WASHINGTON STATE UNIVERSITY EXTENSION

A GUIDE TO WASHINGTON STATE'S URBAN TREE CANOPY

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A GUIDE TO WASHINGTON STATE'S URBAN TREE CANOPY

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Abstract

More than 80% of the nation’s population lives in urban areas. The urban tree canopy (UTC) is an essential part of an urban areas’ infrastructure—an ecosystem characterized by trees and other vegetation in association with people and their developments. This publication outlines the many environmental benefits the UTC provides as well as recommendations for expanding it.

A Guide to Washington State’s Urban Tree Canopy

Abstract

This publication explores the most important environmental, economic, and social benefits of a healthy urban tree canopy across the entire state of Washington. It provides data on 33 different genera, species, and notable cultivars of both deciduous and coniferous trees. It includes a very extensive list of references that can be utilized for further study.

The urban canopy enhances the environment, increases community attractiveness and fosters community civic pride, while balancing economic growth with environmental quality and well-being (McPherson et al. 2002). Use this publication to select, preserve, and expand the urban tree canopy.

Define the Urban Tree Canopy

The urban tree canopy (UTC) consists of publicly and privately owned trees within an urban area, including those alongside streets, in home landscapes, in schools, parks, golf courses, and cemeteries, as well as any remaining rural forest (Safford et al. 2015). Simply stated, it is an ecosystem characterized by the presence of trees and other vegetation in association with people and their developments (Nowak et al. 2010). Urban foresters understand the art, science, and technology of managing trees and natural systems for the health and well-being of communities. As there are differences in ownership between all the different types of property (i.e., both public and private), there is no one way to manage the urban forest. Urban planners typically divide urban trees into three categories: yard trees, street trees, and trees for large public spaces. Street trees are often found in the public right of way (ROW), which is defined as the area between the curb and the sidewalk. In this publication, deciduous trees are classified into three sizes, following protocols used by the US Forest Service (Green Cities Research Alliance 2012) and based on their mature size: less than 30 feet, 30–50 feet, and over 50 feet.

Environmental Benefits

With more than 80% of the nation’s population living in urban areas (US Census Bureau 2010), it is imperative that the UTC is considered an essential part of the green infrastructure (Figure 1). In Washington State, a diverse UTC can serve to complement the broad acres of deep green forests (firs and pines) that lend themselves to the moniker the Evergreen State. In urban areas, people plant trees for their long lives, their architectural shapes, and their beauty.

Figure 1. Deciduous trees have been planted on the south side of these urban apartment buildings in Seattle.

Climate Change

The terms climate change and global warming are often used interchangeably, though the former is considered more accurate as there are other changes besides temperature increases (EPA 2013). Scientists refer to the increasing atmospheric levels of carbon dioxide as the leading greenhouse gas influencing climate change. Trees can take up carbon dioxide and release oxygen in the process of photosynthesis. Carbon storage and sequestration provided by trees has been addressed in a number of studies. Research foresters have collected data on urban forests, including tree species, diameter at breast height, tree height, crown width, and overall tree health. The data collected from urban forests can be compared with native forests. Cities produce 40–70% of all greenhouse gas emissions as they consume resources for energy, infrastructure, and transportation (Safford et al. 2015).

Carbon storage and sequestration

There are two different terms used in climate change studies examining carbon utilization by trees. The term carbon storage refers to the accumulation of carbon in both the aboveground and belowground biomass of the trees over many years (McPherson et al. 2013). Carbon storage is equal to one half of the biomass of each tree (Nowak et al. 2016). As trees increase in size, they store more carbon (Figure 2). The term carbon sequestration is used to describe the carbon stored aboveground and belowground over a single season. The rate of sequestration is typically expressed as the pounds of CO_2 absorbed by a tree each year (McPherson et al. 2007). In a study conducted in Chicago’s urban forest, tree vegetation was found to store 7 million tons of atmospheric CO_2 per year and sequester 155,000 tons of CO_2 annually (Nowak 1994). In a

California study (Nowak et al. 2013a) looking at the cities of Sacramento and Los Angeles, researchers found that the urban tree forests were found to store 2% of the total carbon stored from all forests across the state. The results from California were compared to national data that found that urban trees store and sequester 3.2% of the estimated carbon stored in US forestland and urban forest trees combined. In a similar study conducted in the Midwest (Twin Cities of Minnesota), urban trees were found to sequester 1% of the total carbon emissions produced from human sources (Zhao and Sander 2015), corroborating early work from with other temperate zone urban forests (Nowak and Crane 2002). Taken collectively across the US, urban tree forests are able to store 12.6% of the total carbon emitted from all man-made sources (Safford et al. 2015) and sequester 0.05% of all emissions generated per year. Establishing 100 million trees (ten million trees planted over ten years) would be able to offset less than 1% of the total estimated amount of carbon emitted in the US over the 50-year lifespan of the trees (Nowak and Crane 2002) as the trees mature and die.

Figure 2. In the process of photosynthesis these Regal Prince oak (*Quercus robur* Regal Prince) leaves help store and sequester carbon.

Avoided carbon emissions

While climate scientists find that urban trees play a minor role in storing or sequestering carbon (Mackey et al. 2013), they do recognize the benefits that trees can play in reducing the need to utilize energy to cool a building during the summer or to heat it during the winter. The term "avoided carbon emissions" is defined as the carbon emission reductions from electricity generation and natural gas combustion, as well as the urban forest's effects on annual building energy use for space heating and cooling (McPherson et al. 2013). Researchers estimate that air conditioning can account for 5–10% of peak energy demand during the summer (Akbari 2005), resulting in 20% of the population-weighted smog concentrations in urban areas. Urban tree planting could account for a 25% reduction in net cooling and heating energy usage in urban landscapes (Akbari 2002). During the summer, the combination of a tree's foliage, branches, and trunks provides both shading and reduced wind speeds near adjacent buildings.

Summer shading

When properly placed and scaled around a building, trees can reduce solar radiation from striking the building, thus effectively reducing the need for the carbon used in cooling the air (Figure 3). Deciduous trees would be more appropriate than evergreens as they allow solar gain in the winter while blocking it during the summer (Figure 4). To provide shade from the afternoon sun, primarily between the hours of 3:00 to 7:00 pm, consider a tree that matures to a height of at least 25 feet for a single story home (Kuhns 2016a). Taller trees will be needed for two-story homes. Two large trees on the west side of the home and one on the east side can provide enough shade to reduce air conditioning costs by 30% (American Forests 2016). Deciduous trees planted on the south side of a home will provide summer shading, but their trunks and branches can provide too much shade in the winter. To avoid winter shading, locate trees no closer than 2.5 times their mature height to the south of a building. When trees are planted on the southwest or west side of the home, place them four times their mature height from the building.

Winter heating

In colder regions of the temperate zone, a dense stand of evergreens would shield a building from cold winter winds, thus helping reduce the use of carbon sources for heating. Trees for winter wind protection should be planted upwind of the building to be protected. Under most conditions, winter winds will originate from the north, west, or the northwest. In mountainous regions, however, the winds can originate from

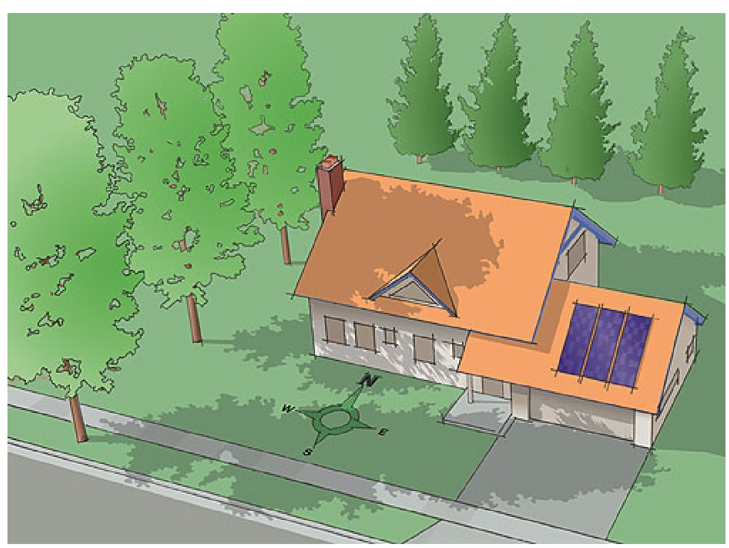


Figure 3. Deciduous trees set on the western edge of the property provide summer shade. Image: US Department of Energy.

Figure 4. This mature sweetgum (*Liquidambar styraciflua*) provides solar gain during the winter.

alternative directions. Consider evergreens with foliage that extends near the ground (Brun and Dinius 2015). Determine the mature height and width of the conifers and space them accordingly (Figure 5). Wind protection extends downwind 10–20 times the windbreak height, so they do not need to be planted close to the structure in order to be effective. Be careful in planting either deciduous or coniferous trees on the south side of buildings as the foliage can block the desired solar heat gain in the winter (McPherson et al. 2007).

Figure 5. A linear stand of Hogan western red cedars (*Thuja plicata* 'Hogan') will mature to 40 feet in height and 20 feet in width, thus blocking the winter wind flows.

Heat Island Effect

The heat island effect is defined as an urban area that has a higher average temperature than adjacent rural areas, owing to the greater absorption, retention, and production of heat by pavement, buildings, and human activities (EPA 2016a). The heat island effect influences two areas of the city: the surface and the atmosphere directly above it. Surface heat island effects are most severe on clear sunny days as rooftops and paved surfaces absorb energy from the sun. The temperature of the building's roof or the pavement surrounding it can be 50–90°F hotter than the surrounding air, while in shaded or moist surfaces that temperature will remain close to air temperature.

At night, the energy is released as heat into the atmosphere, raising the ambient air temperature nearby. The temperature increase is significant. The air temperature can be 5.4°F warmer during the day and up to 22°F warmer at night. With the lack of vegetation, the heat island effect can make a summer day feel very oppressive. Expanding the UTC can help ameliorate the effects of the heat island (EPA 2014). The shading effect of deciduous, coniferous, or evergreen plant vegetation can cut 70–90% of the sun's rays from striking the ground, thus providing an urban cooling effect (Figure 6). The temperature under a shaded tree can be 9°F cooler than in the open. The effects are not due to shading alone, however. The trees will release water vapor in a process known as transpiration. When combined with evaporation from wet surfaces, such as lawns, the collective evapotranspiration (release of water vapor) absorbs the heat from the surrounding air, thus cooling it. In suburban areas, the combined effect of shading and evapotranspiration can reduce the heat island effect by 4–6°F. Shading can reduce the temperature inside the cars by 45°F (Scott et al. 1999). There are a multitude of practices, other than planting urban trees, that can be used to reduce the heat island effect (EPA 2016b).

Figure 6. Urban trees help cool urban areas by providing shade.

Particulate Matter

In addition to providing shade, transpiration, and sequestering CO_2, trees help reduce air pollution by filtering out particulate matter known as PM_{10} (particles 2.5 to 10 micrometers in size). These so-called "inhalable coarse particles" are commonly found near roadways and dusty industries. Humans can suffer severe adverse health effects by breathing in PM_{10} particles (Nowak 2002). The Environmental Protection Agency standard for PM_{10} is 50 $\mu g/m^3$ measured as an annual mean, and 150 $\mu g/m^3$ measured as a daily concentration. In the Pacific Northwest, PM_{10} levels have dropped an average of 56% from 2000 to 2014 as air pollution control measures have been enacted (EPA 2016c). Urban trees have played a role in reducing PM_{10} levels. Particulate matter adheres to the leaves (Figure 7), twigs, and bark. The particles are released and re-suspended in the air or fall to the ground beneath the trees where they are incorporated back into the soil or carried away by stormwater.

$PM_{2.5}$

Smaller particles, referred to as $PM_{2.5}$ (less than 2.5 micrometers) consist of smoke and haze. These particles are directly emitted by power plants and transportation. $PM_{2.5}$ is of concern to human health as the fine particles can result in premature death, aggravated asthma, and increased respiratory symptoms. Recently, climate researchers (Nowak et al. 2013b) have begun to model the relationship between UTC coverage and $PM_{2.5}$ levels within major urban centers. By projecting increases in the UTC, scientists found that the average annual percentage air quality improvements from additional urban tree plantings were minor, ranging from 0.05% in San Francisco to 0.24% in Atlanta. The effects on human mortality ranged from 1.0–7.6 fewer deaths per year, per large city with additional trees. Urban trees thus have a much greater effect on reducing PM_{10} levels than on $PM_{2.5}$ levels.

Figure 7. These 'Armstrong' red maple leaves (*Acer rubrum* 'Armstrong') will absorb PM10 particulate matter.

Air Pollution

The effects of increasing the UTC to reduce air pollution levels has been studied. Trees can absorb ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), the three principal pollutants of urban smog (EPA 2014). All three have serious adverse health effects for people, including asthma, chronic obstructive pulmonary disease, and cardiovascular problems. Trees remove gaseous air pollution primarily by uptake via leaf stomata, in a process referred to as dry deposition. In a modeling study conducted across the US the UTC removed 711,000 metric tons of air pollutants annually (Nowak et al. 2006) during the summer months when the trees were in full leaf. However, the average percentage air quality improvement was typically less than one percent.

In areas with 100% UTC coverage, the average increase in air quality improvement was found to be 2% for PM_{10}, O_3, and SO_2. Large diameter trees (more than 30 inches in caliper; Figure 8) were found to offer the highest absorption rates: 60–70 times greater than trees less than 3 inches in diameter (Nowak and Heisler 2010). While trees can have a minor role in absorbing pollutants, they can also release volatile organic carbon that can contribute to ground-level ozone formation. There are detailed lists of trees that are better at reducing the individual levels of O_3, SO_2, NO_2, and PM_{10} (Nowak et al. 2006). While urban trees may not play a significant role in actually absorbing a great percentage of air pollutants, they can reduce smog levels by 5% through evaporative cooling and shading effects.

Figure 8. This large horse chestnut (*Aesculus hippocastanum*) can mature to 75 feet in height, all the while helping filter the urban atmosphere.

Stormwater Filtration

Urban stormwater runoff is a major source of pollution for surface waters and riparian areas in the Pacific Northwest, threatening salmon and other wildlife as well as human populations (Ecology 2014). Prior to the heavy influx of settlers into the Puget Sound region, the native forest helped protect the riparian zones from runoff from roads and commercial development (Figure 9). Preserving and expanding the UTC has proven to be very useful in the management of stormwater generated from impervious surfaces. During a rain event, tree foliage absorbs water before releasing it back into the atmosphere via both evaporation and transpiration (Fazio 2010). In addition, tree roots and leaf litter will absorb rainfall and help create conditions for good infiltration (Figure 10). In essence, trees have become the first line of defense in filtering the rain, and thus runoff (EPA 2013).

Figure 9. Urban trees help reduce stormwater runoff into area watersheds.

Figure 10. The foliage of this Red Sunset red maple (*Acer rubrum* 'Franksred') helps capture rainfall that would otherwise end up as runoff from this impervious surface.

Green streets

For additional stormwater removal, cities are now utilizing urban trees in civil engineering plans for the design of new streets and the renovation of existing ones. The US Environmental Protection Agency has coined the term "green streets" to utilize urban trees, shrubs, and groundcovers planted alongside streets to naturally reduce stormwater flow, improve water quality, reduce the urban heat island effect, beautify neighborhoods, and enhance pedestrian safety (EPA 2009). Trees are being placed into engineered concrete planters (Figure 11), or curb extensions, situated alongside a road. There are trees that can withstand intense rainfall that would flow into either of these concrete vaults and survive periods of standing or flowing water (Table 1).

Figure 11. A stormwater street planter with green ash trees will filter the runoff from the street.

Table 1. Suggested trees for urban stormwater filtration with seasonal flood tolerance

Acer freemanii	Freeman maple
Acer rubrum	Red maple; multiple cultivars
Amelanchier alnifolia	Serviceberry
Betula nigra	River birch
Carpinus caroliniana	American hornbeam
Fraxinus pennsylvanica	Green ash; multiple cultivars
Nyssa sylvatica	Black gum; multiple cultivars

Sources: Anella and Whitlow (1999) and Jull (2008).
Note: Shading indicates trees that can withstand more than a week with roots submerged.

Rain gardens

Rain gardens are man-made, shallow depressions in the landscape with soils mixes and selected plants that take stormwater runoff from an impervious surface and infiltrate it into the ground. Urban trees can be incorporated into rain gardens to help filter street runoff. These bio-swales, or stormwater curb extensions, are often located at street intersections (Figure 12), incorporating sidewalks for pedestrians and bicycle crossings (City of Portland 2014; City of Seattle 2014). With the additional space, larger trees can be utilized in these situations. There is a greater array of urban trees that can be planted on the edges of a rain garden beyond those listed in Table 1 (Hinman 2013). Consider using vine maple (*Acer circinatum*; Figure 13), Cornelian cherry (*Cornus mas*), or cascara (*Frangula purshiana*).

Figure 12. A vegetative swale incorporating sidewalks, trees, and perennials can serve well as a small park in an older neighborhood.

Figure 13. Vine maple (*Acer circinatum*) is a Washington State native plant that can be planted in both full sun and shade.

Economic Benefits

A healthy UTC can have a significant effect on the value of both private and commercial real estate. The perceived value of a thoughtfully designed landscape attracts homebuyers to different neighborhoods and shoppers to commercial businesses.

Real Estate Value

Home re-sale prices can be 10–12% higher with landscaping. Studies have found that a sophisticated design and large plant sizes (Figure 14) are more important than the diversity of plant material utilized (Niemiera 2009). The placement of trees on the property is important. Siting a wide spreading tree that overhangs adjacent property can lead to conflicts with shade, leaf drop, and visual impairment (Starbuck 1999). Home values are also increased with the addition of shade trees in the adjacent ROW. A Portland, Oregon, study found a positive relationship between real estate values and the presence of street trees in the adjacent ROW (Figure 15). On average,

Figure 14. A well-designed landscape with mature shade trees can add value to a home.

Figure 15. The owner of this home has planted an Edith Bogue southern magnolia (*Magnolia grandiflora* 'Edith Bogue') in the ROW.

street trees added $8,870 to a sales price and reduced the time on the market by 1.7 days (Donovan and Butry 2010).

Business Districts

American Forests is the leading nonprofit organization for urban trees. They advocate that business districts strive to attain a 15% canopy coverage, up from the current average of only 5% (American Forests 2016). Real estate managers have found that shoppers are more willing to spend additional time and dollars (10% more) in well-landscaped districts where urban trees have been either planted in the ROW or in tree planters (Van Buren 2016). The visual perception and shade provide by the urban trees (Figure 16) largely explains the improved business climate. Real estate managers have also found that they can ask higher rents for office complexes that have been constructed with well-designed landscapes.

Figure 16. This business district has been improved with the addition of Emerald Sentinel sweetgums (*Liquidambar styraciflua* 'Clydesform'), which will provide shade to the buildings and sidewalk.

Pavement Protection

The UTC can help protect asphalt from excessive weathering. Asphalt contains stone aggregate and a petroleum-based binding agent. The cooling effect of the overhanging tree foliage helps reduce the excess temperatures that asphalt attains on a hot summer day (Figure 17). By cooling the asphalt, the binding agent lasts longer. As young trees provide little canopy coverage, the effects are greater as the trees mature and the asphalt ages. Unprotected asphalt may need to be resurfaced after only 10 years. Over a period of 30 years, there can be a 60% savings in resurfacing costs (Alliance for Community Trees 2011).

Figure 17. The bigleaf maple (*Acer macrophyllum*) shown here will help extend the life of the pavement.

Social Benefits

The physiological benefits of walking through a shaded grove of trees beside a pond filled with wildlife on a hot summer day gives strong support for the refreshing attributes of nature within our built environment. Time spent outside helps renew our sense of inquisitiveness and alertness while providing an avenue for physical exercise.

Public Health Benefits

The UTC helps with the inherent need for privacy in our highly built environments. Vegetative screens and hedges define our property boundaries. People congregate in shaded parks for serene periods of contemplation, finding respite from the glare of buildings and transportation and in the silence that comes from vegetation (Figure 18). The presence of a healthy UTC helps draw residents into outdoor common areas.

Figure 18. Urban parks provide ample public health benefits.

Mental health

Mental well-being is associated with outdoor exercising where the presence of trees helps reduce tension, anger, and depression (Coley et al. 1997). In a large British study, psychologists surveyed over 10,000 people and found that over time there was a positive relationship between the presence of open space within urban areas and an overall sense of less mental distress, along with a higher level of well-being (White et al. 2012). Parks filled with trees impart a sense of community, which help build social networks (Kweon et al. 1998; Figure 19). In a recent study looking at urban trees and mental health, researchers in London found a positive relationship between the number of urban trees and a reduced need for antidepressant prescriptions (Taylor et al. 2015).

Figure 19. Urban parks provide plenty of opportunities for exercise.

Crime and Public Safety

The presence of trees surrounding a private residence (Figure 20) and in nearby ROWs can contribute to a reduction in crime (Donovan and Prestemon 2012). In the case of public housing buildings, total crime was reduced 52%, property crimes were reduced 48%, and violent crimes were reduced 56% when there were abundant trees (Kuo and Sullivan 2001). The greatest reduction in crime comes with the presence of large trees, which signal criminals that the house receives better care and therefore a potentially higher policing level. Urban trees planted in the ROW had a net positive effect on reducing crime rates. Crime studies have found that the use of tall dense shrubs and small trees on a property, planted close to the structure, can lead to more crime, however. These types of plants can block the view from both within and outside of the home, providing a concealment advantage to criminals.

Green street public works projects, such as street bump-outs and rain garden plantings (Figures 11 and 12) have recently received attention in terms of crime and public safety (Kondo et al. 2015). When neighborhoods were retrofitted with these newer stormwater management techniques, the rate of narcotics possession, narcotics manufacturing, and burglaries

Figure 20. A well-manicured yard with mature trees can help deter crime.

were reduced significantly. Impacts on homicides, assaults, and other forms of civil disobedience were reduced as well, though not significantly. Kondo et al. (2015) speculated that the installation of the trees and associated landscaping improved the visual appearance of the project, thus deterring crime.

Traffic Calming

Road safety has been found to improve with the presence of urban trees as drivers sense the road is narrower, causing them to slow down thus protecting both pedestrians and bicyclists. Tree-lined arterial streets were found to reduce the speeds of both the faster and slower drivers and improve the overall sense of driver safety (Naderi et al. 2008). A ROW filled with trees shades the adjacent sidewalk and provides a buffer between pedestrians and motorists (Figure 21). Planting appropriate-sized trees in the ROW often brings together a large number of volunteers for tree planting, thus improving

Figure 21. Divided boulevards lined with established trees helps keep traffic speeds in check.

relationships within the entire neighborhood. Modern community development requires not only sidewalks, curbs, and underground utilities, but also urban tree installation in public spaces.

Ultraviolet Radiation

The presence of leaves blocks the ultraviolet (UV) exposure from striking the skin and eyes of humans beneath the canopy (EPA 2016a). Excessive exposure to UV radiation has been linked to human skin cancer and the development of cataracts. While large canopy shade trees would provide the best protection, the smaller leaves of thorn-less honey locust (Figure 22) could be used to provide filtered light that blocks the majority of the sun's rays.

Figure 22. True Shade thorn-less honey locust (*Gleditsia triacanthos*) can provide filtered shade and a pleasing appearance.

Measuring the UTC

There are two different ways to measure the existing UTC and its distribution. Using ground-based measurements, managers can look at individual trees to determine species, tree diameter (trunk width at the chest height of the average person), height, overall health, growth rate, and the impact on the surrounding environment (Figure 23). Arborists generally have recognized growth rates for individual tree species. This helps in both setting expectations for new plantings and in determining whether existing trees are performing well enough to remain or should be replaced by another species which will perform better in this location. Ground-based assessment, however, is expensive, and time consuming. It is generally not useful for yard tree assessments as private landowners may refuse to grant permission for the survey work.

Figure 23. Assessing the make-up of the UTC on the ground is slow and laborious. Image: Andrew Koeser, Bugwood.org.

Remote sensing

The second technique to assess the UTC is known as remote sensing: utilizing aerial photos derived from satellite passes over a city. The photo itself includes everything within a certain boundary: the urban area where people live and work, where trees grow, where buildings are sited, and where roads and waterways are located. In order to determine what parts of the photo show tree cover and what does not, the area covered by impervious surfaces (e.g., pavement, buildings), pervious surfaces (including grass and low shrubs), and bare soils and open water (e.g., lakes, rivers) must first be identified. This is done by using data from existing state or federal land use databases and information from urban planning departments that track local parcel size, zoning boundaries, roads, waterways, etc. Remote sensing can quickly cover an entire region.

Using geographic information system (GIS), programming analysts can take remote sensing images and break them down into data sets or individual map layers. Layers typically include: UTC, public buildings, roads, public rights of way, public versus private acreage, city zoning districts, property parcel boundaries, public parks, neighborhoods or districts, and open spaces. In western Washington, the City of Bellevue utilized remote sensing (Landsat satellite) data to help determine its UTC (Figure 24). Foresters found a 36% UTC, which, while higher than many other American cities, was still less than the 40% coverage suggested by the nonprofit conservation organization known as American Forests (City of Bellevue 2008). During the same timeframe, the City of Seattle had only 23% UTC (Figure 25), while the City of Vancouver reported 18% UTC.

UTC species composition

A detailed UTC survey needs to include the types of trees (scientific name) and their sizes (diameter at breast height). Knowing the type of trees, their percentage of the UTC, and where they are located are key features in ensuring a healthy and diverse tree community.

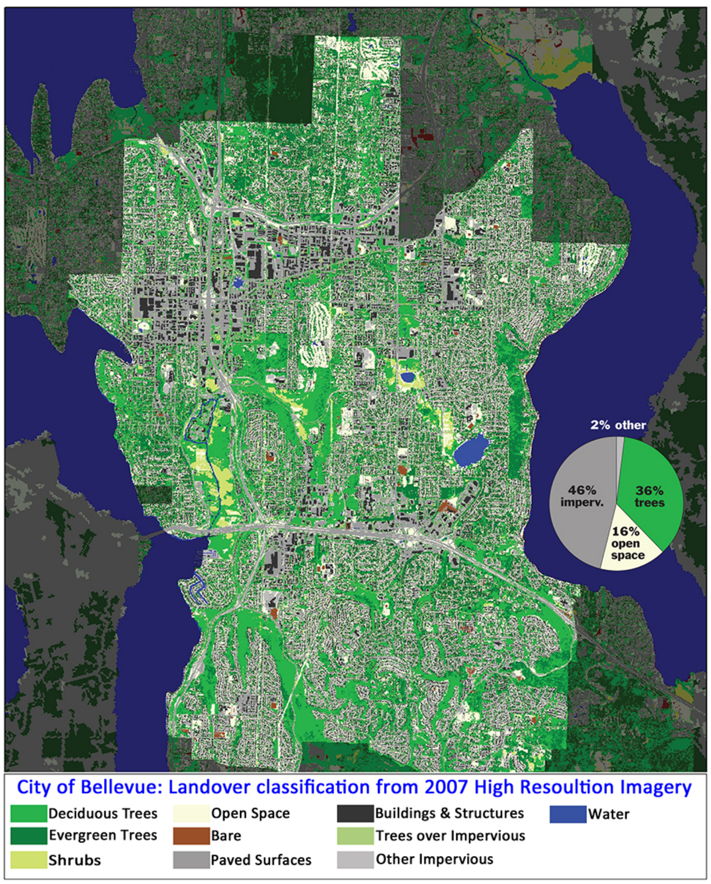


Figure 24. GIS imaging of the City of Bellevue's UTC. Image: City of Bellevue, Dan DeWald.

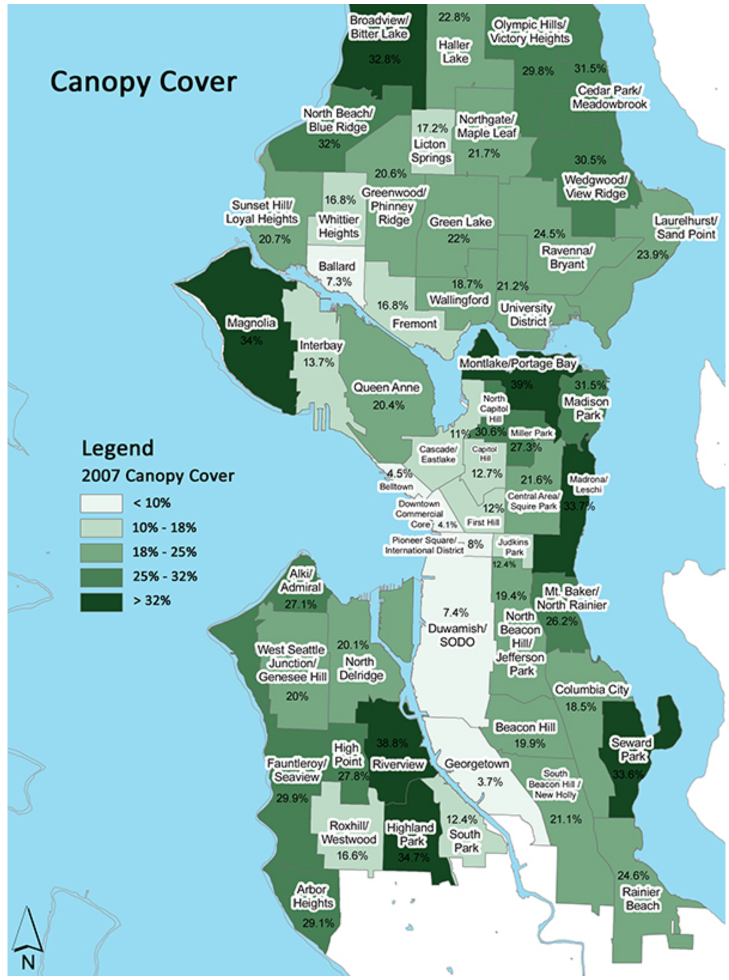


Figure 25. City of Seattle UTC canopy coverage. Image: Seattle Office of Sustainability and Environment, Sarah Wysocki.

It is very important to include a wide array of both deciduous and coniferous tree species. In general, city foresters should strive for having no more than 10% of any one genus predominate the urban forest (Miller and Miller 1991). In a 2007 survey of trees in the City of Seattle, 67% of the street tree population was made up of just 7 genera: Prunus (flowering cherry or flowering plum; Figure 26) and English laurel (Figure 27); Acer (maple; Figure 28); Crataegus (hawthorn; Figure 29); Malus (apple); Quercus (oak); Fraxinus (ash); and Tilia (linden). Together the genera Prunus and Acer made up 42% of the street trees. In a similar study in Spokane (City of Spokane 2013), the two common genera were once again Acer (principally *Acer platanoides*) and Pinus (principally *Pinus ponderosa*).

Figure 26. Mt. Fuji cherry (*Prunus serrulata* 'Mt. Fuji').

Figure 27. English laurel (*Prunus laurocerasus*).

Figure 28. Norway maple (*Acer platanoides*).

Figure 29. English hawthorn (*Crataegus laevigata*).

Diversity of genera

In this publication, 33 genera are discussed. A mix of trees is offered in order to meet the wide variability of climates and soil types across the state. The species listed in Tables 2–5 represent some of the most highly suited genera, species, and cultivars for different regions of the state. Data for these tables was generated by reviewing tree planting lists provided by the City of Seattle (2014), City of Vancouver (2012), City of Spokane (2014), Washington State University Chelan county (Dinius 2009), the City of Pasco (2016), the City of Bellingham (2010), and the City of Tacoma (2014). None of the selections offered are considered invasive, according to the US Department of Agriculture Natural Resource Conservation Service (NRCS 2016). Mature tree height and width data were derived from temperature zone land-grant university references.

Importance of Conifers

The native Pacific Northwest forest is primarily composed of evergreen trees, with lesser percentage of deciduous trees. Dense stands of Douglas fir and Western red cedar predominate in areas west of the Cascades, while Ponderosa pine, Lodgepole pine, and Western larch occur on the east side. In western Washington, many of the native stands of Douglas fir have been severely reduced, especially in the Puget Sound area, due to the increase in population and resultant development. Currently 31% of the forest in western Washington is comprised of evergreens, with the remaining 69% consisting of deciduous trees. Urban foresters in western Washington understand the need to further increase the percentage of conifers where appropriate.

Expanding the UTC

In designing a plan to expand the UTC, city foresters must first determine the extent of the UTC (Nowak and Heisler 2010). Canopy coverage will vary tremendously based upon the size of a community, the population density, the development intensity, and the presence of natural vegetation in parks and surrounding forests. In Washington State, the highest UTC percentage occurs in the wetter regions, west of the Cascade mountains. Statewide tree canopy coverage averaged 36.6% in year 2000, while in urban or community areas it was 27.7% (Nowak and Greenfield 2010). In 2010, the largest cities in Washington reported urban tree canopies of 45% in Lake Forest Park, 40% in Kirkland, 36% in Bellevue, 31% in Shoreline, 28% in Renton, 23% in Seattle, 22% in Spokane, and 19% in Vancouver (Zemke 2015). Citywide, 31% of the trees were found to be evergreens (22% needled conifers and 9% broadleaf), while 69% were deciduous. In the category of single family residential, the ratio was 15% broadleaf evergreens, 34% conifer, and 51% deciduous. In parks the percentage of conifers varied from 10–20%, which is considered very low in terms of native forest populations before the introduction of European settlers. Many of the existing broadleaf evergreens consist of the introduced English Holly (Figure 30) and English laurel (Figure 27), both of which are considered invasive (NRCS 2016).

UTC deficient zones

In addition to measuring the existing UTC, the same measurements can help identify areas of "canopy deficiency." In order to effectively increase the UTC percentage in a city, one must first estimate the amount of future planting sites available, and then assess whether those locations can actually support the mix of trees desired in that area. The City of Seattle (2013) adopted their Urban Forest Stewardship Plan in 2013 that identified areas (Figure 31) where the UTC could be expanded. The goal is to increase the UTC to 30% by the year 2037. Whether looking at existing UTC and managing it effectively, or working toward increasing the UTC percentage, city residents and policymakers should view UTC patterns by neighborhood, by zoning areas, and across public and private lands to fully explore the options. American Forests has stated that urban cities in the Pacific Northwest should strive for 40% canopy coverage across all land use districts, 50% coverage in suburban residential zones, and 25% in urban zones (Alliance for Community Trees 2011).

Figure 30. English holly (*Ilex aquifolium*).

Tree planting incentives

Various types of incentive programs are utilized to expand the UTC. In Seattle, the Trees for Neighborhoods program began in 2009 and has since offered 6,300 trees for private residences, as well as trees for the adjacent ROW. Residents can apply in the fall for up to four trees per household, with a lifetime maximum of eight trees (City of Seattle 2016). Applicants have to attend a tree planting class, where they are taught how to properly install and maintain their new trees (Figure 32). Each year, approximately a dozen different types of trees are offered, including conifers. In Tacoma, residents

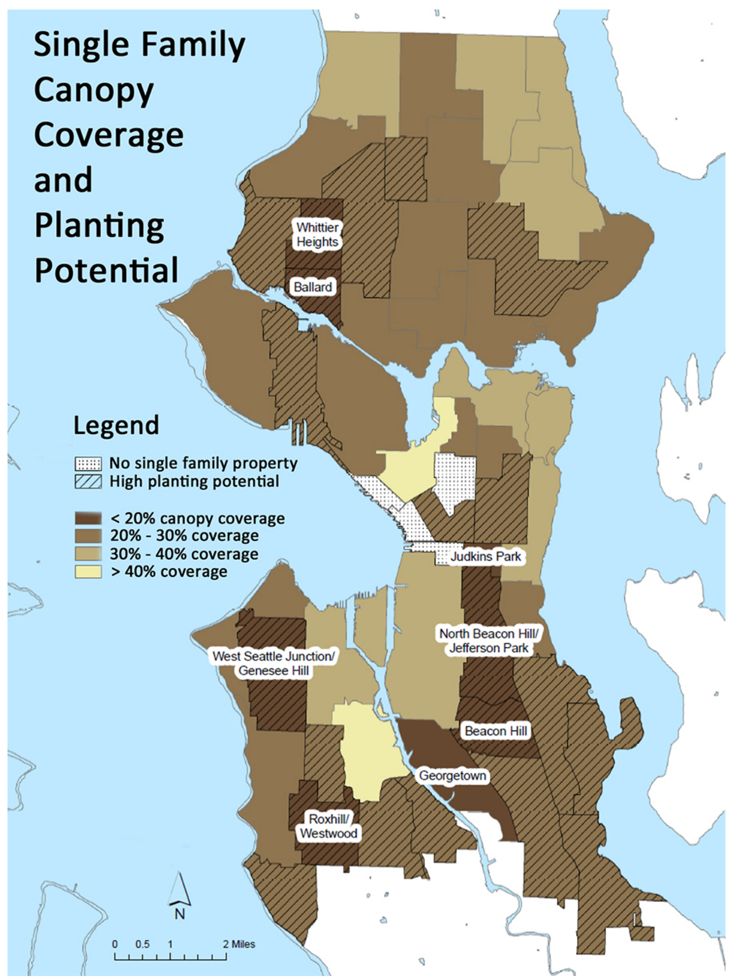


Figure 31. City of Seattle areas to expand UTC canopy coverage. Image: Seattle Office of Sustainability and Environment, Sarah Wysocki.

Figure 32. Neighborhood tree planting volunteers.

can receive a tree planting coupon worth a $15 discount on a shade tree that they can plant in their yards or adjacent ROW. A very wide range of trees is allowed as long as residents conform to an approved tree list (City of Tacoma 2014). The City of Portland offers an incentive program as well, with their rebate program linked to the mature size of the street or ROW tree and its potential to filter stormwater (City of Portland 2016).

National support for the UTC

On a national basis, the nonprofit Arbor Day Foundation (2016) offers up to ten free trees to private citizens for a very a nominal $10 yearly membership fee. This organization supports the Tree City USA program, which currently has over 3,400 cities and towns across the nation as members. Tree City community members receive publicity material that they can use in promoting the benefits of urban trees and can apply for grants from Tree City USA to further expand their UTC. In Washington State, the Department of Natural Resources Urban and Community Forestry (DNR 2016) program works together with the Tree City USA program to offer technical support for tree inventories, planting, and overall community forestry outreach programs.

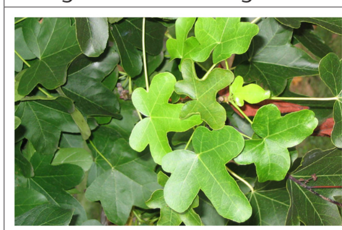
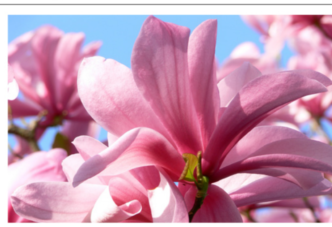
UTC Deciduous Trees 30–50 Feet

Trees that attain a size of 30–50 feet in height and 20–40 feet in width are generally classified as medium sized (Bassuk 2009; Table 2). These trees are important in all parts of the UTC. A medium-sized tree that is 30–35 feet tall is well suited to the average-sized yard (7,000 square feet) with a single story home. The taller species presented here would serve well for a two-story story home, in terms of scale. When used as street trees, these selections often require a boulevard width of six feet. Municipalities often loosely define street trees as those trees growing within the public ROW along public roads (Figure 33). The public ROW can include the boulevard strip (area between the curb and the sidewalk) as well as trees growing in planter spaces surrounded by concrete (Steed and Fischer 2007). All of the selections in this publication will retain their shape after the lower limbs have been removed to a height of 8–9 feet. Municipal foresters require that lower limbs are removed in order to allow for safe passage of motorized vehicles along the street abutting the ROW, as well as pedestrian passage on the sidewalk. As they exceed 30 feet, they should not be used under power lines. Medium-height trees should be offset 25–30 feet horizontally from electric lines (Olsen et al. 2009).

Fort McNair horse chestnut is highly regarded for its excellent spring flowering and general site adaptation. Autumn Flame red maple is suggested for its intense red fall color, while Scarlet Sentinel is one of the few yellow fall cultivars. Norwegian Sunset maple is an excellent replacement for invasive Norway maples. Along with the related cultivar ‘Pacific Sunset,’ the glossier green leaves are a nice contrast to those of the red maples.

Figure 33. Autumn Blaze maple (*Acer freemanii*) is a highly popular medium-sized shade tree for ROWs without overhead power lines.

Table 2. Deciduous trees 30−50 feet

 *Aesculus carnea* **Fort McNair Horse Chestnut** Width: 30 ft. Zone 4 Rounded form to 30 ft; coarse textured leaves; pink and yellow flowers; yellow fall foliage.	 *Acer rubrum* **Autumn Flame Maple** Width: 20 ft. Zone 4 Upright form to 40 ft; dark green summer foliage; yellow orange in the fall.	 *Acer rubrum* **Scarlet Sentinel Maple** Width: 20 ft Zone 4 Upright, narrow form; green summer foliage; yellow-orange in the fall.	 *Acer truncatum* 'Keithsform' **Norwegian Sunset Maple** Width: 25 ft Zone 4 Oval form to 35 ft; dark green glossy leaves; orange-red fall.
 *Betula nigra* 'Cully' **Heritage River Birch** Width: 40 ft Zone 4 Pyramidal form; light green summer foliage; yellow in fall; white/salmon peeling bark.	 *Betula papyrifera* 'Renaissance Reflection' **Renaissance Reflection Birch** Width: 25 ft Zone 3 To 45 ft; pyramidal; crisp white bark; yellow fall foliage.	 *Celtis occidentalis* **Hackberry** Width: 35 ft Zone 3 To 45 ft; oval canopy with arching limbs; warty bark; serrated green leaves; yellow in the fall.	 *Cladrastis kentukea* **American Yellowwood** Width: 40 ft Zone 4 Round form to 30 ft; bright green foliage; smooth grey bark; yellow, bright yellow in the fall.
 *Cornus controversa* 'June Snow–JFS' **June Snow Dogwood** Width: 40 ft Zone 5 Tiered braches to 30 ft; veined leaves; large white flowers; orange to red fall foliage.	 *Davidia involucrata* **Dove Tree** Width: 30 ft Zone 6 To 40 ft; pyramidal crown; heart- shaped leaves; paired white flower bracts; yellow fall foliage.	 *Fraxinus oxycarpa* 'Raywood' **Raywood Ash** Width: 30 ft Zone 6 To 45 ft with an oval canopy; narrow green leaflets; green in summer; red-purple in the fall.	 *Gleditsia triacanthos* 'Skycole' **Skyline Honey Locust** Width: 35 ft Zone 4 To 45 ft; pyramidal canopy; fine texture compound leaves; gold fall foliage.
 *Liquidambar styraciflua* 'Rotundiloba' **Rotundiloba Sweetgum** Width: 25 ft Zone 5 To 45 ft; pyramidal to oval form; green summer foliage; orange to purple fall foliage; sterile.	 *Magnolia* 'Galaxy' **Galaxy Magnolia** Width: 15 ft Zone 5 To 35 ft; tall narrow form; dark reddish-purple blooms attain 8–10 in. in size; green foliage all summer long.	 *Ostrya virginiana* **American Hophornbeam** Width: 25 ft Zone 4 To 40 ft; upright oval crown; serrated green summer foliage morphs to gold in the fall.	 *Quercus frainetto* 'Schmidt' **Forest Green Oak** Width: 30 ft Zone 5 Upright oval form; glossy green summer leaves; rounded lobes; yellow in the fall.

Cully birch is suggested for its creamy orange and pink bark, while Renaissance Reflection birch offers bronze birch borer resistance, making it a better choice than the commonly found Jacquemontii birch (*Betula jacquemontii*) which lack resistance. Hackberry and American Yellowood are known for their excellent yellow fall foliage and ability to with stand alkaline soils. June Snow dogwood and Dove tree are two spring flowering trees for those that enjoy white bloom. Raywood Ash is widely used across the state as it has excellent fall color (reddish-purple) and wide site adaptation. Skyline Honey locust is suggested for all parts of the state where heat and drought tolerance is important. The foliage is fine enough that it does not require raking in the fall. Rotundiloba sweetgum is the only sweetgum cultivar that is fruitless. It still offers excellent purple fall foliage coloration and wet soil adaptation. Galaxy magnolia is a highly regarded street tree selection as it forms a strong central leader and retains a narrow shape, making it ideal for narrow ROWs. Reddish-purple flowers grace the branches in the spring. American Hophornbeam is included here as it would be an ideal candidate for the alkaline sites in south-central Washington. It tolerates drought and urban pollution with ease. Its yellow fall foliage is outstanding. Forest Green oak is a highly regarded selection for the urban environment as it drought tolerant and has no particular site requirement. The glossy green leaves are born on a strong central leader stem.

Trees under 30 Feet as Street Trees

Deciduous trees that grow less than 30 feet may not be suitable as street trees as their smaller sizes would preclude them from being pruned appropriately to allow safe passage under their lower limbs. If one removes a third of the lower limbs of a tree that only grows to 25 feet in height, its natural shape will potentially be destroyed (Kuhns 2016b). In narrow ROWs the crown of a small tree will extend out into the street or over the sidewalk blocking the safe passage. There are a number of different small trees with narrow widths (under 20 feet; Brun and Kohlhauff 2016), some of which can be used as street trees. The form of the crown is an important attribute in selecting a small shade tree used near pavement. Trees with upright forms (Figure 34) generally require less pruning of their lower limbs than smaller spreading or multi-trunked shade trees (Gilman and Sadowski 2007).

UTC Deciduous trees over 50’

Large deciduous shade trees (Table 3) are a key component in the UTC. They are frequently situated in parks, school grounds, cemeteries, green belts, industrial properties, and large private lots due to their mature height and width. They can be used in the ROW as long there is a minimum boulevard strip width of at least 6 feet (City of Seattle 2014). Large-scale

Figure 34. Pyramidal European hornbeam (*Carpinus betulus* ‘Fastigiata’) is a popular compact boulevard shade tree with its columnar form and elevated lower limb structure.

trees should be planted between 35–45 feet apart in the ROW. The selections listed here are found all across the state.

Red maple is one of the most grown shade trees in North America. There are more than a dozen different cultivars available, with ‘Red Sunset’ being the standard in the industry based on its excellent fall foliage. Red maple tolerates nearly all sites, including those that are wet. It tolerates urban air pollution. It lacks the invasive features of Norway maple (Invasive Plant Atlas 2016). The sugar maple cultivar ‘Green Mountain’ is considered the standard for comparison with other sugar maple cultivars (Gillman 2013). It has reliable fall color in western Washington and the colder regions of eastern Washington. Avoid its use on compacted sites. Northern catalpa can grow to over 80 feet, and features a plethora of white and yellow or orange blossoms. American beech is an east coast native that is not common in the Pacific Northwest as it grows very slowly (one foot per year). With its abundant crop of beech-nuts, it could serve as an effective wildlife tree. Ginkgo is a popular shade tree with its crisp clean foliage and its excellent urban adaptation to a multitude of sites. The cultivar known as 'Presidential Gold' is one of the largest cultivars sold in the trade. Kentucky Coffee tree is commonly found in the Midwest where its filtered shade and ability to grow on hot, dry, and alkaline sites make it a highly desired shade tree. It would be highly suited to the south-central region of Washington. The Tulip tree is a very fast growing east coast native that can do very well here in the west if given a moist location along a river bottom. It features green, tulip-shaped flowers and very pleasing yellow fall foliage (US National Arboretum 2009). Dawn redwood grows all across the US in hardiness zones 5 through 8. As it can grow to a very large size, it should be planted where it has sufficient space. While its needles may resemble those found on the California redwood (*Sequoia sempervirens*), it differs in being a deciduous conifer.

American sycamore is a close relative of London Planetree (*Platanus acerifolia*) and are often confused. The leaves of American Sycamore don't have the deep sinuses found on London Planetree. Both species are known for their distinctive shedding bark that creates a dappled brown and cream pattern. London Planetree prefers moist sites but can grow well on all soil types, including those with higher soil pH (Shaughnessy and Polomski 2006) as found in south-central Washington. The American Linden is a very popular shade tree that comes in a number of different cultivars. Also known as American Basswood, this species features large heart-shaped leaves and pale yellow flowers that are highly attractive to honey bees. It generally forms a tall pyramid casting dense shade on the ground beneath it. It can withstand alkaline soils.

Oak trees are commonly recognized and valued for their sturdy growth, large sizes, and abundant acorns for wildlife. Red, Scarlet, and Pin oaks all classify as red oaks in that they have pointed leaf lobes. Scarlet oak is the preferred red oak species for intense fall foliage color. Oregon white oak is a northwest native that grows all through the areas west of the Cascades. While once very abundant, many white oak stands have been lost to development or conversion to Douglas fir forests. While it is very slow growing, it is very tolerant of both poorly drained as well as drier sites. Bur oak is native to the north-central US and the eastern Great Plains. It is good tolerance to urban conditions including compacted sites, air pollution, and high soil pH, thus making it suitable for south central Washington. Pin oak is excellent for wetter sites, but suffers the most on the alkaline sites such as those found in the Tri-Cities area. Pin oak may look unsightly in western Washington as it retains its spent foliage during the winter months. Red oak is often the fastest growing of the red oak species, but has variable fall color ranging from russet red to yellow. Jefferson elm is one of the largest trees for the UTC. The cultivar 'Jefferson' was introduced in the 1930s as a seedling from an American elm at the National Arboretum in Washington DC. It features resistance to Dutch Elm disease, which ravaged the American elms across the Midwest and east coast in the '60s and '70s.

UTC Conifers 25–50 Feet

The conifers listed in Table 4 consist of medium-sized specimens that should be included in the UTC. In terms of scale, their moderate size would make them suitable to the smaller yard (Cervelli 2005). The Weeping Alaska cedar does best west of the Cascades on acidic sites. There are cultivars of this species that are narrower, such as 'Green Arrow,' 'Van den Akker,' and 'Strict Weeping.' Italian cypress is a tall, very narrow species for western Washington that is often used to frame entryways or tall buildings. Eastern red cedar is a highly adaptable east coast native that will grow all across the state, though it is more commonly found on the east side. The spruce cultivar 'Hoopsii' is considered one of the bluest of all the Colorado blue spruce variants sold in the nursery trade. Blue spruce is widely used in eastern Washington as it is cold hardy, and often has fewer insect problems as opposed to western Washington. Shore pine does well all across the state. It is recognized by its contorted trunk and twisted needles. Its close relative is Lodgepole pine, which grows on the east side. Vanderwolf's Pyramid pine is a limber pine with soft, blue tinted needles in bundles of five. It also does well across the entire state. Japanese black pine is widely used in Asian gardens where it can be sculptured into different forms while still retaining its dark green needles and characteristic terminal buds. The western red cedar cultivar 'Zebrina' is a highly variegated selection that would do best in western Washington as it lacks sufficient winter hardiness and can lose its variegation in hotter regions. All of the species and cultivars are raised by wholesale nurseries on the west coast (OAN 2016). They can be found at retail garden centers or through landscape contractors.

Table 3. Deciduous trees over 50 feet

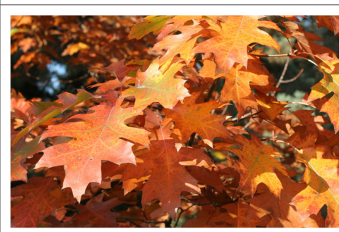
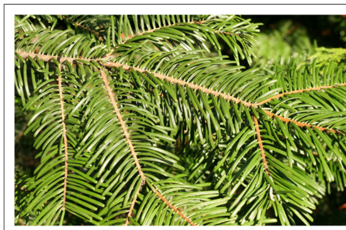
 *Acer rubrum* 'Franksred' **Red Sunset Red Maple** Width: 35 ft Zone 4 Upright, oval form to 50 ft; glossy green summer leaves give rise to orange-red fall foliage.	 *Acer saccharum* 'Green Mountain' **Green Mountain Sugar Maple** Width: 40 ft Zone 3 Broadly oval to 50 ft; dark green in summer; glowing red in fall.	 *Catalpa speciosa* **Northern Catalpa** Width: 35 ft Zone 5 Rounded crown to 50 ft; green heart-shaped leaves; yellow fall foliage; 12–16 in. long seed pods.	 *Fagus grandiflora* **American Beech** Width: 40 Zone 5 To 50 ft with a broad form; glossy green in the summer; bronze in the fall.
 *Ginkgo biloba* 'The President' **Presidential Gold Ginkgo** Width: 40 ft Zone 4 To 50 ft, broadly pyramidal; green in summer; yellow in fall; seedless.	 *Gymnocladus dioicus* 'Espresso' **Espresso Kentucky Coffee Tree** Width: 35 ft Zone 4 To 50 ft; oval canopy; compound green leaves; seedless cultivar; yellow in fall.	 *Liriodendron tulipifera* **Tulip Poplar** Width: 30 ft Zone 5 Oval canopy to 60 ft; 6–8 in. wide leaves; green in summer; yellow-orange in fall.	 *Metasequoia glyptostroboides* **Dawn Redwood** Width: 25 ft Zone 5 To 70 ft, green in summer; 1 in. long cones; orange in fall; deciduous.
 *Plantanus occidentalis* **American Sycamore** Width: 60 ft Zone 4 To 75 ft; rounded form; coarsely toothed three-lobed green leaves are; 1 in. ball-like fruit.	 *Tilia americana* **American Linden** Width: 30 ft Zone 3 To 80 ft; green foliage; pale yellow flowers; globose fruit.	 *Quercus coccinea* **Scarlet Oak** Width: 50 ft Zone 4 To 55 ft; broad spreading habit; green in summer, red in fall.	 *Quercus garryana* **Oregon White Oak** Width: 125 ft Zone 4 Towering to 90 ft; 6 in. rounded lobed leaves; gold in fall. **Native**
 *Quercus macrocarpa* **Bur Oak** Width: 45 ft Zone 3 A stout NW native with a large crown to over 55 ft; dark green summer foliage; yellow in fall.	 *Quercus palustris* **Pin Oak** Width: 40 ft Zone 4 To 55 ft; pyramidal form; leaves with 9 lobes each U-shaped; green in summer; scarlet in fall.	 *Quercus rubra* **Red Oak** Width: 45 ft Zone 4 To 50 ft; rounded canopy; dark green summer foliage; brilliant red fall foliage.	 *Ulmus americana* **Jefferson Elm** Width: 60 ft Zone 4 Vase shaped limbs to 70 ft; dark green leaves; yellow in fall; Dutch elm disease resistant.

Table 4. Conifers 25–50 feet

			
Chamaecyparis nootkatensis 'Pendula' **Weeping Alaska Cedar** Width: 15 ft Zone 4 To 45 ft; drooping branches; soft grey-green needles.	*Cupressus sempervirens* 'Stricta' **Italian Cypress** Width: 3 ft Zone 7 Narrow columnar form to 50 ft; scale like needles, 1 in. round cones.	*Juniperus virginiana* **Eastern Red Cedar** Width: 15 ft Zone 2 To 35 ft; has both awl and scale like needles; light blue berries.	*Picea pungens* 'Hoopsii' **Hoop's Blue Spruce** Width: 15 ft Zone 2 Pyramidal to 40 ft tall; 4–6 in. long cones; striking blue prickly foliage.
			
Pinus contorta **Shore Pine** Width: 30 ft Zone 3 Irregular form to 40 ft; 2–3 in. needles in pairs, needles; egg shape cones. **Native**	*Pinus flexilis* **Vanderwolf's Pyramid Pine** Width: 20 ft Zone 4 Rounded form to 40 ft; blue-green needles; 2.0–3.5 in. long green and white needles.	*Pinus thunbergii* **Japanese Black Pine** Width: 20 ft Zone 6 Pyramidal form when young; spreading form to 30 ft; striking 5 in. long erect terminal buds; dark green needles.	*Thuja plicata* 'Zebrina' **Zebrina Red Cedar** Width: 12 ft Zone 7 Pyramidal to 40 ft; bright green-golden variegated foliage; may scorch in hot regions.

Table 5. Conifers over 50 feet

			
Abies grandis **Grand Fir** Width: 25 ft Zone: 4 Can tower to 250 ft; 2-ranked needles; pleasing smell if crushed. **Native**	*Cedrus atlantica* **Blue Atlas Cedar** Width: 30 ft Zone 6 Pyramidal to 60 ft; horizontal branches; blue-green needles; upright barrel shaped cones.	*Picea pungens* **Colorado Blue Spruce** Width: 20 ft Zone 3 Broad formal pyramid to 60 ft; horizontal branches; blue-cast, stiff and prickly foliage.	*Pinus contorta var. latifolia* **Lodgepole Pine** Width: 20 ft Zone 3 Tall columnar form to 110 ft; needles 2.5 in. long in pairs; egg shaped cones. **Native**
			
Pinus ponderosa **Ponderosa Pine** Width: 35 ft Zone 3 Soars to 100 ft; 7 in. needles; 4–6 in. long cones; orange-brown bark. **Native**	*Pseudotsuga menziesii* **Douglas Fir** Width: 30 ft Zone: 5 Soaring to 200 ft; soft needles; reddish-brown bark; 4 in. long cones. **Native**	*Sequoiadendron giganteum* **Giant Sequoia** Width: 30 ft Zone 6, Over 100 ft; cord-like branches; wide trunk; thick bark; egg shaped cones.	*Thuja plicata* **Western Red Cedar** Width: 30 ft Zone 5 Pyramidal crown to 100 ft; pendulous foliage; reddish-brown bark. **Native**

UTC Conifers over 50 Feet

Table 5 lists seven different genera of very large conifers that exceed 50 feet at maturity. All of them are winter hardy for the majority of the state, other than the very northeast region. These large specimens are best suited to very large urban lots (over 10,000 square feet), schoolyards, greenbelts, highways, cemeteries, and natural areas (Kuhns 2012). All of these trees are highly drought tolerant and generally pest free. While they make stately specimens in the landscape, they also utilize a considerable amount of soil moisture and nutrients, and can cast dense shade making it difficult to raise shrubs, lawns, and gardens in their immediate vicinity. Grand fir grows extensively in western Washington from the coast to the Cascades. It is primarily a lowland species and can withstand wet sites (Foiles et al. 1990), but not those with alkaline soils. The Blue Atlas cedar makes a very large, wide-spreading specimen over time, with its nearly horizontal branches and blue-tinged needles. There are cultivars that don't get as wide, such as 'Fastigiata' and 'Aurea.' Colorado blue spruce is a forest conifer that grows naturally in the drier inter-mountain regions of the west (Petersen 2014). It is frequently used on the east side to block winter winds and trap snow.

Lodgepole pine grows best in the northern portions of Washington where conditions are cool and dry. It does not do well in competition with other species and is strictly shade intolerant. Ponderosa pine prefers the drier regions east of the Cascades, but can perform very well in the southwest corner of the state. It is best recognized by its long needles and thick orange bark. Douglas fir is the most widely grown native forest conifer in the state, eventually attaining heights of over 250 feet west of the Cascades and 125 feet east of the mountains. Giant Sequoia can also attain lofty heights (250 feet or more), retaining its nearly perfect pyramidal shape. Western red cedar is recognized by it pyramidal, buttressed base, and shiny dark green needles. It grows over the entire state of Washington, though it prefers moist, well-drained sites.

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Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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