White Clay Creek Watershed Reforestation Plan
Pennsylvania Portion

Prepared for:

White Clay Creek Wild & Scenic Management Committee

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Foreword

Large-scale watershed-level reforestation is an idea that is long overdue throughout southeastern Pennsylvania – and particularly in the White Clay Creek watershed, an area that was almost completely forested when the first European settlers arrived three centuries ago. Trees are the foundation of watershed health, and while other more common approaches to improving water quality are necessary and important, their effectiveness ultimately depends on the reforestation of the broader watershed. And trees provide many more benefits than improvements to water quality: among other things, they mitigate stormwater runoff; moderate the effects of droughts and floods; slow the erosion of steep slopes and provide important wildlife habitat.

In the headwaters of White Clay Creek near the Stroud Water Research Center, we have planted more than 25,000 trees – both on the Center's land and that of our neighbors – in the last two decades and we hope to do more. We have done this because our research findings in the region have shown that the more forest in a watershed, the healthier the stream ecosystem and cleaner the water both for a given location in the creek and further downstream. In fact, our research shows that the single most important factor explaining variation in water quality in the region is the percentage of tree cover in each watershed. Therefore, in watersheds where tree cover is less than optimal, reforestation is the 'Best Management Practice.'

Such reforestation efforts have significant implications for the people of the watershed. Two examples: drinking water and trout fishing. White Clay Creek provides fresh water to many communities in its watershed, most notably the City of Newark, Delaware. This city of 30,000, which is home to the University of Delaware, will directly benefit from reforestation through both cleaner water and lower treatment costs. And fishermen can expect improved water quality and lower temperatures for trout with increased tree coverage.

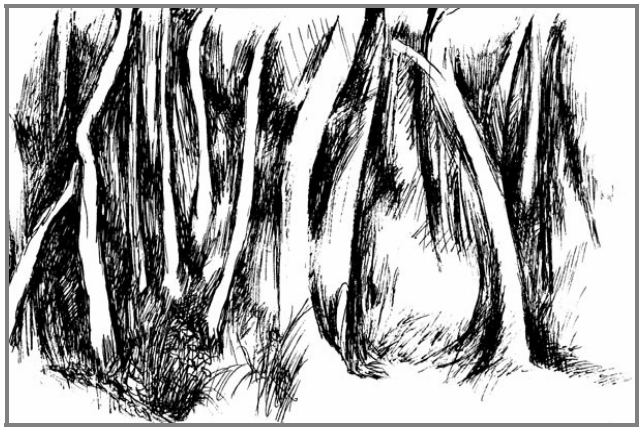
In this era of climate change and more extreme weather events, trees provide an important margin of safety. Masterfully designed to manage rainfall, their thousands of leaves break up the erosive force of raindrops; their intricate root systems conduct huge volumes of water into the ground, where it either is absorbed into the tree or seeps into the water table. By providing critical baseflow to streams during dry months, this groundwater offsets the effects of drought. And of course trees sequester and store carbon, too. With levels of carbon dioxide in the atmosphere now close to 400 parts per million and rising – which is about 30% more than the science indicates has been there over the past 600,000 years – this may be one of the most important functions trees provide.

We must wait no longer. For all these compelling reasons, now is the time for the large-scale reforestation of the White Clay Creek watershed that is proposed in this plan.

Bern Sweeney, Director, Stroud Water Research Center
January 22, 2009, Avondale, PA.

Executive Summary

The Pennsylvania portion of the White Clay watershed, approximately 39,208 acres (61¼ square miles) in size, has been undergoing rapid suburbanization in recent years, the current downturn in the housing market aside. However, the area still contains large amounts of open farmland, as well as approximately 24%, or 9,380 acres, of forest cover. Both land use types are vulnerable to further losses and conversion.



At the same time, although most of the streams in the watershed are federally designated as Wild and Scenic River segments, the water quality in the watershed is generally poor with over three-quarters, 61 miles, of the streams considered as impaired, or polluted.

An ever-increasing body of scientific study documents forest cover to be the most beneficial use of land from a water quality, stormwater runoff, and wildlife habitat standpoint. With global warming, forests are ever more critical for the carbon sequestration functions they provide. Forests are the land cover type that defines and characterizes this region, the land cover type under which watersheds and wildlife evolved over very long periods of time. Chapter One discusses the many ecosystem benefits that forests can provide. Chapter Two discusses the current conditions of forest cover within the Pennsylvania portion of the White Clay Creek watershed.

This Plan calls for a watershed-based reforestation campaign that is integral to sustainable watershed management. The Plan seeks to foster the re-establishment of a strategic minimum of forest or woodland cover across the landscape to support water quality and watershed health, as well as provide additional key wildlife and environmental benefits. It sets a long-term minimum forest cover goal of 40%, a net increase in forest cover across the watershed of approximately 16 percent, or 6,300 acres. While this may seem large, the goal is intended as a reasonable minimum, and is supported by independent scientific analysis and policy recommendations. At the same time, and as a higher priority, ongoing forest cover losses – estimated at approximately 100 acres across the watershed per year every year – must be minimized through stricter local regulations and incentives (see *Appendix B* for further analysis and discussion of this issue).

The Plan proposes to accomplish reforestation in several ways –

1) By identifying and prioritizing sensitive natural resource types and areas (see table below) where reforestation will have the maximum effect with a minimal economic or social cost (see Chapters 3 and 4 as well as the Reforestation Priority maps);

Priority Natural Resource Types/ Areas for Reforestation	
1. Riparian buffer zones	6. Headwater areas
2. Greenway corridors	7. Cockeysville marble areas
3. Steep slopes	8. Select lands adjacent to existing forests
4. Hydric soils and wetlands	

2) By identifying portions of key protected open space lands that are currently unforested (see Chapter 3);

3) By identifying funding sources, partners, and costs for this effort (Appendix C), as well as discussing implementation techniques (Appendix D), maintenance and monitoring needs (Appendix E), and appropriate reforestation species (Appendix G).

Seven of the eight Priority Natural Resource Types/ Areas for Reforestation identified in the table above were mapped and forested and unforested acres were quantified. Although there is overlap between many of the areas, there was a total without overlap of approximately 12,104.4 acres of unforested lands included between these resource types.

It is not expected that 100% of any of these resource types would be reforested. Rather, three (riparian buffers, greenway corridors and steep slopes) are proposed for high (70-85%) forest cover level; one (hydric soils/ wetlands) is proposed for medium (60-70%) forest cover level; and two (headwater areas and Cockeysville Marble Areas) are proposed for low (25-40%) forest cover levels (see Map 7 and Chapter 4).

This approach yields a range in proposed reforestation acreage of approximately 5,900 – 7,900 acres, close to the target reforestation goal of 6,300 acres.

With the exception of a few protected open space lands, most notably the White Clay Creek State Park, this Plan does not identify specific sites where reforestation is proposed. Those details are the work of future, cooperative local efforts, which this Plan seeks to foster.

While forests are of course more than trees, tree-planting is clearly a prerequisite for reforestation. This Plan clearly recognizes the importance of ultimately re-vegetating the ground layer under planted trees, but those details go beyond the scope of this plan.

Introduction

"It is hereby declared to be the policy of the United States that certain selected rivers of the Nation, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."

Section 1 (b), The Wild and Scenic Rivers Act (P.L. 90-542, as amended)

The White Clay Creek Watershed received national Wild and Scenic River Status in 2000. This achievement was the product of a committed group of resident volunteers along with representatives from local, county, state and federal government who worked tirelessly to achieve protection for and recognition of this unique place. A Management Plan for the White Clay Creek was written by the White Clay Creek Wild and Scenic Study Task Force and the National Park Service, Northeast region in 1994 and amended in 2001. Because over half of the White Clay Creek Watershed consists of fragile first order streams, the United States Congress directed the National Park Service to devise a Management Plan for the entire watershed. The administration and implementation of this Plan is the sole responsibility of the White Clay Creek Wild and Scenic Management Committee. In 2001, the National Park Service signed a Memorandum of Understanding with Pennsylvania and Delaware, Chester and New Castle Counties, all the local municipalities, and the Delaware River Basin Commission to implement the Management Plan. "The Plan envisions a cooperative approach to resource management and protection as part of what the Park Service calls their Wild and Scenic "partnership program." Landowners, citizens; private organizations; local, county, state and federal governments; businesses and others are encouraged to work together to achieve the goals and take the actions recommended in the Management Plan."[1]

The Management Plan calls for the preservation and protection of existing "mature" woodlands, as well as restoration at a "location, scale, intensity and frequency dictated by the ecological characteristics of the landscape."[2] The current forest cover of the Pennsylvania portion of the White Clay Creek watershed is approximately twenty-four percent. This Plan proposes reforesting the watershed to obtain a forty percent canopy cover as a minimum to retain and protect watershed health. Many of the goals and objectives of the White Clay Creek Management Plan are consistent with this proposal. They are as follows:

- Improve and conserve water quality and quantity.
- Maintain stream flow and maintain or improve water quality to revitalize fisheries and enhance recreational and scenic qualities, while accommodating legislative demands for water supply.

[1] White Clay Creek Wild and Scenic Study Task Force, National Park Service, *White Clay Creek Watershed Management Plan Amended 2001, 3.*

2 White Clay Creek Wild and Scenic Study Task Force, National Park Service, 61

- Protect and improve base flows and stream habitat through recharge.
- Protect Cockeysville Marble recharge areas from contamination.
- Protect and improve water quality and stream habitat through riparian forest buffers.
- Protect and improve water quality and stream habitat through slope protection.
- Sustain biodiversity through habitat linkage and management.
- Protect fragile wildlife habitats including floodplains, wetlands and riparian vegetation.
- Increase fish and wildlife diversity within the watershed.
- Expand the White Clay Creek Preserve.
- Improve stream quality to support trout populations.[3]

The forty percent canopy coverage goal is further substantiated by the following organizations. American Forests, a nonprofit citizens' conservation organization, is currently recommending a forty percent tree canopy for areas east of the Mississippi. In the past twenty years there has been a thirty percent decline in tree cover in urban areas in this region; while the footprint of these urban areas have increased twenty percent[4]. Environmental quality and tree cover are intrinsically linked.

Research performed by the Stroud Water Research Center located in Avondale, PA indicates that stream health is directly correlated to percent forest cover. The greater percent of forest cover, the healthier the streams tend to be. The healthier the streams are the better able they are to mitigate the impacts of pollutants. While it is understood that streamside forests improve stream health, upland forests also play a critical role as they are directly connected to water quality and quantity of ephemeral and intermittent streams. Furthermore, forests that are structurally intact are best able to provide the ecosystem service of clean water.

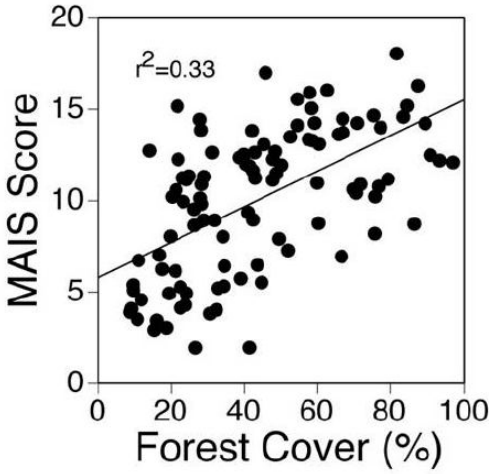
The Pennsylvania Department of Environmental Protection (PA DEP) established formal water quality goals based on various uses that include water supply, aquatic life and recreation. The protected use designations reflect the current conditions of the stream. These designations include Exceptional Value Waters (EV), Cold Water Fisheries (CWF), Trout Stocking (TS) and Warm Water Fisheries (WWF). Stroud Water Research Center reveals that EV streams generally have a sixty to eighty percent forest cover. All other stream designations reflect various levels of stream degradation.[5] To maintain water supply and support a diverse community of aquatic life, preservation of existing forests and reforestation will be necessary.

The White Clay Creek watershed contains over sixty-one miles of state-identified "impaired" (polluted) streams[6]. This listing includes the great majority of the East Branch (including a portion of the EV section and some of which runs through

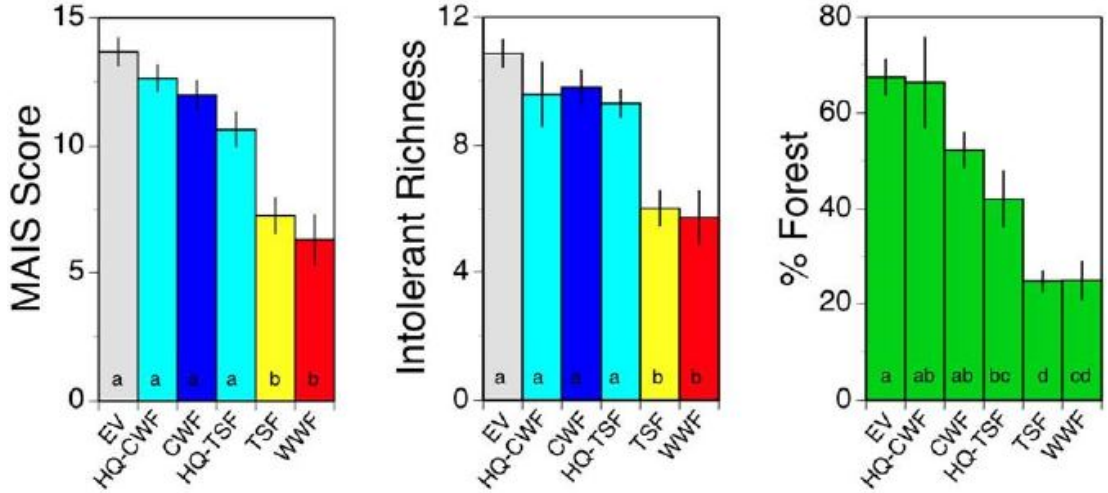
[3] White Clay Creek Wild and Scenic Study Task Force, National Park Service, 60 – 64.
[4] American Forests, http://www.americanforests.org
[5] John K. Jackson, Stroud Water Research Center
[6] White Clay Creek Watershed Action Plan, Chester County Water Resources Authority, West Chester, PA., 2002, Table 8 and Figure 4.

permanently protected lands); essentially all of the Middle Branch and a portion of the main stem. The impaired stream continues another 18.2 miles through Newark, Delaware, to the confluence with the Christina River, where after the Christina remains "impaired." The waters are impaired at two drinking water intakes, one for the City of Newark and the other for United Water Delaware.

The following graphs were provided by Dr. John K. Jackson of the Stroud Water Research Center. They represent data collected from the Schuylkill River. The data suggests that, absent definite excessive sources of pollution, forty percent forest cover would likely result in an "unimpaired" stream using PADEP definitions, perhaps even a High Quality (HQ) Trout Stocking Fishery that would remain too warm for trout year round. However, it is unlikely that forty percent forest cover will result in Exceptional Value or High Quality Cold Water Fishery stream.



Note – Please refer to the text for the definitions of the various water quality designations (EV, HQ, etc.). Also, MAIS refers to a score given for the relative abundance of select pollution-sensitive macro-invertebrate organisms, including aquatic insects like mayflies and stoneflies. The higher the score, the better the water quality and aquatic habitat. "Intolerant richness" refers to the number of those pollution-sensitive (or intolerant) species.



1. **Forests - Functions, Values and Benefits**

The landscape we now know as the White Clay Creek watershed evolved over very long periods of time under primarily forested conditions. The drainage patterns, water flow quantities and quality, the wildlife, both on land and in the water, and even the soils of the watershed have all been shaped by the forest "biome" under which they developed. As a central part of the broader "web of life," forests are fully and intimately connected to many aspects of the environment.

Ecosystem Services

The environmental benefits of woodlands to the human community can be measured in terms of ecosystem services. The greater the amounts of forest cover, the more ecosystem services are produced. A brief list of services is as follows:

- Storm water runoff reduction
- Improved water quality
- Improved air quality
- Carbon sequestration and storage
- Energy reduction
- Wildlife habitat

The roots of the trees, shrubs and herbaceous plants within a woodland, as well as the leaf litter slow the rate of storm water runoff and encourage infiltration, thereby assisting ground water recharge. The leaf litter further traps sediments and reduce the costs of erosion control measures. Civil engineers maintain that woodlands are one of the best and least expensive storm water controls available. American Forest's studies indicate that there has been a twenty percent increase in impervious surfaces over the past two decades, which has translated to a cost of one hundred billion dollars nationally. Local municipalities are utilizing "green infrastructure" to reduce the cost of constructing storm water control infrastructure.

Riparian forests play an essential role in water quality. The healthier the stream, the better able it is to process and degrade contaminants. The forest provides food and habitat for life in and around the stream, as well as creating favorable light and stable temperature conditions. A healthy and diverse aquatic community makes for a healthy stream. Fallen trees and limbs create debris dams, which further sustain the aquatic habitat through providing food and cover. In addition, riparian forests act as filters by intercepting sediments, excess nutrients, and other materials from surface runoff and shallow ground water. The biological processes of the trees convert nitrogen from excess nutrients into a form that sustains the growth of the forest. Thus, riparian forests not only intercept and convert pollutants before they enter the stream or the groundwater; they also mitigate the effects of erosion and excess nutrients occurring from storm water runoff.

Forests have the capability to remove pollutants such as carbon monoxide, sulfur dioxide, nitrogen dioxide, as well as particulate matter from the atmosphere resulting in cleaner air. The increase of atmospheric carbon has contributed to global warming. Trees sequester carbon from the air through absorption and store this carbon as biomass, mainly their own wood. The carbon-related function of trees is measured in two ways: storage, or the total amount currently stored in tree biomass, and sequestration, the rate of absorption per year.[7] Although the economic value of this ecosystem service has yet to be quantified, it likely will soon. This service provides life support for a warming planet.

Increased canopy cover reduces energy costs for the consumer through direct shading, as well as through the reduction of energy production. Less energy production means improved air quality and less carbon emitted to the atmosphere.

In addition to these broad functions, an intact forest supplies a multitude of specific ecosystem services that benefit the residents of the White Clay Creek Watershed. These benefits include maintaining base flow in streams through groundwater re-charge. During times of drought, this service assures water supply for the City of Newark, Delaware. Cool stream temperatures benefit aquatic life, in particular the trout that support recreational fishing within the White Clay Creek watershed.

Because woodlands offer such an array of benefits and services, it is important to understand what constitutes a healthy woodland.

Woodland Composition & Structural Diversity

The White Clay Creek Watershed is located on the Piedmont Province and is part of the Eastern Deciduous Forest. Historically, woodlands were the dominant habitat type of this region. As such, many species of plants and wildlife evolved within a woodland habitat and depend on these conditions for their existence. The forested ecosystem is a matrix of interdependent and synergistic relationships that occur between plants, fungi, organic matter, wildlife and insects. The healthier the system, the greater level of biodiversity it can support.

Within the Pennsylvania portion of the White Clay Creek Watershed xeric (dry) woodlands (ridge tops and upper slopes) are composed of a chestnut oak-heath and red oak-hickory mix. Mesic (moist) woods (lower slopes and upland flats) are composed of a beech-tulip-oak-hickory mix. Finally, wet woods (floodplains and hydric soils) are composed of a maple-pin oak mix.

Healthy and diverse forests are composed of many vegetative layers otherwise known as "structural diversity". Vigorous woodlands will be composed of a canopy, sub-canopy, understory, shrub, herbaceous and humus layer. Combined these layers provide function and habitat. When one or more of these layers are missing, the woodland loses its abilities to provide habitat and it will display characteristics of imbalance. The least understood and one of the most vital layers is the humus layer. This component lies largely beneath the ground and provides a synergistic life support for the entire system.

[7] American Forests, http://www.americanforests.org

Fallen dead wood provides lignin to the forest soil, which is comparable to calcium for human bones. Standing deadwood provides habitat for cavity nesting birds and mammals. Misguided woodland management will "clean up" the forest floor leaving only the live trees standing with no understory or shrub layer. This practice limits habitat for wildlife and seriously disrupts the process of nutrient cycling that supports the forest soils. With the overpopulation of white-tailed deer, much of the shrub layer has been browsed. More alarmingly, natural regeneration of the woodland is disrupted as the hungry deer consume the tree seedlings. The herbaceous layer is particularly vulnerable as it is by its own nature fragile. Poor logging practices (including a practice called 'high-grading' which is the removal of all commercially valuable trees, typically oak trees in this region), fragmentation, erosion, invasive species and white-tailed deer all pose threats to this delicate layer.

Fragmentation

Most of the soils in the Pennsylvania portion of the watershed are *prime agricultural soils* that have been formed through the weathering of crystalline geology, metamorphic and igneous, and the decomposition of organic forest-derived matter. Because these soils are well suited to the agricultural production, much of the forest was cut leaving woodlands on either slopes that were too steep to till or on soils that were too wet to plow. The fragmentation of the forest has resulted in a loss of neo-tropical migrating birds that depend on forest interior habitat for nesting, as well as the loss of other plants and mammals that require large areas of forest in order to survive.

Woodlands provide corridors for the migration of plant and animal species. As the White Clay Creek watershed becomes urbanized, woodlands are further fragmented making them more vulnerable to invasive species and an explosive population of white-tailed deer. Invasive species are a principal cause of biodiversity loss. The impacts of deer browse have impaired the capability of woodlands to regenerate. Intact forests provide a complex web of life support for numerous species. This understanding is essential for the protection of watershed health.

Human Health

Forests and trees inspire art, engender health, and confer therapeutic benefits on residents of local communities.

There is an increasing body of empirical evidence that substantiates the psychological and emotional benefits of time spent in woodlands. Frequent visits to forests can reduce stress, improve health and provide human connection to the natural world. Forests provide beauty and are essential to well-being. Research indicates that time people spend in forests engenders emotional health, improves cognitive function, deepens connections with others and retains physical health.

Summary

To retain and expand many of the functions, values and benefits that have been discussed, the Pennsylvania portion of the White Clay Creek watershed would benefit greatly from a forty percent increase in canopy cover. This increase translates to over 6,300 additional acres of forest. This watershed is valued and recognized by its residents and others for its wild and scenic characteristics. It is, in fact, the first time that an entire watershed (approximately 200 miles of streams) has received this designation. Few watersheds have this kind of community support and recognition. The residents of this watershed, like none other, are likely to support an ambitious restoration goal.

2. Current Conditions

The White Clay Creek watershed has been inhabited by Native Americans for more than 10,000 years[8]. More recently, a Lenni-Lenape village was located along the river in today's White Clay Creek State Park, Pennsylvania. In the early 1700's, the area was cleared and farmed by English, Irish, and Scot settlers[9]. These settlers quickly cleared the diverse forests to farm the rich, forest-created soils, and dammed the streams to generate water power for their mills.

This was the first "wave" of land conversion to sweep across the approximately 39,000 acres (or about 61 square miles) of the watershed in Pennsylvania: The old growth forests were cleared and the prime agricultural soils they produced were widely plowed and planted to agricultural crops. This in turn led to large-scale soil erosion, the effects of which are still evident today in the thick deposits of alluvium present on many of the watersheds floodplains.

Urban- and suburbanization began slowly with the arrival of railroads in the mid-1900's, and boroughs and towns became commercial and residential centers. Over recent decades and now continuing, a second large-scale "wave" of land conversion is occurring as many of those farmlands are being developed into relatively dense residential developments.

All of this change has left the watershed's forests a shrunken remnant of its former diverse and majestic spread, with a net decrease to approximately 24% cover[10] from an estimated cover in 1700 of about 90%. Although there are individual Penn Trees, there is no old growth forest left in the region. Old growth forests of the White Clay watershed included over two dozen tree species that commonly reached over 4 feet in diameter, over 200 years old and over 100 feet tall (see *Appendix A* for statistics on the natural proportions of the trees native to the White Clay watershed). In addition, there was a large amount of forest interior, forest areas sheltered from outside influences by over 300 feet of forest buffer. Today, most of the woods are under 50 acres in size with little to no forest interior, are 75-100 years old, and are heavily infested with dozens of non-native plant species.

Even in the face of enlarging development activity, continued respect for natural resources, particularly those related to soil, water, and woodlands, can result in a pattern of development that is economically viable while posing the least negative impact on the watershed's environment. Emphasis is here placed on the restorative and renewable powers of many natural resources, specifically woodlands. A watershed can in fact improve in many of its key environmental and ecological indicators, including not only watershed

[8] *White Clay Creek Watershed Management Plan*, National Park Service, Philadelphia, PA., 2000, p. 8.
[9] Ibid, p. 9.
[10] Brandywine Conservancy, GIS calculation, 2009, based on 2005 data provided by Chester County Planning Department.

health and water quality, but also wildlife habitat quantity, health, and variety. The specter of climate change adds increased urgency to the consideration of reforestation.

This Reforestation Plan has been developed because forests and woodlands play such an important role in providing ecosystem services to the communities that live near them. And, with community support, they can be increased. Forests are a vital, central part of a watershed. In fact, in this region they represent the 'classic,' defining land cover type under which the watershed evolved over very long periods of time. For example, they played a major role in regulating and apportioning the rainfall of the area, about 44" per year on average in the White Clay. It has been measured[11] that over half of that water was stored and released back into the atmosphere as evapo-transpiration (about 56.4%); over one-quarter of it infiltrated into the soils and aquifers (about 27.9%) and the least amount of it became surface runoff, flowing directly across the land and into streams (about 15.7%).

The 'water budget' under which local drainages developed was stable over time prior to European settlement. This pattern altered with changes in land cover – as the forests were cleared, surface runoff increased dramatically and evapo-transpiration and infiltration decreased just as dramatically, causing unstable watershed conditions including increased erosion, flooding and droughts.

The long-term cooperative goal of this Plan is to increase tree cover (and ultimately, *to reforest*) the Pennsylvania portion of the White Clay watershed from its current level of approximately 23.9% to 40%. While forests are not just trees, increasing tree cover is a necessary fundamental step towards increasing healthy forest cover. Therefore, this Plan focuses on tree-planting An increase from 24 – 40% represents a change in tree cover from approximately 9,380.6 acres to approximately 15,683.2 acres, a net gain of 6,302.6 acres.

Moreover, forests provide ecosystem services no matter where in the watershed they occur – along streams (in riparian areas) as well as in uplands. However, there are forest cover priority areas. Those priorities are discussed further in Chapter Three.

As part of the second wave of land conversion from agricultural to residential lands, there has been a steady erosion in forest cover. Statistics for the Whilte Clay Creek watershed are not available, but Chester County, Pennsylvania as a whole has sustained an average loss of about 1,200 acres of woodlands per year between 1990 and 2005, or about 3.3 acres per day. This rate of loss has clearly slowed during the present real estate recession, but the trend is clear. Since the White Clay Creek watershed is less than 10% of Chester County, this would be equivalent to the loss of some 100 acres of forests per year in the White Clay Creek watershed.

In fact, the effort to prevent the future loss of existing forest cover is the highest priority of this Plan. It is much easier to protect forest than restore it. At the same time, under

[11] *White Clay Creek Watershed Action Plan*, p. 7, Chester County Water Resources Authority, West Chester, PA., 2002

Pennsylvania law and the *Municipalities Planning Code*, it is legally impossible to protect all existing forest if the landowner wants to disturb or remove them for a "lawful purpose." Still, municipalities may enact more or less stringent woodland protection requirements in their zoning and subdivision/ land development ordinances. Because this is so important, we have analyzed the existing ordinances of the watershed's municipalities to identify how relatively effective they may be in protecting existing woodlands from future losses. See *Appendix B* for more information on this study, but in summary the degree of protection for existing woodlands varies considerably among the local townships from minimal protection to what might be considered state-of-the-art levels of protection. Regardless, reforestation efforts clearly need to take annual forest losses into account when trying to create a net increase in the amount of forests in the watershed.

Map 1 – Woodlands and Sub-watersheds within the White Clay Creek Watershed (a base map) displays the current condition of the Pennsylvania portion of the White Clay Creek watershed with respect to woodland cover and sub-watersheds. The current acreage and percentage of woodlands within each of the nine major townships and two boroughs in the Pennsylvania portion of the White Clay watershed is shown in Table 2-1 below.

Table 2-1. Existing Woodlands by Municipality –

Municipal Name	Municipal Ac. (w/i WCC)	Woodland Acreage	Percent Woodlands
1) Franklin Township	5,099.1	1,408.4	27.6
2) Kennett Township	165.4	17.2	10.4
3) London Britain Township*	5,313.9/ 3,998.1	2,436.0/ 1,538.0	45.8/ 38.5
4) London Grove Township	11,043.5	2,049.1	18.6
5) Londonderry Township	1,043.8	199.2	19.1
6) New Garden Township	6,782.5	1,511.5	22.3
7) New London Township	2,307.3	399.6	17.3
8) Penn Township	3,198.6	514.5	16.1
9) West Marlborough Township	3,471.2	758.4	21.9
1) Avondale Borough	317.2	44.5	14.0
2) West Grove Borough	417.4	38.8	9.3
Watershed Totals	**39,169.1**	**9,380.6**	**23.9**

* Because White Clay Creek State Park (WCCSP) is a unique and major feature (at 1,315.8 acres, it occupies approximately 25% of the Township's area) of London Britain Township (LBT), we have recalculated LBT's acreages without WCCSP.

WCCSP - 1,316 ac. total/ 898 acres of woodlands
LBT - 5,314 ac. total/ 2,436 acres of woodlands
Difference - 3,998 ac. w/o WCCSP/ 1,538 acres of woodlands w/o WCCSP

This equals 38.5% wooded w/o WCCSP.

For this study, the watershed has been divided into five larger subwatersheds, two of which have been further subdivided. Table 2-2 displays the acreage and percentage of existing woodlands within each of these subwatersheds.

Table 2-2. Existing Woodlands by Sub-watershed

Woodlands within White Clay Creek Sub-Watersheds				
Sub-Watershed Name	**Sub-Watershed Acreage**	**Water Quality Designation***	**Woodland Acreage**	**Percent Wooded**
UPPER EAST BRANCH WHITE CLAY CREEK	7,316.8	EV/ *partially impaired*	1,598.5	21.8
EAST BRANCH WHITE CLAY CREEK	13,660.4	CWF/ *impaired*	3,700.6	27.1
Broad Run	1,728.8	CWF/ *impaired*	312.9	18.1
Egypt Run	1,336.4	CWF/ *impaired*	273.4	20.5
Trout Run	894.1	CWF/ *impaired*	135.7	15.2
Walnut Run	324.0	CWF/ *impaired*	51.9	16.0
MIDDLE BRANCH WHITE CLAY CREEK	10,050.4	TSF-MF/ impaired	2,579.3	25.7
Indian Run	480.0	TSF-MF/ *impaired*	102.5	21.4
WEST BRANCH WHITE CLAY CREEK	6,360.8	TSF-MF/ *not impaired*	1,751.8	27.5
MAINSTEM WHITE CLAY CREEK	1,707.3	CWF/ *partially impaired*	961.5	56.3

* Water Quality Designations per PA DEP
EV – Exceptional Value Waters
CWF – Cold Water Fishery
TSF – Trout-stocked fishery
MF – Migratory fish
Impaired waters are those that do not meet chemical State Water Quality standards based on the Clean Water Act.

This report intentionally does not analyze or discuss the ecological quality or health of these existing woodlands. It is generally known that they are not in the best health: Excessive white-tailed deer populations impact regeneration of many tree, shrub and herb species and the mature ground and shrub layers; a large host of non-native and invasive

species, including several hundred plant species and an unknown number of non-native animals and microbe species cause further changes and imbalances. Some of this information is better-documented in township-level *Botanical Survey Reports* which have been prepared for Londonderry, London Grove, Franklin and London Britain townships by Janet Ebert and the Brandywine Conservancy.

3. Reforestation Priorities

Priority Reforestation Areas

As described in Chapter Two, the long-term cooperative goal of this *Plan* is to increase tree cover (and ultimately, *to reforest*) the Pennsylvania portion of the White Clay watershed from its current level of approximately 23.9% total land cover to 40%. This represents a net increase in tree cover from approximately 9,380.6 acres to approximately 15,683.2 acres, or, a net increase of 6,302.6 acres.

Although the benefits of increasing tree cover exist at virtually every location across the entire watershed, there are some more sensitive areas where more benefits may be expected to accrue than others. Most of these areas are marginal farmland, an important point in a highly agricultural watershed. Additionally, there are some areas where, from a cultural perspective, it may be more advantageous to consider reforestation. These include lands already permanently protected as open space, particularly state and local parklands, but also homeowner association-owned lands. Other areas include school, church and corporate campuses where there may be lands that are currently unused or under-used for specific active purposes. Finally, there are may be opportunities for tree-planting, if not re-forestation, in urban and suburban settings where more natural landscaping approaches can occur along streets and within side yards and property setback zones. Here, tree planting can increase tree cover from medium- or low-densities to high- or medium-densities. This effort may be important, but a detailed study of opportunities is beyond the scope of this report.

Table 3-1 lists priority areas with environmentally sensitive natural resources that have been identified in the White Clay watershed.

Table 3-1. Priority Natural Resource Types/ Areas for Reforestation

Priority Natural Resource Types/ Areas for Reforestation	
1. Riparian buffer zones	5. Headwater areas
2. Greenway corridors	6. Cockeysville marble areas
3. Steep slopes	7. Select lands adjacent to existing forests
4. Hydric soils and wetlands	

* Floodplain areas would also be a logical place to reforest as well, but floodplains are generally included under the above categories.

To define these areas more precisely –

A ***Riparian Buffer*** is an area of trees and other vegetation adjacent to a stream or watercourse that forms a transition area between the aquatic and terrestrial environment.

For this study, a width of 100 feet from both sides of a stream is included. The riparian buffer is intended, among other functions, to intercept runoff from upland sources for the purpose of mitigating the effects of nutrients, sediment, organic matter, pesticides or other pollutants prior to entry into surface waters. Riparian buffers are also locations where wildlife tends to concentrate as it contains both terrestrial and aquatic resources in proximity. In that sense, it can be an important habitat area. Leaves from riparian trees feed aquatic insects and other macro-invertebrates that form the base of the aquatic food chain. Woody debris from trees can be an important habitat component. Many of these areas were historically cleared for farming, although some may flood regularly.

A ***Greenway Corridor*** is a linear landscape feature of variable width designed to incorporate multiple, often overlapping natural resources, primarily those associated with stream corridors and woodlands, including areas of steep slopes, floodplains, wetlands, and hydric soils. Since there are often overlapping sensitive resources in these areas, greenway corridors represent an opportunity to achieve maximum environmental protection value on a minimal amount of land. Moreover, by rising above the site scale to the landscape scale, these corridors are collectively intended to function as an integrated system or network of natural resources which is multi-purpose in nature, benefiting watershed and biodiversity resources certainly, but also on a case-by-case basis, farmland, scenic, recreational, and historic resources.

If well-managed, greenways can function as wildlife movement corridors that allow wide-ranging species to move from one area to another, allow juveniles to disperse and establish their own home territories, and allow a species' genes to be intermixed between populations. The Chester County Planning Commission identified some of these corridors within *Linking Landscapes*, the 2002 County Open Space Plan. Brandywine Conservancy has gone a step further and identified potential greenway corridors within the entire White Clay Creek watershed (PA portion). Several townships have adopted these plans within their Comprehensive Plans, and although these corridors function imperfectly now as greenways, they await full implementation (including through this Plan).

Steep Slopes are typically considered to be those slopes with greater than a 15% rise. These areas are sensitive because they are prone to erosion from surface runoff. Though they are generally marginal for farming, and contain no prime agricultural soils, many were historically cleared for farming and remain cleared.

Hydric Soils are found in upland depressions and on the fringes of floodplains, generally within or adjacent to wetlands. More than simply an indicator of wetland conditions, hydric soils indicate current or former wetland locations. Hydric soils are used here as the primary indicator of wet soil areas since they are better mapped than wetlands. Wetlands are notoriously poorly mapped through National Wetland Inventory (NWI) maps, based on aerial photography.

Hydric soils exhibit shallow depth to water table and, occasionally, display standing water. These soils often correlate to headwater areas that include springs, seeps and marshes at the

uppermost terminus of stream corridors. Subsurface water, seeping through hydric soils, supplies groundwater to the surface water system. This subsurface water source forms the base flow in streams and defines a baseline for stream water quality. The native vegetation of these soils, according to the Chester County Soil Survey, was generally wet woodlands, chiefly dominated by red maple. Today, many of these areas have been cleared and/ or drained for farming or development.

Wetlands are defined as those areas where the soils are saturated for a significant part of the year, where plants typical of saturated soils occur, and where hydrologic conditions provide evidence of surface ponding, flooding, or flow. In the White Clay Creek watershed these areas are typically found along streams, where they are often narrow and linear in shape, or in upland depressions in headwater areas, where they may broaden out.

Wetlands are a key component of watershed management, positively impacting both water quality and quantity issues through regulating different aspects of water on the landscape. By filtering water, wetlands impede flow, allowing sediments to fall to the bottom and allowing plants to uptake nutrients, thereby improving water quality. By storing water during flooding events, they reduce flood damages and moderate high flows. Wetlands are sometimes referred to as the "kidneys" of a watershed. Like streams, they are greatly benefited by vegetated buffers so as not to be overwhelmed by off-site influences. Wetlands' also are of central importance to natural wildlife diversity, as they form a key part to the life cycle of many animals.

The White Clay Creek watershed once supported a far greater acreage of wetlands than today, as many were converted with drainage tiles to farm fields and converted to farm ponds. Research has determined that slightly more than half (50 percent) of Pennsylvania's wetlands have been filled or otherwise converted to non-wetlands since the 1700's, mostly due to intensive agricultural uses.

In the White Clay Creek watershed probably well more than half and as much as 80 percent of the original wetland acreage have been so converted. This indicates a great opportunity to strategically restore some of these wet acres, especially during the course of new development. However, the watershed is also known to support the federally-threatened bog turtle, a species which requires open (i.e. unforested) groundwater-fed wetlands for its habitat. Therefore, care must be taken when proposing to reforest wetland areas that may support bog turtles. Some wetlands that do support bog turtles are succeeding into woody habitats. Appropriate management for the bog turtles requires that these woody species be removed.

Headwater Areas are those land areas that drain directly into first-order streams, the smallest tributaries of the larger stream system. A first-order stream begins at the location where channelized flow occurs as a result of runoff, melting, springs, or groundwater discharge ("base flow"). These streams are important for many reasons including that they carry the majority of the system's base flow in any watershed to its downstream waterways, contributing significantly to both water quality and quantity in any given stream. Second-order streams are formed at the confluence of two first-order streams,

while a third-order stream is created at the influence of two second-order streams, and so on.

First-order streams are significant beyond their size in the overall hydrologic regime. Given their importance to both water quality and quantity and in the context of relatively low flow individually, first-order streams are disproportionately vulnerable to sedimentation and other degradation. The regularity of flow from headwaters areas is essential to the health of first-order streams and the wildlife on which they depend, particularly during periods of low flow. Thus, the headwaters watershed to these first-order streams is extremely sensitive to introduction of impervious surfaces, improper grading, discharge of pollutants, or poor agricultural practices. Maintenance or restoration of forested headwaters, particularly in close proximity to first-order streams, is especially important given the ability of wooded areas to: slow and filter flows; control erosion and sedimentation; provide shade and water temperature regulation; and supply wildlife food and cover. Because they are sometimes closely associated with cold water seeps and springs, first-order streams can serve as refuge areas for wild trout populations.

Despite their sensitivity, headwater areas tend to be flat (or gently bowl-shaped) and many were historically cleared for farming and are currently maintained in an open condition. Much of State Route 896 follows upland headwater areas and the divide between the White Clay and Elk creeks watersheds. The Brandywine Conservancy has identified headwater areas for two townships in the Pa. portion of the White Clay watershed - London Grove and Franklin townships.

Cockeysville Marble Areas are those areas where limestone deposits that have changed geologically into a type of marble called Cockeysville lie at the surface of the land. These areas are often quite sensitive to surface pollution as the marble/ limestone easily conducts pollution into underground aquifers without much filtering or abatement. Because they are very porous, Cockeysville marble areas also often store and transmit large quantities of groundwater and can be important sources of community water supplies. Such areas are relatively rare, and are among the "outstandingly remarkable values" for which the watershed received its national "wild and scenic" designation.

Lands adjacent to existing forests are important to reforest to help reduce 'edge' and fragmentation effects and enlarge forest interiors. Most woodlands in the White Clay watershed are highly fragmented - by roads, farms, houses and other developments, utility right-of-ways, and other unnatural features. This condition creates a preponderance of what ecologists call "edge effects." Edge effects include such impacts as excess light, noise, air and wind, non-native species, excessive deer, cats and dogs, people and other non-forest influences that penetrate a woodland, usually with negative ecological effects. By planting trees and extending forests on adjacent lands, these edge effects can be strategically reduced and forest interior habitats increased.

Forest interior habitat can be described as 'deep woods' areas which lie beyond many of the influences which degrade a forest from the outside. This 'heart of the woods' is defined as more than 300' from any forest edge. And, forest interiors can support a

micro-climate that is different than the outer, edge woods. Since they are usually the interior part of larger woodlands, forest interiors may support breeding for area- and disturbance-sensitive species that occur in limited numbers elsewhere. In that sense, forest interiors can be *source areas* for such wildlife. These species may include certain increasingly rare plant, bird and salamander species, for example. Forest interiors functions as core areas or 'hubs' that provide optimal nesting, foraging, and retreat areas for wild animals, and ideally are areas where nature comes first. These hubs then become important 'dots' which can be 'connected' by greenway corridors.

We did not attempt to map all such areas in this study; this effort would be better done at a smaller scale of study.

Permanently Protected Open Space

As mentioned above, permanently protected open space is another important consideration when analyzing current conditions for reforestation. Some of these lands would clearly be logical candidates for reforestation efforts.

In the White Clay Creek watershed, there are State lands (White Clay Creek State Park); municipal lands, homeowner association (HOA) lands; and lands, mostly farmlands, under conservation easement to either a land trust, notably the Brandywine Conservancy, or to the Chester County Agricultural Land Preservation Board. Lands eased with conservation easements are still private lands, and are generally working farmlands and were protected to conserve agriculture and their prime agricultural soils. They are no more likely than other farmlands to be available for reforestation. They are not included in the table below, but are included within the analysis of natural resource priorities described above.

Table 3-2. Protected Lands (not including conservation easements - CEs) –

Protected Lands (not incl. CEs)			
Protected Land Category	**Protected (ac.)**	**Protected Woodlands (ac.)**	**Percent Wooded**
Municipal Open Space	288.2	177.4	61.6%
Municipal Rec. Lands/ Parks	187.0	81.4	43.5%
State of Pennsylvania (White Clay Creek State Park)	1,315.8	898.0	68.2%
Homeowners Assn. Open Space	954.0	371.3	38.9%
TOTALS	2,745.0	1,528.1	55.7%

4. **Reforestation Priorities Analysis**

In order to analyze opportunities for reforestation within the White Clay Creek watershed, albeit at a large scale, we have created a set of maps that compare existing woodlands to the geographic extent of the various environmentally sensitive natural resources that have been identified within the White Clay Creek watershed. These maps were then analyzed and non-forested portions of those resource areas were calculated. First we will present the data from the analysis, then below we will present reforestation recommendations based on that data.

Map 2 depicts **Reforestation Priorities - Riparian Buffers** for the Pennsylvania Portion of the White Clay Creek watershed. As mentioned, for this study, a width of 100 feet from each side of a stream is included as the working definition of a riparian buffer. The map shows the buffers in one of three colors – green, yellow and red. These colors correspond to fully buffered with trees to a width of 100 feet per side (200 feet total); partially buffered (anywhere from 1 foot to 199 feet total); and not buffered (called "opportunity" areas in Table 4-1 below, where virtually no woodlands occur within 100 feet per side of the stream). Individual trees may occur in the red zones, but not mapped tree groupings. The results are shown by sub-watershed below.

Table 4-1. Riparian Woodlands within White Clay Creek Sub-Watersheds.

Riparian Woodlands within White Clay Creek Sub-Watersheds		
Sub-Watershed Name	**Riparian Acreage**	**Riparian Percent of Watershed**
EAST BRANCH WHITE CLAY CREEK	**1,751.1**	**100%**
Full	637.8	36.4%
Partial	702.7	40.1%
Opportunity	410.6	23.4%
MAINSTEM WHITE CLAY CREEK	**288.0**	**100%**
Full	241.4	83.7%
Partial	42.5	14.8%
Opportunity	4.1	1.4%
MIDDLE BRANCH WHITE CLAY CREEK	**1,292.7**	**100%**
Full	563.9	43.6%
Partial	420.8	32.6%
Opportunity	308.0	23.8%
UPPER EAST BRANCH WHITE CLAY CREEK	**713.5**	**100%**
Full	181.9	25.5%
Partial	253.7	35.6%
Opportunity	277.9	38.9%
WEST BRANCH WHITE CLAY CREEK	**915.8**	**100%**

Full	431.9	47.2%
Partial	264.6	28.9%
Opportunity	219.3	23.9%

Full – a riparian buffer area that is fully forested to at least 100' on both sides of the stream
Partial - a riparian buffer area that is partially forested within 100' of either side of the stream
Opportunity - a riparian buffer area that is not forested within 100' of both sides of the stream

In summary, there are approximately 4,961.1 total acres of riparian lands within the Pennsylvania portion of the White Clay Creek watershed. Of those, approximately 2,731.0 acres (55.0%) are currently forested. Total unforested acres are 2,230.8 acres; of those 1,219.9 acres are part of unbuffered 'opportunity' areas (the remainder is part of the partially buffered areas). This data is summarized for riparian buffers and the other natural resource types in Table 4-2 below.

Map 3 depicts **Reforestation Priorities – Greenway Corridors** for the Pennsylvania Portion of the White Clay Creek watershed. These watershed-based plans were developed by the Brandywine Conservancy both for this Plan and as a Vision for desirable future watershed conditions and inter-municipal cooperation. These variable-width greenway corridors already incorporate many existing woodlands as a key component to their design, generally along streams and where they enlarge to form "nodes" or "hubs" within the greenway network.

In summary, there are approximately 11,347.3 total acres of greenway corridor lands shown within the Pennsylvania portion of the White Clay watershed. Of those, approximately 7,073.3 acres (62.3%) are currently forested. Total unforested grenway corridor acres are 4,274.0 acres (37.7%).

Map 4 depicts **Reforestation Priorities – Steep Slopes** for the Pennsylvania Portion of the White Clay Creek watershed. There are approximately 5,109.9 total acres of steeply sloped lands (greater than 15% slopes) shown within the Pennsylvania portion of the White Clay watershed. Of those, approximately 2,835.8 acres (55.5%) are currently forested. Total unforested steep slope acres are 2,274.1 acres (44.5%).

Map 5 depicts **Reforestation Priorities – Hydric Soils and Wetlands** for the Pennsylvania Portion of the White Clay Creek watershed. There are approximately 3,412.2 total acres of hydric and wet lands (based on the NRCS Soils Surveys) shown within the Pennsylvania portion of the White Clay watershed. Of those, approximately 1,723.0 acres (50.5%) are currently forested. Total unforested hyudric/ wetland acres are 1,689.2 acres (49.5%).

There is no map depicting **Reforestation Priorities – Headwater Areas** for the Pennsylvania portion of the White Clay Creek watershed. This analysis is a hand made GIS data layer that has never been created for the entire watershed. However, as a part of Comprehensive Planning and Zoning Ordinance updates, the Brandywine Conservancy has created headwater layers for Franklin and London Grove Townships. Combined this

includes all of London Grove Township and over 16,000 acres of the Pennsylvania portion of the watershed, slightly more than 40% of the whole.

For those two townships, the results are as follows: For Franklin Township there are approximately 2,640.1 total acres of headwater areas located within the Pennsylvania portion of the White Clay watershed (51.8% of the township area within the watershed). Of those, approximately 596.4 acres (22.6%) are currently forested. Total unforested headwater area acres are 2,043.7 acres (77.4%).

For LondonGrove Township there are approximately 3,887.5 total acres of headwater areas located within the Pennsylvania portion of the White Clay Creek watershed (35.2% of the 11,043.5 total township acres). Of those, approximately 610.6 acres (15.7%) are currently forested. Total unforested headwater area acres in London Grove Township are 3,276.9 acres (84.3%).

Map 6 depicts **Reforestation Priorities – Cockeysville Marble Areas** for the Pennsylvania Portion of the White Clay Creek watershed. There are approximately 2,881.1 total acres of Cockeysville Marble areas located within the Pennsylvania portion of the White Clay Creek watershed. Of those, approximately 515.0 acres (17.9%) are currently forested. Total unforested Cockeysville Marble area acres are 2,366.1 acres (82.1%).

The final category of priority natural land areas described in the last chapter is "select lands adjacent to existing forests." These areas were not mapped for this report, but could better be identified at the scale of an individual site. There are potentially hundreds of acres that could fit into this category.

Table 4-2. Summary of Reforestation Data for Priority Resource Types

Natural Resource Type	Total Acres	Forested Acres	Forested %	Unforested Acres/ %
Riparian Buffers	4,961.1	2,731.0	55.0%	2,230.8/ 45.0%
Greenway Corridors	11,347.3	7,073.3	62.3%	4,274.0/ 37.7%
Steep Slopes	5,109.9	2,835.8	55.5%	2,274.1. 44.5%
Hydric/ Wetland	3,412.2	1,723.0	50.5%	1,689.2/ 49.5%
Headwater Areas – Franklin Twp.	2,640.1	596.4	22.6%	2,043.7/ 77.4%
Headwater Areas – London Grove Twp.	3,887.5	610.6	15.7%	3,276.9/ 84.3%
Cockeysville Marble Areas	2,881.1	515.0	17.9%	2,366.1/ 82.1%

Setting Reforestation Goals for Natural Resource Types

Now that this analysis is completed, it is important to consider what the reforestation goals are for the above priority natural resource types. No one expects 100% of these

areas to be reforested. What then is a reasonable target level, or range, for reforestation for these areas?

As a starting point for further discussion and refinement, we propose to set the levels as follows:

High -

1) Riparian Buffer forest cover goal = 70 - 85%
2) Greenway Corridor forest cover goal = 70 - 80%
3) Steep Slopes forest cover goal = 70 - 85%

Medium -

4) Hydric/ Wetland forest cover goal = 60 - 70%

Low -

5) Headwater Areas: Franklin and London Grove twps forest cover goal = 30 - 40%
6) Cockeysville Marble Areas forest cover goal = 25 - 30%

We have shown all this on a map - **Map 7** depicts **Reforestation Priorities Grouped by Natural Resource Types** for the Pennsylvania Portion of the White Clay Creek watershed. This map depicts the three priority levels as three different shades of red. Where there is overlap between one or more priority level, the higher level predominates. The totals for each Reforestation Priority category (without overlap) are:

- High – 6,022.8 acres
- Medium – 442.6 acres
- Low – 5,639.0 acres

Multiplying each category's acreage by the appropriate high- and low-end percentages yields the following results:

Table 4-3. High and Low Acreages Proposed to be Reforested by Reforestation Priority Level

Reforestation Priority Level	Total Acres	Percentage Range	Low End (acres)	High End (acres)
High	6,022.8	70 - 85%	4,216.0	5,119.4
Medium	442.6	60 – 70%	265.6	309.8
Low	5,639.0	25 – 40%	1,409.7	2,255.6
TOTAL	-	-	**5,891.3**	**7,684.8**

The target number of reforestation acres (6,302.6 acres) falls between these potential reforestation acres numbers.

If we then turn back to look at permanently protected open space, we can perform a similar exercise:

For the White Clay Creek State Park (WCCSP) it seems that a total forest cover goal of 80 - 90% might be appropriate. Thus, of 1,315.8 acres total, a low end of 1,052.6 acres and a high end of 1,184.2 acres might be appropriate. With 898.0 forested acres today, this would mean a reforestation goal of between an additional 154.6 and 286.2 forest acres.

For homeowner association (HOA) lands a total forest cover goal of 60 - 80% might be appropriate. Of 954.0 total acres today, a low end of 572.4 acres and a high end of 763.2 acres might be appropriate. With 371.3 forested acres today, this would mean a reforestation goal of between an additional 201.1 and 391.9 forest acres.

For municipal open space lands an approximate total forest cover goal of 60 - 80% might also be appropriate, allowing for active recreational areas. Of 475.8 total acres today, a low end of 285.5 acres and a high end of 380.6 acres might be appropriate. With 258.8 forested acres today, this would mean a reforestation goal of between an additional 26.7 and 121.8 forest acres.

Important note - all of these proposed total future forest cover goals should be established through a participatory process, including the general public in the case of public lands.

Still, given the above analysis it does seem that an overall goal of 40% forest cover may well be achievable within the Pennsylvania Portion of the White Clay Creek watershed.

APPENDIX A:
EASTERN FOREST TREES – POTENTIAL PROPORTIONS

There is no known old growth forest left in the Pennsylvania portion of the White Clay watershed. However, there could certainly be old growth created or approximated in the future. The following chart was created to assist the reader in becoming more familiar with some of the characteristics of old growth forests, primarily the size of many of the trees, many of which are almost never seen today.

Note: These trees are common to the Eastern Deciduous Forest biome. However, not all of these tree species are found in the White Clay Creek watershed. Furthermore, not all will reach these proportions on all sites.

Species	Height	Spread	Diameter	Longevity (years)
Eastern White Pine	220’	100’	8’	500
Eastern Hemlock	100’	75’	6’	400+
American Chestnut*	100’	100’	12’	300
White Oak	150’	150’+	10’	600
Red Oak	150’	100’+	10’	400
Black Oak	100’	100’	8’	250
Pin Oak	110’	75’	5’	200+
Scarlet Oak	80’	80’	3’	300
Bur Oak	170’	125’+	7’	300+
Chestnut Oak	100’	100’+	7’	300+
Swamp White Oak	100’	75’	8’	200+
Chinquapin Oak	160’	125’	4’	200
Bitternut Hickory	100’	100’	3’	200
Shagbark Hickory	120’	50’	4’	250+
Pignut Hickory	120’	50’	4’	300+
Mockernut Hickory	100’	50’	3’	250
Black Walnut	150’	125’	7’	250
Butternut	100’	100’	3’	75
Tuliptree	200’	75’	10’	200+
White Ash	100’	75’	7’	200+
American Beech	120’	75’	6’	300
American Basswood	125’	75’	4’	200+
American Elm	125’	100’+	10’	200+
Black Cherry	100’	50’	5’	200+
Sugar Maple	125’	100’+	4’	200+
Silver Maple	120’	120’	5’	125
Red Maple	100’	75’	4’	150
Sweet (Black) Birch	80’	50’	5’	200
Yellow Birch	100’	65’	4’	175
Black Tupelo; Sourgum	125’	65’	5’	200
Eastern Sycamore	175’	150’	12’	600
Sassafras	100’	75’	6’	100
Quaking Aspen	75’	35’	3’	10,000? (by rootstock)

*Former proportions of American chestnut.

Sources:

1) Hightshoe, Gary L., Native trees, shrubs, and vines for urban and rural America, 1988, John Wiley and Sons, NY, NY.
2) Petrides, George A., A Field Guide to Eastern Trees, Peterson Field Guide Series, 1998, Houghton Mifflin Co., NY, NY.
3) American Forests' National Register of Big Trees found at - http://www.americanforests.org/resources/bigtrees/register.php

Summary:

Of the 33 total tree species shown, the number of trees that reach … –

Height -

> or = to 100' tall - 30
> or = to 150' tall - 8

Spread* -

> or = to 100' spread - 15

* Spread is a measure of how complex and 'articulated' individual tree crowns and overall forest canopy may get. Eastern trees generally get tall before they get wide (in their diameter) and achieve their full spread.

Width -

> or = to 4' diameter - 28
> or = to 6' diameter - 16
> or = to 8' diameter - 9

Age -

> or = to 200 years - 28
> or = to 300 years - 12
> or = to 400 years - 5

APPENDIX B:
SUMMARY OF LOCAL WOODLAND PROTECTION ORDINANCE PROVISIONS

Due to the overriding importance of preserving existing woodlands, nine local Pennsylvania townships were investigated as to the regulatory provisions they have adopted into their zoning (ZO) and subdivision and land development (SALDO) ordinances regarding preserving existing woodlands. Two boroughs (Avondale and West Grove) and one township (East Marlborough Township), which has only a very small amount of land in the White Clay watershed, were omitted from this analysis.

Woodlands are often protected as aspects of other natural resource or scenic provisions. For example, provisions that protect steep slopes, wetlands, or riparian buffers will often serve to protect the woodlands that are on those slopes, wetlands, or riparian buffers. Many townships protect individual large trees as "heritage" or "specimen" trees.

Here, the goal was to examine ordinances for provisions specific to woodlands. The regulations were examined primarily for three attributes – woodland disturbance limits, woodland disturbance standards, and tree replacement requirement standards. The results, summarized in the text below and on the following charts, indicate that there is a wide range in how strictly this critical natural resource is protected. A clear priority of this *Plan*, running parallel with reforestation efforts, should be to amend existing local ordinances to strengthen woodlands protection and tree replacement standards.

Summary of Findings:

- While ordinances from eight of the nine townships reviewed contain at least some verbiage encouraging the protection of existing trees or woodlands, only five contain provisions that set strict woodland disturbance limits that require the retention of existing trees. Four (Londonderry, New Garden, New London and Penn) do not contain provisions with strict woodland disturbance limits.

- Three townships have classified the woodlands within their boundaries and determined maximum disturbance limits for each class (London Grove, Kennett and Franklin). In addition, each has guidelines for determining where the permitted woodland disturbance on a site can occur.

- One township has a provision in its Subdivision and Land Development Ordinance (SALDO) that prohibits the damage or removal of any mature tree (defined as greater than 6-inch caliper) on any land within the township without compensatory planting (Londonderry). Though the township encourages retention of existing trees in lieu of compensatory planting, it is not required.

- One township prohibits the removal of any tree greater than 6-inch caliper in existing woodlands unless it occurs within 15 feet of the planned improvement (West Marlborough).

- Seven of the nine townships include requirements to protect any and all mature trees on a site which are not slated for removal. Some define a “tree protection zone” surrounding a disturbance area, which generally protects any tree not slated for removal beyond 10 feet from the proposed improvement.

- Two townships have provisions that require Board approval for the removal of woodlands in select areas (London Britain and New Garden). The efficacy of these regulations is thus dependent upon the nature and composition of the Board at the time of subdivision.

Table B-1: Summary of Local Woodland Protection Provisions

Municipality	Woodland Disturbance Limits	Disturbance Standards*	Tree Replacement Standards
Franklin Township (pending)	Between 5% and 25% depending on woodland classification (see Table B below)	Yes	Yes, for all Class I or II areas; Greenways; any area within 2 feet of dripline of Specimen Vegetation; riparian buffers; any area of Class III greater than 10,000 sq ft. See Table C.
Kennett Township	Between 10% and 40% depending on woodland classification (see Table B below)	Yes	For every 500 sq ft disturbance, one tree 2.5-inch caliper or greater and 24-30 inches high to be planted; AND each tree greater than 12-inch dbh removed to be replanted following requirements detailed in Table C.
London Britain Township	Limited to 5% on areas of slope greater than 20%; "healthy woodlands exceeding one acre shall be preserved and designated as Greenspace areas to the maximum extent possible; subdivisions shall be designed to preserve woodlands along roadways, property lines and lines occurring within a site such as streams, swales, stone fences and hedgerows; disturbance or removal of woodlands occupying environmentally sensitive areas shall be undertaken only when approved by the Board and on a limited, selective basis to minimize the adverse impacts of such actions." All woodlands on any site proposed for subdivision must first be evaluated by a professional to "determine extent to which such woodlands should be designated partly or entirely as Greenspace or development lands."	Yes, for "healthy woodlands greater than one acre" to be designated "Greenspace areas"	No
London Grove Township (pending)	Between 5% and 25% depending on woodland classification (see Table B below)	Yes	Yes, for Class I or II woodlands, greenway corridors, drip line of heritage trees, riparian buffers and in excess of 10,000sq ft disturbance of Class III woodlands. See Table C.
Londonderry Township	No woodland disturbance limits established. Under the subdivision ordinance, the township encourages retention of existing trees	No	Yes, required for damage or removal of all mature trees (defined as deciduous >6" dbh, evergreen >12" dbh) on all lands within township. See Table C.
New Garden Township	"Trees in excess of four inches caliper which are located within any steep slope area, designated floodplain, floodway, flood-fringe, streams, or other woodlands area shall not be cut down or removed without the prior written approval of the Township." No other woodland disturbance limits exist.	No	Yes, but only for trees within protection area [portions of lot 10 feet or more from land development] not slated for removal that are damaged or removed. See Table C.
New London Township	Vegetation disturbance limited to 5% in steep slope areas. No other woodland disturbance limits exist.	No	No

Municipality	Woodland Disturbance Limits	Disturbance Standards*	Tree Replacement Standards
Penn Township	"No portion of tree masses or trees with 8 inch or greater dbh shall be removed unless clearly necessary for effectuation of the proposed development. Developers shall make all reasonable efforts to harmonize their plans with the preservation of existing trees." No woodland disturbance limits established.	No	No
West Marlborough Township	In existing wood areas, no tress greater than 6-inch caliper may be removed unless within 15 feet of planned improvement	No	Yes. For all lands depicted on Natural Features Map of Township Comprehensive Plan, at least 80% of trees greater than 5-inch caliper shall be maintained or replaced. Replacement trees to be minimum of 2" dbh measured at 6" above grade.

- Provisions or guidelines as to where specifically on a site disturbance can occur.

Table B-2: Detailed Disturbance Limits for Townships with Woodland Classifications

	Maximum Disturbance Allowance (Kennett)		Maximum Disturbance Allowance (London Grove)		Maximum Disturbance Allowance (Franklin)
Floodplain	0%				
Steep Slopes					
Moderately Steep	30%				
Very Steep	15%				
Wetlands	0%				
Wetland Margins	20%				
Riparian Buffers					
Zone 1 Buffer	0%				
Zone 2 Buffer	20%				
Woodlands					
Woodlands within a Forest Interior Habitat	10%	Woodlands within a Forest Interior Habitat	10%	Class I Forest Interior Habitat	10%
Class I or II Woodlands or any woodlands within a Woodland or Riparian Corridor not located in BP, C, LI, or R-4 district	15%	Class I or II Woodlands with Prohibitive Slopes	5%	Class I or II Woodlands with Very Steep Slopes	5%
Class III or other unclassified woodlands not	25%	Class I or II Woodlands	15%	Class II Woodlan	15%

located in BP, C, LI, or R-4 district		within Greenway Corridor		ds or Greenway Corridor	
Class I or II Woodlands or any woodlands within a Woodland or Riparian Corridor located in BP, C, LI, or R-4	40%	Class III not within Greenway	25%	Class III Woodlands	25%
Class III or other unclassified woodlands not otherwise protected above when such woodlands are located in BP, C, LI, or R-4	100%				

Table B-3: Summary of Tree Replacement Standards

<table>
<tr><th>Municipality</th><th>Tree Replacement Standards</th></tr>
<tr><td>Franklin</td><td>Whichever results in greater number of trees planted:
For every 500 sq ft disturbance: one tree at least 2-2.5” caliper
-OR-
For each tree greater than 12-inch dbh to be removed:
If 12-18” dbh- replace with two 2-2.5” caliper trees
If 18-24” dbh- replace with three 2-2.5”caliper trees
If 24-26” dbh- replace with four 2-2.5” caliper trees
If >36” dbh- replace with six 2-2.5” caliper trees

For every 100 sq ft disturbance: one shrub at least 24-30” high</td></tr>
<tr><td>Kennett</td><td>For every 500 sq ft disturbance: one tree at least two to 2 ½” caliper and two shrubs at least 24 to 30” in height
-AND-
For every tree greater than 12” dbh removed:
<table><tr><th>Number of Trees Removed; Size (inches of dbh)</th><th>Number of Replacement Trees; Size (inches caliper)</th></tr><tr><td>1; 12 to 18</td><td>1; 3 to 3 1/2</td></tr><tr><td>1; 18 to 24</td><td>2; 3-3 1/2</td></tr><tr><td>1; 24 to 36</td><td>3; 3-3 1/2</td></tr><tr><td>1; greater than 36</td><td>4; 3 to 3 1/2</td></tr></table></td></tr>
<tr><td>London Grove</td><td>Whichever results in greater number of trees planted:
For every 500 sq ft disturbance: two trees at least 2-2.5” caliper
-OR-
For each tree greater than 12-inch dbh to be removed:
If 12-18” dbh- replace with two 2-2.5” caliper trees
If 18-24” dbh- replace with three 2-2.5”caliper trees
If 24-26” dbh- replace with four 2-2.5” caliper trees
If >36” dbh- replace with six 2-2.5” caliper trees

For every 100 sq ft disturbance: one shrub at least 24-30” high</td></tr>
<tr><td>Londonderry</td><td>For each mature tree removed:
Deciduous 6-12” dbh: one inch caliper new for each 6 inches existing
Deciduous 12-24” dbh: one inch caliper new or each 3 inches existing
Deciduous or evergreen >24” dbh: one to one match

All compensatory trees shall be at least 3-3.5” caliper</td></tr>
<tr><td>New Garden</td><td><table><tr><th>Caliper of Tree Damaged or Removed (inches)</th><th>Minimum Number and Minimum Caliper of Replacement Tree (inches)</th></tr><tr><td>6 to 12</td><td>1 tree 5 to 5 ½”, or 3 trees 3 ½”</td></tr><tr><td>12 to 24</td><td>1 tree 6 to 6 ½”, or 4 trees 3 ½”</td></tr><tr><td>Greater than 24</td><td>2 trees 6 to 6 ½”, or 5 trees 3 ½”</td></tr></table></td></tr>
</table>

APPENDIX C:
FUNDING SOURCES, PARTNERS AND COSTS

Funding Programs

Federal Cost Share Assistance Programs

- Conservation Reserve Enhancement Program (CREP)
- Red and White Clay Creek Watersheds PL-566 Program
- Resource Conservation & Development Program (RC & D)
- U.S Fish & Wildlife Service
- USDA Conservation Innovation Grants (CIG)
- Wildlife Habitat Incentive Program (WHIP)

State & County Programs

- Chester County Foundation
- Pennsylvania Department of Conservation and Natural Resources (DCNR) Grant Programs
- Pennsylvania Department of Environmental Protection (DEP) Growing Greener Grant Program
- Pennsylvania Game Commission's Wildlife Diversity Program
- Pennsylvania Horticultural Societies' Treevitalize Program
- Pennsylvania's Stream Releaf Program

Potential Private & Local Funding Sources

- Cora L. Brooks Foundation
- E. Kneale Dockstader Foundation Southeastern Chester County Refuse Authority (SECCRA)
- Clean Water Act Violation Fees
- League of Women's Voters
- Local Arboretums
- Local Corporations, Foundations and Stakeholders
- Longwood Corporation
- National Fish & Wildlife Foundation
- Partnership of the Delaware Estuary
- Winterthur

Potential Future Sources of Funding

- Storm Water Utilities
- Tree Mitigation Bank
- Water Allocation Fees[12]
- Water Quality Trading Banks[13]

[12]Gerald Kauffman *Reinvigoration of the Christina Basin Clean Water Partnership*
[13] Gerald Kauffman

- Local Government Pooled Funds[14]
- Water Rate Surcharge[15]
- Payment for Eco-system services (PES)
- Payment for Carbon Sequestration
- Forest Trust Funds

Potential Partners and Information Sources

In order for restoration of a landscape scale to be successful, it is essential that all the stakeholders are supportive. It is recommended that meetings be held prior to initiating projects to ensure support and to allow for input of the local community. This process is essential to the long term success of the restoration. Creating strategic alliances and partnerships will pave the way for securing funding and project support.

Federal

- American Forests
- Environmental Defense Fund
- Environmental Protection Agency (EPA)
- National Association of Conservation Districts
- National Oceanic and Atmospheric Administration
- Natural Resources Conservation District (NRCS)
- Resource Conservation & Development Program (RC & D)
- The Conservation Fund
- U. S Fish & Wildlife Service (USFWS)
- U.S. Forest Service (USFS)
- United Nations Environment Programme
  The Billion Tree Campaign
- Wildlife Habitat Council

State & County (PA & DE)

- Chester County Conservation District
- Chester County Water Resources Authority
- Christina Basin Tributary Action Team
- Delaware Water Resources Agency
- Department of Natural Resources and Environmental Control (DNREC)
- Environmental Action Committee Network
- New Castle Conservation District (DE)
- Penn State College of Agricultural Sciences
- Pennsylvania Association of Conservation Districts
- Pennsylvania Bureau of Forestry

[14] Gerald Kauffman - Local governments would contribute a percentage annually to a Watershed Fund and a watershed group would implement the restoration projects as a way to meet their MS4 permit obligations

[15] Gerald Kauffman

- Pennsylvania Department of Conservation and Natural Resources (DCNR)
- Pennsylvania Department of Environmental Protection (DEP)
- Pennsylvania Environmental Council (PEC)
- Pennsylvania Environmental Network
- Pennsylvania Federation of Sportsmen's Clubs
- Pennsylvania Fish and Boat Commission
- Pennsylvania Greenways Planning
- Pennsylvania Growing Smarter
- Pennsylvania Natural Heritage Program
- Pennsylvania Bureau of State Parks
- Pennsylvania Resources Council

Private

- Audubon
- Brandywine Conservancy
- Boy Scouts and Girl Scouts
- Chesapeake Bay Foundation
- Habitat Resources Network of Southeastern Pennsylvania
- Heritage Conservancy
- Local Churches
- Local Schools – public, charter, and private
- Natural Lands Trust
- Nature Conservancy: Pennsylvania Chapter
- Quaker Meetings
- Partnership of the Delaware Estuary
- Pennypack Ecological Restoration Trust
- Schuykill Environmental Education Center
- Stroud Water Research Center
- Trees For Life
- White Clay Creek Watershed Association
- White Clay Creek Wild & Scenic Management Committee

Reforestation Material Costs

Depending on the prevalence of invasive species, site preparation costs will comprise one eighth to one third the cost of the restoration[16]

Tree	Unit Cost	Tree Mat Coir Fiber 24”	Pre-planting Herbicide	Tree Shelter*	Wire Cage*	Total
Bare root seedling	**.10 – $2.50**		**$1.00**	**$7.02**		**$8.12 - $10.52**
Bare root seedling	**.10 – $2.50**		**$1.00**		**$10.00**	**$11.10 - $13.50**
Bare root seedling	**.10 – $2.50**	**$3.03**				**$3.13 - $5.53**
Container seedling	**$3.35**		**$1.00**	**$7.02**		**$11.37**
Container seedling	**$3.35**		**$1.00**		**$10.00**	**$14.35**
Container seedling	**$3.35**	**$3.03**				**$6.38**
2 gallon	**$8.50 - $9.50**				**$10.00**	**$18.50 - $19.50**
3 gallon	**$13.00 - $18.00**				**$10.00**	**$23.00 – $28.00**
5 gallon	**$20.00 - $26.00**				**$10.00**	**$30.00 - $36.00**
7 gallon	**$28.00 - $32.00**				**$10.00**	**$38.00 - $42.00**
Bare root liner	**$15.00**				**$10.00**	**$25.00**
2” – 2.5” caliper	**$125.00 - $165.00**				**$10.00**	**$135.00 - $175.00**

*The cost listed is based on a 4’ Tubex tree shelter with a 47” white oak stake.
*The cost listed is based on 3-foot section of 2” X 4”X 5’ welded mesh wire. The cost includes a white oak stake and labor to cut wire.

Contractual labor to plant will cost 2.5 times the cost of the plant plus additional labor costs to install tree shelters or wire cages. This cost will include pickup and delivery to the site.[17] The cost for installing a tree shelter is one dollar.

[16] John Graham The Nature Conservancy, Delaware Chapter
[17] David Vollmer Eco-Bound

APPENDIX D: IMPLEMENTATION APPROACHES

There are varying approaches to consider when planning a reforestation project. Some of these approaches are discussed below. Invasive species and the abundance of White-Tailed Deer pose significant challenges to restoration projects. In order for the reforestation project to be successful, measures need to be taken to control them.

Creating a Plan – What you Need to Know

Restoration Objectives
A plan is to clearly state the project restoration goals and objectives. This intent will govern all aspects of the plan, as well as the management and monitoring of the project.

Succession and Soils
The development of a woodland is characterized by the natural processes of plant succession. Succession is defined as the processes by which plant communities develop over time.[18] There are species that indicate different stages of this development. The woody pioneer species are the first species to occur when a piece of ground is no longer being mowed or cropped. They are fast growers and prolific seeders. They tolerate sunlight and competition from grasses and wildflowers found in meadow plant communities. These species are also tolerant of soils that are bacterial in nature such as those soils found in meadow and old field situations. In the White Clay Creek Watershed (PA portion), Black Cherry, Sassafras, Ash, Tulip Poplar, Sycamore, Box Elder, Black Walnut, Pin Oak and Red Maple are species typical of the early phases of woodland succession. As these trees colonize a site, the soils are amended by their falling leaves, twigs and branches and eventually fungal organisms predominate. These fungally based soils support later successional tree species such as Oaks, Hickories, American Beech, and Black Gum etc.

Typically plant and structural diversity increase as a woodland matures. However, invasive species often arrest the development of woodlands. The result is a tangle of invasive species combined with a few natives that do not offer the food required to support a diverse biotic community. A vibrant community of insects forms the base of the food chain. If the food is not there to support them, the birds and other wildlife that depend on these organisms will also disappear.

When performing a restoration, we are often "jump starting" succession and planting a combination of pioneer and later successional trees. The nature of the soils will largely determine the appropriate species list. Existing vegetation will often give clues as to the nature of the soils. For example if there is a preponderance of Pigweed and Curly Dock found growing on a site, it may suggest that mushroom compost was spread on the field. Because of the prevalence of the mushroom growing industry within the White Clay Creek Watershed, it is not an uncommon occurrence. If compost has been spread on the

[18] Leslie Jones Sauer, *The Once and Future Forest* (Washington, D.C: Island Press, 1998), 23.

site, one can expect that the soils will be highly bacterial in nature; with high levels of nutrients and salts as well as a high soil pH. These soil characteristics are not typical of woodlands. In these more extreme situations, it is suggested that a soil sample be taken. It is likely that the soil sample recommendations will require that granulated sulphur be added to lower soil pH. In addition, leaves and woody debris may be added to the soil surface to increase the fungal components of the soils. This technique is effective and may be employed in many restoration projects. Woody debris within existing woodlands adds lignin to the soil, an essential ingredient within forest soils.

A standard soil test does not assess the condition of the soil microbial community. In order to obtain this analysis, a soil sample may be sent to a soil scientist who specializes in the soil food web. One company that offers this service is Soil Foodweb, Inc in Corvallis, Oregon.[19]

Site Evaluation & Inventory

Before creating a plan, it is essential to become familiar with the site. Several site walks are recommended at varying times of day and, if possible, varying times of year. Consider obtaining baseline inventories of flora, fauna, soils and water quality. This baseline information is invaluable to monitoring the project success.
The following is a list of things to note when in the field.

- Soils conditions wet, dry and transition areas; seasonally wet areas
- Light conditions and site exposure; if ground is sloping, what is the orientation
- Inventory existing vegetation – invasive, native, non-native plants
- Identify any rare and endangered species that may alter the planting plan such as bog turtle
- Note drainage areas and any areas that are experiencing erosion
- Identify a reference site that will serve as a model for the restoration
- Take photographs of existing site conditions and any areas of concern
- Obtain information about land- use history i.e. crop, pasture use. Aerial maps will offer historic land use information dating to the 1920's – 1930's
- Take soil samples
- Obtain any information about potential future uses from landowners
- Observe site access and note where it will be required in the future
- Assess the management capabilities of the landowners, which may determine how the trees are laid out
- Discuss aesthetic needs with landowners i.e. view sheds
- Note wind patterns
- Note screening needs from undesirable neighboring views, roads, or prevailing winds
- Observe signs of deer browse and rub
- Observe sources of shelter, food and water for wildlife
- Note any wildlife and inquire as to what the landowner may have seen on site
- Assess landowner commitment to the restoration

[19] Leslie Jones Sauer, 225.

- Observe neighboring properties that may have objection to planting trees in their "borrowed view"

Site Preparation / Invasive Species Removal Strategy

Prior to taking action, it is important to have an invasive species removal strategy. The entire site should be assessed noting areas that are declining and degraded. Those invasive species that pose the greatest threat are to be prioritized. Generally, it is recommended that the removal begin adjacent to the most intact areas working from areas of health to areas of decline and finally to the most degraded areas. Any large seed repositories should be noted and targeted for removal. When creating a strategy, it is essential to consider what impacts the removal will have on wildlife, potential erosion, and other invasive species that may exploit improved light conditions. A planting priority may become "sealing" the edge to prevent light intrusion into the interior woodland, thereby, limiting the potential for invasive intrusion. It may be advantageous to stage the removal so that the areas can be stabilized through planting before moving on to the next removal area. Finally, it is recommended that the removal strategy be assessed periodically to ensure that it is effective and in accordance with the overall goal of restoring native plant communities to the site.

In the long term, thorough site preparation will save time and dollars. If a project site is compromised by an abundance of invasive species, it is important to control them to the extent possible before planting begins and to ensure that management is in place to manage future intrusion. Depending on the site and soils, this can be accomplished in a number of ways. A weed eater mounted with a brush cutter will effectively cut most invasive woody shrubs to the ground. If the site is overrun with invasive species a tractor mounted with a brush hog, a forestry mower or an ASV Posi Track Loader with a rotary cutter mounted on the front may be used. These methods are not recommended for use in existing woodlands as the forest floor is fragile. In all cases, it is essential to minimize soil disturbance. Therefore where soils are wet, it is recommended removal be performed when soils are either dry or the ground is frozen. The re-sprouts of woody species may be treated with the judicious use of herbicide in late August through October. When shrubs are old, they may be cut to the ground in early spring. They will often not have the reserves to re-sprout. The same is true when a species is growing in deep shade such as Multiflora Rose. Simply cutting it to the ground may exhaust its reserve, thereby eliminating the need for herbicide.

Before applying a chemical, it is recommended that it be thoroughly researched. Minimizing chemical use, careful application and applying them at the appropriate time will be advantageous for all concerned. Herbicide is most effective when applied to *woody* plants in late August through October when the energy is returning to the roots. Those products labeled for use in wetlands are the least toxic. Herbicide application generally requires that an individual be licensed. When an individual is applying herbicide on his own property, it is not necessary; however when applying herbicide on someone else's property, a pesticide license is required from the Pennsylvania Department of Agriculture. A recommended source that details invasive species removal is the Nature Conservancy website.

It is recommended that large shrubs and vines be cut down in late summer or early fall. A small amount of herbicide may be applied to the cut within five to fifteen minutes of cutting with a paintbrush. Any vines left hanging in the trees will decompose and fall within two to three years.

Invasive trees less than four inches in caliper may be pulled using a weed wrench. Small shrubs and small vines may be hand pulled. Large invasive trees may be either cut down, girdled and left standing, or a hack and squirt herbicide injection may be used. The latter requires that a downward cut is made into the tree using a hand ax. Multiple cuts are made around the tree. A solution of glyphosate type herbicide is injected into the cut. This method is most effective when applied on hot summer days when the tree is rapidly transporting water to the canopy. It is important to note that when girdled Norway maple produces an abundance of seed before it dies. Therefore, girdling is not recommended for this species.

Non-woody vines such as Mile-a-minute weed and Japanese hops are best controlled early in the season before they climb over and smother other desirable species. Both species may be hand pulled taking care to wear gloves to protect from the recurved barbs on the former and the dermatitis that may be caused by the latter. Mile-a-Minute Weed begins germinating in early April and continues through early July in the Mid-Atlantic States. Japanese Hops germination begins in April and ends in June. A glyphosate herbicide will suffice. It is to be applied before the plants set seed in early August.

Where possible, thorough site preparation is to be performed in the first year. The second year may be allocated to combating the reservoir of invasive seed bank. By the third year, the site will be ready to plant.

If the site to be planted has a recent crop history, it is recommended that the site be planted with a cover crop such as warm season grasses to allow the soils to recover before planting. Best case scenario, the soils would be given three years post-agricultural production before planting trees.

When planting tree seedlings into well established turf grasses, a pre-planting glyphosate type herbicide treatment applied two weeks before planting may improve survivorship. The planting locations are staked, herbicide is applied in a 3-foot diameter circle using a backpack sprayer. Alternatively, coconut fiber tree mats may be used to eliminate the herbicide application.

Species Lists

When creating a species list, it is important to create a list that recognizes those species that are currently self-propagating and to actively plant those species that are not found on site. As conditions change, species lists will change to reflect the conditions on the ground. For example, Black Cherry is commonly found growing in “old field” situations and is naturally propagated by birds. On such a site, the species list may not include Black Cherry but favor other species that are not prevalent. Tulip Poplar needs soils to

seed contact for the germination of its seed. In abandoned corn fields it readily seeds in when the wind borne seeds find their way to exposed soils. In such a case, a species list would not include Tulip Poplar but would encourage other species to add biodiversity to the site. Likewise, planting species because they are not favored by deer does not improve the diversity of the site. It is advised that the species that are impacted by deer browse be planted and protected to ensure their continued distribution.[20]

Another important issue is utilizing plant material that has been propagated from local seed sources to ensure local genotypes. Unfortunately most nurseries are not, at this time, able to provide plants that have been grown from local seed sources. Ideally, plants would be propagated from the restoration site itself. Understanding that timelines and realities of daily life may not permit local seed collection and growing, it is suggested that when placing an order with a nursery that they be queried as to the sources of their plant material. If enough questions are asked eventually the nurseries may identify a need in the marketplace and begin to grow plant material derived from locally collected seed. Local genotypes are important because they have evolved over the millennia under unique and particular site conditions and, therefore, are most aptly suited to local growing conditions.

Planting cultivars in a restoration is not recommended as genetic variation and diversity are the cornerstones of a healthy system. Most nurseries grow and sell plants that have been selected for their ornamental characteristics. They are grown as clones, known as cultivars, in order to supply the home gardener with dependable and predictable flowering, fruiting and leaf coloration varieties.

A final issue to be aware of when creating a species list is those species that have been identified as rare and endangered in the state of Pennsylvania. The Pennsylvania Natural Heritage Program provides lists of species of concern as it is their mission to support the conservation of biological diversity. Planting species that are listed as rare and endangered is not advised. If a population of a rare and endangered plant is found growing adjacent to a restoration site that has actively planted this species, they may cross- pollinate resulting in a genetically inferior plant that will further threaten an already compromised population.

Direct Seeding

Direct seeding of acorns and nuts has been successful. Pennypack Environmental Restoration Trust achieved favorable results when planting hickory nuts within a tree shelter[21]. The Nature Conservancy of Delaware indicated that direct seedings of acorns and nuts were successful when the fields were pH balanced (i.e., made more acidic). Boy scouts planted acorns with a dibble bar. In other projects the ground was disked, seeds dispersed by hand and an ATV was used to pull a piece of cyclone fence to create soil to seed contact[22].

[20] Leslie Jones Sauer, 188.
[21] David Robertson, Pennypack Environmental Restoration Trust
[22] John Graham, The Nature Conservancy, Delaware Chapter

Planting Density
Optimum planting densities for a reforestation project depends on the restoration objective. If the objective is to jump start succession through planting and restore a streamside forest (Riparian Forest Buffer), the more rapidly that canopy cover is achieved, the earlier those optimum conditions will be restored to the stream. In many cases, funding sources will dictate the planting densities that often limit plantings to three to four hundred trees per acre. The CREP Program further limits planting densities. If the restoration objective is to provide habitat for neo-tropical migrating birds, then the restoration of habitat islands or "nucleations" may be the preferred method. Using this method, trees are planted densely in clusters at times as dense as one tree per square foot.[23]

Planting Patterns
If mowing is to be used as a management tool, then trees must be located to accommodate the width of the mower deck. If, instead of mowing, invasive species will be edited and competing vegetation will be managed around the tree seedings; trees may be planted in naturalistic patterns that mimic their natural distribution. For example, American Sycamore is often found growing along stream banks. Because it is colonial, Sassafras grows in clumps. These distribution patterns may be observed in natural habitats and employed within restoration projects.

A combination of a project site that is vegetated with a robust and established grass cover combined with landowners that have limited ability to address management of the plantings may require that the trees be planted in rows. This arrangement will simplify management and accommodate mowing that will be required for five years post planting to sufficiently discourage competing vegetation. Sinuous rows will obscure the linear pattern. In addition, the linear patterns blur with time as trees die and natural regeneration occurs.

"Habitat islands" or "nucleations" act as "bait" for wildlife to encourage the depositing of hard mast that encourages natural regeneration. They may consist of thirty to thirty-five containerized trees (3 gallon) planted in a grid pattern on seventy square feet. Large trees may be transplanted and planted on eight foot centers. The habitat islands are mulched (2" deep) and a seven foot deer fence is erected around them. On one acre there will be 1.3 to 1.5 islands with two to three super islands of approximately 350 to 500 square feet.[24]

Understory Plantings
The success of understory plantings will be determined by the health of the soils, shade levels and existing herbaceous cover. The planting of woodland herbaceous species will not be appropriate until the canopy has closed and the soils are appropriate i.e. mycorrhizal and fungal layers are intact. As this will not be the case for most reforestation projects for at least twenty years, this plan does not detail the planting of a woodland herbaceous layer.

[23] John Graham The Nature Conservancy, Delaware Chapter
[24] John Graham, The Nature Conservancy Delaware Chapter

The planting of flowering trees and shrubs to "seal" the woodland edge (75 feet from edge of woodland to interior) may be a priority in order to ensure the health of the interior woodland. The edge protects the interior through decreasing light penetration and subsequently the proliferation of invasive species. Another strategy is to plant an understory after the canopy closes (approximately 7 to 10 years). In this case, tree removal may be required to provide canopy gaps for plantings. The berries of many of the Viburnum species, as well as Dogwood provide lipids that are high in fat and are essential for migratory songbirds. In riparian forest buffer restoration, shrubs are often located on stream banks to provide rapid stabilization.

Some funding sources will provide cost share assistance to projects that plant eighty percent trees to twenty percent shrubs. There are few funding sources that will provide assistance for the planting of an understory within existing woodlands.

Bare Root Verses Containerized Plant Material

The Stroud Water Research Center (SWRC) conducted an experiment that evaluated survivorship of tree seedlings planted as containerized seedlings versus one- to two-year old bare root seedlings. No difference in survivorship was noted between the containerized and bare root material[25].

Traditionally bare root plant material has been limited to spring plantings. Those projects that have successfully planted bare root tree seedlings in the fall use a two inch mulch layer to prevent frost heave. The planting of larger bare root liners (1" caliper) have been successful in the fall. In all cases, it is recommended that a polymer gel be applied to the roots to protect the plants from drying out. Some species such as Black Gum are not successful as bare root transplants.[26] These species may be planted as containerized material to augment an otherwise bare root planting. When using volunteer labor to plant trees, containerized plant material is recommended.

<u>Bare Root Plant Material</u>

Advantages

- Less expensive
- Less weight; easier to transport on site

Disadvantages

- Requires skilled labor to plant
- Handling and storage must be performed adequately or losses will result
- Less flexibility when planning the projects. When plant material arrives, it must be planted.
- When planting bare root liners (1" caliper), there is less species diversity available from nurseries. Because this tree size is typically used to line out nurseries for the landscape trade, much of what is available are cultivars and ornamental landscape trees.

[25] Dr. Bern Sweeney, Stroud Water Research Center

[26] Kevin Fryberger, Brandywine Conservancy

Containerized Plant Material

Advantages

- Permits a longer planting season
- Volunteer labor can successfully be used for planting
- Permits greater flexibility with planting because it does not have to be planted immediately

Disadvantages

- Expensive
- Heavy and can require site accessibility

Plant Material Size

Because costs are inevitably a factor, large reforestation projects generally use seedling trees. Smaller trees require less time and water to establish. Occasionally, these projects may be augmented by larger plant material as may be found in a five- to seven-gallon container. Smaller reforestation projects that have the ability to irrigate the trees for at least the first season may plant large containerized or balled and burlapped plant material.

Deer Browse & Rub Protection

There are a couple of choices to consider when specifying deer browse protection. Implementing a project that does not address this issue is not recommended. The use of tree shelters, wire cages, deer fences and deer repellents are all options. The advantages and disadvantages to each method are listed below.

Tree Shelters

Advantages

- Accelerated plant growth due to greenhouse conditions within shelter
- Permits application of herbicide around the base of shelters to minimize plant competition
- Effectively protects against deer browse until seedling has emerged from shelter and has developed a root structure that will withstand browse
- Provides temporary protection from deer rub

Disadvantages

- Accelerated growth and lack of wind resistance causes some trees to be floppy when they emerge from shelter
- Aesthetic objections to shelter
- Expensive
- Must be mounted properly or losses will occur due to a “chimney effect”
- Shelters provide cover for rodents and losses occur due to herbivory
- Shelters removal occurs when trees are ripe for deer rub (2-inch caliper)
- Petroleum based product
- Shelters require removal and do not photo degrade as advertised

Wire Cages

Advantages

- Provides adequate protection from deer browse, as well as deer rub for a longer period than tree shelters
- Plants grow under natural conditions and are strong and wind resistant

Disadvantages

- Expensive
- Cages provide a trellis for invasive vines
- Does not permit application of herbicide around base of the tree seedlings to minimize vegetative competition.

Deer Fence

Advantages

- Allows natural regeneration to occur and in some cases may eliminate the need for planting
- Permits the planting of an understory as shrubs will not be vulnerable to deer browse
- Plants may grow unencumbered by shelter or cage

Disadvantages

- Expensive
- Limits access
- Require maintenance
- Prohibits the movement of small mammals
- Some fences photo degrade
- Aesthetic objections to fence

Deer Repellents

Deer repellents can either repel due to an odor or bitter taste or they can activate the fear response and repel deer through the sense of smell. The latter usually contains dried blood or urine of a predator such as coyote. Products that repel due to a bitter taste are most successful when they contain Bitrex in combination with Latex. However, these products due not prohibit the deer from having an initial taste of the plant.

Advantages

- Products that contain latex require applications every three months as opposed to those that require applications after every rainfall
- Minimize deer browse when applied to trees as they emerge from shelters
- When used correctly, products provide an option for planting without protecting each tree and shrub with a shelter or wire cage. Best utilized on smaller reforestation projects or natural landscapes

Disadvantages

- Products unpleasant to work with as the ingredients are often bitter or have an unpleasant smell
- Require repeated applications
- Not usually an option on large reforestation projects
- Do not address the issue of deer rub

Tree Mats / Mulch

When planting into established turf, the use of tree mats is an option that will reduce management costs and improve survivorship. Because they biodegrade, mats composed of one hundred percent biodegradable coconut fiber are recommended. On smaller reforestation projects, mulching around the base of the tree seedlings will help to jump

start the soil microbes and suppress competition from turf grasses. Take care to ensure that the mulch is not mounded around the tree trunk.

Volunteer Labor

Potential volunteer sources include Eagle Scouts, Master Gardeners, watershed organizations and residents, corporations who offer employee paid volunteer days, deer hunting groups who volunteer time in exchange for hunting rights, school groups, Quaker meeting members, church members, township residents, White Clay Creek State Park volunteer days and conservation organization members.

The keys to success when working with volunteers are the following;

- Train volunteers
- Repeat volunteers will minimize the need for training
- Work in small groups of four to five volunteers with at least one supervisor
- Engage volunteers in the design process to help create a sense of ownership for the project
- Use containerized plant material as opposed to bare root plant material as they are simpler to plant
- Clearly layout planting areas with planting locations marked with a stake and color coded by species

APPENDIX E: MANAGEMENT & MONITORING

"The most important conditions for a restoration project are that it be community-based and that it be science-based. To be community- based, it must represent a consensus, which in turn requires that it be participatory. To be science-based, it must be documented and monitored. While we cannot necessarily know enough at the outset, we can establish a process for learning, for restoration that proceeds developmentally."[27]

Management

Management is key to the success of any project. Without having a clear management strategy, it is likely that the project will fail. A management plan for the restoration is highly recommended that details tasks for at least five years. This plan is to include a task schedule that describes the management tasks and time intervals for its performance. At this time, funding does not cover management costs. It is important that a five year commitment to project management be obtained before initiating the project.

The restoration objective will guide the management strategy. In all cases, the overall management objective will be to direct succession. In order to achieve this goal, invasive species will require on-going management, as will the effects of deer browse. Management methods will include the editing of invasive species and managing vegetative competition to the newly planted trees and shrubs. Mowing is one means for temporarily managing invasive species and vegetative competition. However it is important to understand that mowing halts succession, which is in opposition to the management objective. Therefore if mowing is to be used as a short term management strategy, it is advised that it be used with discretion. Before mowing, any desirable volunteer seedlings should be clearly marked so they are preserved and mowing is to be limited to once or twice a season.

The project area will require a bi-annual site inspections best performed in May and August. These inspections will determine the follow-up site work that is required. Natural recruitment is to be observed and recorded, as are the proliferation of invasive species. Deer browse is to be noted and subsequent actions are to be taken to control it.

A key management tool for increasing survivorship is to manage the competing vegetation around the newly planted trees and shrubs. The use of coconut fiber tree mats, a mulched ring or the applications of herbicide around the base of the plant are the methods to consider. If planting habitat islands, mulch will need to be replenished for the first few years. If tree shelters or wire cages are used, they will require a bi- annual inspection to ensure that they are upright and to remove competing vegetation. Where a deer fence has been installed, it is critical that periodic inspections take place to ensure that the fence has not been breached. When using deer repellents, they will require re-application in order to be effective. Finally, re-planting will be required within canopy gaps, to stabilize stream banks or other priority areas.

[27] Leslie Jones Sauer, 91.

Monitoring

The most effective way to determine whether the restoration and management strategies have been effective is to keep a journal of tasks performed and observations made. This record is essential to measuring progress. Gathering baseline data on flora, fauna, soils and water quality before initiating the project will allow comparison with data collected post-restoration. Identifying individuals that will be responsible for gathering and recording data into a formalized log is essential. The identified reference site will also provide a model for comparison and measurement. Photographs taken from the same location over documented time intervals will go a long way to telling the restoration story. Maps can be created to identify and monitor areas of concern and vegetation. Plots may be identified to observe and document changes on a small scale that can then be used to extrapolate changes on the entire project site.

Funding is not often provided for monitoring restorations. However, it is the only way that lessons learned can be documented. Often students and Eagle Scouts are looking for projects and may be used to procure some of the data that is then to be recorded by the designated individuals.

Periodic reviews of restoration goals and management strategies are recommended to ensure that the time on the ground is spent in the most efficient manner. Essentially the management goal is to direct succession. The only way that this goal can be achieved is through astute, periodic and documented observation.

APPENDIX F: INVASIVE SPECIES LIST

Botanic Name	Common Name
Trees	
Acer platinoides	Norway maple
Acer psuedoplatanus	Sycamore maple
Ailanthus altissima	Tree of heaven
Alnus glutinosa	European alder
Magnolia kobus	Kobus magnolia
Morus alba	White mulberry
Paulownia tomentosa	Paulownia
Phellodendron amurense	Amur cork tree
Prunus calleryana	Callery pear
Ulmus parviflora	Chinese elm
Ulmus pumila	Siberian elm
Shrubs and Woody Vines	
Ampelopsis brevipendunculata	Porcelain berry
Berberis thunbergii	Japanese barberry
Berberis vulgaris	Common barberry
*Buddlei davidi*i	Butterfly bush
Celastrus orbiculatus	Oriental bittersweet
Eleagnus umbellata	Autumn olive
Euonymous alatus	Burning bush
Euonymous fortunei	Wintercreeper
Hedera helix	English ivy
Ligustrum obtusifolium	Privet
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	Amur honeysuckle
Lonicera morrowi	Morrow honeysuckle
Lonicera tatarica	Tartarian honeysuckle
Photina villosa	Oriental photina
Rhodotypos scandens	Jetbead
Rosa multiflora	Multiflora rose
Symphoricarpos orbiculatus	Coralberry
Spirea japonica	Japanese spirea
Viburnum dilatatum	Linden viburnum
Viburnum plicatum	Double file viburnum
Viburnum sieboldii	Siebold viburnum
Wisteria floribunda	Japanese wisteria
Herbaceous	
Alliaria officinalis	Garlic mustard
Coronilla varia	Crown vetch
Fallopia japonica	Japanese knotweed
Hesperis matronalis	Dame’s rocket

Humulus japonicus	Japanese hops
Lythrum salicaria	Purple loosestrife
Microstegium vimineum	Japanese stilt grass
Miscanthus sinensus	Chinese silver grass
Pachysandra terminalis	Pachysandra
Phalaris arundinacea	Reed canary grass
Polygonum perfoliatum	Mile-a-minute weed
Vinca minor	Myrtle or Perriwinke

This list is intended to be comprehensive; however, species are being added to invasive species lists with frequency. Because a species is invasive in the White Clay Creek Watershed does not mean it will be invasive elsewhere.

APPENDIX G:
REFORESTATION SPECIES LIST
WHITE CLAY CREEK WATERSHED, PENNSYLVANIA PORTION

Canopy Trees

Botanic Name	Common Name
Acer negundo	Box elder
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Betula lenta	Sweet (black, or cherry) birch
Carya cordiformis	Bitternut hickory
Carya glabra	Pignut hickory
Carya ovata	Shagbark hickory
Carya tomentosa	Mockernut hickory
Celtis occidentalis	Hackberry
Fagus grandifolia	American beech
**Fraxinus americana*	White ash
**Fraxinus pennsylvanica*	Green ash
Juglans cineria	Butternut
Juglans nigra	Black walnut
Liriodendron tulipifera	Tulip poplar
Nyssa sylvatica	Black gum
Platanus occidentalis	Sycamore
Populus grandidentata	Big-toothed aspen
Prunus serotina	Black cherry
Quercus alba	White oak
Quercus bicolor	Swamp white oak
Quercus coccinea	Scarlet oak
Quercus montana	Chestnut oak
Quercus palustris	Pin oak
Quercus rubra	Northern red oak
Quercus velutina	Black oak
Salix nigra	Black willow
Tilia americana	American basswood
Ulmus rubra	Slippery (red) elm

Coniferous Tree

Juniperus virginiana	Red Cedar

Understory Trees & Shrubs

Alnus serrulata	Smooth alder
Amelanchier arborea	Shadbush/Serviceberry
Aronia arbutifolia	Red chokeberry
Aronia melanocarpa	Black chokeberry
Asimina triloba	Paw paw
Carpinus caroliniana	Ironwood
Cephalanthus occidentalis	Buttonbush
Cornus amomum	Silky dogwood
Cornus alternifolia	Pagoda dogwood
Cornus racemosa	Grey dogwood
Cornus florida	Flowering dogwood
Corylus americana	Hazelnut, filbert
Crataegus phaenopyrum	Washington hawthorn
Diospyros virginiana	Persimmon
Hamamelis virginiana	Witch-hazel
Ilex verticillata	Winterberry
Lindera benzoin	Spicebush
Morus rubra	Red mulberry
Prunus americana	American plum
Rhododendron periclymenoides	Pinxter bloom
Rhododendron viscosum	Swamp azalea
Rhus copallina	Shining sumac
Rhus glabra	Smooth sumac
Rhus typhina	Staghorn sumac
Sambucus canadensis	Elderberry
Sassafras albidum	Sassafras
Staphylea trifolia	Bladdernut
Vaccinium corymbosum	Highbush blueberry
Vaccinium pallidum	Lowbush blueberry
Viburnum acerifolium	Maple leaf viburnum
Viburnum dentatum	Arrowwood
Viburnum prunifolium	Black haw

*****The prevalence of Ash Borer may discourage the planting of these species