



The Fairfax County Tree Commission  
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October 17, 2019

Supervisor Penelope Gross, Chair, BOS Environment Committee and  
Members of the Fairfax County Board of Supervisors  
12000 Government Center Parkway  
Fairfax, VA 22035

Dear Supervisor Gross and members of the Fairfax County Board of Supervisors:

Thank you for your work on behalf of trees in Fairfax County.

As mentioned at the October 7, 2019 BOS Environment Committee meeting, the Fairfax County Tree Commission has updated the Tree Action Plan. The enclosed September 2019 version incorporates changes addressing all questions raised by Supervisors at the October 5, 2018 BOS Environment Committee Meeting.

All questions have been addressed to the satisfaction of the Tree Commission. On September 19, 2019 we unanimously voted to recommend that the Board of Supervisors approve the 2019 Tree Action Plan. Your approval will enable the Tree Commission to formally establish the Community of Practice and implement the recommendations included therein in support of trees.

We look forward your approval of the 2019 Tree Action Plan.

Sincerely,

Catherine C. Ledec, Chairman  
Fairfax County Tree Commission

FAIRFAX COUNTY TREE ACTION PLAN 2019  
September 19, 2019

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## EXECUTIVE SUMMARY

### Purpose

The Tree Action Plan 2019 (TAP 2019) updates the Tree Action Plan adopted by the Fairfax County Board of Supervisors in 2006. Much has changed since then in our understanding of the benefits provided by trees and the stresses impacting our urban forest. TAP 2019 improves on the earlier plan by providing for more effective implementation through greater involvement of key government agencies, private organizations, and county residents.

### Urban Forest Strategic Plan

Part I of TAP 2019, the Urban Forest Strategic Plan (UFSP), treats the urban forest as natural capital, a durable resource that provides benefits to county residents and the environment for generations to come. The plan details benefits that demonstrate how this valuable resource contributes to the environment and our quality of life. It also describes human and environmental stressors to our urban forest that must be addressed to conserve and manage the resource as an asset that will continue to provide benefits into the future.

The stewardship necessary to maintain our urban forest is arranged around five framework goals: 1) know what we have; 2) protect and improve what we have; 3) expand what we have; 4) update urban forestry policies and processes; and 5) communicate and build partnerships. Under these five goals, 24 core recommendations specify actions needed to better manage our urban forest.

### Urban Forest Management Plan

Part II of TAP 2019 addresses implementing and tracking the Urban Forest Management Plan (UFMP). The County will set a strong example for protecting and enhancing our urban forests with the Board of Supervisors' adoption of TAP 2019. Public and private stakeholders in the plan will collectively make up a community of practice in an ongoing process to achieve the goals outlined in the UFSP. The Tree Commission, Urban Forest Management Division, and the VA Department of Forestry Area Forester will reach out to other public and private stakeholders who can play key roles in plan development and implementation and request their support of the goals and recommendations of the UFSP. By recognizing when their work potentially impacts the urban forest and including actions to address core recommendations of the UFSP in their own policies, procedures, and operating plans; goals of TAP 2019 can be achieved. Agencies and organizations will then report to UFMD on their accomplishments in support of TAP 2019 on an annual basis.

## PART I - URBAN FOREST STRATEGIC PLAN

### Introduction

The Tree Action Plan 2019 (TAP 2019) updates the original Tree Action Plan (TAP) adopted by the Fairfax County Board of Supervisors in 2006. TAP 2019 expands and improves the framework to guide and educate residents and county staff for the protection and improvement of Fairfax County's urban forest. The continued deliverance of ecosystem services and the benefits that trees provide will be important to county residents for generations to come.

The Fairfax County Urban Forest is all the trees and other living things, including people, the air, the water, the minerals, the soils and the built environment found in the county; the ecosystems they form; and the services they provide. In this context, the urban forest is natural capital, a durable resource providing a stream of benefits to residents and the environment.

Protection of the natural capital embodied in the urban forest requires a strategic plan to guide our actions and a legal and policy framework to support the plan.

### Background

In 2005, then Chairman of the Board of Supervisors Chairman, Gerry Connolly, visited the Fairfax County Tree Commission and challenged them to develop a plan to manage and enhance the county's forests and trees. The Tree Commission convened a committee of county and state staff, private non-profits and developers, which produced the original Tree Action Plan. The Fairfax Board of Supervisors adopted the plan in December of 2006. Since then much has changed. In 2008 the county sought and got new state enabling legislation to protect trees and used that legislation to enact the Tree Conservation Ordinance (Chapter 122 of the Code of Ordinances) requiring the preservation of a minimum percentage of existing trees during development based on the percentage of the development site covered by existing tree canopy. Then, to support the Tree Conservation Ordinance, the county amended Chapter 12, Tree Conservation, of the Public Facilities Manual to conform to the new ordinance.

It was not just the county's regulatory framework that changed during that time. Our ability to see, analyze and imagine the urban forest has been greatly enhanced by new technologies. In 2006, ten-meter pixels were the standard for aerial or satellite imagery. Today the standard is one meter or less. At this resolution we can see, count, and measure newly planted trees in the landscape that 10 years ago would have blended into the surrounding turf or pavement.

In 2006, the state of the art for tree inventories was a hand-held data collector that was later downloaded into a computer. Today we can collect data on trees with a smart device that can incorporate that data into a Geographic Information System (GIS) database and map in real time. The US Forest Service and partners have produced a suite of tools called i-Tree that measure the

effect of trees on air quality, water quality, stormwater runoff, carbon sequestration, energy use, and property values. One i-Tree tool also allows modeling the effects of tree loss or gain on the hydrology of a watershed.

With the advances in technology and regulation we have developed more precise measures of how trees improve air quality and water quality, save energy and sequester carbon. More importantly, we have gained a deeper insight into how the urban forest improves the quality of people's lives. Studies conducted in the last decade have linked the urban forest and nature to improved physiological and psychological health, reduced personal and property crime, and greater community cohesion. In short, over the past decade we have developed not only a more precise understanding of how trees improve the world in which we live, work and play; but also, greater appreciation for how trees improve the quality of our lives, our work, and our play.

While we are beginning to recognize the importance of trees to the health of our communities, there is a need to assess the health of the urban forest throughout the county to determine where improvements are needed and to prioritize where improvements will add the greatest value. Changes in the rules that govern the urban forest, the way we observe and measure it, and our understanding of the role of the urban forest in our community, have changed the way we think about and manage it. We no longer think of the urban forest as just a collection of trees growing in a developed area. We now think of the urban forest as an ecosystem; a collection of living (people, plants, animals, fungi, protists, bacteria, etc.) and non-living (light, air, water, minerals) components, with a set of relationships between and among those components. Managing the urban forest requires a systems approach that considers the effect the other components have on trees and the effect that trees have on the other components.

After adoption of the original TAP, the Board set a 30-year tree canopy goal of achieving 45 percent tree canopy by 2037. With the advances in technology previously described, and growth of our forests and landscape trees, an Urban Tree Canopy Assessment (UTC) completed in March 2017 found our tree canopy to be 57 percent of the land area of the county.<sup>1</sup> The tree canopy management goal of TAP 2019 is no net loss to maintain our tree canopy of 57 percent based on the March 2017 analysis.

Losses in canopy cover will certainly occur in parts of the urban forest. The goal is to manage for expansion by applying the Tree Conservation Ordinance requirements for tree preservation and planting during development projects, identifying new planting sites and creating conditions favorable for regeneration so the overall canopy area remains at its current level of 57 percent. Management will also strive to improve the quality of the urban forest to improve its capacity to provide the benefits we expect and its resilience in responding to stressors.

We believe it is most important to focus on raising awareness of the full spectrum of benefits that trees provide. Planting, preserving, and maintaining and improving the quality of tree canopy are

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<sup>1</sup> <https://www.fairfaxcounty.gov/publicworks/sites/publicworks/files/Assets/Documents/tree-canopy-report-2015.pdf>

key practices of environmental stewardship and will always be important. Simply to achieve a goal based on a certain percentage of land area does not necessarily make us good stewards. More importantly, the incentive for maintaining and expanding tree canopy is the continuing socio-economic, environmental, and health benefits that the urban forest contributes to improve the quality of our lives.

Expanding and improving the quality of the urban forest is different than working with individual trees where work is focused on the tree itself. The urban forest is often most effectively managed by reducing the negative impacts of stressors such as invasive vegetation, deer and insect pests, and development. Once stressors are limited, the forest is usually able to expand itself with regeneration.

Where and how to use available resources will hinge on assessing stressors and existing conditions and judging where 1) efforts to minimize stress will best improve forest quality, and 2) enhanced forest quality could best improve quality of life.<sup>2</sup> In support of the One Fairfax Policy of racial and social equity in the delivery of policies, programs and services, the Urban Forest Management Plan will address improving environmental quality and quality of life in all our communities, particularly in areas where tree canopy is lacking.<sup>3</sup>

The Board of Supervisors' Environmental Agenda recognizes the essential role that natural capital plays in protecting and enhancing the quality of life for Fairfax County residents. Trees are central to an investment in natural capital. The original TAP recognized this and encapsulated it in the three overarching goals and 12 core recommendations. The TAP also recognized that things would change over time and require periodic review and additional consideration.

A review of the original TAP document revealed that it does not lend itself well to revision and suffers from a degree of ambiguity in its role as a strategic plan or an operational plan. Recognizing the limitations of the original TAP, the rapid changes in our understanding of both the role of the urban forest and how to manage it, and anticipating these changes to continue in the future, we decided to keep the spirit of the original TAP while improving the document.

TAP 2019 is a first step in creating a Community of Practice that includes everybody who affects or is affected by the Fairfax County urban forest. In TAP 2019 we seek to educate the community about the benefits and threats to our urban forest. We lay out a strategic vision that is designed to inform and guide our community in its efforts to protect and manage the urban forest.

## Plan Structure

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<sup>2</sup> [http://depts.washington.edu/hhw/b/Thm\\_StressPhysiology.html](http://depts.washington.edu/hhw/b/Thm_StressPhysiology.html)

<sup>3</sup> <https://www.fairfaxcounty.gov/topics/one-fairfax>

Part I of TAP 2019 is the Urban Forest Strategic Plan (UFSP) which begins by defining the urban forest and focusing on the urban forest as natural capital. Our best interests are served by maintaining this valuable resource for the ecosystem services, human health, and economic benefits it provides. The strategy for stewardship and how to maintain this natural capital is arranged around five framework goals that describe areas of action necessary to protect and expand the urban forest:

1. Know What We Have
2. Protect and Improve What We Have
3. Expand What We Have
4. Improve Urban Forestry Policies and Processes
5. Communicate and Build Partnerships

Under these five goals are 24 core recommendations that specify what must be done to manage our urban forest. The UFSP is a living document, periodically assessed and updated by the current stewards of our natural capital to reflect new information, technology, and strategies for proper management.

Part II of TAP 2019 addresses the development, implementation, and tracking of the Urban Forest Management Plan (UFMP). The UFMP will consist of designated sections of the work plans and strategic plans of county agencies and stakeholder organizations, and will describe how the UFSP will be implemented through the operational plan developed for their businesses.

## The Urban Forest and Urban Forest Benefits

### The Urban Forest

To many people the term urban forest is confusing. The word urban conjures visions of concrete and people, while the word forest brings to mind trees, streams, and untrammelled spaces. An urban forest is a type of forest, like a pine forest or a rain forest. A forest is an ecosystem in which trees play an important and defining function. An ecosystem is a collection of living (plants, animals, fungi, protists, bacteria, etc.) and non-living (light, air, water, minerals) components, and a set of relationships between and among the components. Thus, an urban forest is an ecosystem in which trees play an important function, but people and the things people build like roads, buildings and utilities dominate it.

The Fairfax County Urban Forest is all the trees and other living things including people, the air, the waters, the minerals, the soils and soil organisms, and the built environment. This may seem overly expansive, especially including people and the built environment, but consider this commonly cited definition of urban forestry:

“Urban forestry is generally defined as the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide society.”<sup>4</sup>

Under this definition, urban foresters must consider what effect the rest of the ecosystem has on trees and the effect that trees have on the rest of the ecosystem. People and the things they build are important constraints on the trees of Fairfax County and so must be considered part of the County’s urban forest, just as soils and topography are part of a rural forest. The forest’s close proximity to people within urban areas increases the potential for stress on the urban forest, but also increases the potential for people to benefit from the numerous services and significant contributions to improved quality of life that the urban forest can provide. This interface is the basis for urban forest management.

Another significant difference between urban and non-urban forests is the way they are created and managed. Natural processes, an individual or a small group of people create and manage non-urban forests. The decisions of a huge number of people and organizations create and manage urban forests in Fairfax County. Federal, State, Regional, County and Town agencies own and manage trees on parkland. Trees at schools, public housing, libraries, fire stations and other publicly owned land are managed by several different government agencies. In addition to these public property tree owners and managers there are 353,904<sup>5</sup> taxable residential and commercial

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<sup>4</sup> Konijnendijk, C. C., Richard, R. M., Kenney, A., & Randrup, T. B. (2006). Defining urban forestry - a comparative perspective of North America and Europe. *Urban Forestry & Urban Greening*, 4(3-4), 93-103. 10.1016/j.ufug.2005.11.003

<sup>5</sup> Personal communication from Sam Jackson, Fairfax County Department of Taxation, March 5, 2018



parcels in Fairfax County. The owners of each of these properties decide how many and what species of trees to plant, how to manage their landscapes and how to care for their trees. Each of these public and private landowners and managers is part of the community of practice that creates and manages the Fairfax County Urban Forest.

As discussed below, the urban forest provides a stream of benefits that support and improve people's lives. This stream of benefits is why the urban forest is called green infrastructure and it is just as important as the built gray infrastructure in the community. To protect and enhance the urban forest and the benefits it provides we must embrace, educate and strengthen the community of practice that creates and manages the urban forest.

### Urban Forest Benefits

Trees and the urban forest provide two types of benefits to people.

- Environmental management benefits are the byproducts of trees' lives that people value
- Quality of life benefits result from people interacting with trees.

### Environmental Quality

In the process of life, trees interact with air, water and soils in ways that people find beneficial. Trees improve air quality; manage the quantity and quality of stormwater; help (re)build soil; and store carbon.

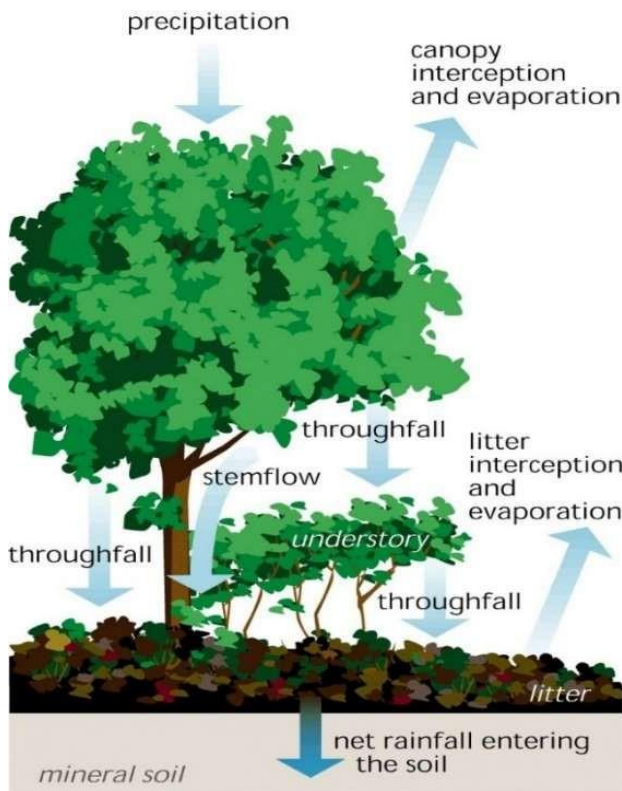
Air quality: The possible negative health outcomes from exposure to poor quality air makes air quality an important environmental health concern. In the process of photosynthesis, trees open their leaf stomata to let in carbon dioxide. During this process, they also take in and denature sulfur dioxide, nitrogen oxides, and ozone and in doing so, clean the air we breathe. Tree canopies and leaf surfaces create drag on moving air, reducing the air's energy and causing deposition of air borne particles. Thus, by interacting with the air, trees in the urban forest directly reduce four of the six criteria pollutants cited as human lung irritants in the Clean Air Act.

Trees also improve air quality indirectly. By shading houses and protecting them from winter winds, trees reduce summer energy use by up to 10 percent and winter energy use by as much as 3 percent, thereby reducing pollution from energy generation. Similarly, trees reduce ambient air temperatures through transpiration, further decreasing energy use and pollutant production.

Soils: Trees interact with the soil ecosystem to build and improve soils. Trees help create the mineral component of soil when physical action of expanding roots and the exhalation of carbon dioxide by roots mechanically and chemically erode rock. Trees feed the soil ecosystem through decomposing leaves and woody debris at the soil surface and the sloughing of fine root mass in the soil, which provide biochemical energy and nutrients to soil microbes. Trees also inject sugars into the soil to attract and keep beneficial soil bacteria and fungi in the root zone. Tree roots are

grazed by a variety of soil-dwelling animals and used as food by pathogenic fungi, bacteria, and protists. These tree eating organisms are then food for predators that are part of the soil ecosystem. The growth of tree roots and the activities of organisms that depend directly and indirectly on trees help create the aggregate structure that allows soil to drain well and hold moisture. Larger pores between soil aggregates allow soil to drain; tiny pores within soil aggregates hold moisture in the soil.

**Stormwater Management and Water Quality:** The erosive forces of stormwater result from the volume of runoff and the velocity at which it moves. Trees intercept stormwater and help create conditions that facilitate its infiltration into the ground, thereby reducing runoff to streams from storms. Interception occurs when precipitation is captured in the canopy of a tree and evaporates without touching the ground. Leaf litter and woody debris lying on the soil surface act like sponges, slowing and holding stormwater. This reduced movement allows water to evaporate or have longer contact with the soil and infiltrate more completely. Even in landscaped areas where maintenance practices remove leaf litter, the effects of tree roots and associated organisms on soil structure help increase infiltration of stormwater.



### Typical Pathways for Forest Rainfall

A portion of precipitation never reaches the ground because it is intercepted by vegetation and other surfaces and held until it is absorbed or evaporates.

In Stream Corridor Restoration: Principles, Processes, and Practices (10/98). Interagency Stream Restoration Working Group (15 federal agencies)

<http://www.novaregion.org/DocumentCenter/Home/View/3099>

Streams have evolved to handle a certain amount of stormwater. Changes in land use increase the quantity of stormwater runoff, eroding the stream bed and banks to accommodate the increased level of runoff. This erosion sends tons of sediment downstream to the Potomac River and Chesapeake Bay. To the extent that interception and infiltration reduces runoff, trees help protect our streams and the Chesapeake Bay.

Stormwater infiltrated and filtered through soil is cleansed of pollutants, particularly nitrogen and phosphorous, by soil microbes before it reaches a stream. Stormwater runoff from paved surfaces is also cooled as it is filtered through soil or flows through shady riparian forest areas adjacent to streams before entering the stream channel. The reduced temperature improves water quality and protects living organisms in our streams, rivers, and the Chesapeake Bay. Trees protect our local streams from erosion and pollution by reducing sediment and absorbing nutrients, improving water quality throughout our waterways.

Sediment and nutrients are the top two pollutants threatening the health of Chesapeake Bay. In general, stormwater runoff will be inversely proportional to the density of the vegetation. Open land covers are considered to be “potential forests”. Encouraging potential forests to succeed to more highly vegetated land covers is the least costly means for reducing stormwater runoff and the nutrients and sediments that runoff carries. The volume of runoff from forests can be further reduced by leaving leaf litter and woody debris in place and by restoring understories over-browsed by deer.

Carbon Storage: Trees are made of and create wood. Wood is primarily lignin and cellulose, both carbon compounds; so, trees are carbon. It is not unreasonable to look at trees and long-lived products from trees (e.g. Mount Vernon, Gunston Hall) as solidified atmospheric carbon dioxide. Trees also inject carbon into the soil through the growth and sloughing of fine root mass and the feeding of the soil ecosystem. The basis of carbon removal and storage is photosynthesis, the process whereby trees and other green plants absorb carbon dioxide from the air and combine it with water and solar energy to form sugars and release oxygen. Some of the sugar is stored, some of it becomes building blocks for wood, but much of it is burned as biochemical energy. Trees use sugar as fuel in the same way that humans do and, like humans, trees release carbon dioxide as a by-product. Unlike humans, much of the carbon dioxide is released through pores in the root system where it combines with soil moisture to form carbonic acid and through soil and rock weathering becomes bound in solid compounds in the soil.

As the above discussion illustrates, trees live complicated lives that are intertwined with air, water, soil, and other organisms. In performing the functions that support their lives, trees affect the environment in ways that humans find beneficial. These effects have been well studied and a body of science has grown up around them that provides a reasonably accurate estimate of the quantity

and dollar value of these services. The Fairfax County Urban Forest Management Division undertook such a study in 2017.<sup>6</sup>

The table below summarizes findings from i-Tree Ecosystem Analysis, Fairfax County, Urban Forest Effects and Values, 2017.

General Environmental and/or Socio-economic Benefit	Quantified Benefit Provided by County Trees	Notes
Building Energy Use and Carbon Emission Reductions	Estimated to save \$34.3 million in energy usage each year through shade and wind speed reduction, and  An additional \$6.74 million in reduced carbon released by power plants	Equates to 954,584 MBTU* in heating energy and 192,231 MWH** in cooling energy on an annual basis.  Includes 51,936 tons of avoided carbon.
Carbon Storage and Sequestration	\$969 Million  &  \$19.5 Million/year	What it would cost to store 7.466 million tons of carbon that is currently tied up in tree biomass.  What it would cost to absorb 150,500 tons of carbon/year.
Air Quality Benefits (annual)	\$1.83 billion: What it would cost to remove 4,538 tons of pollutants a year using alternative forms of pollution control	Applies to gaseous and particulate forms of pollution including: Nitrogen oxide (NO <sub>2</sub> ), Ozone (O <sub>3</sub> ), particulate matter < 2.5 microns (PM <sub>2.5</sub> ), carbon monoxide (CO), and sulfur dioxide (SO <sub>2</sub> )
Stormwater Control Benefits	\$26.3 million: based on \$0.067/cu. ft.	Surface runoff reduced by an estimated 393 million cubic feet/yr. of precipitation intercepted by tree & shrub cover and slowed to promote infiltration and storage in the soil

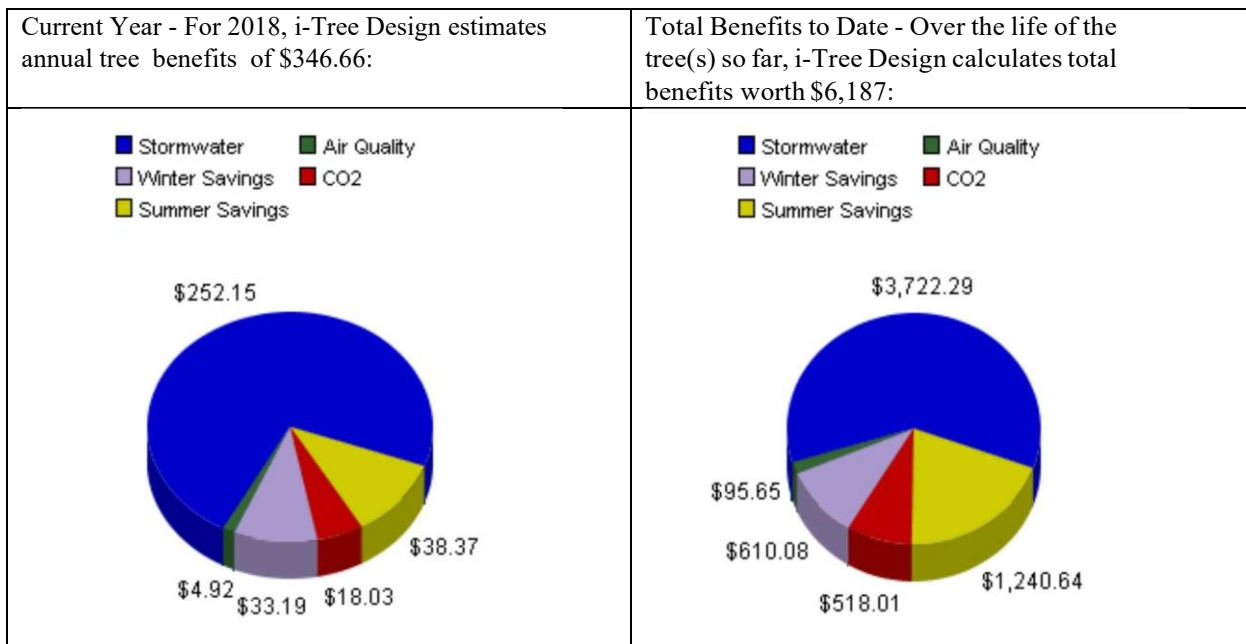
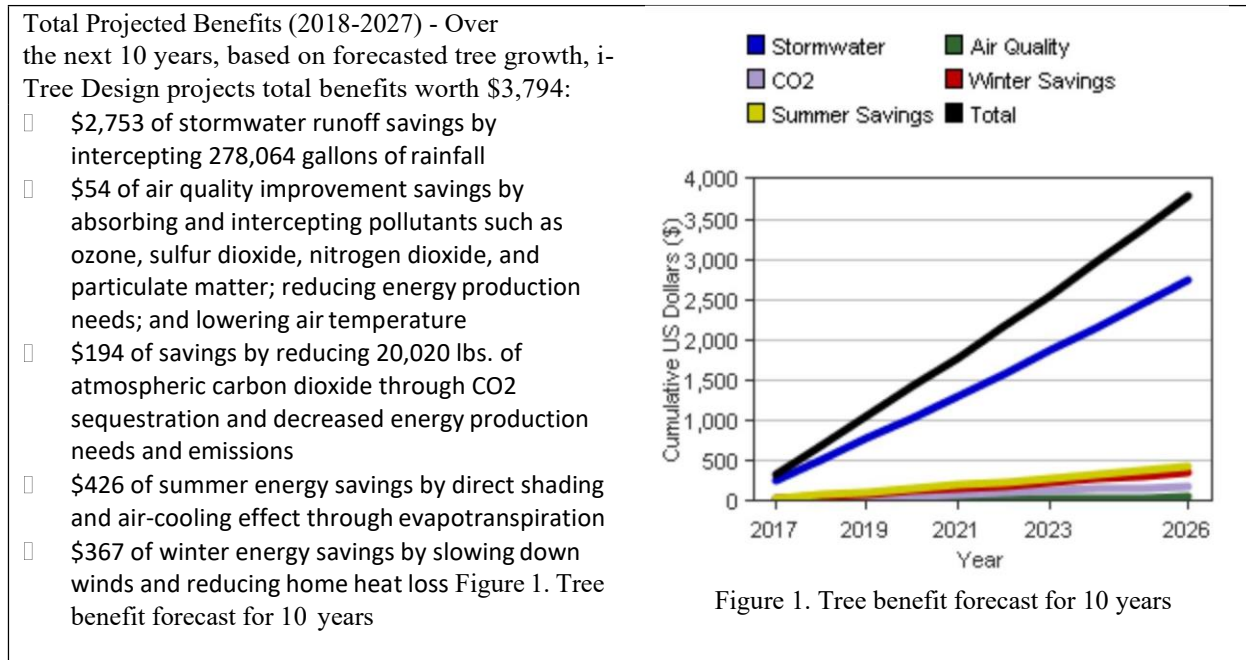
\* Million British Thermal Units

\*\* Megawatt hours

<sup>6</sup> i-Tree Ecosystem Analysis, Fairfax County, Urban Forest Effects and Values, 2017

The same science that supports this i-Tree Ecosystem study is available to homeowners, students and others through the i-Tree Design software (<https://design.itreetools.org/>).

The values below were generated for four trees on a single-family residential parcel in Fairfax County using i-Tree Design software.



Based on the data collected as shown, the four trees yielded individual benefits as follows:

Individual Tree Benefits							
Tree	DBH (in)	Condition	Location to Structure	Benefits			
				Current Year (2017)	Future Year (2027)	Projected Total (2017-2027)	Total to Date
1. Red maple	24	Excellent	Southeast (26 ft)	\$107.94	\$109.43	\$1,087	\$1,450
2. Willow oak	38	Excellent	West (24 ft)	\$225.91	\$260.43	\$2,421	\$4,735
3. Northern red oak	2	Excellent	South (39 ft)	\$8.34	\$15.64	\$107	\$0
4. Tulip tree	2	Excellent	Southwest (41 ft)	\$4.48	\$37.41	\$179	\$1
<b>Total</b>				<b>\$346.66</b>	<b>\$422.89</b>	<b>\$3,794</b>	<b>\$6,187</b>

DBH: "diameter at breast height" is the standard measurement of tree trunk width at 4.5 feet (1.5 meters) above the ground.

### Quality of Life Benefits

While the environmental management benefits of the urban forest are things trees do that humans find useful, quality of life benefits stem from human interaction with and response to trees and forests. Quality of life means more than just aesthetics. It means health, food, water, income, energy and personal security; access to quality education and jobs; equality; having a voice in society; and individual and community resiliency.<sup>7</sup> Some may think it a stretch to link the urban forest to all these elements of the quality of life, particularly the last three. But there are many studies that link trees directly to security and jobs, and tangentially to education.

**Health Benefits:** From an environmental health perspective, urban forests tend to enhance regional biodiversity, mitigate stormwater management demands, and improve air quality. The social and human health aspects of urban forests are not as well known, but a growing body of literature points toward substantial benefits in these areas as well.<sup>4</sup>

In its constitution, the World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."<sup>8</sup> Given this, public health officials are concerned with more than the outbreak of communicable diseases like the flu. In recent years many studies have appeared in the public health literature that link the urban forest to all the aspects of health in the WHO definition.

There is a great deal of medical research being focused on the effect of the human microbiome (the bacteria, fungi and other microbes that inhabit humans) on human health. The original focus of this research was on allergies, asthma, and inflammatory disease which are prevalent in

<sup>7</sup> Vogt, J and Hauer, R, "Sustainability Science for Urban Foresters and Arborists," *Arborist News* Vol 26 No4, August 2017, pp. 28 - 34

<sup>8</sup> Constitution of the World Health Organization, 1946, retrieved from <http://www.who.int/about/mission/en/>

developed countries, but very rare in developing countries<sup>9</sup>. Complimentary research has suggested that ecological biodiversity drives diversity of the human microbiome and may provide the missing link between a healthy diverse urban forest and healthy people.

In one of the first studies of the non-environmental benefits of trees, recovery from abdominal surgery was found to be faster and easier when viewing trees and natural settings compared to a view of a brick wall.<sup>10</sup> Since then thousands of studies have found that interacting with trees and nature improves health. A 2013 study using mobile EEG found that brain wave patterns indicated

“ARBORISTS AND URBAN FORESTERS USUALLY  
FOCUS ON TREE CARE, BUT THEIR MOST  
IMPORTANT PROFESSIONAL ACTIVITY MAY  
ACTUALLY BE PEOPLE CARE”

- Dr. Kathleen L. Wolf, *The Sanitary to Sustainable City: Place, Health, And Trees*, *Arborist News* Vol 26 No 4 August 2017, Pg. 42

reduced stress when experiencing urban green spaces.<sup>11</sup> Shinrin-yoku, a Japanese term for taking in the forest, has been shown in at least one study to increase the activity of parts of the immune system.<sup>12</sup> A study in Toronto found that having more trees on a city block correlated with both increased perception of health and decreased cardio-metabolic conditions.<sup>13</sup> Studies

have also correlated urban tree cover to improved reproductive health<sup>14</sup> and decreased mood disorders<sup>15</sup>.

Another causative link between the quality of the urban forest and human health and well-being can be found in the research of Drs. Frances Kuo and Kathleen Wolf. They have found that the trees and plants of the urban forest are integral in creating spaces that invite people to visit, thereby promoting activity, reducing stress, reducing isolation, and building social cohesion. These inviting spaces have been associated with better human health and lower rates of crime and

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<sup>9</sup> Rudolph, L., Caplan, J., Ben-Moshe, K., & Dillon, L. (2013). *Health in All Policies: A Guide for State and Local Governments*. Washington, DC and Oakland, CA: American Public Health Association and Public Health Institute

<sup>10</sup> Hanson, P., Frank, M. (2017). “The Human Health and Social Benefits of Urban Forests.” Dovetail Partners, Inc.

<sup>11</sup> Aspinall et al. 2013. “The urban brain: Analysing outdoor physical activity with mobile EEG” *British Journal of Sports Medicine* 2015 Feb;49(4):272-6

<sup>12</sup> “Forest bathing enhances human natural killer activity and expression of anti-cancer proteins.”

Li Q1, Morimoto K, Nakadai A, Inagaki H, Katsumata M, Shimizu T, Hirata Y, Hirata K, Suzuki H, Miyazaki Y, Kagawa T, Koyama Y, Ohira T, Takayama N, Krensky AM, Kawada T. *Int J Immunopathol Pharmacol*. 2007 Apr-Jun;20(2 Suppl 2):3-8.

<sup>13</sup> Kardan, O. et al. Neighborhood greenspace and health in a large urban center. *Sci. Rep.* 5, 11610; doi: 10.1038/srep11610 (2015).

<sup>14</sup> Donovan, G.H. et al. Urban Trees and the Risk of Poor Birth Outcomes. *Health & Place*, Vol. 17, No. 2, January 2011, pp. 390-393

<sup>15</sup> Anon. 2007. *Ecotherapy: The Green Agenda for Mental Health*. Mind: For better mental health, London, pp., 36 pp.

domestic violence.<sup>16,17</sup> Urban forests play an extremely important, multi-faceted role in maintaining and improving not only the economic and environmental quality of communities, but also the health of inhabitants.

Wildlife Habitat: Aside from the value that wildlife contributes to the ecosystem itself, there are quality of life benefits and economic value to people that are based on healthy populations of animal life that inhabit the forest. Animal conservation is important to promote biodiversity, provide research opportunities, and sustain ecosystem-based economic activity. Software has been developed to estimate the value of undeveloped land based on its ecosystem services that include wildlife and associated recreational activities, and the increased residential property values that people are willing to pay for parcels with nearby natural areas that support wildlife.<sup>18</sup> Wildlife value is an environmental service benefit resulting from conditions that the urban forest helps create. Value is also based on quality of life benefits resulting from people's interaction with wildlife such as observing and photographing animal activity, bird watching, research, as well as hunting and fishing.

Economic Benefits: Trees are good for business and the bottom line. Contrary to business' objections to trees because they block store fronts and signs, studies have found that people spend more time and money in well-treed, shaded commercial districts, even if they cannot see the shops or signs,<sup>19</sup> because temperatures are cooler and these areas are more comfortable. Tree-lined corporate campuses attract and help retain employees, make them feel better about their jobs, and are correlated with fewer sick days used. Interacting with trees and nature, even by glancing out a window, can reduce directed attention fatigue associated with focusing on work<sup>20</sup>. To the extent that trees improve health and reduce medical expenses, they can lower insurance premiums for workers and employers.

Trees increase private and corporate property values. A large shade tree in a residential yard can increase property value by thousands of dollars,<sup>21</sup> and realtors consider planting a tree one of the best property value investments a homeowner can make. Homes and commercial properties with trees spend less time on the market when being sold or rented. The effect of trees on energy use

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<sup>16</sup> This research can be found at <http://lhlh.illinois.edu/> and [www.naturewithin.info](http://www.naturewithin.info)

<sup>17</sup> Ulmer et al. 2016. Health & Place. Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription," *Health and Place*. 2016 Nov; 42:54-62.

<sup>18</sup> [http://www.landscape.org/explore/ecosystems/ecosystem\\_services/defenders\\_benefit\\_toolkit/1/](http://www.landscape.org/explore/ecosystems/ecosystem_services/defenders_benefit_toolkit/1/)

<sup>19</sup> Kathleen L. Wolf, "More in Store: Research on City Trees and Retail," *Arborist News*, Vol. 18, No.2, April 2009 pp. 22-27

<sup>20</sup> Kathleen L. Wolf, "Urban Nature Benefits: Psycho-Social Dimensions of People and Plants," Center for Urban Horticulture, University of Washington, Seattle

<sup>21</sup> Sanette Tanaka, "How Trees Can Boost a Home's Sale Price," *Wall Street Journal*, Dec. 10, 2013



mentioned above also saves property owners money. Well maintained mature trees have also been shown to reduce property crime.<sup>22</sup>

## Summary

In this section, we have touched on a few of the benefits trees provide. As we go forward in building and strengthening our community of practice, we need to further develop the case for the urban forest. While the case for trees is strong, we must recognize that there are alternatives to some of the benefits of trees and that trees can be dangerous.

We can build structures and facilities to replicate most of the environmental benefits that trees provide, but these are single purpose constructs that do not also provide the quality of life benefits that trees do. Also, to date we have no technology that can replicate photosynthesis and remove carbon from the air on a large scale. Thus, engineering solutions to environmental issues are poor substitutes for trees.

Trees can cause bodily injury and property damage, especially in storms. However, under normal weather conditions, major failures in trees generally occur due to decay and weak structure. Proper inspection can usually detect decay before the tree has an uncontrolled failure and timely maintenance can avoid poor structural development or remove structural weaknesses. The first step in proper maintenance is to plant the right tree in the right place and part of that process is considering any constraints such as hardscape restrictions to root growth, or compacted or shallow soil that can prevent the tree from developing a strong foundation.

Trees can and should be a vital part of the Fairfax County infrastructure. The urban forest can contribute to the effective operation and use of a wide variety of property types. They provide environmental, social, economic, and health benefits to the residents of the county. But they need to be managed in a way that minimizes the risks they may pose and maximizes the benefits they provide. Integrated into the matrix of our urban/suburban lives and landscape, the urban forest can be linked directly to our quality of life in addition to the benefits we derive through its effect on the environment.

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<sup>22</sup> Geoffrey Donovan, "Some city trees may discourage 'shady' behavior." Pacific Northwest Research Station | U.S. Forest Service, November 2010

## Urban Forest Stressors

Trees have evolved to live in complete forest ecosystems. When trees are separated from a complete forest ecosystem, understanding the stressors on individual trees and on populations of trees helps explain the stresses on the urban forest and the challenges faced by Fairfax County's residents and urban forest managers.

In the urban forest, trees can be separated physically from a complete forest by planting them in tree pits or in isolation in suburban landscapes where they are often surrounded by pavement, turf, or another environment in which they did not evolve. These individual or small groups of landscape trees live in a different environment, not the more complete ecosystem of a larger forested area. They can also be separated from the forest ecosystem by altering the components and relationships of the forest, making it an incomplete or different ecosystem, and affecting the way the tree and the surrounding area interact. The introduction of non-native invasive plants, imbalances in populations of animal species, or elimination of fire may leave a forest looking much the same, but it functions as a different place than the one in which trees evolved. To protect the urban forest and the benefits we receive from it, we must understand and address the stressors and changes that threaten it.

In general, stressors are anything that negatively affects the health and vitality of the urban forest. Some stressors, like disease, pests and construction damage, affect the sustainability of the urban forest by reducing the health of existing trees. Other stressors, like deer over browse, expanding house sizes and people's fear of trees, affect the sustainability of the urban forest by reducing its ability to replace trees that are lost. In the end, whether stressors affect existing or future trees, all stressors threaten the benefits that accrue to the residents of Fairfax County from their urban forest.

Climate Change: Changes to the environment resulting from changes in the climate threaten to alter the urban forest of Fairfax County in ways that we can only guess. There are three aspects of climate change that present difficulties to the urban forest and urban forest managers. First is time. Trees are long lived organisms. The mantra of urban forestry is the right tree in the right place. The problem is that the right tree today may be the wrong tree in the climate that may exist in 50 years. Stewards of the urban forest are confronted with the decision of whether to plant trees that typically thrive today, but may struggle in the future; or to plant trees that may struggle today, but seem more likely to thrive in the future.

Another climate change issue is uncertainty. Climate change is more than just a shift to a climate that exists today in communities further south, which could lead us to model our future forest on those more southerly communities. Average temperatures will rise, but wintertime lows will likely stay the same while summertime highs will increase. Total precipitation will remain constant, but precipitation patterns will change and more of our precipitation will come in the form of scattered

heavy downpours that we currently see only in the summer. Taken together, this means our future climate has no current analog to guide urban forest management.<sup>23, 24</sup>

The third issue is phenology, the study of cyclic and seasonal natural phenomena, especially in relation to climate, plant, and animal life. Plants and animals respond to different environmental cues. In the age-old relationship between plants and insects, timing is important. Plants produce chemical defenses against insect grazers timed to head off the worst damage. Insect predators also time their arrival or maturity to coincide with certain aspects of insect grazer life cycles. Climate change may disrupt the balance of these life cycle events. For example, fall cankerworm eggs hatch after they absorb a certain amount of thermal energy. A warmer climate means they will reach that energy threshold sooner and it also means that they will grow faster. The result is that they may reach the portion of their caterpillar life stage when they eat more and do more damage earlier and before trees harden their defenses and before cankerworm predators are ready to eat them.<sup>25</sup>

Climate change will likely threaten human health as well as make conditions more difficult for many plant and animal species. Making the connection between human health and climate change may help to engage a broader constituency and build support for climate change mitigation efforts such as urban greening. Urban greening to reduce greenhouse gas emissions and slow climate change, also provides health benefits such as cooler temperatures, reduced air pollution, and improved water quality.

Loss of Apex Predators: Predators like wolves and mountain lions, have been shown to have a large effect on the distribution of energy throughout an ecosystem.<sup>26</sup> In their absence, a single generalized herbivore dominates and simplifies an ecosystem, eventually causing the system to unravel. In Fairfax County and most of the suburban eastern U.S. that single generalized herbivore is the white-tailed deer. Absent their natural predators – wolves, mountain lions and man – the deer population grew unchecked. A healthy ecosystem can support 15-20 deer per square mile. A sustainable population size will improve the health of the herd, increase the ability of the forest to regenerate, increase habitat and forage for other wildlife species, diminish the risk of deer-vehicle collisions, and minimize destruction of property. Prior to the implementation of the county's deer management program in 1998, the Virginia Department of Game and Inland Fisheries estimated

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<sup>23</sup> "Changing Climates and the No-analog Future," Dr. Jeffery Stehr, University of Maryland, Department of Atmospheric & Oceanic Science, presentation at the Northern Virginia Urban Forest Roundtable Conference: Planning for Climate Resiliency in the Urban Forest, 2013

<sup>24</sup> Douglas Fox "Back to the No-Analog Future?," SCIENCE VOL 316 11 MAY 2007, pp823-4

<sup>25</sup> Raupp, Michael J.: "Hot Times in the Urban Forest: Climate Change and What it Means for Insect Pests," Tree Care Industry Magazine, February 2013 pp. 8-12

<sup>26</sup> Stolzenburg, William: Where the Wild Things Were: Life, Death, and Ecological Wreckage in a Land of Vanishing Predators (Bloomsbury, New York) 2008

deer density levels ranging from 90-419 deer per square mile throughout Fairfax County Parks. More recently, Fairfax County Park Authority has estimated deer density in selected county parks at a minimum of 40-100 deer per square mile.

Deer consume almost all vegetation they can reach and leave behind only that which they find unpalatable, usually non-native species. In the process, they destroy nesting habitat for many birds, reduce diversity of small mammals, and improve habitat for Lyme disease.<sup>27</sup> In particular, deer threaten the sustainability of the urban forest by consuming the seedlings that are the future of the forest. Where the forest lacks young trees in the understory (Fig. 1), there is nothing to replace overstory trees when they begin to die out. In the absence of predators, man must fill this role to reduce deer populations. The problem with overabundant deer is so challenging that even with an aggressive deer management program for our county and regional parks much more is required on private land to restore understory vegetation, including tree seedlings, to forests.

Figure 1. The impact of an overabundant deer population is obvious in this photograph. Deer have been excluded from the forest behind the fence where the healthy forest exhibits trees of various ages and greater species diversity. The forest in the foreground has been denuded and forest structure simplified by deer over browsing.



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<sup>27</sup> Ostfeld, Richard: Lyme Disease: The Ecology of a Complex System (Oxford University Press, New York) 2011



**Non-Native Invasive Species:** Organisms that originated elsewhere and have been imported here are causing ecological and/or economic harm because there are no natural checks and balances to control non-native populations. Of particular concern to the urban forest in Fairfax County are the plants, insects, and fungi that out-compete, eat, and kill our trees and other plants. Non-native invasive plants compete with our native plants for sunlight and growing space.<sup>28</sup> These plants use a variety of strategies to invade and take over ecosystems. Some are prolific seeders that mature early; some are evergreen or leaf out early; some use chemical warfare in a process called allelopathy; all are aided by the distinct preference that native herbivores have for native plants.<sup>29</sup> Non-native invasive vines can shade out or choke and kill mature trees. Non-native insects like gypsy moth, emerald ash borer, and hemlock woolly adelgid sap the vigor of trees, either killing them out right or making them susceptible to other pests that can attack and kill them. Non-native fungi cause landscape altering diseases like chestnut blight, Dutch elm disease, and dogwood anthracnose. These non-native invasive species are reducing biodiversity and simplifying our urban forest.

Figure 2. Japanese stiltgrass (*Microstegium vimineum*) spreads opportunistically after a disturbance. It forms dense patches and displaces native understory vegetation as the patches expand.



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<sup>28</sup> The mid-Atlantic region generally has fertile soils and abundant rainfall, so competition among plants is not centered on these necessities.

<sup>29</sup> See [www.bringingnaturehome.net](http://www.bringingnaturehome.net)

Development: New construction and redevelopment have both obvious and subtle effects on the urban forest. The obvious effect is that when new buildings go up there are generally trees in the way that come down. Fairfax County is approaching build out, the elimination of vacant buildable land, and is shifting from new development to redevelopment. Redevelopment is driven in part by the county's economic success, as well as the expansion of mass transit. As the economy and population grow, the demand for and value of land goes up. The post-World War II practice of putting a small bungalow on a quarter acre of land no longer makes economic sense and the new paradigm is to put as large a dwelling as possible on a lot. The expanded footprint combined with grading for the new larger building, upgraded utilities installation, and often requirements for an on-site stormwater facility and/or a septic system, necessitate clearing existing trees. As a result, increased tree loss on in-fill development lots has further increased pressure on the urban forest, particularly in older residential neighborhoods, and is of particular concern to county residents.

Soil degradation and restrictions: Development alters the soil and generally increases impervious surfaces, both of which limit tree growth and vigor. Typical development practices remove the topsoil, the most biologically active part of the soil, and compact what is left within the limits of clearing and grading approved for the project. This often leaves soils with deficient water and oxygen capacity, poorly drained, and lacking important fungal and bacterial partners that help trees thrive. Also, with increased land use intensity and impervious surface area, the volume of soil available to trees is often inadequate to support even small trees. This is particularly true in parking lots and streetscapes. For trees to have a chance to perform well and provide the benefits we expect, techniques must be used to increase the volume of available soil and disturbed soils need to be restored prior to planting on development sites.

Maintenance on single family parcels often involves disposing of leaves offsite and sometimes removing valuable understory vegetation in open space natural areas on or adjacent to the lot. Leaves and woody debris are important habitat features for soil building organisms that break this organic matter down and return it to the soil. Organic matter in the soil is important for its nutrient content and water holding capacity, and for its resistance to compaction. Without this recycling of nutrients and water holding capacity, soils are often depleted and trees can become stressed. As a general practice, mulching mowers can be used to finely chop leaves and return this vital organic matter to the soil.

Healthy soils are essential for maintaining and improving the health of the urban forest. With all the pressures on trees and competition for rooting space, nutrients and water, soil quality can mean the difference between healthy growth, with the accompanying benefits that trees provide, and slow decline and death.

Forest Fragmentation: Clearing forested land usually creates small islands (fragments) that are incapable of supporting important members of the forest ecosystem and making others more likely to experience extirpation (local extinction) due to normal environmental fluctuations. Islands

support smaller populations that are still subject to normal fluctuations. But with small populations and little or no opportunity for outside replenishment, species are more likely to go extinct on the island during a downswing. A recent study found that the diversity and number of predatory ground beetles was reduced in urban forests. Among those species that decreased were the fiery searchers, *Calosoma scrutator* and *Calosoma wilcoxi*, important predators of fall cankerworm and gypsy moth caterpillars.<sup>30</sup>

Conflicting policies and ordinances: Related to development, built infrastructure restricts and stresses the urban forest by creating additional competition for space. Requirements for sidewalks and bike paths, wider streets, on-site stormwater treatment and detention, and roadway clear zones all reduce space for trees. When combined with the desire for larger houses and the need for utilities, these requirements leave little space for new trees or opportunities to preserve existing trees. The result is a general downsizing from large over-story trees to small ornamental or understory trees.

Endemic Pests and Diseases: Insect pests such as fall cankerworm and two-line chestnut borer, and diseases like *Armillaria* root rot can become deadlier in urban forests due to other stressors. Two-line chestnut borer and *Armillaria* have long been associated with oak decline, a fatal stress-related oak disease syndrome.<sup>31</sup> Fall cankerworm has long exhibited periodic outbreaks in some of its range, but the magnitude and extent of those outbreaks has increased over the past several decades.<sup>32</sup> These are not new pest and disease species to our native forest trees. A combination of changes in ecology and heightened tree stress has made them bigger problems for trees and the urban forest. Furthermore, climate change can disrupt the timing of predator-prey relationships, which may allow native pests to become bigger problems for trees.

Funding Challenges: Trees in the urban forest are frequently called green infrastructure and like built infrastructure they require maintenance. This is true of both landscape trees and remnant forests. Unfortunately, the urban forest of Fairfax County must compete for funding with many other interests. Particularly in the last ten years with shrinking budgets, maintaining the urban forest has been especially challenging. Forests are overcrowded with deer and non-native invasive plant species. Impacts from storms and pest infestations weaken trees and make them more vulnerable to other stressors. Restoring forests is much like rebuilding schools and roads, both in terms of the expense and the long-term value to the county. Fully funded maintenance and

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<sup>30</sup> Raupp, Michael J. and Holly M. Martinson: "Bye-bye Big Beetles in Cities," *Arborist News*, Vol 24, No 6 December 2015 pp 70-73

<sup>31</sup> Wargo, Philip M., David R. Houston, and Leon A. LaMadeleine: Oak Decline; Forest Insect & Disease Leaflet 165, U.S. Department of Agriculture Forest Service, 1983

<sup>32</sup> Asaro, Christopher and Lori A. Chamberlin: "Outbreak History (1953-2014) of Spring Defoliators Impacting Oak-Dominated Forests in Virginia, with Emphasis on Gypsy Moth (*Lymantria dispar* L.) and Fall Cankerworm (*Alsophila pometaria* Harris)," *American Entomologist*, Volume 61, Number 3 Fall 2015, pp174-185

management programs protect the asset of the urban forest and increase the return as with any other investment.

## Summary

As with our discussion of the benefits of the urban forest, we have only briefly touched on some of the major stressors of the urban forest. Our purpose is to make the case that the urban forest is valuable and threatened, and therefore requires managing. The Fairfax County urban forest faces many stressors and the small cadre of professional urban foresters cannot deal with them all alone. The larger community must become more engaged and aware of the sources of stress to help mitigate stress to protect this valuable resource. This becomes increasingly important as the county becomes more urbanized. Urban environments inherently present numerous conditions that can contribute to stress in trees. Managing stress requires recognizing conditions that can result in stress, doing what we can to create conditions more favorable to tree health, and preparing trees to better withstand stressors that cannot be avoided.

Fortunately, recognition of both the benefits of and stressors to the Fairfax County urban forest is increasing. The Fairfax County Park Authority sees a role for active management of the forest resources in its charge and has secured bond funding for its Helping the Land Heal projects. The county has realized the importance of the urban forest in meeting its water quality obligations under its MS4 (Municipal Separate Storm Sewer System) permits and Chesapeake Bay and local TMDLs (Total Maximum Daily Load). This realization has led to a closer alignment of urban forestry and storm water management and to one of the most aggressive deer management programs in the region.

Transit-oriented development that focuses housing density near transit hubs will likely relieve some of the pressure, at least in the short-term, on other parts of the urban forest. Rebuilding streams to handle existing and projected stormwater flows will result in some tree loss now, but will benefit the urban forest in the long run by protecting places where trees can grow. And a closer alignment of urban forestry and stormwater management has focused greater effort on stream restoration designs that preserve and protect higher quality trees. In concert, these practices and policies will help relieve stress on the urban forest as it deals with the long-term challenge of a changing climate.



## Framework Goals and Core Recommendations

As illustrated above, the urban forest provides numerous and valuable benefits and services to people in Fairfax County. Changes to the ecology and the environment, brought about largely by human activities, now threaten the viability of the urban forest. As a result, it is the responsibility of all of us to manage the land, trees, and forests in ways that ensure continued sustainability for the benefit of future generations. The following is a framework of goals and core recommendations for the achievement of these goals. This framework provides the strategies for managing trees and forests to enhance their health, value, and sustainability, and mitigate the stressors that threaten to reduce the benefits and services that contribute extensively to our quality of life.

### 1. Know What We Have

We must assess the condition of the trees, forests, and non-forest vegetative cover to determine their composition and condition to understand what is needed to manage them and ensure the benefits they provide.

#### a. Conduct inventories to determine vegetative cover types and condition.

County staff, individuals, and organizations need to periodically conduct inventories of street trees, tree stands, forests, and non-forested vegetated areas using i-Tree modules and other valid inventory protocols to assess their composition and condition. Site specific inventories should be conducted in advance of proposed development, not only to catalog current condition, but with the aim of avoiding or minimizing impacts to and loss of high-quality trees and natural vegetative communities.

#### b. Monitor to measure forest change and evaluate management efforts.

Monitoring and inventory efforts, including the use of high resolution satellite imagery and urban tree canopy analysis, must not only assess current condition and composition, but be repeated over time to determine how the trees and forests and the associated wildlife species are changing and how changes affect humans and local ecosystems.

### 2. Protect and Improve What We Have

Urban forest resources are not static and must be managed over time to reduce or minimize stressors, maintain the health of the trees and other species, and ensure they continue to provide valuable environmental services. Healthy forests are reliant on more than just trees. Non-forested open space such as meadows and edge ecosystems support biodiversity including many pollinator species. Efforts should include strengthening regulatory

requirements for natural area preservation, creating incentives for landowners to protect and manage their trees, forests and open space resources, establish corridors to connect natural areas, and revitalize communities through investment in green infrastructure.

- a. Improve air quality and address climate change through tree conservation and urban greening.

Trees and forests remove dangerous particulate matter from the air, produce oxygen, and regulate temperatures around homes and communities. To provide these services, the trees, tree stands, and forested areas must be healthy and integrated within all Fairfax County landscapes.

- b. Improve water quality and stormwater management through tree conservation.

Good water quality is directly associated with the amount of mature, healthy vegetation covering the land, especially trees. The percent of Fairfax County covered by trees must be maintained and increased across the county to improve soils and infiltrate stormwater, thus improving soil moisture and protecting water quality in our streams and the Chesapeake Bay. Emphasis should be placed on reducing impacts to and restoring forests and open space resources when constructing and managing stormwater infrastructure. Tree preservation and planting should be incorporated into Watershed Management Plans and clean water regulatory requirements such as TMDL Action Plans and MS4 permit requirements.

- c. Manage the Fairfax County urban forest and natural open space to promote ecosystem services and biodiversity.
  - i. The urban forest must be actively managed over time to reduce stresses on trees and forests and promote native plants that support thousands of insect, mammal, amphibian, reptile, and bird species. Deferring management of natural resources leads to loss of biodiversity and environmental services that degrades our natural areas, human health, and quality of life.
  - ii. It is easier to protect and manage existing natural resources than to restore them after they have been disturbed or destroyed.
  - iii. Stewardship of our resources is an investment in natural capital. To be successful, management must be adaptive over time to address changing conditions and threats, and promote the health of vegetative communities in streetscapes, yards, common grounds, and natural areas. Adaptive management may not only include the removal of invasive species, but could include timber harvest or thinning to promote forest regeneration and health.

- iv. Green waste should be treated as a renewable resource. Property owners should be encouraged to process leaves and branches for mulch, and compost suitable food waste on site. Green waste removed from sites should be properly collected and converted into mulch or other organic forms that can be utilized in land and soil restoration or management.

d. Optimize tree conservation in land development.

Inventories of trees and forested areas should be conducted during site planning. Emphasis should be placed on preserving the best remaining forests and their connectivity to adjacent or nearby natural areas. Landowners should be encouraged to place easements on forested areas, develop plans that protect existing trees on in-fill lots and small sites, and develop and implement plans to manage tree conservation areas over time for vegetative community health. Recreational infrastructure and activities should be minimized in tree and forest preservation areas, and sensitively located and constructed when placed in forested areas, to prevent damage to vegetation, soil compaction, and the introduction of invasive plant species.

e. Optimize tree conservation in utility, transportation, and public facilities projects.

Just as with private land development, tree stands, forests and non-forested open space should be identified, preserved, and properly managed during planning for private utility and public infrastructure, as well as the development and maintenance phases. State and county public agencies should adopt and implement policies and practices for holistic, landscape-scale management of natural resources. Fairfax County agencies should adhere to the Natural Landscaping Policy<sup>33, 34</sup> endorsed by the Board of Supervisors. County agencies should seize opportunities to negotiate with VDOT and utility companies for the replacement of trees removed from areas outside of their rights-of-way during construction and maintenance operations.

f. Control overabundant and invasive species that negatively affect urban forests including, but not limited to, white-tailed deer, non-native invasive species, and forest pests.

Invasive and overabundant species must be controlled to prevent damage to forested and non-forested natural resources, promote the health of vegetative communities, and maintain the environmental services that those communities provide. White-tailed deer

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<sup>33</sup> <https://www.fairfaxcounty.gov/publicworks/sites/publicworks/files/assets/documents/natural-landscaping-implementation-plan.pdf>

<sup>34</sup> <https://www.fairfaxcounty.gov/publicworks/sites/publicworks/files/assets/documents/natural-landscaping-manual.pdf>

populations must be reduced so that native plants can grow and reproduce. Non-native invasive species should be removed to the greatest extent practicable, reducing direct impacts to natural areas and encouraging a majority population of native species that support biodiversity by hosting many more insects and soil organisms, reptiles, amphibians, birds, and mammals. Education should play an increased role in discouraging consumers from buying non-native invasive species and encouraging nurseries and garden centers to offer native alternatives.

g. Support alternative funding mechanisms for forest restoration

Forests are a form of natural capital in that they provide a stream of benefits over time, and require maintenance to protect the asset and support future viability. Much of the urban forest needs restoration, including control of invasive vegetation and pests, to facilitate regeneration. Planting is also needed to connect or expand forest fragments. To ensure sustainability and maximize benefits/services, which equates to return on our investment, forest/tree management plans should be fully funded and include forest restoration.

3. Expand What We Have

Trees and forests in the county should be increased to provide more widespread environmental services and human health benefits, and support biodiversity. A core principle for the future of Fairfax County should be investment in the natural capital embodied in native vegetation that forms the backbone of our ecosystems and green infrastructure.

- a. Plant and protect trees on residential and commercial properties, public lands, and adjacent to streams, streets, and trails.
  - i. Plant on commercial and public properties and extend outward into linear corridors both to expand the environmental benefits and provide connection through the landscape. Do not restrict trees and natural open space to individual properties and parks.
  - ii. Use good quality plant materials, in planting design and implementation, inspected and properly installed in accordance with state and national horticultural standards and the Fairfax County Public Facilities Manual (PFM).
  - iii. When possible, plant trees in clusters with understory plant species and groundcovers. Plant native trees now for the next generation of canopy trees. This is especially important in older neighborhoods that may have canopy trees but lack mid-story and younger trees.

- b. Encourage planting native species for optimum environmental health.

Native trees should be planted on public and private lands to improve landscapes, reduce energy consumption, reduce stormwater runoff, mitigate summertime temperatures, and provide direct human health benefits. Non-forested natural areas including meadows and old fields should be expanded to establish landscape mosaics that promote healthy forests, maximize environmental services, and support the greatest possible biodiversity.

Consumer education focused on raising awareness of invasive plant species and their impacts could reduce requests for these plants at nurseries and garden centers. Nurseries and garden centers could help in this effort by offering alternatives to invasive species and providing labels that clearly identify plant species that are invasive.

- c. Establish new forested areas.

We should not accept that the tree and forest areas we have now is all that we will ever have. Stressors discussed previously make it necessary to plant additional area just to maintain our current level of tree cover. County staff is working to plant and replace trees on public properties under their management. There is much that private landowners can do to maintain, protect and expand the urban forest on their properties.

- i. Reforest open spaces to establish new forests that will mature over decades, directly benefitting neighborhoods and communities, sequestering carbon, improving soils and providing new habitat for native species. Natural regeneration of forests can be encouraged by controlling white-tail deer, establishing no-mow zones and reducing competition from non-native invasive plant species.
  - ii. Use the Tree Preservation and Planting Fund<sup>35</sup> to help cover costs of planting and preserving trees on public properties and homeowner association common open space. Funds can also be used for workshops, seminars and educational materials to educate and inspire the community to value, conserve and enhance urban forest resources.
  - iii. Locate trees and other vegetation to most effectively reduce energy consumption, decrease stormwater runoff, moderate summertime temperature, and provide direct human health and social benefits.
- d. Design and implement functional, sustainable landscapes in areas of intense urbanization.

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<sup>35</sup> <https://www.fairfaxcounty.gov/publicworks/sites/publicworks/files/assets/documents/forms/tppf-application-form.pdf>

- i. Urban designs should be encouraged to include sizable open spaces to support plant communities in the landscape and improve conditions for urban trees. Planted areas should be balanced with open space suitable for informal active recreational opportunities.
  - ii. Streetscapes, plazas and expanses of impervious surface isolate tree planting spaces. Employ technology and advanced tree space designs to improve conditions in which urban trees are planted. Recognize that extreme heat, drought, pollutants in the air and runoff from paved surfaces, and restricted growing spaces among other constraints may persist and make growing conditions difficult. Manage tree assets accordingly.
  - iii. Plant native species where their cultural requirements can be met under post-development conditions.
  - iv. Selected non-native, non-invasive species can be used where their demonstrated adaptability to tough urban conditions may afford them greater viability and benefit delivery capability, and to increase diversity in the landscape.
- e. Expand and establish corridors between existing forested and natural areas.

Isolated trees and forest fragments are more easily stressed, limiting the benefits they can provide, and making it difficult for plant and animal species to maintain their populations and repopulate open areas. The footprint of existing forests should be expanded to improve forest function, limit invasive species effects, and provide greater connectivity between natural areas. These efforts should include encouraging the establishment of backyard habitats that can enrich property owners and act as stepping stones for wildlife to move through the landscape. Local and regional efforts can build on opportunities identified in the Northern Virginia Regional Commission's Conservation Corridors report.<sup>36</sup>

Green infrastructure planning connects intact natural resource assets through a network of multi-purpose corridors that provide for wildlife movement, trails, and pathways for pollinators. By working regionally, we can identify new opportunities to collaboratively plan for the connection, restoration and enhancement of Northern Virginia's natural areas, strengthening public health, local quality of life and the region's economy.

- f. Implement the County's Natural Landscaping Policy.

County staff and agencies should implement the Natural Landscaping Policy endorsed by the Board of Supervisors in 2007, and encourage private property owners to adopt these practices. Natural landscaping is based on the principles of conservation landscaping,

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<sup>36</sup> <https://www.novaregion.org/DocumentCenter/Home/View/3099>

ecological landscaping, and other similar methods which focus on reducing lawn, minimizing use of fertilizers and chemicals, and planting native plant species. These practices improve overall environmental health and the water quality of our wetlands, streams and rivers while, in many cases, lowering overall long-term maintenance costs. As many county residents are actively involved in landscaping projects on their own properties and common open space, natural landscaping practices can be an effective way engage stakeholders in sustainability and stewardship.

- g. Support conservation and open space easements and reforestation on private lands.

Fairfax County should encourage and support private landowners seeking to place easements on their property that will protect trees, forests and other natural vegetation; provide protected areas for reforestation projects; and allow management of these resources for long-term health and sustainability.

#### 4. Improve Urban Forest Policies and Processes

Urban forestry policies should be periodically updated to reflect best management practices, advances in technology and materials, and changes to national and state legislation protecting and expanding tree and forest resources. Adequate funding is important for the continuing support of the Urban Forest Management Division and other county and state agencies that support forest resources.

- a. Optimize tree conservation in county policies.

Protection and expansion of the county's urban forests should be a core principle in the Policy Plan<sup>37</sup> element of the Fairfax County Comprehensive Plan. Promotion of natural capital and green infrastructure in all areas is an important consideration of the Fairfax County vision of "Protecting and enriching our quality of life for people, neighborhoods, and diverse communities," the One Fairfax Policy, and the Board of Supervisor's Economic Success Plan and Environmental Vision.

- b. Strengthen state legislation that promotes forest health.

Fairfax County should work with agencies, organizations, and individuals to support, encourage and guide state laws that seek to better protect and improve the health of forests and provide for forest management activities.

- c. Encourage sustainable design practices.

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<sup>37</sup> <https://www.fairfaxcounty.gov/planning-zoning/comprehensive-plan/policy-plan>

The core of improved site development is environmental site design which encourages the preservation of mature vegetation, in conjunction with use of natural landscaping concepts and stormwater management practices that mimic natural processes. Sustainable design practices must also consider the end user's needs and necessary maintenance of the resource.

- d. Support and refine the county's urban forestry programs.

The Urban Forest Management Division and agencies responsible for managing tree and forest resources should continue to be adequately funded not only for maintenance of the urban forest and to help guide county policy and land development, but also to assess and promote forest health. This support needs to be strengthened and extended to other entities including the Fairfax County Park Authority, Health Department, Department of Public Works and Environmental Services, Facilities Management Department, and Fairfax County Public Schools.

- e. Enforce and periodically update the Fairfax County Tree Conservation Ordinance.

The county must enforce the Tree Conservation Ordinance to ensure proper protection and emphasis on trees and forests. It is important that the ordinance be reviewed periodically and updated to reflect current maintenance needs and best management practices for tree and forests.

## 5. Communicate and Build Partnerships

The future of our natural capital lies within the community. Educating residents and joining together in common efforts will promote stewardship, improve the health of our local ecosystems, and secure the many benefits provided by trees and other native plants for human communities and the environment.

- a. Establish a community of practice to plant, protect, and promote the urban forest in Fairfax County.

Foster a sense of stewardship where one of the most noble acts is the simple act of planting a tree or managing land to help trees plant themselves. Empower and encourage people to improve their communities by implementing sustainable landscape design practices and working with others to increase the footprint of native vegetation, particularly trees, but also other non-forest plant communities. Inform residents about what the urban forest is, how it touches and improves their lives, and how their actions affect the urban forest. Foster a deeper respect for the forest to include the forest in everyone's consciousness.



- b. Engage and educate the public, decision makers, government staff, and NGOs.
  - i. Emphasize education through county schools to ensure that stewardship practices are passed on to future generations to protect and conserve urban forest resources.
  - ii. Work with agencies, organizations and individuals to promote tree and forest resource education and participation in natural resource management through preservation, restoration plantings, and citizen science. Efforts should build on existing programs such as Fairfax ReLeaf and Tree Stewards, and include diverse outlets and formats such as school curricula, web-based resources, outreach to underserved communities, and other ways to ensure that information reaches as many people and groups as possible.
  - iii. Promote the value of the urban forest to individuals and our community to increase understanding of the role it plays in improving the quality of life in Fairfax County.
- c. Build strong partnerships and alliances.

The county should work to strengthen ties and efforts between county agencies and public and private sector organizations to improve design, construction and maintenance practices, promote sustainable landscapes, avoid redundancy of efforts, and develop common goals for improving the state of our local environment. Collaboration should be creative and could include efforts to improve restoration plantings along state roads and highways, provide expertise to developers in plant selection and maintenance, and promote solutions that can bridge divides between the natural environment and development communities.

## PART II - URBAN FOREST MANAGEMENT PLAN

### Implementation

#### A Cultural Shift

As stated in the Board of Supervisors' Environmental Vision, the county has a responsibility to help citizens respect and manage our finite resources. The county can set a strong example by recognizing how the urban forest supports diverse objectives such as revenue enhancement, public health, and quality of life, and acting to protect and enhance this valuable capital asset. The TAP 2019: Part I – Urban Forest Strategic Plan (UFSP) makes a case for the importance of the Fairfax County urban forest and the need to protect and manage it. The strategic vision of the plan is to elevate the perception of the urban forest from a valued accessory to a vital component of life in Fairfax County. This would change how the urban forest is discussed and managed, and result in a cultural shift and a change in the tone of the narrative regarding the urban forest. It is imperative that the connections between the urban forest and other elements that factor into quality of life are recognized and given due consideration. Human health, safety, the economy, education, recreation, and social interaction all have links to the urban forest.

The TAP 2019: Part II - Urban Forest Management Plan (UFMP), as described here, presents a vision for collaboration among stakeholders acting in support of goals and recommendations outlined in the TAP 2019: UFSP. People are an integral part of the urban forest. Different property owners, organizations, and government agencies have different objectives and different budgets that must be considered when determining the best management practices for their piece of the urban forest. The important thing to understand is that the most effective management and maintenance practices for the long-term health and vitality of the trees, is that which conserves the urban forest ecosystem as a whole. Focusing on mature trees at the expense or elimination of understory, shrubs, herbaceous material, woody debris and leaves, and/or soil organisms will ultimately impact successive stages of the urban forest and diminish its long-term viability.

#### A Community of Practice

The most important precursor to changing the narrative of the urban forest is having the full complement of contributors involved in the discussion. Greater understanding of the connections between the urban forest and other components of quality of life will result in county staff, businesses, organizations, and citizens recognizing their place in the community of practice that maintains and manages the urban forest. The community of practice is made up of five groups: the initiating participants; key county government agencies that can have a direct impact on county properties; public and private stakeholder organizations (such as Fairfax County Housing and Community Development, civic groups, HOAs, non-profits, etc.); businesses and other regional and state organizations (such as VDOT, Dominion Energy, private sector professional organizations, etc.); and citizens.

The Fairfax County Tree Commission, Fairfax County Urban Forest Management Division (UFMD), and the Virginia Department of Forestry's Urban Forest Conservationist will initiate contact and engage other participants in a collective effort to further goals and recommendations of the plan. These initiating participants will recruit other agencies and stakeholder organizations as members of a community of practice to actively support goals and recommendations of TAP 2019 through their management of county land and facilities, public rights-of-way, and private lands.

Key county government agencies capable of significant contributions for the successful implementation of the TAP 2019 include Fairfax County Park Authority, Fairfax County Public Schools, Facilities Management Department, Fairfax County Health Department, Department of Planning and Zoning, Land Development Services, and the Stormwater and Capital Facilities business areas of the Department of Public Works and Environmental Services. In their capacity as land use decision makers, land developers, plan reviewers, property managers, project managers, grounds maintenance professionals, advisors, or some combination of these roles, key county government agencies have opportunities and make decisions that will affect the urban forest and its ecosystem. The agencies identified above should not be considered all inclusive. Other county agencies, private sector entities, and non-profit organizations will play important roles in implementing TAP 2019, and will become partners in a community of practice that will ensure success.

We can all encourage and foster a community of practice that understands how the urban forest helps achieve missions and goals for all of us. Participating agencies and organizations, following good stewardship and sustainable environmental practices, will incorporate the concepts of the Framework Goals and Core Recommendations of the TAP 2019 into the plans and policies guiding their own work. In this way, we can all work to effectively further these goals through the development, improvement, and maintenance of the properties for which each stakeholder agency or organization is responsible.

Citizens in the community of practice can have a significant effect on conservation of the urban forest. Private residential properties provide the greatest potential of all land use categories for improvement and expansion of the urban forest. Private citizens are not expected to develop work plans or report on their actions, but how they manage their property and the impact their actions may have on neighboring public property or private common open space can have a significant impact on the urban forest. Citizens are encouraged to find ways to implement the TAP 2019 Goals and Recommendations into their own properties.

Members of the community of practice maintain their differentiated identity and structure, but are bound together by their respect and appreciation for the urban forest which is reflected in their plans of action. Different groups, supporting the same goals and recommendations, can have a collective impact on sustaining our urban forest by making informed decisions to conserve and improve our environment and reduce negative impacts to our ecosystems. As ecosystems are not

defined by jurisdictional boundaries, we should also view this community as inclusive and work to expand the community of practice to a regional and larger scale. Only the joint efforts of the community of practice can achieve successful implementation of this vision.

Participating agencies and organizations will develop a series of two-year work plans guided by the goals and recommendations of TAP 2019 and built on the accomplishments of previous work plans. Semi-annual joint meetings will provide opportunities to collaborate on projects, explore innovations, exchange ideas and information, provide support, share successes and lessons learned, and celebrate partnerships and accomplishments.

### Practicing Good Stewardship

Inventory and assessment of existing resources, facility location and design, contract specifications, erosion and sediment control, tree protection measures, mitigation of stress that can result from construction activities, site monitoring, and species selection and planting in conformance with the county's Natural Landscaping Policy provide numerous opportunities to support the goals and core recommendations outlined in TAP 2019 and champion the Board Matter for Preservation of Trees on County Properties. Members of the community of practice will expand their awareness of these opportunities and make clear and thoughtful choices to understand the resources entrusted to them, protect and improve the urban forest, and take advantage of opportunities to build on what we have. Given these considerations, each agency and organization will incorporate goals supported by the TAP 2019 into their own operational and policy plans. Citizens will manage and maintain their properties in a way that supports goals and recommendations of TAP 2019.

TAP 2019 is not intended to result in large increases in demands on county staff and other partners. Significant changes can occur in the way work is done to reduce impacts and enhance practices that conserve, sustain, and enhance the urban forest, without necessarily increasing the time spent doing the work. The plan asks that we all think about and view the mission and actions of our respective agencies, organizations, and households through the lens of the urban forest to understand better how we affect the urban forest and how the urban forest can support each of our missions and objectives. The list of goals and recommendations should be viewed as a guide to this process rather than a list of specific tasks to be accomplished. In this way, goals and recommendations of the TAP 2019 become part of the cultural awareness of the stakeholders that adopt it.

### Tracking

Much of the work supporting TAP 2019 goals and recommendations is already being done. But the opportunity exists to improve effectiveness and accomplish more. With the Board of Supervisors' adoption of TAP 2019, the Fairfax County Tree Commission, Urban Forest Management Division, and VA Department of Forestry Urban Forest Conservationist will request that key county agencies

designate a champion(s) within their organization for the promotion of the goals and recommendations of TAP 2019.

The champion(s) will ensure that the urban forest is given due consideration when planning the work of their agency. Annual plans of operation will include goals and action items that support the goals and recommendations of TAP 2019. Tree Conservation Plans will be developed when activities undertaken during operations potentially impact the urban forest or its future viability. Plans could also include value added elements, such as removal of invasive vegetation and mulching, to enhance the quality and condition of the urban forest or improve its resiliency.

Regular meetings conducted during the year will afford opportunities to collaborate on projects, exchange ideas and information, and provide support. A cohesive force developed through close cooperation will serve to increase effectiveness by clearly identifying opportunities and encouraging collaboration and cooperation.

Reporting stakeholders include initiating participants and key county government agencies. Champions will document their agency's accomplishments supporting TAP 2019 goals and recommendations and submit these achievements to Urban Forest Management Division to be compiled into a TAP 2019 Annual Report. Non-government stakeholder organizations are encouraged to do the same. The Tree Action Plan 2019 annual report will be submitted to the Tree Commission for review and presented to the Board of Supervisors.

## CONCLUSION

The Board of Supervisors' Environmental Vision sets a farsighted goal: To leave our land, water and air quality better than we found it. Trees are central to an investment in the natural capital on which much of our quality of life is based. As outlined in the framework goals and core recommendations, investing in the research and technology needed to understand the current makeup and condition of our urban forest resources is essential to effectively protecting and improving what we have and expanding and growing the asset.

The urban forest and the benefits it provides society are not restricted by property boundaries or societal divisions, but by our actions. Just as the stressors that impact forest resources are not limited by property lines, but by our awareness, our knowledge, and our actions. We derive many benefits from the urban forest based on the proximity of trees to people and the built environment. At the same time, this proximity can result in stress to trees and a reduction in benefits. Greater understanding of the relationship people have to other elements of the urban forest will help us manage the urban forest more effectively. Management must be a collective effort to be effective, and not simply delegated to professionals in the field.

All who make land use decisions, maintain property, and manage resources affect the extent and the quality of our urban forest ecosystem. The Board of Supervisors' goal requires that we not simply find more effective ways to preserve existing stands of trees. We must also:

- expand our forests;
- understand that forest includes understory trees, shrubs, herbaceous vegetation, woody debris and leaves, and soil organisms, as well as mature trees; all of which are important to the viability of the forest as a whole;
- put the urban forest at the core of comprehensive planning, site planning, and property maintenance;
- set clear and measurable milestones to track progress toward our goals; and
- institute simple but effective communication capabilities to inform and educate the public, the private sector, and government agencies about the value of urban forests.

Understanding the services and benefits that the urban forest provides will cultivate a greater appreciation that well-maintained trees and intact forests are more often part of the solution and not an obstacle or liability, and encourage greater efforts to preserve and maintain them.

## APPENDIX

### Glossary of Terms

Biodiversity – The total number of different species living within a geographic area.

By Right – Land development conducted within the current zoning designation for the subject property.

Cellulose – A major component of wood that gives wood its white color. It combines with lignin to increase the hardness of plant cell walls for protection from viruses and bacteria. It is the most commercially valuable part of wood fiber and is used in making paper, bio-fuels, food additives, and many other products.

Community of Practice – A group of people who share an interest or objective and exercise their capability to work toward that objective. In the case of the urban forest, those people whose work or actions affect the urban forest or whose work, actions, or lives are affected by the urban forest. A Community of Practice can occur naturally or can be created and organized with the intent to increase its effectiveness through collaboration and coordination.

Developed Land – Areas converted to human uses dominated by infrastructure and altered vegetation.

Ecosystem – A collection of living (plants, animals, fungi, protists, bacteria, etc.) and non-living (light, air, water, minerals) components and a set of relationships between and among the components.

Fairfax County Urban Forest – All the trees and other living things, including people, the air, the waters, the minerals, the soils, and the built environment found in the county.

Forest – A forest is an ecosystem in which trees play a primary and defining function.

Green Infrastructure – Living materials within the built and unbuilt landscape. In an urban context, this includes streetscapes, green roofs, stormwater facilities, residential yards and common areas, school and commercial grounds, and natural areas such as stream valley parks – areas that conserve ecosystem values and functions and provide associated benefits to human populations.

Green Waste – Organic materials generated from plants through landscaping, forestry or agricultural operations such as leaves, branches, hedge trimmings, grass clippings, or discarded domestic or commercial food.

Healthy Forest – Tree dominated natural vegetative community with good soil profiles and woody debris, low levels of deer browse, minimal non-native invasive plant cover, diverse native species, good age class diversity of trees, native plant cover occurring in all layers from the ground to the overstory tree canopy.

Landscape Mosaics – A diverse network of ecosystems, such as wetlands and forests, forming a patchwork of land cover across a given land area. This network provides an array of ecosystem, aesthetic and habitat services by supporting biodiversity and a greater range of life cycle needs, and provides more benefits than a single type of ecosystem.

Lignin – A major component in the cell walls of plants that gives wood its brown color and makes it rigid and strong. It also helps the plant to conduct water and sequester carbon.

Natural Area Preservation – Protection of undeveloped lands that contain native vegetative communities to protect the benefits they provide and the biodiversity they contain.

Natural Capital – Living organisms; non-living components, such as air, water, and soil; the ecosystems they form; and the services they provide. In economic terms: a durable resource providing a stream of benefits to residents and the environment.

Non-Native Invasive Species – Are organisms that originated elsewhere and have been imported here and are causing ecological and/or economic harm. Local wildlife has evolved and are interdependent upon native vegetation, without which they cannot survive.

Phenology – The study of cyclic and seasonal natural phenomena, especially in relation to climate, plant, and animal life.

Protists – Eukaryotic cells that are not animals, plants, or fungi. They have specialized cellular machinery that execute defined functions, such as photosynthesis, within the cell. Examples include algae, amoebas, and ciliates.

Urban Forest – A forest in an urban area that is distinct from other forests due to the dominance of humans and their constructs (e.g. buildings, roads, utilities), and the interaction between the forest ecosystem and humans and the built environment.