Urban and Community Forestry

Initiative Summary:

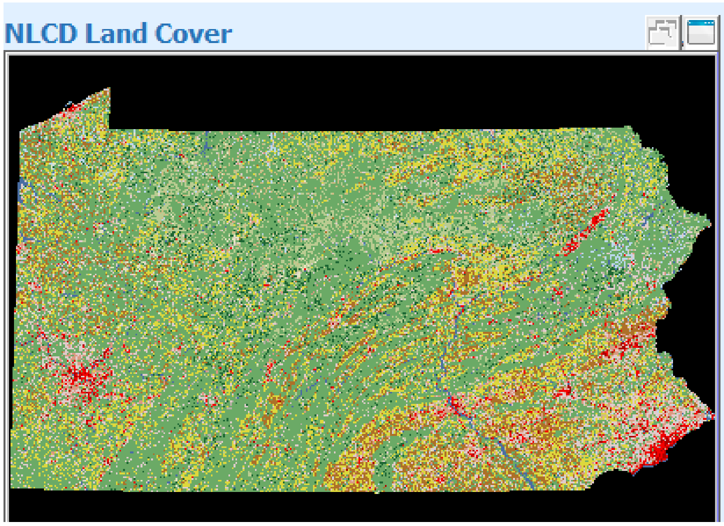
This plan seeks to utilize the planting and maintenance of trees in urban and community settings to increase carbon storage and to reduce residential, commercial, and institutional energy use for heating and cooling purposes. Trees in urban and suburban settings have the advantage of providing value-added benefits beyond carbon storage and energy savings. Properly planted and maintained trees have been shown to improve air quality, reduce flooding, increase property values, stimulate economic development, reduce crime rates, reduce stress and aggression, and much more.

Carbon stocks in trees and soils in urban land uses – such as in parks, along roadways, and in residential settings – can be enhanced in a number of ways, including planting additional trees, reducing the mortality and increasing the growth of existing trees, and avoiding tree removal (or deforestation). Properly designed forest canopy cover can also lower energy demand by reducing a building's heating and cooling needs.

Background Regarding Potential Carbon Sequestration Calculations:

For purposes of this report, i-Tree Vue software was used. i-Tree Vue is one of eight urban and community forestry analysis and benefits assessment programs that make up i-Tree Tools, available through the USDA Forest Service at http://www.itreetools.org. i-Tree Tools have become the standard tool within the forestry profession for tree benefit analyses. Some of the tools utilize ground inventories of trees, while others use various types of aerial imagery. i-Tree Vue was determined to be the most suitable for a statewide assessment of the benefits provided by trees growing in developed areas and for estimating benefits that might be provided if tree cover was increased.

i-Tree Vue utilizes National Land Cover Database (NLCD) satellite-based imagery, most recently collected in 2011 and released to the public in March 2014 (http://www.mrlc.gov/nlcd11_data.php). Vue utilizes three data layers: percent tree canopy, percent impervious cover, and land cover classifications. NLCD imagery is sorted into eight different land cover types: forest, shrub, herbaceous, wetlands, water, barren land, planted/cultivated, and developed land. Each of these is further defined to create the twenty different "land cover classifications." The composite of all twenty land classifications are visible as the various colors and hues shown in the map below.



The areas of interest in this analysis, however, are only developed lands, which cover 12.3% of the total land mass of the state. Developed land is divided into four land cover classifications, each with an increasing amount of land occupied by constructed impervious surfaces. They are defined as:

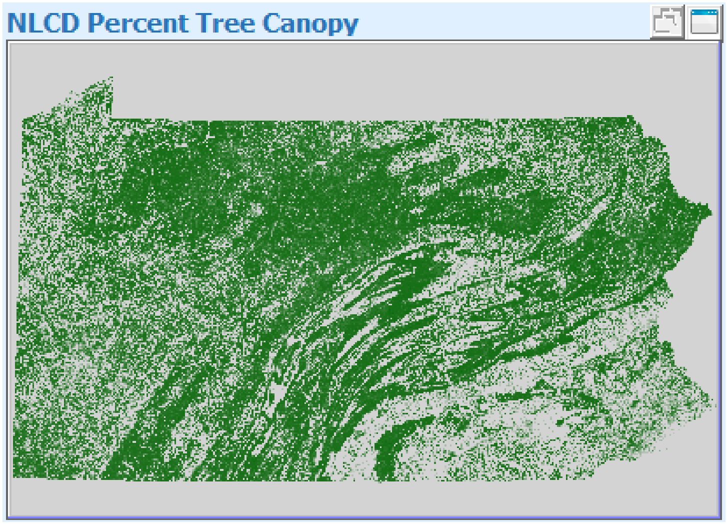
Developed, Open Space – Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed, Low Intensity – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% of total cover. These areas most commonly include single-family housing units.

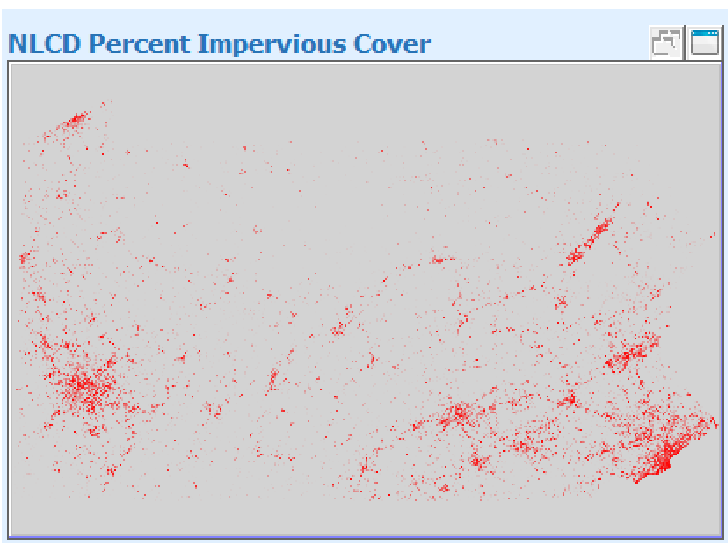
Developed, Medium Intensity – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.

Developed, High Intensity – Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100% of the total cover.

For each of the 20 land cover classifications, a percent tree canopy cover is determined. A graphic portrayal of canopy cover across the state follows:



The map below is another good way to represent the amount of developed land in Pennsylvania, as it shows the percentage of impervious cover throughout the state. There are certainly larger concentrations of developed land in the metropolitan areas, but as the map below shows, development occurs statewide. Developed land is where increased canopy cover can result in increased carbon sequestered and significant energy savings from shading.



Based on the percent canopy cover in a given developed area, i-Tree models calculate the amount of carbon sequestered by those trees. The i-Tree Vue program also allows the user to adjust the level of canopy cover, and it then calculates the resulting benefits that could be realized with additional tree cover. The tables that follow show carbon sequestration benefits in each of the four developed land cover categories at present, as well as what they would be if tree canopy cover increased by a few percentage points. Also shown is the estimated number of trees that would have to be planted annually over fifteen years to achieve the higher levels of cover. The commonly accepted standard for urban tree calculations of 100 trees per acre was used.

Limitations of the Calculations:

Given the complexity of factors that contribute to tree mortality and the unavailability of long term data from planting initiatives, it must be understood that for purposes of this report, mortality is not factored in. Estimates of carbon sequestered and energy saved are based simply on the current canopy cover and on the targeted increased canopy cover sought. The number of trees to be planted to achieve the higher canopy cover assumes no loss of trees.

Goal: Maintain and/or increase urban and suburban tree cover through one of the following scenarios. Implementation Period: 2015-2030

Calculations are reported based on current conditions in each of the four developed land classifications, and with two higher levels of canopy cover in each. The potential for increased canopy cover, and the resulting increased carbon sequestration, is greatest in less intensively developed areas. However, even a moderate increase in canopy cover in heavily developed areas has the potential to significantly reduce energy consumption for cooling in those areas.

	Developed Land Cover Types			
	Developed, Open Space <20% impervious	**Low Intensity Developed 20-49% impervious**	**Medium Intensity Developed 50-79% impervious**	**High Intensity Developed 80-100% impervious**
Baseline Conditions	Maintain existing tree canopy of 32.3% at present level	Maintain existing tree canopy of 13% at present level	Maintain existing tree canopy of 5.9% at present level	Maintain existing tree canopy of 1.3% at present level
Goals	Increase tree canopy to 35%	Increase tree canopy to 15%	Increase tree canopy to 8%	Increase tree canopy to 3%

Carbon Sequestration and Carbon Storage

Carbon sequestration is the capture of carbon dioxide (CO2) from the atmosphere; trees sequester carbon by absorbing CO2 from the atmosphere and combining it with sunlight in a process known as photosynthesis. This process creates the sugars, cellulose, and carbohydrates that are used to sustain the tree. Carbon storage is the storage of that carbon within the structure of the tree, which is approximately 50% carbon by dry weight. Trees will continue to store carbon efficiently until they begin to decay or are burned.

The following tables refer to the four developed land cover classifications and show the amount of CO_2 annually by the tree canopy at present, followed by the amount that would be sequestered annually if canopy cover was increased. The suggested canopy increases are lower in the more intensively developed the land. This is because there is less open space available for additional tree cover in more intensively developed areas, and it is generally more difficult to find suitable planting sites.

Urban Tree Canopy Expansion with Carbon Sequestration

1. **Cost-benefit on least developed land - "Developed, Open Space" where <20% of the land is occupied by impervious surfaces**

A	B	C	D	E	F	G	H
Tree Canopy Goal	Annual CO2 Sequestered	Increase in CO2 Sequestered From Previous Canopy Cover	Cumulative Number of Trees Present When Canopy Goal is Reached	Number of Trees to be Planted to Achieve Canopy Goal by 2030	Number of Trees to be Planted Annually for 15 Years	Total Cost of Trees to Be Planted to Reach Canopy Goal[1]	Annualized Cost Per Ton of CO2 Sequestered over 15 Years
Percent	Tons CO2 per Year	Tons CO2 per Year	Trees	Trees	Trees per Year	Dollars	Dollars per Ton CO2
Baseline (32.3%)	3,375,470	N/A	67,673,700	N/A[2]	N/A	N/A	NA
Increase to 35%	3,653,376	227,906 (B2 – B1)	73,245,350	5,571,650 (D2 – D1)	371,443/ yr (E2 / 15)	$835,747,500 (E2 * 150)	$200/ton ((G2/ C2)/15)

2. **Cost-benefit on Low Intensity Developed land, where 20% - 49% of the land is occupied by impervious surfaces**

A	B	C	D	E	F	G	H
Tree Canopy Goal	Annual CO2 Sequestered	Increase in CO2 Sequestered From Previous Canopy Cover	Cumulative Number of Trees Present When Canopy Goal is Reached	Number of Trees to be Planted to Achieve Canopy Goal by 2030	Number of Trees to be Planted Annually for 15 Years	Total Cost of Trees to Be Planted to Reach Canopy Goal	Annualized Cost Per Ton of CO2 Sequestered over 15 Years
Percent	Tons CO2 per Year	Tons CO2 per Year	Trees	Trees	Trees per Year	Dollars	Dollars per Ton CO2
Baseline (13%)	575,889	N/A	11,545,800	N/A	N/A	N/A	N/A
Increase to 15%	664,263	88,374 (B2 – B1)	13,317,590	1,771,790 (D2 – D1)	118,119/ yr (E2 / 15)	$265,768,500 (E2 * 150)	$200/ton ((G2/ C2)/15)

[1] A conservative cost of $150 per tree is used for the tree, mulch, stakes, and water bag; volunteer labor is assumed.

[2] Tree planting will be needed in order to maintain existing tree cover, but the number of trees necessary for no net loss is unknown at this time.

3. Cost-benefit on Medium Intensity Developed land, where 50% - 79% of the land is occupied by impervious surfaces

A	B	C	D	E	F	G	H
Tree Canopy Goal	Annual CO2 Sequestered	Increase in CO2 Sequestered From Previous Canopy Cover	Cumulative Number of Trees Present When Canopy Goal is Reached	Number of Trees to be Planted to Achieve Canopy Goal by 2030	Number of Trees to be Planted Annually for 15 Years	Total Cost of Trees to Be Planted to Reach Canopy Goal	Annualized Cost Per Ton of CO2 Sequestered over 15 Years
Percent	Tons CO2 per Year	Tons CO2 per Year	Trees	Trees	Trees per Year	Dollars	Dollars per Ton CO2
No net loss (remain at 5.9%)	123,699	N/A	2,479,990	N/A	N/A	N/A	N/A
Increase to 8%	168,084	44,385 (B2 – B1)	3,369,860	889,870 (D2 – D1)	59,325/ yr (E2 / 15)	$133,480,500 (E2 * 150)	$200/ton ((G2/ C2)/15)

4. Cost-benefit on High Intensity Developed land, where 80% - 100% of the land is occupied by impervious surfaces

A	B	C	D	E	F	G	H
Tree Canopy Goal	Annual CO2 Sequestered	Increase in CO2 Sequestered From Previous Canopy Cover	Cumulative Number of Trees Present When Canopy Goal is Reached	Number of Trees to be Planted to Achieve Canopy Goal by 2030	Number of Trees to be Planted Annually for 15 Years	Total Cost of Trees to Be Planted to Reach Canopy Goal	Annualized Cost Per Ton of CO2 Sequestered over 15 Years
Percent	Tons CO2 per Year	Tons CO2 per Year	Trees	Trees	Trees per Year	Dollars	Dollars per Ton CO2
Baseline (1.3%)	10,608	N/A	212,680	N/A	N/A	N/A	N/A
Increase to 3%	24,900	14,292 (B2 – B1)	499,200	286,520 (D2 – D1)	19,101/ yr (E2 / 15)	$42,978,000 (E2 * 150)	$200/ton ((G2/ C2)/15)

Energy Savings

According to American Forests, properly selected, well-placed trees that provide shade for homes and businesses can reduce air conditioning needs by 30%. Trees can also help in the winter by acting as wind breaks for cold winter winds. This can add up to 20-50% energy savings during the winter months. Find out more about these uses at the National Arbor Day Foundation's website: http://www.arborday.org/globalwarming/treeshelp.cfm/. The following goal summaries detail the potential additional energy savings yielded, in dollars, upon reaching the set urban tree canopy goals for three of the four land cover types associated with the urban and suburban environments of Pennsylvania. A goal summary was not prepared for the Developed, Open Space land cover type because the assumption is that the trees planted in this land cover type are not likely to be shading structures.

Background Regarding Potential Energy Savings Calculations:

For the potential energy savings calculations below, several assumptions and generalizations were used:

Generalizations and Basic Information:

- American Forests indicates that properly placed trees can save 30% on cooling costs and between 20% and 50% on heating costs. For the purposes of these calculations, we used 30% savings across the board.
- The average yearly energy expenditure per household in Pennsylvania (not including transportation costs) is $2,400, and approximately 53% of that is for heating and cooling. Therefore the average yearly heating and cooling costs per household are estimated at $1,240[3].

Assumptions:

- Within the High Intensity Developed land cover type, 100% of trees planted have potential to shade structures.
- Within the Medium Intensity Developed land cover type, 60% of trees planted have potential to shade structures.
- Within the Low Intensity Developed land cover type, 35% of trees planted have potential to shade structures.
- Within the Open Space Developed land cover type, 0% of trees planted have potential to shade structures.
- Of the percentage of new trees planted that are likely to shade structures, all will be planted in the optimum locations for energy savings.
- For one average house to save 30% on energy costs, 2 properly selected, well-placed trees are needed.

The Energy Savings Calculation:

Part 1: Figure out the number of goal-related trees that are likely to be planted where there is potential to shade structures. Do this by taking the total number of trees for each land cover type goal and multiplying that by the percentages listed in the assumptions above.

Part 2: The number of trees needed to increase tree canopy to the desired goal divided by 2 trees per household equals number of households affected.

Part 3: The number of households affected multiplied by $1,240 average yearly spending per household equals the total amount spent on energy by affected commonwealth households without the benefit of tree shading and wind-blocking.

[3] http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/pa.pdf

Part 4: The total amount spent on energy by affected commonwealth households without the benefit of tree shading and wind-blocking multiplied by 0.3 (the 30% savings) equals the amount of money saved by residents of the commonwealth from the planting of properly selected, well-placed trees.

The estimated 30% annual energy savings will take place once the planted trees have reached maturity. The length of time for the trees to reach maturity will vary from tree to tree. The calculated energy savings are incorporated during the timeframe of this workplan, even though some of the trees will not reach maturity until after 2030. Mature trees will provide energy savings to nearby homes and buildings for significantly longer than 15 years on average.

The calculations used might be expressed as a formula as:

(# trees to be planted annually to reach canopy goal)	X	(% of those trees that shade structures in this intensity of development)	**X**	($1,240 average annual energy cost per household for heating & cooling)	X	(30% savings reasonably expected from shading)	=	Energy Savings per Year in Dollars
2 well placed trees per home are needed								

EXAMPLE: Low Intensity Developed Land with tree canopy increased to 15%

- Number of trees to be planted to achieve canopy goal: 1,771,790
- 35% of trees planted in low intensity developed land are likely to shade structures

$$\frac{1{,}771{,}790 \times 0.35}{2} \times \$1{,}240 \times 0.30 = \$115{,}343{,}529$$

Low Intensity Developed Land Goal Summary (35% of trees planted assumed to shade structure)

Tree Canopy Goal for Low Intensity Developed	# Trees to Plant to Reach Goal	One-Time Planting Costs	Additional Energy Savings Realized by Increased Tree Canopy Cover	Years Needed to Pay for Costs Via Energy Savings
		Dollars	Dollars	Years
Increase to 15%	1,771,790	265,786,500	$115,343,529	2.3

Medium Intensity Developed Land Goal Summary (60% of trees planted assumed to shade structure)

Tree Canopy Goal for Medium Intensity Developed	# Trees to Plant Annually for 15 Years to Reach Goal	One-Time Planting Costs	Additional Energy Savings Realized by Increased Tree Canopy Cover	Years Needed to Pay for Costs Via Energy Savings
		Dollars	Dollars	Years
Increase to 8%	889,870	133,480,500	$99,309,492	1.3

High Intensity Developed Land, Goal Summary (100% of trees planted assumed to shade structure)

Tree Canopy Goal for High Intensity Developed	# Trees to Plant Annually for 15 Years to Reach Goal	One-Time Planting Costs	Additional Energy Savings Realized by Increased Tree Canopy Cover	Years Needed to Pay for Costs Via Energy Savings
		Dollars	Dollars	Years
Increase to 3%	286,520	42,978,000	$53,292,720	0.8

Limitations of this Calculation

This formula provides a broad overview of what additional properly selected and properly-placed trees might contribute to energy savings. These savings are calculated in today's dollars and are not discounted for future inflation. Calculating existing savings from current tree canopy was not calculated. The $1,240 average annual energy expenditure per household for heating and cooling certainly includes some houses that are already shaded by trees; however, it is likely that the actual energy savings realized if the stated goals are reached would be much, much greater than estimated here. Part of the reason for the likely underestimation is that this calculation does not include specific numbers related to industrial facilities and other businesses, which would also benefit greatly from energy savings derived from tree planting. Industrial and business energy savings are more easily calculated on an individual basis due to wide variation in building size and location. This calculation also does not include savings related to transportation. For example, the shade provided by trees in parking lots helps keep gasoline from volatizing (due to heat) from vehicle gas tanks into the air, especially on particularly hot days when parking lots become intense heat islands.

Implementation Steps:

- Continue to leverage and expand the Commonwealth's TreeVitalize program
- Develop a comprehensive approach to school tree planting
- Educate homeowners about the cost-saving potential of planting trees in residential areas
- Encourage businesses to plant trees on their properties through outreach efforts that promote the use of trees for carbon capture and energy efficiency
- Support non-profit entities and municipalities in the planting, care, and maintenance of their local trees
- Develop new sources of non-federal and non-state funding for tree planting programs
    - Potential sources include Arbor Day Foundation, other private foundations, and community in-kind services as matching funds, such as those used in TreeVitalize
    - Work with PennVEST to solicit corporate donations as carbon credits and sustainability credits to plant trees in PA instead of overseas
- Financial and other incentives for business owners and civic managers to add trees, such as grants for adopting shading and cooling measures
- Meetings with PennDOT and utility companies to work out more flexible options, like allowing smaller trees under power lines, tree pruning agreements, etc…

- Small-scale and large-scale urban retrofit efforts (see Philadelphia) to create new planting areas during streetscape revisions during bike lane additions, traffic calming engineering, storm water improvements, etc…
- Link UTC expansion to MS4 retrofits so carbon sequestration benefits can be realized with storm water retrofits
- Where feasible, explore opportunities to incorporate disease-resistant American chestnut in urban tree planting projects
- Work with tree planting programs (like TreeVitalize) to educate both landowners and municipal staff on tree maintenance needs, costs, and leaf pickup

Ongoing Efforts to Maintain and Increase Urban Tree Canopy

The TreeVitalize Program began in 2004 after a study by American Forests indicated that the tree canopy in Philadelphia and surrounding counties had decreased significantly. The program initially sought an $8 million investment in tree planting and care in southeastern Pennsylvania for a 4-year period of time. The goals of the program included planting 20,000 street trees, restoring 1,000 acres of streamside forests, and training 2,000 citizens to plant and care for trees. It has since expanded to Pittsburgh and throughout the rest of the state while also growing in scope to include all urban and community forestry-related work done by the PA DCNR Bureau of Forestry. To date, nearly 430,000 trees have been planted through community grants and partnerships; approximately 7,000 citizens have received training; many communities have acquired tree inventories; and urban tree canopy analyses have been completed for many large cities in the state. (To find out more about TreeVitalize, visit www.treevitalize.net.)

Cost of Increasing Canopy Cover

The cost of increasing canopy cover is difficult to ascertain because there are so many variables involved. The cost of site preparation varies drastically depending on where the tree is to be planted. In open areas and low intensity developed areas, little site preparation may be required, while in intensively developed areas, concrete cuts and significant subsurface improvements may be needed to support the growth of a tree. The cost of planting will vary based on whether volunteer or paid labor is involved, and whether heavy equipment is required. Maintenance of trees is an essential component of successfully increasing canopy cover that is often overlooked. Early structural pruning of young trees can significantly reduce hazardous defects in mature trees, and a regular pruning cycle is necessary to ensure long term health.

Assuming a cost of $150 per 2" caliper tree and the use of volunteer labor to plant and establish the trees:

- The cost of planting a sufficient number of trees to reach the lower percent canopy goals in developed land cover classes across the state of 35% in open space, 15% in low intensity development, 8% in medium intensity development, and 3% in high intensity development, is estimated at **$86 million per year** (over the course of 15 years).

In addition, there may be less expensive sources of native trees, including wholesale nurseries and county conservation district tree sales. For best results in urban settings, however, larger trees and extra care in siting and planting will be essential for long-term survival. Additional costs due to mortality are not included in the above calculations, nor are the costs of ongoing tree maintenance, which are essential for a healthy urban forest. Still, it should be noted that the above costs are ***one-time expenditures.*** In contrast, the benefits provided by a healthy urban forest are produced annually.

Through i-Tree Vue, the total value of ecosystem services (including carbon stored/sequestered and pollutants intercepted/taken up) that would be provided if the lower percent canopy goals were implemented across all developed land cover classes is ***$2.6 million annually.*** The value of energy savings from shading, calculated as described previously, would total ***$268 million annually.***

Year	2016	2020	2030
Total # of trees planted	567,989	567,989	567,989
Cumulative # of additional trees	567,989	2,839,943	8,519,830
Amount of CO2 Sequesterd (tons)	28,331	141,656	424,969
# of homes shaded by two new trees	48,019	240,095	720,284
Amount of CO2 reduced by tree shading (tons)	38,895	194,477	583,430
Total CO2 reduction by seq. and shading (MMTCO2e)	0.061	0.305	0.915
Total Money saved in energy spending	17,863,049	89,315,247	267,945,741
Total Money spent in planting trees	85,198,300	85,198,300	85,198,300
Net Cost of planting Trees ($ Million)	67.3	-4.1	-182.7
Cost Effectiveness ($ / ton CO2e)	1104.3	-13.5	-199.8

	2030 Annual			**2030 Cumulative**		
	Reductions (MMtCO2e)	**Cost ($MM)**	**Cost-Effectiveness ($/tCO2e)**	**Reductions (MmtCO2e)**	**Total NPV ($MM)**	**Cost-Effectiveness ($/tCO2e)**
Urban Forestry	.915	-182.7	- 199.8	7.32	743.33	101.6