# Cost-Benefit Sensitivity Analysis of the Master Watershed Steward Program in Northampton/Lehigh Counties

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Volunteer environmental groups play an important role in improving water quality in Pennsylvania streams. A new participant in this effort is the Master Watershed Steward program, which initiated in 2013 in Northampton and Lehigh Counties **(1).** This is a government-funded effort to train and manage volunteers in a variety of environmental and natural resource activities, such as tree planting for riparian buffers and stormwater remediation projects. The Penn State Extension Service runs the program in partnership with the local Conservation District watershed specialists. Measuring the monetary value of these conservation efforts is useful to the public and lawmakers, as they want a return to justify the expenses of this program.

Measuring the benefits of environmental volunteer organizations is a challenge. Several techniques are possible, but the one that receives focus here is the direct measurement of the value of the environmental activities (output approach). This relies heavily on information that is not normally available, and it requires local expertise to select necessary parameters. Nonetheless the Lehigh Valley does offer a unique opportunity to do this.

Conceptually, measuring the annual benefits of the MWS program is a matter of monetizing the value the public receives from preserving and improving watershed

services, and then assigning the proportion that is attributable to the MWS volunteers. The former can be done for a given watershed but it is hugely expensive and time consuming. The latter is nearly impossible to determine objectively, but reasonable divisions can prove informative.

In 2014 the Lehigh Valley Planning Commission (LVPC) completed a major study on the value of environment goods in the Lehigh Valley (Lehigh and Northampton counties). It was accomplished with the assistance of a multitude of efforts by a variety of government agencies and a consulting firm. The results are impressive:

> In summary, open space provides value in the form of natural system services for water supply, water quality, flood control, pollination, biological control, habitat and soil formation/retention estimated at $355.5 million or more each year in the Lehigh Valley. (LVPC, p. 2)

Focusing solely on the streamwater resource value:

> The current green infrastructure along streams in the Lehigh Valley reduces tax dollars by avoiding more than $110.3 million annually in expenditures for water supply ($45.0 million), disturbance (flood) mitigation ($50.6 million) and water quality ($14.7 million). (LVPC, p.2)

This major contribution from LVPC informs the community and government officials to the need for continuous conservation efforts to preserve and even enlarge this value. The economic return of the environment is enormous.

More specifically to this proposal, the $110.3 million annual value assigned to the stream infrastructure highlights the importance of protecting watershed health and integrity. (This figure is updated to $117.5 million in 2018, after adjusting for inflation **[2]**). This is the starting point for assessing the value of watershed

conservation efforts. It is proposed here that the monetary value of watershed conservation is the *prevention of lost benefits due to the degradation* that would occur in the absence of conservation **[3].** The cessation of activities includes no monitoring and law enforcement of point and non-point pollution in the streamways, no building or repairing of riparian buffers, no monitoring of new development adjacent to streamways, no stormwater remediation projects, etc. The consequential environmental degradation and higher water treatment costs would be gradual, and the consequences may last for more than a year even if this were only a one-year cessation **[4].**

Monetizing the benefits of conservation efforts for the MWS involves confronting two measurement problems. The first is assigning the appropriate fraction of the $117.5 million to the various conservation activities. This monetizes the benefit of the agency and voluntary efforts needed to preserve the $117.5 million annual environmental value. For example, if conservation efforts cease and the environmental value of the streamway infrastructure falls to $111.625 million (a 5% drop), then the conservation efforts are worth $5.88 million. The benefits are the prevention of loss. The second measurement problem is determining the fraction of the conservation value to assign to the MWS program. For example what portion of the $5.88 million can be assigned to MWS? Each of these measurement tasks will now be discussed.

If all the activities of the Conservation Districts, Penn State Extension and environmental groups in Northampton and Lehigh Counties were to cease at the beginning of the year, what percent of the $117.5 million in streamwater

infrastructure value would eventually be lost due to degradation: 1%? 3%? 5%? Let D be the percent degradation that would apply to the $117.5 million. Now the monetary value (V) of the conservation undertakings can be estimated for a given value of D by applying the degradation parameter to the annual streamwater infrastructure value.

For purposes of illustration, three suggested levels (1%, 3%, 5%), of prevented degradation above lead to three possible economic levels of annual conservation benefits (V x D) in the Lehigh Valley: $1.18 million, $3.53 million, or $5.88 million. This is how the first measurement problem is addressed.

The second measurement problem is that the $1.18 million, $3.53 million, or $5.88 million in conservation benefits needs to be divided between the work provided by the appropriate government conservation agencies, the MWS, and the other volunteer groups. Although there is no obvious way to quantify this, the Conservation District and Penn State Extension staff expertise could suggest several probable apportions (A) for the MWS. With this additional parameter the economic value of annual conservation benefits attributed to the MWS would be V x D x A. For example, if, in the judgment of these staffs, the MWS volunteers should be credited with 3% (A = 0.03) of an annual $3.53 million (D = 0.03) in economic benefits, then the economic value of the Northampton/Lehigh MWS program is $116,325/year (this would be 0.09% of the $117.5 million). On the other hand, if the MWS can be credited with 5% of conservation efforts (A = 5%), then applying this to the same $3.53 million in value credits the MWS program with $176,250 in economic benefits. Other values for D and A can be chosen to demonstrate possible MWS

benefits over a range of parameter values. In Table 1 the economic benefits of the MWS program are shown in the boxes ($1000) for the selected range of values for A and D.

Table 1 Economic Benefits of MWS for Various Values of A and D ($1000)

| V | A | D=0.01 | D=0.02 | D=0.03 | D=0.04 | D=0.05 |
|---|---|---|---|---|---|---|
| 117500 | 0.01 | 11.75 | 23.5 | 35.25 | 47 | 58.75 |
| 117500 | 0.02 | 23.5 | 47 | 70.5 | 94 | 117.5 |
| 117500 | 0.03 | 35.25 | 70.5 | 105.75 | 141 | 176.25 |
| 117500 | 0.04 | 47 | 94 | 141 | 188 | 235 |
| 117500 | 0.05 | 58.75 | 117.5 | 176.25 | 235 | 293.75 |

All this suggests that if values for the parameters D and A can be determined, at least within a range, then a defendable range of economic values for the Master Watershed Steward program can be presented. The table shows a range of possible MWS benefits from $11,750 to $293,750 for the selected parameters. Remembering that this is for only two counties, we can be encouraged by this potential suggested by the lower right values in the table.

Provided the benefits exceed the cost of running this program, the MWS organization is justified. To complete a cost-benefit analysis, the program costs must also be calculated. The costs of volunteering are more directly measured. The MWS program is sponsored by regional and statewide government conservation agencies. These agencies organize recruiting and volunteer training, initiate projects, and provide resources and leadership personnel that generate and enhance the outreach and impact of volunteerism. By examining agency budget allocations directed to these activities one can measure or at least approximate the actual expenses for the government to run the volunteer group. However, given

the difficulty in determining the exact values of A and D, a sensitivity analysis will be conducted to employ a range of values for both parameters. The final results of this study will not arrive at a single net benefits value, but a range of potential values. The key to making such a range useful is examining at what combined values of A and D will a positive outcome occur for this program.

The methodology for this cost-benefit sensitivity analysis is shown in the box below:

Cost-Benefit Sensitivity Analysis on MWS Volunteering

Annual Benefits of MWS = V x D x A

where

V= annual $ value ($1000s) provided by the green infrastructure along streams = $117,500 ($117.5 million) in 2018
D = percent degradation of V that would occur in the absence of conservation efforts, where D ranges from 1% to 5%
V x D = annual $ value of conservation efforts ($1000s)
A = % of V x D that can be credited to the MWS program, where A ranges from 1% to 5%
V x D x A = annual $ value of MWS ($1000s)

Annual Operating Costs of MWS ($1000) in 2018 = operating costs + supplies = $26+ $1= $27 ($27,000)

Net Benefit = V x D x A – (Annual Operating Costs)

Sensitivity Analysis:

For a given V= $117,500 ($1000s) and a given operating cost of $27 ($1000s), what values of A and D combine for a positive net benefit?

With a volunteer expense value the benefits in Table 1 can be used to highlight those values of D and A that would project positive cost-benefit outcomes. The

reported expense for MWS program for Northampton and Lehigh Counties in 2018 is $27,000 **[5]**. This cost is incorporated In Table 2 by subtracting 27 from all values in Table 1:

Table 2 Net Economic Benefits of MWS for Various Values of A and D ($1000)

| V | A | D=0.01 | D=0.02 | D=0.03 | D=0.04 | D=0.05 |
|---|---|---|---|---|---|---|
| 117500 | 0.01 | -15.25 | -3.5 | 8.25 | 20 | 31.75 |
| 117500 | 0.02 | -3.5 | 20 | 43.5 | 67 | 90.5 |
| 117500 | 0.03 | 8.25 | 43.5 | 78.75 | 114 | 149.25 |
| 117500 | 0.04 | 20 | 67 | 114 | 161 | 208 |
| 117500 | 0.05 | 31.75 | 90.5 | 149.25 | 208 | 266.75 |

Table 2 reveals a wide range of values that create net benefits for MWS. With the $27,000 in program costs, positive net benefits occur with an A as low as 3% combined with a D as low as 1% (or vice versa). Net benefits as high as $266,750 ($293,750 - $27,000) are possible with higher parameter values. Obviously net benefits are sensitive to the choice of values for D and A, and this table allows those with different judgments to obtain corresponding estimates.

This analysis can be compared to the traditional replacement cost method to determine the value of volunteer groups. This technique measures benefits by placing a value on the labor input of volunteers, using the average wage in the region. With this the net benefits of MWS for 2018 is $52,329 ($79,329 - $27,000) **(5)**. This underestimates the MWS contribution for values of D and A that result in values greater than $52,329. These combinations are shown in Table 3 with the shaded cells.

Table 3 Net Economic Benefits Showing Combinations of D and A where the Output Method Exceeds the Replacement Cost Method

| V | A | D=0.01 | D=0.02 | D=0.03 | D=0.04 | D=0.05 |
|---|---|---|---|---|---|---|
| 117500 | 0.01 | -15.25 | -3.5 | 8.25 | 20 | 31.75 |
| 117500 | 0.02 | -3.5 | 20 | 43.5 | 67 | 90.5 |
| 117500 | 0.03 | 8.25 | 43.5 | 78.75 | 114 | 149.25 |
| 117500 | 0.04 | 20 | 67 | 114 | 161 | 208 |
| 117500 | 0.05 | 31.75 | 90.5 | 149.25 | 208 | 266.75 |

The output method is preferred because it estimates benefits directly and can incorporate the public good nature of streamway infrastructure. Although favored, it usually is not performed because of measurement problems. In this study the data has been provided by the Lehigh Valley Planning Commission, allowing a unique opportunity to explore the net benefits of the MWS activities, as well as a comparison with the replacement cost method.

Under reasonable, but not verifiable, judgments for avoidable environmental degradation (D) and volunteer contribution (A), the Master Watershed Steward organization provides a good return on the government costs of running this program. This would support proposals for expansion to other counties in Pennsylvania.

**RESOURCE**

Lehigh Valley Planning Commission, Lehigh *Valley Return on the Environment* (2014)

**NOTES**

NOTE 1

*2018 Report on the MWS for Lehigh/Northampton Counties* as reported by Erin Frederick, MWS Coordinator

Since the program began in 2013, the Lehigh/Northampton Master Watershed Steward program has grown to 65 volunteers, most of who had no prior involvement in water resource protection efforts. Trained Master Watershed Stewards have assumed roles on the boards of the Monocracy Creek Watershed Association, Bushkill Stream Conservancy, Maiden Creek Watershed Association, Hokendauqua-Catasauqua Watershed Association, Fry's Run Watershed Association, Cook's Creek Watershed Association, and the Watershed Coalition of the Lehigh Valley. They've helped leverage staff time at partner organizations, such as the Wildlands Conservancy, by assisting with at least 10 educational events when the conservancy has been short-staffed. They've assisted Wildlands and the Northampton County Conservation District with implementing on-the-ground restoration projects. They have also assisted the Pennsylvania Department of Environmental Protection with water quality assessment, and planted riparian buffers throughout the Lehigh Valley. Stewards have shown leadership by

coordinating eight rain barrel workshops across the region, developing a Junior Master Watershed Steward program for high school students, developing presentations to give at local libraries, using their artistic talents to create inviting educational displays at farmers' markets, and making connections with local businesses on their own. With each passing year, the Stewards become more confident in their knowledge and their ability to make a difference. Community organizations continue to turn to them for assistance and support of new projects.

NOTE 2

According to the Bureau of Labor Statistics consumer price index, the U.S. experienced 6.82% higher than prices in 2018 than in 2014. This will make the $110 million in 2014 equivalent to $117.5 million in 2018 after adjusting this inflation. This latter value does not incorporate any increase in economic value for watershed services over the previous three years that might accrue due to a higher population in the Valley.

NOTE 3

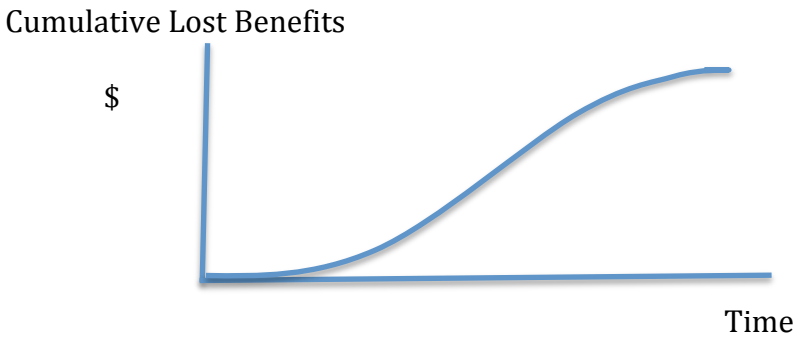
There is no question that the benefits estimates in this proposal are speculative, but this method of measuring the benefits is direct, whereas the usual default method of evaluating volunteer work is the "replacement cost" technique. Replacement cost measures benefits by using inputs instead of outputs. The number of volunteer hours is multiplied by the average hourly wage to calculate the amount the government would have to pay to have the work done. This method greatly

underestimates the contribution by environmental volunteers because of the public goods nature of environmental resources.

NOTE 4

When conservation efforts cease at a point in time, initially there is nearly zero degradation because the integrity of the watershed can handle a small shock. But after days, weeks, and these months the small shocks accumulate. Nitrogen, phosphorous, erosion, and sedimentation levels will slowly increase. Undeveloped land becomes developed without regulation, and managers of current development will be tempted to no longer abide by the previous conservation practices. Any damage to the streamway infrastructure will compromise its flood control role. The degradation due to the ceased conservation efforts will build over time.

The mathematical form for response function this would be difficult to determine theoretically, but intuitively one could argue the total accumulated lost benefits over time for a given value of A would have the following curvature for a one-year cessation:




It seems likely that the total accumulated lost benefits for a one-year cessation would plateau at some point in time, and no further substantive lost benefits would

occur. At higher or lower values of D the curve would be higher or lower, respectively, although the shape of the curves may differ.

NOTE 5

According to Erin Frederick, coordinator of the MLS program for Northampton and Lehigh Counties, there were 65 volunteers providing 3212 volunteer hours in 2018. This generates a replacement cost value of $79,329. She reports the cost of running this program as approximately $26,000 in staffing and administration, and $1000 in materials.

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