Urban Forestry

Initiative Summary: This option seeks to increase carbon stored in urban forests, and thereby to reduce residential, commercial, and institutional energy use for heating and cooling. 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). Forest canopy cover, properly designed, can also reduce energy demand by reducing building heating and cooling needs.

Goal: Increase existing urban and suburban tree cover through one of the following three scenarios.
Scenario 1: Increase existing tree cover in PA urban and suburban forests by 10% by 2020.
Scenario 2: Increase existing tree cover by 25% by 2020.
Scenario 3: Increase existing tree cover by 50% by 2020.

Implementation Period: 2013–2020

Potential GHG Reduction (MMtCO_2e):
This work plan documents the cumulative impact on carbon sequestration and avoided fossil fuel emissions of adding trees to existing canopy cover in PA. Specifically, Scenarios 1, 2, and 3 seek to increase the total number of trees in urban and suburban PA by 10%, 25%, and 50%, respectively, by 2020. Currently, PA contains about 139 million urban trees: thus this option quantifies the effect of adding 13.9, 34.8, and 69.5 million trees by 2020. The number of trees planted each year is constant, with the target number of trees planted by 2020. GHG benefits are twofold:

A. Direct Carbon Sequestration in Urban Trees

A linear rate of increase in tree planting was assumed, with full scenario implementation occurring in 2020 for all three scenarios. Annual carbon sequestration per urban tree is calculated as 0.006 tC/tree/year, based on statewide average data reported by USFS. This is the average annual per-tree carbon sequestration value when the total estimated urban forest carbon accumulation in PA (863,000 tC/year) is divided by the total number of urban trees in PA (139.0 million). Since trees planted in one year continue to accumulate carbon in subsequent years, annual carbon sequestration in any given year is calculated as the sum of carbon stored in trees planted in that year, plus the sequestration by trees that were planted in prior years.

B. Avoided Fossil Fuel Emissions

Offsets from avoided fossil fuel use for heating and cooling are the sum of three different types of savings: avoided emissions from reduced cooling demand, avoided emissions from reduced demand for heating due to wind reduction (this benefit is only available for evergreen trees), and enhanced fossil fuel emissions needed for heat due to wintertime shading. Calculations for avoided fossil fuel offsets are based on calculations presented by McPherson et al. in GTR-PSW-171 (Table 1). For this analysis, it is assumed that the trees planted are evenly split among residential settings with pre-1950, 1950–1980, and post-1980 homes, and that all trees planted are medium-sized, with 50% deciduous and 50% evergreen. These avoided emission factors assume average tree distribution around buildings (i.e., these fossil fuel emissions reduction factors are averages for existing buildings, but do not necessarily assume that trees are optimally placed around buildings to maximize energy efficiency). These factors are also dependent on the fuel mix (coal, hydroelectric, nuclear, etc.) for electricity generation, and thus change as the mix changes.

Overall GHG Benefit of Urban Tree Planting

Total GHG benefits are calculated as the sum of direct carbon sequestration plus fossil fuel offset from reduced cooling demand and wind reduction (Tables 2, 3, and 4).

Table 1. Factors Used to Calculate CO_2e Savings ($MMtCO_2$e/Tree/Year) From Reduced Need for Fossil Fuel for Heating and Cooling, and From Windbreak Effect of Evergreen Trees

Fossil Fuel Offsets: Evergreen Trees (Mid-Atlantic Climate Region)				
Housing Vintage	*Shade–Cooling*	*Shade–Heating*	*Wind–Heating*	*Net Effect*
Pre-1950	0.0168	–0.0315	0.1294	0.1147
1950–1980	0.0275	–0.0403	0.1555	0.1427
Post-1980	0.0232	–0.0324	0.133	0.1238
Average	**0.0225**	**–0.0347**	**0.1393**	**0.1271**
Average ($MMtCO_2$e)				**0.1271**
Fossil Fuel Offsets: Deciduous Trees (Mid-Atlantic Climate Region)				
Housing Vintage	*Shade–cooling*	*Shade–Heating*	*Wind–Heating*	*Net Effect*
Pre-1950	0.0260	–0.0320		–0.0060
1950–1980	0.0425	–0.0409		0.0016
Post-1980	0.0358	–0.0329		0.0029
Average	**0.0348**	**–0.0353**		**–0.0005**
Average ($MMtCO_2$e)				**0.0633**

Source: McPherson et al., 1999.
$MMtCO_2$e = million metric tons of carbon dioxide equivalent.

Table 2. Overall GHG Benefit ($MMtCO_2$e/year) of Scenario 1: Increase Existing PA Urban Tree Canopy by 10%

Year	**Trees Planted This Year**	**Trees Planted in Previous Years**	**GHG Sequestered**	**GHG Avoided**	**Overall GHG Savings**
2013	1,158,500	0	0.026	0.073	0.10
2014	1,158,500	1,158,500	0.053	0.147	0.20
2015	1,158,500	2,317,000	0.079	0.220	0.30
2016	1,158,500	3,475,500	0.105	0.293	0.40
2017	1,158,500	4,634,000	0.132	0.367	0.50
2018	1,158,500	5,792,500	0.158	0.440	0.60
2019	1,158,500	6,951,000	0.185	0.513	0.70
2020	1,158,500	8,109,500	0.211	0.587	0.80
Cumulative Totals	**9,268,000**	**32,438,000**	**0.949**	**2.639**	**3.59**

$MMtCO_2$e = million metric tons of carbon dioxide equivalent.

Table 3. Overall GHG Benefit ($MMtCO_2e$/year) of Scenario 2: Increase Existing PA Urban Tree Canopy by 25%

Year	Trees Planted This Year	Trees Planted in Previous Years	GHG Sequestered	GHG Avoided	Overall GHG Savings
2013	2,896,250	0	0.066	0.183	0.25
2014	2,896,250	2,896,250	0.132	0.367	0.50
2015	2,896,250	5,792,500	0.198	0.550	0.75
2016	2,896,250	8,688,750	0.264	0.733	1.00
2017	2,896,250	11,585,000	0.330	0.916	1.25
2018	2,896,250	14,481,250	0.396	1.100	1.50
2019	2,896,250	17,377,500	0.461	1.283	1.74
2020	2,896,250	20,273,750	0.527	1.466	1.99
Cumulative Totals	**23,170,000**		**2.374**	**6.598**	**8.97**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table 4. Overall GHG Benefit ($MMtCO_2e$/year) of Scenario 3: Increase Existing PA Urban Tree Canopy by 50%

Year	Trees Planted This Year	Trees Planted in Previous Years	GHG Sequestered	GHG Avoided	Overall GHG Savings
2013	5,792,500	0	0.132	0.367	0.50
2014	5,792,500	5,792,500	0.264	0.733	1.00
2015	5,792,500	11,585,000	0.396	1.100	1.50
2016	5,792,500	17,377,500	0.527	1.466	1.99
2017	5,792,500	23,170,000	0.659	1.833	2.49
2018	5,792,500	28,962,500	0.791	2.199	2.99
2019	5,792,500	34,755,000	0.923	2.566	3.49
2020	5,792,500	40,547,500	1.055	2.933	3.99
Cumulative Totals	**46,340,000**		**4.747**	**13.196**	**17.94**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

<u>Economic Cost</u>:

Economic costs of tree planting are calculated as the sum of tree planting and annual maintenance, including the costs of program administration and waste disposal. Economic benefits of tree planting include the cost offset from reduced energy use, as well as the estimated economic benefits of services, such as provision of clean air, hydrologic benefits such as storm water control, and aesthetic enhancement.

Data were not available to assess the cost of tree planting specifically in PA communities. As a result, the cost of planting urban trees in PA is taken from Peper et al. (2007), whose analysis was conducted in New York City. The average annualized cost per tree is estimated at \$39.24 (\$2010), and includes planting, pruning, pest management, administration, removal, and infrastructure repair due to damage from trees.

Two types of data were available to quantify the economic benefit of planting urban trees. The first data source is the New York City analysis of Peper et al. (2007). Average annual cost savings of –\$217.80

($2010) per tree from this work is the average of all trees in the city, and includes benefits of energy savings, improved air quality, improved storm water quality, and improved aesthetics.

A second estimate of economic benefit per tree, specifically for Philadelphia, PA, was also used (Nowak et al., 2007). This analysis quantified the structural benefit of urban trees (i.e., replacement costs) as well as the annual functional benefits of urban trees (i.e., pollution abatement, energy savings). Total structural benefit of Philadelphia's 2.1 million urban trees was estimated at $1.8 billion. To determine the annual structural benefit of the urban tree canopy, this total citywide structural benefit was divided by 50 (the average lifetime of an urban tree). Annual functional economic benefits for the urban tree canopy were calculated as the value of pollution abatement ($3.9 million) plus the value of avoided energy costs ($1.19 million). The citywide structural and functional benefits were divided by the number of trees to estimate the annual economic benefit per tree in PA. From this source, the average annual (structural + functional) benefit per tree per year in PA was calculated at –$20.60.

For this analysis, –$217.80/tree/year and –$20.60/tree/year were averaged to estimate the economic benefits of planting urban trees (–$119.20/tree/year). While these values clearly diverge substantially from one another, the methods used to estimate economic benefits of non-market services, such as clean air and water and pollution abatement, are inexact and variable. The value of –$119.20/tree/year is consistent with results obtained for similar analyses in other states.

Net economic costs for this option, as illustrated in Tables 5 through 7, are calculated as the difference between costs of planting + maintenance and economic benefit realized by urban trees. Negative costs therefore refer to net economic benefits, where estimated benefits exceed overall costs. For this analysis, net economic benefit per tree was estimated at –$75.96/tree/year. Discounted costs were calculated in 2010 dollars and assuming a 5% discount rate. For all scenarios, the cost-effectiveness of implementation is –$610.16/tCO2e, which indicates a net cost savings per tCO_2e reduced.

Table 5. Annual and Cumulative Economics of Implementing Scenario 1

Year	Non-discounted ($)	Discounted ($2010)	Levelized Cost-Effectiveness ($/tCO2e)
2013	-$87,997,729	-$76,015,747	
2014	-$175,995,458	-$144,791,899	
2015	-$263,993,188	-$206,845,570	
2016	-$351,990,917	-$262,661,041	
2017	-$439,988,646	-$312,691,716	
2018	-$527,986,375	-$357,361,961	
2019	-$615,984,104	-$397,068,846	
2020	-$703,981,833	-$432,183,778	-$541.95
Cumulative Totals	**-$3,167,918,250**	**-$2,189,620,559**	**-$610.16**

Table 6. Annual and Cumulative Economics of Implementing Scenario 2

Year	Non-discounted ($)	Discounted ($2010)	Levelized Cost-Effectiveness ($/tCO2e)
2013	-$219,994,323	-$190,039,368	
2014	-$439,988,646	-$361,979,748	
2015	-$659,982,969	-$517,113,925	
2016	-$879,977,292	-$656,652,604	
2017	-$1,099,971,615	-$781,729,290	
2018	-$1,319,965,938	-$893,404,903	
2019	-$1,539,960,260	-$992,672,114	
2020	-$1,759,954,583	-$1,080,459,444	-$541.95
Cumulative Totals	**-$7,919,795,625**	**-$5,474,051,397**	**-$610.16**

Table 7. Annual and Cumulative Economics of Implementing Scenario 3

Year	Non-discounted ($)	Discounted ($2010)	Levelized Cost-Effectiveness ($/tCO2e)
2013	-$439,988,646	-$380,078,735	
2014	-$879,977,292	-$723,959,496	
2015	-$1,319,965,938	-$1,034,227,851	
2016	-$1,759,954,583	-$1,313,305,207	
2017	-$2,199,943,229	-$1,563,458,580	
2018	-$2,639,931,875	-$1,786,809,806	
2019	-$3,079,920,521	-$1,985,344,229	
2020	-$3,519,909,167	-$2,160,918,889	-$541.95
Cumulative Totals	**-$15,839,591,250**	**-$10,948,102,793**	**-$610.16**

Implementation Steps:

- Leverage/expand TreeVitalize program.
- Consider a comprehensive approach to school tree planting.
- Provide incentives for private landowners to plant trees in residential areas.

Goals Support Full Implementation of Target Programs

The TreeVitalize initially sought an $8 million investment in tree planting and care in southeastern Pennsylvania over a 4-year period. The goals of the program included planting 20,000 shade trees, restoring 1,000 acres of forests along streams and water-protection areas, and training 2,000 citizens to plant and care for trees. DCNR initiated preliminary discussions with regional stakeholders in the summer of 2003, and appointed a Project Director in January 2004. Planning, assessment, and resource development continued through 2004. Tree-planting activities began in the fall of 2004 and have continued. Subsequently, the regional Tree Tenders program was launched in 2005. Although TreeVitalize is not a permanent entity, the collaborations created and capacity built will continue to increase tree cover and promote stewardship through expansion across other regions of the state. See: http://www.treevitalize.net/aboutus.aspx.

Enabling Programs May Provide Relevant Information in Support of Implementation

The Rural & Community Forestry Section provides professional forestry leadership and technical assistance promoting forestry and the knowledge of forestry by advising and assisting other government agencies, communities, landowners, the forest industry, and the general public in the wise stewardship and utilization of forest resources. The section also coordinates BOF's conservation education efforts, and provides professional forestry leadership and technical assistance to rural communities and urban areas. Efforts include coordination with Penn State's regional urban foresters, Arbor Day activities, Tree City USA, Penn ReLeaf, the Harrisburg Greenbelt project, the Municipal Tree Restoration program, and the Urban & Community Forestry Council. See: http://www.dcnr.state.pa.us/forestry/rural/index.aspx.

Major funding streams are through USFS state and private forestry through urban forestry funds. These support the work at Penn State by the Statewide Urban and Community Forestry Committee, which also receives some funding from the Bureau of Recreation and Conservation, as well other smaller grants from utilities. There is a Northeast Pennsylvania Urban & Community Forestry Program, which is funded through the 10th congressional district. This northeast area does not include Scranton/Wilkes Barre. Williamsport is the largest city included in this area.

The Animal Plant and Health Inspection Service of the USDA (http://www.aphis.usda.gov/) gets involved in and makes funds available to combat specific issues, such as protection of urban forests from disease, fire, other risks, and proper management of urban forests and street trees.

Develop a package of incentives and programs to encourage retention/enhancement of tree cover on new developments (e.g., Department of Community and Economic Development planning/technical assistance, state funding bonus/priority, model subdivision and land-use development ordinances (SALDOs) for carbon sequestration maintenance/offset requirements associated with tree cover, tax breaks for tree-friendly development, etc.).

Re-greening underutilized/abandoned properties through targeted tree planting programs and comprehensive local/county planning for urban/suburban terrestrial carbon sequestration.

Potential Overlap: None.

Data Sources:

- Information about current numbers of trees in urban forest and annual carbon storage in urban trees in PA from D.J. Nowak et al., USFS, Northern Research Station, *Urban Forest Effects on Environmental Quality*, State Summary data for Washington (http://www.fs.fed.us/ne/syracuse/Data/State/data_PA.htm).
- Fossil fuel reductions through reduced demand for cooling and protection from wind from: E. McPherson and J.R. Simpson. 1999. *Carbon Dioxide Reduction Through Urban Forestry: Guidelines for Professional and Volunteer Tree Planters*. USFS GTR-PSW-171. USFS, Pacific Southwest Research Station.
- Data on the costs of tree planting and maintenance from Peper, P.J., et al. 2007. *New York City, New York Municipal Forest Resource Analysis*. Center for Urban Forest Research, USFS Pacific Southwest Research Station.
- Additional data on benefits of tree canopy in PA are from D.J. Nowak et al. 2007. *Assessing Urban Forest Effects and Values: Philadelphia's Urban Forest.* Resource Bulletin NRS-7. USFS, Northern Research Station