places—over-development, noise, traffic or pollution. They want to get away from all that and be where they can enjoy the peace and beauty of the natural landscape. For my clients, the viewshed, along with the previously mentioned attributes, was a critical driving factor in where they would purchase."***
>
> *– Fran Davenport, retired Realtor*
> *Monterey, Virginia*

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 ACP 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. Potential in-migrants would choose other locations and some long-time residents would move away, draining the region of some of its most productive members. 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.

ENVIRONMENTAL-ECONOMIC EFFECTS AND WHERE THEY WOULD OCCUR

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

First, 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 ACP's construction and operation. Second are effects on property value as owners and would-be owners choose properties farther from the pipeline's right-of-way, evacuation zone, viewshed, or, in the case of the compressor

station, noise. Third and finally are more general economic effects caused by a dampening of future growth prospects or even a reversal of fortune for some industries.

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

Construction of the pipeline corridor itself would require clearing an area 125 feet (38.1 m) wide in most areas and 75 feet (22.9 m) wide in wetlands. After construction, the permanent right-of-way (ROW) would be 75 feet wide along the entire length of the pipeline. It is from within this construction zone and right-of-way that the greatest disruption of ecosystem processes will occur, so it is from these zones that reductions in ecosystem service value (ESV) will emanate. Since we are estimating ecosystem service values at their point of origin, we will focus on this zone in that analysis below. The value of land crossed by the ROW and the somewhat larger number of parcels crossed by the construction zone will be acutely affected.

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" and an even larger evacuation zone. A High Consequence Area (HCA) 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 1,092 feet (332.8 m). 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 3,583 feet (1092.1 m).[12] An explosion would definitely affect ecosystem processes within the HCA, but given the probability of an explosion at any given point along the pipeline at a given time is small, we do not include effects *on ecosystem service value* in this zone in our cost estimates.

Effects on land value are another matter, and it is reasonable to consider land value impacts through both the high consequence area and 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 news reports, YouTube, and other 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 (S. Smith, 2015). Information about pipeline risks translates instantly into buyers' perceptions and, therefore, into the chances of selling a property exposed to those risks, into prices offered for those properties, and, for people who already own such properties, into diminished enjoyment of them.

Along similar lines, compressor stations have been implicated in a variety of illnesses among nearby residents. (Subra, 2009, 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).

[12] See the map (Figure 3) which includes a close-up of these zones near the Augusta-Nelson County line.

These issues have 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). For the estimates of property value effects below, we consider just those properties within one half mile of the proposed compressor station in Buckingham County. Because 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 properties.

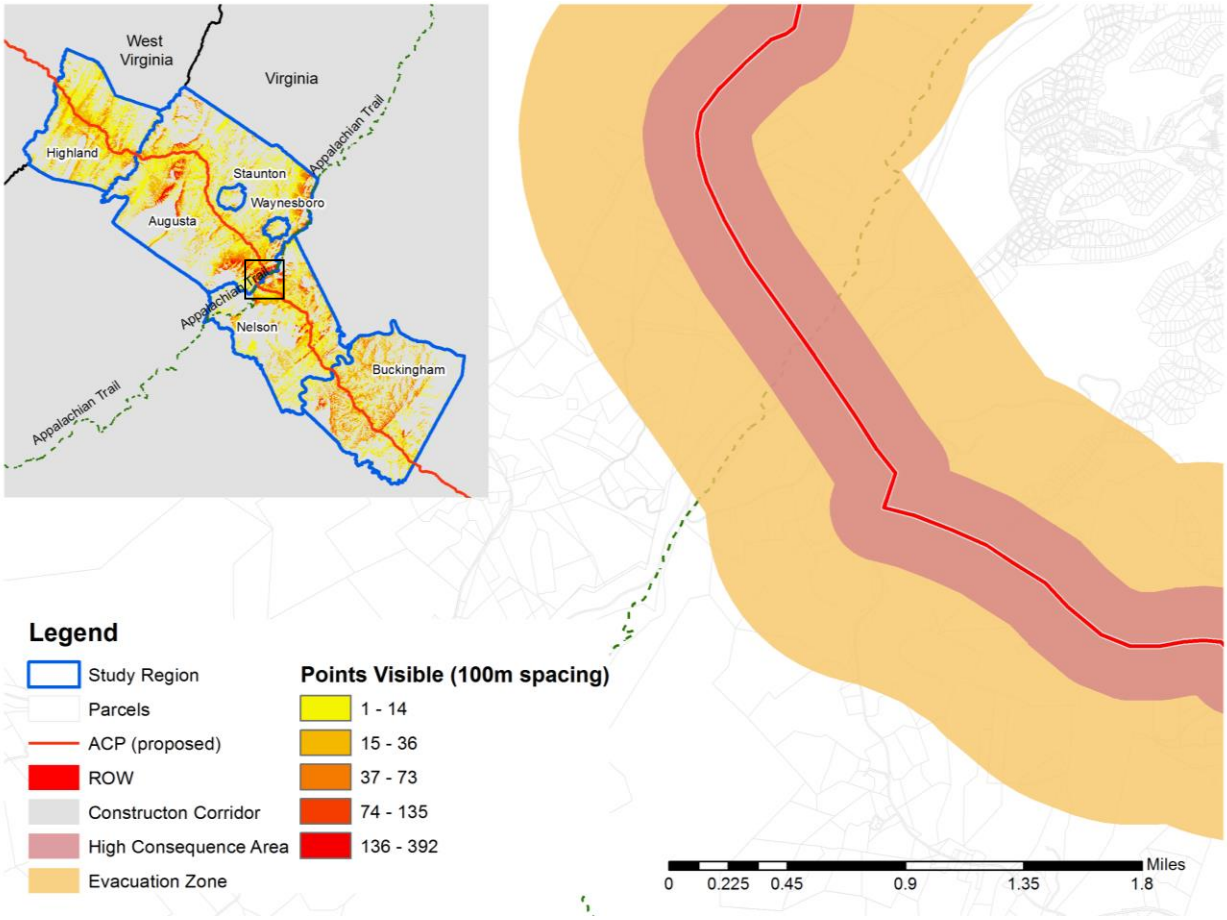

FIGURE 3: Study Region Showing Affected Viewsheds (Inset) and Parcels in Right-of-Way, Construction, High Consequence, and Evacuation Areas.

Sources: ACP route digitized from interactive map, Dominion Resources Inc. (http://dom.maps.arcgis.com/); National Map Study Region (counties) from USGS (http://nationalmap.gov/small_scale/), and Appalachian Trail from the Appalachian Trail Conservancy (http://www.appalachiantrail.org/).

In addition, loss of view quality would be expected for properties both near to and far from the pipeline corridor. Unlike leaks and explosions, view quality impacts will occur with certainty. If the pipeline is built, people will see the corridor as a break in a once completely forested hillside, and their "million-dollar" view will be diminished. Therefore, for our analysis of land value below, we consider any place where there is considerable potential to see the pipeline corridor to be within its direct impact zone.

Beyond the loss of ecosystem services stemming from the conversion of land in the ROW and the loss of property value resulting from the chance of biophysical impacts or the certainty of impacts on aesthetics, the proposed ACP 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 one's scarce vacation time and dollars near the ACP instead of in some other place.

To the extent the ACP causes such decisions to favor other regions, less spending and slower economic growth in the study region would be the result. One would expect a secondary effect of that slower growth on land values, but in this study we consider the primary effects in terms of slower population, employment, and income growth in key sectors. Table 2 summarizes the types of economic values considered in this study and the zones in which they are estimated.

One would also expect economic development effects to spill beyond the county boundaries that define our study region. For example, the Satchidananda Ashram - Yogaville attracts thousands of visitors to the region each year (5,642 in 2014; 3,687 through early August, 2015) from around the world. Based on its own survey of past visitors, leaders there anticipate visits will decrease drastically, perhaps catastrophically if the ACP is built near its campus in Buckingham County. Most of its students, instructors, and other visitors come from out of state, so fewer visits to Yogaville will mean, for example, fewer flights into Charlottesville-Albemarle airport, fewer car rentals, and perhaps fewer side excursions to Monticello or extended stays in the wider region. Such negative economic effects of the pipeline would be felt in Charlottesville and Albemarle County and would be in addition to the direct effects felt by Yogaville and/or within the immediate study region.

The same dynamic would play out if, as business leaders fear, people from outside the study region make fewer trips to Wintergreen for skiing, attend fewer wine tastings or concerts in the Rockfish Valley, skip a stay in the Shenandoah Valley, or make fewer return visits to the Highland Maple festival.

We do not include those outside-the-region effects in the current study. This is a matter of study scoping and budget only, and should not be construed as a suggestion that these and other impacts cease at the Buckingham-Albemarle County line or any other study region boundary. The effects we do include are enumerated and estimated in more detail in the following sections. To recap before proceeding, Table 2 summarizes the geographic extent of the values and analyses included as well as those that should be considered as part of FERC's research agenda to gain an even more complete picture of the proposed ACP's economic effects.

TABLE 2: Geographic Scope of Effects.
A check mark Indicates those zones/effects for which estimates are Included in this study. The "X's" indicate areas for future study.

Values / Effects	Right-of-Way and Construction Zone	High Consequence Area	Evacuation Zone	Com-pressor Station Zone	Pipeline Viewshed	Entire Study Region	The World Beyond the Study Region
Ecosystem Services	✓	a	a		a	✗[a,b]	✗
Land / Property Value	✓[c]	✓[d]	✓[d]	✓	✓[e]	✗	n/a
Economic Develop-ment Effects	f	f	f	f	f	✓	n/a

Notes:

a. Changes in ecosystem services that are 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 of alteration of the ecosystem within the ROW on the productivity of adjacent areas. The ROW, for example provides a travel corridor to invasive species that could reduce the integrity and ecosystem productivity of areas that, without the ACP 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. The reason is that while the compressor station's effects on land value may be similar (that is, they are driven by health and safety concerns and possible loss of use), they are both more acute and more certain. (Noise and air emissions from the compressor stations will be routine, while leaks from the pipeline should be 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 heading of ecosystem services.
f. Economic development effects related to these subsets of the study region are included in estimates for the study region.

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). Other definitions abound, including the following from Gary Johnson of the University of Vermont. It is helpful both because it emphasizes that services are not necessarily things–tangible bits of nature–but rather, they are the effects on people of the functions of bits of nature:

> Ecosystem services are 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 (2010).

This definition also makes clear that ecosystem services happen or are produced and enjoyed in particular places and at particular times.

No matter the definition, different types of ecosystems (forest, wetland, cropland, urban areas) produce different arrays of ecosystem services, and/or they produce similar services to greater or lesser degrees. Certain ecosystems or land uses simply produce a higher flow of benefits than others.

"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.

At a conceptual level, we estimate the potential effects of the ACP on ecosystem service value by identifying the extent to which the construction and longer-term existence of the pipeline would change land cover or land use, which in turn results in a change in ecosystem productivity. Construction would essentially strip bear the 125-foot-wide construction corridor. Once construction is complete and after some period of recovery, the 75-foot-wide right-of-way will be

Ecosystem Service Impacts 1: Water Supply

Currently the Cowpasture River Valley in Highland County enjoys naturally clean water thanks to environmental filtration. However, if the ACP is built any contamination that it causes through erosion, sedimentation, or spills would carry high costs.

For a domestic well, a landowner would face an estimated out-of-pocket expense of $35,000 or more to drill into a potable aquifer. For a livestock operation, which needs more water, a contaminated aquifer would be even worse. Dairies and ranches in the Cowpasture River Valley that need to replace their water supply would face an estimated cost of $50,000, and they would need an emergency supply of 20,000 gallons daily. If a city or town must replace a municipal water supply that becomes contaminated, the costs are even higher; it would take an estimated out-of-pocket cost of $2.5 million to complete geophysical, hydrological, and engineering studies, purchase land, drill a well, and build the necessary surrounding infrastructure.

-Nelson Hoy, Cowpasture River Preservation Association

TABLE 3: Ecosystem Services Included in Valuation

Provisioning Services[a]
Food Production: The harvest of agricultural produce, including crops, livestock, and livestock by-products; the food value of hunting, fishing, etc.; and the value of wild-caught and aquaculture-produced fish. **Associated land uses[b]:** Cropland, Pasture/Forage, Forest
Raw Materials: Fuel, fiber, fertilizer, minerals, and energy. **Associated land uses[b]:** Forest
Water Supply: Filtering, retention, storage, and delivery of fresh water—both quality and quantity—for drinking, 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, 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, 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
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, 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, Urban Open Space, Wetland
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]:** Forests, 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]:** Forest, Pasture/Forage, Urban Open Space, Wetland
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, etc. **Associated land uses[b]:** Cropland, 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.

occupied by a different set of ecosystem (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 service types, we can estimate ecosystem service value before, during, and after construction. The difference between ecosystem service value during construction and before construction is the cost during construction. The difference between the ecosystem service value during ongoing operations (i.e., the value produced in the ROW) and the before-construction baseline is the annual ecosystem service cost that will be experienced indefinitely.

This overall process is illustrated in Figure 4 and the details of our methods, assumptions, and calculations are described in the following two sub sections.

Ecosystem Service Estimation Methods

Economists have developed widely used methods to estimate the dollar value of ecosystem services and/or natural capital. The most widely known example was a study by Costanza et al. (1997) that valued the natural capital of the entire world. That paper and many others since employ the "benefit transfer method" or "BTM" to establish a value for the ecosystem services produced or harbored from a particular place.[13] 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).

As the name implies, 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 very much like 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 to select "comps" (data from source areas) that match the circumstances of the study area as closely as possible.

Typically, values are drawn from previous studies that estimate the value of various ecosystem services from similar land cover or ecosystem 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. So, for example, if data for the source area includes the value of forest land for recreation, one would apply per-acre values from the source area's forest to the number of acres of forestland in the study area. Furthermore, it is important to use source studies that are from regions with underlying economic, social, and other conditions similar to the study area.

Following these principles as well as techniques developed by Esposito et al. (2011), Esposito (2009), and Phillips and McGee (2014, 2016), and as illustrated in Figure 4, we employ a four-step process to evaluate the short-term and long-term effects of the ACP on ecosystem service value in our study region. The steps are described in greater detail below, but in summary, they are:

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

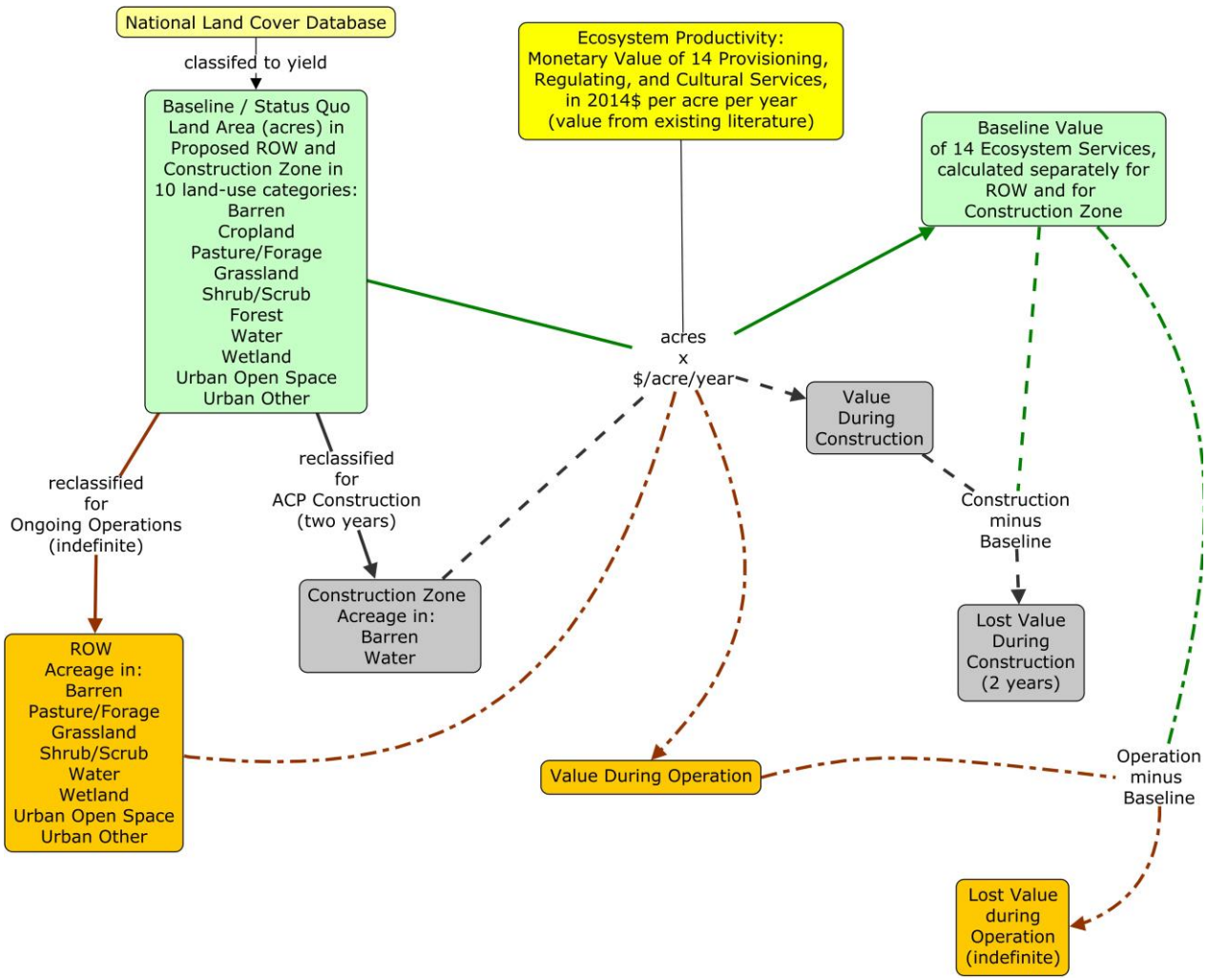

FIGURE 4: Ecosystem Service Valuation Concept Map
Follow the green lines to baseline (without ACP) ecosystem service value. Grey dashed lines show the path to ecosystem service value during construction. Brown dashed lines lead to values during ongoing operation. Differences between construction and operations value and the baseline yield estimates of the cost of the ACP in terms of ecosystem services forgone.

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 ACP" 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") to obtain estimates of aggregate ecosystem service value under the baseline/no ACP scenario, for the construction corridor (and period), and for the ROW during ongoing operation.

For simplicity and given the two-year construction period, we assume that the construction

corridor will remain barren for a full two-year period. We recognize that revegetation will begin to occur soon after the trench is closed and fill and soil are returned, but it will still be some time until something like a functioning ecosystem has actually been restored.

4. Subtract baseline ESV from ESV for the construction period (and in the construction corridor) 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;[14] 15 of these land cover types are present in the study region (Table 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 four-county study region. Unfortunately, there are not value estimates 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. The first is that, left to their devices, such wetlands would normally become forest in the study region. Second, wetlands have some of the highest per-acre values for several ecosystem services. So, to avoid over-estimating the ecosystem services contribution of "woody wetlands," we count them as "forest" instead of "wetland".

In the end, at least for baseline conditions, we have land in 10 land uses. The total area that would be disturbed in the construction corridor through the study region is 1,900 acres,[15] and 1,140 acres would be occupied by the permanent right-of-way. Tables 5 and 6 show acreage in the land cover types across the four counties in the study region.

[14] Because 30 meters is wider than the right-of-way and not much narrower than the 125-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.

[15] Note that these are minimum estimates of the land that would be taken during construction and for ongoing operations. Not counted in these totals are staging areas, temporary or permanent access roads, and the footprint of any infrastructure, such as the compressor station proposed to be sited in Buckingham County. Consequently (and in addition to other minimizing factors) the estimates of ecosystem service cost of the ACP will likely be much smaller than what would be experienced if the ACP were to be built and operated.

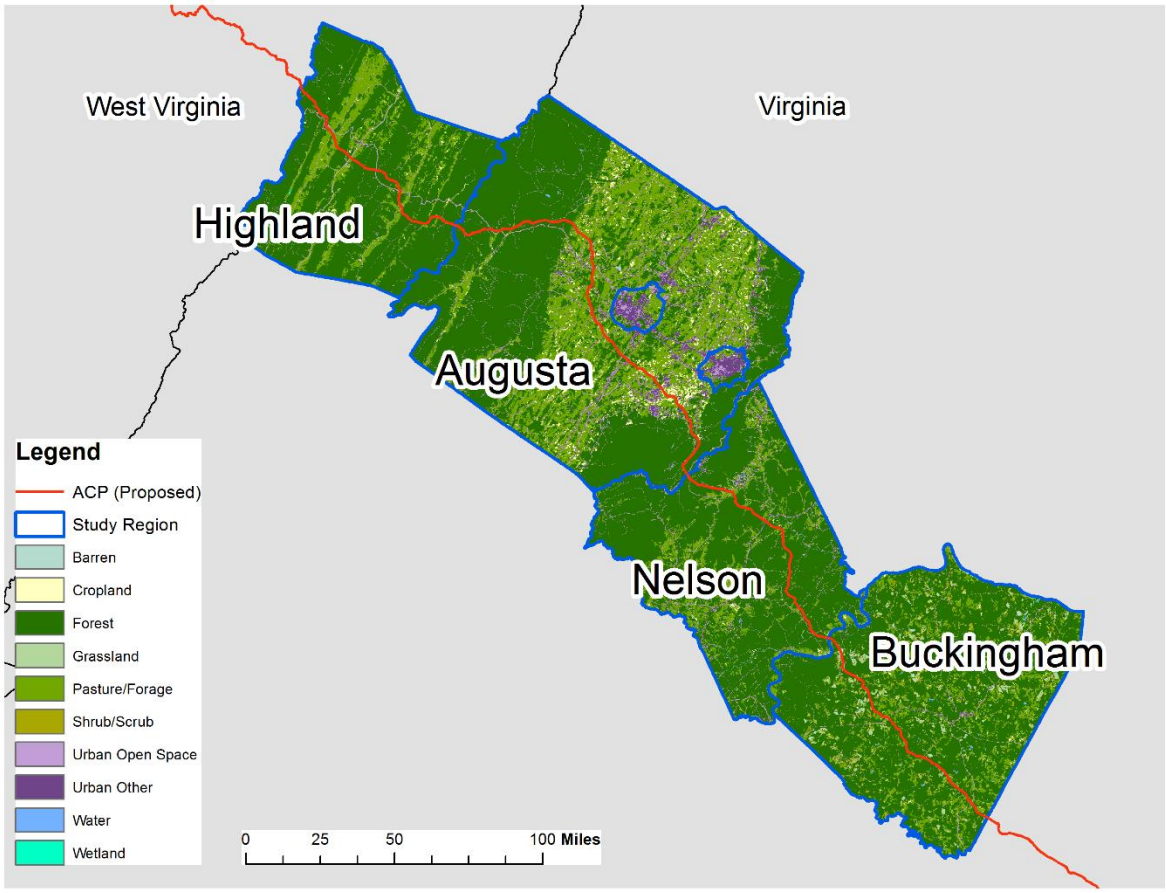

FIGURE 5: Land Use in the Study Region, Classified for Ecosystem Service Valuation
Land cover for the entire study region is shown to display the overall range and pattern of land use. The ecosystem service valuation itself covers only those portions of the study region that would be occupied by the ACP right-of-way and construction corridor.
Source: National Land Cover Database (Fry, et al. 2011).

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

Table 4 lists the reassignment assumptions in detail, but in general, we assume that 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 4: Land Cover Reclassification

NLCD Category	Reclassification for Baseline	Reclassification for Construction	Reclassification for Ongoing Operation
Barren Land	Barren	Barren	Barren
Cultivated Crops	Cropland	Barren	Pasture/Forage
Pasture/Hay	Pasture/Forage	Barren	Pasture/Forage
Grassland/Herbaceous	Grassland	Barren	Grassland
Shrub/Scrub	Shrub/Scrub	Barren	Shrub/Scrub
Deciduous Forest	Forest	Barren	Shrub/Scrub
Evergreen Forest	Forest	Barren	Shrub/Scrub
Mixed Forest	Forest	Barren	Shrub/Scrub
Woody Wetlands	Forest	Barren	Shrub/Scrub
Open Water	Water	Water	Water
Emergent Herbaceous Wetlands	Wetland	Barren	Wetland
Developed, Open Space	Urban Open Space	Barren	Urban Open Space
Developed, Low Intensity	Urban Other	Barren	Urban Other
Developed, Medium Intensity	Urban Other	Barren	Urban Other
Developed, High Intensity	Urban Other	Barren	Urban Other

For the indefinite period following construction—during ongoing operations—we assume that pre-ACP forestland will become shrub/scrub, and cropland will become pasture/forage. We recognize that some pre-ACP cropland may be used for crops after construction has been completed, but as expressed in comments to FERC and elsewhere and as we discovered through personal interviews with agricultural producers in the region, it seems likely that the ability to manage acreage for row crops will be greatly curtailed, if not eliminated entirely by the physical limits imposed by the ACP and by restrictions in easements to be held by ACP LLC. 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 generally less productive of ecosystem services) recognizes these effects while also recognizing that 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. As 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 the pipeline]." Thus the true loss in food and other ecosystem service value from pasture/forage acreage would be larger than our estimates reflect.

TABLE 5: Acreage in Proposed Construction Corridor, by Land Cover and County, Baseline and in "With ACP" Scenario

Land Cover Classification	Highland		Augusta		Nelson		Buckingham	
	Baseline	*w/ ACP*	*Baseline*	*w/ ACP*	*Baseline*	*w/ ACP*	*Baseline*	*w/ ACP*
Barren	0.0	386.0	0.3	708.1	-	395.9	12.6	409.0
Cropland	3.5	-	37.9	-	2.1	-	0.3	-
Pasture/Forage	76.4	-	249.0	-	35.2	-	52.4	-
Grassland	-	-	-	-	-	-	26.5	-
Shrub/Scrub	-	-	-	-	-	-	13.2	-
Forest	293.5	-	386.6	-	345.7	-	297.1	-
Water	0.2	0.2	-	-	0.8	0.8	0.4	0.4
Wetland	-	-	-	-	0.3	-	-	-
Urban Open Space	12.6	-	31.7	-	11.6	-	6.6	-
Urban Other	-	-	2.6	-	1.1	-	0.2	-
Total	**386.2**	**386.2**	**708.1**	**708.1**	**396.7**	**396.7**	**409.4**	**409.4**

TABLE 5: Continued

Land Cover Classification	Study Region	
	Baseline	*w/ ACP*
Barren	12.9	1,899.0
Cropland	43.8	-
Pasture/Forage	413.0	-
Grassland	26.5	-
Shrub/Scrub	13.2	-
Forest	1,322.9	-
Water	1.3	1.3
Wetland	0.3	-
Urban Open Space	62.5	-
Urban Other	3.8	-
Total	**1,900.3**	**1,900.3**

TABLE 6: Acreage in Proposed Right-of-Way, by Land Cover and County, Baseline and in "with ACP" Scenario

Land Cover Classification	Highland		Augusta		Nelson		Buckingham	
	Baseline	*w/ ACP*	*Baseline*	*w/ ACP*	*Baseline*	*w/ ACP*	*Baseline*	*w/ ACP*
Barren	-	-	0.0	0.0	-	-	7.5	7.5
Cropland	2.0	-	23.2	-	1.2	-	0.2	-
Pasture/Forage	46.1	48.1	148.8	172.1	20.8	22.0	31.2	31.4
Grassland	-	-	-	-	-	-	16.3	16.3
Shrub/Scrub	-	176.4	-	233.0	-	207.6	7.7	185.9
Forest	176.4	-	233.0	-	207.6	-	178.2	-
Water	0.1	0.1	-	-	0.5	0.5	0.2	0.2
Wetland	-	-	-	-	0.2	0.2	-	-
Urban Open Space	7.7	7.7	18.4	18.4	6.8	6.8	4.1	4.1
Urban Other	-	-	1.5	1.5	0.6	0.6	0.1	0.1
Total	**232.3**	**232.3**	**425.0**	**425.0**	**237.8**	**237.8**	**245.5**	**245.5**

TABLE 6: Continued

Land Cover Classification	Study Region	
	Baseline	*w/ ACP*
Barren	7.6	7.6
Cropland	26.7	-
Pasture/Forage	246.9	273.6
Grassland	16.3	16.3
Shrub/Scrub	7.7	802.9
Forest	795.2	-
Water	0.8	0.8
Wetland	0.2	0.2
Urban Open Space	37.0	37.0
Urban Other	2.2	2.2
Total	**1,140.5**	**1,140.5**

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

After obtaining acreage by land use in the construction corridor and the ROW, we are ready to multiply those acres times per-acre-per-year ecosystem service productivity 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).[16]

[16] 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.

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 central and western Virginia, we identified 91 per-acre estimates in the TEEB that adequately provide approximations of ecosystem service value in our study region.[17]

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 had examined ecosystem service value in this general region (Phillips, 2015a; Phillips & McGee, 2016) and to specific data on cropland and pasture/hayland value from Virginia Cooperative Extension and the National Agricultural Statistics Service (Lex & Groover, 2015).

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

Ecosystem Service Effects 2: Food and Farmland

Cros-B-Crest Farm in Staunton was established in 1894 and is now recognized by the Commonwealth of Virginia as a "Century Farm." Harry Crosby is the fourth generation to farm this land and has seen the damage that a utility corridor (last time it was a power line) can do to property values and quality of life. This time, Crosby says, the impacts would be even more profound.

The proposed ACP would affect the farm operations and the farm in several ways. First, the pipeline would run more or less directly down the natural slope of one of Cros-B-Crest's best fields, while Mr. Crosby, to conserve soil and otherwise exercise good stewardship, farms the field along the natural contour. Interrupting the contour with the pipeline would lead to increased erosion. Due to restrictions on crossing the pipeline with larger farm equipment, the ACP would effectively take the entire field (30-40 acres in total) out of production.

Even if the field could still be used, Crosby expects that it would not return to its current high level of productivity any time soon. Digging up, trenching, filling, and attempting to put back the soil will, however carefully done, disrupt the soil profile, increase compaction and otherwise depress fertility that has taken nature and the Crosby family generations to build. (Crosby, 2015a, 2015b).

Beyond the impact on farm operations themselves, Crosby says, the ACP will reduce the enjoyment the family receives from owning and living on the property (Crosby, 2015b). The family might not realize the financial loss unless or until it sells the farm, but it will experience the loss of well-being every day.

[17] 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.)

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 162 separate estimates from 60 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 fairly sparse coverage, given that there are 140 possible combinations of the 10 land uses and 14 services. We therefore know that 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. One can either live with that known underestimation, or one can 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 that 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 ACP.

With acreage and per-acre ecosystem service values in hand, we can now calculate ecosystem service value for each of the four area/scenario combinations. To repeat, these are:

- Baseline ecosystem service value in the proposed construction corridor
- Ecosystem service value in the construction corridor during construction
- Baseline ecosystem service value in the proposed right-of-way
- Ecosystem service value in the right-of-way during the (indefinite) period of ongoing operations.[18]

Value calculations are accomplished according to this formula

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

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 ESV from ESV in "with ACP" Scenario

With the steps above complete, we can now estimate the cost in ecosystem service value of moving from the baseline or status quo to a scenario in which the ACP is built and operating.

The cost of construction is the ESV from the construction corridor during construction, minus baseline ESV for the construction corridor, times two. The multiplication by two is due to the conservative

[18] 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.

assumption that revegetation and restoration to a land use that is functionally different from barren land will take at least two years.

The ecosystem service cost of ongoing operations is ESV from the ROW in the "with ACP" scenario minus the baseline ESV for the ROW. This will be an annual cost borne every year in perpetuity.

Ecosystem Service Value Estimates

In the baseline or "no pipeline" scenario, the construction corridor and land slated for temporary roads and workspaces produces between $11.4 and $41.1 million per year in ecosystem service value (ESV). The largest contributors to this total (at the high end) are aesthetic value, water supply, and protection from extreme events. Under a "with MVP" scenario, and not surprisingly given the temporary conversion to bare/barren land, these figures drop to near zero, or between $451 and $3,552 per year for each of the two years. Taking the difference as described above, estimated per-year ecosystem service cost of the ACP's construction would be between $11.4 and $41.1 million, or between $22.8 and $82.2 million over two years in the eight-county study region.

Loss of aesthetic value and impacts on water (both supply and regulation of flow) represent the largest losses during the construction phase (Table 7).

TABLE 7: Ecosystem Service Value Lost to the Construction Corridor and Temporary Roads and Workspaces in Each of Two Years, Relative to Baseline, by Ecosystem Service (2014$)

	Study Region			
Ecosystem Service	*Baseline (low)*	*Loss (low)*	*Baseline (high)*	*Loss (high)*
Aesthetic Value	8,046,503	(8,046,503)	32,491,871	(32,491,871)
Air quality	666,647	(666,647)	680,270	(680,270)
Biological Control	12,524	(12,524)	30,044	(30,044)
Climate Regulation	209,199	(209,199)	228,236	(228,236)
Erosion Control	15,104	(15,104)	146,466	(146,466)
Protection from Extreme Events	1,447,945	(1,447,945)	1,482,118	(1,482,118)
Food Production	10,929	(10,929)	10,929	(10,929)
Pollination	369,769	(369,769)	433,706	(433,706)
Raw materials	43,763	(43,763)	297,240	(297,240)
Recreation	64,090	(63,722)	967,718	(965,459)
Soil formation	12,837	(12,837)	41,061	(41,061)
Waste Treatment	22,692	(22,666)	527,395	(527,369)
Water Supply	84,501	(84,444)	2,306,613	(2,305,346)
Water flows	417,057	(417,057)	1,444,340	(1,444,340)
Total	**11,423,559**	**(11,423,108)**	**41,088,007**	**(41,084,455)**

The ecosystem service costs for the ROW are predictably smaller on a per-year basis, but because they will persist indefinitely the cumulative effect will be much higher. Under the "with MVP" scenario, and using minimum values, annual ecosystem service value from the ROW falls from $4.2 million to about $159,000 for an annual loss of over $4.1 million. At the high end, the ecosystem service value of the ROW would fall from $15.3million to about $435,000 for an annual loss of $14.8 million (Table 8).

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 gains are dwarfed, however, by the loss of much more productive forests. Similarly, the 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 $1,700 and $28,600 per year.[19]

TABLE 8: Ecosystem Service Value Lost Each Year Post Construction in Right-Of-Way, Relative to Baseline, by Ecosystem Service (2014$)

	Study Region			
Ecosystem Service	*Baseline (low)*	*Loss (low)*	*Baseline (high)*	*Loss (high)*
Aesthetic Value	2,985,838	(2,945,731)	12,089,964	(12,040,073)
Air quality	248,102	(222,539)	251,931	(222,539)
Biological Control	4,062	(1,673)	10,554	(8,166)
Climate Regulation	68,141	(32,887)	75,238	(39,900)
Erosion Control	4,926	12,931	51,847	(26,014)
Protection from Extreme Events	536,977	(529,386)	547,721	(529,386)
Food Production	3,308	(1,043)	3,308	(1,043)
Pollination	137,114	(133,628)	160,576	(153,309)
Raw materials	16,306	(16,278)	110,739	(110,711)
Recreation	18,729	1,738	355,391	(332,073)
Soil formation	4,641	(4,083)	15,136	(14,579)
Waste Treatment	8,197	(7,182)	194,147	37,326
Water Supply	31,478	(31,450)	859,334	(857,620)
Water flows	155,301	(152,619)	536,635	(529,356)
Total	4,223,118	(4,063,831)	15,262,520	(14,827,442)

Finally, the establishment of permanent access roads and other surface installations 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 only 76 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 effect occur year after year for as long as the MVP would exist. The annual loss of ecosystem service value from these areas under a "with MVP" scenario would range from $350,000 and $1.3 million

It bears repeating that the benefit transfer method applied here is useful for producing first-approximation estimates of ecosystem service impacts. For several reasons, we believe that this

[19] 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.

approximation of the effect of the ACP's construction and operation on ecosystem service values is too low rather than too high. These reasons include:

- The estimates include only the loss of value that would otherwise emanate from the ROW and construction corridors themselves.

- The estimates do not account for the extent to which the construction and long-term presence of the ACP could damage the ecosystem service productivity of adjacent land. During construction, the construction corridor itself could be a source of air and water pollution that may compromise the ability of surrounding or downstream areas to deliver ecosystem service value of their own. For example, if sediment from the construction zone in Nelson County were to reach the Rockfish River or its tributaries, those surface waters will lose some of their ability to provide clean water, food (fish), recreation, and other services. This reduced productivity may persist well after construction is complete. [20]

  Over the long term, the right-of-way would serve as a pathway by which invasive species or wildfire could more quickly penetrate areas of interior forest habitat, thereby reducing the natural productivity of those areas.

- Finally, these estimates reflect only those changes in natural benefits that occur due to changes in conditions on the surface of the land. Particularly because the proposed pipeline would traverse areas of karst topography there is well-founded concern that subsurface hydrology could be affected during construction and throughout the lifetime of the pipeline (Jones, 2015; Pyles, 2015). Blasting and other activities during construction could alter existing underground waterways and disrupt water supply. There is also a risk that sediment and other contaminants could reach groundwater supplies if sinkholes form near the pipeline during construction or afterwards. For example, in Nelson County, where steep slopes with shallow soils over bedrock is common (Nelson County Planning Commission, 2002), there is concern that erosion and landslides during and after pipeline construction will harm water quality. These scenarios would entail further loss of ecosystem service value and, for the homeowners or municipalities affected, major expenditures. Officials in Augusta County estimate it would cost at least $2.1 million to establish a new municipal well, for example (Hoover, 2015).

[20] This is not a small risk. As noted by the Dominion Pipeline Monitoring Coalition "pipeline construction over steep Appalachian mountains creates significant runoff and slope-failure problems" (Webb, 2015b). In one example, multiple problems during and after construction of a relatively small pipeline on Peters Mountain in Giles County caused extensive erosion and damage to waterways (Webb, 2015a). The coalition points out that "the potential for water resource problems will be greatly multiplied for the proposed larger projects [like the ACP], both in terms of severity and geographic extent."

Buckingham County Compressor Station

One way the ACP impacts air quality is 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 some chance of leaks occurring at any place along the proposed route, leaks and major releases of gas and other substances (lubricants, etc.) at the 40,645 horsepower (hp) compressor station proposed for the Union Hill section of Buckingham County would certainly occur.

The negative effects of the compressor station would 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. 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, "Officials To NYS: Take A Second Look At Pipelines."). 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 2015). Odors associated with compressor stations include sulfur smell, odorized natural gas, ozone, and burnt butter. (Subra, 2009). Finally, compressors emit constant low-frequency noise, which can cause negative physical and mental health effects (Luckett, Buppert, & Margolis, 2015).

In Buckingham, 471 people live within 2 miles of the proposed compressor station (US Census Bureau, 2015). This would mean 424 people experiencing odor events, 334 people experiencing respiratory impacts, 273 people experiencing sinus problems, and 184 people experiencing 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.

Yogaville, an ashram, teaching, and retreat center located approximately 5 miles from the proposed compressor station, is especially concerned about these impacts on its 10,000 annual visitors and on the peace, tranquility, and air quality available at its iconic Mount Kailash and Lotus Shrine. Officials there worry that the air and noise pollution may entirely destroy the Shrine's ability to serve as a place of silent prayer, meditation, and healing (Yogaville, 2015).

The selection of Union Hill for the compressor station also raises environmental justice questions that FERC and others must consider as part of their review (Luckett, Buppert, & Margolis, 2015; Executive Order 12898).

Buckingham County Compressor Station, Continued.

In addition to the direct effects on nearby residents' health and quality-of-life, compressor stations have caused some homes to lose value and some homeowners to move away rather than endure the noise, smells, and illnesses they have experienced. In one case from Minisink, New York, a family of six moved to escape the effects of a 12,600 hp compressor station operated by Millennium Pipeline LLC. 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 slightly larger (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, Bruce, Personal Communication, 12/31/2015).

As of this writing, there have not been statistical studies of the relationship between a property's value and its proximity to a compressor station. The mounting anecdotal information does suggest that there is a negative relationship, however, and that depending on the particular circumstances, the effect can be large–up to the 100% loss sustained by the family in Minisink (less whatever the bank can recover at auction). With the caveat that the effect on property value of the compressor station in Buckingham County may be different in scope and intensity, we do include such effects among the total estimated cost of the pipeline in the study region.

For our estimates, we follow the example of the Hancock New York case and assume that properties within one half mile of the Buckingham compressor station would lose 25% of their value if the station is built. We believe this assumption provides a conservative estimate in part because the Buckingham compressor station would be nearly three times the size. 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. The resulting loss of value would affect Buckingham landowners over a wider area and, possibly, the percentage reduction would be greater at any given distance.

Beyond health and safety concerns, compressor stations might also affect property values due to a "stigma of industrialization" similar to that found for high-voltage lines, according to real estate expert Kurt Kielisch of the Forensic Appraisal Group (Personal Communication 1/6/2016). It is reasonable to assume that such an effect would occur if a portion of Buckingham County's landscape of working forests, farms, and small villages were turned into a compressor station.

EFFECTS ON PROPERTY VALUE

Land Price Effects

To say that the impacts and potential impacts of the ACP on private property value is important to people along its proposed route would be an extreme understatement. Some 521 comment letters submitted by study region residents to FERC during the scoping period mentioned property value (Docket (PF15-6)). Of these, 517, or 99.2%, expressed a belief that the pipeline would have a negative effect on that value. Those reductions are not merely hypothetical. Landowners and Realtors along the proposed route of the Atlantic Coast Pipeline report that buyers have backed out of contracts and that other buyers are simply less interested in potentially affected properties (Davenport, 2015; Hotz, 2015; R. Smith, 2015a).[21] In the words of one Realtor, "every single one of my buyer clients who are looking to buy property in Augusta County have told me that they do not want to even look at properties that are located ON or NEAR the proposed locations of the ACP" (Adler, 2015). While it is impossible to know how large an effect the specter of the ACP, including the compressor station in Buckingham County, has already had on land prices, there is strong evidence from other regions that the effect would be negative.

> ***"Buyers are concerned about safety, views, and resale values. The permanent easement that it will create will devalue every property in its path."***
>
> *– Daniel Hotz, Realtor*
> *McDowell, Virginia*

In a systematic review, Kielisch (2015) presents evidence from surveys of Realtors, home buyers, and appraisers demonstrating that natural gas pipelines negatively affect property values for a number of reasons. Among his key findings relevant to the ACP:

- 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.

[21] FERC's docket for the pre-filing phase of the Atlantic Coast Pipeline (PF15-6) is rife with testimony from landowners concerned that their property will be or already has been negatively affected by the mere possibility of the pipeline's construction.

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).

If one considers just those buyers who are still willing to purchase the property, the expected loss in market value would be 10.5%.[22] This loss in value provides the mid-level impact in our estimates. A much greater loss (and higher estimates) would occur if one takes into account 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%.[23] 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 ACP corridor could be said to be "coming to the nuisance," one would expect them to offer less for such a 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 other infrastructure, the authors found that

Diminished Property Value, Lost Revenue, Higher Costs: Mt. Rush Farm

Mt. Rush Farm located in Buckingham County is a 1,000-acre family farm that has been operated by the Leech family for over 100 years. About half the farm is in managed forests, with the remainder in Angus cattle and crop production. It is one of the largest remaining active farms in the county. The farm typically employs 3 full-time workers, and 4 families live on the property.

The pipeline will bisect the property mainly through the un-wooded portion, which is in daily use. The pipeline will be directly in the way of bringing the cattle in from pasture, a monthly activity. To simply feed their cattle the Leech family would need to cross the pipeline twice daily with heavy equipment. With restrictions on where they could cross the pipeline, these trips would be more time consuming and costly, creating a serious burden on the farm.

"We do not make a lot of money; margins are tight. The pipeline could make it so that we cannot continue farming." If farming is no longer viable, the family worries that the pipeline will also hurt its value for other uses such as housing.

-Irene Ellis Leech, Owner of Mt Rush Farm

[22] 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%.

[23] This is the expected value calculated as 0.622*(-100%)+0.189*(-21%)+0.189*(0%).

properties within the "emergency plan response zone" of sour gas[24] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

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

The ACP has both a high consequence area (HCA) and an evacuation zone radiating from both sides of the pipeline that are 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 ACP's HCA and evacuation zones or, at a minimum, regarding the presence of the ACP in the study region.

As described in the box above, the compressor station proposed for the Union Hill section of Buckingham 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 one half mile of the proposed compressor station.

While there remains a paucity of statistical analysis on the effects of high-pressure natural gas transmission lines on property value, there have been many analyses demonstrating the opposite analog–namely, that amenities such as scenic vistas, access to recreational resources, proximity to protected areas, cleaner water, and others convey positive value to real property.[25] There are also studies demonstrating a negative impact on land value of various other types of nuisance that impose noise, light, air, and water pollution, life safety risks, and lesser human health risks on nearby residents (Bixuan Sun, 2013; Bolton & Sick, 1999; Boxall et al., 2005). 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 may be invalid.

Both FERC and ACP LLC have cited several 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. In its Final EIS regarding the Constitution Pipeline, for example, FERC cited two articles concluding, in brief, that effects on property value from the presence of a pipeline can be either positive or negative, and that decreases in values due to a pipeline explosion fade over time (Diskin, Friedman, Peppas, & Peppas, 2011; Hansen, Benson, & Hagen, 2006). In its filing, ACP LLC cites additional studies drawing similar conclusions based on comparison of market and/or assessed prices paid for properties "on" or "near" a pipeline versus those farther away (Allen, Williford & Seale Inc., 2001; Fruits, 2008; Natural Resource Group, 2015b; Palmer, 2008).

[24] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.
[25] Phillips (2004) is one such study that includes an extensive review of the literature on the topic.

While the studies differ in methods, they are similar in that each fails to take into account two factors that may void their conclusions entirely. The first is that the studies do not consider that the property value data used do not represent prices arising from transactions in which all buyers have full information about the subject properties. The second is that, for the most part, the definition of nearness to the pipelines may be inappropriate or inadequate for discerning actual effects on property value of that nearness.

Economic theory holds that for an observed market price to be considered an accurate gauge of the 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—their risk aversion—to bear on their decision about how much to offer for the property. As a result, buyers' offer prices will be higher than they would be if they had full information.

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.

The study by Hansen, Benson, and Hagen (2006) actually reinforces the conclusion that when buyers know about a nearby pipeline, market prices drop. The authors found that property values fell after a deadly 1999 liquid petroleum pipeline explosion in Bellingham, Washington. They 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.

We do not think it is appropriate to conclude from this study (as FERC did in the case of the Constitution Pipeline) that natural gas transmission pipelines would have no effect on land prices in today's market. 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 stories, citizens' videos, news reports, 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 home buyers.

Online based tools have changed the ways people shop for homes, and we are now in a real world much closer to the competitive economic model that assumes all buyers have full information about the homes they might purchase. Anyone with an eye toward buying property near the proposed ACP corridor would quickly learn that the property is in fact near the corridor, that there is a danger that the property could be adversely affected by still-pending project approval, and that fossil fuel pipelines and related infrastructure have an alarming history of negative health and environmental effects. Accordingly, the price that buyers would offer for a home near the ACP will be lower than the price offered for one farther away or in another community or region entirely.

The second problem with the studies is that while they 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 the subject pipelines that health and safety concerns could influence prices. In both studies written by the Interstate Natural Gas Association of America (INGAA), for example, the authors compare prices for properties directly on pipeline rights-of-way to prices of properties off the right-of-way. However, in almost all cases the geographic scope of the analysis was small enough that most or all of the properties not on the right-of-way are still within the pipelines' respective evacuation zones (Allen, Williford & Seale Inc., 2001; Integra Realty Resources, 2016).[26]

The 2016 INGAA study suffers from the same problems, including the comparison of properties "on" and "off" the six pipelines analyzed when a majority of the "off" properties are within the pipelines evacuation zones. In four of the case studies—those for which a specific distance from pipeline was reported—an average of 72.5% of the "off" properties were actually within the evacuation zone. (We estimated the evacuation zone based information available information about the pipelines' diameter and operating pressure.) For the other two of the pipelines, the study reported a simple "yes" or "no" to indicate whether the property abutted the pipeline in question. For these cases, we assume the 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.

If one wants to compare the price of properties with and without a particular feature, one must be sure that some properties have the feature and others do not. It is a case where one actually does need to compare apples to oranges. But if there is no variation in the feature of interest, which in this case would be the presence of a nearby risk to health and safety, then one would expect to find no systematic variation in the price of the properties. By comparing apples to apples when it should be comparing apples to oranges, the INGAA study reaches the forgone and not very interesting conclusion

[26] This is based on a best estimate of the location of the pipelines derived from descriptions of the pipeline's 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).

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 in ACP LLC's filing suffer from the same problem. Fruits (2008), who analyzes properties within one mile of a pipeline that has 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 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 detect such a threshold effect. Such an effect would show up, of course, 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, one cannot conclude from these flawed studies' failure to identify a negative effect of pipelines on property value that no such effect exists. To evaluate the effects of the proposed ACP on property value, FERC and others must therefore look to studies (including those summarized in the previous section) in which buyers' willingness to pay is fully informed about the presence of nearby pipelines and in which the properties bought are truly different in terms of their exposure to pipeline-related risks.

Visual Effects and Viewshed Analysis

Information about how the visual effects of natural gas transmission pipelines are reflected in property value 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 can be seen decrease property values (by 6.3% in one study) (Bolton & Sick, 1999). This suggests a pipeline corridor reduces property value either by impairing a good view or, if like power lines, by simply being unattractive. It is reasonable to conclude that the proposed ACP would have effects on property value that are mediated through visual effects, but the literature to date does not offer clear guidance on how large or strong the effect may be. We therefore have not included separate estimates of the impact of the ACP on property value in the viewshed. Moreover, we do not wish to double-count a portion of the impact of the ACP on "Aesthetics," which is already included among the ecosystem service value effects.

We do want to know, however, how many properties might suffer a portion of that lost aesthetic value. To keep the estimate conservative, we count only those properties with a higher-than-average likelihood the ACP corridor could be seen from them. To determine this for each parcel, a GIS-based visibility 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. To keep the computing needs manageable, we analyzed a sample of points placed at 100m intervals along the proposed ACP route.

Because weather, smog, and other conditions limit the distance at which one can see anything in the mountains and valleys of Virginia, 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. As a practical matter, this meant that we analyzed a section of the ACP beginning 25 miles west of the western boundary of Highland County, Virginia and extending to a point 25 miles east of the eastern boundary of Buckingham County.

By tallying the number of points on the pipeline corridor that could be seen from each spot in the study region and then connecting those spots to parcel boundaries, we obtain an estimate of how much of the pipeline could be seen from some spot within a given parcel. In Figure 6, yellow spots on the maps are those where one could see between 1 and 14 points on the pipeline, whereas red spots have a view of up to as many as 392 points along the pipeline. Since each point represents 100 meters of pipeline, there are places in the study region where 39.2 km, or 24.4 miles, of pipeline corridor could be visible.

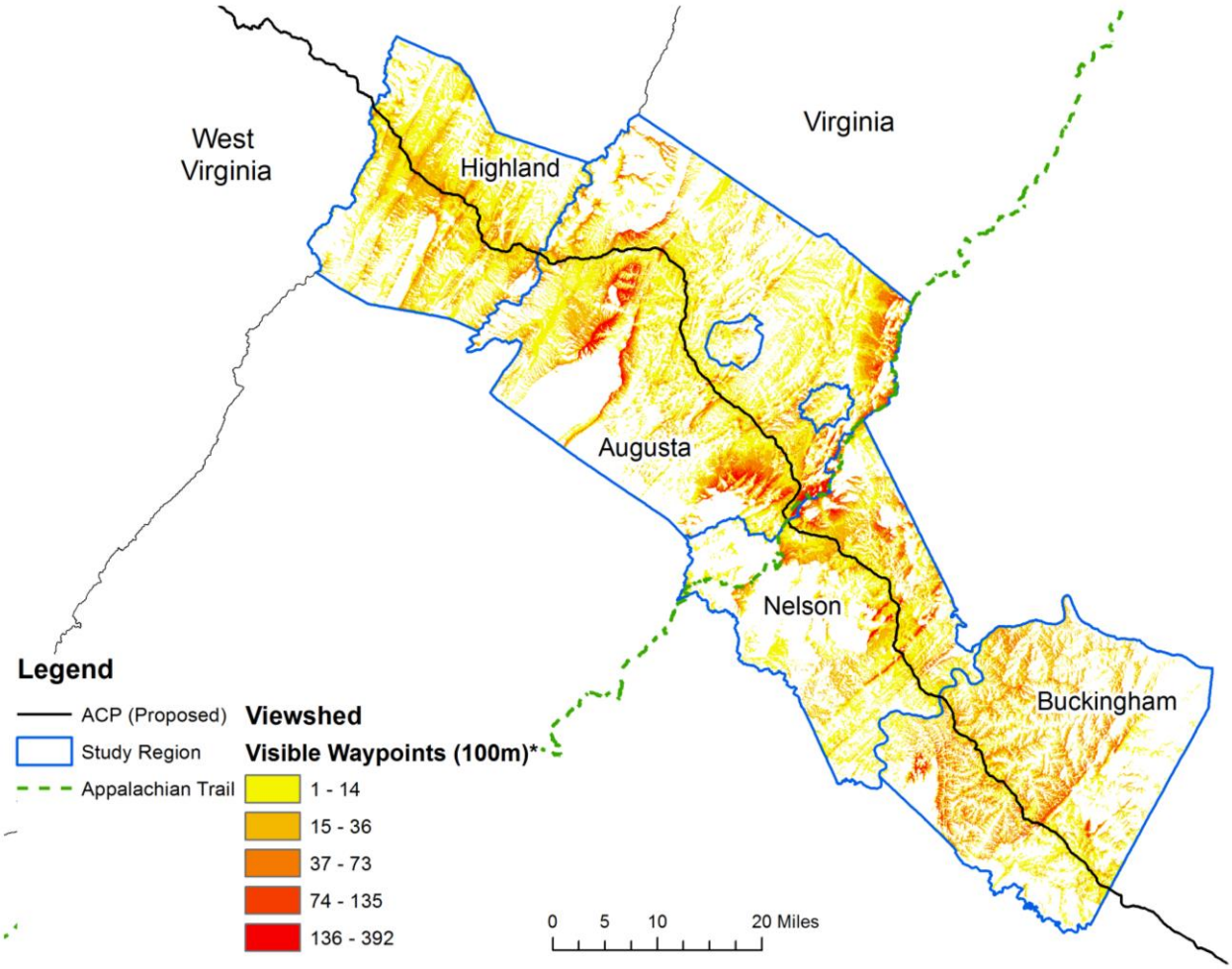

FIGURE 6: Visibility Analysis Results

*The color indicates the number of waypoints, spaced 100m apart along the proposed route that would be visible from the colored grid cell. Only waypoints within 25 miles are considered. Does not account for obstructions like buildings or trees.

Taking into account those spots on nearly every parcel from which one could <u>not</u> see the ACP corridor, the average of the maximum number of points visible from a parcel is 12. This serves as our threshold for identifying parcels from which the pipeline would be "visible." Parcels containing no spot (again each spot is a 30m-by-30m square) from which one could see more than 12 pipeline points is

considered to have no view of the pipeline. By this rule, and out of 106,717 parcels in the study region, some 31,117 parcels, or just under one-third, would have a potential view of the pipeline. The total value of these properties is currently $7.44 billion.

We call this a potential view of the pipeline because we have not taken other visual obstructions, such as trees or buildings into account. In particular, smaller parcels in the more densely developed areas could be at elevations relative to the pipeline that could afford a view of it, but the house next door could block that view. The restriction of our analysis to those parcels that have comparatively many spots from which to potentially see the pipeline mitigates this limitation of our GIS analysis. The reason is simply that smaller urban lots have very few 30-meter-square spots to begin with. A parcel has to be at least 13 spots in size (2.9 acres), with the pipeline visible from every spot, to cross the 12-spot threshold.

Parcel Values

With the exceptions of the City of Staunton and Highland County, parcel value is obtained from the jurisdictions' public records. We obtained Staunton's parcel boundaries (the GIS file) from the city, but it is not possible to download or create a file with the assessed value that corresponds to each parcel. For Highland County, we obtained the parcel boundaries from the Commonwealth of Virginia's web-based map service, but those parcels lack any identifying information, such as an address or key code by which parcels could be connected to property value obtained separately from the County.

For both Staunton and Highland County, we adopted a second-best approach to enable some spatial analysis of property value impacts. We extracted the median house value for block groups in those two jurisdictions from the American Community Survey (ACS) (2014). After adjusting the ACS's figures for inflation, we attached those values to each parcel, according to which block group the parcel occupies.[27]

Each of the remaining jurisdictions have some parcels with missing value data or parcels where a match in the jurisdictions' separate assessment records could not be found. This will lead to some underestimation of any land value effects, since the value of these parcels is set to zero.

Two other features of the parcel data required adjustments prior to performing any land value impact calculations. First, the Buckingham County data had instances in which two or more individual tracts in different parts of the County are listed on a single tax record with a single property value. The consequence is that the value of all of the land connected to such multi-tract tax records would be swept up with the value of just those tracts actually crossed by the proposed ROW, in the evacuation zone, or near the compressor station. To avoid overstating impacts, we split the multi-tract parcels into separate tax records and assigned each tract its own value based on its size and the per-acre value of the original multi-tract parcel.

The second remaining issue deals with public land that is unlikely to be sold and therefore does not

[27] Because many parcels overlap block group boundaries, each parcel is assigned to a block according to whether its centroid, or geometric center, lies within the block group.

possess any market value. To ensure these properties would not inflate overall property value effects, we used the "Protected Areas Database" from the National Gap Analysis Program to identify fee-owned conservation properties, such as portions of the George Washington National Forest and state, county, and municipal parks (Conservation Biology Institute, 2012). Once identified, we set the value of all such properties equal to zero.

With all of these adjustments made, there remains the comparatively straightforward matter of identifying parcels of six types for which one could expect some effect of the ACP on the value. In order of increasing distance from the pipeline itself, these are:

1. Parcels crossed by the right-of-way
   (508 parcels, with total value (before ACP) of $277.5 million)
2. Parcels crossed by the construction corridor
   (553 parcels, with total value (before ACP) of $281.8 million)
3. Parcels at least partially within the High Consequence Area (HCA)
   (1,799 parcels, with total value (before ACP) of $539.7 million)
4. Parcels at least partially within the Evacuation Zone
   (5,553 parcels, with total value (before ACP) of $1.13 billion)
5. Parcels with their geographic center (centroid) within one half mile of the compressor station
   (87 parcels, with total value (before ACP) of $4.9 million)
6. Parcels from which the pipeline would be visible (as defined above)
   (31,117 parcels, with total value (before ACP) of $7.44 billion)

Note that there is overlap among these zones. All ROW parcels are within the construction, HCA, and evacuation zones, and 13 are near the compressor station, for example. To avoid double counting we apply only one land value effect to any given parcel. We assume that the health and safety concerns associated with the compressor station dominate the effects of the ROW and of the evacuation zone, and so we exclude the compressor zone parcels from estimates of the impact of those zones and estimate a separate effect of the compressor station. Similarly, ROW parcels are assumed to suffer no further reduction in value due to their location within the evacuation zone.

We ignore the construction corridor for this analysis. Even though the additional 32 parcels and $4.3 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 the 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 way and apply 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 that one would need to evacuate one's home at any time day or night would, one would expect, have a smaller effect on property value than living with the possibility that one would not survive a "high consequence" event and, therefore, not have the chance to evacuate at all. We do not have data or previous study results that allow us to draw such a distinction, so instead we apply the lower evacuation zone effect to all HCA and evacuation zone parcels.

To summarize, Table 9 repeats a portion of Table 2, but with the property value effects discussed above 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 ACP would include between $55.8 million and $80.2 million in diminished property value. Some of the most intense effects will be felt by the owners of 508 parcels in the path of the right-of-way, who collectively would lose between $11.7 million and $36.1 million in property value. There are 87 parcels in the compressor station zone, and their owners would together experience a drop of $1.2 million in property value. Some 5,553 additional parcels lie outside the ROW and compressor station zones but are within or touching the evacuation zone. These parcels' owners would lose an estimated $43.0 million. (See Table 10). A far greater number of parcels, 31,117, would experience a loss in value due to diminished quality of the view from their properties.

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

	Effects in Right-of-Way			Effects in Evacuation Zone
County	**Realtor Survey (4.2%)**	**Buyer Survey (10.5%)[a]**	**Impact Studies (13.0%)**	**Boxall Study (3.8%)**
Augusta	-5,201,628	-13,004,069	-16,100,276	-28,380,818
Buckingham	-993,700	-2,484,249	-3,075,737	-2,884,845
Highland	-360,981	-902,453	-1,117,323	-2,094,518
Nelson	-5,082,259	-12,705,646	-15,730,800	-9,596,010
Study Region Total	**-$11,654,492**	**-$29,136,230**	**-$36,073,427**	**-$42,956,191**

TABLE 10: Continued

	Effects Near Compressor	Total of ROW, Compressor Station, and Evacuation Zone Effects		
	Hancock, NY Finding (25%)	Low	Medium	High
Augusta	n/a	-33,582,445	-41,384,887	-44,481,094
Buckingham	-1,214,140	-5,092,685	-6,583,234	-7,174,722
Highland	n/a	-2,455,500	-2,996,972	-3,211,841
Nelson	n/a	-14,678,268	-22,301,656	-25,326,810
Study Region Total	**-$1,214,140**	**-$55,808,898**	**-$73,266,748**	**-$80,194,467**

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 $281,000 and $408,000 per year (see Table 11). To keep their budgets balanced in the face of this decline in revenue, the 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. The ACP, in other words, could drive up expenses while driving down the counties' most reliable revenue stream.[28]

TABLE 11: Effects on Local Property Tax Revenue

	Median Tax Rate (% of Value)[a]	Lost Property Tax Revenue		
		Low	Medium	High
Augusta County	0.47%	-157,837	-194,509	-209,061
Buckingham	0.56%	-28,519	-36,866	-40,178
Highland	0.46%	-11,295	-13,786	-14,774
Nelson	0.57%	-83,666	-127,119	-144,363
Study Region Total		**-$281,318**	**-$372,281**	**-$408,377**

a. Source: Property Taxes By State (Virginia Counties and Independent Cities) (propertytax101.org, 2015)

In addition to factors that make our estimates of the effects on property value itself conservative,[29] there is one other factor that makes the estimates of effects on property taxes lower than what one would expect if the ACP is permitted. Namely, nearly a quarter of the properties in the ROW are currently undeveloped but still assessed at a value that assumes a single house site. Buckingham County has 70 such properties, Nelson has 7, and Augusta has 46.[30] The total assessed value of these

[28] We recognize that ACP anticipates making tax payments, but because those payments are tied to net income from the operation of the pipeline, they may fluctuate from year to year or disappear entirely if pipeline operations become unprofitable.

[29] These factors include using the lower expected price reduction from the buyer survey and applying the same price reduction to the entire evacuation zone (including the HCA).

[30] There are no such properties in Highland County, where the County does not assume any development value until development is imminent. In Buckingham County all unimproved properties are assessed as if they include at least one

properties is $15.1 million. Depending on where and how the ROW crosses these properties, it is likely that some will lose their potential usefulness for future residential or other development. In those cases, the assessed value (which by law reflects market value) will fall, and tax revenue generated by future development will never materialize.

EFFECTS ON ECONOMIC DEVELOPMENT

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. Augusta County's Economic Development Strategic Plan, for example, stresses "Respect for Heritage and Environment: Promote a quality of life that embraces our heritage, preserves the environment and effectively manages the resources we have been given" (Glover & Castle, 2015). In Highland County, the Economic Development Authority states its mission is to "promote sustainable economic development in order to achieve a desirable quality of life for the citizens of Highland County," and it aims to complete that by "preserving our rural heritage and natural beauty, supporting existing businesses, promoting new investment and igniting entrepreneurship" (Billingsley et al., 2015).

The ACP would undermine the progress toward these visions if the loss of scenic and recreational amenities, the perception and the reality of physical danger, and environmental and property damage were to discourage people from visiting, relocating to, or staying in the study region. Workers, businesses, and retirees who might otherwise choose to locate along the ACP's proposed route will instead pick locations retaining their rural character, productive and healthy landscapes, and promise for a higher quality of life.

This is already occurring in the region. With the possibility of the ACP looming, business plans have stalled and the real estate market has slowed (Adler, 2015; R. Smith, 2015a, 2015b). Study region residents are also concerned the ACP could have broad, negative impacts on the economy. Of those

Forgone Economic Development: Eco-Village

In April of 2014 a father and son purchased two parcels near Bold Rock Cidery in Nelson County in order to begin developing a "stunning boutique eco-resort focused on the natural beauty of the Rockfish Valley and the delightful Virginia-Made craft beers, wines, ciders, foods, and handmade goods."

Designed to be a top destination on the East Coast, the developers predict $35 million in investment costs to create this vision. They began developing a plan in April of last year and have already hired a world-class landscape design firm. The eco-resort would provide 50 full-time and 50 or more part-time jobs as well as $15-30 million in annual taxable revenue for Nelson County.

This project, which will be "a pure celebration of Virginia", will be entirely derailed by the ACP, which would cut "right through the heart of this project and destroy any opportunity to develop this land in a meaningful way." This project represents just one of many "small business owners investing in their own ideas and opportunities to serve the exploding tourism market and our local economy."

- Richard Averitt
Developer of Spruce Creek Resort and Market

house site. Nelson County assumes that all unimproved properties of 10 acres or smaller include a single house site. Augusta County applies the single house site assumption to unimproved properties of between 0.5 and 20 acres in size.

who mentioned the economy in written comments to the Federal Energy Regulatory Commission during the scoping phase of its environmental review, 91.4% expressed a belief that the ACP would have a negative effect. Of those who mentioned agriculture, 98.6% thought the effect would be negative, and 99.5% of those who addressed tourism said the effect would be negative.

These fears are consistent with research results from this region and around the country demonstrating that quality of life is often of primary importance when people choose places to visit, live, or do business. As 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 in the southern Appalachians. 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).

Along similar lines, 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.

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

Natural and Scenic Resources [Goals]
– Recognize that the natural environment is an important facet of our quality of life and efforts should be made to support and enhance that environment.
– Protect the county's scenic resources as essential to the county's rural character, economic strength and quality of life.

- Nelson County Comprehensive Plan

As noted above, the study region's residents believe the ACP will harm the travel and tourism industry. Wintergreen Resort, located in Nelson and Augusta Counties, expects a 40% drop in business relative to a planned expansion (Theiss, 2015). The nearby Fenton Inn projects it "will be losing at least 10% of projected income for [the life of the pipeline]" and that insurance and other costs will further impact its bottom line (Fenton & Fenton, 2015). In one widely reported case, a planned resort in Nelson County will never be built if the ACP is constructed—effectively a 100% loss for a business that would supply 50 full-time and 50 part-time jobs (Averitt, 2015). Finally, Yogaville in Buckingham County surveyed current and former guests regarding how a pipeline near its campus could affect future demand for its programs and found some 95% of those surveyed responded they would visit less often if the pipeline were constructed.

While more systematic research could provide refined estimates of the impact of natural gas transmission pipelines on recreation and tourism spending, one plausible scenario is that the impact is at least as high as the minimum of these business owners' reported expectations. That is, if the ACP were to cause a 10% drop in recreation and tourism spending from the 2014 baseline, the ACP could mean $41.3 million less in travel expenditures each year. Those missing revenues would otherwise support roughly $7.5 million in payroll, $1.3 million in local tax revenue, $1.8 million in state tax revenue, and 387 jobs in the four-county region's recreation and tourism industry each year.[31] 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 those additional demands presented by the ACP.

Along similar lines, retirement income is an important economic engine that could be adversely affected by the ACP. In county-level statistics from the US 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 1.5% per year from 2000 through 2014, and age-related transfer payments grew by 5.4% per year. During roughly the same time period (through 2013), the number of residents age 65 and older grew by 27.3% (2.1% per year), and this age cohort now represents 17.6% of the total population.[2]

It is difficult to precisely quantify the effect of the ACP on retirement income, but given the strong 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 just a *10% slowing of the rate of increase* might entail. Such a scenario entails an annual decrease in investment income and age-related transfer payments of approximately $6.6 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.

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 41 fewer jobs and $1.6 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.

[31] Raw data on travel expenditures is from the Virginia Tourism Corporation (2015). This reduction in economic activity would be in addition to the lost recreation benefits (that is, the value to the visitors themselves over and above their expenditures on recreational activity) that are included with ecosystem service costs above.

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

CONCLUSIONS

The full costs of the proposed Atlantic Coast Pipeline in our four-county study area and beyond are wide-ranging. They include one-time costs like reductions in property value and lost ecosystem services during pipeline construction, which we estimate to be between $72.7 and $141.2 million. Plus there are ongoing costs like lost property tax revenue, diminished ecosystem service value, and dampened economic growth that would recur year after year for the life of the pipeline. These annual costs range from an estimated $54.8 to $67.8 million per year. Most of these costs would be borne by residents, businesses, and institutions in Highland, Augusta, Nelson, and Buckingham Counties.

By contrast, the ACP's one local benefit is much smaller. It is an estimated average tax payment of $3.2 million per year (for the four-counties) through 2025 (Natural Resource Group, 2015b, pp. 5–31). Other ACP-promoted benefits, such as jobs from the ACP's construction and operation and those stemming from lower energy costs, would accrue primarily in other places (Atlantic Coast Pipeline, LLC, n.d.).[32]

The decision to approve or not approve the ACP does not hinge on a simple comparison of estimated benefits and estimated costs. The scope and magnitude of the costs outlined here, however, reflect and are an important component of the full environmental effects that must be considered in making that 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 Atlantic Coast Pipeline.

If these considerations and FERC's overall review, under the National Environmental Policy Act, result in selection of the "no-action" alternative and the Atlantic Coast Pipeline is never built, most of the costs outlined in this report will be avoided. It is *most*, but not *all* costs because there has already been the cost of delaying implementation of business plans, the cost of 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.

Another possible scenario is that the FERC, considering the impacts of the ACP *as currently proposed* on ecosystem services, property values, and economic development, would conduct a thorough analysis of all possible alternatives. Those alternatives may include 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 (as opposed to permitting pipelines on a company-by-company basis). 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.

[32] Due to issues with the methods and assumptions used in the ACP-sponsored studies, the benefit estimates they present may be inflated. See Stanton, et al. (2015), and Phillips (2015b) for a review.

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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 ACP 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 areas 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-Maîître & 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) *

Land Use	Ecosystem Service	Minimum $/Acre/year	Maximum $/Acre/year	Source Study
Pasture, cont'd	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) *
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)

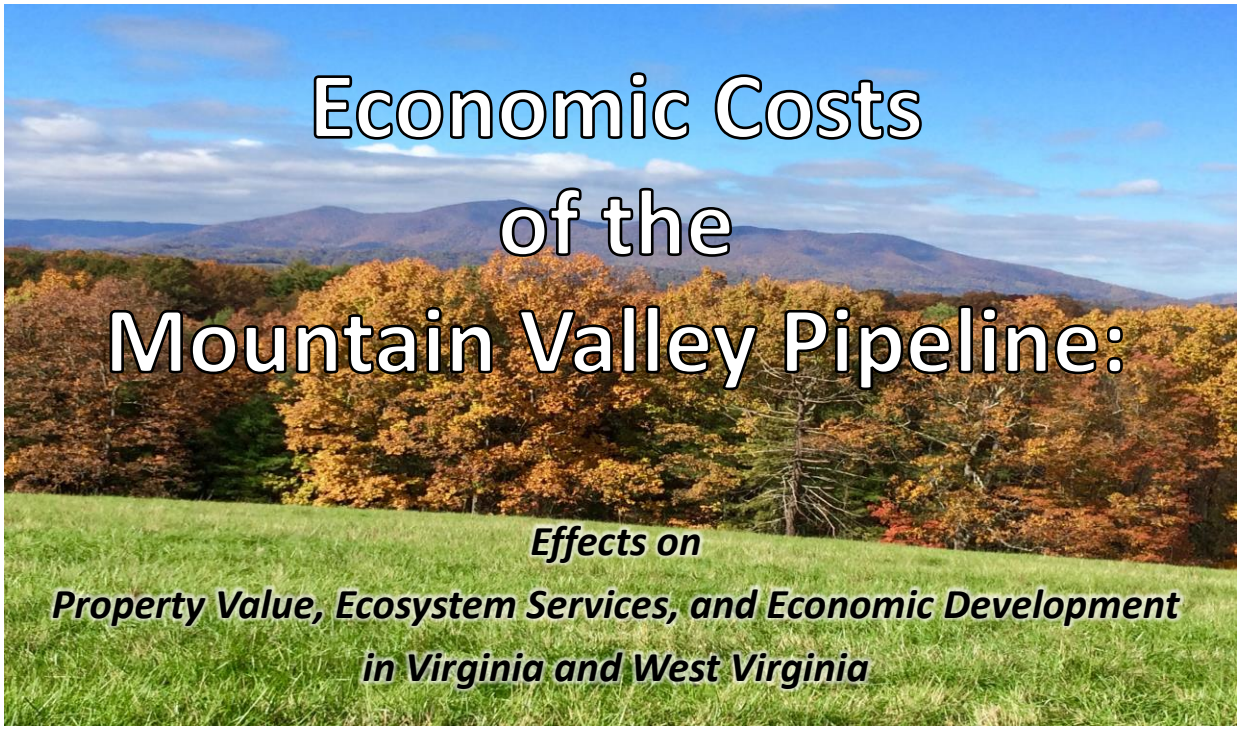
Land Use	Ecosystem Service	Minimum $/Acre/year	Maximum $/Acre/year	Source Study
Water	Recreation	446.31	446.31	(Brenner Guillermo, 2007) *
	Recreation	155.36	914.10	(Cordell & Bergstrom, 1993)
	Recreation	304.18	437.19	(Mullen & Menz, 1985)
	Recreation	148.68	148.68	(Postel & Carpenter, 1977)
	Waste	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)

Land Use	Ecosystem Service	Minimum $/Acre/year	Maximum $/Acre/year	Source Study
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)
	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 2014 dollars.
* Indicates source is from the TEEB database.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 3, Key-Log Economics, LLC, Economic Costs of the Mountain Valley Pipeline, May 2016.



Economic Costs of the Mountain Valley Pipeline:

Effects on Property Value, Ecosystem Services, and Economic Development in Virginia and West Virginia

MAY 2016

Report to:
Protect Our Water, Heritage, Rights (The POWHR Coalition)
powhr.org

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EXECUTIVE SUMMARY

The Mountain Valley Pipeline (MVP) is proposed to carry natural gas from the Marcellus and Utica Shale approximately 300 miles through 11 West Virginia and 6 Virginia counties before terminating at the existing Transcontinental pipeline compressor station in Pittsylvania County, Virginia. Mountain Valley Pipeline, LLC, which would construct and operate the pipeline as a joint venture of EQT Corporation and NextEra Energy, Inc., and some public officials have promoted the MVP as both environmentally safe and economically beneficial, providing economic opportunity for local communities along the proposed route.

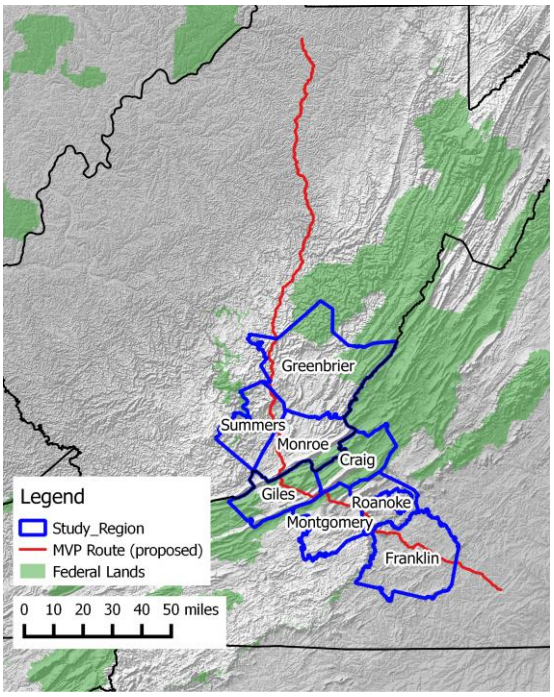

FIGURE 1: Eight-County Study Region

Note: Roanoke County includes the independent cities of Salem and Roanoke

Sources: MVP route digitized from online maps and MVP LLC filings (http://mountainvalleypipeline.info/maps/); Study Region (counties), federal lands, and hill shade from USGS and http://nationalmap.gov/small_scale/

Promised economic benefits, however, are only part of the impact the Federal Energy Regulatory Commission (FERC) must review before deciding whether to approve the construction and operation of the pipeline. Under its own policy and the more comprehensive requirements of the National Environmental Policy Act, FERC's review must consider the full range of environmental effects of the proposed pipeline. These include the various ways in which environmental effects would result in changes in human well-being—including economic benefits and costs. While estimates of the positive economic effects, including construction jobs and local tax payments, have been developed and promoted as reasons to move forward with the pipeline, no systematic consideration of the potential negative economic effects—economic costs—of the MVP has been completed.

To help fill the gap in current information, the POWHR (Protect Our Water, Heritage, Rights) coalition of community groups from an eight-county region in West Virginia and Virginia commissioned this independent research into key economic costs of the MVP. This region comprises Greenbrier, Monroe, and Summers Counties in West Virginia and Craig, Franklin, Giles, Montgomery, and Roanoke Counties in Virginia (Figure 1). The MVP's construction, operation, and presence would impose three types of costs on this region. First, the pipeline would impact property values along the approximately 143 miles of pipeline proposed for the study region. Affected properties are those touched by the 50-foot-wide right-of-way, within the 1.4-mile-wide evacuation zone, and throughout the viewshed of the proposed pipeline. Second, construction and the ongoing operation of the pipeline would alter land use/land cover in ways that diminish the value of ecosystem services, such as aesthetics, water supply, and timber and food production. Third, and in part due to a loss of scenic and quality-of-life amenities, there would be decreases in visitation, in-migration, tourism, small business development, plus a loss of jobs and personal income those activities would otherwise support.

Considering this eight-county region alone, estimated one-time costs range from $65.1 to $135.5 million. These one-time costs comprise lost property value and the value of ecosystem services lost during construction. Annual costs following the construction period include lower ecosystem service productivity in the MVP's right-of-way, lower property tax revenue due to the initial losses in property value, and dampened economic development. These total between $119.1 and $130.8 million per year and would persist for as long as the MVP right-of-way exists—that is, in perpetuity. (See "At a Glance," page iii for details.) Putting the stream of costs

into present value terms [1] and adding the one-time costs, the total estimated cost of the MVP in the eight counties is between $8.0 and $8.9 billion.

The costs represented by the estimates presented here are what economists call "externalities," or "external costs," because they would be imposed on parties other than (external to) the company proposing to build the pipeline. Unlike the private (or internal) costs of the pipeline, external costs borne by the public do not affect the company's bottom-line. From an economic perspective, the presence of externalities is what demands public involvement in decisions about the MVP. Without consideration of all of the costs of the project, too much pipeline (which may mean any pipeline at all) is the inevitable result. FERC must consider the true bottom line and ensure that the full costs of the pipeline, especially those external costs imposed on the public, are rigorously examined and brought to bear on its decision about whether or not to permit the MVP project to proceed.

For reasons explained in the body of this report, estimates of external costs developed as part of this study and reported here are conservative. One reason is simply that there are categories of impacts that are beyond the scope of the study. These impacts include changes to sites or landscapes that have 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, historical and cultural impacts matter to humans and, therefore, can be expressed as monetary value. We have also not included the cost to communities of increased emergency response planning and capacity necessary during the operation of the proposed pipeline or of increased law enforcement, road maintenance and repair, or other costs that would accompany its construction.[2]

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 such 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 Mountain Valley Pipeline.

Finally, while this report covers many of the costs that *will* happen if the MVP is constructed and operated, it does not include an assessment of natural resource damage and other effects that *might* happen during construction and operation. For example, there is some probability that erosion of steep slopes and resulting sedimentation of streams and rivers will occur during construction. Similarly, there is some probability that there will be a leak and explosion somewhere along the length of the MVP during its lifetime. If, when, and where such events occur with the MVP, there will be clean-up 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 that they will occur, yields additional "expected costs," which would then be added to the more certain costs estimated in this study. The same is true of the costs that could accrue after the MVP is no longer used and maintained.

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 pipeline safety, and reductions in economic vitality stemming from changes in the landscape—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 West Virginia and Virginia if the MVP is approved, built, and operated.

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[1] The present value of a perpetual stream of costs is the one-year cost divided by the 1.5% 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).

[2] As of this writing, a pilot study of these cost for one Virginia county in our study region is underway, with results expected in the coming weeks.

[3] While no one was killed in the incident, one need look no further than the recent explosion of Spectra Energy's Texas Eastern gas transmission line in Pennsylvania to see such impacts. See, for example, https://stateimpact.npr.org/pennsylvania/2016/05/04/pa-pipeline-explosion-evidence-of-corrosion-found/

At a Glance:

The Mountain Valley Pipeline in Virginia and West Virginia

Craig, Franklin, Giles, Montgomery, and Roanoke Counties in Virginia and Greenbrier, Monroe, and Summers Counties in West Virginia

- Miles of pipeline: 143
- Acres
  - In the construction corridor and temporary roads and workspaces: 2449
  - In the permanent right-of-way (ROW): 861
  - In permanent access roads and other facilities: 76
- Most impacted land cover types (ROW only): forest (664 acres) and pasture (142 acres)
- Parcels touched by ROW: 716
- Parcels in the 1.4-mile-wide evacuation zone: 8,221
- Residents and housing units in the evacuation zone: 20,389 people and 9,700 homes
- Parcels from which the pipeline would be visible: 78,553 or 31% of all parcels in the six counties for which detailed parcel data are available
- Baseline (no pipeline) property value at risk (and expected one-time cost due to the MVP):
  - In the ROW: $125.9 million ($5.3 to $16.4 million)
  - In the evacuation zone: $972.6 million ($37.0 million)
  - In the viewshed: $16.8 billion (to avoid double counting with lost aesthetic value under ecosystem services, this impact is not separately estimated)
- Total property value lost (a one-time cost): $42.2 to $53.3 million
- Resulting loss in property tax revenue (annual): $243,500 to $308,400
- Lost ecosystem service value, such as for water and air purification, recreational benefits, and others:
  - Over the two-year construction period (a one-time cost): between $22.9 and $82.2 million
  - In the ROW (annual): between $4.1 and $14.8 million
- Lost economic development opportunities due to the erosion of these counties' comparative advantages as attractive places to visit, reside, and do business. Under the scenarios described below, these could include:
  - Annual loss of recreation tourism expenditures of $96.8 million that supports 1,073 jobs and $24.3 million in payroll and generates $4.8 million in state and $2.6 million in local taxes
  - Annual loss of personal income of $15.6 million due to slower growth in the number of retirees
  - Annual loss of personal income of $2.1 million due to slower growth in sole proprietorships
- Total of estimated costs:
  - One-time costs (lost property value and lost ecosystem service value during construction) would total between $65.1 to $135.5 million
  - Annual costs (costs that recur year after year) would range from $119.1 to $130.8 million
    - Present discounted value of all future annual costs (discounted at 1.5%): $7.9 to $8.7 billion
  - One-time costs plus the discounted value of all future annual costs: $8.0 to $8.9 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

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 Mountain Valley Pipeline

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: 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

MVP: Mountain Valley Pipeline, which in this report generally refers to the pipeline corridor itself

MVP LLC: Mountain Valley Pipeline, LLC, a joint venture of EQT Midstream Partners, LP, NextEra US Gas Assets, LLC, Con Edison Gas Midstream, LLC, WGL Midstream, Vega Midstream LLC, and RGC Midstream, will own and construct the proposed Mountain Valley Pipeline

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

AUTHOR'S NOTE

We are grateful for the assistance of POWHR—for "Protect Our Water, Heritage, Rights" (information at powhr.org)—coalition members and other groups in identifying local information sources and making contacts in the study region. These groups include Blue Ridge Land Conservancy, Border Conservancy, Chesapeake Climate Action Network, Greenbrier River Watershed Association, Preserve Bent Mountain, Preserve Craig, Preserve Franklin, Preserve Giles County, Preserve Greenbrier County, Preserve Monroe, Preserve Montgomery County, Va., Preserve the New River Valley, Preserve Roanoke, Roanoke Valley Cool Cities Coalition, Save Monroe, Summers County Residents Against the Pipeline, Virginia Chapter, Sierra Club, and Virginia Citizens Consumer Council.

We also thank Professor Stockton Maxwell of Radford University and his students John DeGroot and Bryan Behan for their assistance acquiring and processing spatial (GIS) data for the land value and visibility analyses. Key-Log Economics remains solely responsible for the content of this report, the underlying research methods, and the conclusions drawn. We have 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 if the MVP is built.

Cover Photo from Franklin County, Virginia courtesy of David Sumrell

BACKGROUND

The proposed Mountain Valley Pipeline (MVP) is a high-volume transmission pipeline intended, as described in filings with the Federal Energy Regulatory Commission (FERC), to transport up to two million dekatherms per day of natural gas from the Marcellus and Utica Shale region in West Virginia to markets in the Mid- and South-Atlantic Region of the United States (Mountain Valley Pipeline LLC, 2015a). MVP LLC partners have also indicated that the pipeline could facilitate export of liquefied natural gas to India or other overseas markets (Adams, 2015).

The majority of the pipeline, and the entire portion in the eight-county region considered in this study (Figure 1), would consist of 42-inch diameter pipe and would be operated at a nominal pressure of 1,480 pounds per square inch gauge (PSIG).

Along the way, the MVP would cross portions of the Jefferson National Forest, the Appalachian Trail, the Blue Ridge Parkway, and other public conservation, scenic, and natural areas. Its permanent right-of-way and temporary construction corridor—50 and 125 feet wide, respectively—would also cross thousands of private properties. Pipeline leaks and explosions, should they occur, would cause substantial physical damage and require evacuation of even wider swaths, affecting perhaps 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 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 MVP. This report, commissioned jointly by several regional and local groups, is both an attempt to understand the nature and potential magnitude of the economic costs of the MVP in a particular eight-county area, 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 MVP along its entire length and, by extension, throughout the region in which its effects will occur.

Policy Context

Before construction can begin, the MVP must be approved by 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 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), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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 approving or denying the MVP–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.

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 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). The Commission'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

[4] MVP LLC has published estimates of economic benefits in the form of employment and income stemming from the construction and operation of the MVP (Ditzel, Fisher, & Chakrabarti, 2015a, 2015b). As has been well documented elsewhere, 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 MVP. Most significantly, the studies make no mention of likely

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 just recently, FERC has never rejected a pipeline proposal (van Rossum, 2016).

Because MVP LLC failed to acquire a sufficient portion of the right-of-way and other federal agencies, including the US Forest Service, needed to evaluate how the MVP would affect resources under its stewardship, the Commission issued a Notice of Intent to prepare an EIS in February of 2015 (Federal Energy Regulatory Commission, 2015). 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. Of those, several including "domestic water sources…, Appalachian Trail…, Residential developments and property values; Tourism and recreation" and others are particularly important as environmental effects that resonate in the lives of people. These effects can take the form of economic costs external to MVP LLC that would be borne by individuals, businesses, and communities throughout the landscape the MVP would traverse.

Based on a review of written comments submitted to FERC in January through March of 2015, citizens do seem to have emphasized these issues. Key issues include economic impacts, environmental degradation, public safety, property value effects, and issues related to cultural and historical resources (Pipeline Information Network, 2015).

Study Objectives

Given the policy setting and what may be profound effects of the proposed MVP on the people and communities of Virginia and West Virginia, 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 MVP.
2. An estimate of the potential magnitude of economic effects in this eight-county subset of the landscape where the MVP's environmental effects will be felt.

We do not claim the estimates below represent the total of all potential costs that would attend the construction, operation, and presence of the pipeline. Specifically, we have included several categories of cost: "passive-use value,"[5] including the value of preserving the landscape without a pipeline for

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 (Phillips, 2015b) for details on these shortcomings.

[5] 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 MVP, people who have not yet visited the Blue Ridge Parkway or otherwise spent vacation time and dollars in the region are better off knowing that the setting for their planned activities is

future direct use, increases in the cost of community services like road maintenance and emergency response that may increase due to the construction and operation of the pipeline,[6] and probabilistic damages to natural resources, property, and human health and lives in the event of mishaps during construction and leaks/explosions during operation.

Therefore, our figures should be understood to be conservative, lower-bound estimates of the true total cost of the MVP in the sub-region and, of course, they do not include costs for the remainder of the region proposed for the MVP. We urge that the FERC augment the results of this study with its own similar analysis for the entire region and with additional research to determine the costs of community services and other relevant classes of costs not counted here.

Current Economic Conditions in the Study Region

Our geographic focus is an eight-county region encompassing Craig, Franklin, Giles, Montgomery, and Roanoke counties in Virginia[7] as well as Greenbrier, Monroe, and Summers counties in West Virginia. This 3,964-square-mile region supports diverse land uses, including wild and pristine forests, both the Appalachian Trail and Blue Ridge Parkway, thriving cities, working farms, and extensive commercial timberland. These natural, cultural, and economic assets are among the reasons more than

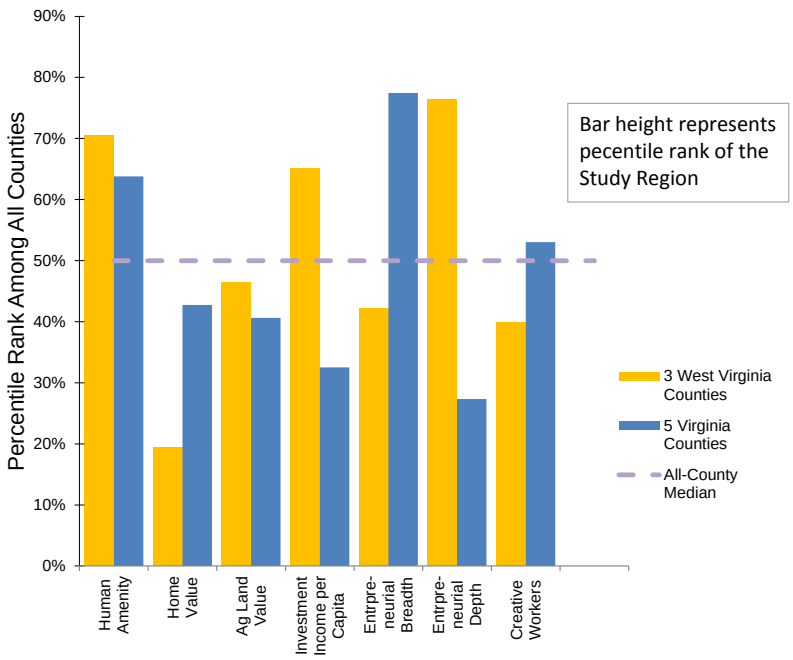


FIGURE 2: Regional Asset Indicators for Study Region Counties, Relative to their Respective States
(Source: Federal Reserve Bank of Kansas City)

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 an MVP-free landscape.

[6] As with communities impacted by the shale gas boom itself, 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).

[7] Two independent cities, Salem and Roanoke, lie within the geographic borders of Roanoke County. In this report, subject to some limitations where noted, statistics, estimates, and other information labeled as "Roanoke County" reflect totals for the County plus the two independent cities. The City of Radford at the southern edge of Montgomery County lies on the other side of the New River from the rest of the County, and is considered in this study to be far enough removed from the proposed MVP that it is not included in the statistics or estimates.

342,000 people call this region home and an even larger number visit each year for hiking, boating, sightseeing, festivals, weddings, and other events.

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 most West Virginia or Virginia counties (Figure 2).[8] The West Virginia counties are stronger in terms of investment income per capita than the average for other West Virginia counties. The five Virginia counties have slightly more creative workers, as a percentage of the workforce, than the average for the Commonwealth.

More traditional measures of economic performance suggest the region is generally strong and resilient, though there are some differences among the Virginia and West Virginia Counties. From 2000 through 2014, for example:[9]

- Population in the study region grew by 9.6%, compared to a -0.5% loss of population for non-metro Virginia and West Virginia[10]
    - Population in the Virginia section of the study region grew by 10.5%, compared to a -0.2% loss of population for non-metro Virginia
    - Population in the West Virginia section of the study region grew by 0.8%, compared to a -1.1% loss of population for non-metro West Virginia
- Employment in the study region grew by 3.5%, compared to a -4.0% loss for non-metro Virginia and West Virginia
    - Employment in the Virginia section of the study region grew by 3.4%, compared to a -6.7% loss of employment for non-metro Virginia
    - Employment in the West Virginia section of the study region grew by 5.1%, compared to a 2.4% growth of employment for non-metro West Virginia
- Personal income in the study region grew by 20.6%, compared to 15.1% for non-metro Virginia and West Virginia
    - Personal income in the Virginia section of the study region grew by 20.7%, compared to 13.1% growth of personal income for non-metro Virginia

[8] 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.

[9] These data are from Headwaters Economics (2015), US Bureau of Economic Analysis (2015), and US Bureau of the Census (2014, 2015).

[10] "Non-metro Virginia" and "Non-metro West Virginia" comprises those counties that are not a part of a federally defined metropolitan statistical area (MSA). While the Virginia counties in the study region are in MSAs, each of the study region counties are predominantly rural in landscape and character and are much more like other non-metro counties than they are like Northern Virginia or Tidewater, for example. Therefore, we believe that averages for non-metro Virginia provide a more appropriate point of comparison than statistics that include the Commonwealth's more urban areas. None of the West Virginia counties in the study region are part of an MSA.

    - Personal income in the West Virginia section of the study region grew by 19.7%, compared to 19.6% growth of personal income for non-metro West Virginia
- On average, earnings per job in the study region are higher, by about $7,400/year, than the average for non-metro Virginia and West Virginia
    - Earnings per job in the Virginia section of the study region are higher, by about $9,300/year, than the average for non-metro Virginia
    - Earnings per job in the West Virginia section of the study are lower, by about $5,100/year than the average for non-metro West Virginia
- Per capita income is higher in the study region, by $4,100/year, than the average for non-metro Virginia and West Virginia
    - Per capita income in the Virginia section of the study region is higher, by about $4,400/year, than the average for non-metro Virginia
    - Per capita income in the West Virginia section of the study region, while growing, is lower, by about $1,400/year, than the average for non-metro West Virginia
- The unemployment rate in the study region is 2.5%, compared to 2.3% for non-metro Virginia and West Virginia, during 2000-2014
    - The unemployment rate in the Virginia section of the study region is 2.9%, compared to an unemployment rate of 3.2% for non-metro Virginia, during 2000-2014
    - The unemployment rate in the West Virginia section of the study region is 0.3%, compared to an unemployment rate of 1.0% for non-metro West Virginia, during 2000-2014

These trends are consistent with what regional economists McGranahan and Wojan have called the "Rural Growth Trifecta" of outdoor amenities, a creative class of workers, and a strong "entrepreneurial context" (innovation-friendliness) (2010). Individual workers, retirees, and visitors are attracted to the natural beauty of the region while entrepreneurs are attracted by the quality of the environment, by the quality of the workforce, and by existing support from local government. Workers, for their part, are retained and nurtured by dynamic businesses that fit with the landscape and lifestyle that attracted them to the region in the first place. As further indication of this dynamic, consider since 2000:[9]

- The region's population growth has been primarily due to in-migration
- The proportion of the population 65 years and older has increased from 14.5% to 15.5%
- Proprietors' employment is up by 28.9%
- Non-labor income (primarily investment returns and age-related transfer payments like Social Security) is up by 39.0%.

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

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 more

than $1.2 billion in the study region in 2014. The companies that directly served those tourists employed 11,642 people, or 15.4% of all full- and part-time workers (Dean Runyan Associates, 2015; Headwaters Economics, 2015; Virginia Tourism Corporation, 2015).

It is in this context the potential economic impacts of the MVP 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 MVP 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 members. 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.

ENVIRONMENTAL-ECONOMIC EFFECTS AND WHERE THEY WOULD OCCUR

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

First, 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 MVP's construction and operation. Second are effects on property value as owners and would-be owners choose properties farther from the pipeline's right-of-way, evacuation zone, and viewshed. Third and finally are more general economic effects caused by a dampening of future growth prospects or even a reversal of fortune for some industries.

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

Construction of the pipeline corridor itself would require clearing an area at least 125 feet (38.1 m) wide. (It would be wider in some areas depending on slope.) After construction, the permanent right-

of-way (ROW) would be 50 feet wide along the entire length of the pipeline. Within the construction zone and right-of-way is where the greatest disruption of ecosystem processes will occur, so these zones are where reductions in ecosystem service value (ESV) emanate. Since we are estimating ecosystem service values at their point of origin, we will focus on the ROW and the construction zone, as well as temporary and permanent access roads, temporary workspaces, and permanent surface infrastructure.

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" and an even larger evacuation zone. A High Consequence Area (HCA) 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 1,095 feet (333.9 m). 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 3,583 feet (1092.1 m).[11] (See map, Figure 3, for a close-up of these zones in part of the study region.) An explosion would undoubtedly affect ecosystem processes within the HCA and possibly the evacuation zone, but given the probability of an explosion at a 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.

> ***"I saw no other option than to cancel my home building project once the MVP was proposed to cross the property."***
>
> *— Christian Reidys, Blacksburg, VA*

Effects on land value are another matter, and it is reasonable to consider land value impacts through both the high consequence area and 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 news reports, YouTube, and other 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, therefore, into the chances of selling properties exposed to those risks, into prices offered for those properties, and, for people who already own such properties, diminished enjoyment of them (Freybote & Fruits, 2015).

In addition, loss of view quality would be expected for properties both near to and far from the pipeline corridor. Unlike leaks and explosions, view quality impacts will occur with certainty. If the pipeline is built, people will see the corridor as a break in a once completely forested hillside, and their "million-

[11] The maximum operating pressure proposed for the MVP is 1,480 PSIG, but the source data for this evacuation distance is a table with pressure in 100 PSIG increments. The full evacuation distance would be between 3,583 feet and 3,709 feet, the distance recommended for a 42" pipeline operated at 1,500 PSIG. The upshot for this study is a slightly more conservative estimate of the effect of the MVP on property value.

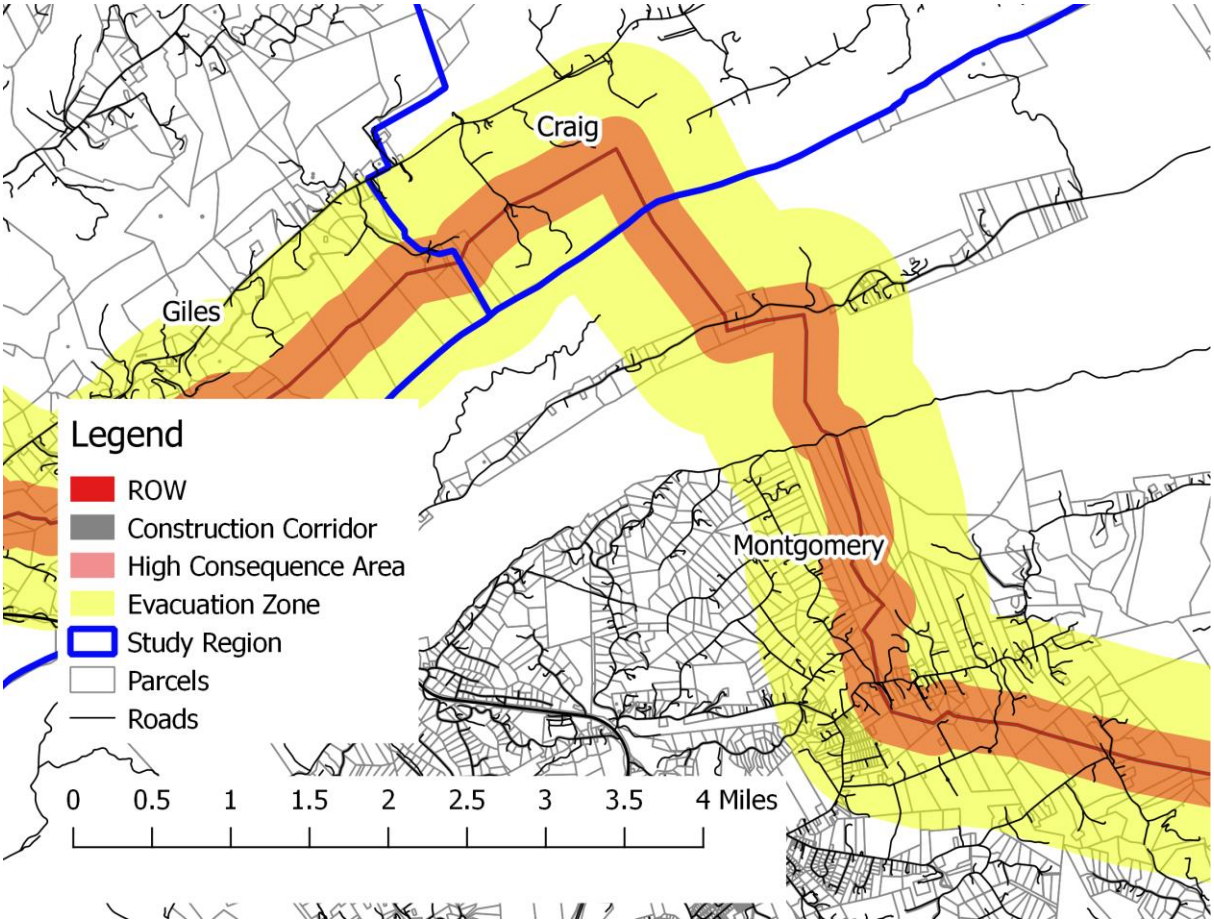


FIGURE 3: Right-of-Way, Construction, High Consequence, and Evacuation Areas
Note that the overlay of the HCA (in rose) and the evacuation zone (in yellow) shows up as the orange band in the map. The ROW covers much of the construction corridor, leaving a thin band of grey visible.
Sources: MVP route digitized from online maps and MVP LLC filings (http://mountainvalleypipeline.info/maps/); Counties and roads from USGS (http://nationalmap.gov; Parcels from public records in Giles and Montgomery County, respectively. (Parcel boundaries are not available in electronic form for Craig County.)

dollar" view will be diminished. Therefore, for our analysis of land value, we consider any place where there is considerable potential to see the pipeline corridor to be within its direct impact zone. (See map, Figure 7, in the land value section for the results of the visibility analysis.)

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, or the certainty of impacts on aesthetics, the proposed MVP 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 MVP instead of in some other place.

To the extent the MVP 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 1 summarizes the types of economic values considered in this study and the zones in which they are estimated.

TABLE 1: Geographic Scope of Effects

A check mark indicates those zones/effects for which estimates are included in this study. The "X's" indicate areas for future study.

Values / Effects	Right-of-Way and Construction Zone	High Consequence Area	Evacuation Zone	Pipeline Viewshed	Entire Study Region	The World Beyond the Study Region
Ecosystem Services	✓	a	a	a,b	✗[a,b]	✗
Land / Property Value	✓[c]	✓[d]	✓[d]	✓[e]	✗	n/a
Economic Develop-ment Effects	f	f	f	f	✓	n/a

Notes:

a. Changes in ecosystem services that are 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 of alteration of 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 MVP 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.

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 "Ecosystem Services" section.

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

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). Other definitions abound, including the following from Gary Johnson of the University of Vermont:

> Ecosystem services are 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 (2010).

This definition is helpful because it emphasizes services are not necessarily things–tangible bits of nature–but rather, they are the effects on people of the functions of the natural world. It also makes clear ecosystem services happen or are produced and enjoyed in particular places and at particular times.

No matter the definition, different types of ecosystems (forest, wetland, cropland, urban areas) 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.

"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 2, lists the provisioning, regulating, and cultural ecosystem services included in this study.

At a conceptual level, we estimate the potential effects of the MVP on ecosystem service value by identifying the extent to which the construction and long-term existence of the pipeline would change land cover or land use, resulting 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.

Construction would essentially strip bear the 125-foot-wide construction corridor. Once construction is complete and after some period of recovery, the 50-foot-wide right-of-way will be occupied by a different set of ecosystem (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 service types, we can estimate ecosystem service value produced per year in the periods before, during, and after construction. The difference between annual ecosystem service value *during* construction and *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.

TABLE 2: Ecosystem Services Included in Valuation

Provisioning Services[a]
Food Production: The harvest of agricultural produce, including crops, livestock, and livestock by-products; the food value of hunting, fishing, etc.; and the value of wild-caught and aquaculture-produced fish. **Associated land uses[b]:** Cropland, Pasture/Forage, Forest
Raw Materials: Fuel, fiber, fertilizer, minerals, and energy. **Associated land uses[b]:** Forest
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, 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, 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
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, 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, Urban Open Space, Wetland
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]:** Forests, 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]:** Forest, Pasture/Forage, Urban Open Space, Wetland
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, 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.

In addition to the ROW and construction corridor, the MVP would require the construction of various temporary and permanent access roads, temporary work areas, and several areas for maintenance facilities. All temporary roads and temporary work areas are treated as though they are part of the construction zone. Permanent roads and installations are treated separately. Note that many of the access roads already exist and will simply be used for pipeline access. Since there is no change in the land use for those roads, there is no loss in ecosystem service value associated with them. It is only when areas are converted from forest, pasture, or other land covers to the developed use (a road or surface facility) that ecosystem service value is altered.

This overall process is illustrated in Figure 4 and the details of our methods, assumptions, and calculations are described in the following two sub sections.

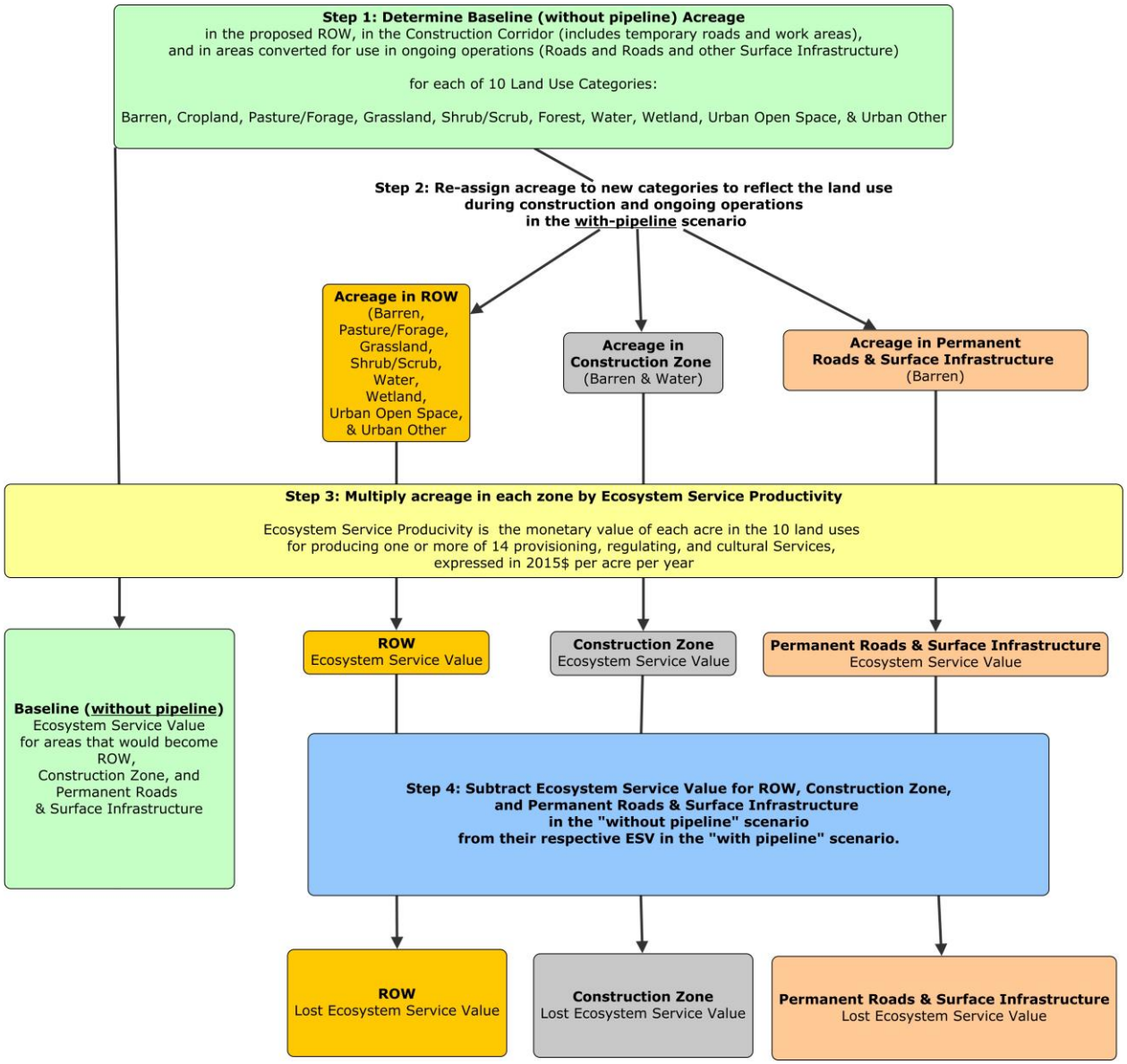


FIGURE 4: Ecosystem Service Valuation Process

Ecosystem Service Estimation Methods

Economists have developed widely used methods to estimate the monetary value of ecosystem services and/or natural capital. The most widely known example was 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" or "BTM" to establish a value for the ecosystem services produced or harbored from a particular place.[12] 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).

As the name implies, 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 to select "comps" (data from source areas) that match the circumstances of the study area as closely as possible.

Typically, values are drawn from previous studies estimating the value of various ecosystem services from similar land cover or ecosystem 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 forest land for recreation. In that case, one would apply the per-acre value of recreation from the source area's forestland to the number of acres of forestland in the study area. Multiplying that value by the number of acres of forestland in the study area produces 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 underlying economic, social, and other conditions similar to the study area.

Following these principles as well as techniques developed by Esposito et al. (2011), Esposito (2009), and Phillips and McGee (2014, 2016a), and as illustrated in Figure 4, we employ a four-step process to evaluate the short-term and long-term effects of the MVP on ecosystem service value in our study region. The steps are described in greater detail below, but in summary, they are:

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 MVP" 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 MVP scenario, for the construction corridor (and period), and for the ROW during

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

ongoing operation.

For simplicity and given the two-year construction period, we assume the construction corridor will remain barren for a full two-year period. We recognize revegetation will begin to occur soon after the trench is closed and fill and soil are returned, but it will still be some time until something like a functioning ecosystem has actually been restored.

4. Subtract baseline (no pipeline) ESV from ESV (with pipeline) for the construction period (and in the construction corridor) 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;[13] 15 of these land cover types are present in the study region (Table 3 and Figure 5).

TABLE 3: Land Area Affected By MVP, Study Region Total (See Also Figure 6)

Land Use	Baseline acreage in ROW	Baseline acreage in construction corridor, including temp work zones, etc.	Baseline acreage in permanent surface infrastructure
Urban Other	6.6	22.9	1.3
Urban Open Space	23.9	85	3.3
Wetland	0.5	1.4	0
Water	0.8	2.5	0
Forest	663.7	1781.4	54
Shrub/Scrub	0.5	2	0
Grassland	3.6	10.5	0.4
Pasture/Forage	141.5	485.3	15.6
Cropland	11.9	32.3	0.9
Barren	8.2	26.1	0.2
Total	**861.2**	**2449.4**	**75.7**

Looking forward to the final step, we will use land use categories to match per-acre ecosystem value estimates from source areas to the eight-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

[13] Because 30 meters is wider than the right-of-way and not much narrower than the 125-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.

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."

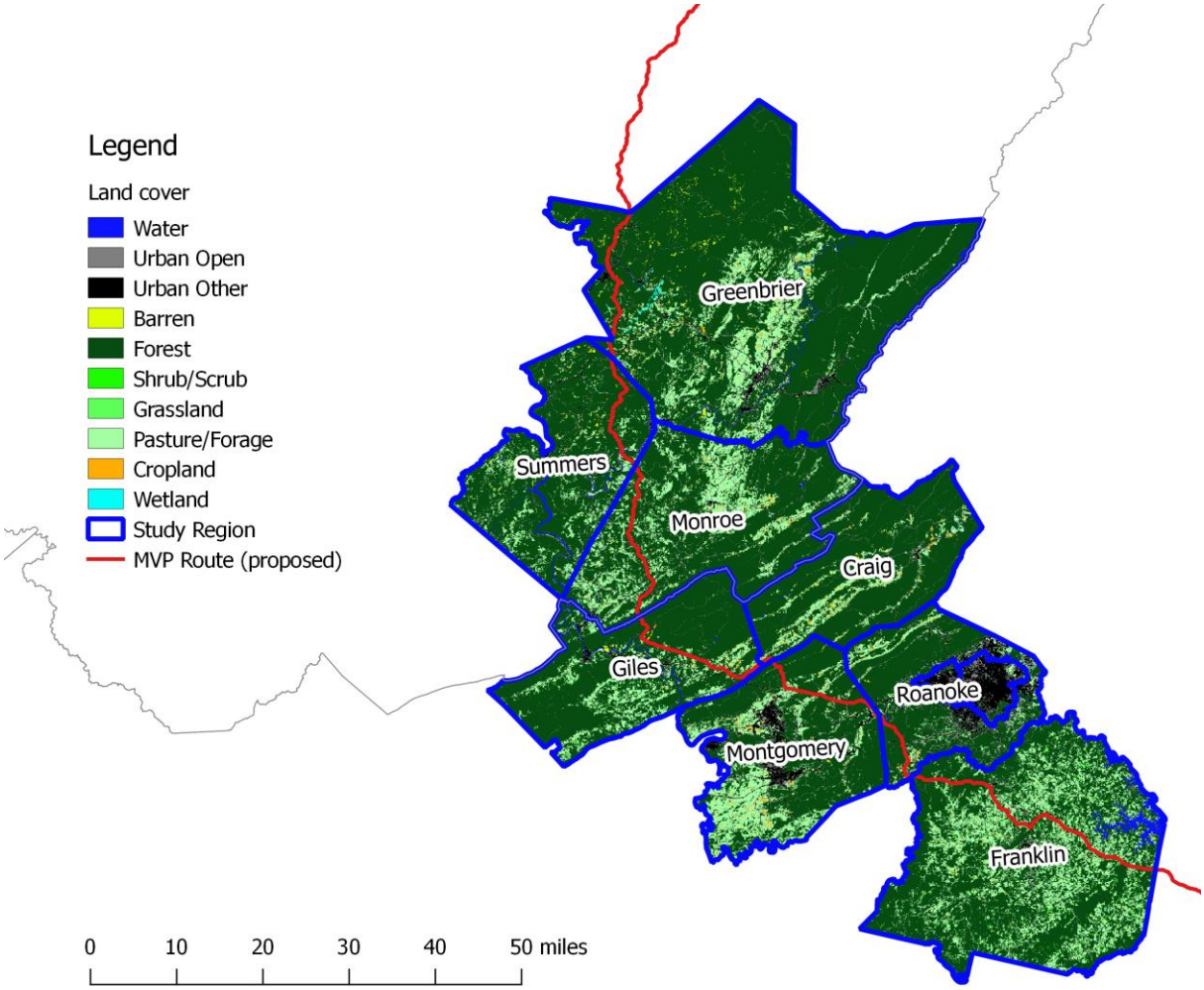
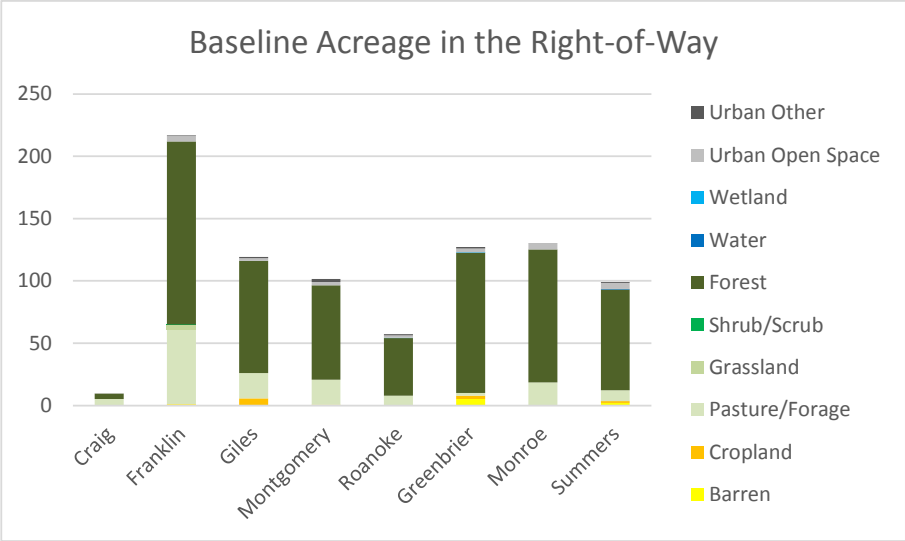


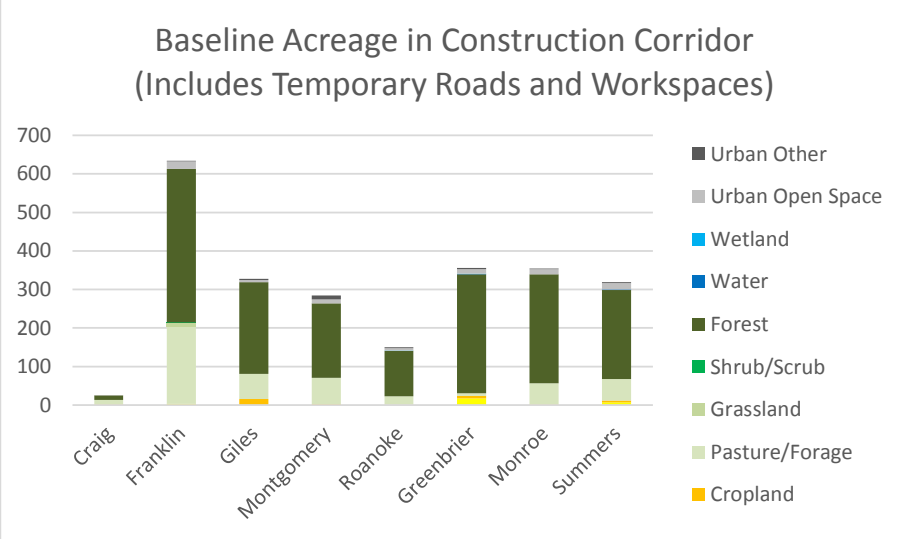
FIGURE 5: Land Use in the Study Region, as Classified for Ecosystem Service Valuation

Land cover for the entire study region is shown to display the overall range and pattern of land use. The ecosystem service valuation itself covers only those portions of the study region that would be occupied by the MVP right-of-way and construction corridor.

Sources: Land Cover from National Land Cover Database (Fry, et al. 2011); MVP route digitized from online maps and MVP LLC filings (http://mountainvalleypipeline.info/maps/); Counties from USGS (http://nationalmap.gov).

In addition and for two reasons, 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, 2016a). Second, wetlands possess some of the highest per-acre values for several ecosystem services. To avoid over-estimating the ecosystem services contribution of "woody wetlands," we count them as "forest" instead of "wetland."





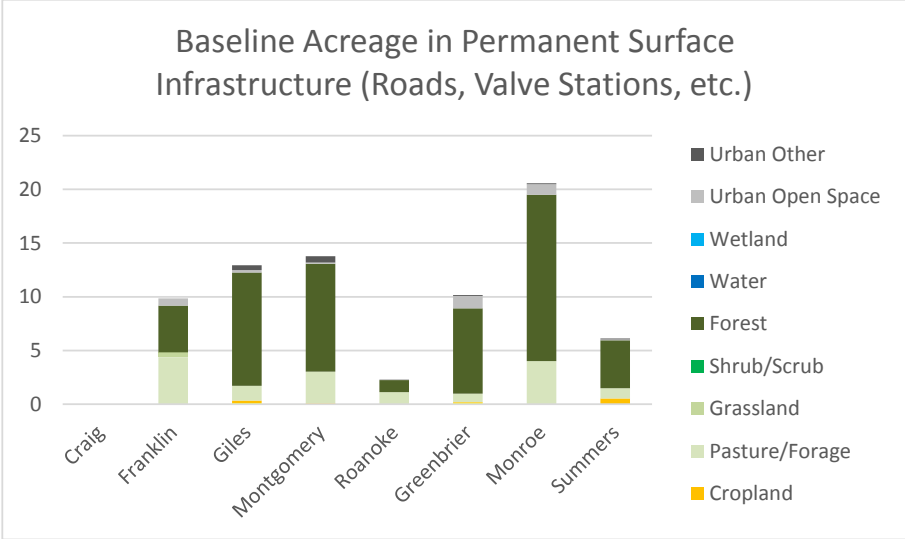


FIGURE 6: Baseline (Pre-MVP) Land Use, by County, in the Row, Construction Zones, and Permanent Surface Infrastructure. (See also Table 3.)

In the end, at least for baseline (no pipeline) conditions, we have land in 10 land uses. The total area that would be disturbed in the construction corridor and temporary roads and other work areas is 2,449 acres, of which 861 acres would be occupied by the permanent right-of-way. An additional 76 acres would be devoted to permanent access roads and other installations on the surface. Figure 6 shows the distribution of acreage in the ROW, construction zone, and in land needed for permanent surface infrastructure by county and pre-MVP, or baseline land use.

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 4 lists the reassignment assumptions in detail.

TABLE 4: Land Cover Reclassification

NLCD Category	Reclassification for Baseline	Reclassification for Construction	Reclassification for Ongoing Operation in the ROW	Reclassification for Ongoing Operation Roads and Surface 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
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-MVP forestland will become shrub/scrub, and cropland will become pasture/forage. We

recognize some pre-MVP cropland may be used for crops after construction has been completed, but as expressed in comments to FERC and elsewhere, and as we discovered through personal interviews with agricultural producers in the region, it seems likely that the ability to manage acreage for row crops will be greatly curtailed, if not eliminated entirely by the physical limits imposed by the MVP and by restrictions in easements to be held by MVP LLC. 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. As 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 the pipeline]." Thus, the true loss in food and other ecosystem service value from pasture/forage acreage would be larger than our estimates reflect.

Permanent access roads and sites for main line 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 corridor 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).[14] 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 Virginia and West Virginia, we identified 91 per-acre estimates in the TEEB that adequately provide approximations of ecosystem service value in our study region.[15]

[14] 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.

[15] 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.

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, 2015a; Phillips & McGee, 2016b) and to specific data on cropland and pasture/hayland value from Virginia Cooperative Extension and the National Agricultural Statistics Service (Lex & Groover, 2015; 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 MVP.

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 corridor
- Ecosystem service value in the construction corridor during construction
- 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[16]

[16] 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.

Value calculations are accomplished according to this formula

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

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 MVP" ESV from ESV in "with MVP" Scenario

With the steps above 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 MVP is built and operating.

The cost of construction is the ESV from the construction corridor during construction, minus baseline ESV for the construction corridor, multiplied by two. The multiplication by two is due to the conservative assumption that revegetation and restoration to a land use that is functionally different from barren land will take at least two years.

The ecosystem service cost of ongoing operations is ESV from the ROW in the "with MVP" scenario minus the baseline ESV for the ROW. This will be an annual cost borne every year in perpetuity.

Ecosystem Service Value Estimates

In the baseline or "no pipeline" scenario, the construction corridor and land slated for temporary roads and workspaces produces between $11.4 and $41.1 million per year in ecosystem service value. The largest contributors to this total (at the high end) are aesthetic value, water supply, and protection from extreme events. Under a "with MVP" scenario, and not surprisingly given the temporary conversion to bare/barren land, these figures drop to near zero, or between $451 and $3,552 per year for each of the two years. Taking the difference as described above, estimated per-year ecosystem service cost of the MVP's construction would be between $11.4 and $41.1 million, or between $22.8 and $82.2 million over two years in the eight-county study region (Table 5).

The ecosystem service costs for the ROW are predictably smaller on a per-year basis, but because they will persist indefinitely, the cumulative effect will be much higher. Under the "with MVP" scenario, using minimum values, the annual ecosystem service value from the ROW falls from $4.2 million to about $160,000 for an annual loss of over $4.1 million. At the high end of the range, the ecosystem service value of the ROW would fall from $15.3 million to about $436,000 for an annual loss of $14.8 million in the study region (Table 6).

TABLE 5: Ecosystem Service Value Lost to the Construction Corridor and Temporary Roads and Workspaces in Each of Two Years, Relative to Baseline, by Ecosystem Service (2015$)

Ecosystem Service	Study Region			
	Baseline (low)	*Loss (low)*	*Baseline (high)*	*Loss (high)*
Aesthetic Value	8,046,503	(8,046,503)	32,491,871	(32,491,871)
Air Quality	666,647	(666,647)	680,270	(680,270)
Biological Control	12,524	(12,524)	30,044	(30,044)
Climate Regulation	209,199	(209,199)	228,236	(228,236)
Erosion Control	15,104	(15,104)	146,466	(146,466)
Protection from Extreme Events	1,447,945	(1,447,945)	1,482,118	(1,482,118)
Food Production	10,929	(10,929)	10,929	(10,929)
Pollination	369,769	(369,769)	433,706	(433,706)
Raw Materials	43,763	(43,763)	297,240	(297,240)
Recreation	64,090	(63,722)	967,718	(965,459)
Soil Formation	12,837	(12,837)	41,061	(41,061)
Waste Treatment	22,692	(22,666)	527,395	(527,369)
Water Supply	84,501	(84,444)	2,306,613	(2,305,346)
Water Flows	417,057	(417,057)	1,444,340	(1,444,340)
Total	**11,423,559**	**(11,423,108)**	**41,088,007**	**(41,084,455)**

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 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 $1,000 and $28,000 per year.[17]

TABLE 6: Ecosystem Service Value Lost Each Year Post Construction in Right-Of-Way, Relative to Baseline, by Ecosystem Service (2015$)

Ecosystem Service	Study Region			
	Baseline (low)	*Loss (low)*	*Baseline (high)*	*Loss (high)*
Aesthetic Value	2,985,838	(2,945,731)	12,089,964	(12,040,073)
Air Quality	248,102	(222,539)	251,931	(222,539)
Biological Control	4,062	(1,673)	10,554	(8,166)
Climate Regulation	68,141	(32,887)	75,238	(39,900)
Erosion Control	4,926	12,931	51,847	(26,014)

[17] 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.

Protection from Extreme Events	536,977	(529,386)	547,721	(529,386)
Food Production	3,308	(1,043)	3,308	(1,043)
Pollination	137,114	(133,628)	160,576	(153,309)
Raw Materials	16,306	(16,278)	110,739	(110,711)
Recreation	18,729	1,738	355,391	(332,073)
Soil Formation	4,641	(4,083)	15,136	(14,579)
Waste Treatment	8,197	(7,182)	194,147	37,326
Water Supply	31,478	(31,450)	859,334	(857,620)
Water Flows	155,301	(152,619)	536,635	(529,356)
Total	4,223,118	(4,063,831)	15,262,520	(14,827,442)

Finally, the establishment of permanent access roads and other surface installations 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 only 76 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 MVP exists. The annual loss of ecosystem service value from these areas under a "with MVP" scenario would range from $350,000 to $1.2 million.

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

- The estimates include only the loss of value that would otherwise emanate from the ROW, construction corridors, access roads, temporary workspaces, and other surface installations themselves.

  The estimates do not account for the extent to which the construction and long-term presence of the MVP could damage the ecosystem service productivity of adjacent land. During construction, the construction corridor itself could be a source of air and water pollution that may compromise the ability of surrounding or downstream areas to deliver ecosystem services of their own. For example, if sediment from the construction zone that reaches surface waters, the sediment will cause those streams and rivers to lose some of their ability to provide clean water, food (fish), recreation, and other valuable services. This reduced productivity may persist well after construction is complete.[18]

- Over the long term, the right-of-way would serve as a pathway by which invasive species or wildfire could more quickly penetrate areas of interior forest habitat, thereby reducing the natural

[18] This is not a small risk. As noted by the Dominion Pipeline Monitoring Coalition "pipeline construction over steep Appalachian mountains creates significant runoff and slope-failure problems" (Webb, 2015b). In one example, multiple problems during and after construction of a relatively small pipeline on Peters Mountain in Giles County caused extensive erosion and damage to waterways (Webb, 2015a). The coalition points out that "the potential for water resource problems will be greatly multiplied for the proposed larger projects [like the MVP], both in terms of severity and geographic extent."

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 reflect only those changes in natural benefits that occur due to changes in conditions on the surface of the land. Particularly because the proposed pipeline would traverse areas of karst topography there is well-founded concern that subsurface hydrology could be affected during construction and throughout the lifetime of the pipeline (Jones, 2015; Pyles, 2015). Blasting and other activities during construction could alter existing underground waterways and disrupt water supply. There is also a risk that sediment and other contaminants could reach 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 MVP on private property value are important to people along its proposed route would be an extreme understatement. The Pipeline Information Network (2015) reviewed all MVP comments submitted to FERC in the first three months of 2015. Some 60% of these comment letters mentioned property value or property rights concerns. Landowners and Realtors along the proposed route of the Mountain Valley Pipeline report have abandoned building plans, seen lower than expected appraisals, and have had buyers walk away from properties potentially affected by the MVP (Adams, 2016). At least one ROW landowner has been told by two insurance agencies that rates would likely increase for properties like hers if, indeed, coverage remains available at all (Roston, 2015).

> ***"I never met a client who would choose, for a family home, a property with a 42" pipeline full of explosive gas over a similar property without such an environmental and personal-safety hazard."***
>
> *– Patricia Tracy, Realtor*
> *Blacksburg, Virginia*

While it is impossible to know precisely how large an effect the specter of the MVP 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 MVP:

- 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).

  Considering only those buyers who are still willing to purchase the property, the expected loss in market value would be 10.5%.[19] 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 <u>all</u> potential buyers 66.2%.[20] 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 MVP 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" of sour gas[21] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

The risks posed by the MVP would be different – it would not be carrying sour gas, for example—but there are similarities between the MVP scenario and the situation in the study that makes their finding particularly relevant. Namely, the emergency plan response zones (EPZs) are defined by the health and safety risks posed by the gas operations and infrastructure. Also, in contrast to MVP-cited studies

[19] 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%.
[20] This is the expected value calculated as 0.622*(-100%)+0.189*(-21%)+0.189*(0%).
[21] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.

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 MVP has both a high consequence area (HCA) 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 MVP's HCA and evacuation zones or, at a minimum, regarding the presence of the MVP in the study region.

In addition to the emerging body of evidence that there is a negative relationship between natural gas infrastructure and property value, there have been many analyses demonstrating the opposite analog. Namely, it is well-established that amenities such as scenic vistas, access to recreational resources, proximity to protected areas, cleaner water, and others convey positive value to real property.[22] There are also studies demonstrating a negative impact on land value of various other types of nuisance that impose noise, light, air, and water pollution, life safety risks, and lesser human health risks on nearby residents (Bixuan Sun, 2013; Bolton & Sick, 1999; Boxall et al., 2005). 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 may be invalid.

Both FERC and MVP LLC have cited several 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. In its final EIS regarding the Constitution Pipeline, for example, FERC cited two articles concluding, in brief, that effects on property value from the presence of a pipeline can be either positive or negative, and that decreases in values due to a pipeline explosion fade over time (Diskin, Friedman, Peppas, & Peppas, 2011; Hansen, Benson, & Hagen, 2006). In its filing, MVP LLC cites additional studies drawing similar conclusions based on comparison of market and/or assessed prices paid for properties "on" or "near" a pipeline versus those farther away (Allen, Williford & Seale Inc., 2001; Fruits, 2008; Mountain Valley Pipeline LLC, 2015b; Palmer, 2008).

While the studies differ in methods, they are similar in that each fails to take into account two factors potentially voiding their conclusions entirely. First, the studies do not consider that the property value data used do not represent prices arising from transactions in which all buyers have full information about the subject properties. Second, for the most part, the definition of nearness to the pipelines may be inappropriate or inadequate for discerning actual effects on property value of that nearness.

Economic theory holds that for an observed market price to be considered an accurate gauge of the 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—their risk aversion—to bear on

[22] Phillips (2004) is one such study that includes an extensive review of the literature on the topic.

their decision about how much to offer for the property. As a result, buyers' offer prices will be higher than they would be if they had full information.

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.

The study by Hansen, Benson, and Hagen (2006) actually reinforces the conclusion that when buyers know about a nearby pipeline, market prices drop. The authors found that property values fell after a deadly 1999 liquid petroleum pipeline explosion in Bellingham, Washington. They 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.

We do not think it is appropriate to conclude from this study (as FERC did in the case of the Constitution Pipeline) that natural gas transmission pipelines would have no effect on land prices in today's market. 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, citizens' 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.

Online based tools have changed the ways people shop for homes. We are now in a real world much closer to the competitive economic model that assumes all buyers have full information about the homes they might purchase. Anyone with an eye toward buying property near the proposed MVP corridor would 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 and environmental effects. Accordingly, the price buyers would offer for a home near the MVP will be lower than the price offered for another farther away or in another community or region entirely.

The second problem with the studies is that while they 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 the subject pipelines that health and safety concerns 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. However, in almost all cases the geographic scope of the analysis was small enough that most or all of the properties not on the right-of-way are still within the pipelines' respective evacuation zones (Allen, Williford & Seale Inc., 2001; Integra Realty Resources, 2016).[23]

The 2016 INGAA study suffers from the same problems, including the comparison of properties "on" and "off" the six pipelines analyzed when a majority of the "off" properties are within the pipelines' evacuation zones. In eight of the case studies—those for which a specific distance from pipeline was reported—an average of 72.5% of the "off" properties were actually within the evacuation zone. (We estimated the evacuation zone based on available information about the pipelines' diameter and operating pressure.) For the other two pipelines, the study reported a simple "yes" or "no" to indicate whether the property abutted the pipeline in question. For these cases, we assume the 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 the feature. It is a case where one actually does need to compare apples to oranges. However, because there is no variation in the feature of interest (i.e., the majority of properties are within the evacuation zone), the study is only looking at and comparing "apples." In this case, the feature of interest is the presence of a nearby risk to health and safety. With no variation in that feature, one would not expect a systematic variation in the price of the properties. By comparing apples to apples when it should be comparing apples to oranges, the INGAA study reaches the forgone and not very interesting conclusion that properties that are similar in size, condition, and other features <u>including their location within the evacuation zone of a natural gas pipeline</u> have similar prices.

To varying degrees, the other studies cited by FERC and in MVP LLC's filing suffer from the same problem. Fruits (2008), who analyzes properties within one mile of a pipeline that has 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 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 detect such a threshold effect. Such an effect would show up, of course, only if the

[23] 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).

buyers of the properties included in the study had been aware of their new property's proximity to the pipeline.

In short, one cannot conclude from these flawed studies' failure to identify a negative effect of pipelines on property value that no such effect exists. To evaluate the effects of the proposed MVP on property value, FERC and others must look to studies (including those summarized in the previous section) in which buyers' willingness to pay is fully informed about the presence of nearby pipelines and in which the properties bought are truly different in terms of their exposure to pipeline-related risks.

Visual Effects and Viewshed Analysis

Information about how the visual effects of natural gas transmission pipelines are reflected in property value 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 can be seen 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, if like power lines, by simply being unattractive. It is reasonable to conclude that the proposed MVP would have effects on property value that are mediated through visual effects, but the literature to date does not offer clear guidance on how large or strong the effects may be. We therefore have not included separate estimates of the impact of the MVP on property value in the viewshed. Moreover, we do not wish to double-count a portion of the impact of the MVP on "Aesthetics," which is already included among the ecosystem service value effects.

We do want to know, however, how many properties might suffer a portion of that lost aesthetic value. To keep the estimate conservative, we only count properties with a higher-than-average likelihood the MVP corridor could be seen from them. To determine this for each parcel, a GIS-based visibility 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. To keep the computing needs manageable, we analyzed a sample of points placed at 100m intervals along the proposed MVP route.

Because weather, smog, and other conditions limit the distance at which one can see anything in the mountains and valleys of Virginia and West Virginia, 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. We analyzed a section of the MVP beginning 25 miles north of the western boundary of Greenbrier County, West Virginia that extended to a point 25 miles east of the eastern boundary of Franklin County, Virginia.

By tallying the number of points on the pipeline corridor that could be seen from each spot in the study region and then connecting those spots to parcel boundaries, we obtain an estimate of how much of the pipeline could be seen from some spot within a given parcel. In Figure 6, yellow spots on the maps are points where between 1 and 10 points on the pipeline are visible, whereas orange and red spots have a view of up to as many as 251 points. Since each point represents 100 meters of pipeline, there are places in the study region where 25.1 km, or 15.6 miles, of pipeline corridor could be visible.

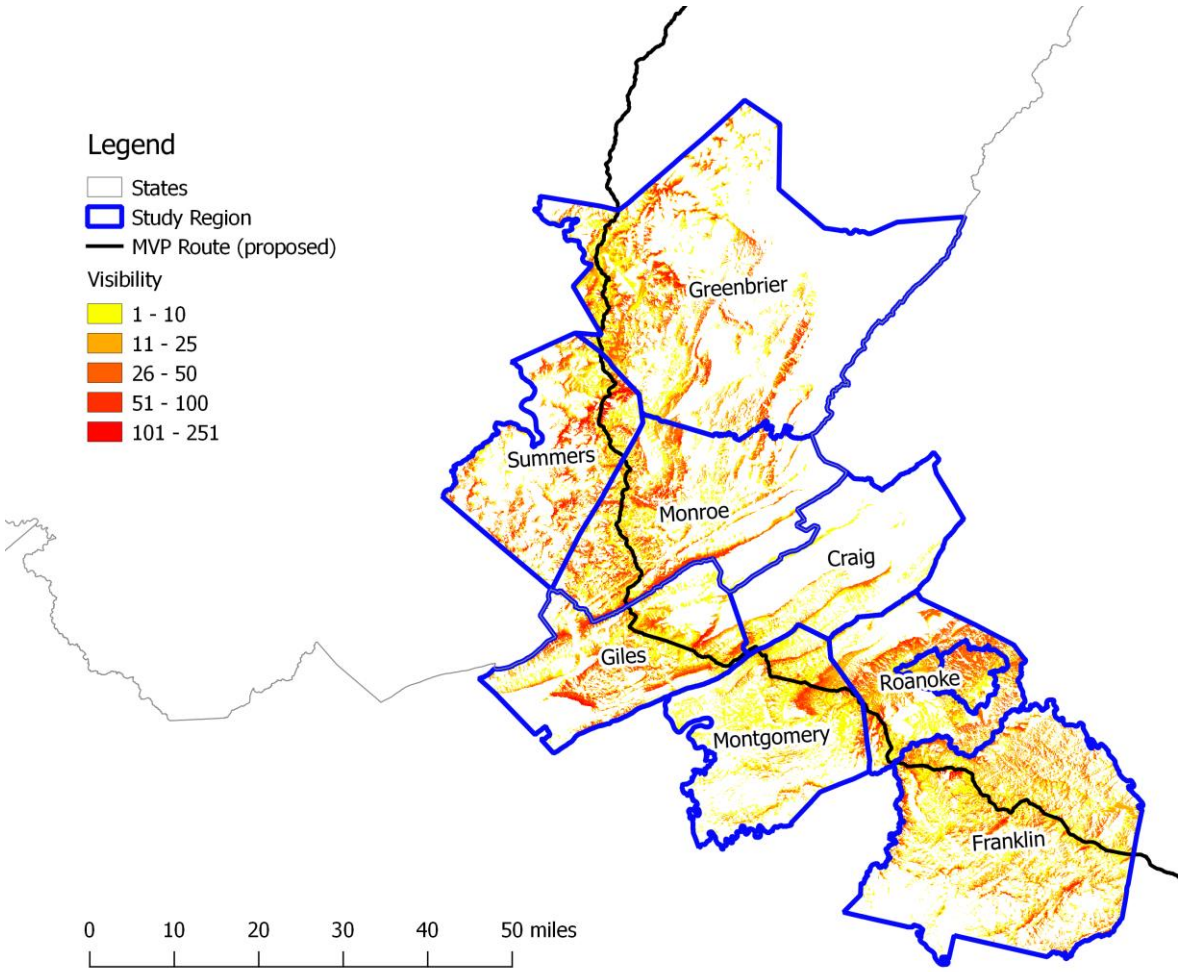


FIGURE 7: Visibility of the Proposed Mountain Valley Pipeline

The color of each point on the map indicates the number of waypoints, spaced 100m apart along the MVP 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: MVP route digitized from online maps and MVP LLC filings (http://mountainvalleypipeline.info/maps/); Counties from USGS (http://nationalmap.gov); Visibility analysis thanks to Bryan Behan and Stockton Maxwell of Radford University.

Taking into account those spots on nearly every parcel from which the MVP corridor is not visible, the average of the maximum number of points visible from a parcel is 10. This serves as our threshold for identifying parcels from which the pipeline would be "visible." Parcels containing no locations (again each spot is a 30m-by-30m square) from which more than 10 pipeline points are visible are considered to have no view of the pipeline. By this rule, and out of 253,880 parcels in the study region, 78,553 parcels, or just under one-third, would have a potential view of the pipeline.[24] The total value of these properties is currently $16.8 billion.

This a potential view of the pipeline because other visual obstructions, such as trees or buildings, are not taken into account. In particular, smaller parcels in more densely developed areas could be at elevations relative to the pipeline which would make it possible to see the MVP corridor, but the house

[24] Because GIS parcel maps are unavailable for Craig and Monroe Counties, those counties are not included in these figures.

next door may block that view. The restriction of our analysis to those parcels that have comparatively many spots from which to potentially see the pipeline mitigates this limitation of our GIS analysis. The reason is simply that smaller urban lots have very few 30-meter-square spots to begin with. A parcel has to be at least 10 spots in size (2.2 acres), with the pipeline visible from every spot, to cross the 10-spot threshold.

Parcel Values

For five of the eight counties in the study region, GIS data on parcel boundaries and corresponding tabular data with parcel value was obtained from the jurisdictions' public records. For the remaining three counties, electronic data on parcel boundaries, parcel values, or both were unavailable. In those cases, we adopted variations on a second-best approach to ensure more complete coverage of land value effects.

- Summers County, WV parcel boundaries were available, but the corresponding parcel values were not. We therefore used median house value from the US Census Bureau's American Community Survey (ACS) (2014) as a proxy. After adjusting the ACS figures for inflation, we attached those values to each parcel, according to which block group the parcel occupies.[25]
- Monroe County, WV parcel boundaries are viewable via the County's online map service, which allowed us to develop a list of parcels crossed by the ROW and those that overlap the evacuation zone. Similar to Summers County, we used median house value from ACS as a proxy for parcel value.
- For Craig County, parcel maps and corresponding parcel values are not available. MVP's route map, however, does show the 10 parcels crossed by the (ROW) through the County's southwest corner. We assume that 10 more parcels would be within the evacuation zone. For parcel value, we use the same proxy from ACS.

Two other features of the parcel data required adjustments prior to performing any land value impact calculations. First, the Giles County data had instances in which two or more individual tracts in different parts of the County are listed on a single tax record with a single property value. The consequence is that the value of all of the land connected to such multi-tract tax records would be swept up with the value of just those tracts actually crossed by the proposed ROW, or in the evacuation zone. To avoid overstating impacts, we split the multi-tract parcels into separate tax records and assigned each tract its own value based on its size and the per-acre value of the original multi-tract parcel.

The second remaining issue deals with public land that is unlikely to be sold and therefore does not possess any market value. To ensure these properties would not inflate overall property value effects, we used the "Protected Areas Database" from the National Gap Analysis Program to identify fee-owned conservation properties, such as portions of the Jefferson National Forest and state, county, and

[25] Because many parcels overlap block group boundaries, each parcel is assigned to a block according to whether its centroid, or geometric center, lies within the block group.

municipal parks (Conservation Biology Institute, 2012). Once identified, we set the value of all such properties equal to zero.

With all of these adjustments made, there remains the comparatively straightforward matter of identifying parcels of six types for which one could expect some effect of the MVP on the value. In order of increasing distance from the pipeline itself, these are:

1. Parcels crossed by the right-of-way
   (716 parcels, with total value (before MVP) of $125.9 million)
2. Parcels crossed by the construction corridor
   (768 parcels, with total value (before MVP) of $132.6 million)
3. Parcels at least partially within the high consequence area (HCA)
   (2,333 parcels, with total value (before MVP) of $320.6 million)
4. Parcels at least partially within the evacuation zone
   (8,221 parcels, with total value (before MVP) of $972.6 million)
5. Parcels from which the pipeline would be visible (as defined in the previous section)
   (78,553, with total value (before MVP) of $16.8 billion, not counting Monroe or Craig County)[26]

Note there is overlap among these zones. All ROW parcels are within the construction, HCA, and evacuation zones, for example. To avoid double counting we apply only one land value effect to any given parcel. ROW parcels are assumed to suffer no further reduction in value due to their location within the evacuation zone.

We have not considered the construction corridor separately this analysis. Even though the additional 52 parcels and $6.7 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 the parcels' proximity to the ROW or their location within the evacuation zone.

> *[Upon learning of the proposed MVP route through my property,] I immediately put the land on the market, disclosing its [bisection] by the pipeline…I was told by a realtor that a sale was out of the question, as the land had lost its value for building…. As of now I have not received any offers except ones that make a purchase contingent on the pipeline not being built. Apparently buyers do care.*
>
> *- Christian M. Reidys, Ph.D.*
> *Montgomery County Landowner*

Furthermore, we treat parcels in the HCA and in the evacuation zone the same way and apply 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 one's home at any time day or night could 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 previous study

[26] Monroe and Craig County are excluded because we do not have the necessary GIS parcel boundary data.

results that allow us to draw such a distinction, so instead we apply the lower evacuation zone effect to all HCA and evacuation zone parcels.

To summarize, Table 7 repeats a portion of Table 1, but with the property value effects in place of check marks.

TABLE 7: Summary of Marginal Property Value Effects

Values / Effects	Right-of-Way (Low, Medium, & High Effects)	High Consequence Area	Evacuation Zone	Pipeline Viewshed
Land / Property Value	-4.2%[a] -10.5%[b] -13.0%[c]	-3.8%[d]		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.

Estimated Land Value Effects

Following the procedures outlined in the previous section, our conservative estimate for costs of the proposed MVP would include between $42.2 million and $53.3 million in diminished property value. Some of the most intense effects will be felt by the owners of 716 parcels in the path of the right-of-way, who collectively would lose between $5.3 million and $16.4 million in property value. Some 8,221 additional parcels lie outside the ROW but are within or touching the evacuation zone. These parcels' owners would lose an estimated $37.0 million (Table 8). A far greater number of parcels, 78,553, would experience a loss in value due to diminished quality of the view from their properties.

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 $243,500 and $308,400 per year (Table 9). To keep their budgets balanced in the face of this decline in revenue, the 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. The MVP could drive up expenses while driving down the counties' most reliable revenue stream.[27]

[27] We recognize that MVP anticipates making tax payments, but because those payments are tied to net income from the operation of the pipeline, they may fluctuate from year to year or disappear entirely if pipeline operations become unprofitable.

TABLE 8: Summary of Land Value Effects, by Zone and County

	Effects in Right-of-Way			Effects in Evacuation Zone
Area	**Realtor Survey (4.2%)**	**Buyer Survey (10.5%)[a]**	**Impact Studies (13.0%)**	**Boxall Study (3.8%)**
Study Region	-5,288,289	-13,220,723	-16,368,514	-36,958,088
Virginia Portion	-4,484,041	-11,210,102	-13,879,174	-30,656,302
Craig	-60,223	-150,557	-186,404	-54,487
Franklin	-2,138,174	-5,345,434	-6,618,157	-14,855,120
Giles	-792,099	-1,980,248	-2,451,735	-4,174,604
Montgomery	-714,101	-1,785,252	-2,210,312	-7,009,533
Roanoke	-779,444	-1,948,611	-2,412,566	-4,562,557
West Virginia Portion	-804,248	-2,010,620	-2,489,339	-6,301,786
Greenbrier	-186,961	-467,402	-578,688	-1,438,278
Monroe	-382,228	-955,571	-1,183,088	-3,321,634
Summers	-235,059	-587,647	-727,563	-1,541,874

TABLE 8: Continued

	Total of ROW and Evacuation Zone Effects		
Area	**Low**	**Medium**	**High**
Study Region	-42,246,377	-50,178,810	-53,326,601
Virginia Portion	-35,140,343	-41,866,404	-44,535,476
Craig	-114,710	-205,045	-240,892
Franklin	-16,993,293	-20,200,554	-21,473,277
Giles	-4,966,703	-6,154,852	-6,626,339
Montgomery	-7,723,634	-8,794,785	-9,219,845
Roanoke	-5,342,002	-6,511,168	-6,975,123
West Virginia Portion	-7,106,034	-8,312,406	-8,791,125
Greenbrier	-1,625,239	-1,905,680	-2,016,966
Monroe	-3,703,862	-4,277,204	-4,504,721
Summers	-1,776,933	-2,129,522	-2,269,438

In addition to factors that make our estimates of the effects on property value conservative,[28] there is one other factor that makes the estimates of effects on property taxes lower than expected if the MVP is permitted. Some portion of properties in the ROW are currently undeveloped but still assessed at a

[28] These factors include using the lower expected price reduction from the buyer survey and applying the same price reduction to the entire evacuation zone (including the HCA).

value that assumes a single house site. Depending on where and how the ROW crosses these properties, it is likely that some will lose their potential usefulness for future residential or other development. In those cases, the assessed value (which by law reflects market value) will fall, and tax revenue generated by future development will never materialize.

TABLE 9: Effects on Local Property Tax Revenue

Area	Median Tax Rate (% of Value)[a]	Lost Property Tax Revenue		
		Low	Medium	High
Study Region		-243,476	-289,966	-308,414
Virginia Portion		-217,097	-259,111	-275,783
Craig	0.50%	-574	-1,025	-1,204
Franklin	0.47%	-79,868	-94,943	-100,924
Giles	0.72%	-35,760	-44,315	-47,710
Montgomery	0.67%	-51,748	-58,925	-61,773
Roanoke	0.92%	-49,146	-59,903	-64,171
West Virginia Portion		-26,379	-30,855	-32,631
Greenbrier	0.42%	-6,826	-8,004	-8,471
Monroe	0.36%	-13,334	-15,398	-16,217
Summers	0.35%	-6,219	-7,453	-7,943

a. Source: Property Taxes By State (Virginia Counties and Independent Cities) (propertytax101.org, 2015).

EFFECTS ON ECONOMIC DEVELOPMENT

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. Franklin County's Comprehensive Plan, for example, states that "the County wishes to maintain its rural character and scenic views…" (Franklin County Planning Commission, 2007). Greenbrier County's Comprehensive Plan notes the County's melding of old and new economy businesses (farming and high tech, for example) and recognizes that "a healthy environment is central to citizens' health, welfare, and quality of life" (Greenbrier County Planning Commission, 2014).

The MVP would undermine the progress toward these visions if the loss of scenic and recreational amenities, the perception and the reality of physical danger, and environmental and property damage were to discourage people from visiting, relocating to, or staying in the study region. Workers, businesses, and retirees who might otherwise choose to locate along the MVP's proposed route will instead pick locations retaining their rural character, productive and healthy landscapes, and promise for a higher quality of life.

This is already occurring in the region. With the possibility of the MVP looming, business plans have stalled and the real estate market has slowed. Study region residents are also concerned about the effect the MVP could have on the economy. Based on the Pipeline Information Network's review of comment letters submitted in the first three months of 2015, more than half mentioned the economy,

Forgone Economic Development: Sustainable Agriculture

Owners Patti and Constantine Chlepas describe their 23-acre Birdsong Farm as "pristine land in the heart of Monroe County." They use organic practices to produce natural raw honey and natural beeswax products. In part because pesticides are threatening honeybee operations worldwide, Birdsong Farm is an oasis from which the Chlepas can sell bees to and serve as mentors for apiarists in other places that have been hit hard. With the proposed MVP right-of-way adjacent to their property—and the likelihood that the ROW would be maintained using chemical defoliants that could harm bees—the owners are concerned that their core business would be wiped out.

The Chlepas have put on hold their planned investment in a pick-your-own strawberry operation and a new line of business selling locally-grown fresh strawberries, strawberry plugs, and value-added products to sell in an on-site store. Birdsong Farm was planning to hire employees to help run their local operation. However, because of the MVP, they cancelled their grant to build a high tunnel greenhouse, and estimate the long-term loss in revenue to the County may run as high as half a million dollars.

with property value, tourism, recreation, and agriculture looming large in citizens' concerns (Pipeline Information Network, 2015).

These fears are consistent with research results from this region and around the country demonstrating that quality of life is often of primary importance when people choose places to visit, live, or do business. As 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 in the southern Appalachians. 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).

Along similar lines, 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.

It is difficult to predict just how large an effect the MVP 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 reasonable scenarios for how the MVP might affect key portions of the region's overall economy.

The study region's residents believe the MVP will harm the travel and tourism industry. In the words of the owner of one recreation and tourism business in Summers County, West Virginia, the MVP would "completely destroy the use, purpose, business operation, well, commercial septic system, two rental houses, and public campground on [the] property," with one-time losses valued at $800,000, not to mention the owners loss of livelihood and employment (Berkley, 2015). While more systematic research could provide refined estimates of the impact of natural gas transmission pipelines on recreation and tourism spending, one plausible scenario is that the impact is at

> ***Recognizing that a healthy environment is central to citizens' health, welfare, and quality of life, Greenbrier County strongly supports the wise stewardship of our natural environment, including air and water resources, agricultural and forest resources, and geologic resources, with special emphasis on the protection of environmentally sensitive areas and features (springs, sinkholes, caves, other karst features, floodplains, and wetlands) which contribute to overall environmental health and citizens' quality of life.***
>
> *–Greenbrier County Comprehensive Plan*

least as high as the minimum of these business owners' reported expectations. If the MVP were to cause a 10% drop in recreation and tourism spending from the 2014 baseline, the MVP could mean $96.8 million less in travel expenditures each year. Those missing revenues would otherwise support roughly $24.3 million in payroll, $2.6 million in local tax revenue, $4.8 million in state tax revenue, and 1,073 jobs in the eight-county region's recreation and tourism industry each year.[29] 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 those additional demands created by the MVP.

Along similar lines, retirement income is an important economic engine that could be adversely affected by the MVP. In county-level statistics from the US 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 0.8% per year from 2000 through 2014, and age-related transfer payments grew by 5.8% per year. During roughly the same time period (through 2013), the number of residents age 65 and older grew by 15.1% (1.2% per year), and this age cohort now represents 15.5% of the total population.[2]

It is difficult to precisely quantify the effect of the MVP 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 just a *10% slowing of the rate of increase* might entail. Such a scenario entails an annual decrease in investment income and age-related transfer payments of approximately $15.6 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.

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

[29] Raw data on travel expenditures is from the Virginia Tourism Corporation (2015) and Dean Runyan Associates (2015). 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 with ecosystem service costs above.

region were dampened to the same degree as retirees' enthusiasm for moving there, the 10% reduction in the rate of growth would mean 722 fewer jobs and $2.0 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 MVP will not be known unless and until the pipeline is built. Even so, and especially because the pipeline is promoted by supporters as bringing some jobs and other economic benefits to the region, it is important to consider the potential for loss.

A pipeline route through here will destroy our farm business. Our customers drive here for the scenery and tranquility as much as for the fresh blueberries. Construction of a pipeline this large does not fit into this picture. Our customers would recoil and take their business elsewhere.

–Shirley & Lewis Woodall
Craig County, Virginia

CONCLUSIONS

The full costs of the proposed Mountain Valley Pipeline in the eight-county study area and beyond are wide-ranging. They include one-time costs like reductions in property value and lost ecosystem services during pipeline construction, which we estimate to be between $65.1 and $135.5 million. Plus there are ongoing costs like lost property tax revenue, diminished ecosystem service value, and dampened economic growth that would recur year after year for the life of the pipeline. Our estimates of the annual costs range from $119.1 to $130.8 million per year. Most of these costs would be borne by residents, businesses, and institutions in Craig, Franklin, Giles, Montgomery, Roanoke, Greenbrier, Monroe, and Summers Counties.

By contrast, the MVP's one local benefit is much smaller. It is an estimated average tax payment of $6.1 million per year (for the five Virginia counties) and $4.5 million per year (for the 3 West Virginia counties) through 2025 (Ditzel, Fisher, & Chakrabarti, 2015a, p. 15, 2015b, p. 13). Other MVP-promoted benefits, such as jobs from the MVP's construction and operation and those stemming from lower energy costs, would accrue primarily in other places (Ditzel et al., 2015a, 2015b).[30]

The decision to approve or not approve the MVP does not hinge on a simple comparison of estimated benefits and estimated costs. The scope and magnitude of the costs outlined here, however, reflect an important component of the full extent of the MVP's likely environmental effects that must be considered when making the 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 Mountain Valley Pipeline.

If these considerations and FERC's overall review result in selection of the "no-action" alternative and the Mountain Valley Pipeline is never built, most of the costs outlined in this report will be avoided. It

[30] Due to issues with the methods and assumptions used in the MVP-sponsored studies, the benefit estimates they present may be inflated. See Phillips (2015b) for a review.

is *most*, but not *all* costs because there has already been the cost of delaying implementation of business plans, the cost of 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.

Another possible scenario is that the FERC, considering the impacts of the MVP *as currently proposed* on ecosystem services, property values, and economic development, would conduct a thorough analysis of all possible alternatives. Those alternatives may include 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 (as opposed to permitting pipelines on a company-by-company basis). 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.

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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 MVP 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) *

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/Acre/year	Source Study
Pasture, cont'd	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) *
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)

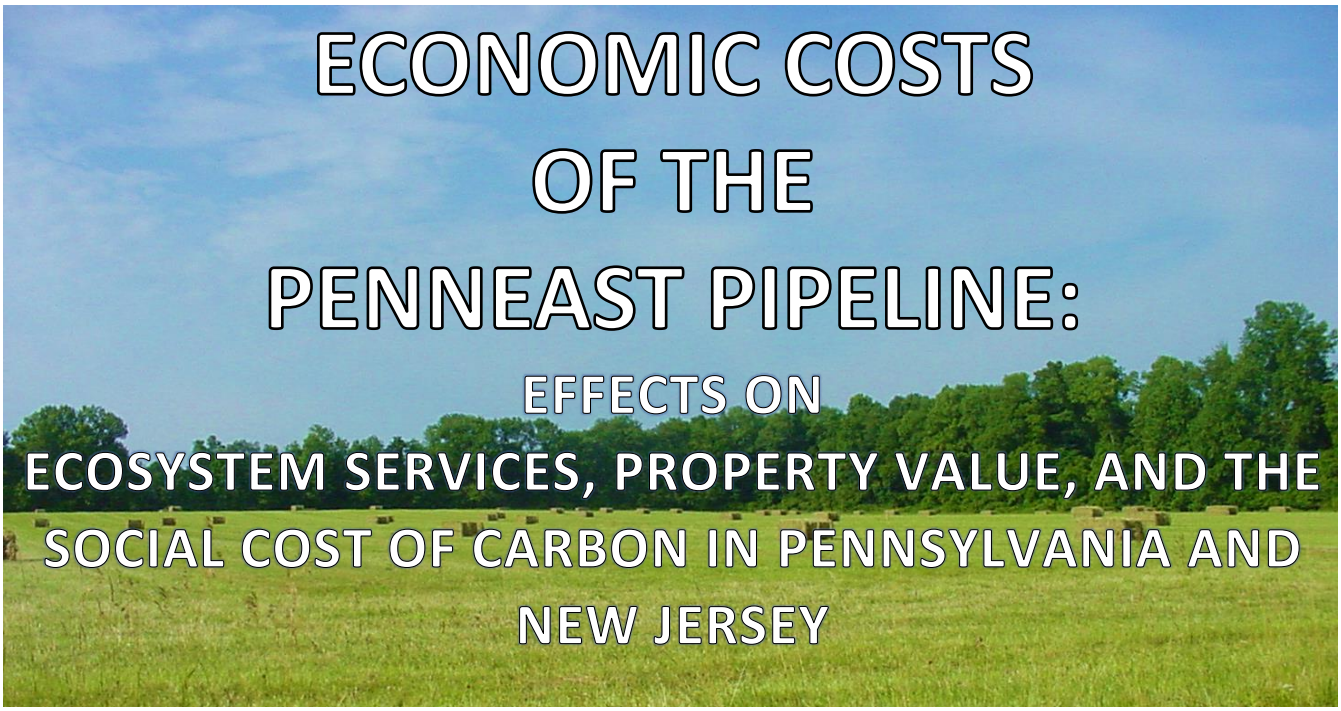
Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/Acre/year	Source Study
Water	Recreation	446.31	446.31	(Brenner Guillermo, 2007) *
	Recreation	155.36	914.10	(Cordell & Bergstrom, 1993)
	Recreation	304.18	437.19	(Mullen & Menz, 1985)
	Recreation	148.68	148.68	(Postel & Carpenter, 1977)
	Waste	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)

Land Use	Ecosystem Service	Minimum $/acre/year	Maximum $/Acre/year	Source Study
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)
	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 2014 dollars.
* Indicates source is from the TEEB database.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 4, Key-Log Economics, LLC, Economic Costs of the PennEast Pipeline, January 2017.



ECONOMIC COSTS OF THE PENNEAST PIPELINE:

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

JANUARY 2017

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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.

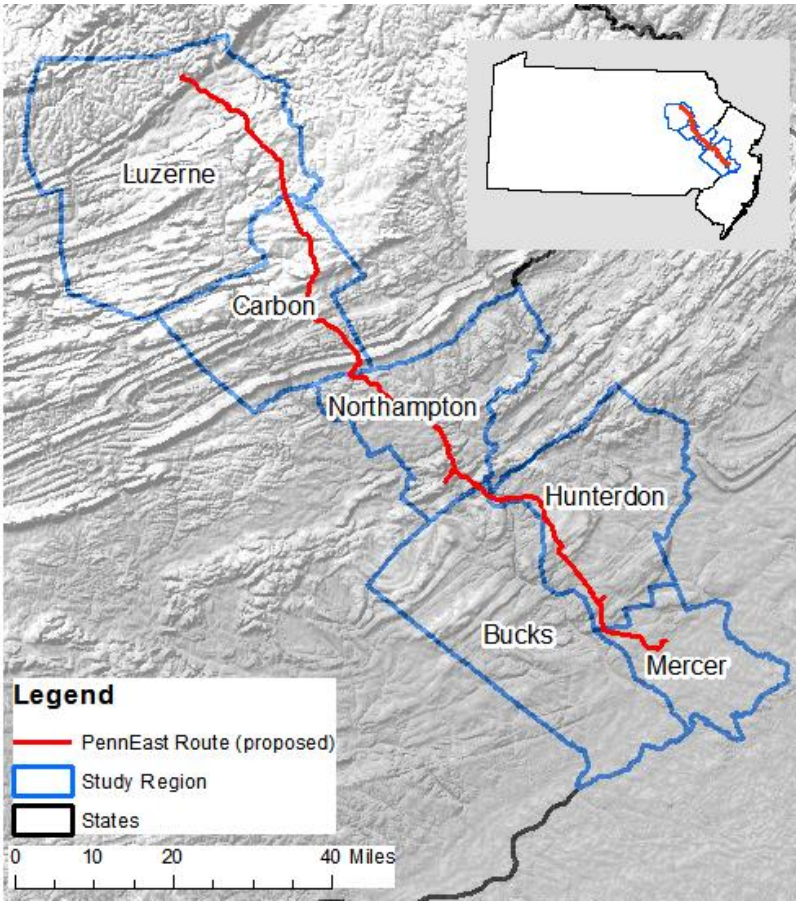

FIGURE 1: PennEast Pipeline (Proposed)

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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APPENDIX A: CANDIDATE PER-ACRE VALUES FOR LAND-USE AND ECOSYSTEM SERVICE COMBINATIONS A-1

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.)

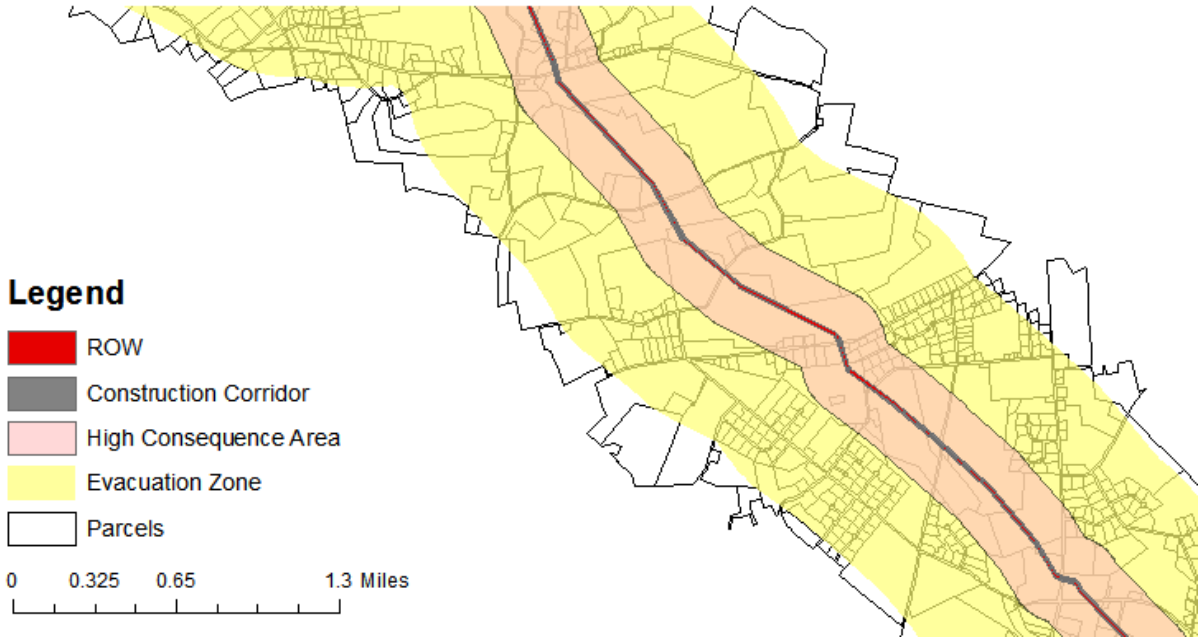

FIGURE 2: Right-of-Way, Construction Corridor, High Consequence, and Evacuation Areas for a Section in Northampton, PA.

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.

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[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.

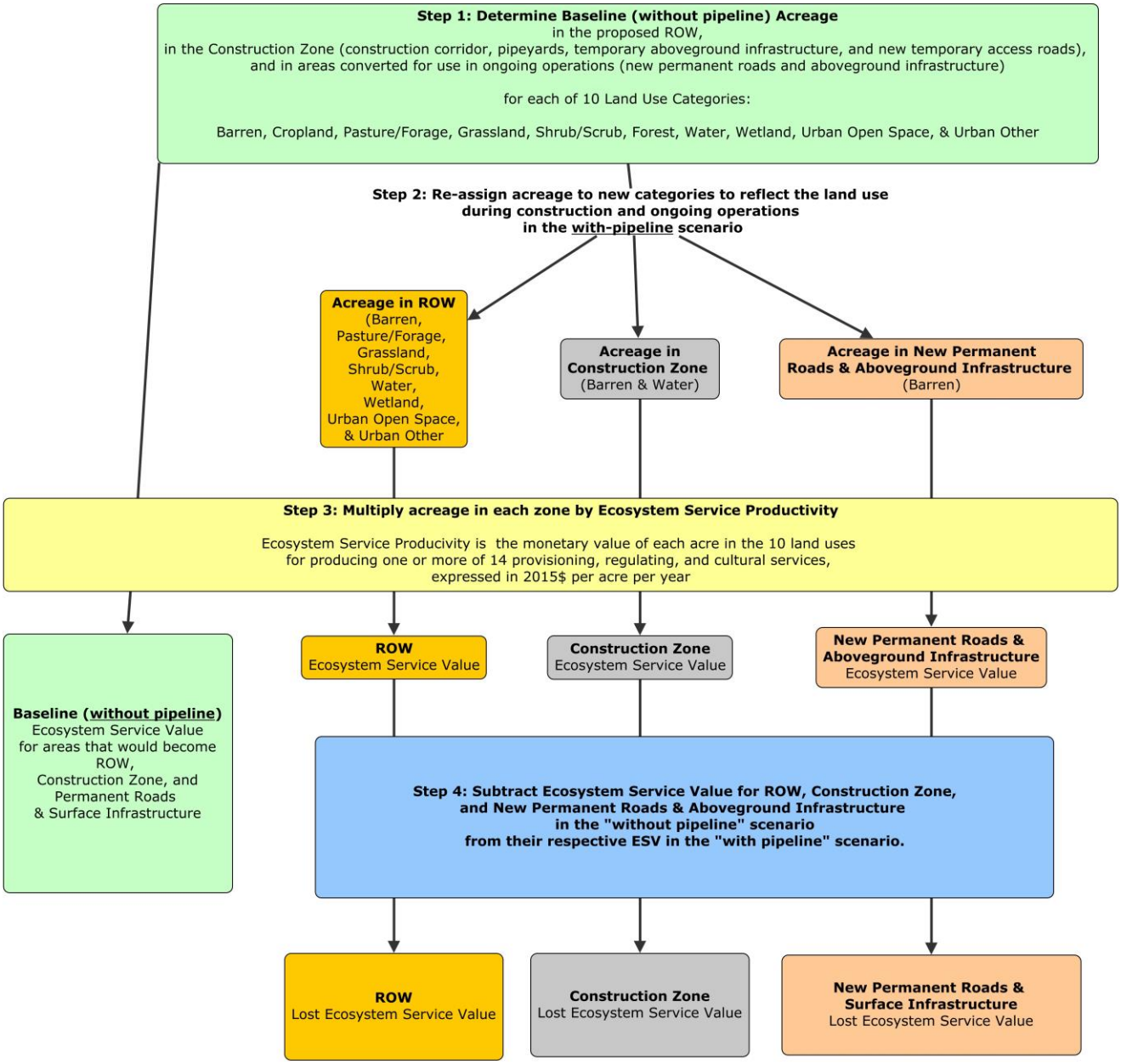


FIGURE 3: Ecosystem Service Valuation Process

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.

[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.

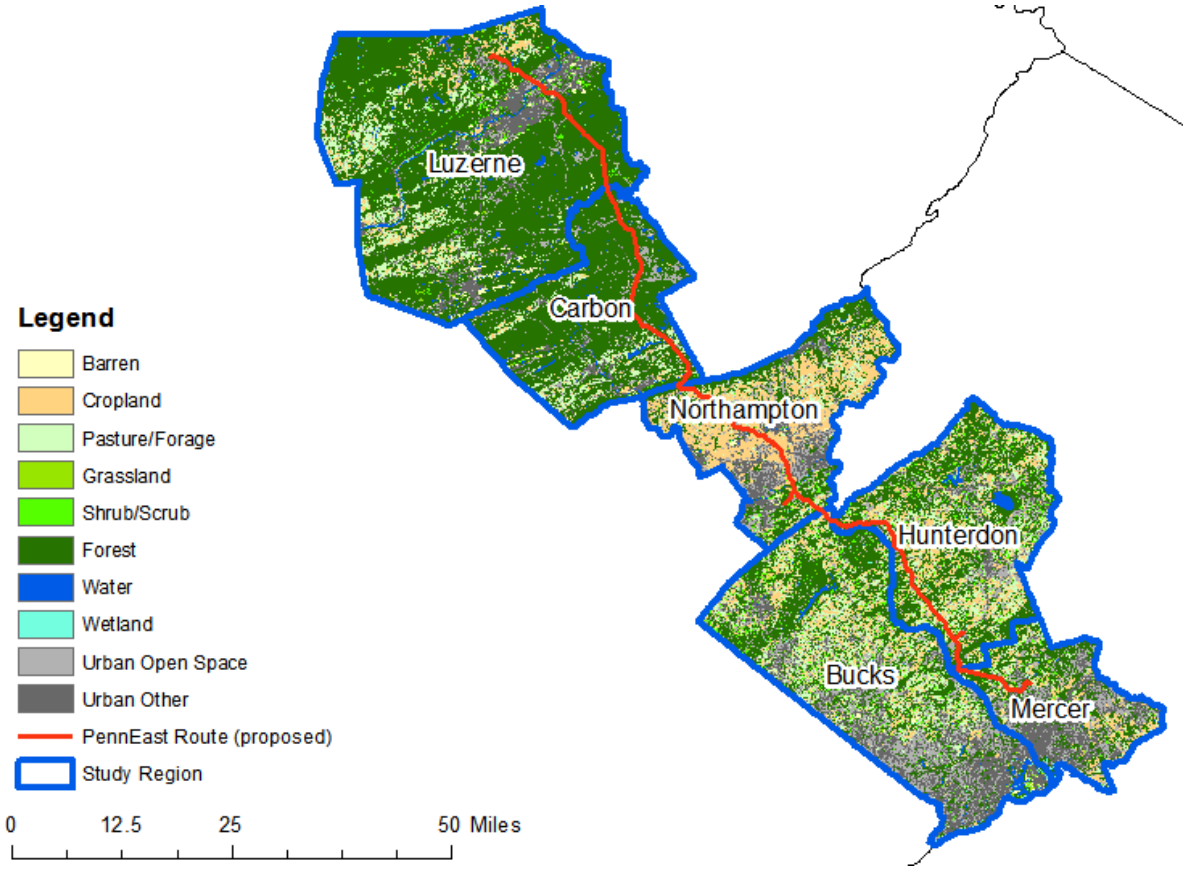


FIGURE 4: Land Use in the Study Region, as Classified for Ecosystem Service Valuation

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**

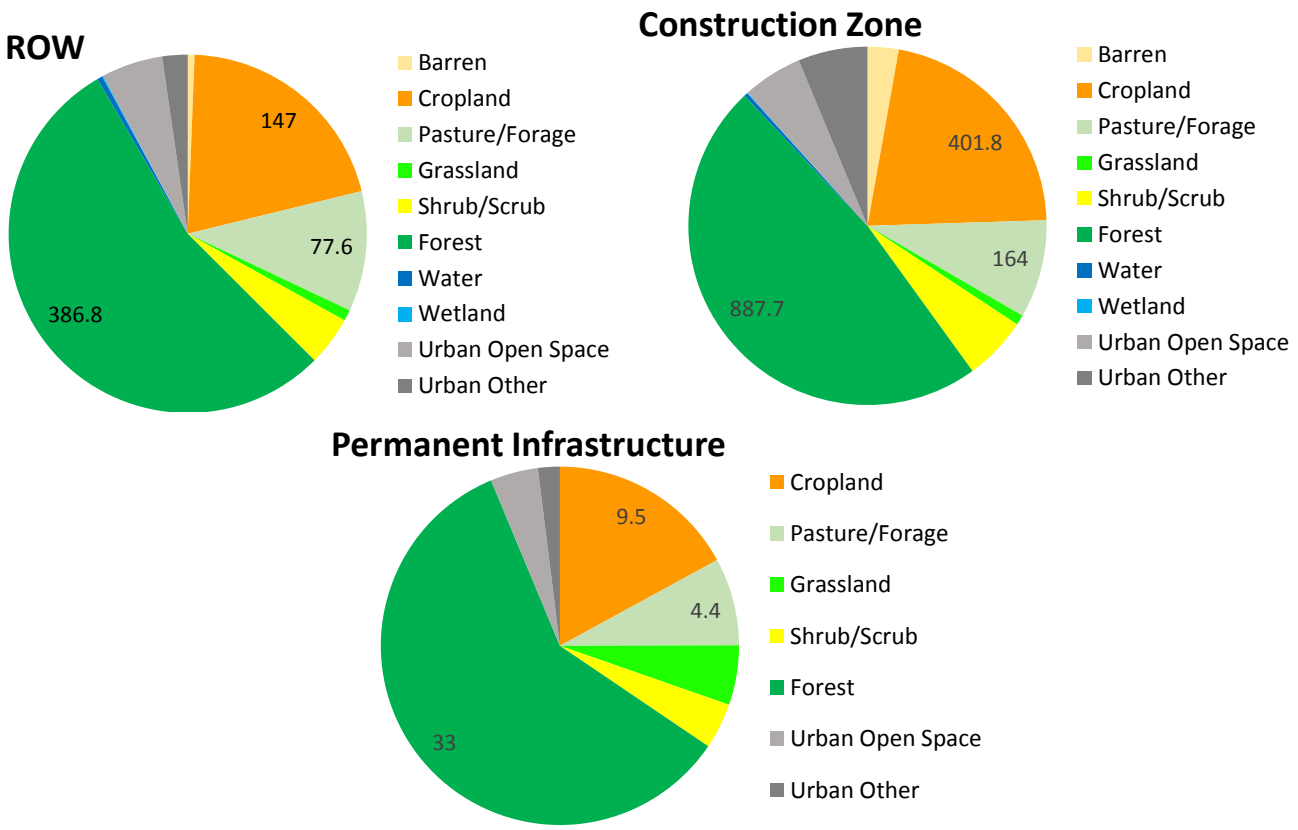


FIGURE 5: Baseline (Pre-PE) Land Use in the ROW, Construction Zone, and Permanent Access Roads and Aboveground Infrastructure (Acres) (See also Table 4)

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.

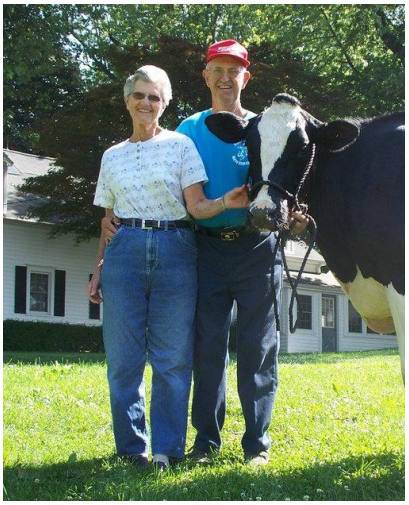
TABLE 5: Land Cover Reclassification

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

[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:

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

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).

[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,

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.

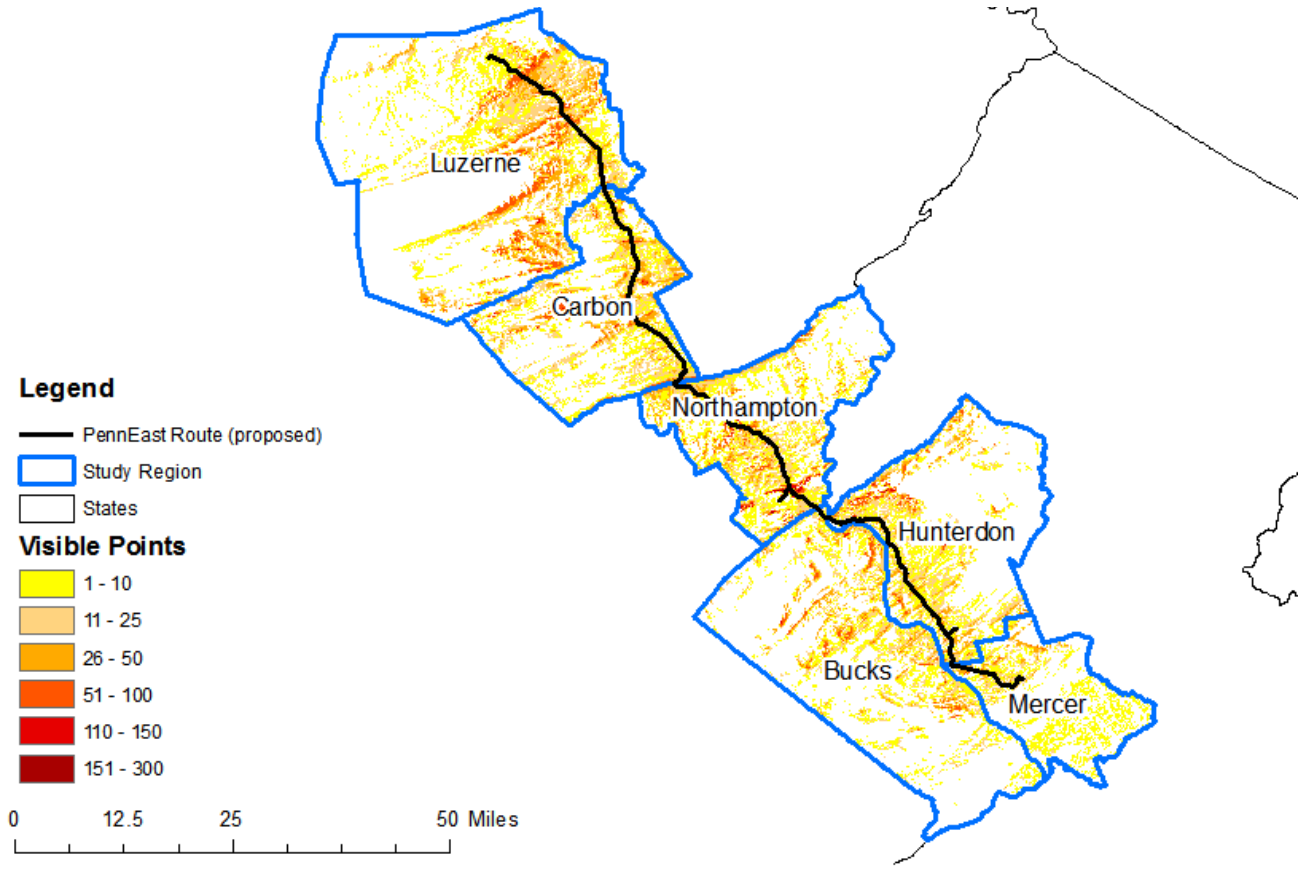


FIGURE 6: Visibility of the Proposed PennEast Pipeline

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).

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[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-Maîître & 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.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 5, Key-Log Economics, LLC, Economic Costs of the Millennium Eastern System Upgrade Project, April 2017.

Economic Costs of the Eastern System Upgrade:

EFFECTS ON PROPERTY VALUE, THE SOCIAL COST OF CARBON, AND PUBLIC HEALTH

APRIL 2017

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EXECUTIVE SUMMARY

The Eastern System Upgrade project ("ESU") is a multi-part project intended to expand the capacity of the Millennium Pipeline in New York State. The project includes construction of approximately 7.8 miles of 30- and 36-inch pipeline loop in Orange County, construction and operation of a new compressor station ("the Highland Compressor Station" or "Highland CS") in Sullivan County, an additional compressor at the existing Hancock Compressor Station ("Hancock CS") in Delaware County, modifications to the existing Ramapo Meter and Regulator station in Rockland County, and additional pipeline appurtenant facilities at the existing Huguenot Meter Station and Westtown Meter Station in Orange County.

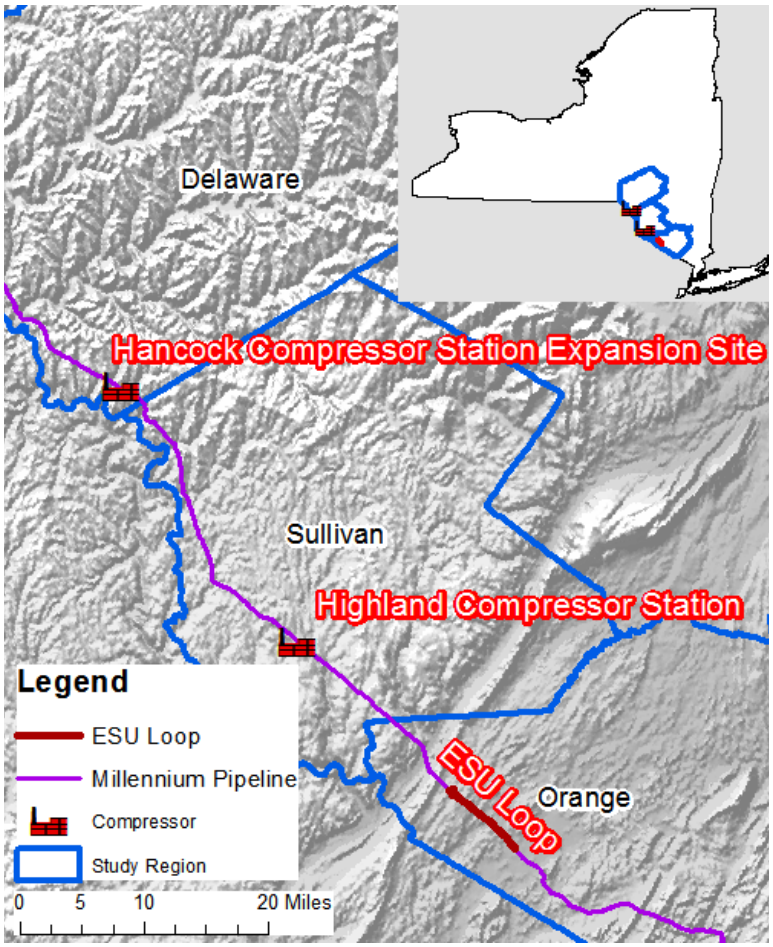

FIGURE 1: Eastern System Upgrade Project (Proposed)

Sources: Eastern System Upgrade loop obtained from Stephen Metts of the New School; Millennium Pipeline Route obtained from OpenStreetMap; Study region (counties), federal lands, and hill shade from USGS (U.S. Department of Interior & U.S. Geological Survey, 2015).

Millennium Pipeline Company, L.L.C ("Millennium LLC") would be in charge of the construction and operation of the project.

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

Under FERC's policy, the applicant of the project provides estimates of economic benefits for review. Millennium LLC's estimates include jobs and income associated with the construction and operation of the pipeline, and additional jobs and income that could occur if the pipeline's operation results in lower net energy costs for industrial, commercial, and individual customers. Due to flaws in methods,

assumptions, and execution of its study, we conclude that the benefit estimates Millennium has provided are overstated.

On the cost side, the situation is worse. Millennium LLC and FERC have thus far discounted or ignored important environmental effects (and the economic consequences of those effects) of the proposed expansion project that would harm the human environment. In other words, Millennium LLC has not yet given serious or adequate consideration to potential negative economic effects—that is, costs—of the ESU.

Delaware Riverkeeper Network commissioned this report to fill that information gap and provide independent research into some of the ESU's principal external costs. In light of data limitations, we provide quantitative estimates of just two types of costs in this report.

First, the construction, operation, and presence of the project would reduce property values along the pipeline and around the compressor stations. Affected properties, those touched by the right-of-way ("ROW"), the 0.9-mile-wide evacuation zone, and within half a mile of the Highland and Hancock compressor stations, could lose a total of $2.0 million in property value. (See "At a Glance" for details.) This one-time reduction in property asset value will spawn a recurring loss of local property tax revenue of $36,000 per year forever.

Second, there is also the social cost of carbon ("SCC"), the additional economic cost of harm associated with the emission of carbon from the project encompassing the cost of methane transport, with the annual cost 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 $50.1 to $115.0 million per year between 2019 and 2048. With a 2.5% discount rate, the annual social cost of carbon ranges from $256.5 to $420.1 million.

Putting the stream of costs into present value terms and adding the one-time costs (the initial loss of property value), the total estimated economic cost of the ESU project in the study region is $4.7 and 18.8 billion.[1] To put this in perspective, and using the (inflated) estimates of benefit provided by the applicant, the Eastern System Upgrade would impose between $2.31 and $9.24 in costs for every dollar of benefit promised.

For reasons explained fully in the body of this report, these are conservative estimates of the external costs for the proposed ESU. One reason is simply that categories of impacts exist that, due to lack of sufficient data, we could not quantify. These include public health costs to residents that would

[1] 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 calculated the appropriate real discount rate for each year the project is in operation for up to 50 years (until 2068), the minimum physical life of the project facilities given by Millennium (Millennium Pipeline Company, L.L.C., 2016). 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.

experience negative health impacts from compressor stations, the potential impact on the economic development, 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 ESU project.

Finally, while this report covers some of the costs that will occur if the ESU is approved, it does not include an assessment of natural resource damage and other effects that might happen during construction and operation. For example, there is a probability that erosion 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 or at the compressor station. If, when, and where these events occur, there will be clean-up 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.[2]

The magnitude of these damages, multiplied by the probability of occurrence, yields additional "expected costs" which add to the certain costs estimated in this study. To be clear, the costs estimated here—the impact on land values resulting from buyers' concerns about the pipeline and compressor station, the social cost of carbon, and public health impacts associated with the compressor station—will occur with or without any discrete events like stream damage or explosions ever happening. These impacts and their monetary equivalents are simply part of what will happen in New York if the ESU is approved, built, and operates without incident.

FERC could and should thoroughly investigate all of these costs before determining whether or not the Millennium ESU project meets what the Commission describes as an "economic test"—whether the public benefits outweigh the costs—of the merits of natural gas transmission projects and before rendering its decision on the project.

[2] 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 Eastern System Upgrade in New York

Delaware, Orange, and Sullivan Counties

- **Miles of pipeline loop:** 7.8
- **Additional aboveground facilities:** Highland CS, new compressor at the Hancock CS; new pig launcher/receiver, alternate interconnect, and modifications to 3 metering stations
- **Impacted acres:**
  - In the permanent right-of-way (ROW): 26.0
  - In the construction zone: 156.9
  - At the existing Hancock Compressor Station in Delaware County during construction and operation: 9.05, 5.5
  - At the new Highland Compressor Station in Sullivan County during construction and operation: 14.31, 5.4
- **Parcels in the portion of the loop not co-located with the existing Millennium Pipeline:**
  - In the ROW: 5
  - In the 1.2-mile-wide evacuation zone: 196
  - Within half a mile of the compressor stations: 32 for the Hancock CS and 11 for the Highland CS
- **Residents and housing units in the pipeline evacuation zone:** 1,092 people, 470 homes
- **Property value:**
  - Baseline—that is, in a "no ESU" scenario—property value at risk (with the expected one-time cost due to the ESU in parentheses):
    - In the ROW: $186,050 ($7,814 to $24,187)
    - In the 0.9-mile-wide evacuation zone: $19.8 million ($753,700)
    - Within half a mile of the compressor stations: $2.1 million ($519,900) for the Hancock CS and $2.9 million ($715,500) for the Highland CS
  - Total property value lost (a one-time cost): $2.0 million
  - Resulting loss in property tax revenue (annual): $36,005 to $36,298
- **The social cost of carbon (equivalent):**
  - An annual cost that varies year to year, the project would contribute to an equivalent of 3.9 million metric tons of carbon dioxide a year. Using a 5% discount rate, the social cost of carbon ranges from $50.1 to $115.0 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 $256.5 and $420.1 million per year.
- **Other impacts for consideration:**

  Economic activity that depends on the region's scenic, recreational, and quality of life: We consider a conservative scenario in which visitor spending declines by 5% from current levels, and the rate of growth in retirement and proprietor's income slows by 5%)
    - Annual loss of recreation tourism expenditures of $47.2 million that would otherwise support 745 jobs and generate $3.1 million in local taxes and $2.6 million in state taxes
    - Annual loss of personal income of $6.3 million due to slower growth in the number of retirees
    - Annual loss of personal income of $1.2 million due to slower growth in sole proprietorships
    - The total of these losses is $82.5 million per year
- **Total estimated costs:**
  - One-time costs (property value lost during construction) would be $2.0 million
  - Annual costs (costs that recur year after year) would range from $36,005 to $36,298 PLUS the social cost of carbon, which also varies year by year, and ranges between $50.1 and $420.1 million
  - One-time costs plus the discounted value of all future annual costs: $4.7 to $18.8 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 temporary construction right-of-way, temporary work spaces (TWS), additional temporary workspace (ATWS), access roads from public roadways to the construction work areas, pipe/contractor yards, and staging areas.

EA: Environmental Assessment, a document prepared under the National Environmental Policy Act used to determine whether a proposed agency action would require an environmental impact statement of a finding of no significant impact.

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.

ESU: The Eastern System Upgrade Project, generally referring to the proposed loop in Orange County and the Hancock and Highland Compressor Stations.

FERC or The Commission: Federal Energy Regulatory Commission, the agency responsible for preparing the EA or 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

Millennium LLC: Millennium Pipeline Company, L.L.C., the company responsible for construction and operation of the Eastern System Upgrade; also “the applicant”

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

Author's Note

Delaware Riverkeeper Network commissioned this report to help ensure that the likely costs of the Eastern System Upgrade 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 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 Eastern System Upgrade is approved.

Cover Photo from Mark Egan.

BACKGROUND

The Eastern System Upgrade Project proposed by Millennium Pipeline Company, L.L.C. ("Millennium LLC") is seeking a federal permit to expand capacity on parts of the Millennium Pipeline (See Table 1 for a timeline of the Millennium Pipeline and associated infrastructure). The project would transport an additional 200,000 dekatherms per day of natural gas from the Corning Compressor Station to an interconnect with Algonquin Gas Transmission, L.L.C. in Ramapo, New York (Millennium Pipeline Company, L.L.C., 2016a). The ESU includes the construction of about 0.1 miles of 30-inch and 7.7 miles of 36-inch pipeline loop in Orange County, New York, construction of a new 22,400 horsepower (hp) compressor station in Sullivan County, New York (Highland CS), adding an additional 22,400 hp to the existing 15,900 hp Hancock Compressor Station in Delaware County, New York (Hancock CS) for a total of 38,300 hp, modifications to the existing Ramapo Meter and Regulator Station in Rockland County, New York, and additional pipeline facilities at the Huguenot Meter Station and Westtown Meter Station in Orange County, New York (Millennium Pipeline Company, L.L.C., 2016).

Table 1. Brief timeline of Millennium LLC's work with Millennium Pipeline and the ESU project work.

Milestone(s)	
Date	**Description**
December 1997	Millennium LLC files an application for a certificate of public convenience and necessity authorizing the construction and operation of the Millennium Project
June 2007	FERC authorizes Millennium LLC to commence construction
December 2008	Millennium Pipeline went into service
October 2012	Construction of the Minisink Compressor Station begins
June 2013	Minisink Compressor station went into service
October 2013	Construction of the Hancock Compressor Station begins
April 2014	Hancock Compressor Station went into service
January 2016	Millennium LLC files a request for a pre-filing review with FERC for the ESU project
May 2016	FERC announces that they will prepare an environmental assessment for the ESU project
July 2016	Millennium LLC files an application requesting a certificate of public convenience and necessity authorizing the ESU project

For this report, "ESU" refers to those portions of the entire Eastern System Upgrade project that entail (a) the addition of pipeline or an increase in the amount of land consumed by pipeline right-of-way (i.e., the new pipeline and loop in Orange County), and (b) construction of the new (Highland) compressor station and addition of compression capacity at the existing (Hancock) station. We did not analyze the other components of the project because the changes would occur in areas already modified from their previous natural land cover and/or would not represent a major change from the status quo in terms of land consumption, air, noise or other direct impacts. We are not, in other words, rolling back the clock to estimate the external costs of the existing Millennium pipeline facilities in the study area: we are instead focused only on the new costs that the ESU project would impose.

According to Millennium LLC, the ESU project is necessary for meeting natural gas market demand in the region. The applicant also argues that the ESU will stimulate the local economy during the construction phase and produce long-run economic benefits due to energy cost savings for New York electric utility customers in the long run. These claims are detailed in a report prepared for Millennium LLC by Concentric Energy Advisors ("Concentric"). Concentric estimates that construction will have a total impact of $314 million and that the first ten years of operation will result in $703 million in additional economic output. These estimates include predicted consumer energy cost savings, spending on labor and materials during construction and operation, re-spending of consumer cost savings, workers' wages and firm revenues in the local economy, and property tax payments from project facilities associated with the proposed project (Concentric Energy Advisors, 2016; Millennium Pipeline Company, L.L.C., 2016b).

However, there needs to be a more thorough examination into how the permanent right-of-way, the temporary construction corridor of the pipeline, and the proposed compressor stations would impose additional external costs on local residents and businesses, including costs that accrue due to safety concerns. All natural gas pipelines present some danger of leaks and explosions that can cause substantial physical damage. Noise and air pollution from the compressor stations present risks to health and quality of life for nearby residents and businesses (Table 2) (Pipeline Safety Trust, 2015). According to the Pipeline Safety Trust (2015), these dangers are greater with pipelines installed after 2010 than with older facilities. Besides the physical dangers, pipeline incidents may require evacuation of a wide area (up to 0.9 miles across in the case of the ESU loop), a potential constant concern for the thousands of people who live or work in that zone. The economic consequences of these impacts can include diminished property value, lost natural benefits, higher healthcare costs, and dampened economic development, if the physical effects and safety concerns reduce the attractiveness of the region as a place to live, visit, retire, or do business.

TABLE 2. 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.	11,208	360	1,376	$6.9 Billion
New York	201	23	124	$ 78.2Million

To date, the negative effects mentioned above and estimates of their attendant economic costs have not received much attention in the debate surrounding the proposed ESU project. This report, commissioned by the Delaware Riverkeeper Network, is both an attempt to understand the nature and potential magnitude of the economic costs of the project in New York, 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 project.

Policy Context

Before construction can begin, the project must be approved, or "certified," by the Federal Energy Regulatory Commission (FERC). That approval, while historically granted to pipeline projects, depends on FERC's judgment that the project would meet a public "purpose and need" and that the public benefits of the project are balanced against the "potential adverse consequences" of natural gas transmission projects. 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 Assessment ("EA") or Environmental Impact Statement ("EIS") that evaluates all of the relevant effects. Of particular interest here, such relevant effects include those direct, indirect, and cumulative effects on or mediated through the economy. As the NEPA regulations state,

> "Effects" includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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 1508.8; Council on Environmental Quality, 1978).

To begin its review, FERC issued a Notice of Intent to prepare an EA in May of 2016 (Federal Energy Regulatory Commission, 2016). In The Notice of Intent, FERC anticipated issues of concern regarding geology and soils, land use, water resources, fisheries, and wetlands, cultural resources, vegetation and wildlife, migratory birds, air quality and noise, endangered and threatened species, public safety, and cumulative impacts (Federal Energy Regulatory Commission, 2016). Each of these can translate into economic costs external to Millennium LLC that would be borne by individuals, businesses, and communities throughout the landscape the project would traverse and beyond.

Market Failure: External Costs and the Need for Countervailing Public Action

All market transactions involve two sets of costs and benefits. The first set includes private costs, such as the costs of constructing and operating a pipeline, and private benefits, such as the value to consumers of natural gas delivered through the pipeline. Under the certain highly restrictive preconditions that currently exist, it is possible to say that the price of gas, the amount consumed, and therefore the number of pipelines built and operated functions as the "right" number. "Right" in an economic context translates to "efficient," as in there are no other combinations of gas use/pipeline capacity that could

produce greater net societal benefits. However, the reality is that these pre-conditions do not hold and the market does not give us the right answer to the question of how many pipelines (and how much gas use) should exist. Economists call these situations "market failures." Market failures justify extra-market processes to get us to solutions that are more like the theoretical ideal.

The markets for natural gas and natural gas transmission pipelines fail in many ways. The most important, from the perspective of NEPA and FERC's certification policy, is the presence of "externalities." Externalities are costs generated by market transactions not borne by the parties to those transactions. In this case, externalities include the costs of building and operating the pipeline imposed on people other than the pipeline company and its customers (natural gas shippers and wholesale purchasers, including local distribution companies).

External costs include effects mediated through market transactions (a good example is the reduction in property value when people know a pipeline is nearby) as effects on human well-being that exceed the number of dollars that actually change hands. This "nonmarket value" includes the total value to people (reflected in their full willingness to pay for a good) over and above what they actually pay for a market good (such as a safe place to live, or clean water to drink). Nonmarket benefits and costs also include changes in human welfare from environmental effects for which there is no out of pocket payment at all. Enjoying the aesthetic quality of a view may cost nothing to experience, but the observer still values it. Whether or not there is a market component to the resulting change in value, damage to environmental goods and services caused by the construction and operation of natural gas transmission infrastructure represents a reduction in human welfare and, therefore, an economic cost.

Because these reductions are external costs, neither the pipeline company nor its customers see or consider these costs when making decisions about how much pipeline capacity or natural gas they require. The result is too much pipeline capacity and too much gas delivered at too low a price. The pure economic problem with this over-investment in pipeline capacity and over-consumption of gas stems from resources spent on excess pipeline capacity and gas that could have been more wisely invested in other infrastructure, other services, or other activities that produce higher net benefits.

From an economic point of view, compliance with the National Environmental Policy Act is one way to ensure that costs not considered by the market are nevertheless considered in resource allocation decisions. The NEPA review adds, or should add, the necessary breadth to FERC's analysis of the economics costs of proposed natural gas infrastructure. NEPA requires an evaluation of all relevant effects, but of particular interest here are the direct, indirect, and cumulative economics effects of changes in human welfare that might or might not be reflected in the market economy–i.e. the external costs.

Policy Failure: The Review and Certification of Natural Gas Transmission Projects Discounts External Costs and Inflates Social Benefits

To help address the market failure inherent in the construction and operation of natural gas transmission pipelines, additional analyses and decision making processes are required. FERC's policy on the Certification of New Interstate Natural Gas Pipeline Facilities (88 FERC, para. 61,227) is one example of an attempt to ensure consideration of at least some external costs. The policy requires that 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, 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" (88 FERC, para. 61,227, pp. 18, 26). The Commission's policy contends that 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 at an individual, community, and broader population level.

The policy's confusion over what counts as an environmental effect (again, most of which will have economic effects) is further expressed by the following statement:

> Traditionally, the interests of the landowners and the surrounding community have been considered synonymous with the environmental impacts of a project; However, these interests can be distinct. Landowner property rights issues are different in character from other environmental issues considered under the National Environmental Policy Act of 1969 (NEPA) (88 FERC, para. 61,227, p. 24).

By the Commission's reasoning, environmental effects are a matter of the Commission's "traditions," not science, and environmental effects are deemed to be both synonymous with, and distinct from, interests of landowners and the surrounding community. This statement seems to contradict the statement one page earlier in the policy that "[there] are other interests [besides those of customers, competitors, and landowners and surrounding communities] that may need to be separately considered in a certificate proceeding, such as environmental interests (p. 23)." While it is true that separate/additional consideration of environmental "interests" must indeed be part of the Commission's review, the policy embodies such a muddle of contradictions on the question of what impacts to examine and why (tradition versus science), that it seems unlikely that any pipeline certification granted under the policy would be scientifically or economically sound.

FERC's own policies and track record, including an over-reliance on the applicants' own estimates of project benefits, make it extremely unlikely that the ESU project certification process would meet NEPA's requirement to consider all project costs and benefits, let alone produce a decision that could be

construed as generating or supporting net economic benefits.[3] 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" (88 FERC, para. 61,227, p. 26). The applicant therefore has an incentive to be generous in counting the benefits and parsimonious in counting the costs of its proposal.[4]

Given the weaknesses of the policy, and as evidenced by the track record, FERC's "economic test" does not provide a robust evaluation of the public merits of natural gas transmission projects. It is a "test" in which difficult questions (such as about external costs borne by all stakeholders) are not asked, and where those taking the test (the applicants) provide the answer key. It is therefore not surprising that FERC's environmental reviews typically have not provided estimates of the magnitude of the full external costs associated with natural gas transmission pipelines. Also not surprising, pipeline applicants typically employ methods, assumptions, and a selective review of effects that result in a rosy and grossly distorted picture of the net benefits of their proposed projects.[5]

Current Economic Conditions

Our geographic focus is the three county region of Delaware, Orange, and Sullivan, containing the ESU loop, the Highland CS, and the Hancock CS. This 3,300-square-mile county region supports diverse land uses, including the headwaters of the Delaware River, thriving agri-tourism businesses, and various other attractions. These natural, cultural, and economic assets are among the reasons more than 1.8 million people call this three county region home and an even larger number visit each year for hiking, fishing, skiing, festivals, kayaking, horseback riding, weddings, and other events.

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), strong entrepreneurship, and higher agricultural land value, relative to the average for New York counties.[6]

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[3] It is important to note that NEPA does not require that federal actions–which in this case would be approving or denying the ESU certification–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.

[4] Millennium LLC and Concentric published estimates of economic benefits in the form of employment and income stemming from the construction and operation of the ESU project (Concentric Energy Advisors, 2016; Millennium Pipeline Company, L.L.C., 2016b). 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 project. Most significantly, the studies make no mention of likely economic costs. See Phillips & Wang (2016), and Appendix A for details on these shortcomings.

[5] See, for example, FERC's Environmental Impact Statements (Draft or Final) for the Constitution Pipeline (CP13-499), Mountain Valley Pipeline (CP16-10), Atlantic Coast Pipeline (CP15-554), PennEast Pipeline (CP-15-558), and the Atlantic Sunrise Pipeline (CP15-138).

[6] 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.

More traditional measures of economic performance suggest the counties are strong and resilient, though there are some differences among the counties.[7] From 2000 through 2014, for example:[8]

- Population
  - Population in Orange County grew by 9.7%, which is more than twice the average growth rate of 4.4% increase for all of New York's metropolitan counties.
  - Population in Delaware and Sullivan Counties increased by 0.4%, compared to an average 1.7% decrease for New York's non-metro counties.
- Employment
  - Orange County employment increased by 18.0%, compared to a 14.1% increase for New York's metropolitan counties.
  - In Delaware and Sullivan Counties, job growth was 2.1%, compared to an average 0.1% decline for non-metro New York.
- Personal income
  - Personal income, which includes wages and salaries as well as income from investments and transfer payments, like Social Security, grew by 26.2% in Orange County, compared to 19.2% average growth in New York metropolitan counties.
  - Delaware and Sullivan Counties saw personal income grow by 15.0%, outpacing the New York non-metro average of 14.3%.
- Earnings per job
  - Average earnings per job increased 7.7% in Orange County, compared to a 1.6% increase for metro New York.
  - Earnings per job in Delaware and Sullivan Counties increased by just 5.8%, compared to the 9.5% increase seen in all of non-metro New York.
- Per capita personal income[9]
  - Per capita income is lower in Orange County, by about $24,700, than the average for New York's metro counties.
  - For Delaware and Sullivan Counties, per capita personal income was about $1,100 higher than the average for non-metro New York counties.
- Unemployment rate
  - The 2014 unemployment rate was 5.5% in Orange County, compared to 6.3% unemployment rate for New York's metropolitan counties.
  - The unemployment rate in Delaware and Sullivan Counties was 6.6%, the same as the unemployment rate for non-metro New York overall.

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[7] Orange County is included in the NY-NJ-PA Metropolitan Statistical Area but Delaware and Sullivan are not (Office of Management and Budget, 2015). Therefore, statistics from Orange County will be compared to the New York metro benchmark and statistics from Delaware and Sullivan Counties will be compared to New York non-metro areas.

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

[9] 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.

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,

- In-migration contributed to 24% of population growth in Orange and 100% of population growth in Delaware and Sullivan.
- The proportion of the population 65 years and older increased from 10.3% to 11.8% in Orange and from 16.0% to 17.5% in Delaware and Sullivan.
- Proprietors' employment is up by 44.3% in Orange and 16.2% in Delaware and Sullivan.
- Non-labor income (primarily investment returns and age-related transfer payments like Social Security) is up by 37.1% in Orange and 27.5% in Delaware and Sullivan.

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 $944.3 million in the study region in 2015 and the companies that directly served those tourists employed 14,907 people (Tourism Economics, 2016a & Tourism Economics, 2016b).

It is in this context that potential economic impacts of the ESU project should 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.

The Neversink River where Millennium LLC proposes to cross.
Photo credit: Stephen Metts

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 ESU 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.

Study Objectives

Given the policy setting and the potential for the project to impact the people and communities in the study region, Key-Log Economics has undertaken this study to provide information of three types:

1. An additional critique positive economic impacts that Millennium, LLC and their consultant, Concentric, has promoted as potential results of the project.
2. An example of the scope and type of analyses that FERC could, and should, complete as part of its assessment of the environmental (including economic) effects of the ESU project.
3. An estimate of the magnitude of key economic effects of the ESU.

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 and associated infrastructure. 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.

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 ESU project, people who have not visited the Catskills, for example, 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. The value that future visitors would be willing to pay to maintain that possibility would be part of the "option value" of a landscape without the ESU.

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

Millennium LLC Overestimates Economic Benefits and Discounts or Ignores Economic Costs Associated With the Project

Economic *efficiency* requires that the total societal benefits of a proposed public action (like approval of a pipeline) balance or exceed the total societal costs of the action. That efficient outcome does not require that the costs be zero, but it does require that it be at least conceptually possible to re-allocate benefits in such a way that those who bear the costs *could be* compensated for their losses. If, in other words, the gainers *could* compensate the losers, then we can declare the project to be a good idea from an economic efficiency standpoint.[10]

As noted under "Policy Failure: The Review and Certification of Natural Gas Transmission Projects Discounts External Costs and Inflates Social Benefits" (p. 4) FERC's pipeline policy states an intention that pipeline projects "would be approved only where the public benefits to be achieved from the project can be found to outweigh the adverse effects" (88 FERC, para. 61,227, p. 23). It is therefore incumbent upon FERC to ensure that estimates of both public benefits and the public costs (i.e., adverse effects) are vigorously and completely investigated. Given that FERC relies almost exclusively on information about costs and benefits provided by private companies seeking pipeline approval, it is up to FERC to ensure that the information it receives is complete and credible as the basis for a comparison of public benefits and costs.

In the case of the ESU project, an initial review of economic information presented to FERC by Millennium Pipeline LLC[11] does not meet this test. We found that the studies overestimated positive impacts (benefits) associated with construction, ongoing operation, and consumer spending of assumed savings elsewhere in local economies, while discounting or ignoring adverse effects (costs). It would therefore be impossible for FERC to conclude, given the information put forth by the applicant, that the Millennium ESU would have benefits that outweigh the costs and, therefore, that granting a certificate would be economically efficient and "good" for society.

The review was included in comments on the project filed by Delaware Riverkeeper Network.[12] Millennium LLC and Concentric Energy Advisors provided an initial and supplemental response to the review of our original critique suggesting FERC not allow our comments "to affect the normal processing of Millennium's Application" (Millennium Pipeline Company, L.L.C., 2016d, p.1; Millennium Pipeline Company, L.L.C., 2017a). We disagree with this recommendation for the simple reason that consideration of input from interested parties, such as Delaware Riverkeeper Network or Millennium

[10] Economic *justice* would require the further step of gainers actually compensating the losers.

[11] See *Estimated Savings For New York Consumers From The Millennium Pipeline Eastern System Upgrade Project* (Concentric Energy Advisors, 2016), and *Draft Resource Report 5: Socioeconomics* (Millennium Pipeline Company, LLC, 2016b).

[12] Available as submittal 20161207-5162 at https://elibrary.ferc.gov/. The review is Phillips, S., & Wang, S. Z. (2016). *Economics of the Eastern System Upgrade: Credible and Complete Estimates of Benefits and Costs are Needed* (p. 16). Charlottesville, VA: Key-Log Economics, LLC for Delaware Riverkeeper Network.

Pipeline Company, LLC is an essential—and legally mandated—part of the normal processing of a pipeline certification application. Moreover, and in light of the substance of the Millennium/Concentric responses, it remains clear that the FERC has yet to receive sufficient and reliable information from the applicant regarding the potential economic benefits and costs of the proposed ESU project. Please see Appendix A for details regarding the Millennium/Concentric responses to our earlier review.

In general, and to summarize from that initial review, Millennium LLC has still not defended its misuse of a short-term economic base model to predict long-term project impacts; it continues to cite fundamentally flawed studies to support the dubious contention that natural gas infrastructure does not affect property values; and it has not shown that the social cost of carbon and public health impacts have been considered and/or will be offset by project benefits. The reasons for caution regarding the benefit estimates are summarized below, and further details regarding the potential costs of the project comprise the remainder of this report.

Millennium LLC relies on an input-output model (specifically, IMPLAN), to estimate long-term impacts though it is well known that such models are unsuitable for estimating such impacts. Due to the underlying assumptions and structure of such models, economic actors (firms and households), at least as represented in the models, cannot respond to changing economic conditions, including new technology, changes in relative prices for goods and services, and changing consumer preferences. Input-output modeling is therefore only appropriate for estimating impacts over the short-term, during which technology, prices, and preferences might be reasonably stable.

Indeed, empirical tests have shown that input-output models have very little value as predictors of economic impacts occurring more than a year or so into the future.[13] The consequence of misapplying input-output techniques to the long-term impacts of the proposed ESU is that the estimates of economic impact presented are too high. FERC needs to understand and acknowledge these limitations, given that part of the rationale for the project is its promised regional economic benefits.

Potential overestimation of impacts occurs because Millennium LLC assumes that the entire state of New York is the proper region for analysis. Because input-output models are built to track the flow of dollars among actors in the defined study region, the bigger the region, the more times those dollars will change hands within the region before “leaking” into some other region. Thus, the bigger the region, the larger the estimated impact. We would suggest defining a more compact study region to obtain more plausible estimates of the short-term economic impact of the project’s construction. Such a region would include the counties where the construction would occur, to be sure, and possibly additional counties where significant construction-related planning, engineering, etc. would occur.

Further potential benefits of the project are assumed to result from energy savings for utility customers. Concentric Energy Advisors (2016) estimated these savings for New York consumers using a partial equilibrium model that assumes a competitive energy market. Accordingly, Key-Log recommends FERC also consider the many factors affecting energy prices–and potential savings–over time that are not considered in such a model. These include additional planned natural gas pipelines, natural gas storage, the increasing rate of growth in renewable energy sources for electricity generation, electricity imports

[13] See Robertson (2003), Haynes et al. (1997), Hoffmann and Fortmann (1996), and Krikelas (1992).

into the NYISO from other regional transmission organizations, weather variations, and state demand management programs.

Overestimates in the benefit to New York electric utility customers of increased natural gas supply could result from a failure to consider costs of the pipeline construction, including a rate of return (Phillips & Wang, 2016, pp. 8-9). Millennium states New York ratepayers will not bear the costs of the Project because none of the ESU Project shippers directly provide service to New York customers (Millennium Pipeline Company, L.L.C., 2017a, p. 4). By estimating the benefits to New York consumers as a result of increased natural gas supply without considering corresponding costs—because they are not borne by New York consumers—Millennium has provided incomplete and unbalanced information regarding the potential consequences of the ESU Project.

With regard to potential negative economic impacts of the proposed project, Millennium LLC relies on flawed analyses that purport to demonstrate that natural gas infrastructure does not affect nearby property values. The studies in question fail in two ways. First, they do not consider whether or not buyers have full information about the purchased properties' proximity to natural gas pipelines. When buyers do not know a pipeline is nearby, it is impossible to conclude from a lack of property price differences, that pipelines do not affect willingness to pay for properties near pipelines.

Second, the studies fail to compare the prices of properties that are meaningfully different with respect to their proximity to natural gas infrastructure. With few exceptions, nearly all of the properties included in the studies can be said to be "near" the pipelines in that they are within the evacuation zone, or at least within its high consequence area. There is therefore no meaningful difference in pipeline proximity between what the studies define as properties that are "near" (or on) the pipeline and "far" (or off) the pipeline. With no difference in the key feature of the subject properties, one would not expect to find any difference in price between those types of properties. To put it more simply, if one wants to know whether there is a price difference between apples and oranges, one has to consider the price of apples and the price of oranges. The studies cited by Millennium however, only consider the price of apples, which makes it impossible to say anything about the relative price of oranges. (See "Effects on Property Value" on p. 17 for more details.)

With regard to the social cost of carbon, we recognize that there is precedent in previous FERC proceedings to ignore this important external cost of natural gas infrastructure. (See "The Social Cost of Carbon: An Additional Cost of Methane Transport" on p. 28.) We make a distinction, however, between what is done by habit and by precedent, and what should be done, if we as a society are to arrive at an economically efficient level of natural gas extraction, transportation, and use. To that end, we agree with the advice of former FERC Commissioner Norman Bay where he states that "the Commission should also be open to analyzing the downstream impacts of the use of natural gas and to performing a life-cycle greenhouse gas emissions study" (Federal Energy Regulatory Commission, 2017).[14]

[14] The Trump Administration has recently rescinded guidance that requires federal agencies to use the social cost of carbon in their environmental reviews. However, this executive action does not make the cost go away; it merely increases the likelihood that agencies will make economically sound decisions.

The possible health effects of the proposed ESU project present a challenge that can only be addressed with further research beyond the scope of this study. On one hand, Millennium LLC has recently released a study that concludes that the *modeled* emissions of hazardous air pollutants associated with the Compressor Stations are "below a level of health concern" (Millennium Pipeline Company, L.L.C., 2017b, p. 2). Specifically, the model predicts an excess lifetime cancer risk for a "reasonably maximally exposed adult" living near either of the proposed compressor stations to be well below the benchmark level of one-in-a-million deemed acceptable under Clean Air Act rules. In addition, the model predicts that the risk of acute health effects is also well below legally acceptable levels.

On the other hand, evidence from other studies suggest that *actual* emissions from compressor stations may exceed allowable levels and that people living near those stations may experience higher incidence of acute health effects, such as nosebleeds, loss of sleep, and severe headaches, compared to people living farther away. A five-state study examining air pollutants around compressor stations found high concentrations of benzene and formaldehyde that exceeded federal guidelines (Macey et al., 2014). In a survey and testing study focused on Pennsylvania, Steinzor, Subra, and Sumi (2013) compared the rate of various health effects experienced by people living closer to (within 1,500 feet) and farther from natural gas facilities, including compressor stations. They found that people living closer to the facilities were more likely to experience 18 of 20 possible symptoms, with several symptoms, like throat irritation and severe headaches affecting more than half of the respondents living within 1,500 feet of the facilities.

It is important to note that further epidemiological research would be required to determine the extent to which such effects are the result of exposure to emissions from compressor stations, as opposed to wells and other facilities, and to control for other relevant factors (e.g., smoking or other behavioral factors, and exposure to other environmental hazards, such as vehicle emissions for people living in congested areas). Such research would shed light on the seeming disconnect between the results of predictive models and the experience of people living near compressor stations.

For this report, we do not include the cost of potential health effects in our estimates of the likely costs of the ESU project. Instead, we discuss those effects and associated treatment costs under the separate heading of "Public Health Effects" (p. 29) along with other possible effects where further investigation is needed.

Environmental-Economic Effects and Where They Would Occur

In the remainder of this report, we follow this potential cycle and consider three distinct types of economic consequences. For the first two of these, there are sufficient data on which to base numerical estimates of economic costs. The latter two are described qualitatively.

1. **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, and compressor stations.
2. **The Social Cost of Carbon:** The economic cost of harm associated with the emission of carbon.

3. **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.
4. **Public Health:** The potential for diminished human health due to the operation of compressor stations.

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 would require clearing an area of on average about 125 feet (38.1 m or 0.02 miles) wide.[15] After construction, the permanent right-of-way ("ROW") would be an average of 50 feet (15.2 m or 0.01 miles) wide along the entire length of the pipeline.[16]

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" and an even larger evacuation zone. A High Consequence Area ("HCA") 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 the 30" portion of the pipeline would have a radius of 711.87 feet (216.98 m or 0.13 miles) and for the 36" portion of the pipeline, a radius of 854.25 feet (260.38 m or 0.16 miles).[17]

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 2,369 feet (722.07 m or 0.45 miles) for the 30" portion of the pipeline and 2,843 feet (866.55 m or 0.54 miles) for the 36" portion (Figure 2).

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

[15] Table 1A-1 in *Draft Resource Report 1: General Project Description (2016a)* gives the approximate width of the construction corridor by milepost. For our analysis, we took into account the different widths.

[16] In *Draft Resource Report 1: General Project Description (2016a)*, Millennium LLC notes that they will increase the existing 50-foot wide permanent easement of the Millennium Pipeline by 25 feet to accommodate the ESU loop in areas where the loop and existing easement co-locate. For the areas where the ESU loop and existing pipeline easement do not co-locate, a new 50- foot permanent easement will be created for the loop.

[17] The HCA calculations used the maximum allowable operating pressure of 1,200 PSIG, as noted in *Draft Resource Report 1: General Project Description (2016a)*.

FIGURE 2: Right-of-Way, Construction Corridor, High Consequence, and Evacuation Areas

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 (besides for the area where a permanent ROW will not exist). The size of the ROW and construction corridor vary throughout the entire loop.

Sources: ESU loop obtained from Stephen Metts of the New School and parcels from Orange County obtained from New York State's GIS Clearinghouse.

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 Stations

The proposed compressor stations are likely to have separate effects on property value and on human health. Based on the experience of homeowners near the compressor station in Hancock, New York, the same one for which the ESU would increase horsepower, we consider the possibility of a property value effect within one half mile of both compressor stations (Catskill Citizens for Safe Energy, 2015). This zone overlaps the ROW and the evacuation zone. 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 the properties affected by the compressor stations.

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 two proposed stations, however, without such research, we do not include the potential public health costs in the present study.

Proposed compressor station site.
(Photo credit: George Billard)

Municipalities and Counties

If the ESU is built, there will likely be increases in the costs of community services, such as for traffic control and extra law enforcement capacity needed during construction and for emergency preparedness/emergency services during operation. As municipality and county governments, as well as volunteer fire companies meet these needs, costs for services could increase.

Millennium states that they expect the construction and operation of the project to have minor to no short-term impacts or long-term increases to public services (Millennium Pipeline Company, L.L.C., 2016b). Millennium LLC did not confirm in Resource Reports that they interviewed officials responsible for such services, therefore, FERC should not base the claim that the project will not impact public services entirely on Millennium's assurance. Rather, FERC needs to confirm and base their decision on real data, which should be collected before the final decision regarding the pipeline.

Region-Wide Effects

Beyond the loss of property value resulting from the chance of biophysical impacts (leaks and explosions), or the certainty of impacts on aesthetics, the proposed ESU would also diminish 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 ESU project instead of in some other place.

To the extent the ESU 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 3 summarizes the types of economic values considered in this study and the zones in which they are estimated.

TABLE 3. 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, but not quantified in this report.

Values/ Effects	ROW & Construction Zone	High Consequence Area & Evacuation Zone	Near Compressor Station	Entire Study Region	Beyond the Study Region
Human Health and Safety	?	?	✓	?	?
Land/ Property Value	✓[a]	✓[b]	✓[b]	?	?
Economic Development	c	c	c	c	?

Notes:

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

b. 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: 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 major leak occurring at a given time from the pipeline is rare.) We assume that the ongoing effects of the compressor station on the use and enjoyment of properties nearby would overshadow or dominate the possibility of a high-consequence event or the need to evacuate.

c. Economic development effects related to these subsets of the study region are scenarios that are not included in the total cost estimates for the study region.

Effects on Property Value

To say the impacts and potential impacts of the ESU loop and the compressor stations on private property value are important to people along its proposed route would likely be an extreme understatement. Key-Log Economics and Delaware Riverkeeper Network are conducting an analysis of comments FERC received in regards to the report. While results from that analysis are not yet available, one can look to the nearby example of the proposed PennEast pipeline. Landowners and Realtors in the region affected by that proposal, along the proposed route of the PennEast Pipeline, a 36" high-pressure natural gas pipeline designated to transport gas through Pennsylvania and New Jersey, are already reporting lower than expected appraisals (Kohler, 2015).

While it is impossible to know precisely how large an effect the ESU project has already had on land prices, there is strong evidence from other regions that the effect would be negative. In an independent and 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 ESU project:

- 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), which shows that home buyers (and home prices) are sensitive even to low-probability threats to the safety of their families.

Considering only those buyers who are still willing to purchase the property, the expected loss in market value would be 10.5%.[18] 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 <u>all</u> potential buyers 66.2%.[19] 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 ESU project 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

[18] 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%.

[19] This is the expected value calculated as 0.622*(-100%) + 0.189*(-21%) + 0.189*(0%).

response zone" (EPZs) of sour gas[20] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

The risks posed by the ESU project would be different—it would not be carrying sour gas, for example—but there are similarities between the ESU 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 Millennium-cited studies showing no price effects (see "Claims that pipelines do not harm property value are 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 ESU 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 ESU's HCA and evacuation zones or, at a minimum, regarding the presence of the ESU in the study region.

The two compressor stations would likely cause their own more severe reduction in the value of nearby properties. Around the existing Hancock compressor station, properties within half a mile of the proposed compressor station saw property devalued 25% ("Proximity of Compressor Station Devalues Homes by as much as 50%," 2015). We use the 25% devaluation to estimate the amount of property value lost within half a mile of the Highland CS and Hancock CS.[21]

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, 2015a; "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.[22] 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.

[20] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.

[21] We re-evaluate the property value lost around the Hancock CS to reflect more up to date parcel information. We believe these estimates may be conservative due to the fact that under the update, the Hancock CS would receive additional horsepower.

[22] Phillips (2004) is an example of a study that includes an extensive review of the literature on the topic.

Claims That Pipelines Do Not Harm Property Value Are Invalid

In *Draft Resource Report 5: Socioeconomics* (2016b), Millennium, LLC cites studies purporting to show that natural gas pipelines have at most an ambiguous and non-permanent effect on property values (Diskin et al. 2011; Integra Realty Resources, 2016). Millennium LLC also cites the authors of Wilde, Loos, & Williamson (2012) and their statement that there is "no credible evidence based on actual sales data that proximity to pipelines reduces property values" (p. 16). While the studies referenced differ in methods, they are similar in that they fail to take into account two factors that void entirely their conclusions that natural gas pipelines have no effect on property values.

First, the studies fail to 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 infrastructure. For prices to reflect willingness to pay (and therefore true economic value), buyers would need full information about the subject properties, including whether the properties are near a pipeline. Second, the studies finding 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.[23] 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 Preconditions 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 possess 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 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).

[23] The Kinnard studies mentioned in Wilde, Loos, & Williamson (2012).

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, thus demonstrating that once would-be buyers become aware of the presence of a pipeline and its hazards, they can "vote with their feet" and their wallets and buy elsewhere. 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, citizen's own videos, and other media describing and depicting such explosions and their aftermath. Whether or not the pre- and (in the long term) post-explosion prices in that Bellingham neighborhood reflected the presence of the pipeline, it is hard to imagine that the evident dangers of living near a fossil fuel pipeline would be so easily missed or so quickly forgotten by today's would-be homebuyers.

What Zillow and other sites do accomplish is a lowering of the effort/cost of acquiring information about properties. Potential homebuyers can easily 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 do make it more likely that prospective buyers will gain and act on information about the hazard they could be buying into.

With more vocal/visible opposition to large, high-pressure natural gas pipelines and associated natural gas infrastructure it also seems likely that prospective home buyers will not have to wait for an incident involving the ESU project to learn of it and, therefore, for the project to affect willingness to pay for properties nearby. Anyone with an eye toward buying property near the proposed path of the project 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 ESU upgrade will be lower than the prices offered for otherwise similar homes farther away or in another community or region.

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 *Draft Resource Report 5: Socioeconomics* 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 the Interstate Natural Gas Association of America (INGAA) study, the authors compare prices for properties directly on a pipeline right-of-way to prices of properties off the right-of- way (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 (Integra Realty Resources, 2016).[24]

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 therefore likely to suffer a loss in property value relative to properties farther away.[25]

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 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

FINANCIAL DAMAGE ALREADY OCCURRING

Mark and Alycia Egan live 0.59 miles, directly across the street, from the proposed Highland compressor station. Upon learning about the plans for the Highland CS, the Egan's put their home on the market for fear their property value would be significantly diminished. A year later, with their home still on the market, the Egan's have had to lower the cost of their home and learned a recent buyer loved the home but declined entering an offer once they knew about the potential of the compressor station.

The Egan's contacted Millennium regarding their worries that their property may be unsellable but their only response was that buyers were "clearly misinformed." Millennium LLC and FERC continue to put industry supported studies falsely claiming property values are not impacted by pipelines and related infrastructure over the actualized harms suffered by homeowners.

Mark and Alycia walking along old route 55. (Photo credit: Mark Egan)

[24] 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).
[25] We estimated the evacuation zone based on available information about the pipeline diameter and operating pressure (Pipeline Association for Public Awareness, 2007).

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. 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.

A prime example of this problem is embodied in the 2014 study by Allen, Williford, and Seale, which is summarized in the latter INGAA study (Integra Realty Resources, 2016). The authors compare the prices of homes and lots "on" and "off" a Transco-operated pipeline in Luzerne County, Pennsylvania. In the map below (Figure 3), the green-shaded properties are those identified by the authors as "on the pipeline," because they are crossed by the 50-foot right-of-way. The orange properties are what the authors call "off the pipeline."

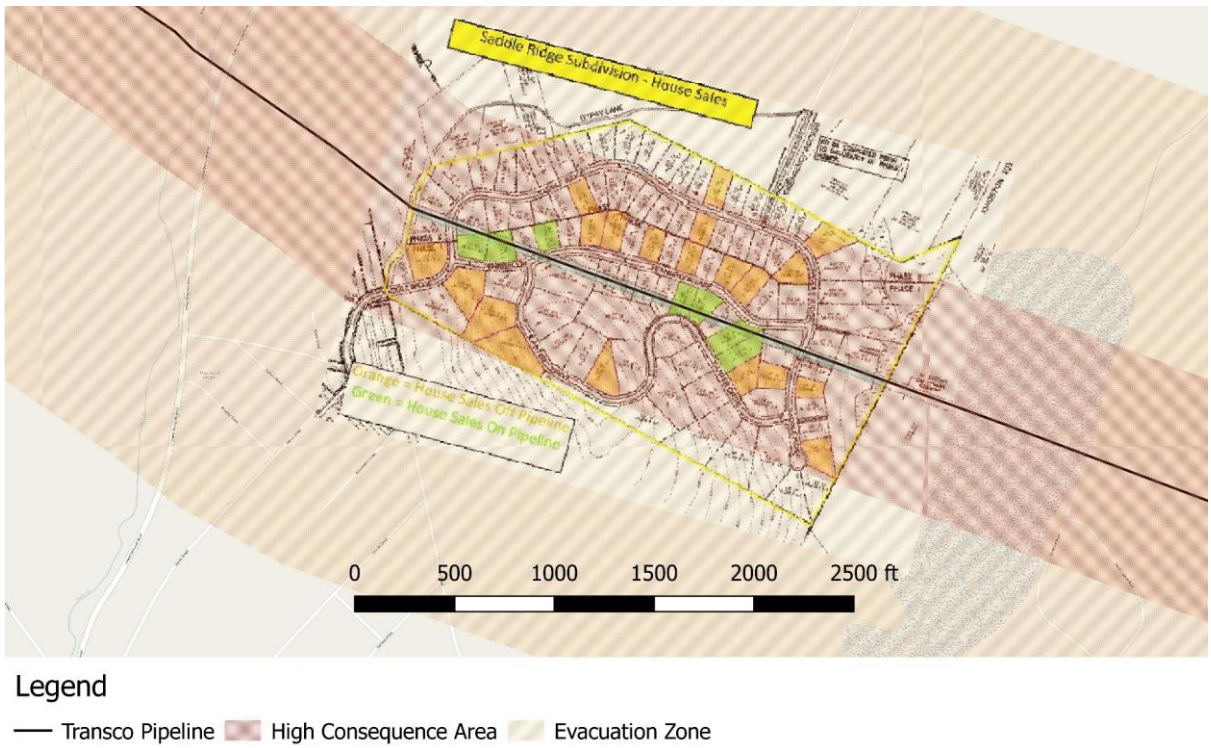

FIGURE 3. Transco Pipeline evacuation zone covers all, and the high-consequence area covers most, of properties in the Saddle Ridge case study area.

Sources: Saddle Ridge subdivision image from Allen, Williford, and Seale (2014) as reproduced in Integra Realty Resources (2016, p. 69); Transco Centerline digitized from approximated ROW shown in blue and, beyond the subdivision, from Google satellite imagery (2017).

Figure 3 also shows, in pink shading, the 1,139-foot-wide high-consequence area and, in tan, the 3,796-foot-wide evacuation zone. <u>All</u> of the properties that Allen, Williford, and Seale consider as either "on" or "off" the pipeline are well within the evacuation zone, and all of the properties are at least touched by the high-consequence area. Because perceptions of the risk to life and property in the event of an explosion or, at minimum, worry and inconvenience homeowners, living within the evacuation zone

should likely affect offer prices for all of the properties in the study area, making the authors' definitions of "on" and "off" the pipeline substantially irrelevant. As in the other cases included in INGAA's review (Integra Realty Resources, 2016), Allen, Williford, and Seale simply document the unsurprising result that similar properties have similar prices.

As economic research, their exercise is a perhaps harmless but wasted effort. As the basis for FERC's and others' contention that natural gas pipelines do not affect property values, the exercise is one of costly, and possibly dangerous, misdirection.

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 ESU project on property value, FERC and others must look to studies (e.g., Boxall et al. (2005), Kielisch (2015)) in which the buyers' willingness to pay are 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 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 the compressor stations. In one documented case from Minisink, New York, a smaller (12,600 hp) compressor station just southeast of the proposed Highland compressor station, a family of six moved to escape the effects of the compressor station operated by Millennium LLC. 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, 2015a).

Around the existing Hancock CS, three homeowners living around 15,900 hp compressor station, which would get an additional 22,400 hp upgrade under the ESU project, 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 have not been statistical studies conducted demonstrating the relationship between a property's value and its proximity to a compressor station. However, the mounting anecdotal information suggests there is a negative relationship, and depending on the particular circumstances, the effect can be large–up to the 100% loss sustained by a family in Minisink (less than whatever the bank can recover at auction). FERC must therefore count the potential loss of property value associated with the compressor stations proposed for Sullivan County and further losses associated with the existing station in Delaware County.

For our estimates, we follow the existing example of the Hancock, New York case and assume that properties within one half mile of the Highland CS would lose 25% of their value if the station is built.[26] For the analysis, we re-analyzed the potential property value loss around the Hancock CS in order to reflect up to date parcel value information. We believe our estimates are conservative in part because the horsepower proposed for the Highland CS (22,400 hp) and the upgrade for the Hancock CS (38,300 total hp) are both larger than the horsepower of the existing Hancock Station (15,900 hp), about 1.5x and 2.4x respectively. It is therefore likely that noise, odor events, and other physical effects would be experienced at a greater distance and/or with greater intensity than the existing property devaluation example.

Parcel Values

We obtained parcel data in electronic form from the New York state GIS clearinghouse as well as from county level GIS departments. The data included Geographic Information System ("GIS") layers with the valuation/assessment data for the counties. Because publicly owned conservation lands (parks, etc.[27]) 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:

1. Parcels crossed by the right-of-way
   (5 parcels, with total baseline value (without the ESU project) of $186,050)
2. Parcels crossed by the construction corridor
   (18 parcels, with total baseline value (without the ESU project) of $6.1 million)
3. Parcels at least partially within the high consequence area (HCA)
   (20 parcels, with total baseline value (without the ESU project) of $5.9 million)
4. Parcels at least partially within the evacuation zone
   (196 parcels, with total baseline value (without the ESU project) of $19.8 million)
5. Parcels with their geographic center (centroid) within one-half mile of the parcel containing the compressor station
   (43 parcels, with total baseline value (without PE) of $4.9 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.

[26] For land value analysis of the compressor stations, we buffered a half mile radius around the workspace of the station.

[27] We used the "Protected Areas Database" from the National Gap Analysis Program to identify fee-owned conservation properties (Conservation Biology Institute, 2012).

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 18 parcels and $6.1 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.

TABLE 4: Summary of Marginal Property Value Effects

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

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.

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 4 repeats a portion of Table 3, but with the property value effects in place of check marks.

Estimated Land Value Effects

Following the procedures outlined in the previous section, our conservative estimate for costs of the proposed ESU would include $2.0 million in diminished property value with the most intense effects felt by the owners of 5 parcels in the path of the right-of-way, who collectively would lose between $7,814 and $24,187 in property value. Some 196 additional parcels lie outside the ROW but are within or

touching the evacuation zone. These parcels' owners would lose an estimated $753,692 (Table 5). Finally, the compressor stations would reduce the value of 43 properties by a total of $4.9 million.

Table 5: Summary of Land Value Effects, by Zone and County

	Delaware County	Sullivan County	Orange County	Total
Effects on ROW Properties (2015$)				
Realtor Survey (4.25%)	n/a	n/a	-7,814	**-7,814**
Buyer Survey (10.5%)	n/a	n/a	-19,535	**-19,535**
Impact Studies (13%)	n/a	n/a	-24,187	**-24,187**
Effects on Evacuation Zone Properties (2015$)				
Boxall Study (3.8%)	n/a	n/a	-753,692	**-753,692**
Effects Near Compressor Stations (2015$)				
Hancock, NY Finding (25%)	-519,888	-715,474	n/a	**-1,235,361**
All Effects (2015$)				
Low	-519,888	-715,474	-761,506	**-1,996,868**
Medium	-519,888	-715,474	-773,227	**-2,008,589**
High	-519,888	-715,474	-777,879	**-2,013,240**

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 $36,005 and $36,298 per year (Table 6). The present value of this stream of lost revenue over the 2018-2068 operating period would be $1.6 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 ESU could drive up expenses while driving down the counties' most reliable revenue stream.

TABLE 6. Effects on Local Property Tax Revenue

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

	Delaware County	Sullivan County	Orange County	Total
Median Tax Rate (% of Home Value)				
	1.62%	1.95%	1.79%	
Lost Property Tax Revenue (2015$)				
Low	-8,422	-13,952	-13,631	**-36,005**
Medium	-8,422	-13,952	-13,841	**-36,215**
High	-8,422	-13,952	-13,924	**-36,298**

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 helps better inform regulation because it allows agencies to more accurately weigh the environmental costs and benefits of a new rule or regulation. After challenges questioning the accuracy of SCC, 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). Even more recently, 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 or EA 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" (2016, p.34).

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).

Millennium LLC estimates the ESU loop would transport 73,000,000 dekatherms annually, contributing to an equivalent of 3.9 million metric tons of CO2 emitted per year (U.S. EPA, 2016). 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 2068.[28] Using U.S. EPA estimates based on the average of impacts from three 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 ESU project would total between $4.8 and $18.8 billion over 50 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 malady of health concerns. 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 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 (Fleischman, McCabe, & Graham, 2016).

Air Pollution from the Proposed Compressor Stations

The ESU project impacts air quality by converting forests, which remove normal levels of impurities from the air, to other land uses. 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.) will certainly occur at the two proposed compressor stations. Leaks in seals on the moving parts of natural gas compressors produce a significant amount of VOC emissions (Fleischman, McCabe, & Graham, 2016). Also, after the compressor station in Hancock began operation, there was a 5x increase in the amount of ambient methane for roughly a one mile radius (Cohen, 2015).

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. David Carpenter, the director of the Institute for Health and the Environment at the University at Albany, notes that compressor stations are among the worst of fracking related infrastructure (Lucas, 2015). A five-state study examining air quality near compressor stations found that levels of several volatile chemicals, including benzene and formaldehyde, exceeded federal guidelines (Macey et al., 2014). As more

[28] Based on information provided by Millennium LLC in *Draft Resource Report 1: General Project Description (*2016a), construction on the project would begin in 2017 and the first year of operation, or the first year the project would produce associated emissions, would be 2018. Millennium LLC also states that the ESU facilities “are projected to have a 50-year minimum physical life” (Millennium Pipeline Company, L.L.C., 2016, p. 1-42). Given a 50-year minimum physical life, we use 2068 as the final year of operation for the project.

> ***"I have worked on the Town of Highland's Comprehensive Management Plan and its zoning that expressly, clearly and specifically bans any and all compressor stations - as have a number of surrounding towns concerned with protecting the quiet enjoyment of our homes and rural, tourism-friendly environment."***
>
> -Debra R. Conway, Resident
> Barryville, New York

negative documented health impacts arise from other existing compressor stations, this has led the Highland Town Board to draft a unanimous resolution opposing the compressor station, citing potential health impacts as a cause of great concern (Times Herald-Record, 2016).

The documented negative health impacts from other existing compressor stations led the Highland Town Board to draft a unanimous resolution opposing the compressor station, citing potential health impacts as a cause of great concern (Times Herald-Record, 2016).

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, 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 Sullivan County, 115 people live within 2 miles of the proposed Highland CS (U.S. Census Bureau, 2015). Applying the results of Subra (2015) to the population in Sullivan living within 2 miles, 104 people would experience odor events, 82 people would experience respiratory impacts, 67 people would experience sinus problems, and 45 people would experience sleep disturbances and/or severe headaches.

In Delaware County, 256 people live within 2 miles of the existing compressor station in Hancock (U.S. Census Bureau, 2015). Applying the results of Subra (2015) to the population in Delaware living within 2 miles, 230 people would experience odor events, 182 people would experience respiratory impacts, 148 people would experience sinus problems, and 100 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.

Effects on Economic Development

In each county analyzed, 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 Orange County Comprehensive Plan, one of the priority goals is to "strengthen the economy in Orange County by attracting and supporting businesses that will enhance the County's economic base and provide jobs, tax revenues, and an orderly and sustainable land use pattern that accommodates the best of the County's old economy while providing the attributes necessary to build the new economy" (Orange County Planning Board, 2010). Sullivan County's Comprehensive Plan dedicates an entire section to alternative energy sources and the importance that the county supports environmentally conscious initiatives that generate economic benefits and simultaneously preserve significant natural resources (Sullivan County Planning and Environmental Management, 2005). Along similar lines, Delaware County recognizes that preserving water quality and supporting their growing agri-tourism sector go hand in hand (Delaware County Planning Department, 2008).

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.

"This area is known for its unspoiled natural beauty, clean water and fresh air. The local economy is entirely dependent on nature tourism and vacation homes, including ours. The area is heavily forested, with a number of endangered and threatened species. There is no municipal water supply and all homeowners are dependent on the purity of the aquifer, which is replenished by our myriad of lakes and streams. Industrial use is specifically banned in The Town of Highland in order to preserve the unique natural habitat."

- John Caplan, Landowner
Highland, New York

Part of what makes tourism an important part of the study region's economy is the high aesthetic quality and environmental amenities available in the study region. In 2015 alone, tourism in the study region is a $944.3 million industry, up $61.7 million from 2010. The industry provides 14,907 jobs across the study region, contributing to $441.3 in payroll, $63.0 million in local taxes, and $52.4 in state taxes (Tourism Economics, 2016a, 2016b).

The ESU 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 ESU could discourage people from visiting, relocating to, or staying in the region. Workers, businesses, and retirees who might otherwise choose to locate along the ESU's proposed route or near the compressor stations 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 ESU looming, business plans are stalling and the real estate market is slowing. In nearby Minisink, community members impacted by Minisink compressor station have had signs in opposition of the construction stolen from their property by other neighbors fearing if too much press highlights the negativity of the station for the town that it will harm the agricultural industry that the town depends on (Rugh, 2014).

Many of the region's residents believe the ESU will also harm the travel and tourism industry. For example, Juliette Hermant, a small business owner in Narrowsburg, an area heavily dependent on nature tourism and vacation homes has heard from clientele expressing heavy concern over the proposed project (Carazo, 2015).

It is difficult to predict just how large an effect the ESU 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 ESU might affect key portions of the region's overall economy, such as tourism and recreation, retirement, and entrepreneurship.

"This whole Upper Delaware River Valley is a sacred national asset. The economy here, and the livelihood of the people who live here, are as fragile as the river valley itself. Thus, the number one economic engine here has always been, quite appropriately, the sanctity of our natural habitat. We should never, ever, ever, ever take a risk of damaging or diminishing that asset, our only real economic engine."

-Mark Righter, Community Member
Glen Spey, New York

If, for example, the ESU were to cause a 5% drop in recreation and tourism spending from 2015 baselines, the project could mean $47.2 million less in travel expenditures each year (Tourism Economics, 2016a, 2016b). Those missing revenues would otherwise support roughly $3.1 million in local tax receipts, $2.6 million in state tax revenue, 745 jobs, and $22.1 million in payroll in the three-county region. 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 ESU.

Along similar lines, retirement income is an important economic engine that could be adversely affected by the ESU. 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 4.5% per year. During roughly the same time period (through

2013), the number of residents age 65 and older grew by 20.3% (1.6% per year), and this age cohort now represents 13.2% of the total population (U.S. Department of Commerce, 2015a; U.S. Department of Commerce, 2015b).

It is difficult to precisely quantify the effect of the ESU 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, again, we consider what a *5% reduction of the growth rate* might entail. A 5% growth reduction scenario would mean an annual decrease in investment income and age-related transfer payments of approximately $6.3 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.

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 5% reduction scenario in the rate of growth would mean 74 fewer jobs and $1.2 million less in proprietor's 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 living near the pipeline or a compressor station is not an issue. If so, further opportunities for local job and income growth will be missed.

These are simple, but plausible scenarios regarding the potential economic development impacts of the ESU. Other methods and assumptions would lead to different estimates, of course, and it is incumbent on FERC to complete its own evaluation of the merits of the proposal. Especially because the project 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, as well as to take a hard look at the project applicant's claims regarding possible gains.

Conclusions

The full costs of the proposed Eastern System Upgrade to people and communities in the three-county study region and beyond are wide-ranging. The costs include one-time costs like reductions in property value during pipeline construction, which we estimate to be about $2.0 million. There are also ongoing costs like lost property tax revenue and the cost of increased carbon emissions that recur year after year for the life of the pipeline. Diminished property tax revenues would total between $36,005 and $36,298 per year. The majority of these costs would be borne by the residents, businesses, and institutions in Orange, Delaware, and Sullivan Counties.

Beyond the immediate region, the Eastern System Upgrade would also impose a cost on people worldwide due to the addition and 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 $50.1 and $420.1 million, raising the total annual external costs to between $50.2 and $420.2 million.

Adding up all one-time recurring costs, and discounting those future costs to 2017, we estimate the total external costs of the Eastern System Upgrade to be between $4.7 and $18.8 billion in 2015 dollars.

Construction and operation of the project would produce comparatively few economic benefits. Using Millennium LLC's estimates, the construction period would produce $314 million (2015$) in economic impact (additional spending by firms and households in Millennium's study region, which is the entire state of New York). Spending on operation and maintenance of the completed project, plus assumed cost savings for energy users would, in Millennium LLC's estimation, generate $70.3 million (2015$) in output annually for 10 years (Concentric, 2016).[29] Applying the same methods to calculate the present value of the positive effects,[30] the pipeline promises a total of $2.0 billion in economic impact over 50 years of operation. This means for every dollar of benefit promised, the Eastern System Upgrade would impose between $2.31 and $9.24 in costs.

While the decision to approve or not approve the ESU does not hinge on a simple comparison of estimated benefits versus estimated costs, the difference between the external economic costs presented in this report and the potential payments to local governments and residents suggests that, from an economic perspective, the proposed project is inefficient. The scope and magnitude of the costs outlined here reflect a closer examination into important components of the full extent of the ESU's likely environmental effects that must be considered when FERC makes 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 Eastern System Upgrade.

If these considerations and FERC's overall review result in selection of the "no-action" alternative and the ESU is never approved, 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 project 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 ESU *as currently proposed* on property values, economic development, and climate impacts, conducts a thorough analysis of all possible alternatives. Those alternatives may include using alternative energy technologies for meeting the energy needs of the region, making better use of existing gas transmission infrastructure, 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

[29] Concentric (2016) uses 2019-2028 as the operational phase, however, in Draft Resource Report 1 (2016), Millennium LLC states that the first year of operation will be in year 2018. For estimates in this report, we use 2018 as the first year of the ESU's operational period.

[30] Although Concentric (2016) only provides operational benefits for 10 years after the first year of operation, for our present discounted value calculations, we use their given average of $70.3 million per year as the annual benefit.

environmental damage and, thereby, minimizes the economic costs to individuals, businesses, and the public at large.

Adequate environmental review by FERC and, subsequently, an economically efficient outcome cannot be achieved if FERC 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. The analysis presented here, therefore, should be seen and used as a first step to filling a major gap in the information on which to base public decisions about the Eastern System Upgrade.

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Appendix A: Key-Log Economics Response to Millennium LLC and Concentric

In this Appendix we provide further details regarding Millennium Pipeline Company LLC's and Concentric Energy Advisors' responses to DRN's earlier review, as summarized on p. 10. We begin with arguments put forth by Millennium, followed by arguments posed by Concentric. Our replies further document the unbalanced analyses prepared to date and presented in documents which focus on purported benefits of the proposed project without adequate consideration of the possible economic costs in and beyond the region.

Millennium Pipeline Company L.L.C.

From *Answer of Millennium Pipeline Company, L.L.C. to Comments on the Eastern System Upgrade Project* (Millennium Pipeline Company, L.L.C., 2016d):

Millennium Assertion 1: "Millennium Has Demonstrated That the ESU Project's Public Benefits Outweigh Any Potential Adverse Impacts" (Millennium Pipeline Company, L.L.C., 2016d, p.1).

> Millennium LLC states that, "the Commission should apply the standard set forth in the [Natural Gas Act, or] NGA, in which the Commission determines whether a project is required by the public convenience and necessity pursuant to the criteria set forth in the Certificate Policy Statement. Under the Certificate Policy Statement, the Commission determines that a "need" for a project exists as part of its process of approving the project" (Millennium Pipeline Company, L.L.C., 2016d, p. 2).
>
> They also state, "Because Millennium has demonstrated that the ESU project will have minimal impact upon landowners and the surrounding communities, the Project satisfies the Commission's economic balancing test" (Millennium Pipeline Company, L.L.C., 2016d, p.3).
>
> Millennium is mistaken on both points.
>
> It cannot be said that current procedures are sufficient to establish a need for or public benefit from proposed pipelines. As Commissioner Norman C. Bay noted in his statement attached to *Order Granting Abandonment and Issuing Certificates* in the National Fuel Gas Supply Corporation / Empire Pipeline, Inc. case (2017), in order to respond to increasing public interest in the Commission's work, FERC needs to further explore how it establishes need when completing certificate reviews. Bay notes, "The Commission has largely relied on the extent to which potential shippers have signed precedent agreements for capacity on the proposed pipeline" (Federal Energy Regulatory Commission, 2017). However, the problem with focusing on precedent agreements is that a "variety of other considerations, including, among others: whether the capacity is needed to ensure deliverability to new or existing natural gas-fired generators, whether there is a significant reliability or resiliency benefit; whether the additional capacity promotes competitive markets; whether the precedent agreements are largely signed by affiliates; or whether there is any concern that anticipated markets may fail to materialize" (Federal Energy Regulatory Commission, 2017).

FERC's policies and procedures for evaluating pipeline costs and benefits are not sufficient to ensure a true "economic test" of the merits of any natural gas infrastructure proposal. This is primarily because they rely on applicants overinflated estimates of benefits and ignore important external costs. (Please see "Policy Failure: The Review and Certification of Natural Gas Transmission Projects Discounts External Costs and Inflates Social Benefits" on p. 4 of this report.)

On the second point, and as we have explained in the body of this report as well as in the review to which Millennium responded, the contention that natural gas pipelines and related infrastructure have no effect on landowners is not defensibly argued by Millennium, and there are entire classes of external costs that Millennium has not considered at all.

Millennium Assertion 2: That "[the] Commission should reject DRN's[31] misplaced suggestion to apply a cost-benefit analysis when evaluating the environmental impact of the Project" (Millennium Pipeline Company, L.L.C., 2016d, p. 2).

First, note that this argument is inconsistent with the first argument, which is that, at least in Millennium's view, the ESU project passes a cost-benefit test. If Millennium believes that cost-benefit analysis of its proposed project is invalid, then it should not also argue, on cost-benefit grounds, for approval of the project.

Second, note that Millennium's argument on this point is in the context of whether or not the National Environmental Policy Act requires FERC (or any agency) to balance or directly compare benefits and costs. It does not, but NEPA does require agencies to consider the effects of their actions on the human environment, and that includes economic effects (40 CFR 1508.8). As the NEPA regulations state "When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment" (40 CFR 1508.14). To make this perfectly clear, economic effects <u>are</u> benefits and costs. So while NEPA does not require that agencies directly compare benefits to costs, or to select an alternative for which benefits outweigh costs, it does require that those economic effects be considered as part of agencies' environmental reviews.

Third, Millennium has advanced their own studies of potential benefits to argue in support of the project.[32] The reports ignore the full array of costs the project will inflict. To the extent Millennium wants to argue for a cost benefit analysis to support its project, it must consider the full picture which we help provide.

Rather than arguing, contrary to FERC and NEPA policy as well as its own past communication, that cost and benefit concerns are irrelevant, we would recommend that the applicant support

[31] Our report *Economics of the Eastern System Upgrade: Credible and Complete Estimates of Benefits and Costs are Needed* (Phillips & Wang, 2016) was filed by DRN. References to DRN should therefore be interchangeable with Key-Log Economics.

[32] See *Estimated Savings For New York Consumers From The Millennium Pipeline Eastern System Upgrade Project* (Concentric Energy Advisors, 2016), and *Draft Resource Report 5: Socioeconomics* (Millennium Pipeline Company, LLC, 2016b).

an independent, thorough, and rigorous evaluation of the full range of costs and benefits. Again, and based on our review of the information presented by the applicant to date, we do not believe that such an evaluation has previously been completed.

Our current report attempts to enumerate and quantify *some* of the key external costs likely to attend the construction and operation of the ESU project. We recommend that FERC use this information and/or expand and improve upon this effort.

Millennium Assertion 3: That DRN [Key-Log Economics] agrees that Millennium's estimated economic benefits of the ESU Project are "substantial" (Millennium Pipeline Company, L.L.C., 2016d, p. 5).

In full, Millennium states, "Despite DRN's [Key-Log Economics'] contention that the Concentric Study overestimates the Project's economic benefits, DRN's [Key-Log Economics] recognizes that the Project has substantial economic benefits"[33] (Millennium Pipeline Company, L.L.C., 2016d, p. 5). Here, Millennium seems to mistake the enumeration of the ways in which it has overstated the economic benefits of the project with agreement that the [true] benefits are "substantial". To be clear, we have not claimed that the benefits are *nonexistent*, but rather, and as we have explained previously (Phillips & Wang, 2016) as well as in the current report, there are several reasons to suspect that the benefits will be fewer or smaller than Millennium has claimed. In addition, when compared to the high level of costs the project inflicts, the benefit claims do not appear to be high enough to economically justify the project.

Millennium Assertion 4: "The Commission Should Disregard DRN's Assertions That the ESU Project Will Adversely Affect Property Values" (Millennium Pipeline Company, L.L.C., 2016d, p. 6).

Millennium states that we have not cited "credible studies or information" regarding our claim that pipelines adversely affect property values in our initial review. Estimation of land price effects was not intended to be a part of that initial review. Our evaluation of the project's external costs presented in this report however, includes such estimates and we stand behind our method—including use of credible studies and information—for estimating the extent to which the ESU project would affect nearby property values. (See the section titled "Effects on Property Value," p. 17)

Moreover, in both the initial review and in this report, we described in detail the fundamental flaws in the studies on which Millennium bases its claim that proximity to natural gas infrastructure does not affect property value. To summarize, those studies do not account for the extent to which buyers know that the property they purchased was near a pipeline, and they do not compare prices for properties that are, in any meaningful sense, nearer to, versus farther from, natural gas infrastructure. These flaws render the studies' results meaningless, and they are simply not credible as the basis for any conclusion regarding the effects of natural gas infrastructure on property value. (See the sections "Effects on Property Value"/ "Studies Concluding That Proximity to Pipelines Do Not Result in Different Property Values Are Not

[33] In the quoted passage, Millennium attributes this contention and recognition to Delaware Riverkeeper Network. They reference page 7 of DRN's submission to FERC which is in fact in the Key-Log Economics' report attached to DRN's letter.

Actually Comparing Prices for Properties That Are Different" (p. 17 and p. 21) of this report for details on the flaws in the studies in question.)

Millennium Assertion 5: That "The Commission Is Not Required to Utilize the Social Cost of Carbon to Evaluate Impacts of Greenhouse Gas Emissions Associated with the Project" (Millennium Pipeline Company, L.L.C., 2016d, p. 9).

In support of this argument, Millennium notes that "the Commission had determined that the social cost of carbon is a useful tool for considering climate benefits of rulemakings and policy alternatives, but not for considering the environmental impacts associated with individual pipeline projects" (Millennium Pipeline Company, L.L.C., 2016d, p. 9) and repeats the components of the Commission's rationale for this determination. These components and our response are as follows:

1. There is a lack of consensus on the appropriate discount rate.

   Key-Log's response: The debate of what discount rate to use for the evaluation of future effects of public projects and decisions is longstanding, and is not limited to questions about natural gas infrastructure. While it is correct to say that there is not a consensus on what particular discount rate to use, it is spurious in the extreme to suggest that the lack of consensus means that one should not consider the costs to which the (or any) discount rate is applied. The correct way to deal with this is to consider a range of different discount rates and to consider the range of estimates of impact (costs) under different discount rates.

2. The social cost of carbon does not measure actual incremental impacts of a project; and "there are no established criteria for identifying the monetized values that are to be considered significant for NEPA purposes" (Millennium Pipeline Company, L.L.C., 2016d, pp. 9-10).

   Key-Log's response: The social cost of carbon, including upstream environmental impacts of natural gas production, is an important component of the external costs of any pipeline project. The social cost of carbon, is an economically essential component of the adverse impacts that, per FERC's certification policy, must be considered.

   Norman Bay, former Commissioner, in *Order Granting Abandonment and Issuing Certificates* (2017), stated that "the Commission has never conducted a comprehensive study of the environmental consequences of increased production from that region [the Marcellus and Utica]...Even if not required by NEPA, in light of the heightened public interest and in the interests of good government, I believe the Commission should analyze the environmental effects of increased regional gas production from the Marcellus gas production and Utica" (Millennium Pipeline Company, L.L.C., 2016d, pp. 4-5).

Millennium Assertion 6: "DRN Mischaracterizes the ESU Project's Health Impacts" (Millennium Pipeline Company, L.L.C., 2016d, p. 10).

Millennium states, "DRN incorrectly applies the results of a study conducted on residents living in the vicinity of unconventional oil and gas production sites to population estimates of Sullivan and Delaware Counties" (Millennium Pipeline Company, L.L.C., 2016d, p. 10).

First, the premise of this criticism is incorrect. The studies in question were of people living near compressor stations, not oil and gas production sites. Second, we applied the rates of symptoms from those studies to a subset of the population of Sullivan and Delaware Counties, namely those persons living in Census Blocks within two miles of either the Hancock Compressor Station or the proposed Highland Station.

That said, the question of health effects has not yet been answered in a way that would allow for definitive estimates of the full range of possible health care costs that may ensue if the ESU project is approved. Millennium LLC released a report titled *Supplemental Information-Human Health Risk Assessment Report* (2017b) that uses modeling to evaluate the potential human health risks of possible exposure to air emissions during operation of the proposed compression stations. Results of the risk assessment show there are risks of cancer and other (unspecified "non-cancer") health effects. Millennium discounts the health findings by asserting that the rate of cancer and other health effects are at levels that are below EPA's acceptable risk range. For example, the adult cancer risk from exposure to potential emissions from the Hancock Compressor Station would be 6 in 100,000,000 and the EPA's acceptable risk range is 1 in 10,000 to 1 in 1,000,000 (Millennium Pipeline Company, L.L.C., 2017b, p. 14).

However, and as noted in the body of this report, statistical and anecdotal evidence from areas around operating compressor stations suggest that actual (as opposed to modeled) air emissions exceed allowable levels and that people living closer to compressor stations experience more health symptoms like severe headaches, sleep loss, and others, than people living farther away (Macey et al., 2014; Steinzor, Subra, & Sumi, 2013; Subra, 2015). It is important to note that further epidemiological research would be required to determine the extent to which such effects are the result of exposure to emissions from compressor stations, as opposed to exposure to other factors, including other environmental hazards. Until results of such research is available, however, it is prudent to consider that health effects reported in the vicinity of other natural gas compressor stations could occur in the population living near proposed new and expanded facilities.

Concentric Energy Advisors

Supplemental Answer of Millennium Pipeline Company, L.L.C. to Comments on the Eastern System Upgrade Project (Millennium Pipeline Company, L.L.C., 2017a) includes material prepared by Concentric Energy Advisors, Inc. They raise two key contentions.

Concentric Assertion 1: That "Key-Log-Log's Claim the Economic Impacts of the ESU project are Overstated is Incorrect" (Millennium Pipeline Company, L.L.C., 2017a).

1. Concentric claims that "using IMPLAN to estimate-long-term economic impacts of large projects is a widely-accepted, commonly-used approach" (Millennium Pipeline Company, L.L.C., 2017a, p. 3).

   Key-Log Economics does not disagree with the fact that IMPLAN is a widely used input-output model, but we would not agree that this use constitutes a defense of the quality of the model in general, of the applicability of the model to any particular research question, or of the value of any particular results obtained the model as a guide for public policy. To repeat, IMPLAN models a static economy, which assumes that there will be no changes in relative prices, no factor mobility, no change in products or consumers' tastes and preferences, no regional migration, no changes in technology, and no changes in state and local tax laws – to name a few – during the years of the project operation considered. However, economies are constantly in flux, affected by policies, decisions made in businesses and households, and environmental factors.

   Concentric should explicitly acknowledge the limitations associated with the use of 2014 IMPLAN data for future, multi-year impacts and the interpretation of model results. This includes stating what information would be needed to improve model predictions. For example, in order to project what a given economy will look like even five years from now, one would need to predict future demand for goods and services, the impact of new technologies on the production of goods and services, and the local availability of resources to meet that demand (Day, 2015).

2. Concentric asserts Key-Log's claim of overstated economic benefits during construction is incorrect (Millennium Pipeline Company, L.L.C., 2017a, p. 3).

   Key-Log Economics acknowledges and thanks Concentric for the clarification that they did not assume that the total cost of construction was injected into the economy four separate times over a four-year period. However, Concentric's report only indicates that construction expenses would be approximately $275 million—it does not provide a year-by-year breakdown—and it is therefore not possible for the reader to know how that figure was used within IMPLAN to estimate total constructions impacts. It would have been helpful if Concentric had included a table in their report showing annual construction activities and costs, especially as they vary from year to year (Concentric Energy Advisors, 2016). Specifically, how were the construction costs presented in Millennium's *Abbreviated Application for a Certificate of Public Convenience and Necessity* (comprising $41 million for Measuring and Regulation: $41 million, $114 million for Compressor, and $120 million for Pipeline) (Millennium Pipeline Company, L.L.C., 2016c, Exhibit K) allocated each year during the construction period?

   We remain concerned that the construction period assumed by Concentric is inconsistent with the construction period stated in documents previously filed with

FERC (which are also conflicting). In *Resource Report 1: General Project Description (2016a),* Millennium states the construction period is one year (Millennium Pipeline Company, L.L.C., 2016a). In their *Abbreviated Application for a Certificate of Public Convenience and Necessity*, Millennium, "affirms that it had begun to incur capital expenditures for the Project" in December 2015 with a targeted in-service date of September 2018 (Millennium Pipeline Company, L.L.C., 2016c, p. 11), a period of at least two years. If the activities Concentric is including in "construction" differ from those that are described as "construction" in Resource Reports, such a distinction should be clarified to allay confusion to readers of Project documents.

3. Concentric Energy Advisors, Inc., state "Key-Log's claim that Concentric's economic benefits are overestimated by using the entire state of New York as the study region is without basis" (Millennium Pipeline Company, L.L.C., 2017, p. 6).

   Concentric states that their study "analyzed the State of New York as the study area because the purpose of the study was to calculate and demonstrate the Project benefits to the State of New York" (Millennium L.L.C., 2017, p. 3). But this circular logic does not provide any reason the state is the correct level for analysis. While state-level impacts may be of interest to some, Concentric has not followed IMPLAN guidance regarding study region definition. IMPLAN documentation states, "The Study Area defines the boundaries of what will be included in the calculation of *local* impacts" (Day, 2015, p. 9; emphasis added). This geographic zone, "should include the region where the original impact occurs, the region of large suppliers whose impact should be included, and the location where most of the industry's workers live and spend their earnings" (Day, 2015, p. 8). Based on this guidance from IMPLAN itself and on information provided in ESU project documents indicate that Delaware, Sullivan, and Rockland Counties would comprise the correct study region. The following statements related to the ESU support this four county study region:

   - "...The economic benefits generated from the construction of the ESU project are largely expected to be realized in the areas where the infrastructure upgrades to the Millennium pipeline system are being undertaken (i.e., Delaware, Sullivan, Orange, and Rockland Counties), as Millennium intends to rely on local contractors, union labor, and construction materials wherever possible" (Concentric Energy Advisors, March 2016, p. 19).
   - "[T]he socioeconomic effect area for the Project focuses on Orange, Delaware, Sullivan and Rockland Counties…" (Millennium Pipeline Company, L.L.C., 2016b, p. 5-2)
   - These counties are identified as "Project Counties" and "Project Area" in *Resource Report 1: General Project Description* and *Resource Report 5: Socioeconomics* (Millennium Pipeline Company, L.L.C., 2016a and 2016b).
   - Workforce estimates presented in Table 5-A8, "Summary of Estimated Construction Workforce and Payroll for the Project" of *Resource Report 5:*

Socioeconomics for Orange, Sullivan, Delaware and Rockland Counties are described as hired "locally" (Millennium Pipeline Company, L.L.C., 2016b, p. 33).

- *Resource Report 5: Socioeconomics* states, "Approximately 60 percent of the construction workforce for the Huguenot Loop and 40 percent of the construction workforce for the aboveground facilities will be from the impacted and nearby surrounding areas" (Millennium Pipeline Company, L.L.C., 2016b, p. 5-6).

Concentric Assertion 2: That "Key-Log's Claim the Energy Market Savings may be Overstated is Incorrect" (Millennium Pipeline Company, L.L.C., 2017a, p. 7).

1. Concentric Energy Advisors, Inc., state "the effect of Millennium's alleged guaranteed rate of return on its investment in the ESU project is irrelevant to benefits to New York" (Millennium Pipeline Company, L.L.C., 2017, p. 7).

   Key-Log Economics expressed concern that overestimates in the estimated benefit to New York electric utility customers from increased natural gas supplies resulted from Concentric's failure to consider costs of the pipeline construction, including a rate of return. Millennium responded that New York ratepayers will not bear the costs of the Project because none of the ESU Project shippers directly provide service to New York customers (Millennium Pipeline Company, L.L.C., 2017a, p. 4). By estimating the benefits to New York consumers as a result of increased natural gas supply without considering the corresponding costs that will be borne by people other than New York consumers, Millennium has provided incomplete and unbalanced information regarding the net benefits to ALL consumers from the ESU Project.

   With regard to the rate of return, Key-Log Economics acknowledges and thanks Concentric for clarifying that, "since the ESU project shippers elected negotiated rates for transportation on the ESU project, they will not be subject to Millennium's cost-based recourse rates" (Concentric Energy Advisors, 2016, p. 7). While we understand, "there are no guarantees that Millennium, or any other natural gas pipeline, will fully recover their costs and earn a specified rate of return" (p. 8), Millennium expects its pre-tax 11.51% rate of return included in their *Abbreviated Application for a Certificate of Public Convenience and Necessity* (Millennium Pipeline L.L.C., 2016c, Exhibit N) to be realized since revenues from negotiated rates are estimated to exceed the cost of service: "As shown on Schedule 1, Line 9, the negotiated contract rates agreed to by Millennium and the Project Shippers for service on the Eastern System Upgrade Project, together with the anticipated revenues from the sale of the currently unsubscribed capacity, will generate reservation rate revenues that are greater than the Eastern System Upgrade Project cost of service by $51,524 in year 1, and sufficiently cover the cost of the project over the 15-year primary term of the contract."

2. Projected increases in renewable generation are not likely to significantly affect the energy market savings from the ESU project.

Concentric (2016, p. 12) states, "It is expected that the addition of the capacity associated with the ESU Project will result in lower natural gas prices than otherwise would be experienced…") based on their use of GPCM, a partial equilibrium model of the North American natural gas market which assumes perfect competition. There are a number of other factors influencing the natural gas market and prices however, and these should be acknowledged by Concentric in a discussion of the limitations of the modeling approach and results. These include additional sources of natural gas, such as new supplies from other natural gas pipeline expansions (U.S. Energy Information Administration, 2016); NYISO's status as a net importer of electricity from other regional transmission organizations (Hibbard, Schatzki, Aubuchon, & Wu, 2015); and factors that affect demand, such as weather, state demand management programs and federal/state incentives. Furthermore it remains likely that generation of electricity from nonconventional and renewable energy sources will increasingly affect energy prices in the future - especially given New York's commitment to achieve 50% of its electricity from renewable sources by 2030 (Morris, 2016; Kennedy, 2016). Furthermore, a recent article in *The Economist* describing the increasing growth rate of wind and solar energy notes that the more renewable energy is deployed, the more it lowers the price of power from any source (The Economist, 2017).

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 6, Catskill Citizens, Press Release, Proximity of Compressor Station Devalues Homes by as Much as 50%, July 7, 2015.

For Immediate Release: July 7, 2015

PROXIMITY OF COMPRESSOR STATION DEVALUES HOMES BY AS MUCH AS 50%

Fremont Center, NY - Homeowners living near the Millennium Pipeline Company's 15,000 horsepower compressor station on Hungry Hill Road in Hancock, New York have seen the value of their homes decline by as much as 50 percent since the industrial facility was constructed in the midst of what used to be a quiet, rural community.

In May 2014 several Hungry Hill residents sought real estate tax relief citing the adverse impact of the compressor station on their property values. The Town of Hancock, denied the tax grievances, but Catskill Citizens for Safe Energy subsequently offered to fund homeowner appeals. On August 25, 2014, small claims hearings were held in the Hancock Town Hall. Two homeowners, a certified Real Estate Appraiser, and a representative of Catskill Citizens testified that the compressor station was responsible for heavy truck traffic, noxious odors, persistent low-level vibrations, and air contamination. The witnesses also asserted that the facility presented a safety threat and recounted how a Millennium employee suddenly knocked on the door of a house late one evening and urged the family to quickly evacuate their home. Finally, it was alleged that blasting during the construction of the compressor station had cracked the foundation of one house, which in turn led to an unsafe spike of radon levels. (Pre and post-construction radon tests conducted by Professional Home Inspection Service of Binghamton, New York showed that radon levels in the home jumped from 3 pCi/L to 6.1 pCi/L, which is above the EPA recommended action guideline of 4.0 pCiL.)

In light of the evidence proffered, the Town of Hancock tax assessors agreed to decrease the assessed valuation and real estate taxes on two homes by 25 percent. The assessed valuation and taxes on a third home, the one that had been physically damaged, were cut by 50 percent. Hearing Officer John Creech, who presided over the settlement, was familiar with the compressor station and remarked, "I wouldn't want to live next to it." After the tax assessors agreed to the 50 percent tax cut he told the owners, "You have a good lawsuit here."

For further information contact: info@catskillcitizens.org or call (845) 468-7063.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 7, Key-Log Economics, LLC, FERC's Approval Based on Incomplete Picture of Economic Impacts, March 2017.

Atlantic Sunrise Project:

FERC's Approval Based on an Incomplete Picture of Economic Impacts

March 2017

Prepared for:

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EXECUTIVE SUMMARY

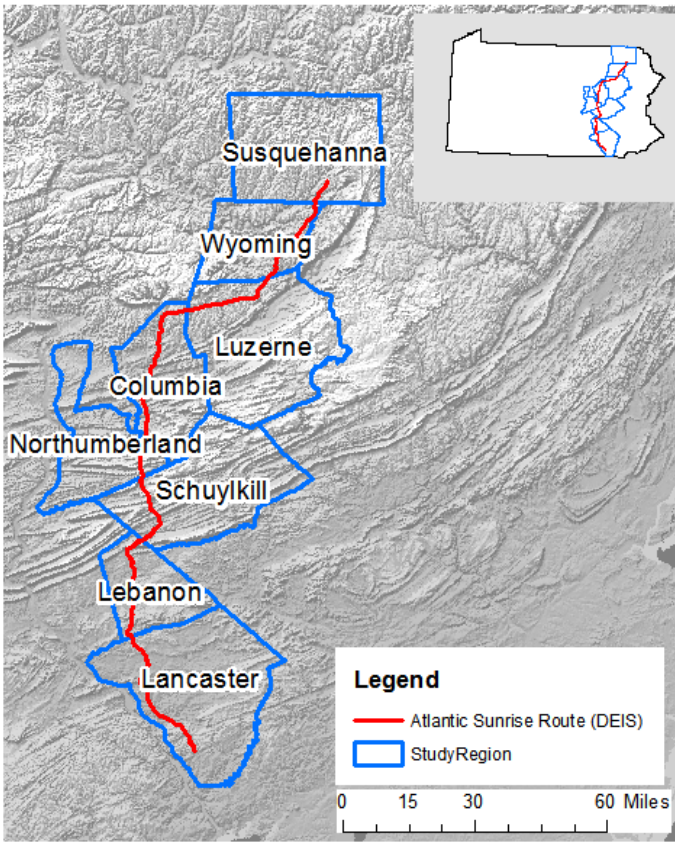

Figure 1. Geographic scope of interest for the Atlantic Sunrise Project. The Central Penn Line was adapted from the Shalefield Organizing Committee (2015); Study region (counties) and hill shade from USGS reprinted from the U.S. Department of Interior & U.S. Geological Survey (2015).

The Atlantic Sunrise Pipeline Project ("the project"), includes the installment of new 30- and 42- inch diameter high-pressure natural gas pipeline through 10 counties in Pennsylvania which would transport 1.7 million dekatherms/Mcf per day of natural gas from the Marcellus Shale region to Transcontinental Gas Pipeline Company, LLC's ("Transco LLC") existing markets. Transco LLC is an indirect subsidiary of Williams Partners L.P (Transcontinental Gas Pipe Line Company, LLC, 2015a).

The Federal Energy Regulatory Commission ("FERC") is the federal agency responsible for reviewing Transco LLC's proposal and either approving or rejecting the project.[1] 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 and 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.

Transco 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 project would have "minor to moderate positive impacts on socioeconomic characteristics and economies within the region of influence" (Federal Energy Regulatory Commission, 2016, p. 4-189). While even these minor benefits may be overstated (See section, "The Economic Benefits Associated with the Atlantic Sunrise Project are Overstated"), the major problem over the public consideration of the project is that there are also important costs that, to date, Transco LLC and FERC have discounted or ignored. The information provided by Transco LLC and by FERC in the Final

[1] On February 3rd, 2017, FERC granted Transco LLC the requested certificate authorizations (Federal Energy Regulatory Commission, 2017).

Environmental Impact Statement falls severely short of systematically considering the potential negative economic effects, or more simply, the economic costs of the project.

Appalachian Mountain Advocates and The Sierra Club commissioned this report to fill that information gap and provide research into some of the key economic and environmental costs that will certainly occur with the approval of the project. In this report, we provide quantitative estimates of several types of costs and consider other important costs FERC ignored in granting the certificate.

The construction, operation, and presence of the pipeline would 1) Diminish ecosystem service value, 2) Create economic damages associated with increases in carbon dioxide emissions (the social cost of carbon) (U.S. EPA, Climate Change Division, 2016), 3) Contribute to health maladies, and 4) Potentially impose public health costs and property value impacts (See "At a Glance," page iv for details.). The temporary construction right-of-way, 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 $6.2 and $22.7 million during construction and an annual loss of between $2.9 and $11.4 million during operation. Air pollution from the compressor stations slated for Columbia and Wyoming counties could potentially contribute to 7,530 people experiencing health impacts such as severe headaches, respiratory problems, vision impairment, and more.

The estimated one-time costs for the study region, comprised of diminished ecosystem services lost during the construction period, range from $6.2 to $22.7 million. Annual costs, costs that would begin following the construction period and recur each year for as long as the Atlantic Sunrise right-of-way ("ROW") exists, total between $2.9 and $11.4 million for lower ecosystem service productivity in the pipeline ROW, new permanent roads, and permanent acreage associated with the compressor stations. 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 $457.0 to $952.0 million per year between 2019 and 2048. With a 2.5% discount rate, the annual social cost of carbon ranges from $2.3 to $3.5 billion during the same time period.

Putting the streams of annual costs into present value terms[2] and adding the one-time costs, the total estimated economic cost of the project for our 10 county study region in Pennsylvania ranges between $21.3 and $91.6 billion. In contrast, 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 Atlantic Sunrise Project. One reason is simply that categories of impacts exist that are beyond the

[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 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 ecosystem services.

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. Also, due to data limitations, we did not estimate the potential property value impacts along the ROW and within the Evacuation Zone of the pipeline.

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 project.

Finally, while this report covers some of the costs that *will* occur if the project 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 temporary construction right-of-way and the social cost of carbon—will occur with or without any discrete or extreme events like landslides or explosions ever happening. These impacts and their monetary equivalents are simply part of what will happen in Pennsylvania with the approval of the Atlantic Sunrise.

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

At a Glance:

The Atlantic Sunrise Project in Pennsylvania

Columbia, Lancaster, Lebanon, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wyoming Counties in PA

- **Miles of pipeline[a]:** 183
- **Impacted acres (area converted temporarily or permanently from its existing use or cover based)[a]:**
  - In the permanent right-of-way (ROW): 1,114
  - In the construction zone (the temporary construction right-of-way, new temporary roads, and workspace associated with the compressor stations): 2,232
  - In new permanent access roads and area occupied by the compressor stations: 85.1
  - The most heavily affected land cover types: forest (468.5 acres) and cropland (299.1 acres) (ROW only)
- **Residents and housing units in the evacuation zone:** 45,032 people, 19,200 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): $6.2 to $22.7 million
  - In the ROW and in other permanent infrastructure (annual): $2.9 to $11.4 million
- **The social cost of carbon:**
  - The project would contribute to an equivalent of 32.9 million metric tons of carbon dioxide a year. The social cost of carbon increases with the year in which it is emitted because carbon emitted in the future, when mitigation and adaptation options will be more limited, will be more damaging than carbon emitted today. Using a 5% discount rate, the social cost of carbon ranges from $457.0 in 2018 to $952.0 million in 2048. Using a 2.5% discount rate, the social cost of carbon ranges between $2.3 and $3.5 billion per year.
- **Public health**
  - Air pollution from the operation of the compressor stations could potentially cause 7,530 people to experience adverse health effects, such as respiratory illnesses, sinus problems, vision impairment, and severe headaches.
- **Total estimated costs:**
  - One-time costs (ecosystem service lost during construction) would total between $6.2 and $22.7 million
  - Annual costs (costs that recur year after year) would range from $2.9 to $11.4 million in diminished ecosystem service productivity, PLUS the social cost of carbon, which ranges between $457.0 million and $3.5 billion per year.
  - One-time costs plus the discounted value of all future annual costs: $21.3 to $91.6 billion

Note:

a. These figures differ somewhat from those reported in the Final Environmental Impact Statement. At the time of this writing, the most recent digital version of the proposed route is from the DEIS, and we used that data for the Central Penn Line. The FEIS concludes that the Central Penn line will increase to 186 miles, so the impacts on ecosystem services would be somewhat greater than our estimates reported here. We used data from Resource Report 1 to approximate the extent of land use change associated with the compressor station and associated workspaces.

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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 temporary construction right-of-way, new temporary roads, and the workspace associated with the compressor stations

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 Atlantic Sunrise Project (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

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

SCC: Social Cost of Carbon

The Project: The portion of the Atlantic Sunrise Project that generally refers to the temporary construction right-of-way and permanent easement for the Central Penn Line North and the Central Penn Line South and the associated new compressor stations

Transco LLC: Transcontinental Gas Pipe Line Company, LLC. An indirect subsidiary of Williams Partners L.P.

ABOUT THE AUTHORS

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Key-Log Economics remains solely responsible for the content of this report, the underlying research methods, and the conclusions drawn. We have 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 experienced if the Atlantic Sunrise Project is constructed and operated

BACKGROUND

The Atlantic Sunrise Project ("the project") proposed by Transcontinental Gas Pipe Line Company, LLC ("Transco LLC") would include 186 miles[4] of new 30- and 42- inch diameter greenfield natural gas pipeline, 11 miles of new 30- and 42- pipeline looping in Pennsylvania, and 2.5 miles of 30-inch diameter replacements in Virginia (Federal Energy Regulatory Commission, 2016). The project would also include two new compressor stations in Pennsylvania ("Compressor 605" and "Compressor 610"), 30,000 horsepower ("hp") and 40,000 hp, respectively, adjustments to three existing compressor stations in Pennsylvania and Maryland, new meter station and regulator stations, and modifications to existing above ground facilities (Federal Energy Regulatory Commission, 2016). In total, the project is estimated to transport an incremental 1.7 million dekatherms per day (MMDth/d) of natural gas from the Marcellus Shale in northern Pennsylvania to Transco's existing market areas (Federal Energy Regulatory Commission, 2016).

For this report, "The Project" refers to those portions of the entire Atlantic Sunrise Project that entail (a) the addition of new pipeline or an increase in the amount of land consumed by pipeline right-of-way, i.e., the 186 mile Central Penn Line North and South ("CPL") that would traverse Columbia, Lancaster, Lebanon, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wyoming counties in Pennsylvania, and (b) construction of the new compressor stations 605 and 610 (located in Clinton Township, Wyoming County, PA, and Orange Township, Columbia County, respectively). In addition to restricting our analysis to the portion of the project in Pennsylvania, we did not analyze the other components of the project because the changes would occur in areas already modified from their previous natural land cover and/or would not represent a major change from the status quo in terms of land consumption, air, noise or other direct impacts. We are not, in other words, rolling back the clock to estimate the external costs of the existing Transco pipeline facilities in the study area: we are instead focused only on the new or incremental costs that the upgrade project would impose.

We are, moreover, focused on those costs that will occur due to an uneventful construction, normal operation, and ongoing presence of the project. Additional costs, the estimation of which is beyond the scope of this study, would occur in the event of spills, mudslides, vehicle accidents or other events during construction. Still more costs would be added if leaks and explosions during operation cause property damage, human illness, and death. Public concern regarding such effects are not unfounded. Pipeline leaks and explosions, when they occur, cause substantial and expensive physical damage (Table 1). Such accidents are also a larger problem for the newest pipelines. The Pipeline Safety Trust (2015), found that there are more incidents per mile of pipe for gas transmission pipelines installed after 2010 than for those installed at any time in the past 100 years. The new pipelines are also larger and operated at higher pressure. Due to life safety concerns, an incident on a pipeline like the CPL would require evacuation of a wide swath of countryside and the disruption of potentially tens of thousands of lives, farms and other businesses. While we do not have sufficient data to include these probabilistic costs in

[4] As noted in "At-a-Glance," the Final Environmental Impact Statement covers a Central Penn line 186 miles in length. Due to data limitations, we have analyzed the 183 miles included in digital maps based on the Draft Environmental Impact Statement.

the current study, we do raise them to reinforce the fact that the costs we have included are but a subset of what will be the eventual and total costs of the Atlantic Sunrise Project.

Table 1.
Pipeline Incidents, Impacts, and Costs, 1997 to 2016. Includes gas distribution, gas gathering, gas transmission, hazardous liquid, and LNG lines.

Place	Incidents	Fatalities	Injuries	Total Cost
U.S.	11,460	324	1,331	$7.0 Billion
Pennsylvania	299	20	72	$137.1 Million

Source: Pipeline and Hazardous Materials (2017), *Pipeline Incident 20 Year Trend.*

There are, however, effects of the project that will occur with certainty and that can now be estimated with some confidence. For example, construction of the pipeline and related facilities will result in at least temporary land use change leading to reductions in the value of ecosystem services produced from those disturbed areas. Similarly, for land in the ROW and new permanent infrastructure, the productivity of the area in its post-construction land use, such as shrub/scrub, may be lower than it had been pre-construction, as, for example, a forest. Lost ecosystem service productivity can mean less aesthetic and recreational value, higher water treatment costs for households and municipalities, and higher property losses due to flooding or other effects of extreme weather events.

In addition, a pipeline designed to carry natural gas will inexorably contribute to climate change as gas is vented at compressor stations, leaks from other parts of the system, or is combusted for its end use. (We include estimates of the third of these effects on climate change in this study.)

Finally, and while time and data resources do not allow for numeric estimation in this report,[5] it is possible to evaluate the reduction in property value the project would cause as well as the ongoing loss of property tax revenue for local communities.

To date, these negative effects and estimates of their attendant economic costs have not received adequate attention in the otherwise vigorous public debate surrounding the Atlantic Sunrise Project. This report is both an attempt to understand the nature and potential magnitude of the economic costs of the project in the ten-county region, as well as to highlight important issues that the Federal Energy Regulatory Commission ("FERC") failed to consider before improperly issuing the certificate for the project.

Policy Context

On February 3rd, the Federal Energy Regulatory Commission issued a ruling granting a certificate of public convenience and necessity (Federal Energy Regulatory Commission, 2017). That approval reflects FERC's judgment that the pipeline project would meet a public purpose and need. Because the approval is a federal action, FERC needed to comply with the procedural and analytical requirements of the

[5] The omission of estimates of property value effect from this report is solely a matter of the time required to assemble and process GIS and associated land value data for the affected parcels. We do discuss here the contrary and unsubstantiated claim that natural gas and other energy infrastructure does not affect property value.

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), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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).

Much of what FERC heard from citizens (Deppen, 2016) echoed and expanded upon the list of potential environmental effects listed in its Notice of Intent to prepare an EIS (Federal Energy Regulatory Commission, 2014). In the Notice of Intent, FERC anticipated issues of concern regarding geology, soils, water resources and wetlands, vegetation and wildlife, fisheries and aquatic resources, threatened, endangered, and other special-status species, land use, recreation, special interest areas, visual resources, socioeconomics, cultural resources, air quality, noise, reliability and safety, and cumulative environmental impacts (Federal Energy Regulatory Commission, 2014). Each of these can translate into economic costs external to Transco LLC that would be borne by individuals, businesses, and communities throughout the landscape the project would traverse.

Market Failure: External Costs and the Need for Countervailing Public Action

All market transactions involve two sets of costs and benefits. The first set includes private costs, such as the costs of constructing and operating a pipeline, and private benefits, such as the value to consumers of natural gas delivered through the pipeline. Under the certain highly restrictive preconditions that currently exist, it is possible to say that the price of gas, the amount consumed, and therefore the number of pipelines built and operated functions as the "right" number. "Right" in an economic context translates to "efficient," as in there are no other combinations of gas use/pipeline capacity that could produce greater net societal benefits. However, the reality is that these pre-conditions do not hold and the market does not give us the right answer to the question of how many pipelines (and how much gas use) should exist. Economists call these situations "market failures." Market failures justify extra-market processes to get us to solutions that are more like the theoretical ideal.

The markets for natural gas and natural gas transmission pipelines fail in many ways. The most important, from the perspective of both NEPA and FERC's pipeline certification policy (see below), is the presence of "externalities." Externalities are costs generated by market transactions not borne by the parties to those transactions. In this case, externalities include the costs of building and operating the pipeline imposed on people other than the pipeline company and its customers (natural gas shippers and wholesale purchasers, including local distribution companies).

External costs include effects mediated through market transactions (a good example is the reduction in property value when people know a pipeline is nearby) as well as effects on human well-being that exceed the number of dollars that actually change hands. This "nonmarket value" includes the total

value to people (reflected in their full willingness to pay for a good) over and above what they actually pay for a market good (such as a safe place to live, or clean water to drink). Nonmarket benefits and costs also include changes in human welfare from environmental effects for which there is no out of pocket payment at all. Enjoying the aesthetic quality of a view may cost nothing to experience, but the observer still values it. Whether or not there is a market component to the resulting change in value, damage to environmental goods and services caused by the construction and operation of natural gas transmission infrastructure represents a reduction in human welfare and, therefore, an economic cost.

Because these reductions are external costs, neither the pipeline company nor its customers see or consider these costs when making internal decisions about how much pipeline capacity or natural gas they require. The result is too much pipeline capacity and too much gas delivered at too low a price. The pure economic problem is one of inefficiency: there is a waste of resources, including "critical natural capital" in the form of highly functioning ecosystems (Farley, 2012), that could have been more wisely invested or used to build and maintain other infrastructure, to provide other services, including ecosystem services like supplying clean water and recreational opportunities, that provide higher net benefits.

From an economic point of view, compliance with the NEPA is one way to ensure that costs not considered by the market are nevertheless considered in resource allocation decisions. The NEPA review adds, or should add, the necessary breadth to FERC's analysis of the economics costs of natural gas infrastructure. NEPA requires an evaluation of all relevant effects, but of particular interest here are the direct, indirect, and cumulative economic effects of changes in human welfare that might or might not be reflected in the market economy–i.e. the external costs.

Policy Failure: The Review and Certification of Natural Gas Transmission Projects Discounts External Costs and Inflates Societal Benefits

To help address the market failure inherent in the construction and operation of natural gas transmission pipelines, additional analyses and decision making processes are required. FERC's policy on the Certification of New Interstate Natural Gas Pipeline Facilities (88 FERC, para. 61,227) is one example of an attempt to ensure consideration of at least some external costs. The policy requires that 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, 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" (88 FERC, para. 61,227, pp. 18, 26). The Commission's policy contends that 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 at an individual, community, and broader population level.

The policy's confusion over what counts as an environmental effect (again, most of which will have economic effects) is further expressed by the following statement:

> Traditionally, the interests of the landowners and the surrounding community have been considered synonymous with the environmental impacts of a project; However, these interests can be distinct. Landowner property rights issues are different in character from other environmental issues considered under the National Environmental Policy Act of 1969 (88 FERC, para. 61,227, p. 24).

By the Commission's reasoning, environmental effects are a matter of the Commission's "traditions," not science, and environmental effects are deemed to be both synonymous with, and distinct from, interests of landowners and the surrounding community. This statement seems to contradict the statement one page earlier in the policy that "[there] are other interests [besides those of customers, competitors, and landowners and surrounding communities] that may need to be separately considered in a certificate proceeding, such as environmental interests (p. 23)." While it is true that separate/additional consideration of environmental "interests" must indeed be part of the Commission's review, the policy embodies such a muddle of contradictions on the question of what impacts to examine and why (tradition versus science), that it seems unlikely that any pipeline certification granted under the policy would be scientifically or economically sound.

FERC's own policies and track record, including an over-reliance on the applicants' own estimates of project benefits, make it extremely unlikely that the project certification process would meet NEPA's requirement to consider all project costs and benefits, let alone produce a decision that could be construed as generating or supporting net economic benefits.[6] 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" (88 FERC, para. 61,227, p. 26). The applicant therefore has an incentive to be generous in counting the benefits and parsimonious in counting the costs of its proposal (See "The Economic Benefits Associated with the Atlantic Sunrise Project are Overstated")

Given the weaknesses of the policy, and as evidenced by the track record, FERC's "economic test" does not provide a robust evaluation of the public merits of natural gas transmission projects. It is a "test" in which difficult questions (such as about external costs borne by all stakeholders) are not asked, and where those taking the test (the applicants) provide the answer key. It is therefore not surprising that

[6] It is important to note that NEPA does not require that federal actions 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.

FERC's environmental reviews typically have not provided estimates of the magnitude of the full external costs associated with natural gas transmission pipelines. Also not surprising, pipeline applicants typically employ methods, assumptions, and a selective review of effects that result in a rosy and grossly distorted picture of the net benefits of their projects.[7]

Current Economic Conditions in the Study Region

Our geographic focus is the ten-county region the CPL portion of the project is proposed to cross. This study region encompasses Columbia, Lancaster, Lebanon, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wyoming counties in Pennsylvania. This 5,238-square-mile region supports diverse land uses, important waterways such as the Susquehanna, Tunkhannock, and Conestoga Rivers and other pristine creeks, the habitat of several federally listed endangered species (Federal Energy Regulatory Commission, 2016), thriving cities and townships, wetlands, and parks. These natural, cultural, and economic assets are among the reasons more than 1.4 million people call this ten-county region home and an even larger number visit each year for hiking, fishing, festivals, canoeing, kayaking, horseback riding, weddings, and other events.

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), higher agricultural land value relative to the average for Pennsylvania. Home value and investment income per capita are on par with statewide averages, while the region lags the state average of indices of innovation, entrepreneurial activity, and the concentration of creative workers.[8]

More traditional measures of economic performance suggest the counties are generally strong and resilient, though there are some differences among the Pennsylvania counties.

From 2000 through 2015, for example:[9]

- Population in the study region grew by 5.9%, compared to a -2.5% increase for non-metro Pennsylvania overall.
- Employment in the study region grew by 10.3%, compared to a 0.3% increase for non-metro Pennsylvania overall.
- Personal income in the study region grew by 22.0%, compared to an 18.7% increase in personal income for non-metro Pennsylvania overall.
- On average, earnings per job in the study region are higher, by about $3,900/year, than the average for non-metro Pennsylvania overall.

[7] See, for example, FERC's Draft and/or Final Environmental Impact Statements the Constitution Pipeline (Docket no. CP13-499), Mountain Valley Pipeline (Docket no. CP16-10), Atlantic Coast Pipeline (Docket no. CP15-554), and PennEast Pipeline (Docket no. CP-15-558).

[8] 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.

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

- As it happens, per capita income is also higher than the state average, by the same $3,900/year.[10]
- The unemployment rate in the study region is 5.0%, compared to 5.8% for non-metro Pennsylvania overall.

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 16.8% to 17.2%,[11]
- Proprietors' employment is up by 44.0%, and
- Non-labor income (primarily investment returns and age-related transfer payments like Social Security) is up by 34.0%.

In a similar time period, from 1998 to 2014, travel and tourism employment in the region grew by 9,211 jobs (U.S. Department of Commerce, 2016).[12]

It is in this context the potential economic impacts of the Atlantic Sunrise Project must be weighed and the apprehension of the region's residents understood. Many believe the construction and operation of the project 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 project 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.

[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.
[11] From 2000-2014 rather than 2000-2015.
[12] Travel and tourism consists of the retail trade, passenger transportation, arts, entertainment and recreation, and accommodation and food sectors.

STUDY OBJECTIVES

Given the policy setting and what may be profound effects of the project on the people and communities of Pennsylvania, we have undertaken this study to provide information of three types:

1. An independent and rigorous review and critique of the positive economic impacts that Transcontinental Gas Pipe Line Company, LLC has promoted as potential results of the project.
2. An example of the scope and type of analyses that FERC should have undertaken as part of its assessment of the environmental (including economic) effects of the project.
3. An estimate of the potential magnitude of economic effects in this region where the project's environmental effects will be felt.

The estimates presented in this report, however, represent less than the total of all potential costs that would attend the construction, operation, and presence of the project. 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.
- Property value impacts along the ROW and in the evacuation zone (See section titled "Other Impacts Not Quantified: Claims That Pipelines Do Not Harm Property Value are Invalid").

Our overall estimates, therefore, should be understood to be conservative, lower-bound estimates of the true total cost of the project 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 project, people who have not visited the region or spent vacation time and dollars in the region, are better off knowing that the backcountry, pastoral and other settings 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 landscape that remains free of the project.

THE ECONOMIC BENEFITS ASSOCIATED WITH THE ATLANTIC SUNRISE PROJECT ARE OVERSTATED

The Atlantic Sunrise Project is said to be necessary because it would, "provide Transco LLC's customers and the markets they serve with greatly enhanced access to Marcellus Shale supplies" (Transcontinental Gas Pipe Line Company, LLC, 2015a, p 1-2). It is also promoted as having the potential to create savings for consumers served by Transco from Alabama to New Jersey and stimulating local economies during the construction and operations phases. Transco LLC, commissioned two economic impact studies that include estimates of how construction and operation of the pipeline might affect the economy of the 10-county study region and the state of Pennsylvania (Blumsack & Kleit, 2015; Kleit, Prete, Blumsack, Guo, & Yoo, 2015). In the first study, Blumsack and Kleit (2015) estimate that construction could have a total impact of $1.6 billion (gross output) in Pennsylvania, and that the long-term economic impacts associated with operation of the project could generate $1.0 million in value added. The second study, by Kleit, Prete, Blumsack, Guo, & Yoo (2015), estimates consumers served by Transco from Alabama to New Jersey could have enjoyed $2.6 billion in total benefits if the Atlantic Sunrise had been operating in a previous 30-month period.

Transco LLC promotes these estimated impacts as the sole economic effects of the project, but apart from their project-related expenditures there is no mention of what may be significant (and certainly non-zero) costs of the project. Most importantly, Transco has not presented estimates of likely external or societal costs that would result from the construction and operation of the project. By ignoring external/societal costs, Transco LLC has failed to provide FERC with the critical information necessary for the Commission to evaluate the balance of public benefits and costs of the proposed action.

Transco LLC's studies may overestimate the economic impacts of the Atlantic Sunrise Project in two areas (Blumsack & Kleit, 2015; Kleit, Prete, Blumsack, Guo, & Yoo, 2015; Transcontinental Gas Pipe Line Company, LLC, 2015b):

- Impacts associated with the ongoing operation of the project; and
- Impacts associated with consumer's spending of assumed savings elsewhere in local economies.

The overestimation of economic impacts during the operational phase of the project emanate from limitations inherent in the empirical model used to estimate those benefits, particularly its use to estimate future impacts. Long-term benefits may also have been overestimated due to overly optimistic assumptions about whether and to what extent the Atlantic coast states would continually use natural gas, especially with the majority of states requiring an increasing share of electricity generation from renewable sources over the next decades (U.S. Department of Energy, 2016).

Overestimate of Economic Impacts During Operation

The estimates of the additional jobs and income stimulated by operation of the project are inflated due to the choice of a short-term empirical model to estimate long-term impacts. The Blumsack & Kleit (2015) study uses input-output analysis, specifically, the IMPLAN modeling software and 2012 data, to generate estimates of annual economic impacts during the proposed project's operational phase. This

implies that the economic relationships in the study region will be the same well into the future as they were in 2012, which is unlikely.

Rooted in economic base theory, input-output models purport to translate an exogenous change in the economy—the "input," which in this case is spending on the operation of the pipeline, including employees' wages—into "output," which includes spending by the project's employees, by other firms, by their employees, and so on. Additional rounds of impact occur as the businesses where those households spend their wages (grocery stores, gas stations, physicians, etc.) pay suppliers and their own employees. With each round of spending, some money leaks out of the study region's economy in the form of spending on imported goods or wages paid to workers who reside outside the study region.

While intuitively satisfying, empirical input-output models like IMPLAN are built on a very restrictive set of assumptions about how each and every spending and/or hiring decision in the entire economy is made. Namely, the models assume that spending decisions are made the way they have always been made, and if wages or demand for a product goes up, the only way households and firms can respond is by doing more of what they did in the past to meet demand. They follow the same recipe, but just increase the amount of each ingredient. Households buy a larger quantity of the same mix of goods and services, and firms employ more labor, buy more raw materials, and burn more fuel (among other inputs) in exactly the same proportions as before the exogenous change occurred.

Firms in the real world, by contrast, innovate and adjust their manufacturing and other processes to take advantage of economies of scale, new technology, changes in relative prices, and new business processes. That innovation leads to cost minimization, and cost minimization means firms will do less indirect spending, and that means less induced spending stemming from changes in workers' wages. As Hoffmann and Fortmann (1996) found, this disconnect from real world behavior means that that input-output models produce overestimates of firm spending and "multiplier effects."

Due to restrictive assumptions, economic base models possess a dismal track record when it comes to predicting economic growth in the real world and in the long run. Again, the "long run" is more than a year into the future, when firms change technology, prices can adjust, and people change what they want to buy. In a review of 23 studies, Krikelas (1991) compared predictions of the economic base model against the actual experience of subject regions and found only 4 studies where the models correctly predicted longer run economic growth. Similarly, Robertson (2003) tested predictions from input-output models against actual experience in 15 communities in Southeast Alaska (a region in which many of the restrictive assumptions of economic base theory might actually apply). He found that initial economic stimulus does not "cause changes in economic activity serving local demand for the average community…The implications of these results [are that] secondary economic impacts [i.e. "multiplier effects"] cannot be taken as a foregone conclusion in policy analysis" (p. iii).

In the case of the Atlantic Sunrise Project, there are a small number of permanent jobs associated with the operational phase of the pipeline and associated infrastructure. The multiplier effect would be smaller than Transco LLC suggests, however, due to Blumsack & Kleit's (2015) misapplication of the input-output model to estimate long-term effects.

As Haynes et al. (1997) note:

> Where the economic base approach gets into trouble is when it is used inappropriately as a tool for planning or predicting impacts of greater than one year in duration; A snapshot of current conditions tells little about the form a region's future economy may take.

Because IMPLAN models a static economy, the Blumsack & Kleit (2015) study implicitly assumes there will be no changes in relative prices, no labor mobility, no change in products or consumers' tastes and preferences, no regional migration, and no changes in state and local tax laws–to name a few–during the years of the project operation considered. But economies are in flux, affected by policies, decisions made in businesses and households, and environmental factors.

Unfortunately, and as Blumsack & Kleit (2015) state, IMPLAN is still commonly used to forecast long-term impacts. By its estimates from the model, 29 total jobs[13] and $1.8 million in new income result from the operation of the project per year. These impacts include 15 direct jobs and spending necessary for operation of the pipeline itself and indirect and induced effects resulting from those direct effects. Regardless of the size of the estimate, to ascribe these indirect and induced jobs to the project assumes that the workers in those indirect and induced jobs would otherwise be idle. Such an assumption is not realistic: idle-workers in the real world typically retrain or relocate to take already open jobs, or they create new employment opportunities for themselves where they live. Those additional jobs, in other words, will most likely exist somewhere (in another sector in the study region or in another region) with or without the direct jobs from the project.

In short, we do not doubt that the operation of the project will spur some economic activity in the form of associated jobs and income. However, because the estimated level of activity presented by the applicant through the Blumsack & Kleit (2015) study is minimal and the effects overstated, we conclude that the employment and income effects are miniscule relative to the study regions' economies.

Energy Market Savings May Be Overestimated

Transco has also potentially overestimated energy cost savings due to the added gas transmission capacity. Kleit, Prete, Blumsack, Guo, & Yoo (2015) estimate that consumers served by Transco from Alabama to New Jersey could have enjoyed $2.6 billion in total benefits if the Atlantic Sunrise Project had been operating in a previous 30-month period (Kleit, Prete, Blumsack, Guo, & Yoo, 2015). The estimated impacts include energy cost savings realized by consumers, as well as induced effects that would result from consumers' spending their energy savings on the purchase of additional fuel. However, more than 60% of the estimated benefits would have accrued in one month (January 2014) due to the high level of gas demand associated with the polar vortex in that month. Benefit estimates excluding that weather anomaly were not provided. The authors do state however, that "during periods of relatively moderate natural gas demand…the impacts of Atlantic Sunrise on consumer surplus are relatively modest" (Kleith, Prete, Blumsack, Guo, & Yoo, 2015, p. 39).

[13] For comparison, employment in the two-county study region stood at 94,472 in 2015. Thus, even the inflated total employment impact is less than one-tenth of one percent (0.03%) (U.S. Census Bureau, 2017).

A further question is whether estimates of the impact of the project on energy prices takes into account the cumulative effect of additional natural gas supplies in the Marcellus region delivered by other planned pipelines. If the supply increases from the project and drives down electricity prices, supply from other pipelines could drive prices down farther. In that case, the savings attributable to the project would be lower than those modeled.

Kleit, Prete, Blumsack, Guo, & Yoo (2015) base consumer surplus estimates on a market model that assesses the impact of the project on flows, injections, withdrawals, and natural gas prices along the Transco mainline from Alabama to New Jersey. The model includes arbitrage conditions, demand and supply elasticities, and different equilibrium prices and flows at various points on the Transco system that could result from the project. It uses data from five days in different seasons between February, 2013 and May, 2014, but does not provide important information about the assumptions applied for the simulation. In particular, there are two factors that, if excluded from consideration, would tend to result in overestimates of the benefit to electric utility customers of increased natural gas supply. These are:

- The effect of Transco LLC's rate of return and costs of providing pipeline service, as regulated by FERC, on Transco's tariff rates and thus prices included in the model; and
- The effect of competition from other sources of electric power, especially renewables, which could be cheaper for utilities and/or consumers than power generated in gas-fired plants.

FERC not only approves pipelines, but also sets the rate, or tariff, that pipeline operators may charge for the service of transporting natural gas. The tariff is based on various factors and allows the operator "a reasonable return on its investment" (Federal Energy Regulatory Commission, 2017b). "Cost of service" is the primary method used to establish rates and requires the operator to submit cost and revenue data to support their requested tariff. Transco LLC's *Application for Certificate of Public Convenience and Necessity* filed for the Atlantic Sunrise Project includes a 15.34% pre-tax return in its cost estimate for the initial rate base, or $278.7 million annually (Federal Energy Regulatory Commission, 2015, Exhibit P). The total cost of service is estimated at $480.7 million and also includes lease payments, operations and maintenance, depreciation, and taxes (Federal Energy Regulatory Commission, 2015). It is not clear that all these costs—above the cost of the natural gas—are included in the prices modeled by Kleit, Prete, Blumsack, Guo, & Yoo (2015); therefore the consumer surplus estimates could be overstated.

The second concern regarding consumer benefits estimated by Kleit, Prete, Blumsack, Guo, & Yoo (2015) deals with competition in the electric power market, rather than in the gas market. The model is designed to estimate equilibrium (market clearing) prices of natural gas, not of electric power. Therefore, it does not appear to compute the derived demand for gas based on broader markets for electric power. If gas-fired electricity generation were to face increasing competition from other sources, particularly wind and solar, then derived demand for gas would fall, and at least some gas-related cost savings for electric utility customers would never materialize. In turn, the induced economic impacts from building the pipeline would be smaller than Kleit, Prete, Blumsack, Guo, & Yoo (2015) have estimated.

It is true that the Atlantic coast states currently rely heavily on natural gas for electricity generation. However, most of these states have implemented regulations requiring an increase in electricity from renewable sources over the next decades (U.S. Department of Energy, 2016). New York, for example,

must provide 50% of electricity from renewables by 2030, Delaware 25% by 2026; and Maryland 25% by 2020 (U.S. Department of Energy, 2016; U.S. Department of Energy, 2017b). The market itself is making it easier for the states to achieve their goals. Indeed, the levelized cost of electricity estimated by the U.S. Department of Energy shows that solar PV and onshore wind are competitive with gas-fired generation, and Bloomberg has found that onshore wind is "to be fully competitive against gas and coal in some parts of the world, while solar is closing the gap" (U.S. Energy Information Administration, 2016; Zindler, 2015). This is even more true when the cost of greenhouse gas emissions are counted.

It does not appear, however, that the model's (Kleit, Prete, Blumsack, Gou, & Yoo, 2015) standard demand curves reflect new region-specific policies and/or the continuing decline in the price of wind and solar photovoltaic generation relative to gas- and other fossil-fuel-based generation. With renewable power generation becoming cheaper, end users and public utilities may switch to wind or solar power rather than switch to more gas-fired power, as Kleit, Prete, Blumsack, Gou, & Yoo (2015) assume. In this scenario, there would be less energy savings due to lower gas prices (the energy savings would in fact come from the shift away from gas), and the economic impacts of the project would be smaller than the estimates put forward by Transco LLC. Kleit, Prete, Blumsack, Gou, & Yoo (2015) neither discuss nor address the Atlantic coastal states' energy plans or the changing opportunities and conditions and, therefore, its estimates of economic benefit are rooted in an incomplete picture of the energy market into which the excess gas transported by the project would go.

EXTERNAL COSTS: HOW AND WHERE ENVIRONMENTAL EFFECTS IMPINGE ON HUMAN WELL-BEING

However large or small the output, employment, and income impacts associated with the project might be, economic efficiency demands, and FERC's own policy requires, that the costs as well as any benefits of a proposed pipeline be considered before certifying a need for it. Unfortunately, the Commission and the applicant failed to seriously consider important economic costs that may result from the project. Combined with similar failures in evaluation of several other proposals to transport gas from the Marcellus Shale region, the Commission missed an opportunity to promote an economically efficient and environmentally suitable level and pattern of natural gas infrastructure development across the region. As partial remedy to this problem in the case of the Atlantic Sunrise, we offer a means of estimating two key costs currently ignored or discounted by FERC, and enumerate others that, with further study, could be incorporated into numerical estimates of the total external cost of the Atlantic Sunrise Project.

Specifically, we estimate

1. **Effects on Ecosystem Service Value.** Corresponding to the direct biophysical impacts of the CPL 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 project's construction and operation.
2. **The Social Cost of Carbon ("SCC").** The economic cost of harm associated with the emission of carbon.

In addition there may be important impacts in the form of

3. **Public Health costs.** We consider possible increases in acute and chronic health problems due to the operation of the compressor stations along the route. With further study, refined estimates could be converted into the cost of illness borne by nearby residents and local health systems.
4. **Property value impacts.** While there is a well-established negative relationship between property values and proximity to natural gas transmission pipelines and compressor stations, time constraints prevent the inclusion of estimates in this report. We do, however consider the contrary claims by Transco LLC and FERC that there are no such property value effects.

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 the Temporary Construction Right-of-Way

The temporary construction right-of-way would require clearing a width of 90 feet for the 30-inch diameter line and 100 feet for the 42-inch diameter line (27.4 and 30.5 m, respectively). 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"). The HCA 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 the 30-inch portion of the pipeline would have a radius of 790.6 feet (241.0 m or 0.15 miles) and an 1106.8 feet (337.4 m or 0.21 miles) for the 42-inch portion.

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 2,631 feet (801.93 m or 0.5 miles) for the 30-inch portion of the pipeline and 3,683.8 feet (1122.82 m or 0.7 miles) for the 42-inch portion.[14] (See map, Figure 2, for a close-up of these zones in part of the study region.)

The greatest disruption of ecosystem processes would occur within the temporary construction right-of-way and permanent ROW. 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,

[14] The maximum operating pressure for the project is 1,480 PSIG, but source data for the evacuation distance is a table with pressure in 100 PSIG increments. For the 30-inch portion of the CPL line, for example, the full evacuation distance would be between 2,559 ft. and 2,649 ft., the distances recommended for a 30" pipeline operated at 1,400 and 1,500 PSIG. The exact evacuation distance is determined by subtracting the 1500 PSI 30" distance value from the 1400 PSI 30" value, taking 80% of that value, and adding it to the 1400 value to determine the appropriate evacuation distance for a 1480 PSI 30" pipeline.

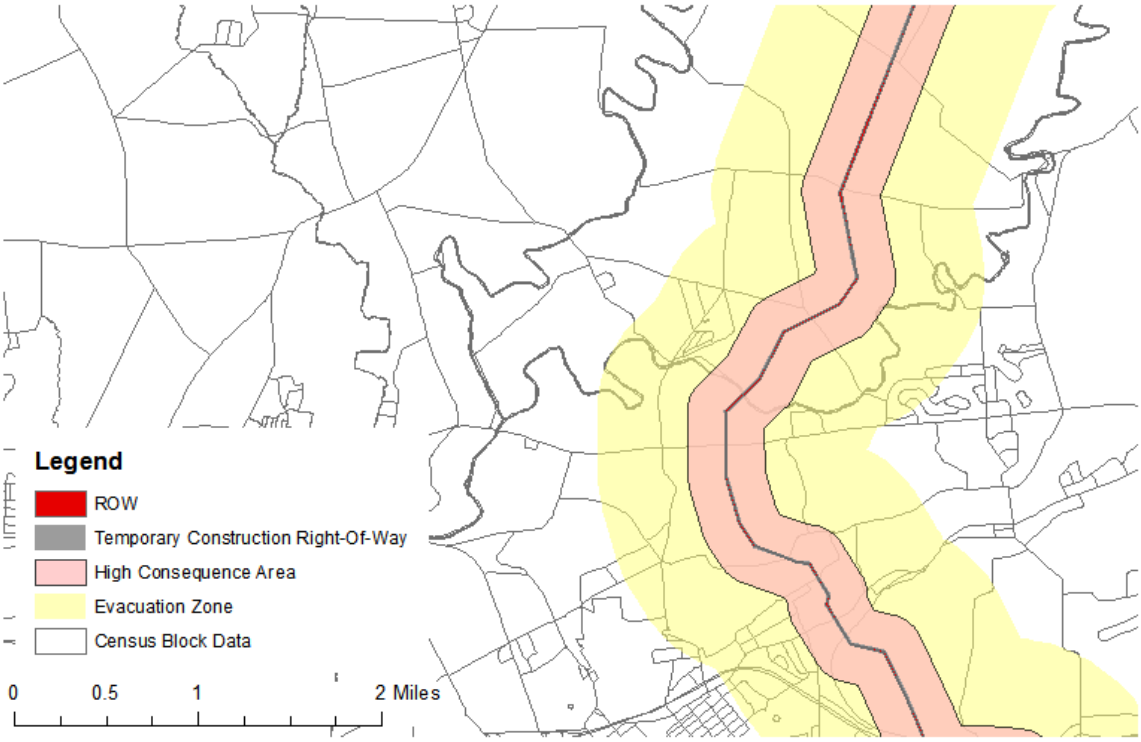

Figure 2. The right-of-way, temporary construction right-of-way, high consequence area, and evacuation zone for a section of the Central Penn Line. The overlay of the HCA (in pink) and the evacuation zone (in yellow) shows up as the salmon band in the map. The ROW covers much of the temporary construction right-of-way, leaving a thin band of red/grey visible. The Central Penn Line was adapted from the Shalefield Organizing Committee (2015); Study region (counties) reprinted from the U.S. Department of Interior & U.S. Geological Survey (2015); Census block data reprinted from the U.S. Census Bureau (2015).

the construction zone (the temporary construction right-of-way and new temporary roads[15]), new permanent access roads[15], and permanent aboveground infrastructure (the compressor stations). An explosion would undoubtedly affect ecosystem processes within the HCA and possibly the evacuation zone, but given the probability of an explosion at a 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.

Compressor Station

The compressor stations will likely have separate effects on human health. Compressor stations have 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

[15] 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, we assume no change in their function as sources of ESV and, therefore, there no decrease in value due to their use related to the project.

those effects for the two stations, however, without such research, we do not include the potential public health costs in the present study.

Boroughs, Townships, Cities, and Counties

When the project is constructed and operating, there will likely be increases in the costs of community service, such as for costs associated with road degradation from increased traffic volume, traffic control, 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 could increase more than Transco LLC anticipates.

Region-Wide Effects

Beyond the loss of ecosystem services stemming from the conversion of land in the ROW or the certainty of impacts on aesthetics, the proposed project 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 project instead of in some other place.

Table 2.
Geographic Scope of Effects

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]	?
The Social Cost of Carbon	✓	✓	✓	✓	✓	✓
Human Health and Safety	?	?	✓	?	?	?

Note. 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.
[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 project would remain core ecological areas, interior forest habitat, etc.

To the extent the project causes such decisions to favor other areas, less spending and slower economic growth in the study region would be the result. Table 2 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, 2005). "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
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

Regulating Services[a] Continued
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

Note. [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 project on ecosystem service values by identifying the extent to which the CPL'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.

Construction will strip bear the 90-foot or 100-foot-wide temporary construction right-of-way and the rest of the construction zone.[16] Once construction is complete and after some period of recovery, much of the 50-foot-wide permanent 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

[16] For this report, we did not quantify the ecosystem services lost during construction from new meter and regulation stations, pipeyards, contractor ware yards, or contractor staging areas. Thus, our results for the true value of ecosystem services lost during construction are conservative.

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 project) is the annual ecosystem service cost that will be experienced indefinitely.

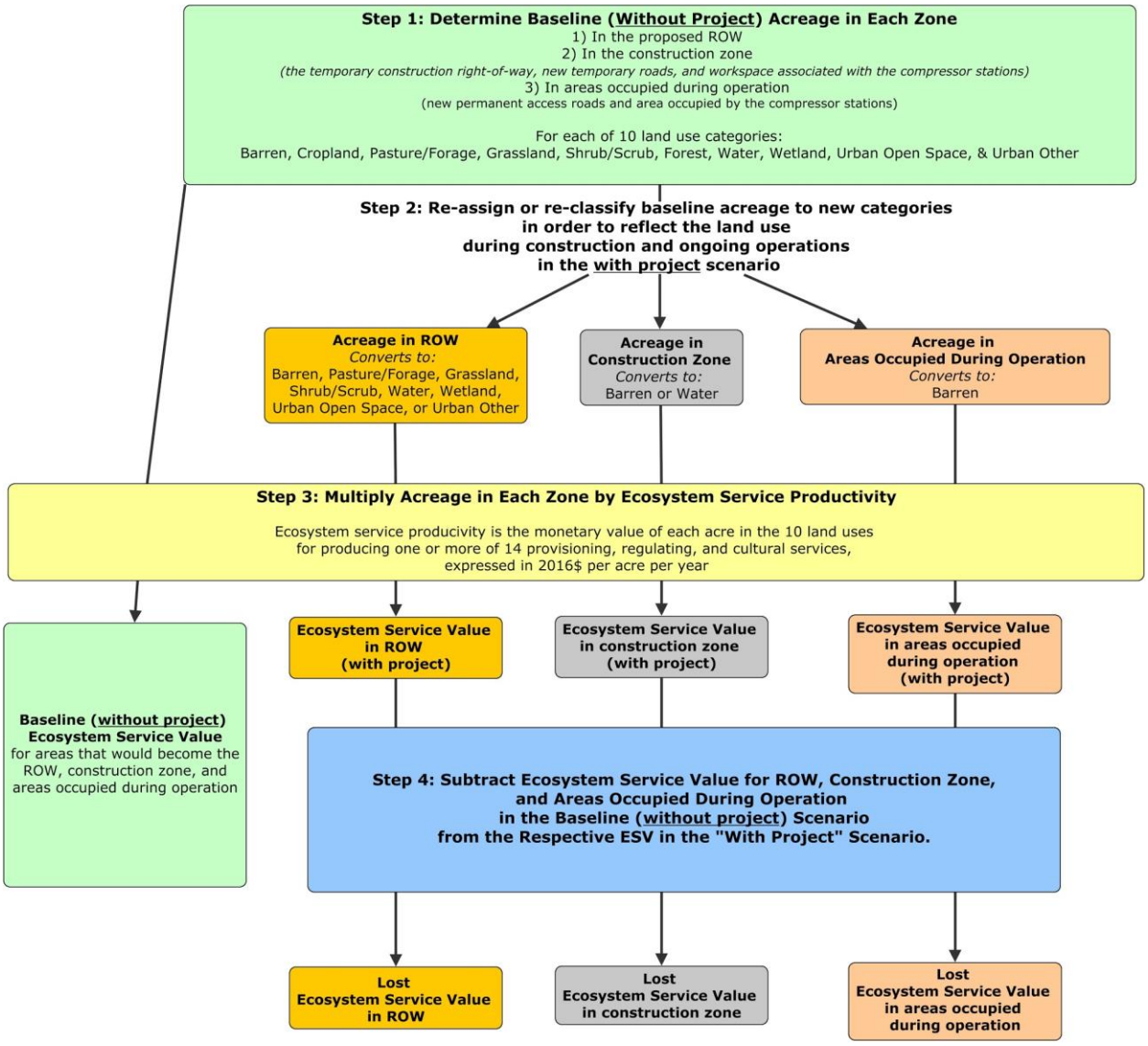

Figure 3. Ecosystem service valuation process.

In addition to the ROW and temporary construction right-of-way, the project would require the construction of various temporary and permanent access roads[17] as well as workspace for the

[17] As noted above, we only consider the ecosystem service conversion of *new* temporary and permanent access roads, not partially existing roads. Appendix D of the FEIS (Federal Energy Regulatory Commission, 2016) provides the length and width of each road as well as the existing land condition, such as "grass" or "vegetation." We used this land condition as a proxy for the baseline land cover (grassland). For the "with project" scenario, all of these areas would, for ecosystem services estimation purposes, be converted to the barren land category.

construction of the new compressor stations. These additional features are treated as though they are part of the construction zone.[18] Permanent roads and permanent aboveground infrastructure are treated separately.[18] 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.[19] 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.

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 project on ecosystem service value in the study region.

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[18] In Table 2.2-1, the FEIS (Federal Energy Regulatory Commission, 2016) states that compressor station 605 will affect 50.1 acres during construction and 39.2 during operation and compressor station 610 will occupy 33.5 acres during construction and operation. In a mapping supplement provided by Transco LLC (Transcontinental Gas Pipe Line Company, LLC, 2015c), the workspaces are bound by a "limit of disturbance." However, for compressor station 605, the mapping supplement does not distinguish between the limits of disturbance between construction and operation. We therefore assumed the construction workspaces and the permanent workspaces were equal at compressor station 605.

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

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 project" 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 project scenario, for the construction zone (and period) and for the ROW during ongoing operation.
   For simplicity, given the one year construction period (Federal Energy Regulatory Commission, 2016), we assume the construction zone will remain barren the entire one year 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 project) ESV from ESV (with project) 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;[20] 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 10-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 project) conditions, we have land in 10 land uses (Figure 4 and Table 4). The total area that would be disturbed in the construction zone (the temporary construction right-of-way,

[20] Because 30 meters is wider than the right-of-way and not much narrower than the 100-foot temporary construction right-of-way, 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 ROW and temporary construction right-of-way.

new temporary access roads, and by the compressor stations) is 2,157.3 acres, of which 1,113.3 acres would be occupied by the permanent right-of-way. An additional 55.8 acres would be devoted to new permanent access roads and the permanent acreage associated with the compressor stations. Figure 5 shows the distribution of acreage in the ROW, construction zone, and in land needed for permanent surface infrastructure pre-project, or baseline land use.

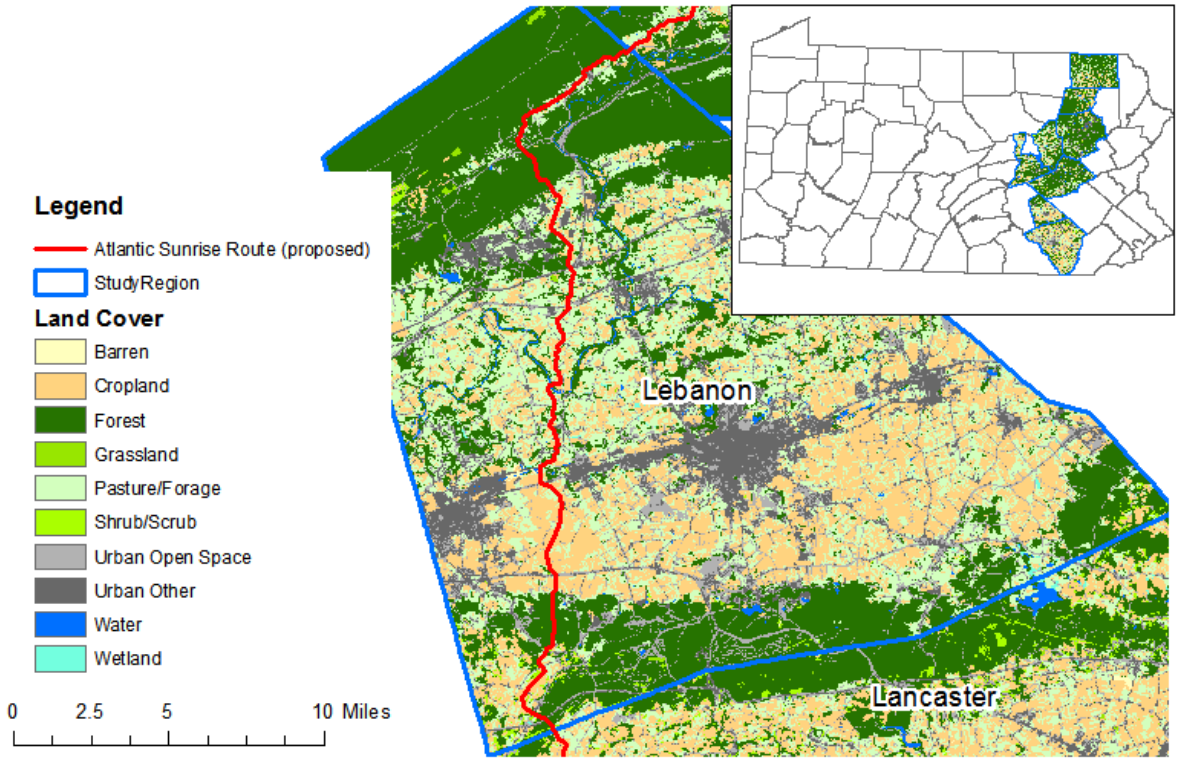

Figure 4. Land use in the study Region, as classified for ecosystem service valuation. Land cover for the entire study region is shown to display the overall range and pattern of land use. The ecosystem service valuation only covers portions of the study region occupied by the project right-of-way and construction zone. The Central Penn Line was adapted from the Shalefield Organizing Committee (2015); The study region (counties) was reprinted from the U.S. Department of Interior & U.S. Geological Survey (2015); The land cover data was reprinted from National Land Cover Database (Fry, et al. 2011).

Table 4.

Land Area Affected By Atlantic Sunrise Project, 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	1.3	2.7	0
Cropland	299.1	646.3	72.6
Pasture/Forage	260.4	520.1	7.1

Table 4 Continued			
Grassland	5.7	12.1	2.0
Shrub/Scrub	18.4	35.1	0
Forest	468.5	892.3	2.1
Water	2.5	5.0	0
Wetland	0.5	1.1	0
Urban Open Space	45.4	90.6	0.9
Urban Other	12.6	26.3	0.3
Total	**1,114.3**	**2,231.6**	**85.1**

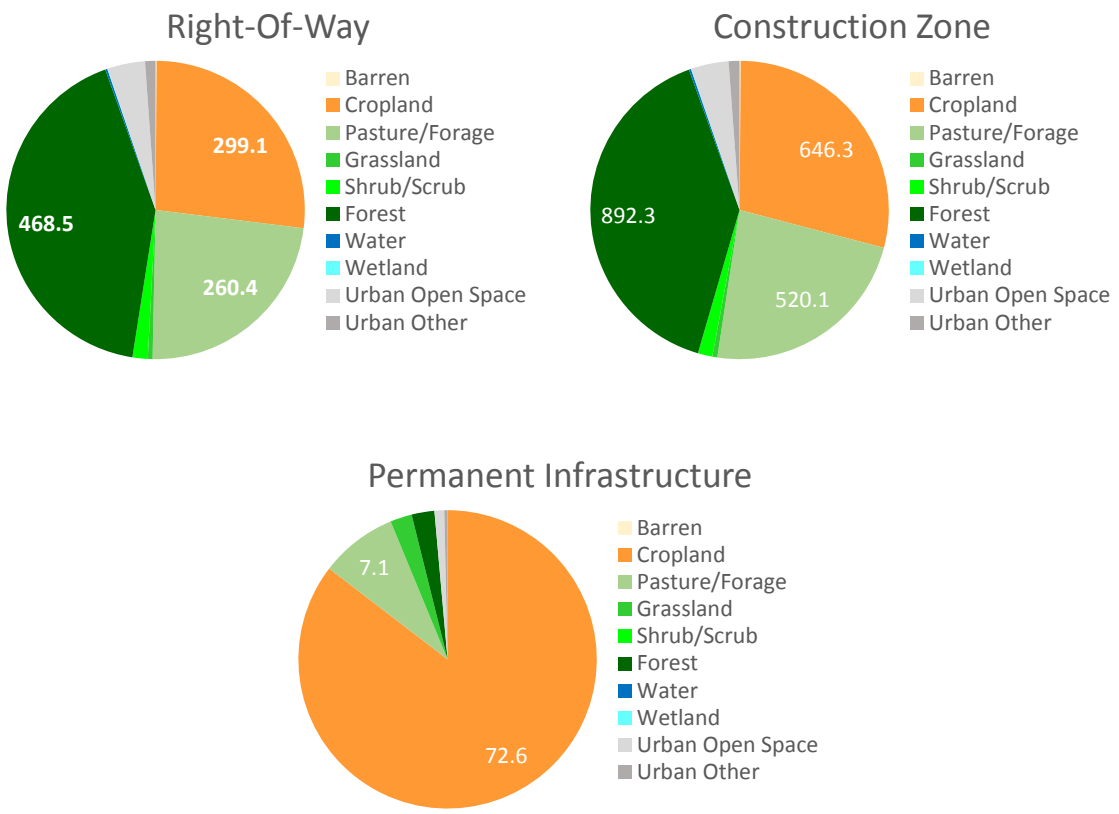

Figure 5. The Baseline (Pre-Project) Land Use in the ROW, Construction Zone, and Permanent Access Roads and Compressor Station Operation Space (Acres). (See also Table 4)

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

We assume all land in the temporary construction right-of-way 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
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-project 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 permanent easement at any given point and difficulty using best soil conservation practices, such as tilling along a contour, which may be perpendicular to the permanent easement. (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. For example, Rob Fulper, a farmer in 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.

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-project 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).[21] 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.[22]

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

[21] 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.

[22] 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.

region (Phillips & McGee, 2015, 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 project.

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 project) ecosystem service value in the construction zone
- Ecosystem service value in the construction zone during construction
- Baseline (no project) ecosystem service value in the right-of-way
- Ecosystem service value in the right-of-way during the (indefinite) period of ongoing operations[23]

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.

[23] Note that while the ROW and temporary construction right-of-way 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 temporary construction right-of-way. 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.

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

With steps 1-3 complete, we now estimate the cost in ecosystem service value of moving from the baseline (no project) or status quo to a scenario in which the project is operating. The cost of construction is the ESV from the construction zone during construction, minus the baseline ESV for the construction zone. The ecosystem service cost of ongoing operations is ESV from the ROW in the "with project" 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 $6.2 and $22.7 million. Those one-time losses will be followed by annual losses in the ROW of between $2.9 and $11.4 million and annual losses from other permanent surface infrastructure of between $36,308 and $247,144. 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 land occupied by the compressor stations 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 $85.2 and $330.0 million. Combined with the one-time loss during construction this puts the total loss of ecosystem service value due to the project at $91.4 and $352.4 million.

In the baseline or "no project" scenario, the land in the construction zone (including the temporary construction right-of-way, new temporary roads, workspace required for the compressor stations) produces between $6.2 and $22.7 million per year in ecosystem service value. The largest contributors to this total (at the high end) are aesthetics, pollination, and water. Under a "with project" scenario, and not surprisingly given the temporary conversion to bare/barren land, these figures drop to near zero, or between a total of $910 and $7,176 during the one year long construction period. Taking the difference as described in step 4, estimated per-year ecosystem service cost of the project's construction would be between $6.2 and $22.7 million (Table 6).

Table 6.
Ecosystem Service Value Lost to the Temporary Construction Right-of-Way, New Temporary Roads, and Workspace Associated with the Compressor Stations, Relative to Baseline, by Ecosystem Service

Ecosystem Service	Study Region			
	Baseline (low) (2016$)	*Loss (low) (2016$)*	*Baseline (high) (2016$)*	*Loss (high) (2016$)*
Aesthetic Value	4,130,074	(4,130,074)	16,428,534	(16,428,534)
Air Quality	336,791	(336,791)	351,304	(351,304)
Biological Control	19,651	(19,651)	148,503	(148,503)
Climate Regulation	166,768	(166,768)	176,362	(176,362)
Erosion Control	30,513	(30,513)	139,239	(139,239)
Protection from Extreme Events	740,494	(740,494)	773,868	(773,868)
Food Production	106,701	(106,701)	106,701	(106,701)
Pollination	196,269	(196,269)	1,474,649	(1,474,649)
Raw Materials	21,940	(21,940)	148,911	(148,911)
Recreation	73,727	(72,985)	541,228	(536,665)
Soil Formation	12,025	(12,025)	94,179	(94,179)
Waste Treatment	96,426	(96,373)	380,915	(380,861)
Water Supply	42,421	(42,306)	1,158,232	(1,155,673)
Water Flows	211,525	(211,525)	734,934	(734,934)
Total	**6,185,324**	**(6,184,414)**	**22,657,558**	**(22,650,383)**

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 project" scenario, the land in the ROW produces between $3.2 and $11.8 million per year in ecosystem service value. Under the "with project" scenario, using minimum values, the annual ecosystem service value from the ROW falls from $3.2 million to about $310,013 for an annual loss of over $2.9 million. At the high end of the range, the ecosystem service value of the ROW falls from $11.8 million to about $599,439 for an annual loss of $11.2 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) (2016$)	*Loss (low) (2016$)*	*Baseline (high) (2016$)*	*Loss (high) (2016$)*
Aesthetic Value	2,163,369	(2,059,799)	8,617,077	(8,491,102)
Air quality	176,742	(157,090)	184,015	(157,090)
Biological Control	9,536	(937)	69,519	(60,921)
Climate Regulation	84,556	(22,183)	89,587	(27,133)
Erosion Control	14,686	6,269	69,271	(19,604)
Protection from Extreme Events	388,079	(373,692)	404,706	(373,692)
Food Production	50,914	(25,651)	50,914	(25,651)
Pollination	102,418	(92,558)	694,035	(681,404)
Raw materials	11,517	(11,491)	78,177	(78,151)
Recreation	35,394	597	279,930	(239,864)
Soil formation	5,973	(3,967)	44,763	(42,757)
Waste Treatment	45,225	(41,809)	193,355	6,621
Water Supply	22,268	(22,201)	607,933	(605,392)
Water flows	110,845	(106,997)	385,229	(372,934)
Total	**3,221,522**	**(2,911,508)**	**11,768,512**	**(11,169,073)**

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 project" 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 $44,051 and $722,605 per year.[24]

Finally, the establishment of new permanent access roads and the area occupied by the compressor stations 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 85.1 acres across the study

[24] 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.

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 project exists. The annual loss of ecosystem service value from these areas under a "with project" scenario would range from $33,308 to $247,144.

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) (2016$)	*Loss (low) (2016$)*	*Baseline (high) (2016$)*	*Loss (high) (2016$)*
Aesthetic Value	13,856	(13,856)	47,340	(47,340)
Air quality	822	(822)	972	(972)
Biological Control	1,188	(1,188)	15,042	(15,042)
Climate Regulation	1,354	(1,354)	1,376	(1,376)
Erosion Control	2,150	(2,150)	6,024	(6,024)
Protection from Extreme Events	1,991	(1,991)	2,256	(2,256)
Food Production	1,687	(1,687)	1,687	(1,687)
Pollination	1,316	(1,316)	144,954	(144,954)
Raw materials	52	(52)	355	(355)
Recreation	1,018	(1,018)	3,292	(3,292)
Soil formation	574	(574)	8,443	(8,443)
Waste Treatment	9,677	(9,677)	10,760	(10,760)
Water Supply	101	(101)	2,746	(2,746)
Water flows	522	(522)	1,897	(1,897)
Total	**36,308**	**(36,308)**	**247,144**	**(247,144)**

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 project'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 project 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.

THE SOCIAL COST OF CARBON: AN ADDITIONAL COST OF METHANE TRANSPORT

The social cost of carbon 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).

Transco LLC estimates the entire project would transport 620.5 million dekatherms annually, contributing to an equivalent of 32.9 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.[25] Using U.S. EPA estimates

[25] The FEIS estimates that the in-service date of the project would be either February or March of 2018 (Federal Energy Regulatory Commission, 2016), therefore, for our calculations of the SCC, we use 2018 as the first year of associated emissions for the project. We also assume a 30-year lifetime for the pipeline.

based on the average of impacts from three 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 Atlantic Sunrise Project would total between $21.2 and $91.2 billion over 30 years. FERC must consider this significant cost among the effects of the project.[26]

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 (Fleischman, McCabe, & Graham, 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 Compressor Stations

The Atlantic Sunrise Project would impact 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 route, leaks and major releases of gas and other substances (lubricants, etc.) would certainly occur at the compressor stations slated for Columbia and Wyoming. 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. David Carpenter, the director of the Institute for Health and the Environment at the University at Albany, notes that compressor stations are among the worst of fracking related infrastructure (Lucas, 2015). A five-state study examining air quality near compressor stations found that levels of several volatile chemicals, including benzene and formaldehyde, exceeded federal guidelines (Macey et al., 2014).

[26] Due to the Regional Greenhouse Gas Initiative, the first mandatory cap-and-trade program to limit CO_2 emissions, some of the social cost of carbon is paid for with proceeds used for societally beneficial projects. However, the auction clearing price in 2015 was only $6.10, far below the social cost of carbon price (Potomac Economics, 2016).

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, 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 (Earthworks, n.d.).

In Columbia County, 4,182 people live within 2 miles of the proposed compressor station (U.S. Census Bureau, 2015). Translating the findings from Subra (2015), 3,764 people would experience odor events, 2,969 people would experience respiratory impacts, 2,426 people would experience sinus problems, and 1,631 people would experience sleep disturbances and/or severe headaches.

In Delaware County, 3,348 people live within 2 miles of the existing compressor station in Hancock (U.S. Census Bureau, 2015). Applying the results of Subra (2015) to the population in Delaware living within 2 miles, 3,013 people would experience odor events, 2,377 people would experience respiratory impacts, 1,942 people would experience sinus problems, and 1,306 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.

OTHER IMPACTS NOT QUANTIFIED: CLAIMS THAT PIPELINES DO NOT HARM PROPERTY VALUE ARE INVALID

The FEIS (Federal Energy Regulatory Commission, 2016) and Transco LLC (Transcontinental Gas Pipe Line Company, LLC, 2015b) 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 & 2014 (summarized in Integra Realty Resources, 2016 and in Seale & Bethel, 2015); Fruits, 2008; Diskin, Friedman, Peppas, & Peppas, 2011; Integra Realty Resources, 2016; Palmer, 2008; and Wilde, Loos, & Williamson, 2012). While the studies differ in methods, they are similar in that they fail to take into account two factors that could completely invalidate their conclusions.

First, the studies do not 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 full information about

the subject properties, including whether the properties are near a pipeline. Second, and for the most part, the studies finding 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 project would have.

When the Preconditions 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 possess 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 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 an article using similar techniques and authored by Diskin, Friedman, Peppas, & Peppas (2011)[28]:

> 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, thus demonstrating that once would-be buyers become aware of the presence of a pipeline and its hazards, they can "vote with their feet" and their wallets and buy elsewhere. 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

[27] The exception is the Kinnard study referenced in Wilde, Loos, & Williamson (2012).
[28] This is the article FERC cites in the DEIS and FEIS as "International Right of Way Online, 2011".

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, home videos, and other media describing and depicting such explosions and their aftermath. Whether or not the pre- and (in the long term) post-explosion prices in that Bellingham neighborhood reflected the presence of the pipeline, it is hard to imagine that the evident dangers of living near a fossil fuel pipeline would be so easily missed or so quickly forgotten by today's would-be homebuyers.

What Zillow and other sites accomplish is lowering the effort/cost of acquiring information about properties. Potential homebuyers can easily 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 and act on information about a hazard they could be buying into.

With more vocal/visible opposition to large, high-pressure natural gas pipelines and associated natural gas infrastructure it also seems likely that prospective home buyers will not have to wait for an incident involving the project to learn of it and, therefore, for the project to affect willingness to pay for properties nearby. Anyone with an eye toward buying property near the path of the project could quickly learn that the property is in fact near the easement, that there is a danger the property could be adversely affected by the 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 project will be lower than the prices offered for otherwise similar homes farther away or in another community or region.

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 Socioeconomics* and the FEIS 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 such that 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 & 2014; Integra Realty Resources, 2016; Seale & Bethel, 2014).[29]

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 therefore likely to suffer a loss in property value relative to properties farther away.[30]

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 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 (i.e., the majority of properties are within the evacuation zone). INGAA instead relied upon case studies with little to no variation in the feature of interest 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.

A prime example of this problem is embodied in the 2014 study by Allen, Williford, and Seale, which is summarized in the latter INGAA study (Integra Realty Resources, 2016) and cited in FERC's FEIS. The authors compare the prices of homes and lots "on" and "off" a Transco-operated pipeline in Luzerne County, Pennsylvania. In the map below (Figure 6), the green-shaded properties are those identified by the authors as "on the pipeline," because they are crossed by the 50-foot right-of-way. The orange properties are what the authors call "off the pipeline."

Figure 6 also shows, in pink shading, the 1,139-foot-wide high-consequence area and, in tan, the 3,796-foot-wide evacuation zone. <u>All</u> of the properties that Allen, Williford, and Seale consider as either "on" or "off" the pipeline are well within the evacuation zone, and all of the properties are at least touched by the high-consequence area. Because perceptions of the risk to life and property in the event of an explosion or, at minimum, worry and inconvenience homeowners, living within the evacuation zone should likely affect offer prices for <u>all</u> of the properties in the study area, making the authors' definitions

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

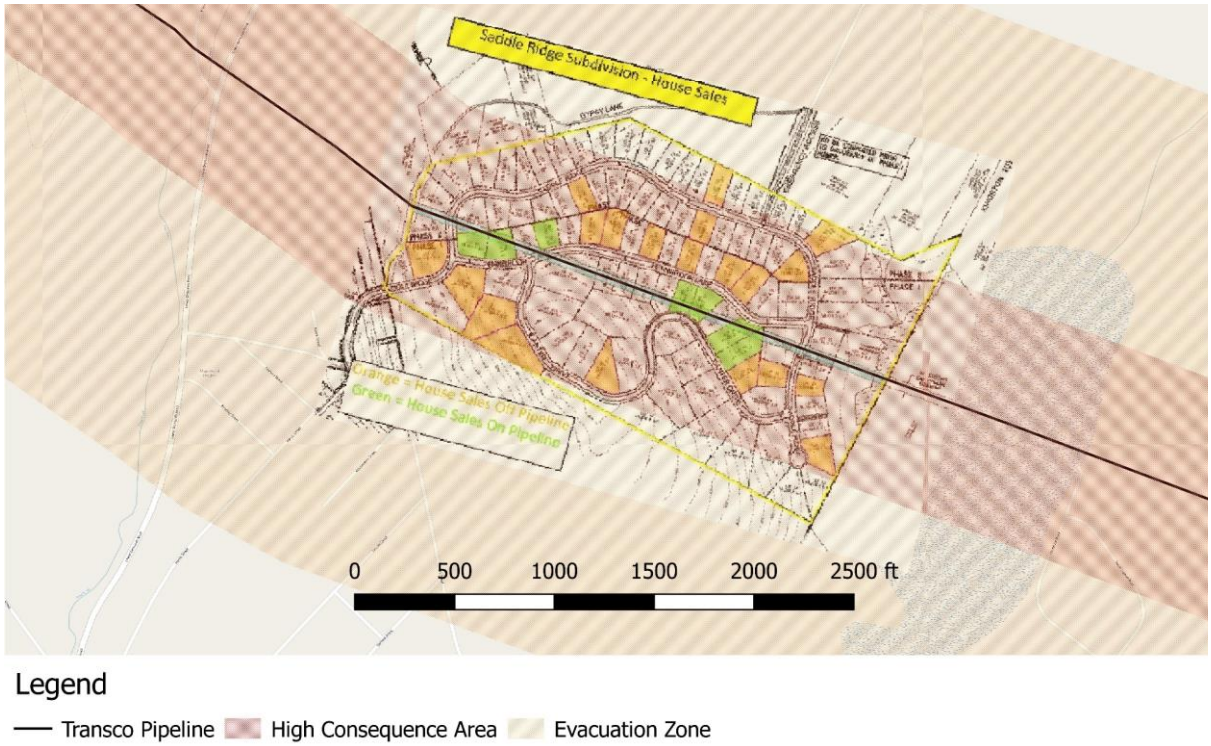

Figure 6. Transco Pipeline evacuation zone covers all, and the high-consequence area covers most, of properties in the Saddle Ridge case study area. Adapted from Allen, Williford, and Seale (2014).

of "on" and "off" the pipeline substantially irrelevant. As in the other cases included in INGAA's review (Integra Realty Resources, 2016), Allen, Williford, and Seale simply document the unsurprising result that similar properties have similar prices.

As economic research, their exercise is a perhaps harmless but wasted effort. As the basis for FERC's and others' contention that natural gas pipelines do not affect property values, the exercise is one of costly, and possibly dangerous, misdirection.

To varying degrees, the other studies cited by FERC and Transco LLC suffer from the same problem. Fruits' (2008) analysis of 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 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 methodologically flawed studies. To evaluate the effects of the Atlantic Sunrise Project on property value, FERC and others must look to studies 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 30,000 and 40,000 hp compressor stations slated for construction in Wyoming and Columbia, 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 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 smaller (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 stations.

CONCLUSIONS

The full costs of the Atlantic Sunrise Project to people and communities in the 10-county study region stem from ecosystem service value lost due to land clearing (during construction) and long-term changes in land cover (during operation). The loss during construction, according to our conservative estimates, would be between $6.2 and $22.7 million. During operations, and owing to the fact that much of the right-of-way will never revert to its natural, pre-pipeline land cover, would total between $2.9 and $11.4 million per year each year for 30 years.

Beyond the immediate region, the Atlantic Sunrise Project would impose a cost on people worldwide, due to the combustion of natural gas transported through the pipeline. Depending on how deeply future costs are discounted, the project's social cost of carbon would total between $457.0 million and $3.5 billion per year.

Taken together, these one-time and recurring costs have an estimated present value between $21.3 and $91.6 billion.

By contrast and in the words of FERC's DEIS, the project would likely be beneficial, based on increases in tax revenue (Federal Energy Regulatory Commission, 2016). Using Transco LLC's estimates (Blumsack & Kleit, 2015; Kleit, Prete, Blumsack, Guo, & Yoo, 2015) and applying the same methods to calculate the present value of all future benefits, the pipeline promises a total of $445.2 million in economic impact over 30 years of operation. This means for every dollar of benefit promised, the Atlantic Sunrise Project would impose between $47.85 and $205.74 in costs.

While the decision to approve the project did not hinge on a simple comparison of estimated benefits versus estimated costs—indeed there was little consideration given to costs at all—the difference between the external economic costs presented in this report and the potential economic benefits to the region suggests that the project is grossly inefficient. The comparison also suggests that FERC had not taken the required "hard look" at the full scope and magnitude of the potential economic effects before granting approval of the Atlantic Sunrise project.

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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 project's temporary construction right-of-way and permanent easement. 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	(USDA National Agricultural Statistics Service, 2016)
	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-Maiître & 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) *

	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) *
	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)
	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 2016 dollars.

* Indicates source is from the TEEB database.

People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 8, Key-Log Economics, LLC, Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines and FERC Docket No. PL18-1, Economic Costs of the Atlantic Coast Pipeline, July 23, 2018.

KEY-LOG. economics LLC

Research and strategy for the land community.

To: Maya K. van Rossum, Delaware Riverkeeper
From: Spencer Phillips, Ph.D., Economist & Principal
Date: July 23, 2018
Subject: Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines, and FERC Docket No. PL18-1-000

Based on my and my colleagues' analyses of several recent pipeline projects, it is well—and long overdue—that the Federal Energy Regulatory Commission (hereinafter "FERC" or "the Commission") is examining its policy regarding Certification of New Interstate Natural Gas Facilities (Docket No. PL18-1-000). Key-Log Economics is pleased to provide this expert review and comment on the existing certification policy and its application to date. We pay particular attention to the extent to which the Commission's past evaluations and certification decisions have adequately considered the economic consequences of the construction, presence, and operation of interstate natural gas pipelines.

Our question is whether the Commission's policy—as stated or as implemented—typically results in economically sound outcomes in which the public benefits delivered by new interstate natural gas transmission pipelines are likely to exceed the costs imposed on the public. Based on our independent review of several recent proposed pipelines and expansion projects[1] this is a very real and profound concern. Despite the stated intention of FERC's existing policy on "Certification of New Interstate Natural Gas Pipeline Facilities", namely, that projects "would be approved only where the public benefits to be achieved from the project can be found to outweigh the adverse effects" (88 FERC ¶ 61,227), the answer to our question is simply "no": we find no evidence to date that either the Commission's existing policy and its current practice are adequate to ensure the development of an interstate natural gas transportation system in which the public benefits exceed the public costs.

In particular and as detailed below, it is our observation that:

1. The Commission has not adequately assessed the potential public benefits from proposed interstate natural gas pipelines. It instead relies on the claims of projected benefits advanced by project applicants that, in turn, are based on outdated methods that are proven to be useless, at best, for making such projections. The Commission has not conducted its own expert, critical review of these claims, and this leaves the Commission's decisions subject to the same bias inherent in applicants' representations regarding their projects' benefits.

2. The Commission has failed to evaluate the full economic effects, especially external costs—that is, costs borne by third parties like nearby landowners, businesses impacted by pipeline construction and operation, and the general public—of proposed interstate natural gas pipelines. Similar to its lack of due diligence regarding benefit claims, the Commission relies on information about costs that are provided by pipeline applicants and other industry stakeholders, such at the Interstate Natural Gas Association of America (INGAA). Not surprisingly, these vested interests promote the view that proposed pipelines and other projects would result in no damage to natural resources, no

[1] These include the proposed Atlantic Coast, Mountain Valley, PennEast, and Atlantic Sunrise pipelines, and the Millenium Eastern System Upgrade. Examples referenced in these comments are drawn primarily from these cases.

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associated economic costs, and no adverse economic effects on the "surrounding communities" that are among the stated interests of FERC's policy (88 FERC ¶ 61,227, p. 24).

A contributing factor to both of these failures is the Commission's lack of capacity even to critically review and evaluate the economic information the Commission does receive, let alone to conduct analyses of its own. The Office of Energy Projects (OEP), whose "mission…is to foster economic and environmental benefits for the nation through the approval and oversight of hydroelectric and natural gas pipeline energy projects that are in the public interest"[2] has no economists among its staff.[3] The Office of Energy Policy and Innovation, which otherwise collaborates with various FERC offices to evaluate industry proposals, reportedly does not support OEP in the form of economic review and analysis of pipeline certification projects.[4] The Commission has, in effect, been flying blind with regard to the critical question of whether its actions in approving new pipelines does or does not meet the "economic test" it sets in the current policy.

Furthermore, and as suggested in the Notice of Inquiry, both the state of the natural gas industry and the state of knowledge regarding the impacts of natural gas exploration, development, transmission, and end use have changed since 1999. Just last month, for example, the journal *Science* reported findings that methane emissions along the U.S. supply chain are 60% higher than previous US Environmental Protection Agency (EPA) estimates had indicated (Alvarez et al., 2018). This makes the oft-repeated (but seldom examined) claim by industry representatives and government officials that increased natural gas transmission capacity will help solve climate change problems even more suspect. Without countervailing measures to control leaks, the construction and use of additional pipeline capacity will cause methane emissions to increase. Given that the global warming potential (GWP) of methane is approximately 30 times that of carbon dioxide, any fuel switching to natural gas encouraged by new transmission capacity could actually exacerbate, rather than mitigate climate change.

In short, the review of the 1999 policy is greatly needed and, one hopes, will result in upgrades in FERC policy, capacity, and practice that make it more likely that the benefits of natural gas transmission and use will outweigh the costs of that system.

I will conclude this review with a summary of our findings related to several pipeline projects. I will begin, however, by laying out a framework, grounded in standard neoclassical resource economics (NRE), against which to compare those examples and on which those upgrades should be based.

Ecological economics would provide a broader, more modern, approach to these questions. This transdiscipline includes the efficiency concerns of NRE, but adds considerations of equity/justice, as well as sustainable scale and puts them on an equal footing with efficiency (Daly & Farley, 2011). Equity does get some mention in the current policy. It comes in the form of concern for impacts of new pipelines on existing pipeline/natural gas customers and on current shippers. And some Environmental Impact Statements (EISs) have mentioned environmental justice concerns raised by members of the public. The Commission, however, has not been proactive or systematic in evaluating the distribution of impacts, positive and negative, of proposed interstate natural gas transmission pipelines. Such an evaluation would take into account whether negative impacts disproportionately affect minority,

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[2] Federal Energy Regulatory Commission. (2017, February 21) Office of Energy Projects (OEP), "What we do." Retrieved from https://www.ferc.gov/about/offices/oep.asp.

[3] Federal Energy Regulatory Commission. (2017, February 3). 2017 Employee Phone Directory. Retrieved from https://www.ferc.gov/contact-us/tel-num/phone.pdf.

[4] Personal communication with OEPI's Administrative Officer. (2017, March 17).

low-income, or otherwise vulnerable populations. And if there are cases in which overall expected benefits outweigh overall expected costs (thus passing an efficiency test), the Commission's process should include a thorough evaluation of who would reap the the benefits and who would bear the costs. The Commission, furthermore, should require mitigation payments from the applicants and ensure that those payments are distributed in a way that equitably offsets the costs borne by various communities within the broader category of "the public."

Scale gets only a faint nod in that the Commission does weigh the "need" for new capacity, but that consideration begins and ends with the question of whether the applicant has identified customers for the gas it would transport in the proposed pipeline. There is no indication in the policy or in individual cases that FERC has concerned itself with the more important question of whether the transmission system is of *sustainable* scale. That is, the Commission has not attempted to determine whether proposed pipeline capacity is needed to make the overall system more efficient or effective in delivering natural gas to important markets. Indeed, in rejecting pleas to conduct regional environmental analyses, such as in the case of the Atlantic Coast and Mountain Valley Pipelines, FERC has likely missed opportunities to avoid a scenario in which further system buildout results in overcapacity in the transportation system and/or overuse of natural gas in general.

Market Failure: Pipeline Externalities

It is a firmly established economic principle that a change in economic organization–in the case at hand, this would be a change in land use/management–that leaves some people better off while harming others can still be said to be worth doing if it is at least hypothetically possible for those who gain to compensate those who lose as a result of the change. The reason is that the change produces a net benefit across all of human society. If one considers economic justice as well as overall welfare, then we would require that the compensation not only be hypothetical, but that it actually be paid so that those who lose something due to the change can at least receive the cash equivalent of what they have lost.

Setting aside for the moment the obvious question of whether any and all types of human suffering, including changes in physical, psycho-social, or cultural well-being could or should be assumed to have a monetary equivalent, this compensation principle provides a sound conceptual rationale for mitigating the adverse impacts of actions such as pipeline certification and subsequent construction and operation of pipelines. It also suggests the scope and scale of the compensation that should be paid if the change is to be deemed both efficient and just.

In the case of the natural gas transmission pipelines, those potentially gaining from increased pipeline capacity may include gas shippers who could pay less to move natural gas to market, the pipeline owners who will receive compensation for building and operating pipelines based on market and non-market processes (i.e. guaranteed rates of return), and, at least hypothetically, energy consumers. Pipeline applicants and their surrogates also often promise broader economic benefits in the form of jobs and income due to pipeline construction as well as further employment, income, and economic output stimulated by lower energy prices.[5]

[5] As noted below, it is not at all clear that pipeline capacity translates into either lower energy prices or that any downstream or "multiplier" effects stimulated by additional capacity exist outside the realm of theory and promoters' wishful thinking.

Those suffering losses due to expanded natural gas pipeline transmission capacity include those "three interests" enumerated in existing FERC Policy: natural gas customers, owners of competing pipelines, and "landowners and communities affected by the proposed project" (FERC Docket No. PL99-3-000).

I do not wish to diminish the importance of the certification policy to first two of those interests, but effects on customers and competitors are "merely" financial. Customers may suffer if regulated rates exceed rates just sufficient to just cover pipeline operators costs. In other words, if regulated rates result in end-of-pipe natural gas prices that include a subsidy to the operators in addition to a price that covers the market costs of producing and delivering the gas to the end of the pipe, customers will suffer real financial harm. Competitors might lose some customers and revenue and, in the extreme, could be be forced out of business by the operation of the new pipeline. Assuming there is no bias against existing pipelines' operators, such "market discipline" is what one would normally expect, with the more efficient or lower cost firms ending up with a greater share of the market.

Both of these types of impact may represent economic inefficiency, including the costs of a landscape littered with pipeline corridors abandoned by bankrupt firms. It does does seem at least possible, however, such concerns could be addressed through other of the Commission's process. For example, if the Commission were to assess the need for additional pipelines systematically and at appropriate regional scales, problems of overcapacity leading to abandoned pipelines could be avoided. (This is the question of scale alluded to above.) In addition, the Commission's rate setting process could be more carefully executed to ensure that operators are not permitted to garner excess profits at the expense of customers. If pipeline operators (and their investors) can expect only normal rates of return, there would be fewer incentives to propose, build, and operate unnecessary pipelines in the first place.

It is the third interest—of communities affected by pipelines built through them—that raises the more important economic questions regarding the certification of new natural gas pipelines. The reason is that the construction, presence, and operation of pipelines will impose "external costs" on members of those communities. External costs, also known as "negative externalities" are costs associated with a transaction imposed on individuals and entities who are not a party to the transaction. In this case the transaction is selling natural gas, which entails all of the activities associated with exploration, development, transportation, and use of natural gas. The negative externalities associated with transporting natural gas via the pipelines under FERC jurisdiction would include the following:

- The loss of physical use of/access to land occupied by pipeline rights of way;
- Diminished productivity of the land within or proximate to rights of way. Such land could otherwise be used (or used more effectively) for producing timber, crops, recreation services, clean water supply, erosion control, and other important ecosystem services
- A loss of physical and psychological well-being due to health and safety concerns imposed by the presence and operation of pipelines, compressor stations, and other infrastructure on one's land or in one's community;
- A loss of psychological well-being due to damage to home places, familiar landscapes, and cultural traditions associated with the use and enjoyment of those landscapes;
- Diminished local/regional economic activity as recreationists and tourists make decisions to spend their leisure and vacation time in locales without pipelines and, therefore, perceived to be safer and/or more aesthetically attractive, and/or more valuable for pursuits ranging from hunting and fishing, to bird watching, hiking, driving for pleasure, and others.

- Along similar lines, decisions by retirees, entrepreneurs, telecommuters and others who can locate where they want and who choose locations perceived to be safer and with more intact natural landscapes
- Accelerated climate change and associated secondary losses of ecosystem services due to the upstream and downstream effects of methane and carbon dioxide emissions
- Delayed transition to more sustainable, renewable, and increasingly lower-cost energy sources.

(These effects are of the sort that must be analyzed in order to comply with the National Environmental Policy Act (NEPA), regulations for which state that

> Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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 (36 CFR 1508.b).)

The costs associated with these effects can be measured as lost property value, higher insurance premiums, lost revenue for recreation and tourism businesses, employment and income forgone when businesses, retirees, and mobile workers choose to locate elsewhere, lost productivity in agriculture and forestry, higher costs to provide clean drinking water, flood and erosion control and other services that intact natural landscapes would otherwise provide for free[6], and the diminution of human welfare (whether expressed in dollar-valued terms or not) of people living in constant fear of property loss, injury, or death due to pipeline accidents.

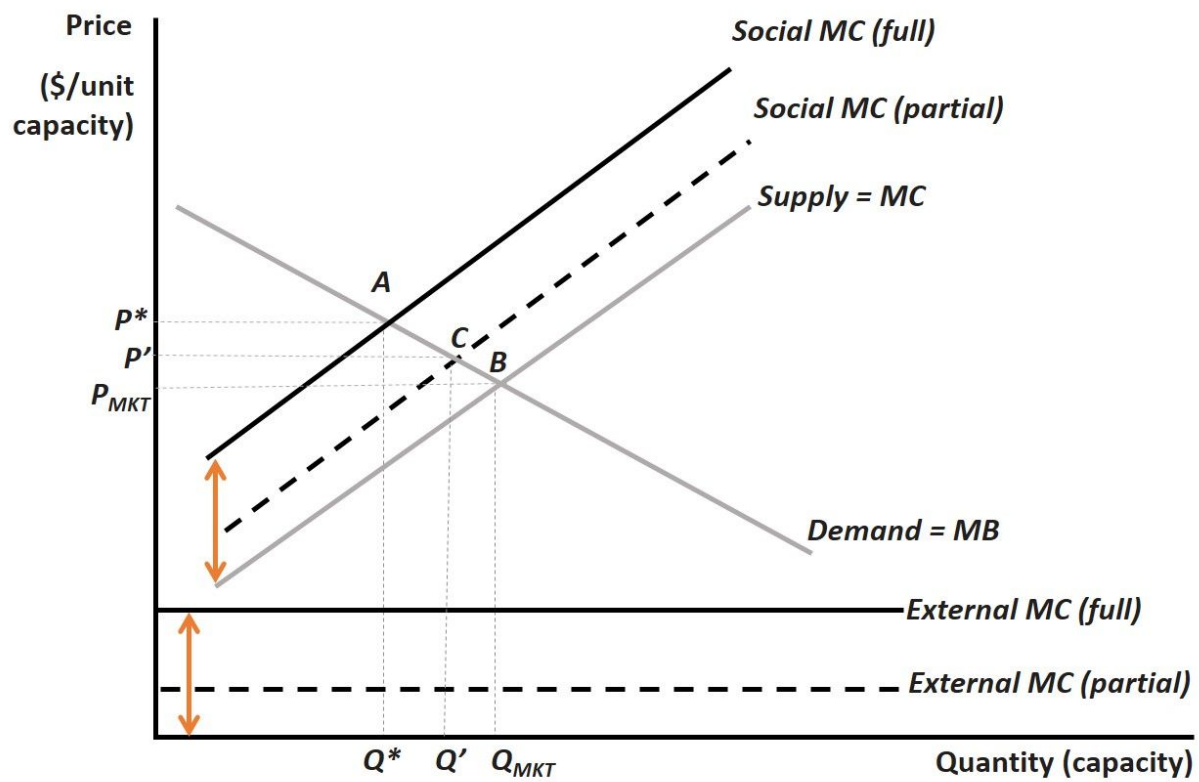
Figure 1, below, depicts presents the standard NRE view of such external costs, why they are "bad" for society, and how/where in the example at hand, the Commission could conceptualize cases in which "the public benefits to be achieved from the project can be found to outweigh the adverse effects" (88 FERC ¶ 61,227). The quantity of pipeline capacity is measured along the horizontal axis. The price per unit of capacity is measured on the vertical axis. Demand for pipeline capacity (also the marginal benefit, "MB", of capacity) is shown by the downward-sloping grey line. It slopes downward because people get less additional benefit from the existence or use of each successive unit of capacity.[7]

The supply of pipeline capacity is the upward-sloping grey line. Supply is (generally) equal to firms' marginal cost of production—that is, it is the cost of bringing the last increment of pipeline capacity online and including all *private* costs (land acquisition, materials, labor, insurance, financing, etc.) associated with constructing and operating pipelines. This line is therefore labeled "Supply = MC". Under ideal conditions, including a lack of any external costs (impacts on parties other than pipeline operators and users), net societal benefit from pipelines would be maximized where demand (marginal benefit to buyers/users) equals supply (marginal cost to producers/sellers), or at point "B" in the diagram. At this point, buyers value the increment of capacity at exactly the cost of producing the last

[6] See Balmford, et al. (2010) for a full description of this framework that maps ecosystem processes (what happens in ecosystems that is of potential value to humans) to ecosystem benefits (the particular ways in which humans make use of or enjoy the results of what happens in ecosystems).

[7] This is one of the reasons that it is important that the Commission evaluate the addition to system-wide capacity that each pipeline represents—cumulative impacts in other words—rather than as single, stand-alone pipelines. Otherwise, it will be impossible for the Commission to gauge whether the next pipeline will be push capacity beyond the point at which even market costs exceed benefits.

Figure 1: The Natural Resource Economics of Natural Gas Pipelines



increment of capacity. The amount produced/used will be Q_{MKT}, and that amount will be sold/bought for P_{MKT}. These are the "market-clearing" quantity and price of pipelines.

External costs are depicted in the diagram by the horizontal black lines. The dashed black line depicts a subset of external marginal costs ("External MC (partial)"), such as the effects of pipelines on the owners of properties crossed by the pipeline right-of-way (ROW). The solid line depicts the full external costs ("External MC (full)"), including the impact on the value of land near, but not crossed by, the ROW, the monetary value of diminished production or availability of ecosystem services, the cost of greenhouse gas emissions—i.e., the social cost of carbon—and the monetary equivalent of the other external effects listed above.[8]

To arrive at a socially optimal level of pipeline capacity, one must add the external marginal costs to the private marginal costs to the get the "Social Marginal Cost" of pipeline capacity and then compare the

[8] To keep the diagram as simple as possible, I have depicted these as horizontal lines, implying that the external marginal cost (partial or full) of the first unit of pipeline capacity is the same as the external cost of the nth unit. In the real world, it is quite likely that marginal external costs will increase with capacity and will be nonlinear if there are threshold effects.

social marginal cost to the marginal benefits. In the diagram, adding the External MC (partial or full) to the private marginal cost ("Supply = MC") at each quantity gives us the darker upward-sloping "Social MC" curves. When all external costs are taken into account, the efficient level of pipeline capacity is lower, and the corresponding price per unit of capacity is higher than would be the case if external costs are not considered.

In the diagram, this economically efficient level of production and consumption is at point "A" with Q* units of capacity provided and sold at a price equal to P* dollars per unit. For all units of capacity beyond beyond Q*—any units up to or beyond Q_{MKT}—the social cost of producing another unit of capacity is higher than the value society of that additional unit of capacity. In other words, the added capacity imposes external costs on society that are not worth the benefit derived from the the additional use.

This excess of social costs over social benefits is, in essence and in economic terms, a "market failure" that entails a "deadweight loss" to society. It is this market failure that the current Certification Policy has the potential to address. The policy requires that 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]" ((FERC Docket No. PL99-3-000, 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).

Policy Failure: Pipeline Certification without Sufficient Economic Review

Relative to the need to address the market failure presented by the construction, presence, and operation of natural gas transmission pipelines, the Commission has not gathered, created, or adequately considered sufficient information related to the benefits, and, especially, the external costs of natural gas transmission pipelines to know whether or not benefits outweigh the adverse effects. In terms of Figure 1, the Commission does not know where on the quantity (capacity) axis the natural gas transmission system is and, therefore, whether any addition to total capacity would create or exacerbate the deadweight loss associated with new transmission pipelines. Thus, rather than addressing and attempting to correct the market failure stemming from pipeline externalities, the Commission has practiced serial policy failure that has undoubtedly increased the effects of the market failure.

Some of the Commission's failure is rooted in the language of the current policy. 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" (88 FERC, para. 61,227, pp. 18, 26). The Commission's policy contends that 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 at an individual, community, and broader population level. It ignores the vast majority of the external costs of pipelines described in the preceding section.

The policy's confusion over what counts as environmental effects (again, most of which will have economic effects) is further expressed by the following statement:

> Traditionally, the interests of the landowners and the surrounding community have been considered synonymous with the environmental impacts of a project; However, these interests can be distinct. Landowner property rights issues are different in character from other environmental issues considered under the National Environmental Policy Act of 1969 (88 FERC, para. 61,227, p. 24).

By the Commission's reasoning, environmental effects are a matter of the Commission's "traditions," not science, and environmental effects are deemed to be both synonymous with, and distinct from, interests of landowners and the surrounding community. This statement seems to contradict the statement one page earlier in the policy that "[there] are other interests [besides those of customers, competitors, and landowners and surrounding communities] that may need to be separately considered in a certificate proceeding, such as environmental interests (p. 23)." While it is true that separate/additional consideration of environmental "interests" must indeed be part of the Commission's review, the policy embodies such a muddle of contradictions on the question of what impacts to examine and why (tradition versus science), that it seems unlikely that any pipeline certification granted under the policy would be scientifically or economically sound.

FERC's own policies and track record, including an over-reliance on applicants' own estimates of project benefits, make it extremely unlikely that the project certification process would meet requirements of the National Environmental Policy Act (NEPA) that agencies consider all project costs and benefits, let alone produce a decision that could be construed as generating or supporting net economic benefits.[9]

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" (88 FERC, para. 61,227, p. 26). The applicant therefore has an incentive to be generous in counting benefits and parsimonious in counting the costs of its proposal. And as reflected in the DEIS at hand, FERC has made no effort itself to ensure a full accounting of economic costs to landowners or the broader community despite the wealth of comments placed on the docket that could support such an assessment.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.

Given the weaknesses of the policy, and as evidenced by the track record, FERC's "economic test" does not provide a robust evaluation of the public merits of natural gas transmission projects. It is a "test" in which difficult questions (such as about external costs borne by all stakeholders) are not asked, and where those taking the test (the applicants) provide the answer key. It is therefore not surprising that FERC's environmental reviews typically have not provided estimates of the magnitude of the full

[9] It is important to note that NEPA does not require that federal actions 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.

external costs associated with natural gas transmission pipelines. Also not surprising, pipeline applicants typically employ methods, assumptions, and a selective review of effects that result in a rosy and grossly distorted picture of the net benefits of their projects.

In the following sections, we review examples of these problematic benefit estimates and present, as examples, independent estimates of some of the external costs of recently proposed pipeline projects.

Pipeline Benefits are Often Overstated

In the course of research over several years, my colleagues and I at Key-Log Economics have evaluated the claims of potential economic benefit put forward by the applicants seeking certification of several pipelines, including the Atlantic Sunrise Pipeline (Docket No. CP15-138), Atlantic Coast Pipeline (Docket no. CP15-554), PennEast Pipeline (Docket no. CP-15-558), Mountain Valley Pipeline (Docket no. CP16-10), and the Millenium Pipeline's Eastern System Upgrade (Docket No. PF16-3). In one form or another, including in Resource Reports 5, applicants typically make some form of the following claims regarding the benefits of their projects:

1. Construction of the project will have significant positive economic impacts, including the "creation" of jobs and increases in personal income.
2. Operation of the project will also have significant positive economic impacts (again in the form of jobs and income).
3. The project will result in sustained, lower end-user costs for natural gas and/or for electricity generated in gas-fired power plants.
4. Project-stimulated reductions in energy costs will stimulate output, income, and employment in energy-intensive manufacturing and other sectors and, thereby, cause further positive economic impacts.

For the impacts of project construction and operation, as well as for impact stemming from lower energy prices, applicants typically present as their evidence projections generated from an quantitative "input-output" model, typically IMPLAN.[10] Rooted in economic base theory, input-output models purport to translate an exogenous change in the economy—the "input," which in this case is spending on the operation of the pipeline, including employees' wages—into "output," which includes spending by the project's employees, by other firms, by their employees, and so on. Additional rounds of impact occur as the businesses where those households spend their wages (grocery stores, gas stations, physicians, etc.) pay suppliers and their own employees. With each round of spending, some money leaks out of the study region's economy in the form of spending on imported goods or wages paid to workers who reside outside the study region.

While intuitively satisfying, empirical input-output models like IMPLAN are built on a very restrictive set of assumptions about how each and every spending and/or each and every hiring decision in the entire economy is made. Namely, the models assume that spending decisions are made the way they have always been made, and if wages or demand for a product goes up, the only way households and firms can respond is by doing more of what they did in the past to meet demand. They follow the same recipe, but just increase the amount of each ingredient. Households buy a larger quantity of the same

[10] See, for example, Chmura (2014), ICF International (2014), Ditzel et al (2015 a,b), Econsult Solutions & Drexel University School of Economics (2015), Concentric Energy Advisors (2016), and Blumsack & Kleit (2015)

mix of goods and services, and firms employ more labor, buy more raw materials, and burn more fuel (among other inputs) in exactly the same proportions as before the exogenous change occurred.

Firms in the real world, by contrast, innovate and adjust their manufacturing and other processes to take advantage of economies of scale, new technology, changes in relative prices, and new business processes. That innovation leads to cost minimization, and cost minimization means firms will do less indirect spending, and that means less induced spending stemming from changes in workers' wages. As Hoffmann and Fortmann (1996) found, this disconnect from real world behavior means that that input-output models produce overestimates of firm spending and "multiplier effects."

Due to restrictive assumptions, economic base models possess a dismal track record when it comes to predicting economic growth in the real world and in the long run. Again, the "long run" is more than a year into the future, when firms change technology, prices can adjust, and people change what they want to buy. In a review of 23 studies, Krikelas (1991) compared predictions of the economic base model against the actual experience of subject regions and found only 4 studies where the models correctly predicted longer run economic growth. Similarly, Robertson (2003) tested predictions from input-output models against actual experience in 15 communities in Southeast Alaska (a region in which many of the restrictive assumptions of economic base theory might actually apply). He found that initial economic stimulus does not "cause changes in economic activity serving local demand for the average community…The implications of these results [are that] secondary economic impacts [i.e. "multiplier effects"] cannot be taken as a foregone conclusion in policy analysis" (p. iii).

Beyond these general problems with input-output analysis, there have been some particular problems when applied to the construction phase of the projects we have analyzed. One major complaint is that the regions analyzed have been too large. In the case of the Mountain Valley Pipeline (MVP), for example, the applicant's consultants chose to use the entire states of Virginia and West Virginia as regions for analysis (they analyzed impacts separately in the two states). Regional economic impact depends on the degree to which direct, indirect and induced spending can occur within the study region. The bigger the region, the more likely it is that you can find a firm in the region from which to buy materials or services, and the more likely it becomes that one could hire labor from someone living inside the region. In other words, the larger the region, the larger the multiplier effect. The MVP studies do not present a rationale for the choice of entire states as the study regions. While the appropriate regions might be somewhat larger than the 10 West Virginia and 5 Virginia counties the proposed MVP would cross, they should not consist of the entirety of both states.

A second pervasive problem with applicants' economic analyses—one crippling to claims of economic benefit stemming from the operation of pipelines and/or increased output due to energy cost savings—is the misuse of the input-output model to estimate long-term effects.

As Haynes et al. (1997) note:

> Where the economic base approach gets into trouble is when it is used inappropriately as a tool for planning or predicting impacts of greater than one year in duration; A snapshot of current conditions tells little about the form a region's future economy may take.

The reason for this caution is that economic base theory and empirical input-output models grounded in that theory (i.e., the IMPLAN model used to generate numerous pipeline impact estimates) assume a static economy. In such an economy, there are no changes in relative prices, no input substitution or

technological change in the production processes, no labor mobility, no change in products or consumers' tastes and preferences, no regional migration, and no changes in state and local tax laws—to name a few. The constant technology assumption, for example, prevents firms from using cost-savings innovations, forcing them to be inefficient, and the result is higher multiplier effects than are actually experienced (Hoffmann and Fortmann 1996).

Due to these restrictive assumptions, economic base models have a dismal track record when it comes to predicting economic growth in the real world and in the long run. (The "long run" is more than a year into the future, when firm can change technology, prices can adjust, and people can change what they want to buy.) In a review of 23 studies, Krikelas (1991) compared predictions of the economic base model against the actual experience of the subject regions and found only 4 studies where the models correctly predicted longer run economic growth. Similarly, Robertson (2003) tested predictions from input-output models against actual experience in 15 communities in Southeast Alaska (a region in which many of the restrictive assumptions of economic base theory might actually apply). He found that initial economic stimulus does not "cause changes in economic activity serving local demand for the average community.... The implications of these results [are that] secondary economic impacts [i.e., "multiplier effects"] cannot be taken as a foregone conclusion in policy analysis" (p. iii).

To count indirect and induced jobs to the operation of natural gas pipelines as the cause of new, ongoing economic activity more than a year from the start of operations requires an assumption that workers in those indirect and induced jobs would otherwise be idle. Such an assumption is not realistic: idle workers in the real world typically retrain or relocate to take already open jobs, or they create new employment opportunities for themselves. Those "multiplier effect" jobs, in other words, will most likely exist somewhere with or without the direct jobs in pipeline operations. Operation of a pipeline, in other words, will no more create new jobs in the long run than it will create the methane pumped through it.

When it comes to estimates of long-term stimulus due to assumed (see below) reductions in lower energy costs due to the operation of new pipelines, input-output analysis and those basing economic benefits on it, run into a double bind. On the one hand, and for the reasons just discussed, input-output analysis should not be used to estimate longer-term effects of lower energy prices in the first place.

The bigger issue is that, ironically, these models assume that there are no changes in relative prices and no input substitution. Thus even if a change in the price of energy occurs, or if the price of natural gas drops relative to the price of other fuels, the assumption of no input substitutions means that manufacturers and other energy users cannot switch to the lower cost fuel, nor can they change production and other processes in ways that take advantage of the lower energy prices.

For residential consumers, whom several applicants claim will benefit from pipeline-induced reductions in energy prices, the situation is similar. Assuming such reductions materialize, there could be cost savings for energy users in the real economy as people respond to the changes in relative prices. People might respond by putting off an upgrade to a more energy-efficient furnace, for example. Or they might respond by selecting less-expensive, but more poorly insulating, windows for their home renovation project. Afterall, if energy gets cheaper relative to the cost of other goods, there will be less reason to use it as efficiently as possible.

But the input-output models employed by pipeline applicants to generate numeric estimates of assumed benefits are not the real world. Because the models do not allow for input substitution, the only thing

consumers in the models can do with their energy savings is buy more of everything, including more energy, more new furnaces, and more higher-quality replacement windows. Moreover, these models assume that consumers' desire for the same exact bundle of goods and services can never be sated. At no point do people get enough new furnaces and shift their spending into more elaborate vacations (perhaps to places where they can escape the now excessive heat in their homes), into saving for retirement, or into their children's college tuition.

In short, and in the words of H.W. Richardson (1985) it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection (Richardson 1985)." With regard to pipeline certification, the Commission simply must require better information and analysis rooted in more appropriate models, such as computable general equilibrium, systems models and others, that are more likely to approximate the behavior of economic agents confronted with changes that new pipelines may bring.

Direct effects of added pipeline capacity have not been proven.

In the estimation of several pipeline applicants, reduced energy prices is an assumed initial economic change that constitutes direct economic benefits to energy users that, if acted upon via input substitution, stimulates additional direct, indirect and induced effects. Clearly two critically important considerations for evaluating claims of such benefits is whether or not new pipeline capacity does, in fact, result in persistent reductions in energy prices and whether or not new pipeline capacity results in greater output, employment, or income in energy-intensive industries or in the broader economy.

Key-Log Economics is currently conducting a thorough, retrospective, statistical analysis of the experience of the region affected by the Marcellus Shale-based boom in natural gas availability and natural gas pipeline construction since 2000. We look forward to sharing our research results with the Commission at a later date, but we include here some preliminary observations that bear on the question of whether and how natural gas transmission capacity affects natural gas and/or electricity prices. Namely, while natural gas prices have been falling for end users during the Marcellus Shale boom, electricity prices have not.

From 2001 through 2015—a period encompassing the beginning of the Marcellus Shale gas boom—the total natural gas transmission capacity available in the Marcellus region increased from 20,195 million cubic feet per day (Mmcfd) in 2001 to 1,098,894 Mmcfd (citation). That is an increase of more than 5,300%. If the contentions that increased pipeline capacity drives down electricity prices were true, we would expect to see dramatically lower electricity prices during this same period. What we observe, however, is the opposite: total electricity prices (including residential, commercial, and industrial customers for utilities), have increased from an average of 69.62$/MWh in 2001 to 98.80$/MWh in 2015 (in inflation-adjusted 2017$)—a 42% increase. For residential customers, the price increase was 36%, from 86.65$/MWh in 2001 to 118.12 $/MWh in 2015 (in 2017 $) (U.S. Energy Information Administration, 2017). During the same time period, however, the average price of natural gas to end users (i.e. "distribution price") did fall from $9.04/Mcf to $4.80/Mcf (in 2017$) (U.S. Energy Information Administration, 2018).

Again, these are simply raw observations from the data, but they do call into question the assumption that natural gas transmission capacity, in and of itself, can bring about lower end-user electricity prices and, farther downstream, positive job and income benefits in manufacturing and other sectors.

Pipeline externalities are often discounted or ignored

However large or small the output, employment, and income impacts associated with new interstate natural gas pipelines, economic efficiency demands, and FERC's own policy requires, that the costs as well as any benefits of projects be thoroughly considered before certification. Unfortunately, the Commission and applicants routinely fail to seriously consider the external costs—that is, the residual adverse effects—of the proposed projects.

These costs can be significant and staggering. Key-Log Economics has developed conservative estimates of various external costs of several recently proposed pipeline and other natural gas infrastructure projects. Please see Table 1, below, for a summary of these estimates and the referenced studies for detailed descriptions of the the methods, data, and assumptions specific to each case.[11]

We and other organizations have provided these estimates in comments on the projects respective dockets and have observed that the Commission itself has not provided any substantive response to the enumeration and valuation of most of the external costs of the projects. In the Final Environmental Impact Statements (FEISs) for the Atlantic Coast and Mountain Valley Pipelines, for example, the Commission ignores entirely the loss of ecosystem service value and the potential impact on recreation/tourism income and amenity-based development.

And where the Commission does focus some attention, which is on possible effects on property values, it simply repeats a selective and inadequate reading of the literature and echo's applicant's contention that pipelines have no effect on the value of nearby properties. Particularly troubling is that the Commission continues to rely on deeply flawed studies sponsored by INGAA. I have provided a substantive critique of these studies in previous comments to the Commission and include an updated version of that critique at the end of this section. I will first provide a brief review of some of the other impacts of natural gas pipelines and other infrastructure routinely discounted or completely ignored by the Commission in its deliberations and decisions.

Ecosystem Services: FERC should evaluate the potential loss of human benefit due to pipeline-induced land conversion.

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, 2005). According to a White Memorandum titled "Incorporating Ecosystem Services into Federal Decision Making" (Donovan, Goldfuss, & Holdren, 2015), ecosystem services are "benefits that flow from nature to people." They include tangible physical quantities, such as food, timber, and clean drinking water, life support functions like assimilating waste that ends up in air and water or on the land, as well as aesthetics, recreational opportunities, and other benefits of a more cultural, social, or spiritual nature.

[11] Each of these studies is available for download from http://keylogeconomics.com/natural-gas-development-and-transmission/

Table 1: Summary of Cost Estimates for Several Proposed Interstate Natural Gas Transmission Projects.

Estimated impacts (costs)	Atlantic Coast Pipeline[a]	Mountain Valley Pipeline[b]	PennEast Pipeline[c]	Atlantic Sunrise Pipeline[d]	Millennium Eastern System Upgrade[e]
Lost Property Value (one-time cost)	$57.8 - 83.0 million	$43.7 - 55.2 million	$165.1 - 183.4 million	Not Estimated	$2.1 million
Lost Property Tax Revenue (Annual loss for the life of the project)	$0.29 - 0.42 million	$.25 - 0.32 million	$2.8 - 3.1 million	Not Estimated	$0.0376 million
Lost Ecosystem Service Value during Construction (one-time)	$17.5 - 63.2 million	$23.6 - 85.0 million	$6.5 - 22.8 million	$6.3 - 23.1 million	Not Estimated
Lost Ecosystem Service Value during Operation (annual)	$5.0 - 18.4 million	$4.2 - 15.3 million	$2.5 - 9.3 million	$3.0 - 11.4 million	Not Estimated
Forgone Economic Development[f] (annual)	$51.3 million 387 jobs	$136.9 million 1,164 jobs	$537.6 million 4,090 jobs	Not Estimated	$85.3 million 745 jobs
Social Cost of Carbon[g] (annual)	Not Estimated	Not Estimated	$301.8 - 2,339.0 million	$466.5 - 3,615.1 million	$51.8 - 434.5 million
Lifetime costs in Present Discounted Value	$9.5 - 11.8 billion	$23.7 - 25.8 billion	$14.5 - 60.3 billion[h]	$22.2 - 95.1 billion[h]	$4.9 - 19.5 billion

Sources and Notes:

a. Phillips, Bottorff, and Wang (2016). The study scope covered four Virginia counties and approximately 20% of the overall length of the pipeline.
b. Phillips, Wang, and Bottorff (2016). The study covered three West Virginia and five Virginia counties, and approximately 50% of the overall length of the pipeline.
c. Phillips, Wang, and Bottorff (2017)
d. Phillips, Wang, and Alkire (2017a)
e. Phillips, Wang, and Alkire (2017b)

f. Includes lost visitor spending and related state and local taxes, lost retirement income, and lost proprietors' income. Job and income losses are direct only (no multiplier effects).
g. The range of estimates for the social cost of carbon reflect different assumptions about how heavily future costs are discounted as well as differences over time in the impact of each tonne of CO_2 equivalent emitted.
h. Economic development impacts were not included in the PDV calculations for these pipelines.

If ecosystem services are the products of nature, then ecosystems themselves—the land—are the factories where those products and values are produced. Just as with different man made factories, different types of ecosystems (forest, wetland, cropland, urban areas) 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.

By similar reasoning, a changes in ecosystems or more fundamentally, changes in land use, will change the type, amount, and value of the ecosystem services produced in the affected area. In the case of natural gas transmission pipelines, there is the conversion in the short run of all land in the construction zone from forests, cropland, urban open space, and other productive uses to barren land with very little, if any ecosystem service value.

In the longer run, a portion of the construction zone will revert to its pre-disturbance land cover, though the effects of soil compaction, introduction of invasive species, etc. may make even reverted land formerly in the construction zone less productive. In the right-of-way however, land that had been forested before construction, will revert to the (less productive) land cover of grassland, or perhaps shrub scrub, depending on the frequency of mowing to keep the right-of-way free of trees.

Cropland in the ROW could revert to cropland, but if there are restrictions on the weight of vehicles that can be operated on top of the buried pipeline, it may turn out to be the case that cropland reverts, at best, to pastureland. Moreover, there could be long-standing harm to agricultural productivity due to soil compaction, soil temperature changes, and alteration of drainage patterns due to pipeline construction. As agronomist Richard Fitzgerald (2015) concludes in the context of another proposed pipeline, "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 the pipeline]." In the path of the PennEast pipeline, grower Ron Fulper of West Amwell, New Jersey has seen "very low [corn] yields" in the portion of his fields crossed by an existing natural gas pipeline (Colaneri, 2015).

By applying per-acre ecosystem service productivity estimates (denominated in dollars per acre per year) to the various arrays of ecosystem service types, one can estimate ecosystem service value produced per year in the periods before, during, and after construction. The difference between annual ecosystem service value during construction and 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.

FERC's failure to include an analysis of ecosystem services lost due to the construction and operation of pipelines has been is a glaring example of inadequacy of FERC's "traditional" conflation of the interests of landowners and surrounding communities with environmental impacts. The exclusion of ecosystem service losses means that many of the economic consequences of environmental effects, not to mention many environmental effects, have not been considered at all. This shortcoming renders many, if not all

FERC environmental assessments DEIS inadequate for informing decision making about natural gas transmission infrastructure.

As it revises its certification policy, FERC should develop the capacity to undertake its own assessments of the ecosystem services impacts of its proposed action. Such a review would be consistent with current executive branch direction and coming implementation guidance (Donovan, Goldfuss, & Holdren, 2015). FERC should follow the lead of other agencies and use existing resources, such as *Federal Resource Management and Ecosystem Services* (National Ecosystem Services Partnership, n.d.) and *Best Practices for Integrating Ecosystem Services into Federal Decision Making* (Olander et al., 2015) in its review. Such a review would help ensure that these important environmental effects (and their economic consequences) are no longer ignored in FERC's decision making.

Social Cost of Carbon: FERC should account for the upstream and downstream impacts of CO2 emissions facilitated by each natural gas transmission project.

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 or EA 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).

FERC must count this significant cost among the effects of the proposed pipeline.

Public Health: FERC should account for impacts on health and related societal costs of emissions from compressor stations and other infrastructure.

Compressor stations have been implicated in a variety of illnesses among nearby residents. (Subra, 2009, 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 have 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).

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

FERC's review of each pipeline and infrastructure project should include an estimates of the exposure to noise and pollutants and the expected costs of any resulting illnesses. These costs would include the cost of treating illnesses, the cost of lost work, and impacts on the quality of life.

Air emissions associated with natural gas production and transmission can also 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).

Property Value: FERC must inform and update its understanding of the effect of pipelines on property.

In several EISs, FERC repeats applicants contention that natural gas pipelines have, at most, an ambiguous and non-permanent effect on property values. The Commission relies on studies including Allen, Williford & Seale Inc. (2001), Fruits (2008), Palmer (2008), and Diskin et al. (2011). While the studies differ in methods, they are similar in that each fails to take into account two factors potentially voiding their conclusions entirely. First, the studies do not 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 have to have full information about the subject properties, including whether the properties are near a pipeline.

Second, and for the most part, 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. 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 a proposed pipeline would have.

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

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 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 had full information, which was not the case in the study.

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 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, citizens' 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 for the PennEast pipeline, for example, PennEast, 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" (2015). This is grossly misleading and plainly illogical. One cannot conclude a lack of a negative effect from the fact that home sellers do not typically, and counter to 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 one is trying to sell. 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.

PennEast 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 PennEast LLC does not understand rational buyer/seller behaviour, 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 do 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 (or any other) pipeline to learn of its presence and, therefore, for the pipelines to affect home buyers' 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 is likely to 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 pipeline 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 have 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 a pipeline will be lower than the prices offered for other homes farther away or in another community or region.

Studies concluding that proximity to pipelines does not result in different property values do not actually compare prices for properties that are different.

While the studies typically cited in Resource Reports 5 and FERC's Draft and Final EISs 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 that the studies count 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. However, in almost all cases 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).[12]

In the 2016 INGAA study, the specific distance from pipeline was reported for eight case studies. In those cases, an average of 72.5% of the "off" properties were actually within the evacuation zone and, like the "on" properties, are therefore likely to suffer a loss in property value relative to properties farther away. (I have based my estimates of the evacuation zones on available information about the pipelines' diameter and operating pressures.) For the other two cases, the study reported a simple "yes" or "no" to indicate whether the property abutted the pipeline in question. For these cases, I assume the

[12] 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).

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 the feature. It is a case where comparing apples and oranges is not only reasonable, but also essential. In the case of these studies, there is little to no variation in the feature of interest (i.e., the majority of properties are within the evacuation zone). The studies are looking at and comparing only "apples." In this case, the feature of interest is the presence of a nearby risk to health and safety. With no variation in that feature, a systematic variation in the price of the properties would not be expected. By comparing apples to apples when it should be 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, other studies commonly cited by FERC and pipeline applicants suffer from the same problem. Fruits (2008), who analyzes properties within one mile of a pipeline that has 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 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. (It should go without saying that 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 the next section) 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.

Better information about the effect of pipelines on property values is available.

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. His key findings include the following.

- 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" (Kielisch, 2015, p. 7). Considering only those buyers who are still willing to purchase the property, the expected loss in market value would be 10.5%.[13] 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%.[14] In our estimates (see below), 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.

Kielisch's findings demonstrate that properties on natural gas pipeline rights-of-way suffer a loss in property value. Boxall, Chan, and McMillan (2005), 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" of sour gas[15] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

The risks posed by interstate natural gas transmission pipelines would be different–they would not be carrying sour gas, for example–but there are similarities that make Boxall et al.'s finding particularly relevant. Namely, the emergency plan response zones (EPZs) are defined by the health and safety risks posed by the gas operations and infrastructure. Also, and in contrast to the studies often cited by FERC which show no price effect the Boxall study examines prices of properties for which landowners must inform prospective buyers when one or more EPZs intersect the property.

In addition to the emerging body of evidence that there is a negative relationship between natural gas infrastructure and property value, there have been many analyses demonstrating the opposite analog. Namely, it is well-established that amenities such as scenic vistas, access to recreational resources, proximity to protected areas, cleaner water, and others convey positive value to real property.[16] There are also studies demonstrating a negative impact on land value of various other types of nuisance that impose noise, light, air, and water pollution, life safety risks, and lesser human health risks on nearby residents (Bixuan Sun, 2013; Bolton & Sick, 1999; Boxall et al., 2005). The bottom line is that people

[13] 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%.
[14] This is the expected value calculated as 0.622*(-100%)+0.189*(-21%)+0.189*(0%).
[15] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.
[16] Phillips (2004) is one such study that includes an extensive review of the literature on the topic.

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.

Table 1, above, includes estimates based on the results established by Kielisch (2015) and Boxall, Chan, McMillan (2005) for several recently proposed pipelines.

Conclusion

In conclusion, FERC should update/upgrade both its policy, its capacity, and its practice regarding the economic effects of new interstate natural gas pipelines. To ensure that future certification decisions result in efficient use of land and other natural resource, FERC must establish procedures, and install analytical capacity sufficient to provide independent, rigorous, and credible analysis of the benefit claims promoted by pipeline applicants. It must also conduct (or contract to have conducted) thorough analyses of the external economic costs likely to result from the construction, presence, and operation of each pipeline. For any pipelines approved on efficiency grounds (i.e. benefits exceed costs), FERC should further ensure that the successful certification application pays compensation to the parties harmed by those external costs. Finally, to prevent problems of overcapacity and the associated problems of accelerated climate change and a delayed transition to safer, cleaner, more renewable fuels, FERC should ensure that all new pipeline capacity applications are considered in the context of existing (and previously certified) capacity in the entire gas transmission system.

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People's Dossier: FERC's Abuses of Power and Law →Economic Harms

Economic Harms Attachment 9, Key-Log Economics, LLC, The Social Cost of Carbon of the Adelphia Gateway Project, February 2019.

KEY-LOG ECONOMICS

Research and strategy for the land community

The Social Cost of Carbon and the Adelphia Gateway Project

FERC ignores Costs of Natural Gas Transmission

Spencer Phillips, Ph.D., & Sonia Wang | February 2019

Policy Setting

As we have previously reported, the Federal Energy Regulatory Commission's (FERC), environmental and economic review of natural gas transmission projects has been inadequate in two key respects: FERC's unqualified and uncritical acceptance of applicants' claims that new pipeline capacity will produce economic benefits; and FERC's equally unqualified and uncritical disregard for likely, significant, and economically costly external effects (Philips, 2018). These effects include

- diminished property value within the high consequence area and evacuation zones surrounding pipelines and in the vicinity of new compressor stations;
- lost ecosystem service value as natural areas are converted from forests to shrublands, from open space to industrial zones, or from more to less productive agricultural land;
- dampened economic development opportunity in communities dependent on a safe, clean, natural environment to support recreation and tourism business and to attract amenity migrants and retirees; and
- the cost of upstream and downstream greenhouse emissions that are facilitated by more natural gas transmission.

These costs, conservatively estimated, can run into tens of billions of dollars over their designed lifetime. See, for example, analyses done for the following projects to see the costs and methods used to calculate: the Mountain Valley Pipeline, PennEast Pipeline, and the Millenium Eastern System Upgrade project (Phillips, 2018). (Please see Appendix A a full copy of that report.)

While we have not produced estimates of the full suite of the external costs of the Adelphia Gateway Project (AGP, or "the Project"), we do provide, below, estimates and analysis of the Social Cost of Carbon (SCC) associated with the Project.

FERC, for its part, does acknowledge that the Adelphia Project will entail greenhouse gas emissions both from operations and from the use of the natural gas transported (FERC, 2019). The Commission further acknowledges that methods exist for calculating the incremental impact of a given quantity of greenhouse gas emissions, and references the "Social Cost of Carbon methodology" specifically, stating

> We recognize that the SCC methodology does constitute a tool that can be used to estimate incremental physical climate change impacts, either on the national or global scale. The integrated assessment models underlying the SCC tool were developed to estimate certain global and regional physical climate change impacts due to incremental GHG emissions under Indicated specific socioeconomic scenarios. (FERC, 2019, p. 172)

And, being a tool for estimating the social COST of carbon, SCC is similarly suitable for estimating the incremental economic impact of incremental GHG emissions. Because the AGP would result in incremental GHG emissions (see FERC, 2019, Table B-21, p. 128), it follows that the costs associated with those emissions should be counted among the costs of the overall project. In the parlance of FERC's existing policy on the certification of new pipelines, such costs would be among the "residual adverse effects" (88 FERC 61,227, p. 19) of the Adelphia project and, also per the policy, "projects that 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" (88 FERC 61,227, p. 23).

Such a policy is precisely what standard economic reasoning would applaud: doing things or permitting activities when the benefits outweigh the costs can be presumed to be economically "good" or more technically, "efficient". Conversely, doing/permitting things when the costs are greater than the benefits would be "bad" or "inefficient". The latter is bad, economically, because it results in a misallocation of limited resources, including land and the capacity of the atmosphere to absorb or assimilate GHG emissions, away from uses that would, potentially, produce more benefits than damages.

It is fundamentally important that those purporting to make decisions about what is good and bad for society do so with a full set of facts. In this case, that means actually estimating and weighing the societal costs of the AGP. FERC should have used SCC and/or other tools to determine the extent to which a project may have "residual adverse effects" and to estimate the magnitude of those effects. Completion of such an analysis would begin to make it possible that the Commission's later decisions on whether or not to to certify the project would be informed by relevant facts.

In this case, and as we have observed in previous cases, FERC fails to develop the relevant facts and, therefore, to prepare the Commission to make a fully informed decision regarding whether or not the Adelphia Gateway Project should be approved. Rather than presenting SCC results or an alternative appropriate assessment, the writers of Environmental Assessment (EA) for the AGP claim that the SCC itself is not ideal for the purposes of assessing the GHG cost of the project and "As such, FERC staff did not use the SCC tool in this NEPA analysis" (FERC 2019, p. 177).

FERC lists three excuses for this decision, none of which bear up to scrutiny, but all of which belie issues documented in our previous research (see Appendix A) that FERC and, specifically, the Office of Energy Projects which is responsible for the AGP EA, lack the capacity to provide meaningful analysis of of the economic costs and benefits of natural gas transmission projects. The excuses are that

> (1) the incorporation of the SCC tool into our review under NEPA cannot meaningfully inform the Commission's decision whether and how to authorize a proposed project under the NGA;
>
> (2) the Commission does not use monetized cost-benefit analyses as part of the review under NEPA or the decision under the NGA; and
>
> (3) the SCC tool has methodological limitations (e.g., different discount rates introduce substantial variation in results and no basis exists to designate a particular monetized value as significant) that limit the tool's usefulness in the review under NEPA and the decision under the NGA.

The first of these excuses is an admission that the writers do not have the capacity to make meaning out of SCC results. The second directly contradict the Commission's policy on pipeline certification found at

88 FERC 61,227. And the first and third are absurd from an economic and scientific perspective. Facts about the residual adverse impacts of the Project are exactly what is meaningful to the Commission's decision. If the FERC staff cannot present those facts in a meaningful way, they should add capacity, either on staff or via contractors, to do the Commission and the public the necessary service.

If the standard is to ignore economic information developed using any tools that have methodological limitations, then one would expect to not see the Commission employ estimates of the economic impact of natural gas transmission projects in its decision-making. (See Appendix A for details on the limitations of economic impact models.) While this EA does not explicitly state how it arrives at the conclusion (i.e., what data and models were used or what the methodological limitations of their methods might be), the EA does present information about direct employment changes during Project construction and operation, and it states that both construction and operation would have "negligible" impacts on employment/unemployment rates in the area.

We do not aim to support or to dispute that particular conclusion (though it does seem reasonable that such a small project will not have significant positive employment or other economic impacts in the region). What we do find objectionable is that where what might be the best available data pertains to the potential (even if negligible) benefits of the AGP, FERC staff see no reason to ignore the data, but where the best available data pertain to the costs of the AGP, "methodological limitation" are suddenly an excuse to ignore the data entirely.

As statistician George Box famously wrote "All models are wrong; some are useful." It follows then, from FERC's rational quoted above that all statistical estimates, scientific inferences, and economic insights that could and should bear on the environmental and economic implications of AGP must be dismissed as not "useful" to the Commission's deliberations. We do not, of course, advocate that approach. Rather, as suggested above, we would recommend that FERC acquire or hire the capacity to engage in a meaningful and useful way with the scientific and economic models, literature, and insights that do legitimately bear on the Commission's work and, thereby, the health, safety, and economic costs and benefits of natural gas transmission pipelines.

That information should include estimates of the full external costs of transmission projects (see Appendix A), including the cost of GHG emissions associated with the projects, including both upstream and downstream emissions.

The Social Cost of Carbon

As FERC acknowledges, the Social Cost of Carbon is one way to get at the economic effects of incremental GHG emissions. 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 or EA 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).

In 2009, the Interagency Working Group on the Social Cost of Greenhouse Gasses ("Working Group") was assembled to develop estimates of the social cost of carbon (SCC), a measure that quantifies the economic cost of harm associated with releasing carbon dioxide into the atmosphere (Resources for the Future, 2010). The Working Group assessment of the SCC marks the first effort made by the federal government to develop a consistent approach for calculating and evaluating societal benefits of reducing greenhouse gas emissions in regulatory cost-benefit analysis (Resources for the Future, 2010).

According to the Working Group, which uses "SC-CO2" for what we and FERC staff have called "SCC",

> The SC-CO2 is meant to be a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. However, given current modeling and data limitations, it does not include all important damages. The IPCC Fifth Assessment report observed that **SC-CO2 estimates omit various impacts that would likely increase damages**. The models used to develop SC-CO2 estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research. **Nonetheless, the current estimates of the SC-CO2 are a useful measure to assess the climate impacts of CO2 emission changes** (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2016, emphasis added).[1]

In the original 2010 Technical Support Document on the Social Cost of Carbon (TSD) (Interagency Working Group on Social Cost of Carbon, United States Government, 2010), the working group established SCC values, expressed in terms of dollars per metric ton (tonne, or MT) of carbon dioxide equivalent (CO2E) for GHG emissions occurring in years up until 2050 (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2016). Three of the SCC values are based on averages from three integrated assessment models (IAMs), at discount rates of 2.5, 3, and 5 percent discount rates (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2016). The fourth SCC value, the 95th percentile at a 3 percent discount rate, is included to represent a "low probability, high impact" scenario, or in other words, higher than expected impacts from increases in temperature (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2016).[2]

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[1] Note, with regard to the point about about the use of scientific information in the previous section, that the Working Group acknowledges the limitations of its model, omits some economic effects about which the information is not yet sufficiently precise, but still is able to provide a useful model for others to use in decision making. The Working Group does not throw out the entire model because it is imperfect. Rather it uses the best available information while recognizing that there may be other costs not reflected in the SC-CO2/SCC model results.

[2] The different discount rates affect the the extent to which future costs are considered from the point of view of the present day. Higher discount rates, as the name implies, means that future effects will be discounted more severely than would be the case for lower discount rates. At one extreme, a discount rate of 0% means that the monetary value of the effects of GHG emissions that will not occur until 2050 are just as important, economically,

The interagency working group has revised the TSD three times since the original 2010 report, in 2013, 2015, and 2016. The revisions incorporate changes to the SCC due to updates in the IAMs and the most recent TSD includes additional discussions regarding the uncertainties of the estimates as suggested by the National Academy of Sciences, Engineering, and Medicine (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2016). Table 1 provides the most recent SCC estimates from the 2016 TSD and the new interim guidance estimates.

Table 1. Annual Estimates of the Social Cost of Carbon Under Interagency Guidance and under New Interim Guidance, 2015 - 2050. (All figures adjusted for inflation to 2018$).

	Interagency Working Group Guidance			Based on new Interim Guidance	
Year	Average SCC 5% discount	Average SCC 2.5% discount	High, 95th percentile, SCC 3% discount	Average SCC 3% discount	Average SCC 7% discount
2020	$14.54	$75.10	$148.99	$6.70	$1.09
2025	$16.96	$82.37	$167.16	$7.81	$1.09
2030	$19.38	$88.43	$184.12	$7.81	$1.09
2035	$21.80	$94.48	$203.50	$8.93	$1.09
2040	$25.44	$101.75	$221.67	$10.05	$2.18
2045	$27.86	$107.81	$238.63	$10.05	$2.18
2050	$31.49	$115.08	$256.80	$11.16	$2.18

as the effects of GHG emissions today. At the other extreme, a discount rate of 100% means that any and all future financial losses due to GHG emissions are of no importance at all to the people living today.

The choice of discount rates for public decision making has been a raging debate in environmental economics for decades, and we do not attempt to solve that here. But as we see in Tables 1 and 2, below, the choice can result in large changes in the estimates of the future cost, in present value terms, of future GHG emissions.

Source: Adapted from the U.S. Environmental Protection Agency, 2016 & 2017)

It is worth noting that many believe that the SCC understates the full economic cost of GHG emissions, a point that the Working Group concedes in the quote above.

> At the time, some researchers and environmentalists criticized the Obama number for being incomplete. It did not, for example, fully account for many plausible climate impacts like damage from increased wildfires or the loss of diverse ecosystems. In one survey of climate economists from 2015, 51 percent of respondents said the number was probably too low. Only 9 percent said it was probably too high.
>
> —Brad Plumer, New York Times, 23 August, 2018

This criticism, FERC should note, does not suggest that the SCC has no value for decisonmaking. Rather, it simply reinforces the notion that SCC produces conservative estimates.

In 2017, President Trump disbanded the interagency work group and tasked the EPA with producing new interim SCC numbers based only on damages occurring within domestic borders, and using 3% and 7% discount rates (Table 1) (Plumer, 2018 & U.S. Environmental Protection Agency, 2017). Clearly this directive results in radically lower estimates of the cost of each tonne of GHG emitted.

By focusing only on potential climate change related costs in the United States, the Trump Administration is ignoring the fact that climate change is a global issue and that emissions created in the U.S. have the ability to affect other global states and vice versa. If the U.S. disregards emissions impacts on other countries, the U.S. is setting the precedent for other countries to do the same (Plumer, 2018). Furthermore, the reality is that future climate change impacts will have an effect on the United States. According to the National Academy of Sciences, “Climate change in other regions of the world could affect the United States through such pathways as global migration, economic destabilization, and political destabilization” (National Academies of Sciences, 2017).

In the new interim SCC estimates, the EPA also uses different discount rates to estimate the future impacts of climate change. A discount rate is used to value costs and benefits across time, or in other words, what is the opportunity cost of spending money today to fight climate change impacts in the future. A higher discount rate, like the 7% discount rate used in the new interim SCC estimate, results in a lower social cost for carbon. Economists, however, argue that higher discount rates are not appropriate for addressing long-range problems like climate change because issues like ocean acidification or melting ice caps can have effects lasting centuries (Plumer, 2018)[2].

Setting aside the question of whether the assumptions or policy choices embodied in the Trump Administrative directive are scientifically or economically appropriate, we do use the new interim estimates as well as the old guidance in our methods below so that readers can have a sense of the possible range of SCC effects due to the AGP.

Methods

Estimating SCC for the Project requires information on the per-tonne cost of GHG emissions described above as well as estimates of the incremental GHG emissions of the Project. If completed, the AGP will have result in the transport of a total of 850 million cubic feet (MCF) of natural gas per day. Some of this is existing capacity being acquired, and some is new capacity developed through the construction of

pipelines, compressor stations, and other infrastructure (Federal Energy Regulatory Commission, 2019). Of this total, 325 MCF/day is new or incremental capacity created by the project. That includes an additional 250 MCF/day along the southern end of the existing mainline and an increase of 75 MCF/day along the northern segment (Federal Energy Regulatory Commission, 2019).

Adelphia expects the project to become fully operational in the fourth quarter of 2019 (Federal Energy Regulatory Commission, 2019). For our calculations we assume a 2020 start date for the project and a 30-year operational period. We use the 5% average, 2.5% average, and the 3% 95th percentile discount rate estimates provided by the 2016 interagency Working Group estimates, as well as the new estimates developed under the new interim guidance from the Trump Administration (Table 1). "Average" here refers to the average of estimated costs in future years, as provided by the IAMs themselves. The 95th percentile estimate is an estimate below which 95% of estimates from those models would expect to fall and therefore represents a high estimate of possible SCC. Because per-tonne SCC estimates are reported for only every fifth year, we interpolate the SCC statistic for the intervening years, assuming a uniform increase from year to year.

We calculate SCC due to the AGP for each year from 2020 through 2050 by the following steps (with 2020 and the "average, 5% discount" scenario as the specific example[3]:

1. Determine additional annual natural gas use, in dekatherms (dth), due to AGP:

   (Incremental Capacity/day) / 10 (dth/MCF) x 365 (days/year) = added natural gas use (dth/year)

   325 (MCF/day) / 10 (dth/MCF) x 365 (days/year) = 118,625,000 (dth/year)

2. Multiply annual natural gas use times a conversion factor to convert MCF natural gas into CO2E emissions

   118,625,000 (dekatherms/year) x .053 (MT C02E/dth) = 6,287,125 (MT C02E/year)

   where 0.53 is tonnes (MT) C02E per dekatherm (US EPA, 2015)

3. Multiply GHG emissions (now in CO2E) by the per-tonne SCC estimate(s)

   6,287,125 (MT C02E) x $14.54 (2018$/MT CO2E) = $91.4 million (2018$)

For each year of AGP operation, this calculation yields an estimate of the cost to society of GHG emissions in that year, but in dollars that, due to the discounting (and to a lesser degree the adjustment for inflation) can make sense to decisionmakers today. If we sum those estimates across all years of operation (i.e., 2020 through 2050), we obtain an estimate of the total SCC for the AGP.

[3] In this example, $14.54 is the per-tonne SCC estimate representing the average IAM output and using a 5% discount rate for emissions occurring in year 2020, and adjusted for inflation from the 2007 original estimates to be expressed in 2018 dollars.

Results and Discussion

The AGP's 325 MCF per day translates to 6.3 million metric tons of CO2E in GHG in each year of operation. Using the 5% average, 2.5% average, and the 3% 95th percentile discount rate estimates provided in Table 2, the SCC of the incremental capacity added by the project over the 30-year operation period ranges from $4.4 to $40.0 billion (2018$). Under the Trump Administration's new guidance, these estimates drop to a range of $0.3 to $1.7 billion.

Table 2. Summary SCC estimates for the Adelphia Gateway Project's 30-year operational period, in millions of 2018$.

	Interagency Working Group Guidance			Based on new Interim Guidance	
Total CO2 Emissions	Average SCC 5% discount	Average SCC 2.5% discount	High, 95th percentile, SCC 3% discount	Average SCC 3% discount	Average SCC 7% discount
194,900,875	4,371.4	18,513.8	39,563.7	308.8	1,740.6

It is important to note that these are low estimates of what would be the actual social cost of carbon associated with the AGP, and why. First, the methods here assume that each MCF makes it through the pipeline and is combusted for heating, power generation, or some other useful purpose. The reality is that some of the methane will leak from the pipes, valves, and other facilities, and some will be deliberately released during blowdowns at the compressor stations. Because methane is a GHG 86 times more potent than carbon dioxide in the coming decades run and 34 times more potent over the next century (Intergovernmental Panel on Climate Change, via Vaidyanathan, 2015), the leaks, blowdowns, and other fugitive emissions will have a much greater impact on climate change than will the CO2 released as a product of methane combustion by its end users.

In addition, and to the extent that excess natural gas transmission capacity[4] would induce the development, extraction, and delivery of more natural gas than would otherwise be the case. Thus the AGP would be responsible for some additional "upstream" GHG emissions. The upstream GHG/SCC effects of certifying the AGP, therefore, would include not only the GHG emissions associated with the use of the gas transported, but also those emissions associated with the extraction of the gas in the first instance. These emissions would include the following

- emissions from the use of diesel and gasoline in equipment used to clear and developwell pads,

[4] This is capacity in excess of the economically efficient level one would identify if all of the external costs of natural gas transmission infrastructure were counted and paid for in the course of building and operating pipelines. See Appendix A.

- emissions from vehicles used by workers to commute to and from the well sites
- emissions from vehicles used to transport hydraulic fracking chemicals and water to and from well sites,
- loss of carbon sequestration provided by trees cleared from drilling sites, and
- operation of pumping, compression, and other equipment used to move gas from the wells to interstate natural gas transmission pipelines.

Each of these contributes to the GHG emissions associated with the regional natural gas development, transmission, and consumption system to which AGP would add, and it would be reasonable to allocate some portion of those emissions to the AGP itself. A full accounting for these upstream effects would therefore result in higher SCC estimates for the project than those we have developed in this short paper.

As we have argued previously (see Appendix A), a comprehensive, systematic or programmatic review of the natural gas transmission system serving or tapping into the Marcellus Shale is needed before any of the pipeline projects now under construction or under consideration could possibly be determined to be in the public interest. Such a review would consider both needs and impacts, or both benefits and costs. And it would enable and encourage the use of the best available information and tools for estimating all of the external environmental and social effects—upstream, midstream, and downstream—of the region's natural gas systems.

Even at the extreme low end of the SCC estimates presented in Table 2, the economic losses associated with the GHG emissions facilitated by the proposed AGP are far from trivial. If we were to follow the "polluter pays principle" and implement climate change mitigation policies that internalize the external costs of GHG emissions, AGP's owners would be rightly concerned to see the addition of even a $309 million line item to the liabilities on the company's balance sheet, and the possibility of facing the risk of nearly $40 billion in liabilities should be downright chilling on shareholders' enthusiasm for the project.

But we do not yet have such policies in place to ensure that private corporations' actions do not inflict undue harm on the rest of society. We instead have regulators, like FERC, who are supposed to be looking out for the public interest. Were FERC fulfilling that role, it would conduct analyses and make decisions to ensure that projects under its jurisdiction "would be approved only where the public benefits achieved from the project can be found to outweigh adverse effects" (88 FERC 61,227, p. 23). But as outlined in the first section, FERC staff preclude the consideration of SCC, making it impossible for FERC to perform due diligence with respect to the adverse effects of pipelines and, therefore, to render decisions that yield economically desirable outcomes.

The impact of FERC's failure to consider SCC is multiplied by the failure in the EA to adequately consider (or to even mention) other external costs, including lost ecosystem services, diminished property values, and others listed above. (Please see "Pipeline externalities are often discounted or ignored" pp. 13-22, of the attached memo for a review of these costs of natural gas transmission projects.)

While we recognize that it has not been FERC's practice to properly consider and count the external costs of natural gas transmission projects, we disagree with FERC staff's inference that FERC's previous failure in this regard should bound the the scope or quality of its analysis of the AGP or any later project. Indeed, the EA references FERC's ruling on the Southeast Market Pipelines Project (Docket Nos. CP14-554-002, CP15-16-003, and CP15-17-002) as part of its rationale for ignoring SCC in the case of the

AGP. In a separate statement regarding that decision, Docket, however, Commissioner LaFleur expressed misgivings regarding the Commission's rejection of climate change impacts as important to its deliberations. "I am troubled", she wrote, "by the manner in which today's order addresses the significance of the downstream GHG emissions. The order fails to even concede that GHG emissions are an indirect impact that must be quantified in NEPA. More broadly, the order asserts that GHG emissions quantifications cannot 'meaningfully inform'" our public interest determination. I fundamentally disagree (LaFleur, 2018, p. 2)."

The Commissioner goes on to explain the National Environmental Policy Act requires that the Commission consider the impact of GHG emissions. In direct contrast to the arguments of FERC staff presented in the EA and outlined above, LaFleur "reject[s] the contention that the Commission is unable to discern the significance of GHG emissions" and notes that "it is our responsibility to use the best information we have" to evaluate the significance of GHG emissions associated with natural gas transmission projects (LaFleur, 2018, p. 2).

Along similar lines, Commissioner LaFleur rejected the full Commission's conclusions regarding the Social Cost of Carbon in particular. She does concede that SCC "as a tool for cost-benefit does not fit neatly within our NEPA review" (LaFleur, 2018, p. 3), but she goes on to explain that the reason for the current lack of a neat fit is that the Commission has not yet developed a record to support that sort of cost-benefit analysis approach to pipeline reviews.

As indicated in the Appendix, such an effort to incorporate rigorous assessment of costs and benefits of proposed natural gas transmission projects is long overdue, and FERC should stop using its past failure to complete such assessments as an excuse for a continued failure to complete them. If one were to follow the logic presented by FERC staff in the AGP EA, such an effort could never start. The staff argument is essentially, that FERC has not used cost-benefit analysis before, and therefore FERC staff will not use it in the current EA (for the AGP). That makes it impossible for the Commission itself to use cost-benefit analysis in its review of the AGP. FERC staff are content to stay in an "infinite loop" of ignorance that guarantees and economically inefficient and environmentally disastrous over-capacity in natural gas transmission and over-use of natural gas as a fuel source.

LaFleur observes that the Commission's objection to incorporation of SCC into its review of the Southeast Markets Pipelines Project (and presumably of other natural gas transmission projects) boils down to the fact that doing so might be difficult (2018). Her response to that is this:

> I agree that consideration of climate change is difficult. That is because climate change is broader in scope and scale than other environmental impacts generally considered in our pipeline reviews. However, **the nature of the issue does not relieve us of the burden of considering it, but rather makes it more important that we do so**. (p.3)

In his separate dissent to FERC's ruling on the same Southeast Markets Pipeline project, Commissioner Glick gets to the heart of the problem with FERC's refusal to use the SCC or similar tools:

> Willful ignorance of readily available analytical tools to support an enhanced qualitative assessment for the single largest environmental threat in our lifetime will undermine informed public comments and informed decisionmaking. Furthermore, the void in evaluating indirect environmental impacts from GHG emission while simultaneously concluding there is no significant impact means the Commission remains in the unstable position of granting

certificates of public convenience and necessity without fully considering the public interest under the NGA.

The predictable result of this dynamic is an economically inefficient—that is, wasteful—over supply of natural gas transmission capacity. Among the long-term damages to the economy will be a landscape littered with abandoned or disused transmission infrastructure, time lost in the needed transmission to more sustainable sources of energy, and of course the economic losses inherent in crop damage, property lost to coastal flooding, excess human illness, and other effects whose costs are counted by the SCC.

We applaud Commissioners LaFleur and Glick for raising this issue and would urge, as a simple matter of sound economic science and good, responsible governance, that FERC now begin the (difficult) process of counting the social cost of carbon as well as the full external environmental costs of natural gas transmission projects under its jurisdiction.

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About

Key-Log Economics, LLC is an independent, employee-owned consultancy that believes that better (more efficient, more just, more sustainable) outcomes are attainable when complete information is available to and used in making decisions that affect human and natural systems. Accordingly, we completed this report, commissioned by Delaware Riverkeeper Network, to augment the amount and quality of information available to FERC, stakeholder groups, and the public regarding certain ecological-economic implications of the proposed Adelphia Gateway Project. We have used the best available data and employed appropriate and feasible estimation techniques and broader research methods throughout. While Key-Log Economics, remains solely responsible for the content of this document, we make no claim regarding the extent to which estimates reported will match the actual magnitude of costs likely to accompany the operation of the Adelphia Gateway Project (should it be approved). Beyond the conclusions stated herein, any inferences or uses of the reported estimates are the responsibility of the reader.

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Appendix A: Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines, and FERC Docket No. PL18-1-000

A copy of this July 2018 report begins on the following page. It's format has been slightly modified from the original.

KEY-LOG. economics LLC

Research and strategy for the land community

Economic Issues related to FERC Policy Regarding Certification of Interstate Natural Gas Pipelines

re: FERC Docket No. PL18-1-000

Spencer Phillips, Ph.D. | July 2018

Based on our analyses of several recent pipeline projects, it is well—and long overdue—that the Federal Energy Regulatory Commission (hereinafter "FERC" or "the Commission") is examining its policy regarding Certification of New Interstate Natural Gas Facilities (Docket No. PL18-1-000). Key-Log Economics is pleased to provide this expert review and comment on the existing certification policy and its application to date. We pay particular attention to the extent to which the Commission's past evaluations and certification decisions have adequately considered the economic consequences of the construction, presence, and operation of interstate natural gas pipelines.

Our question is whether the Commission's policy—as stated or as implemented—typically results in economically sound outcomes in which the public benefits delivered by new interstate natural gas transmission pipelines are likely to exceed the costs imposed on the public. Based on our independent review of several recent proposed pipelines and expansion projects[1] this is a very real and profound concern. Despite the stated intention of FERC's existing policy on "Certification of New Interstate Natural Gas Pipeline Facilities", namely, that projects "would be approved only where the public benefits to be achieved from the project can be found to outweigh the adverse effects" (88 FERC ¶ 61,227), the answer to our question is simply "no": we find no evidence to date that either the Commission's existing policy and its current practice are adequate to ensure the development of an interstate natural gas transportation system in which the public benefits exceed the public costs.

In particular and as detailed below, it is our observation that:

1. The Commission has not adequately assessed the potential public benefits from proposed interstate natural gas pipelines. It instead relies on the claims of projected benefits advanced by project applicants that, in turn, are based on outdated methods that are proven to be useless, at best, for making such projections. The Commission has not conducted its own expert, critical review of these claims, and this leaves the Commission's decisions subject to the same bias inherent in applicants' representations regarding their projects' benefits.

2. The Commission has failed to evaluate the full economic effects, especially external costs—that is, costs borne by third parties like nearby landowners, businesses impacted by pipeline construction and operation, and the general public—of proposed interstate natural gas pipelines. Similar to its lack of due diligence regarding benefit claims, the Commission relies on information about costs that are provided by pipeline applicants and other industry stakeholders, such at the Interstate Natural Gas Association of America (INGAA). Not surprisingly, these vested interests promote the view that proposed pipelines and other projects would result in no damage to natural resources, no associated economic costs, and no adverse economic effects on the "surrounding communities" that are among the stated interests of FERC's policy (88 FERC ¶ 61,227, p. 24).

[1] These include the proposed Atlantic Coast, Mountain Valley, PennEast, and Atlantic Sunrise pipelines, and the Millenium Eastern System Upgrade. Examples referenced in these comments are drawn primarily from these cases.

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A contributing factor to both of these failures is the Commission's lack of capacity even to critically review and evaluate the economic information the Commission does receive, let alone to conduct analyses of its own. The Office of Energy Projects (OEP), whose "mission…is to foster economic and environmental benefits for the nation through the approval and oversight of hydroelectric and natural gas pipeline energy projects that are in the public interest"[2] has no economists among its staff.[3] The Office of Energy Policy and Innovation, which otherwise collaborates with various FERC offices to evaluate industry proposals, reportedly does not support OEP in the form of economic review and analysis of pipeline certification projects.[4] The Commission has, in effect, been flying blind with regard to the critical question of whether its actions in approving new pipelines does or does not meet the "economic test" it sets in the current policy.

Furthermore, and as suggested in the Notice of Inquiry, both the state of the natural gas industry and the state of knowledge regarding the impacts of natural gas exploration, development, transmission, and end use have changed since 1999. Just last month, for example, the journal *Science* reported findings that methane emissions along the U.S. supply chain are 60% higher than previous US Environmental Protection Agency (EPA) estimates had indicated (Alvarez et al., 2018). This makes the oft-repeated (but seldom examined) claim by industry representatives and government officials that increased natural gas transmission capacity will help solve climate change problems even more suspect. Without countervailing measures to control leaks, the construction and use of additional pipeline capacity will cause methane emissions to increase. Given that the global warming potential (GWP) of methane is approximately 30 times that of carbon dioxide, any fuel switching to natural gas encouraged by new transmission capacity could actually exacerbate, rather than mitigate climate change.

In short, the review of the 1999 policy is greatly needed and, one hopes, will result in upgrades in FERC policy, capacity, and practice that make it more likely that the benefits of natural gas transmission and use will outweigh the costs of that system.

I will conclude this review with a summary of our findings related to several pipeline projects. I will begin, however, by laying out a framework, grounded in standard neoclassical resource economics (NRE), against which to compare those examples and on which those upgrades should be based.

Ecological economics would provide a broader, more modern, approach to these questions. This transdiscipline includes the efficiency concerns of NRE, but adds considerations of equity/justice, as well as sustainable scale and puts them on an equal footing with efficiency (Daly & Farley, 2011). Equity does get some mention in the current policy. It comes in the form of concern for impacts of new pipelines on existing pipeline/natural gas customers and on current shippers. And some Environmental Impact Statements (EISs) have mentioned environmental justice concerns raised by members of the public. The Commission, however, has not been proactive or systematic in evaluating the distribution of impacts, positive and negative, of proposed interstate natural gas transmission pipelines. Such an evaluation would take into account whether negative impacts disproportionately affect minority, low-income, or otherwise vulnerable populations. And if there are cases in which overall expected benefits outweigh overall expected costs (thus passing an efficiency test), the Commission's process should include a thorough evaluation of who would reap the the benefits and who would bear the costs.

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[2] Federal Energy Regulatory Commission. (2017, February 21) Office of Energy Projects (OEP), "What we do." Retrieved from https://www.ferc.gov/about/offices/oep.asp.

[3] Federal Energy Regulatory Commission. (2017, February 3). 2017 Employee Phone Directory. Retrieved from https://www.ferc.gov/contact-us/tel-num/phone.pdf.

[4] Personal communication with OEPI's Administrative Officer. (2017, March 17).

The Commission, furthermore, should require mitigation payments from the applicants and ensure that those payments are distributed in a way that equitably offsets the costs borne by various communities within the broader category of "the public."

Scale gets only a faint nod in that the Commission does weigh the "need" for new capacity, but that consideration begins and ends with the question of whether the applicant has identified customers for the gas it would transport in the proposed pipeline. There is no indication in the policy or in individual cases that FERC has concerned itself with the more important question of whether the transmission system is of *sustainable* scale. That is, the Commission has not attempted to determine whether proposed pipeline capacity is needed to make the overall system more efficient or effective in delivering natural gas to important markets. Indeed, in rejecting pleas to conduct regional environmental analyses, such as in the case of the Atlantic Coast and Mountain Valley Pipelines, FERC has likely missed opportunities to avoid a scenario in which further system buildout results in overcapacity in the transportation system and/or overuse of natural gas in general.

Market Failure: Pipeline Externalities

It is a firmly established economic principle that a change in economic organization–in the case at hand, this would be a change in land use/management–that leaves some people better off while harming others can still be said to be worth doing if it is at least hypothetically possible for those who gain to compensate those who lose as a result of the change. The reason is that the change produces a net benefit across all of human society. If one considers economic justice as well as overall welfare, then we would require that the compensation not only be hypothetical, but that it actually be paid so that those who lose something due to the change can at least receive the cash equivalent of what they have lost.

Setting aside for the moment the obvious question of whether any and all types of human suffering, including changes in physical, psycho-social, or cultural well-being could or should be assumed to have a monetary equivalent, this compensation principle provides a sound conceptual rationale for mitigating the adverse impacts of actions such as pipeline certification and subsequent construction and operation of pipelines. It also suggests the scope and scale of the compensation that should be paid if the change is to be deemed both efficient and just.

In the case of the natural gas transmission pipelines, those potentially gaining from increased pipeline capacity may include gas shippers who could pay less to move natural gas to market, the pipeline owners who will receive compensation for building and operating pipelines based on market and non-market processes (i.e. guaranteed rates of return), and, at least hypothetically, energy consumers. Pipeline applicants and their surrogates also often promise broader economic benefits in the form of jobs and income due to pipeline construction as well as further employment, income, and economic output stimulated by lower energy prices.[5]

Those suffering losses due to expanded natural gas pipeline transmission capacity include those "three interests" enumerated in existing FERC Policy: natural gas customers, owners of competing pipelines, and "landowners and communities affected by the proposed project" (FERC Docket No. PL99-3-000).

[5] As noted below, it is not at all clear that pipeline capacity translates into either lower energy prices or that any downstream or "multiplier" effects stimulated by additional capacity exist outside the realm of theory and promoters' wishful thinking.

I do not wish to diminish the importance of the certification policy to first two of those interests, but effects on customers and competitors are "merely" financial. Customers may suffer if regulated rates exceed rates just sufficient to just cover pipeline operators costs. In other words, if regulated rates result in end-of-pipe natural gas prices that include a subsidy to the operators in addition to a price that covers the market costs of producing and delivering the gas to the end of the pipe, customers will suffer real financial harm. Competitors might lose some customers and revenue and, in the extreme, could be be forced out of business by the operation of the new pipeline. Assuming there is no bias against existing pipelines' operators, such "market discipline" is what one would normally expect, with the more efficient or lower cost firms ending up with a greater share of the market.

Both of these types of impact may represent economic inefficiency, including the costs of a landscape littered with pipeline corridors abandoned by bankrupt firms. It does does seem at least possible, however, such concerns could be addressed through other of the Commission's process. For example, if the Commission were to assess the need for additional pipelines systematically and at appropriate regional scales, problems of overcapacity leading to abandoned pipelines could be avoided. (This is the question of scale alluded to above.) In addition, the Commission's rate setting process could be more carefully executed to ensure that operators are not permitted to garner excess profits at the expense of customers. If pipeline operators (and their investors) can expect only normal rates of return, there would be fewer incentives to propose, build, and operate unnecessary pipelines in the first place.

It is the third interest—of communities affected by pipelines built through them—that raises the more important economic questions regarding the certification of new natural gas pipelines. The reason is that the construction, presence, and operation of pipelines will impose "external costs" on members of those communities. External costs, also known as "negative externalities" are costs associated with a transaction imposed on individuals and entities who are not a party to the transaction. In this case the transaction is selling natural gas, which entails all of the activities associated with exploration, development, transportation, and use of natural gas. The negative externalities associated with transporting natural gas via the pipelines under FERC jurisdiction would include the following:

- The loss of physical use of/access to land occupied by pipeline rights of way;
- Diminished productivity of the land within or proximate to rights of way. Such land could otherwise be used (or used more effectively) for producing timber, crops, recreation services, clean water supply, erosion control, and other important ecosystem services
- A loss of physical and psychological well-being due to health and safety concerns imposed by the presence and operation of pipelines, compressor stations, and other infrastructure on one's land or in one's community;
- A loss of psychological well-being due to damage to home places, familiar landscapes, and cultural traditions associated with the use and enjoyment of those landscapes;
- Diminished local/regional economic activity as recreationists and tourists make decisions to spend their leisure and vacation time in locales without pipelines and, therefore, perceived to be safer and/or more aesthetically attractive, and/or more valuable for pursuits ranging from hunting and fishing, to bird watching, hiking, driving for pleasure, and others.
- Along similar lines, decisions by retirees, entrepreneurs, telecommuters and others who can locate where they want and who choose locations perceived to be safer and with more intact natural landscapes
- Accelerated climate change and associated secondary losses of ecosystem services due to the upstream and downstream effects of methane and carbon dioxide emissions
- Delayed transition to more sustainable, renewable, and increasingly lower-cost energy sources.

(These effects are of the sort that must be analyzed in order to comply with the National Environmental Policy Act (NEPA), regulations for which state that

> Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. 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 (36 CFR 1508.b).)

The costs associated with these effects can be measured as lost property value, higher insurance premiums, lost revenue for recreation and tourism businesses, employment and income forgone when businesses, retirees, and mobile workers choose to locate elsewhere, lost productivity in agriculture and forestry, higher costs to provide clean drinking water, flood and erosion control and other services that intact natural landscapes would otherwise provide for free[6], and the diminution of human welfare (whether expressed in dollar-valued terms or not) of people living in constant fear of property loss, injury, or death due to pipeline accidents.

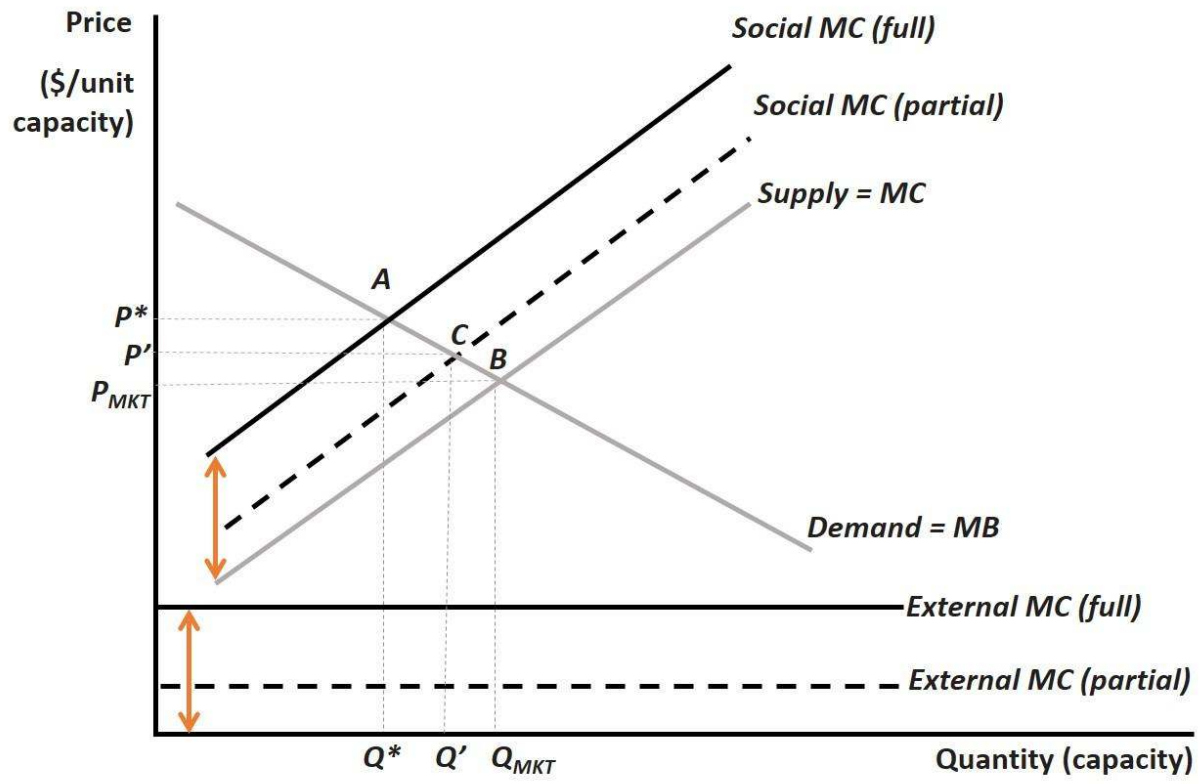
Figure 1, below, depicts presents the standard NRE view of such external costs, why they are "bad" for society, and how/where in the example at hand, the Commission could conceptualize cases in which "the public benefits to be achieved from the project can be found to outweigh the adverse effects" (88 FERC ¶ 61,227). The quantity of pipeline capacity is measured along the horizontal axis. The price per unit of capacity is measured on the vertical axis. Demand for pipeline capacity (also the marginal benefit, "MB", of capacity) is shown by the downward-sloping grey line. It slopes downward because people get less additional benefit from the existence or use of each successive unit of capacity.[7]

The supply of pipeline capacity is the upward-sloping grey line. Supply is (generally) equal to firms' marginal cost of production—that is, it is the cost of bringing the last increment of pipeline capacity online and including all *private* costs (land acquisition, materials, labor, insurance, financing, etc.) associated with constructing and operating pipelines. This line is therefore labeled "Supply = MC". Under ideal conditions, including a lack of any external costs (impacts on parties other than pipeline operators and users), net societal benefit from pipelines would be maximized where demand (marginal benefit to buyers/users) equals supply (marginal cost to producers/sellers), or at point "B" in the diagram. At this point, buyers value the increment of capacity at exactly the cost of producing the last

[6] See Balmford, et al. (2010) for a full description of this framework that maps ecosystem processes (what happens in ecosystems that is of potential value to humans) to ecosystem benefits (the particular ways in which humans make use of or enjoy the results of what happens in ecosystems).

[7] This is one of the reasons that it is important that the Commission evaluate the addition to system-wide capacity that each pipeline represents—cumulative impacts in other words—rather than as single, stand-alone pipelines. Otherwise, it will be impossible for the Commission to gauge whether the next pipeline will be push capacity beyond the point at which even market costs exceed benefits.

Figure 1: The Natural Resource Economics of Natural Gas Pipelines



increment of capacity. The amount produced/used will be Q_{MKT}, and that amount will be sold/bought for P_{MKT}. These are the "market-clearing" quantity and price of pipelines.

External costs are depicted in the diagram by the horizontal black lines. The dashed black line depicts a subset of external marginal costs ("External MC (partial)"), such as the effects of pipelines on the owners of properties crossed by the pipeline right-of-way (ROW). The solid line depicts the full external costs ("External MC (full)"), including the impact on the value of land near, but not crossed by, the ROW, the monetary value of diminished production or availability of ecosystem services, the cost of greenhouse gas emissions—i.e., the social cost of carbon—and the monetary equivalent of the other external effects listed above.[8]

To arrive at a socially optimal level of pipeline capacity, one must add the external marginal costs to the private marginal costs to the get the "Social Marginal Cost" of pipeline capacity and then compare the social marginal cost to the marginal benefits. In the diagram, adding the External MC (partial or full) to the private marginal cost ("Supply = MC") at each quantity gives us the darker upward-sloping "Social MC" curves. When all external costs are taken into account, the efficient level of pipeline capacity is

[8] To keep the diagram as simple as possible, I have depicted these as horizontal lines, implying that the external marginal cost (partial or full) of the first unit of pipeline capacity is the same as the external cost of the nth unit. In the real world, it is quite likely that marginal external costs will increase with capacity and will be nonlinear if there are threshold effects.

lower, and the corresponding price per unit of capacity is higher than would be the case if external costs are not considered.

In the diagram, this economically efficient level of production and consumption is at point "A" with Q* units of capacity provided and sold at a price equal to P* dollars per unit. For all units of capacity beyond beyond Q*—any units up to or beyond Q_{MKT}—the social cost of producing another unit of capacity is higher than the value society of that additional unit of capacity. In other words, the added capacity imposes external costs on society that are not worth the benefit derived from the the additional use.

This excess of social costs over social benefits is, in essence and in economic terms, a "market failure" that entails a "deadweight loss" to society. It is this market failure that the current Certification Policy has the potential to address. The policy requires that 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]" ((FERC Docket No. PL99-3-000, 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).

Policy Failure: Pipeline Certification without Sufficient Economic Review

Relative to the need to address the market failure presented by the construction, presence, and operation of natural gas transmission pipelines, the Commission has not gathered, created, or adequately considered sufficient information related to the benefits, and, especially, the external costs of natural gas transmission pipelines to know whether or not benefits outweigh the adverse effects. In terms of Figure 1, the Commission does not know where on the quantity (capacity) axis the natural gas transmission system is and, therefore, whether any addition to total capacity would create or exacerbate the deadweight loss associated with new transmission pipelines. Thus, rather than addressing and attempting to correct the market failure stemming from pipeline externalities, the Commission has practiced serial policy failure that has undoubtedly increased the effects of the market failure.

Some of the Commission's failure is rooted in the language of the current policy. 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" (88 FERC, para. 61,227, pp. 18, 26). The Commission's policy contends that 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 at an individual, community, and broader population level. It ignores the vast majority of the external costs of pipelines described in the preceding section.

The policy's confusion over what counts as environmental effects (again, most of which will have economic effects) is further expressed by the following statement:

> Traditionally, the interests of the landowners and the surrounding community have been considered synonymous with the environmental impacts of a project; However, these interests can be distinct. Landowner property rights issues are different in character from other

> environmental issues considered under the National Environmental Policy Act of 1969 (88 FERC, para. 61,227, p. 24).

By the Commission's reasoning, environmental effects are a matter of the Commission's "traditions," not science, and environmental effects are deemed to be both synonymous with, and distinct from, interests of landowners and the surrounding community. This statement seems to contradict the statement one page earlier in the policy that "[there] are other interests [besides those of customers, competitors, and landowners and surrounding communities] that may need to be separately considered in a certificate proceeding, such as environmental interests (p. 23)." While it is true that separate/additional consideration of environmental "interests" must indeed be part of the Commission's review, the policy embodies such a muddle of contradictions on the question of what impacts to examine and why (tradition versus science), that it seems unlikely that any pipeline certification granted under the policy would be scientifically or economically sound.

FERC's own policies and track record, including an over-reliance on applicants' own estimates of project benefits, make it extremely unlikely that the project certification process would meet requirements of the National Environmental Policy Act (NEPA) that agencies consider all project costs and benefits, let alone produce a decision that could be construed as generating or supporting net economic benefits.[9]

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" (88 FERC, para. 61,227, p. 26). The applicant therefore has an incentive to be generous in counting benefits and parsimonious in counting the costs of its proposal. And as reflected in the DEIS at hand, FERC has made no effort itself to ensure a full accounting of economic costs to landowners or the broader community despite the wealth of comments placed on the docket that could support such an assessment.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.

Given the weaknesses of the policy, and as evidenced by the track record, FERC's "economic test" does not provide a robust evaluation of the public merits of natural gas transmission projects. It is a "test" in which difficult questions (such as about external costs borne by all stakeholders) are not asked, and where those taking the test (the applicants) provide the answer key. It is therefore not surprising that FERC's environmental reviews typically have not provided estimates of the magnitude of the full external costs associated with natural gas transmission pipelines. Also not surprising, pipeline applicants typically employ methods, assumptions, and a selective review of effects that result in a rosy and grossly distorted picture of the net benefits of their projects.

In the following sections, we review examples of these problematic benefit estimates and present, as examples, independent estimates of some of the external costs of recently proposed pipeline projects.

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[9] It is important to note that NEPA does not require that federal actions 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.

Pipeline Benefits are Often Overstated

In the course of research over several years, my colleagues and I at Key-Log Economics have evaluated the claims of potential economic benefit put forward by the applicants seeking certification of several pipelines, including the Atlantic Sunrise Pipeline (Docket No. CP15-138), Atlantic Coast Pipeline (Docket no. CP15-554), PennEast Pipeline (Docket no. CP-15-558), Mountain Valley Pipeline (Docket no. CP16-10), and the Millenium Pipeline's Eastern System Upgrade (Docket No. PF16-3). In one form or another, including in Resource Reports 5, applicants typically make some form of the following claims regarding the benefits of their projects:

1. Construction of the project will have significant positive economic impacts, including the "creation" of jobs and increases in personal income.
2. Operation of the project will also have significant positive economic impacts (again in the form of jobs and income).
3. The project will result in sustained, lower end-user costs for natural gas and/or for electricity generated in gas-fired power plants.
4. Project-stimulated reductions in energy costs will stimulate output, income, and employment in energy-intensive manufacturing and other sectors and, thereby, cause further positive economic impacts.

For the impacts of project construction and operation, as well as for impact stemming from lower energy prices, applicants typically present as their evidence projections generated from an quantitative "input-output" model, typically IMPLAN.[10] Rooted in economic base theory, input-output models purport to translate an exogenous change in the economy—the "input," which in this case is spending on the operation of the pipeline, including employees' wages—into "output," which includes spending by the project's employees, by other firms, by their employees, and so on. Additional rounds of impact occur as the businesses where those households spend their wages (grocery stores, gas stations, physicians, etc.) pay suppliers and their own employees. With each round of spending, some money leaks out of the study region's economy in the form of spending on imported goods or wages paid to workers who reside outside the study region.

While intuitively satisfying, empirical input-output models like IMPLAN are built on a very restrictive set of assumptions about how each and every spending and/or each and every hiring decision in the entire economy is made. Namely, the models assume that spending decisions are made the way they have always been made, and if wages or demand for a product goes up, the only way households and firms can respond is by doing more of what they did in the past to meet demand. They follow the same recipe, but just increase the amount of each ingredient. Households buy a larger quantity of the same mix of goods and services, and firms employ more labor, buy more raw materials, and burn more fuel (among other inputs) in exactly the same proportions as before the exogenous change occurred.

Firms in the real world, by contrast, innovate and adjust their manufacturing and other processes to take advantage of economies of scale, new technology, changes in relative prices, and new business processes. That innovation leads to cost minimization, and cost minimization means firms will do less indirect spending, and that means less induced spending stemming from changes in workers' wages. As

[10] See, for example, Chmura (2014), ICF International (2014), Ditzel et al (2015 a,b), Econsult Solutions & Drexel University School of Economics (2015), Concentric Energy Advisors (2016), and Blumsack & Kleit (2015)

Hoffmann and Fortmann (1996) found, this disconnect from real world behavior means that that input-output models produce overestimates of firm spending and "multiplier effects."

Due to restrictive assumptions, economic base models possess a dismal track record when it comes to predicting economic growth in the real world and in the long run. Again, the "long run" is more than a year into the future, when firms change technology, prices can adjust, and people change what they want to buy. In a review of 23 studies, Krikelas (1991) compared predictions of the economic base model against the actual experience of subject regions and found only 4 studies where the models correctly predicted longer run economic growth. Similarly, Robertson (2003) tested predictions from input-output models against actual experience in 15 communities in Southeast Alaska (a region in which many of the restrictive assumptions of economic base theory might actually apply). He found that initial economic stimulus does not "cause changes in economic activity serving local demand for the average community…The implications of these results [are that] secondary economic impacts [i.e. "multiplier effects"] cannot be taken as a foregone conclusion in policy analysis" (p. iii).

Beyond these general problems with input-output analysis, there have been some particular problems when applied to the construction phase of the projects we have analyzed. One major complaint is that the regions analyzed have been too large. In the case of the Mountain Valley Pipeline (MVP), for example, the applicant's consultants chose to use the entire states of Virginia and West Virginia as regions for analysis (they analyzed impacts separately in the two states). Regional economic impact depends on the degree to which direct, indirect and induced spending can occur within the study region. The bigger the region, the more likely it is that you can find a firm in the region from which to buy materials or services, and the more likely it becomes that one could hire labor from someone living inside the region. In other words, the larger the region, the larger the multiplier effect. The MVP studies do not present a rationale for the choice of entire states as the study regions. While the appropriate regions might be somewhat larger than the 10 West Virginia and 5 Virginia counties the proposed MVP would cross, they should not consist of the entirety of both states.

A second pervasive problem with applicants' economic analyses—one crippling to claims of economic benefit stemming from the operation of pipelines and/or increased output due to energy cost savings—is the misuse of the input-output model to estimate long-term effects.

As Haynes et al. (1997) note:

> Where the economic base approach gets into trouble is when it is used inappropriately as a tool for planning or predicting impacts of greater than one year in duration; A snapshot of current conditions tells little about the form a region's future economy may take.

The reason for this caution is that economic base theory and empirical input-output models grounded in that theory (i.e., the IMPLAN model used to generate numerous pipeline impact estimates) assume a static economy. In such an economy, there are no changes in relative prices, no input substitution or technological change in the production processes, no labor mobility, no change in products or consumers' tastes and preferences, no regional migration, and no changes in state and local tax laws—to name a few. The constant technology assumption, for example, prevents firms from using cost-savings innovations, forcing them to be inefficient, and the result is higher multiplier effects than are actually experienced (Hoffmann and Fortmann 1996).

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into the future, when firm can change technology, prices can adjust, and people can change what they want to buy.) In a review of 23 studies, Krikelas (1991) compared predictions of the economic base model against the actual experience of the subject regions and found only 4 studies where the models correctly predicted longer run economic growth. Similarly, Robertson (2003) tested predictions from input-output models against actual experience in 15 communities in Southeast Alaska (a region in which many of the restrictive assumptions of economic base theory might actually apply). He found that initial economic stimulus does not "cause changes in economic activity serving local demand for the average community.... The implications of these results [are that] secondary economic impacts [i.e., "multiplier effects"] cannot be taken as a foregone conclusion in policy analysis" (p. iii).

To count indirect and induced jobs to the operation of natural gas pipelines as the cause of new, ongoing economic activity more than a year from the start of operations requires an assumption that workers in those indirect and induced jobs would otherwise be idle. Such an assumption is not realistic: idle workers in the real world typically retrain or relocate to take already open jobs, or they create new employment opportunities for themselves. Those "multiplier effect" jobs, in other words, will most likely exist somewhere with or without the direct jobs in pipeline operations. Operation of a pipeline, in other words, will no more create new jobs in the long run than it will create the methane pumped through it.

When it comes to estimates of long-term stimulus due to assumed (see below) reductions in lower energy costs due to the operation of new pipelines, input-output analysis and those basing economic benefits on it, run into a double bind. On the one hand, and for the reasons just discussed, input-output analysis should not be used to estimate longer-term effects of lower energy prices in the first place.

The bigger issue is that, ironically, these models assume that there are no changes in relative prices and no input substitution. Thus even if a change in the price of energy occurs, or if the price of natural gas drops relative to the price of other fuels, the assumption of no input substitutions means that manufacturers and other energy users cannot switch to the lower cost fuel, nor can they change production and other processes in ways that take advantage of the lower energy prices.

For residential consumers, whom several applicants claim will benefit from pipeline-induced reductions in energy prices, the situation is similar. Assuming such reductions materialize, there could be cost savings for energy users in the real economy as people respond to the changes in relative prices. People might respond by putting off an upgrade to a more energy-efficient furnace, for example. Or they might respond by selecting less-expensive, but more poorly insulating, windows for their home renovation project. Afterall, if energy gets cheaper relative to the cost of other goods, there will be less reason to use it as efficiently as possible.

But the input-output models employed by pipeline applicants to generate numeric estimates of assumed benefits are not the real world. Because the models do not allow for input substitution, the only thing consumers in the models can do with their energy savings is buy more of everything, including more energy, more new furnaces, and more higher-quality replacement windows. Moreover, these models assume that consumers' desire for the same exact bundle of goods and services can never be sated. At no point do people get enough new furnaces and shift their spending into more elaborate vacations (perhaps to places where they can escape the now excessive heat in their homes), into saving for retirement, or into their children's college tuition.

In short, and in the words of H.W. Richardson (1985) it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection (Richardson 1985)."

With regard to pipeline certification, the Commission simply must require better information and analysis rooted in more appropriate models, such as computable general equilibrium, systems models and others, that are more likely to approximate the behavior of economic agents confronted with changes that new pipelines may bring.

Direct effects of added pipeline capacity have not been proven.

In the estimation of several pipeline applicants, reduced energy prices is an assumed initial economic change that constitutes direct economic benefits to energy users that, if acted upon via input substitution, stimulates additional direct, indirect and induced effects. Clearly two critically important considerations for evaluating claims of such benefits is whether or not new pipeline capacity does, in fact, result in persistent reductions in energy prices and whether or not new pipeline capacity results in greater output, employment, or income in energy-intensive industries or in the broader economy.

Key-Log Economics is currently conducting a thorough, retrospective, statistical analysis of the experience of the region affected by the Marcellus Shale-based boom in natural gas availability and natural gas pipeline construction since 2000. We look forward to sharing our research results with the Commission at a later date, but we include here some preliminary observations that bear on the question of whether and how natural gas transmission capacity affects natural gas and/or electricity prices. Namely, while natural gas prices have been falling for end users during the Marcellus Shale boom, electricity prices have not.

From 2001 through 2015—a period encompassing the beginning of the Marcellus Shale gas boom—the total natural gas transmission capacity available in the Marcellus region increased from 20,195 million cubic feet per day (Mmcfd) in 2001 to 1,098,894 Mmcfd (citation). That is an increase of more than 5,300%. If the contentions that increased pipeline capacity drives down electricity prices were true, we would expect to see dramatically lower electricity prices during this same period. What we observe, however, is the opposite: total electricity prices (including residential, commercial, and industrial customers for utilities), have increased from an average of 69.62$/MWh in 2001 to 98.80$/MWh in 2015 (in inflation-adjusted 2017$)—a 42% increase. For residential customers, the price increase was 36%, from 86.65$/MWh in 2001 to 118.12 $/MWh in 2015 (in 2017 $) (U.S. Energy Information Administration, 2017). During the same time period, however, the average price of natural gas to end users (i.e. "distribution price") did fall from $9.04/Mcf to $4.80/Mcf (in 2017$) (U.S. Energy Information Administration, 2018).

Again, these are simply raw observations from the data, but they do call into question the assumption that natural gas transmission capacity, in and of itself, can bring about lower end-user electricity prices and, farther downstream, positive job and income benefits in manufacturing and other sectors.

Pipeline externalities are often discounted or ignored

However large or small the output, employment, and income impacts associated with new interstate natural gas pipelines, economic efficiency demands, and FERC's own policy requires, that the costs as well as any benefits of projects be thoroughly considered before certification. Unfortunately, the Commission and applicants routinely fail to seriously consider the external costs—that is, the residual adverse effects—of the proposed projects.

These costs can be significant and staggering. Key-Log Economics has developed conservative estimates of various external costs of several recently proposed pipeline and other natural gas infrastructure

projects. Please see Table 1, below, for a summary of these estimates and the referenced studies for detailed descriptions of the the methods, data, and assumptions specific to each case.[11]

We and other organizations have provided these estimates in comments on the projects respective dockets and have observed that the Commission itself has not provided any substantive response to the enumeration and valuation of most of the external costs of the projects. In the Final Environmental Impact Statements (FEISs) for the Atlantic Coast and Mountain Valley Pipelines, for example, the Commission ignores entirely the loss of ecosystem service value and the potential impact on recreation/tourism income and amenity-based development.

And where the Commission does focus some attention, which is on possible effects on property values, it simply repeats a selective and inadequate reading of the literature and echo's applicant's contention that pipelines have no effect on the value of nearby properties. Particularly troubling is that the Commission continues to rely on deeply flawed studies sponsored by INGAA. I have provided a substantive critique of these studies in previous comments to the Commission and include an updated version of that critique at the end of this section. I will first provide a brief review of some of the other impacts of natural gas pipelines and other infrastructure routinely discounted or completely ignored by the Commission in its deliberations and decisions.

Ecosystem Services: FERC should evaluate the potential loss of human benefit due to pipeline-induced land conversion.

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, 2005). According to a White Memorandum titled "Incorporating Ecosystem Services into Federal Decision Making" (Donovan, Goldfuss, & Holdren, 2015), ecosystem services are "benefits that flow from nature to people." They include tangible physical quantities, such as food, timber, and clean drinking water, life support functions like assimilating waste that ends up in air and water or on the land, as well as aesthetics, recreational opportunities, and other benefits of a more cultural, social, or spiritual nature.

[11] Each of these studies is available for download from http://keylogeconomics.com/natural-gas-development-and-transmission/

Table 1: Summary of Cost Estimates for Several Proposed Interstate Natural Gas Transmission Projects.

Estimated impacts (costs)	Atlantic Coast Pipeline[a]	Mountain Valley Pipeline[b]	PennEast Pipeline[c]	Atlantic Sunrise Pipeline[d]	Millennium Eastern System Upgrade[e]
Lost Property Value (one-time cost)	$57.8 - 83.0 million	$43.7 - 55.2 million	$165.1 - 183.4 million	Not Estimated	$2.1 million
Lost Property Tax Revenue (Annual loss for the life of the project)	$0.29 - 0.42 million	$.25 - 0.32 million	$2.8 - 3.1 million	Not Estimated	$0.0376 million
Lost Ecosystem Service Value during Construction (one-time)	$17.5 - 63.2 million	$23.6 - 85.0 million	$6.5 - 22.8 million	$6.3 - 23.1 million	Not Estimated
Lost Ecosystem Service Value during Operation (annual)	$5.0 - 18.4 million	$4.2 - 15.3 million	$2.5 - 9.3 million	$3.0 - 11.4 million	Not Estimated
Forgone Economic Development[f] (annual)	$51.3 million 387 jobs	$136.9 million 1,164 jobs	$537.6 million 4,090 jobs	Not Estimated	$85.3 million 745 jobs
Social Cost of Carbon[g] (annual)	Not Estimated	Not Estimated	$301.8 - 2,339.0 million	$466.5 - 3,615.1 million	$51.8 - 434.5 million
Lifetime costs in Present Discounted Value	$9.5 - 11.8 billion	$23.7 - 25.8 billion	$14.5 - 60.3 billion[h]	$22.2 - 95.1 billion[h]	$4.9 - 19.5 billion

Sources and Notes:

a. Phillips, Bottorff, and Wang (2016). The study scope covered four Virginia counties and approximately 20% of the overall length of the pipeline.
b. Phillips, Wang, and Bottorff (2016). The study covered three West Virginia and five Virginia counties, and approximately 50% of the overall length of the pipeline.
c. Phillips, Wang, and Bottorff (2017)
d. Phillips, Wang, and Alkire (2017a)
e. Phillips, Wang, and Alkire (2017b)

f. Includes lost visitor spending and related state and local taxes, lost retirement income, and lost proprietors' income. Job and income losses are direct only (no multiplier effects).
g. The range of estimates for the social cost of carbon reflect different assumptions about how heavily future costs are discounted as well as differences over time in the impact of each tonne of CO_2 equivalent emitted.
h. Economic development impacts were not included in the PDV calculations for these pipelines.

If ecosystem services are the products of nature, then ecosystems themselves—the land—are the factories where those products and values are produced. Just as with different man made factories, different types of ecosystems (forest, wetland, cropland, urban areas) 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.

By similar reasoning, a changes in ecosystems or more fundamentally, changes in land use, will change the type, amount, and value of the ecosystem services produced in the affected area. In the case of natural gas transmission pipelines, there is the conversion in the short run of all land in the construction zone from forests, cropland, urban open space, and other productive uses to barren land with very little, if any ecosystem service value.

In the longer run, a portion of the construction zone will revert to its pre-disturbance land cover, though the effects of soil compaction, introduction of invasive species, etc. may make even reverted land formerly in the construction zone less productive. In the right-of-way however, land that had been forested before construction, will revert to the (less productive) land cover of grassland, or perhaps shrub scrub, depending on the frequency of mowing to keep the right-of-way free of trees.

Cropland in the ROW could revert to cropland, but if there are restrictions on the weight of vehicles that can be operated on top of the buried pipeline, it may turn out to be the case that cropland reverts, at best, to pastureland. Moreover, there could be long-standing harm to agricultural productivity due to soil compaction, soil temperature changes, and alteration of drainage patterns due to pipeline construction. As agronomist Richard Fitzgerald (2015) concludes in the context of another proposed pipeline, "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 the pipeline]." In the path of the PennEast pipeline, grower Ron Fulper of West Amwell, New Jersey has seen "very low [corn] yields" in the portion of his fields crossed by an existing natural gas pipeline (Colaneri, 2015).

By applying per-acre ecosystem service productivity estimates (denominated in dollars per acre per year) to the various arrays of ecosystem service types, one can estimate ecosystem service value produced per year in the periods before, during, and after construction. The difference between annual ecosystem service value during construction and 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.

FERC's failure to include an analysis of ecosystem services lost due to the construction and operation of pipelines has been is a glaring example of inadequacy of FERC's "traditional" conflation of the interests of landowners and surrounding communities with environmental impacts. The exclusion of ecosystem service losses means that many of the economic consequences of environmental effects, not to mention many environmental effects, have not been considered at all. This shortcoming renders many, if not all FERC environmental assessments DEIS inadequate for informing decision making about natural gas transmission infrastructure.

As it revises its certification policy, FERC should develop the capacity to undertake its own assessments of the ecosystem services impacts of its proposed action. Such a review would be consistent with current executive branch direction and coming implementation guidance (Donovan, Goldfuss, & Holdren, 2015). FERC should follow the lead of other agencies and use existing resources, such as *Federal Resource Management and Ecosystem Services* (National Ecosystem Services Partnership, n.d.) and *Best Practices for Integrating Ecosystem Services into Federal Decision Making* (Olander et al., 2015) in its review. Such a review would help ensure that these important environmental effects (and their economic consequences) are no longer ignored in FERC's decision making.

Social Cost of Carbon: FERC should account for the upstream and downstream impacts of CO_2 emissions facilitated by each natural gas transmission project.

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 or EA 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).

FERC must count this significant cost among the effects of the proposed pipeline.

Public Health: FERC should account for impacts on health and related societal costs of emissions from compressor stations and other infrastructure.

Compressor stations have been implicated in a variety of illnesses among nearby residents. (Subra, 2009, 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 have 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).

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

FERC's review of each pipeline and infrastructure project should include an estimates of the exposure to noise and pollutants and the expected costs of any resulting illnesses. These costs would include the cost of treating illnesses, the cost of lost work, and impacts on the quality of life.

Air emissions associated with natural gas production and transmission can also 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).

Property Value: FERC must inform and update its understanding of the effect of pipelines on property.

In several EISs, FERC repeats applicants contention that natural gas pipelines have, at most, an ambiguous and non-permanent effect on property values. The Commission relies on studies including Allen, Williford & Seale Inc. (2001), Fruits (2008), Palmer (2008), and Diskin et al. (2011). While the studies differ in methods, they are similar in that each fails to take into account two factors potentially voiding their conclusions entirely. First, the studies do not 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 have to have full information about the subject properties, including whether the properties are near a pipeline.

Second, and for the most part, 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. 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 a proposed pipeline would have.

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

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 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 had full information, which was not the case in the study.

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 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, citizens' 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 for the PennEast pipeline, for example, PennEast, 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" (2015). This is grossly misleading and plainly illogical. One cannot conclude a lack of a negative effect from the fact that home sellers do not typically, and counter to 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 one is trying to sell. 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.

PennEast 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 PennEast LLC does not understand rational buyer/seller behaviour, 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 do 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 (or any other) pipeline to learn of its presence and, therefore, for the pipelines to affect home buyers' 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 is likely to 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 pipeline 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 have 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 a pipeline will be lower than the prices offered for other homes farther away or in another community or region.

Studies concluding that proximity to pipelines does not result in different property values do not actually compare prices for properties that are different.

While the studies typically cited in Resource Reports 5 and FERC's Draft and Final EISs 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 that the studies count 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. However, in almost all cases 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).[12]

In the 2016 INGAA study, the specific distance from pipeline was reported for eight case studies. In those cases, an average of 72.5% of the "off" properties were actually within the evacuation zone and, like the "on" properties, are therefore likely to suffer a loss in property value relative to properties farther away. (I have based my estimates of the evacuation zones on available information about the pipelines' diameter and operating pressures.) For the other two cases, the study reported a simple "yes" or "no" to indicate whether the property abutted the pipeline in question. For these cases, I assume the 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 the feature. It is a case where comparing apples and oranges is not only reasonable, but also essential. In the case of these studies, there is little to no

[12] 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).

variation in the feature of interest (i.e., the majority of properties are within the evacuation zone). The studies are looking at and comparing only "apples." In this case, the feature of interest is the presence of a nearby risk to health and safety. With no variation in that feature, a systematic variation in the price of the properties would not be expected. By comparing apples to apples when it should be 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, other studies commonly cited by FERC and pipeline applicants suffer from the same problem. Fruits (2008), who analyzes properties within one mile of a pipeline that has 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 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. (It should go without saying that 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 the next section) 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.

Better information about the effect of pipelines on property values is available.

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. His key findings include the following.

- 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" (Kielisch, 2015, p. 7). Considering only those buyers who are still willing to purchase the property, the

expected loss in market value would be 10.5%.[13] 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%.[14] In our estimates (see below), 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.

Kielisch's findings demonstrate that properties on natural gas pipeline rights-of-way suffer a loss in property value. Boxall, Chan, and McMillan (2005), 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" of sour gas[15] wells and natural gas pipelines faced an average loss in value of 3.8%, other things being equal.

The risks posed by interstate natural gas transmission pipelines would be different–they would not be carrying sour gas, for example–but there are similarities that make Boxall et al.'s finding particularly relevant. Namely, the emergency plan response zones (EPZs) are defined by the health and safety risks posed by the gas operations and infrastructure. Also, and in contrast to the studies often cited by FERC which show no price effect the Boxall study examines prices of properties for which landowners must inform prospective buyers when one or more EPZs intersect the property.

In addition to the emerging body of evidence that there is a negative relationship between natural gas infrastructure and property value, there have been many analyses demonstrating the opposite analog. Namely, it is well-established that amenities such as scenic vistas, access to recreational resources, proximity to protected areas, cleaner water, and others convey positive value to real property.[16] There are also studies demonstrating a negative impact on land value of various other types of nuisance that impose noise, light, air, and water pollution, life safety risks, and lesser human health risks on nearby residents (Bixuan Sun, 2013; Bolton & Sick, 1999; Boxall et al., 2005). 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.

Table 1, above, includes estimates based on the results established by Kielisch (2015) and Boxall, Chan, McMillan (2005) for several recently proposed pipelines.

Conclusion

In conclusion, FERC should update/upgrade both its policy, its capacity, and its practice regarding the economic effects of new interstate natural gas pipelines. To ensure that future certification decisions

[13] 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%.
[14] This is the expected value calculated as 0.622*(-100%)+0.189*(-21%)+0.189*(0%).
[15] "Sour" gas contains high concentrations of hydrogen sulfide and poses an acute risk to human health.
[16] Phillips (2004) is one such study that includes an extensive review of the literature on the topic.

result in efficient use of land and other natural resource, FERC must establish procedures, and install analytical capacity sufficient to provide independent, rigorous, and credible analysis of the benefit claims promoted by pipeline applicants. It must also conduct (or contract to have conducted) thorough analyses of the external economic costs likely to result from the construction, presence, and operation of each pipeline. For any pipelines approved on efficiency grounds (i.e. benefits exceed costs), FERC should further ensure that the successful certification application pays compensation to the parties harmed by those external costs. Finally, to prevent problems of overcapacity and the associated problems of accelerated climate change and a delayed transition to safer, cleaner, more renewable fuels, FERC should ensure that all new pipeline capacity applications are considered in the context of existing (and previously certified) capacity in the entire gas transmission system.

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