University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Ecosystem Services of Landscape Plants

A GUIDE FOR CONSUMERS AND COMMUNITIES

Joshua Knight and Dewayne L. Ingram, Horticulture

Introduction

This publication is intended to assist consumers and community groups in learning about the value of landscape plants. Landscape plants play an important role in the urban environment, from reducing urban heat islands to improving the aesthetic experience (i.e. curb appeal) we derive from the landscape of an individual home. Further, there is a growing body of scientific literature evaluating the critical role of trees in landscaping within urban and suburban environments such as residential neighborhoods, commercial/industrial areas, and associated green infrastructure such as park systems and green belts. One useful tool for articulating the functions landscape plants perform for us is the concept of ecosystem services.

An **ecosystem** is a community of living organisms in combination with the nonliving components (air, water, mineral soil) interacting as a system. One useful tool for articulating the functions landscape plants do for us is the concept of **ecosystem services**. "Ecosystem services are the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life" (Daily 1997).

Simply put, landscape plants do a lot for us. Though this is easily stated, it may not be easy to precisely describe or quantify the contributions of landscape plants to ecosystem services. The focus of this publication is describing the contributions of woody landscape plants to urban ecosystems and to individuals and groups with ecologically minded demands, such as a private business capitalizing on sustainability initiatives, a community association promoting open spaces, or a public firm engaged in climate change mitigation, as well as private home owners hoping to increase the value of their properties.

The resource list at the end of this document provides more detailed information for readers. The free, peer-reviewed software suite i-Tree from the U.S. Forest Service is particularly valuable to individuals, firms, and communities looking to quantify the environmental services provided by existing and potential trees in their communities. The software was particularly valuable in compiling a list for comparing site suitability and ecosystem service benefit potential among a list of landscape trees. For this list, see the Species Reference Table located in the Appendix.

Types of Ecosystem Services

Following is a list of ecosystem services relevant to woody landscape plants.

Air Quality

Back in the 1800s, parks, as habitats for trees and other landscape plants, were referred to as the "lungs of cities" by Frederick Law Olmsted, considered the "Father of American Parks." Air pollution is a significant risk factor for a number of health conditions including respiratory infections, heart disease, stroke, and lung cancer. The human health effects of poor air quality are far reaching. The most common sources of air pollutants include particulate matter, ozone, nitrogen dioxide, and sulfur dioxide. Indoor air and urban air quality are among the worst toxic air pollution concerns.

Carbon monoxide is a colorless, odorless, and tasteless gas. It is toxic to humans above concentrations of 35 ppm. As a product of exhaust from internal combustion engines, it is common in urban areas.

Though not emitted directly by car engines or industrial operations, **ozone** is formed by the reaction of sunlight on air containing products of fuel combustion. Ground-level ozone has the following health effects at concentrations common in urban air: reduced lung function, aggravation of asthma, increased susceptibility to respiratory infections, and damage to lung lining. A study in 2004

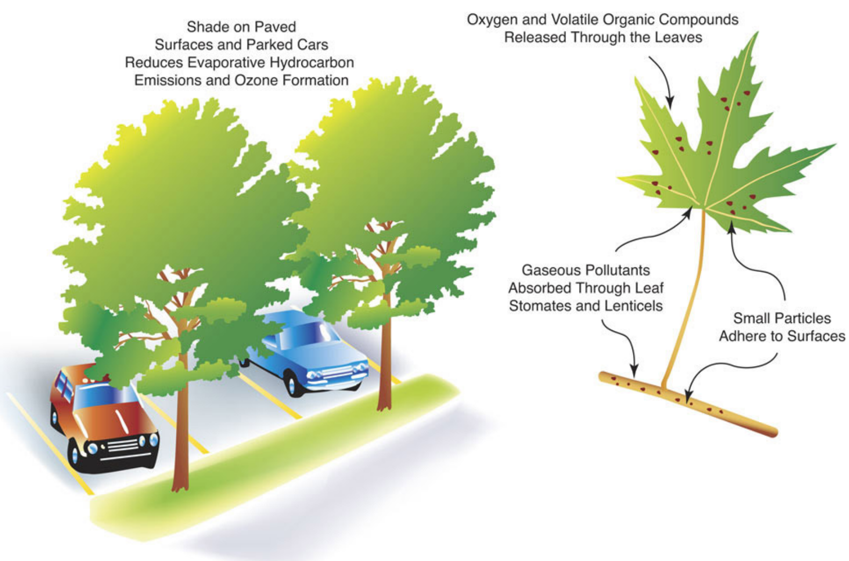


Figure 1. The interaction between trees and air pollutants. Mike Thomas, International Society of Arboriculture.

Table 1. Landscape plants with high tolerance to and potential for removal of carbon monoxide.

Latin name	Common Name	Latin name	Common Name
Aesculus hippocastanum	Horse chesnut	*Fagus grandifolia*	American beech
Betula alleghaniesis	Yellow birch	*Liriodendron tulipifera*	Tulip tree
Carpinus betulus	European hornbeam	*Prunus serotine*	Black cherry
Carya glabra	Pignut hickory	*Sassafras albidum*	Sassafras
Catalpa speciosa	Northern Catalpa	*Thuja plicata*	Western red cedar
Celtis occidentalis	Common hackberry	*Tilia americana*	American basswood
Chamaecyparis thyoides	Atlantic white cedar	*Ulmus americana*	American elm

Table 2. Landscape plants with high tolerance to and potential for removal of ground level ozone.

Latin name	Common Name	Latin name	Common Name
Acer rubrum	Red maple	*Juglans nigra*	Black walnut
Aesculus hippocastanum	Horse chesnut	*Liriodendron tulipifera*	Tulip tree
Betula alleghaniesis	Yellow birch	*Magnolia acuminate*	Cucumber tree
Carpinus betulus	European hornbeam	*Metasequoia glyptostroboides*	Dawn redwood
Carya laciniosa	Shellbark hickory	*Sassafras albidum*	Sassafras
Carya ovata	Shagback hickory	*Sequoia sempervirens*	Coast redwood
Celtis occidentalis	Common hackberry	*Prunus serotine*	Black cherry
Corylus colurna	Turkish hazelnut	*Tilia americana*	American basswood
Fagus grandifolia	American beech	*Ulmus americana*	American elm
Fraxinus americana	White ash	*Zelkova serrata*	Japanese zelkova

Table 3. Landscape plants with high tolerance to and potential for removal of sulfur and nitrogen.

Latin name	Common Name	Latin name	Common Name
Acer rubrum	Red Maple	*Liriodendron tulipifera*	Tulip tree
Aesculus hippocastanum	Horse Chesnut	*Magnolia acuminate*	Cucumber tree
Betula alleghaniesis	Yellow birch	*Picea abies*	Norway spruce
Cedrus deodara	Deodar Cedar	*Pinus strobus*	eastern white pine
Celtis occidentalis	Common hackberry	*Platanus hybrid*	London planetree
Fagus grandifolia	American beech	*Populus deltoids*	Eastern cottonwood
Fraxinus americana	White ash	*Tilia americana*	American basswood
Ginkgo biloba	Ginkgo	*Ulmus americana*	American elm
Gymnocladus dioicus	Kentucky coffeetree	*Zelkova serrata*	Japanese Zelkova
Juglans negra	Black walnut		

Table 4. Landscape plants with high tolerance to and potential for removal of particulate matter.

Latin name	Common Name	Latin name	Common Name
Abies concolor	White fir	*Pinus strobus*	Eastern white pine
Calocedrus decurrens	Incense cedar	*Pinus taeda*	Loblolly pine
Cedrus libani stenocoma	Hardy Cedar of Lebanon	*Taxus cuspidate*	Japanese yew
Chamaecyparis thyoides	Atlantic white cedar	*Thuja plicata*	Western redcedar
Cryptomeria japonica	Japanese red cedar	*Tilia americana*	American basswood
Magnolia grandiflora	Southern magnolia	*Ulmus americana*	American elm
Picea abies	Norway spruce	*Zelkova serrata*	Japanese zelkova
Picea pungens	Blue spruce		

estimated that decreasing urban ozone concentrations by 33 percent would save roughly 4,000 lives per year across the U.S.

Particulate matter (PM10) is the term for solid or liquid particles suspended in the air. Some are large enough to be seen, such as soot or smoke. Others can only be detected with an electron microscope. Particulate matter can be emitted directly from combustion or formed in the atmosphere when sulfur and nitrogen oxides react to form fine particles. The PM-10 standard includes particles with a diameter of 10 micrometers or less. Major concerns from exposure include effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death.

Both **sulfur** and **nitrogen oxides** are products of fossil fuel combustion, though sulfur is linked to power plants and industrial facilities, while nitrogen oxides are more commonly a product of transportation and off-road equipment. Within 50 meters of a roadway, concentrations have been measured to be approximately 20 to 100 percent higher than concentrations away from roadways. As with other air pollutants, the primary health impact is reduced respiratory function with risk for asthma in children and the elderly (EPA).

Leaves contribute to the removal of pollutants from the air (Figure 1), so it is important to develop landscapes with leaf growth at multiple layers using shrubs and herbaceous perennials as well as small to large trees (Figure 2). A few ways that plants reduce air pollution:

- Absorption of gaseous pollutants (e.g. ozone, nitrogen oxides, and sulfur dioxide) through their leaves

- Reduction of ozone concentrations at ground level by reducing temperatures via evapotranspiration and shading
- Fuzzy leaves are much more effective in capturing particulate matter than smooth/hairless leaves
- Collection of dust, ash, pollen, and other particulate matter on their leaves, reducing its presence in the air breathed

Plants with a high tolerance of pollutants and potential for removal of various air pollutants are listed in Tables 1, 2, 3, and 4.

Cultural and Aesthetic Value

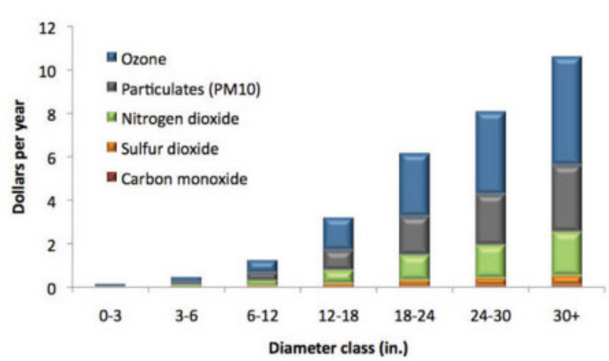
The easiest means to show the monetary value landscape plants add to a landscape is their contribution to increasing property values: Good tree cover can raise total sale price by 6 to 9 percent, the mere presence of trees adds 3 to 5 percent premium to sale price, and hedges or landscaped walls raise the sales price 4 percent. It has been reported that investing 5 percent of the value of your home in the installation of a quality, low-maintenance landscape increased resale values by 15 percent. That would be a 150 percent return on the landscape investment. A low-maintenance landscape is an uncrowded, simple landscape design which is not labor intensive. General characteristics include smaller grassy areas, often offset by hardscaping, mulched beds and locally adapted, hardy perennial plant material. Numerous studies show that more trees in urban areas improves perception of health. In one such study, having 10 or more trees in a city block improves health perception comparable to an increase of per capita income of $10,000 or being seven years younger.

Biodiversity Potential

Biodiversity is the variety of life on earth. Biodiversity allows ecosystems to adjust to disturbances. Ecosystems that can withstand disturbance are said to be resilient. Genetic diversity prevents and/or limits the impact of diseases and helps species adjust to changes in their environment. Healthy native landscape plants, when used intentionally to develop ecosystems, will protect the biodiversity of local communities and provide habitat for local wildlife. This wildlife can include butterflies and songbirds. It is important to note that butterflies are attracted to species of flowering plants based on the seasonality of flowering, while songbirds are attracted to trees based on height and other growth characteristics. Additionally, native insects attracted to native plants support the dietary requirement of native song birds.

Bringing Nature Home is a reference book for native landscape plants with wildlife habitat value across the United States divided into general regions: Mid-Atlantic, Southeast, Southwest, and Pacific Northwest. It also includes tables of butterflies, moths, and their hosts. Urban areas offer an important opportunity for conservation: Green infrastructure can preserve local biodiversity, create corridors for wildlife to nonurban habitat, and act as a community resource for environmental education.

Figure 2. Comparative economic value of pollutant removal. Nowak and Heisler, National Recreation and Park Association



Source: NRPA.org - Air Quality Effects of Urban Trees and Parks (2010)

Carbon Sequestration

Increased concentrations of atmospheric carbon dioxide are contributing to the increase in average global temperature and disrupting climates around the world. Carbon dioxide concentrations in the atmosphere have been increasing rapidly since the industrial revolution, primarily from the use of fossil fuels but also from changing land uses. Each person, product, and activity emits carbon dioxide, and other greenhouse gases such as methane and nitrous oxide, into the atmosphere. The potential impact of those emissions on global warming is also called the carbon footprint of that product or activity. We each have a carbon footprint that has a negative impact on the atmosphere. Such human activity can be offset by carbon sequestration by woody plants and soil carbon storage. Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide. In the context of woody landscape plants, carbon sequestration is a function of photosynthesis: The plant builds itself by taking the carbon from carbon dioxide in the atmosphere. At maturity, approximately 50 percent of an individual tree or shrub's dry biomass is carbon, depending upon the density of the wood.

When weighted for a portion of a standard international 100-year assessment period, it has been estimated that a deciduous shade tree (*Acer rubrum*) in the suburban landscape can reduce the potential global warming impact from carbon dioxide by 670 kg CO_2, after accounting for emissions during production and take down at the end of life. Published impact data on atmospheric carbon weighted annually for their functional life estimated that red maple, flowering deciduous tree (redbud), evergreen tree (blue spruce), evergreen shrub (*Taxus*), and deciduous shrub (*Viburnum*) in the Lower Midwest reduce CO_2 in the atmosphere by an estimated 666, 430, 63, 9, and 11 kg CO_2 over their lifetime, respectively (Table 5). These estimations do not consider the long-term carbon storage in plant roots, which has not been quantified at this time but could be substantial for some plants.

After woody plants are taken out of the landscape, their utilization has an effect on projected carbon sequestration. Smaller plants and many trees are typically chipped for use as mulch or soil conditioner. The carbon in this mulch would be released into the atmosphere over a one- to three-year period.

Table 5. Global warming impact of aboveground plant growth weighted by life expectancy after accounting for emissions during production and take-down at end of life.

Landscape Plant	Years	kg CO_2
Red maple tree – *Acer rubrum*	60	-666
Evergreen tree – *Picea pungens*	50	-430
Flowering deciduous tree – *Cercis canadensis*	40	-63
Deciduous shrub – *Viburnum x juddi*	50	-11
Evergreen shrub – *Taxus x media 'Densiformus'*	50	-9

The post-takedown use of urban trees for wood and paper products is still in its infancy, however it is drawing increasing attention from researchers, community officials, arborists, tree care firms, and wood-using industries including bioenergy producers. Potential for use after takedown is driven by species and tree size. For example, damaged sections of denser species such as bur oak and pignut hickory may be used as fuel, while larger sections of more valuable species such as black walnut or sugar maple could be used in furniture construction.

An estimated 25 million tons of dry urban tree residues are produced annually in the U.S. Only 25 percent of this residue was reported as recycled or sold/used for a product; 70 percent of the residue is given away, landfilled, or left on site. The USDA Forest Service's Forest Products Laboratory estimated that in 2002 urban wood residues in the municipal solid waste stream alone totaled 16.2 million tons of chips, logs, stumps, tree tops, and brush with 9.3 million tons recovered for compost and mulch, 1.9 million tons were sent to combustion facilities, 1.7 million tons were considered unusable, and more than 3.5 million tons went on to be used as "good wood" for further processing into products.

Use of urban trees for bioenergy in residential wood stoves or for large scale energy production is ultimately preferable to the use of fossil fuel sources for similar purposes, as the carbon sequestered is "young" (less than 100 years old) and therefore closer to being a neutral impact on climate change when compared to fossil carbon stores, which can exceed 650 million years. Communities are already taking advantage of the synergy between the availability of urban tree residues and the demand for energy in urban areas. In downtown St. Paul, Minnesota, less than a mile from the State Capital Building, District Energy St. Paul operates a combined heat and power plant serving the commercial, industrial, and residential downtown area. A steam-powered turbine generates 25 megawatts of electricity for the grid, while "waste" energy—heat energy not converted to electricity by the turbine—created in the process is used to heat the downtown area. The multi-fuel plant is capable of burning coal, natural gas, or biomass in the form of wood chips, consuming just 300,000 tons of wood chips per year which provide 60 percent of its fuel. Considering the estimated volume of urban tree removals nationwide—17 million tons annually—the magnitude of bioenergy potential from urban tree removals to generate renewable energy should not be overlooked.

Energy Conservation and Microclimate Regulation

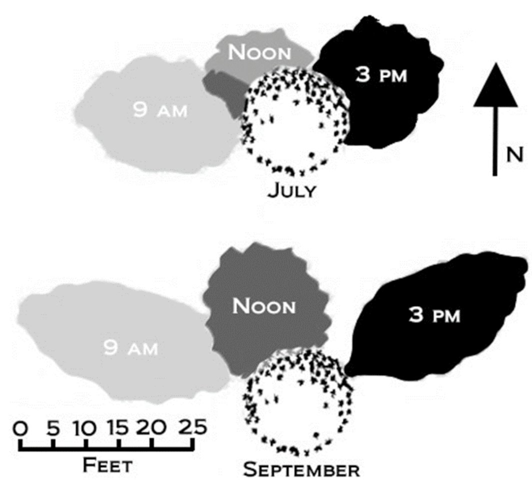
A microclimate is the climate of a small area which is different from the area around it, and landscape plants can dramatically effect microclimate. Small areas could be warmer or colder, wetter or drier, or more or less prone to frosts. Microclimates can be very small, as in a protected courtyard near a building compared to an open field nearby. Landscape plants influence significant factors in the formation of microclimates such as sun exposure and air movement. Additionally, trees evaporate substantial amounts of water through their leaves, which can significantly reduce nearby air temperatures.

Shading by plants can greatly increase human comfort in a given area. Effects of shade from a plant in a microclimate varies because the angle of the sun changes throughout the day as well as throughout the season (Figure 3). Seasonality may also influence the direction and speed of prevailing winds. For example, winds in the Lower Midwest come predominately from the southwest during hot summer months and from the northwest during cold winter months.

Deciduous trees and shrubs provide a unique tool in microclimate regulation in addition to providing shade: By losing their leaves in winter—though the remaining trunk and branches block 30 to 40 percent of sunlight—sunlight will penetrate and warm the air and ground beneath (Figure 4). In the summer months (Figure 5), their leaves provide shade and reduce the temperature of objects and the air below the canopy. In contrast, evergreens will consistently provide shade (blocking 80-90% of sunlight) and function as windbreaks throughout the year. Additionally, small evergreen shrubs placed a few feet from the home provide a gap of insulating air, protecting the home from heat loss due to wind (Figures 4 and 5).

As landscape plants impact the air temperature and flow around them, the placement of landscape plants in relation to climate controlled buildings can have a profound impact on energy savings, both for heating and cooling. Evergreens used for winter windbreaks reduce infiltration of cold air into buildings by up to 50 percent.

Figure 3. Shade patterns of a 20-foot tree during July and September. Joshua Knight, Horticulture, University of Kentucky



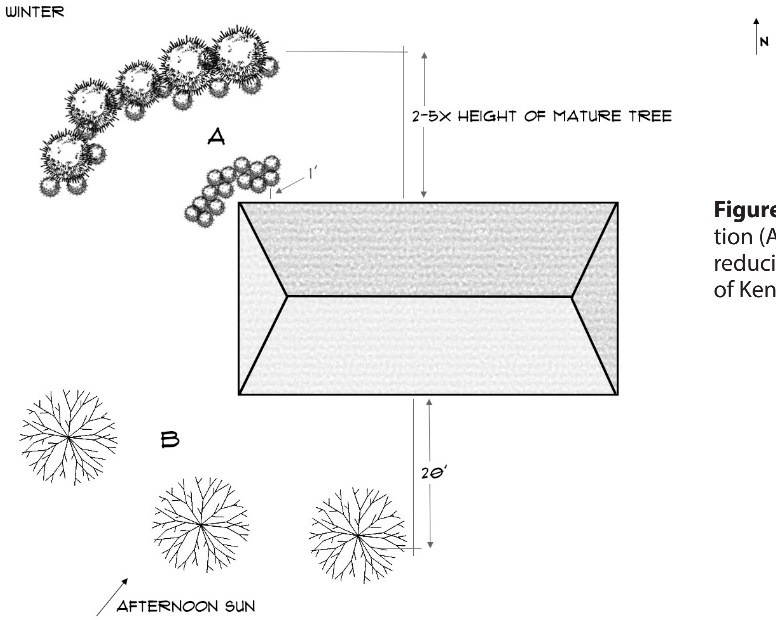


Figure 4. In winter, evergreen trees provide wind and noise reduction (A); bare deciduous trees allow afternoon sun to warm house, reducing heating costs (B). Joshua Knight, Horticulture, University of Kentucky

Suburbs with trees were, on average, 4 to 6 degrees cooler than suburbs without trees, with tree groves being 9 degrees cooler than open terrain, on average (Figure 6). Schoolyards are a typical built environment and are hot places; they are often covered by the three hottest materials found in the urban environment: asphalt pavement, steel or tar and chip roofs, and mowed turf. As such, they tend to retain heat and act as heat islands. The surface temperature of schoolyards can be reduced by over 45 degrees (Fahrenheit) and air temperature by almost 18 degrees when properly placed trees shaded the surfaces and cooled the space through evapotranspiration. A single properly watered tree can evaporate-transpire 40 gallons of water in a day, offsetting the heat equivalent to that produced by one hundred 100-watt lamps burning 8 hours a day.

Human Health

Many connections between urban green spaces and human health have been documented. The presence of plants in hospital recovery rooms and/or views of aesthetically pleasing gardens help patients heal faster. Going outside or being under the influence of plants can increase memory retention. People who spend more time around plants are much more likely to help others and often have more advanced social relationships. Children who spend time around plants absorb and retain information better.

Evidence suggests three principal ways green infrastructure can contribute to people's health and quality of life: through support for physical activity such as walking; through support for mental health by offering restorative experiences and

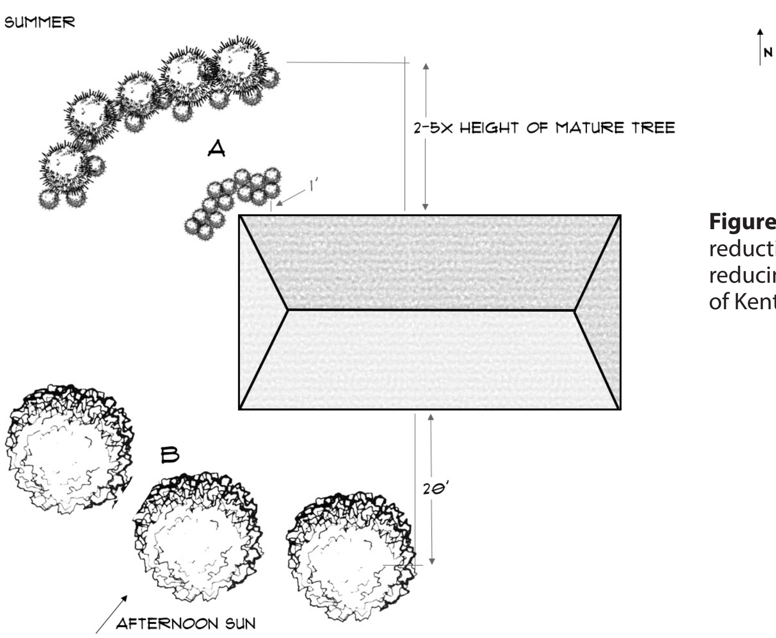


Figure 5. In summer, evergreen trees provide wind and noise reduction (A); deciduous trees provide shade from afternoon sun, reducing cooling costs (B). Joshua Knight, Horticulture, University of Kentucky

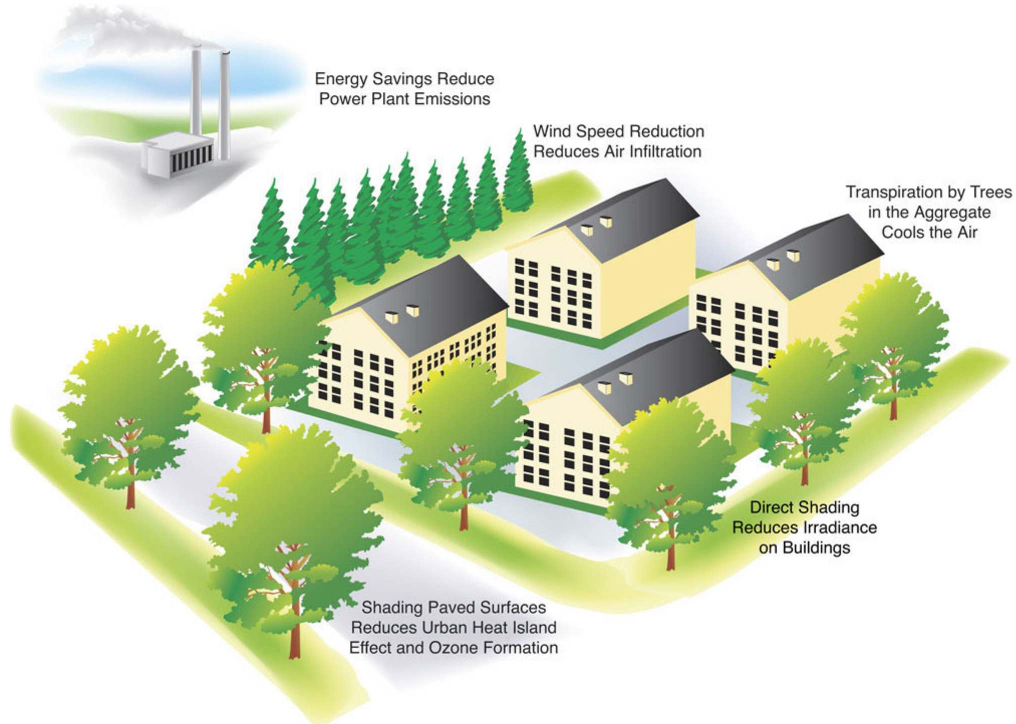


Figure 6. Urban vegetation saves energy in a variety of ways, many of which reduce power plant emissions. Mike Thomas, International Society of Arboriculture

engagement with the natural environment; and through opportunities for positive social interaction. These three areas of support—physical, psychological, and social—encompass the range of ecosystem services as seen in Figure 7.

Noise Attenuation/Reduction

Screens and hedges also provide noise reduction, especially in urban areas where noise reverberates from hard surfaces such as pavement or buildings. Plants are more effective at absorbing high-frequency sounds—which are most bothersome to human ears—than they are at absorbing low frequency sounds. Plants can also reflect noise and direct sound waves much like objects in a stream of water will reflect or redirect the flow of water. Denser plants with larger leaves reflect and absorb more noise than plants with less dense foliage.

Combinations of a mounded area covered with low-growing plants, medium-sized plants, and larger plants located close to the source of the noise can provide the most noise abatement. Any one of these elements can reduce noise in the built environment but when used in combination can be most effective, as seen in an airport design (Figure 8).

Stormwater Management

A plant's leaves and branches create a crown. The crowns of many plants together make up an urban forest's canopy. Unless a storm is particularly intense or occurs in a location without significant canopy cover, most of the rain hits a leaf or branch surface and remains there before evaporating or falling to the ground (Figure 9). Interception of rainfall by plants also slows runoff, thereby reducing impact. Root systems provide channels for water infiltration into urban soils. As water moves through soil layers it is filtered for contaminants, putting less pressure on filtration systems and improving water quality downstream. This brief storage of rainwater by the plant is called rainfall interception. Mature deciduous trees can intercept 500 to 700 gallons of water per year. Mature evergreen trees can intercept more than 4,000 gallons per year. Canopy cover over impervious surfaces (concrete, asphalt) has a profound effect on runoff, as most runoff is a product of impervious surfaces. Even tree cover over pervious surfaces such as soil and turf reduces total runoff by as much as 40 percent. Though some water eventually reaches the impermeable surfaces of the streets and goes into

Figure 7. Benefits of green infrastructure on human health and well-being. Pitman, Daniels, and Ely 2014

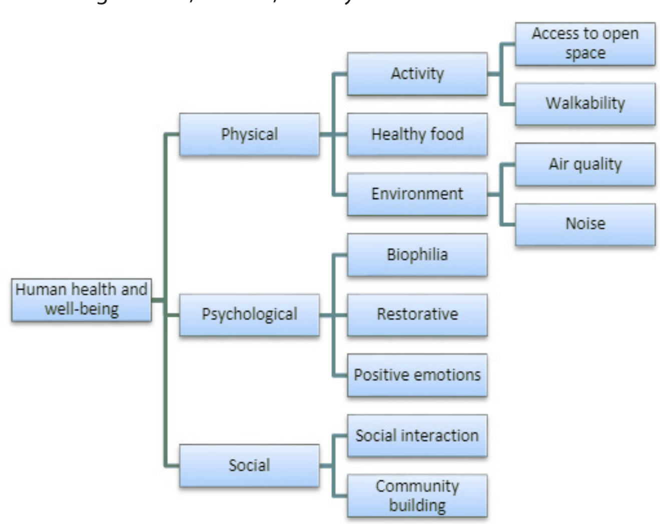
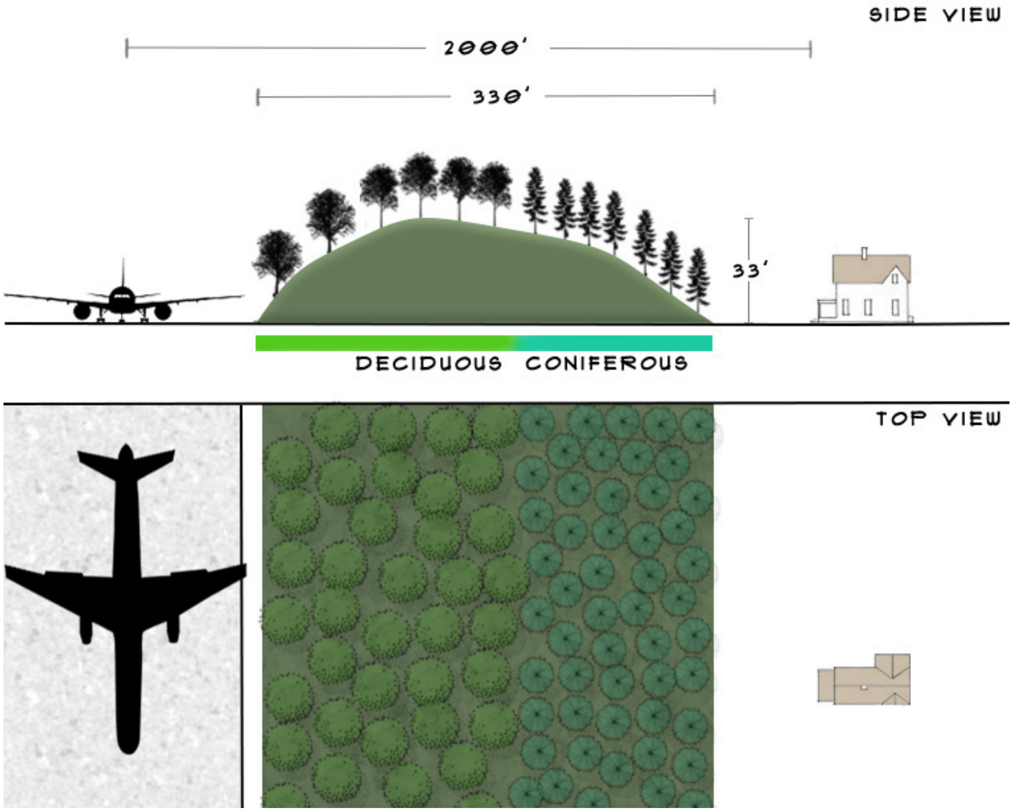


Figure 8. Cross-section and overhead image of a noise mitigation embankment used for airport design. Joshua Knight, Horticulture, University of Kentucky



the stormwater infrastructure, even the slowing of the water moving into these systems increases the capacity of existing infrastructure to handle water, because stormwater infrastructure is limited primarily by its capacity to handle water during peak precipitation events. Trees and green infrastructure have a leveling effect on these peaks, ultimately augmenting the overall capacity of stormwater handling.

The costs of upgrading conventional stormwater management infrastructure are often prohibitive for many municipalities and in some cases result in diminished returns, especially when compared to the cost and capacity for green infrastructure to manage stormwater. In economic analysis of the benefits provided by individual urban trees drawing on data from i-Tree (Figure 10), stormwater management often represents the greatest economic return on investment due to the fact that expanding stormwater infrastructure in developed areas is expensive for municipalities, often requiring a bond and interest payments.

Landscape plants used in combination with depressions in the landscape can improve the reduction in stormwater runoff by increasing water infiltration and evapotranspiration. Rain gardens, bioretention basins, or bioswales are increasingly constructed as part of green infrastructure in urban areas, and there are many other examples of the impact of green infrastructure in urban areas that slow and filter sediments from stormwater runoff.

Figure 9. Water movement of trees in a landscape. Mike Thomas, International Society of Arboriculture

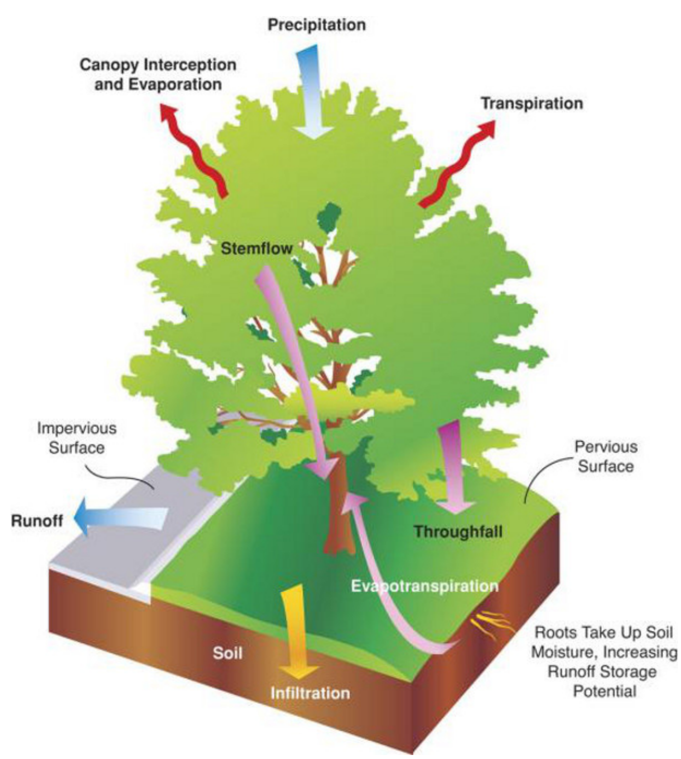


Figure 10. Before, during (below), and after (far right) construction of the Thoraton Creek water quality channel. SvR Design Company 2009

In 2009, the city of Seattle developed the Thornton Creek Water Quality Channel, a 2.5 acre "facility" of constructed landscape and native species plantings which slows and filters stormwater runoff from the largest watershed in the city. This is a public, open space that is integrated into adjacent private development which is also highly functional green infrastructure; the channel removes sediments and associated pollutants from 91 percent of the annual runoff from the 680-acre, heavily urbanized drainage area before it is released into Thornton Creek.

Summary

Landscape plants provide many critical services to people and our built environments, improving land value, health, comfort, and overall quality of life. If planted in 2015, after 20 years of age, a single, healthy red maple placed 25 feet from the southwest corner of a climate-controlled structure will save $143 dollars in winter heating costs and reduce summer cooling costs by $210 in the state of Kentucky (Figure 11). This single tree would intercept 44,028 gallons of water and save the community $273 in stormwater reduction costs. Over the course of its life, it will actively remove NOx, CO, and particulate matter from the air valued at $18 in savings to air quality improvement, and reduce contributions of atmospheric carbon by 9,766 pounds through sequestration, decreased energy production needs, and emissions.

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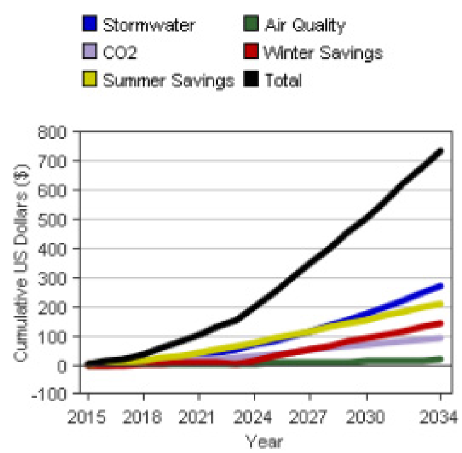
Figure 11. Cumulative tree benefit forecast for a properly sited red maple planted in 2015. i-Tree Design



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Appendix: Species Reference Table

Species	Common Name	Approved Lexington street tree	Native to Kentucky	Maximum height (feet)	Relative growth rate	Resistance to insect pests	Resistance to disease problems	Resistance to storm damage	Will grow on poorly-drained soil	Will grow in hot, dry areas	Easy to transplant	Withstands city conditions	Storm water reduction	Air quality improvement	Wind reduction	Carbon sequestration
Large Trees																
Elm	**Elm**															
*Ulmus americana**	American elm*	A	Yes	120	●●●	○	○	●	●●	●	●●●	●●	●●●	●●●	●●●	●●●
Maple	**Maple**															
Acer rubrum	Red		Yes	90	●●●	●●	●●	●	●●●	●	●●	●	●●●	●●●	●●●	●●●
Acer saccharinum	Silver	NO	Yes	90	●●●	●●	●●	○	●●●	●	●●	●	●●	●●	●●	●●●
Acer saccharum	Sugar	A	Yes	90	●●	●	●	●●	●	●	●●	○	●●●	●●	●●	●●●
Oak	**Oak**															
Quercus alba	White	A	Yes	80	●	●●	●●●	●●●	●	●●●	○	●●	●	●●	●●	●●●
Quercus bicolor	Swamp white	A	Yes	60	●●	●●	●●	●●●	●●●	●●	●●	●●●	●	●●	●●	●●●
Quercus imbricaria	Shingle	A	Yes	60	●●	●●	●●	●●●	●●	●●	●	●●	●	●●●	●●	●●●
Quercus macrocarpa	Bur		Yes	80	●	●●	●●●	●●●	●	●●	●	●●●	●●	●●	●●	●●●
Quercus meuhlenbergii	Chinkapin		Yes	50	●●	●●	●●	●●	●●	●●	●	●●	●●	●	●●	●●●
Quercus palustris	Pin	NO	Yes	70	●●	●●	●●	●●●	●●	●	●●	●●	●	●	●●	●●●
Quercus phellos	Willow	A	Yes	75	●●●	●●	●●	●●	●●	●	●●●	●●●	●●	●●●	●●	●●●
Quercus robur	English		No	60	●●	●●	●●●	●●●	●	●●	●●	●●	●	●	●●	●●●
Quercus rubra	Red, Scarlet	A	Yes	70	●●●	●●	●	●●	●●●	●●●	●●	●●●	●	●●●	●●	●●●
Quercus shumardii	Shumard	A	Yes	80	●●●	●●	●●	●●	●●	●●	●●	●●	●●●	●●●	●●●	●●●
Fagus grandifolia	American beech	A	Yes	60	●	●●●	●●●	●●	●	●	●●	●●	●●●	●●●	●●	●●●
Ginkgo biloba	Ginkgo (male)			60	●	●●●	●●●	●●●	●	●●	●●	●●●	●●●	●●	●●	●●●
Gymnocladus dioicus	Kentucky Coffeetree	A	Yes	75	●	●●	●●	●●	●	●●	●●	●●	●●	●	●●●	●●●
Larix decidua	European larch	A	No	60	●●	●●●	●●●	●●	●	●●●	●●	●●	●●●	●●●	●●●	●●
Liquidambar styraciflua	Sweet gum	A	Yes	80	●●	●●	●	●●	●●●	●	●	●●	●●●	○	●●	●●
Liriodendron tulipifera	Tulip poplar	A	Yes	100	●●	●●	●●	●	●	○	●	●●	●●●	●●●	●●●	●●●
Platanus occidentalis	American Sycamore		Yes	100	●●●	●●	●	●●	●●●	●●	●●	●●	●●●	○	●●●	●●●
Taxodium distichum	Bald cypress	A	Yes	100	●●	●●●	●●●	●●	●●●	●●	○	●●	●●●	●●	●●	●●
Tilia americana	American basswood	A	Yes	80	●●	●●	●●	●●	●	●●	●●	●●●	●●●	●●●	●●●	●●●
Medium-sized trees																
Betula nigra	River birch		Yes	60	●●	●●	●●●	●●	●●●	●	●●	●●	●●	●●	●●	●●
Cladrastis kentukea	Yellowwood		Yes	40	●	●●●	●●●	●●	●	●●	●	●●	●●	●●	●●	●●●
Nyssa sylvatica	Black gum		Yes	30	●	●●●	●●●	●●	●●	●	○	●	●●	●●	●●	●●
Styphnolobium japonicum	Japanese pagoda tree		No	40	●●	●●●	●●	●●	●	●●	●●	●●●	●●	●●	●●	●●●
Small trees																
Acer buergerianum	Trident maple		No	30	●●	●●	●●	●●	●	●●●	●●●	●●	●●	●●	●●	●●
Koelreuteria paniculata	Golden-rain tree		No	20	●	●●●	●●	●	●	●●	●●●	●●	●●	●●	●●	●

*resistant cultivars only
○ poor
● fair
●● good
●●● excellent

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