Atlantic Sunrise Project:

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

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Prepared for:

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EXECUTIVE SUMMARY

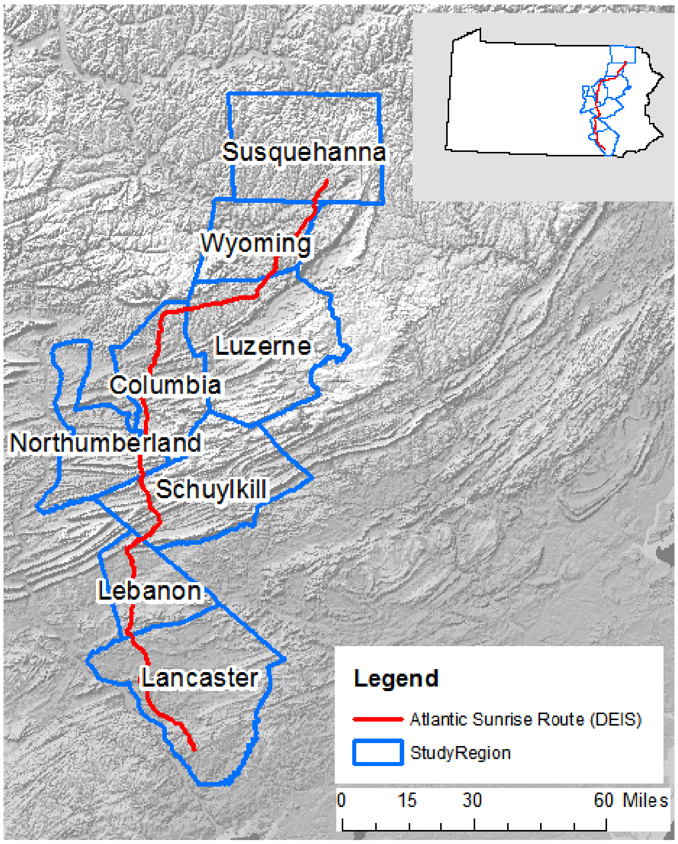

Figure 1. Geographic scope of interest for the Atlantic Sunrise Project. The Central Penn Line was adapted from the Shalefield Organizing Committee (2015); Study region (counties) and hill shade from USGS reprinted from the U.S. Department of Interior & U.S. Geological Survey (2015).

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

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[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 <u>total</u> present discounted value for <u>all</u> 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.

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[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,

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[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.

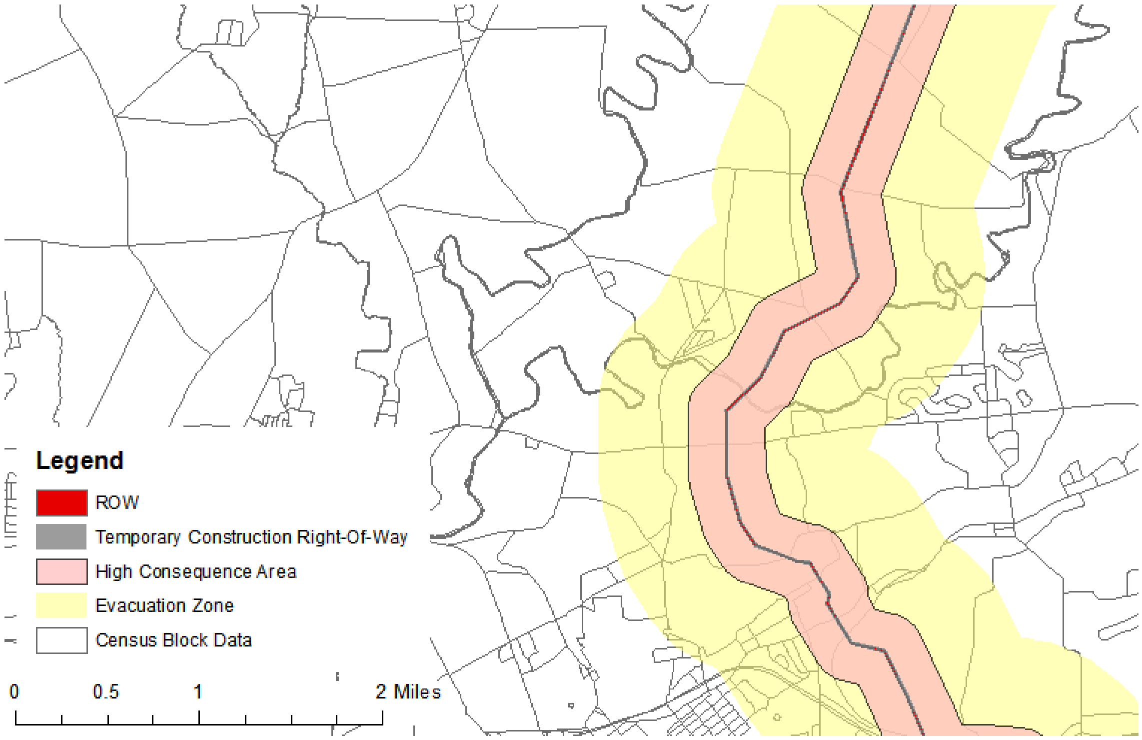

Figure 2. The right-of-way, temporary construction right-of-way, high consequence area, and evacuation zone for a section of the Central Penn Line. The overlay of the HCA (in pink) and the evacuation zone (in yellow) shows up as the salmon band in the map. The ROW covers much of the temporary construction 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.

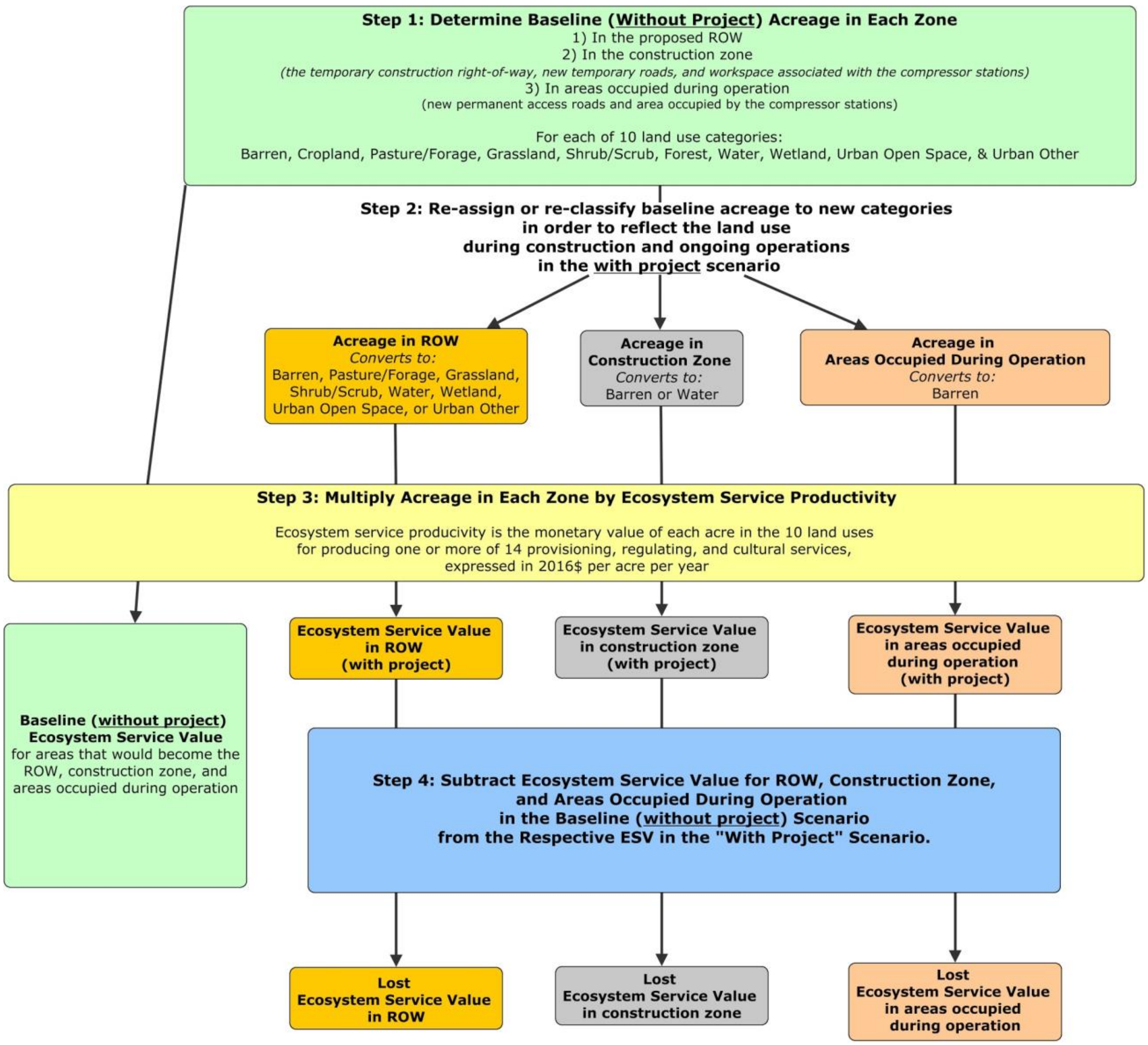

Figure 3. Ecosystem service valuation process.

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.

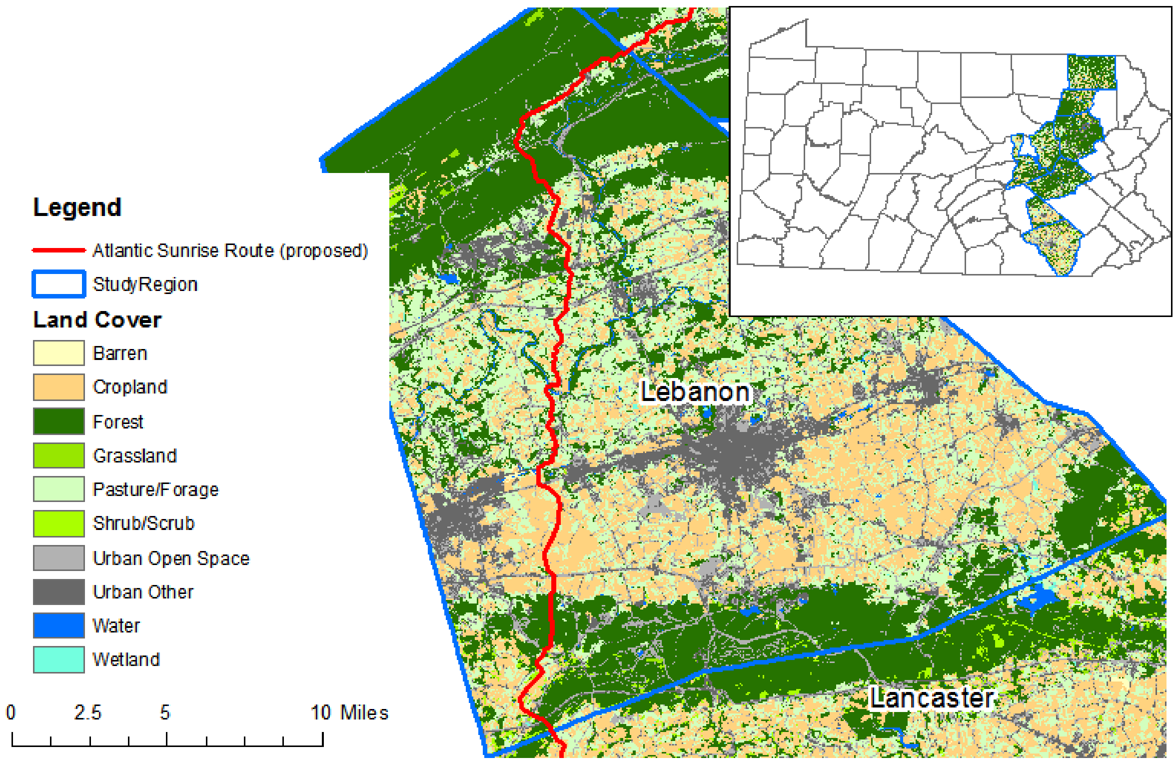

Figure 4. Land use in the study Region, as classified for ecosystem service valuation. Land cover for the entire study region is shown to display the overall range and pattern of land use. The ecosystem service valuation only covers portions of the study region occupied by the project right-of-way and 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**

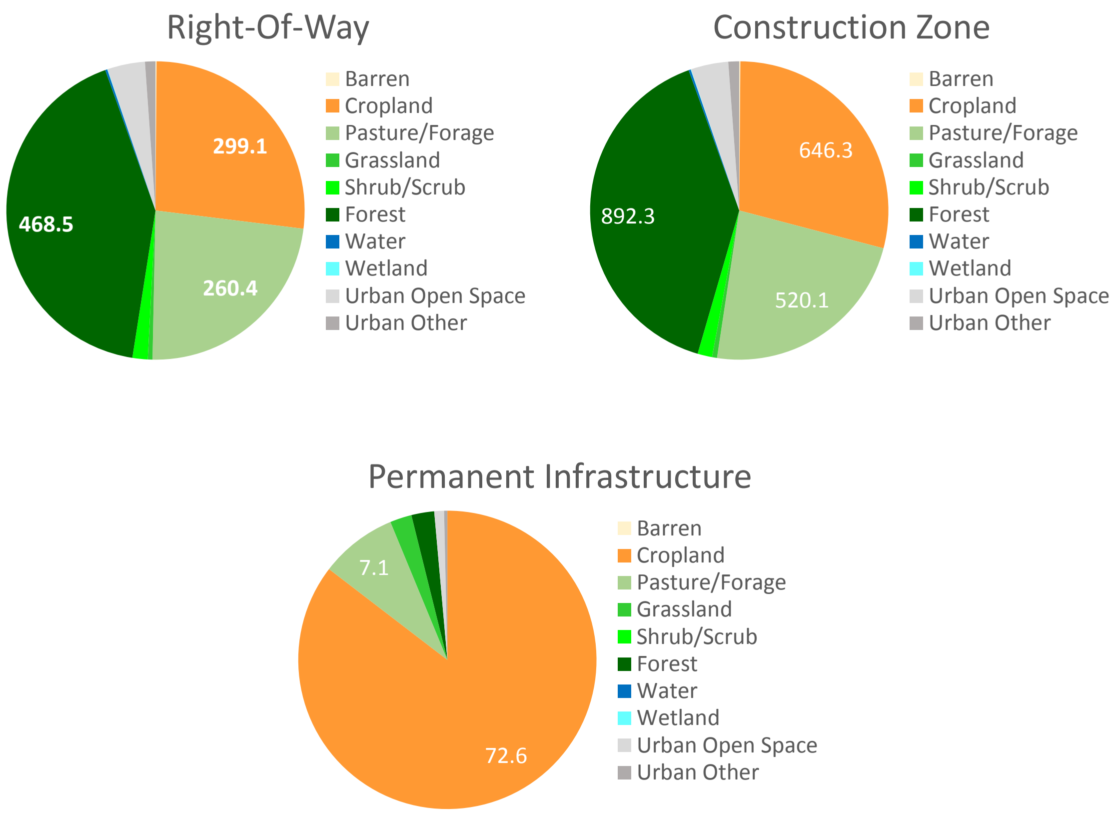

Figure 5. The Baseline (Pre-Project) Land Use in the ROW, Construction Zone, and Permanent Access Roads and Compressor Station Operation Space (Acres). (See also Table 4)

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

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[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

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[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).

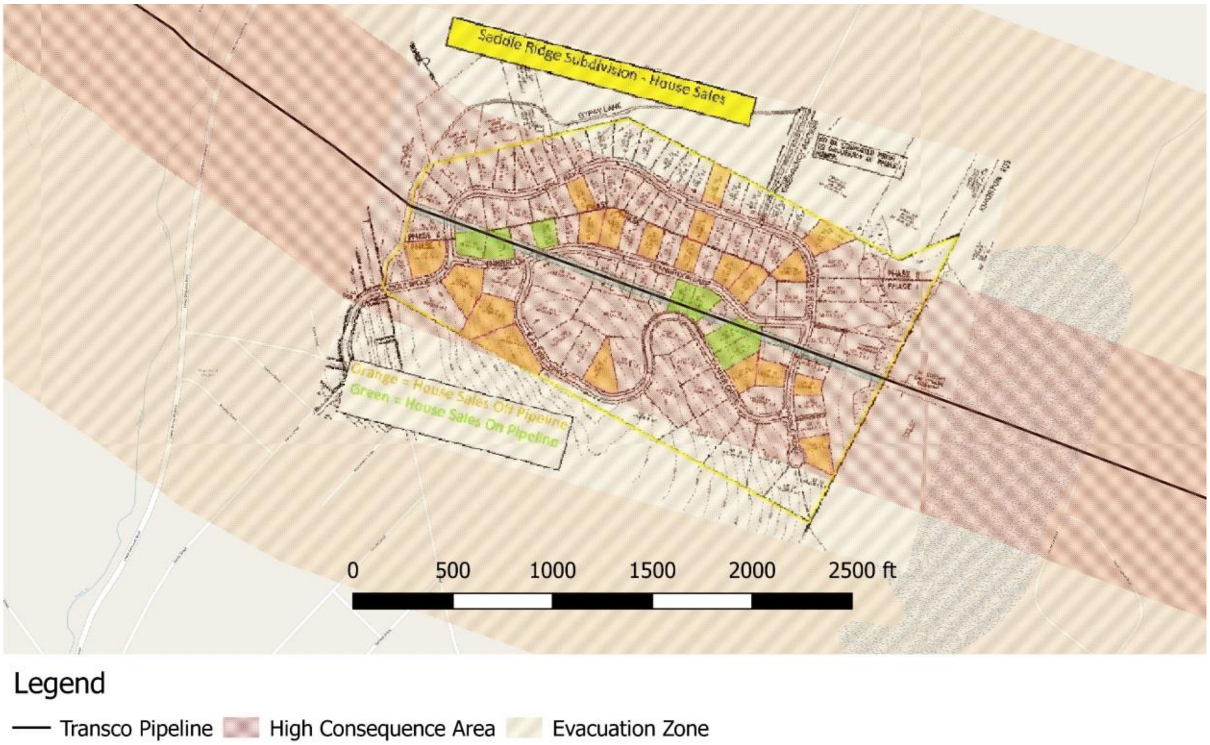

Figure 6. Transco Pipeline evacuation zone covers all, and the high-consequence area covers most, of properties in the Saddle Ridge case study area. Adapted from Allen, Williford, and Seale (2014).

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-Maître & Davis, 2001) *

Grasslands	Aesthetic	102.38	116.61	(Ready, Berger, & Blomquist, 1997)
	Biological Control	15.21	15.21	(Brenner Guillermo, 2007) *
	Climate	3.55	3.55	(Brenner Guillermo, 2007) *
	Erosion	17.48	17.48	(Barrow, 1991) *
	Erosion	68.28	68.28	(Sala & Paruelo, 1997) *
	Food	15.50	15.50	(Lex & Groover, 2015) *
	Pollination	16.23	16.23	(Brenner Guillermo, 2007) *
	Soil Fertility	3.55	3.55	(Brenner Guillermo, 2007) *
	Waste	55.28	55.28	(Brenner Guillermo, 2007) *
	Waste	5.88	64.40	(Ministerie van Landbouw & Natuur en Voedselkwaliteit, 2006) *
	Water Flows	2.54	2.54	(Brenner Guillermo, 2007) *
Pasture	Aesthetic	102.38	116.61	(Ready et al., 1997)
	Biological Control	15.21	15.21	(Brenner Guillermo, 2007) *
	Climate	3.55	3.55	(Brenner Guillermo, 2007) *
	Erosion	17.48	17.48	(Barrow, 1991) *
	Erosion	68.28	68.28	(Sala & Paruelo, 1997) *
	Food	15.50	15.50	(Lex & Groover, 2015)
	Pollination	16.23	16.23	(Brenner Guillermo, 2007) *
	Soil Fertility	3.55	3.55	(Brenner Guillermo, 2007) *
	Waste	55.28	55.28	(Brenner Guillermo, 2007) *

	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.