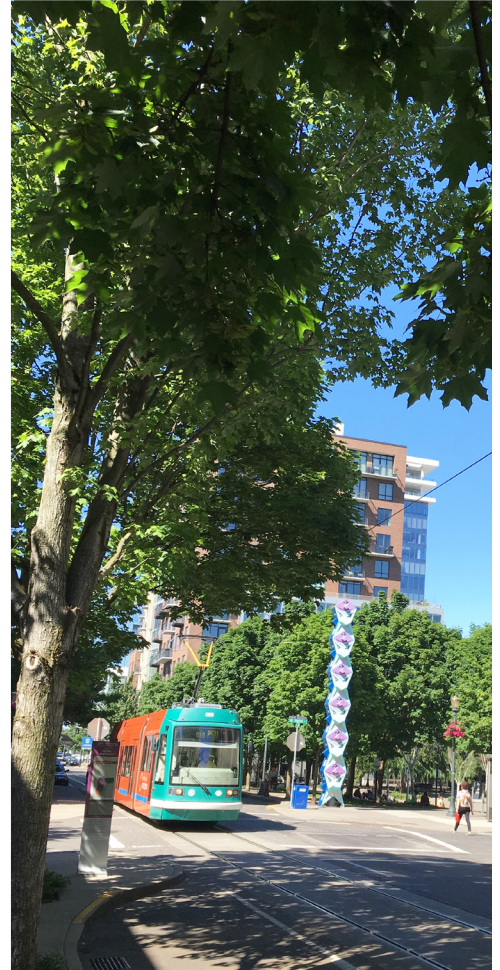




PORTLAND PARKS & RECREATION

Healthy Parks, Healthy Portland



Street Tree Inventory Report The Pearl District

June 2016

Street Tree Inventory Report: The Pearl District

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Cover Photos (from top left to bottom right):

- 1) The interesting, textured bark of a sycamore maple (*Acer pseudoplatanus*).
- 2) A flowering ash (*Fraxinus ornus*) fruiting profusely.
- 3) A Portland Streetcar on a tree-lined street in the Pearl District.
- 4) Sunlight on the flower of a sweetbay magnolia (*Magnolia virginiana*).
- 5) The distinctive fan-shaped foliage of a ginkgo (*Ginkgo biloba*).
- 6) A view of the Fremont Bridge through The Fields park.
- 7) Fragrant flowers clustered on a lilac tree (*Syringa reticulata*).
- 8) The leaf of a London planetree (*Platanus x acerifolia*), an uncommon sight in the Pearl.

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Portland Parks & Recreation Urban Forestry staff collected data on all 1,855 street trees within the Pearl District to compile the neighborhood's first complete street tree inventory.

Key Findings

This report provides the results of a street tree inventory conducted in the Pearl District in 2016, along with Portland Parks & Recreation (PP&R) Urban Forestry staff recommendations for the Pearl District. Staff collected data on each of the neighborhood's 1,855 street trees.

URBAN FOREST STRUCTURE

- **The Pearl's street tree population is dominated by red maple and Norway maple and does not meet recommended species diversity guidelines.** While 38 tree types were found in this inventory, the *Acer* (maple) genus accounts for over half of the street tree resource, leaving the Pearl's street tree population vulnerable to pests, pathogens, and effects of a changing climate.
- **The dominance of broadleaf deciduous trees (98%) points to a need to plant more evergreen trees for year-round benefits and to help create a more resilient, sustainable urban forest.**
- **The Pearl District lacks enough young trees to adequately replace declining older trees.** Plantings are needed to increase the proportion of young trees to ensure that as mature trees decline, they are replaced by maturing younger trees, thus keeping canopy benefits continuous over time.
- **Sixty percent of trees are on their way to maturity and are sized between 6" and 18" DBH.** These trees have survived the establishment period and should be monitored and maintained to ensure they reach maturity and to reduce future maintenance costs.
- **Only 16% of the Pearl's street trees are large form varieties.** Large form trees are necessary to increase canopy cover and the benefits they provide for the Pearl's residents. Planting the estimated 158 large and medium available spaces identified in this inventory will maximize tree canopy in the Pearl.

TREE CONDITION

- **The majority of trees inventoried in the Pearl are in fair or good condition, however, 65% of the trees that are rated poor are in the *Acer* genus.**

PLANTING SITES AND STOCKING LEVEL

- **Only 79% of street tree planting sites have trees in the Pearl.** Planting efforts should focus on the large and medium sites first, as large and medium form trees will provide the most long-term benefits to the neighborhood.
- **Increasing current canopy levels will require planting trees outside of the existing right-of-way spaces.** Available right-of-way sites may not be enough to equitably distribute canopy in the Pearl. Creative expansion of planting sites or increased planting in parks, private property and parking lots may be the only ways to increase canopy much above the current level of 8%.

URBAN FOREST VALUE AND BENEFITS

- **The Pearl's street trees produce an estimated \$329,443 annually in environmental and aesthetic benefits.** The replacement value of this resource is \$4.8 million. Planting efforts focused on appropriately sized trees distributed across the neighborhood will ensure that future benefits are equitably distributed among all residents.



*Clockwise from top left: 1) Cutouts are the most common planting site for trees in the Pearl, which is a challenge for providing adequate space for large form trees. This limits the potential for canopy growth in the neighborhood. 2) Poor condition trees like these Norway maples (*Acer platanoides*) should be monitored individually and evaluated for replacement. 3) At 52.7" DBH, this elm (*Ulmus* sp.) is the largest diameter street tree in the Pearl District. 4) A row of mature katsura (*Cercidiphyllum japonicum*) provides shade for pedestrians and adds diversity to the Pearl's urban canopy.*

About Portland's Street Tree Inventory

THE IMPORTANCE OF STREET TREES

Street trees are an important public asset in urban environments, serving as a buffer between our transportation corridors and our homes while enhancing the livability of our city. As integral components of a community's green infrastructure, street trees provide multiple economic, environmental, and social benefits such as cleaner air and water, cooler summer temperatures, safer streets, and increased property values. Unlike traditional, "grey" infrastructure, which begins to deteriorate the moment it is installed, the benefits that street trees provide increase over the lifetime of the tree, making their planting and maintenance one of the best investments a city and its residents can make.

While street trees are only one component of Portland's urban forest, they are particularly important because they are the trees that residents interact with most. Having adequate information about the street tree population allows a community to make informed decisions about species selection, planting, and maintenance priorities. Information on the location, condition, and diversity of the street tree population enables our communities to steward this resource and ensure its continued benefits into the future. Undertaking a street tree inventory is not only an investment in the current and future well-being of the trees, but in the community itself.

THE INVENTORY PROCESS

Portland's Tree Inventory Project began with a pilot street tree inventory in 2010, and since then many neighborhoods have partnered with Urban Forestry to inventory street trees and create action-oriented Neighborhood Tree Plans. By the end of 2016, volunteers will have identified, measured, and mapped more than 220,000 street trees! Neighborhood groups interested in trees begin by gathering volunteers to help conduct an inventory. Urban Forestry staff provides training, tools, and event organization. Together information is collected on tree species, size, health, site conditions, and available planting spaces.

Urban Forestry staff analyze data for each neighborhood and present findings to stakeholders at an annual Tree Summit in November. At the summit, neighborhood groups begin developing tree plans that set achievable strategies to improve existing trees, expand tree canopy, and connect the neighborhood with City and nonprofit resources. The resulting Neighborhood Tree Plan is based on the status and health of street trees and recommends specific actions to improve and expand this resource. Urban Forestry then partners with groups to organize stewardship events, including pruning, planting, and educational workshops.

The Tree Inventory Project supports Portland's *Urban Forest Management Plan* goals: to manage the urban forest in order to maximize community benefits for all residents; to develop and maintain support for the urban forest; and to protect, preserve, restore, and expand Portland's urban forest.

Urban forests are complex, living resources that interact both positively and negatively with the surrounding environment. They produce multiple benefits and have associated management costs. In order to fully realize the benefits, a sound understanding of the urban forest resource is needed. This understanding starts at the most basic level with a forest inventory to provide baseline data for management decisions.

Neighborhood tree teams and volunteers are the backbone of this inventory. This partnership between residents and government is key to successful management of street trees in Portland, where Urban Forestry regulates street tree removal, planting, and maintenance through a permitting process, and property owners are responsible for the care and maintenance of trees. Creating a healthy urban forest depends on the active engagement of residents to care for their street trees.

If you would like to get involved with the Pearl's urban forest, contact the Pearl District Neighborhood Association by visiting <http://www.pearldistrict.org/> or contact Urban Forestry.

Data from the inventory are available to the public in spreadsheet or ArcGIS format. Visit the Tree Inventory Project website at <http://portlandoregon.gov/parks/treeinventory> to learn more about the project and download reports, data, and maps.



Clockwise from top left: 1) A linden (Tilia sp.) is impacted during construction. Retaining large trees during development is necessary to ensure their continued contribution to the urban forest. 2) Kentucky coffeetree (Gymnocladus dioica) is an attractive, fast-growing, drought tolerant street tree that is now being planted more often in Portland. 3) Many streets in the Pearl District lack street trees or planting spaces; creation of new cutouts or strips is needed before trees can be planted.



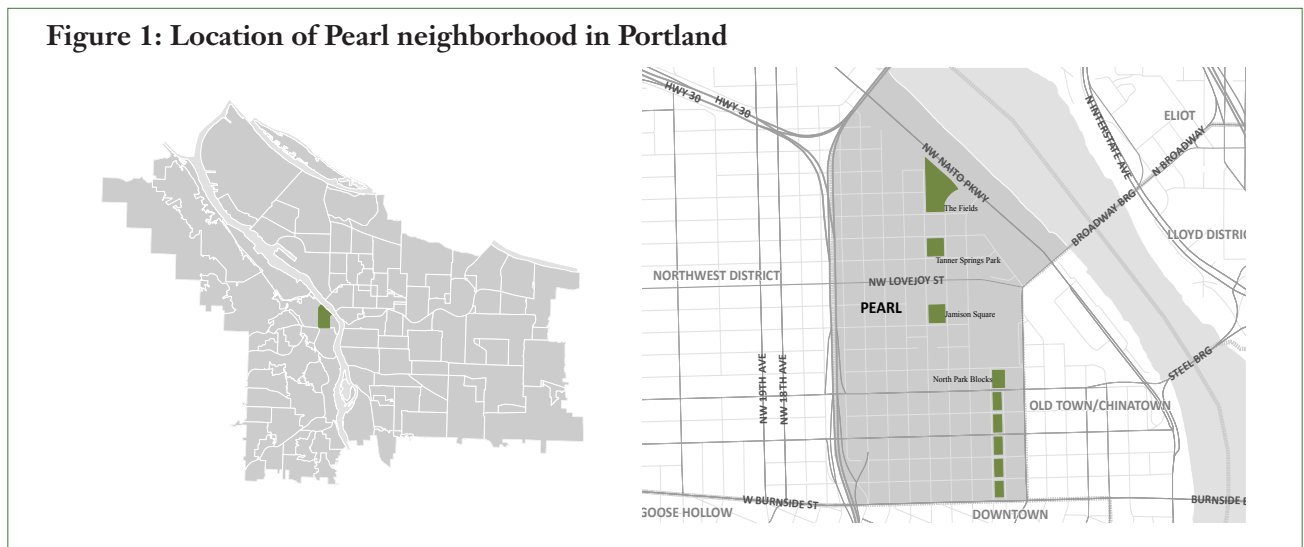
Pearl Street Tree Inventory

Neighborhood Characteristics

A neighborhood's history and land use have an important effect on the presence and condition of street trees and the urban forest. Over time, different development patterns have been more or less favorable to street trees. Areas of Portland's neighborhoods that were designed without the inclusion of street trees or with small planting spaces limit the potential for street trees. With redevelopment of areas and new designs that include adequate space for trees, there is opportunity for increased use of street trees to expand overall tree canopy. Because care and maintenance of Portland's street trees is the responsibility of the adjacent property owner, rates of homeownership and income level also influence the presence and condition of trees in a neighborhood, as the cost of proper maintenance over a tree's lifetime can be a barrier to planting and care.

The Pearl District is a small neighborhood located within the Willamette River watershed in northwest Portland (Figure 1). The Pearl neighborhood boundaries are the Fremont Bridge to the north, W Burnside Street to the south, I-405 to the west, and NW Broadway to the east.

Figure 1: Location of Pearl neighborhood in Portland



The Pearl District is a young neighborhood, established as a neighborhood association under the current name in 1991. The Pearl was originally an industrial area, settled in the 1860s. After zone reclassification in the 1980s, the neighborhood has evolved into a dense, walkable, residential community – the epitome of urban renewal.

The Pearl is a mix of high-rise condominiums and warehouse conversions, art galleries, bars, and restaurants, easily accessible by foot, bike, or public transportation. Parks in the neighborhood include The Fields, Tanner Springs Park, Jamison Square, and the North Park Blocks. Major employers include the US Post Office, REI, and Powell's Books.

Tree canopy covers 8% of the Pearl, well below Portland's citywide canopy level of 29% (Metro 2016). The Pearl's population density is higher than citywide averages at 21 persons per acre (Table 1). Home ownership is lower than citywide averages, as 36% of homes in the Pearl are owner-occupied. Forty-nine percent of households are considered low-income which is slightly higher than citywide averages.

Table 1: Neighborhood and citywide demographics

Demographics (2010 Census)	Pearl	Portland
Area	285 acres	85,376 acres
Population	5,997	583,776
Density	21 persons/acre	7 persons/acre
Race	82% white, 2% black, 4% Hispanic/Latino, 1% Native American, 7% Asian, 0% Pacific Islander, 3% mixed race	72% white, 6% black, 9% Hispanic/Latino, 1% Native American, 7% Asian, 1% Pacific Islander, 4% mixed race
% of properties occupied by homeowners	36%	54%
% of low income households	49%	45%

Urban Forest Composition

SPECIES DIVERSITY AND TREE TYPE COMPOSITION

A diverse tree population in terms of species, age, form, and function maximizes urban forest benefits through time while minimizing costs and risk. Maintaining a diverse species mix is a critical way to promote a healthy and resilient urban forest. The conventional metric for evaluating urban forest species diversity is the 10-20-30 rule (Santamour 1990), according to which the urban forest population consists of no more than 10% of one species, 20% of one genus, or 30% of one family. However, this guideline has been found to be inadequate in some cases, leaving cities vulnerable to catastrophic forest loss due to pests and pathogens (Raupp et. al 2006). Considering Portland’s temperate climate, where a great variety of trees are able to thrive, limiting this to 5-10-20, as other progressive urban forestry programs have, should be the goal. Trees were identified to the genus or species level and categorized as “tree types” (Appendix A).

Results

The Pearl’s public rights-of-way host a wide variety of tree types. The street tree population consists of 1,855 trees of 38 types (Appendix B). Red maple is the most common tree type, representing 33.4% of all street trees (Table 2). Norway maple, pear, and hornbeam are also common, representing 20.2%, 9.9%, and 6.7% of trees, respectively. The most common 15 tree types comprise 95% of the resource, leaving the remaining tree types to each represent 0.6% or less of the street tree population.



A row of red maples (Acer rubrum), which are the most abundant street tree type in Pearl.

Thirty-three genera are represented in the neighborhood. The *Acer* genus comprises a significant portion of the resource at 54.5%, followed by *Pyrus* at 9.9% (Figure 2). All other genera each comprise 6.7% of the resource or less.

Twenty families are represented in the neighborhood and the ten most abundant families comprise 96% of the resource (Table 3). Sapindaceae and Rosaceae are the most common families and represent 54.8% and 11.5% of trees, respectively. All other families represent 6.8% or less of the resource each.

The Bottom Line

The Pearl does not meet the 5-10-20 guideline. Of most concern is the *Acer* genus, which has over five times the recommended percentage for a single genus. Furthermore, more than half of all trees belong to the Sapindaceae family.

Loss of street trees can have significant impact at the neighborhood scale. Increasing diversity at the genus and family level can help reduce risk and expense due to the introduction of Asian longhorned beetle, emerald ash borer, or other potential pests and pathogens which predominately attack only select genera. To illustrate impact from pests, vulnerable tree types are mapped (Appendix D). Nearly 63% of all trees in the Pearl are susceptible to emerald ash borer, Asian longhorned beetle, Dutch elm disease, or bronze birch borer.

Table 2: The 15 most abundant street tree types in Pearl

Common Name	Scientific Name	# of Trees	% of Total	Mean DBH
maple, red	<i>Acer rubrum</i>	617	33.4%	8.8
maple, Norway	<i>Acer platanoides</i>	374	20.2%	11.3
pear	<i>Pyrus</i> spp.	183	9.9%	7.9
hornbeam	<i>Carpinus</i> spp.	123	6.7%	10.7
oak, deciduous	<i>Quercus</i> spp.	77	4.2%	8.1
ash	<i>Fraxinus</i> spp.	72	3.9%	5.9
zelkova	<i>Zelkova serrata</i>	71	3.8%	5.0
ginkgo	<i>Ginkgo biloba</i>	68	3.7%	4.2
linden	<i>Tilia</i> spp.	48	2.6%	10.7
elm	<i>Ulmus</i> spp.	31	1.7%	23.5
honey locust	<i>Gleditsia triacanthos</i>	22	1.2%	4.5
Western redcedar	<i>Thuja plicata</i>	21	1.1%	14.1
katsura	<i>Cercidiphyllum japonicum</i>	19	1.0%	13.2
cherry	<i>Prunus</i> spp.	15	0.8%	8.4
tupelo	<i>Nyssa</i> spp.	14	0.8%	2.9
all other		92	5.0%	8.1
Total		1,847	100.0%	9.2

Figure 2: The 15 most abundant street tree genera in The Pearl, with recommended maximum (10%) in red

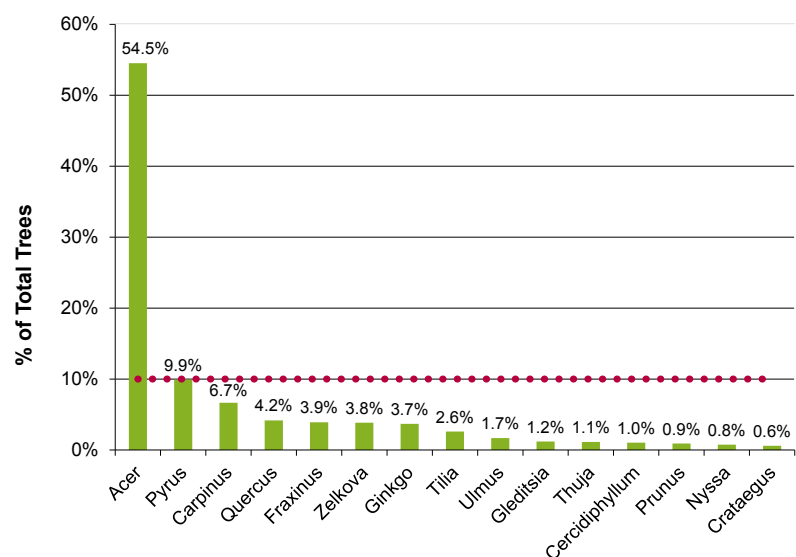


Table 3: The 10 most abundant tree families in Pearl

Family Scientific Name	Tree Types Included in the Family	# of Trees	% of Total
Sapindaceae	golden rain tree, maple	1,013	54.8%
Rosaceae	cherry, crabapple, hawthorn, mountain-ash, pear, plum	213	11.5%
Betulaceae	hornbeam, hophornbeam	125	6.8%
Ulmaceae	elm, zelkova	102	5.5%
Fagaceae	beech, oak (deciduous)	85	4.6%
Oleaceae	ash, lilac tree	77	4.2%
Ginkgoaceae	ginkgo	68	3.7%
Malvaceae	linden	48	2.6%
Cupressaceae	cypress, false cypress, Western redcedar	23	1.2%
Leguminosae	honey locust, Kentucky coffeetree	23	1.2%
all other		70	3.8%
<i>Total</i>		<i>1,847</i>	<i>100.0%</i>

FUNCTIONAL TREE TYPE

Trees are categorized into functional types: broadleaf, conifer, or palm and either deciduous or evergreen. In Portland, where the majority of precipitation falls in winter, evergreens reduce storm water runoff during these wet months, improving water quality in our streams and rivers when this function is most needed. During the dry summer months, many evergreen conifers are less reliant on water availability than broadleaf deciduous trees which require more water to drive photosynthesis. Despite their advantages, conifers are challenging to place in rights-of-way, as they typically require larger spaces and their growth form conflicts with overhead wires and traffic sightlines.

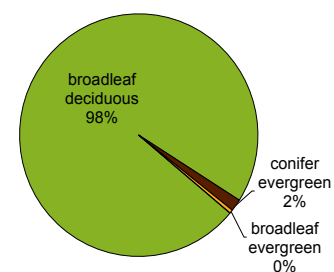
Results

Broadleaf deciduous trees dominate the landscape, accounting for 98% of all street trees in the Pearl (Figure 3). Coniferous evergreens comprise the remaining 2% of the Pearl's street trees.

The Bottom Line

The street tree population is dominated by broadleaf deciduous trees. Increasing use of evergreens, both broadleaf and conifer, would enhance certain benefits including reduced storm water runoff, and also provide winter cover and habitat for urban wildlife. Though conifers still need adequate water during establishment, in general they require less water than broadleaf deciduous trees during the increasingly warm and dry Portland summers. Large planting sites without overhead wires provide an opportunity for planting these important trees.

Figure 3: Functional tree types



SIZE CLASS DISTRIBUTION

Age diversity ensures the continuity of canopy coverage and benefits through time. Although various tree species have different lifespans and mature at different sizes, older trees will generally have a larger size, as measured by diameter at breast height (DBH). As trees increase in size and age, the value of the tree and the

magnitude of the benefits that the tree provides also increase until the tree nears the end of its lifespan and begins to decline.

The general management principle underlying size class distribution is to maintain a consistent proportion of young trees in the population—recognizing that there will be some level of mortality as trees grow—while also keeping a good distribution of mid to large sized trees. This will ensure a sustainable age class structure and produce maximum urban forest benefits over time.

Trees were categorized into diameter size classes (Figure 4; Appendices C, E, F). Trees that are 0" to 6.0" in diameter represent young trees. Trees that are 6.1" to 18" in diameter represent midlife trees, as well as mature, small form trees. Trees that are 18.1" or greater in diameter represent mature trees.

Results

The Pearl's streets host a wide range of tree sizes from the smallest sapling to the largest tree, a 52.7" DBH elm (*Ulmus* spp.). In the Pearl, the greatest proportion of trees is in the mid-size diameter classes. Small trees under 6.0" DBH account for nearly one third of the neighborhood inventory, while mid-size trees with DBH between 6.1" and 18.0" represent 60.7% of trees. Only 6.4% are larger than 18.1" DBH (Figure 4).

Of tree types that represent at least 0.5% of the population, the types with the largest average size DBH are poplar and elm, with mean DBH of 28" and 23.5", respectively (Appendix B).

The Bottom Line

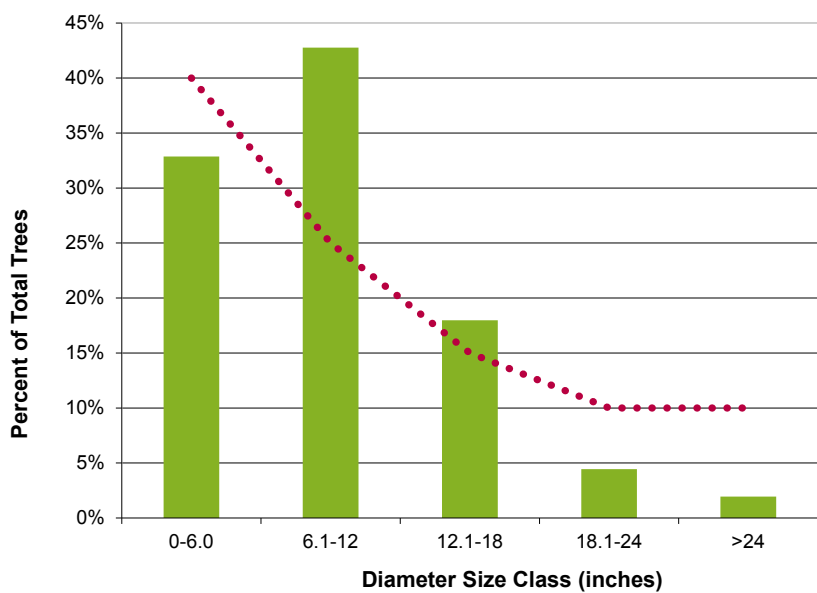
The Pearl District lacks enough young trees to adequately replace declining older trees. Plantings are needed to increase the proportion of young trees to ensure that as mature trees decline, they are replaced by maturing younger trees, thus keeping canopy benefits continuous over time. With almost two-thirds of all trees in the mid-size diameter size

classes, special attention should be paid to ensure their health and longevity. Typically trees in this size class require the least amount of maintenance, but in a high traffic, urban setting such as the Pearl, monitoring for pruning needs, defects, and infrastructure conflicts is beneficial. Lastly, preservation and maintenance of mature trees is key to keeping this small population as productive members of the urban canopy.

MATURE TREE FORM DISTRIBUTION

Mature tree size is determined by the height, canopy width, and general form of the tree at maturity; tree types are classified as small, medium, or large. Generally, small trees grow to 30' in height, medium trees

Figure 4: Trees by diameter size class, with ideal distribution in red



grow to 50' in height, and large trees grow more than 50' in height (Figure 5). Large form trees also have the potential for greatest longevity, living longer than most small form trees.

While some neighborhoods, due to their design, may not have many spaces big enough to accommodate large form trees, it is important that the spaces that do exist are planted with trees that will grow to be large at maturity. The cost to a community of under planting large spaces can be great over the course of a tree's lifetime. Research has shown that while small and large form trees have similar annual costs of care and maintenance, a large form tree will live four times longer on average and provide over 16 times the benefits over its lifetime (CUFR 2006). In the case of certain benefits, the disparity is much greater; for example, large trees have been found to remove 60-70 times more air pollution annually than small trees (Nowak 1994).

Results

Small form trees account for 2% of the resource, medium form trees account for 82% of the resource, and large form trees account for 16% of the resource (Figure 6) in the Pearl.

The Bottom Line

Long lived and large form trees provide substantially more benefits than small and medium form trees. Therefore, planting trees that will be large at maturity helps to ensure that canopy cover and its benefits will be maintained or enhanced even as some trees die or are removed. The Pearl's most common large form tree types include deciduous oak, ginkgo, and linden. Planting, maintenance, and care for young, large form trees will ensure that when they reach maturity, they will provide the most benefits to the community and the environment.

IMPORTANCE VALUE

Another way to evaluate how reliant a community is on a single tree type is importance value. Importance value is a calculation based on relative abundance and relative leaf area. In other words, it accounts for how many trees of the type there are and how much of the neighborhood's canopy they represent at the time of inventory. The value informs us which tree types dominate the urban forest structure. For example, a tree type might represent 10% of a population, but have an importance value of 25 because of its large average size. Conversely, another tree type representing 10% of the population may only have an importance value of 5 if it represents young or small form trees.

Importance values tell us which tree types provide the bulk of the benefits for a particular snapshot in time and will change through time as trees grow and species composition changes. Reliance on only a few tree types of high importance value is risky, as loss from a pest, pathogen, or a catastrophic event may put excessive strain on the urban

Figure 5: Tree form sizes

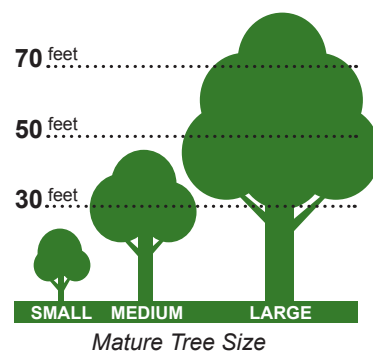
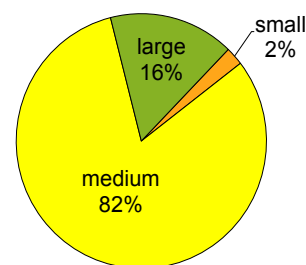


Figure 6: Mature tree size



Red maple (Acer rubrum) has the highest importance value of all tree types in Pearl due to overabundance.

forest even though only a single tree type may be affected.

Importance values were calculated using iTree Streets, an urban forest analysis software suite developed by the USDA Forest Service.

Results

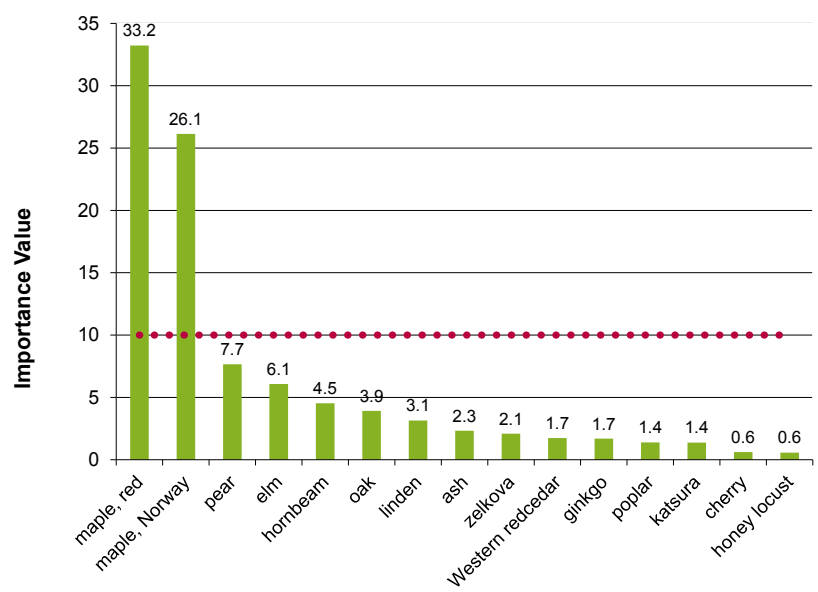
Red maple and Norway maple have the highest importance values of 33.2 and 26.1 respectively (Figure 7). Thus, the Pearl's urban forest is reliant on these two species due to their current size and abundance in the neighborhood. The next highest importance values are for pear at 7.7, elm at 6.1, and hornbeam at 4.5. All other tree types had importance values of 3.9 or less.

The Bottom Line

Trees with the highest importance values, such as red maple and Norway maple, should be de-emphasized in future plantings to ensure that the street tree population is less susceptible to loss from a pest or pathogen impacting those tree types. The Pearl's heavy reliance on these tree types in the present means that their loss would have a serious impact on the neighborhood's urban forest. Increasing the level of maintenance of these large, mature trees will help prolong their lifespan, reduce hazards, and keep these high value members of the urban forest contributing to the neighborhood.

The Pearl is highly reliant on red and Norway maple, which exceed Urban Forestry's recommended maximum importance value. The City no longer permits planting of Norway maple as a street tree because the species is considered invasive, and red maple is not permitted because of overabundance. Without continued planting, the populations of Norway and red maple will fall over time.

Figure 7: Tree types with the highest importance values, with recommended maximum (10) in red



Tree Condition

The urban environment is a challenging place for trees to thrive because of limited growing space, compacted soil, poor air quality, and direct damage from vehicles and pedestrians. Tree condition reflects species hardiness, site conditions, and maintenance history. Street trees that are well suited to Portland's climate are able to withstand the challenges of growing in an urban environment, and have been well maintained, are generally the most successful.

Tree condition was assessed by assigning trees to one of four categories: good, fair, poor, or dead. These general ratings reflect whether or not a tree is likely to continue contributing to the urban forest (good and fair trees) or whether the tree is at or near the end of its life (poor and dead trees). Because it was subjective to

determine the difference between good and fair ratings, these categories are reported together.

Results

The majority of street trees in the Pearl, 93%, are in good or fair condition, while 6.6% are poor and 0.4% of trees are dead (Figure 8, Appendix G).

Of the most commonly found tree types, the healthiest trees are ash, ginkgo, and tupelo, of which 100% are rated good or fair (Table 4). In poorest condition are katsura, cherry, and Norway maple, of which, 21.1%, 20%, and 13.6% are rated poor, respectively. Interestingly, 65% of all trees in the Pearl District that are rated poor are in the *Acer* genus.

The size class with the greatest percentage of trees in poor condition were those with a DBH between 6.1” and 18.0”, with nearly two-thirds of all trees rated poor falling into this range. While larger, more mature trees naturally decline with age, preventative maintenance including proper pruning (e.g., not topping) can extend their lifespan and reduce risk of failure.

The Bottom Line

Large trees in poor condition pose the biggest potential risk of failure (i.e., falling apart). Proper early maintenance on young trees, such as structural pruning, is much less expensive than attempting to correct issues in larger trees that have been maintained improperly. Important maintenance activities for young trees include structural pruning to remove co-dominant leaders and pruning trees for branch clearance over sidewalks and roadways to reduce the likelihood of branches being hit by vehicles. Though only a small portion of the street trees in the Pearl are in poor condition, a substantial proportion of Norway maples are in poor and declining condition. Furthermore, Norway maple is in the Sapindaceae family which is over represented in the Pearl and therefore replacement of these trees represents a great opportunity to improve the Pearl’s urban forest. All poor rated trees should be monitored and individually evaluated for potential risk and replacement opportunities.

Figure 8: Tree condition

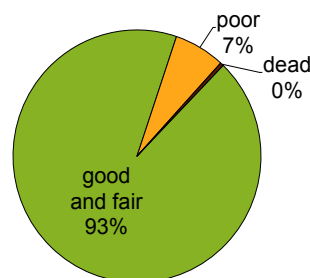


Table 4: Tree condition for the most abundant tree types

Common Name	Scientific Name	% of Total (# of Trees)	
		Good/Fair	Poor
ash	<i>Fraxinus</i> spp.	100% (72)	0% (0)
cherry	<i>Prunus</i> spp.	80% (12)	20% (3)
elm	<i>Ulmus</i> spp.	96.8% (30)	3.2% (1)
ginkgo	<i>Ginkgo biloba</i>	100% (68)	0% (0)
honey locust	<i>Gleditsia triacanthos</i>	95.5% (21)	4.5% (1)
hornbeam	<i>Carpinus</i> spp.	98.4% (121)	1.6% (2)
katsura	<i>Cercidiphyllum japonicum</i>	78.9% (15)	21.1% (4)
linden	<i>Tilia</i> spp.	97.9% (47)	2.1% (1)
maple, Norway	<i>Acer platanoides</i>	86.4% (323)	13.6% (51)
maple, red	<i>Acer rubrum</i>	95.5% (589)	4.5% (28)
oak, deciduous	<i>Quercus</i> spp.	94.8% (73)	5.2% (4)
pear	<i>Pyrus</i> spp.	91.8% (168)	8.2% (15)
tupelo	<i>Nyssa</i> spp.	100% (14)	0% (0)
Western redcedar	<i>Thuja plicata</i>	95.2% (20)	4.8% (1)
zelkova	<i>Zelkova serrata</i>	98.6% (70)	1.4% (1)

Planting Site Composition and Stocking Level

Planting site composition varies greatly amongst neighborhoods and this directly impacts a neighborhood’s capacity for growing large trees that provide the most canopy coverage and benefits. While some

neighborhoods are lucky enough to have inherited wide planting sites and mature trees, many areas of Portland struggle to establish tree canopy in small planting sites, which are challenging spaces for trees to grow due to limited soil and growing space. Understanding a neighborhood's composition and distribution of planting sites allows for a more strategic tree planting effort and informs us of potential challenges to tree planting and tree development within the right-of-way.

PLANTING SITES

Street trees grow in a diverse array of planting sites ranging from traditional grassy strips between curbs and sidewalks, to concrete cutouts, and unimproved areas without curbs or sidewalks. Tree growth is limited by site width; wider sites provide more soil to support growth and more space aboveground to reduce conflicts with sidewalks and streets. Overhead high voltage wires limit the height of trees, as trees will be pruned away from wires for safety.

Planting site sizes are categorized as small, medium, or large based on the width of the planting site and presence of overhead wires. These categories reflect the mature tree size that can be supported by the site. In other words, small planting sites can support small trees such as dogwoods and snowbells and large planting sites can support large trees such as oaks and elms. Improved planting sites (i.e., with curbs and sidewalks) generally have a clearly defined width while unimproved sites (i.e., without curbs and sidewalks) do not.

Results

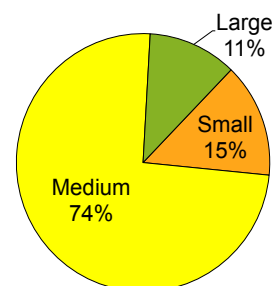
Most street trees in the Pearl District are found in improved rights-of-way sites with only 1% situated in unimproved rights-of-way (Table 5, Appendix H). Cutouts are the most common tree planting site representing 84% of site types.

In the Pearl, 15% of planting sites where street trees are found are small, 74% are medium, and 11% are large sites (Figure 9).

Table 5: Planting site types

Site Type		# of Trees	% of Total
improved sites	curbtight	113	6.1%
	cutout	1,564	84.3%
	median	3	0.2%
	strip	146	7.9%
	swale	10	0.5%
	<i>Improved Totals</i>	<i>1,836</i>	<i>99.0%</i>
unimproved sites	curb only	19	1.0%
	<i>Unimproved Totals</i>	<i>19</i>	<i>1.0%</i>
Overall		1,855	100.0%

Figure 9: Planting site sizes



STOCKING LEVEL

Street tree stocking level reflects the percentage of planting spaces that are currently occupied by trees. In Portland, trees are more likely to be planted in large planting sites and improved planting sites. Because this project did not inventory all available planting sites, but only sites where trees are currently growing, data for planting site sizes were supplemented with available planting space data collected by Urban Forestry and the Bureau of Environmental Services (BES) staff between 2009 and 2016 (See Appendix A for methods).

Results

Ideally, stocking level should be near 100%. The Pearl's stocking level is 79% (Table 6). According to the BES data, 415 empty spaces have been identified for tree planting (Appendices J and K). Stocking levels are highest in medium sites. Taxlots with multiple frontages may have variously sized planting sites associated with the address and are therefore uncategorized. Depending on the number of such properties within a given neighborhood, stocking level data may not provide detailed information on the types of sites available for planting. In the Pearl, improved uncategorized sites, which includes large sites, are at least 80% stocked.

Table 6: Street tree stocking level

Size Type	Size Size	Planting Site Description	Stocking Level	Available Planting Spaces
improved sites	small	3.0 - 3.9' with or without wires	62%	91
	medium	4.0 - 5.9' with or without wires, ≥6.0' with wires	84%	55
	uncategorized	≥6.0' without wires, and multiple frontages	81%	269
	Improved Site Totals		55%	3,572
Total			79%	415

RIGHT TREE IN THE RIGHT PLACE

Selecting an appropriately sized tree for the site is important for maximizing benefits and minimizing avoidable costs. A tree well suited to its location has fewer obstacles to reaching maturity which maximizes the benefits it provides the community and environment over its lifetime. However, an inappropriately sized tree may cost more to maintain, be less healthy, and have a shorter lifespan thereby providing fewer benefits.

A small form tree planted in a large planting site is a missed opportunity because larger trees contribute many times more benefits than do smaller ones. Planting these sites and replacing undersized trees is especially important in neighborhoods that contain few large planting sites to begin with. Although permits and appropriate species selection are required to plant street trees, historically trees may have been planted without regard to appropriate tree selection.

Results

Overall, 69% of trees are planted in sites that are the appropriate size for their type (Table 7). Eight percent of all trees are too small for their planting site, and 23% of trees are too large for their site. Looking closer at only the large sites, 61% of trees are undersized for the site.

Table 7: Tree form fit in planting sites

Fit	% of trees	# of trees
Tree form is too small for the site	8%	150
Tree form is appropriate size for the site	69%	1273
Tree form is too big for the site	23%	432
Total	100%	1,855

The Bottom Line

Planting all available sites with appropriately sized trees will ensure that trees live to maturity at the least cost to homeowners and the community. Because of the importance of large trees to the urban forest, planting large, empty spaces should be a tree team's top priority, followed by replacing poor condition, undersized trees in large planting sites. In the Pearl, this includes an estimated 269 uncategorized sites and 10 poor condition, undersized trees in large planting spaces. Planting these spaces would yield over 22 acres of potential canopy in 30 years (Appendix A, Figure 10). These benefits are almost 10 times greater than if small trees are planted in these large sites.

How would planting all available spaces impact the Pearl's canopy? Planting all sites would provide 25 additional acres. Furthermore, if all of the currently undersized trees in large planting spaces had been planted with large form trees, this would add another six acres of potential canopy. Combined, taking these actions would more than double the Pearl's canopy cover!

Replacement Value

Replacement value is an estimate of the full cost of replacing a tree at its current size and condition, should it be removed for some reason. Replacement value is calculated using the tree's current size, along with information on regional species ratings, trunk diameter, and replacement costs. Replacement values were calculated using iTree Streets. Replacement values are generally highest for the largest, more abundant tree types.

Results

The replacement cost of the Pearl's street tree population is valued at \$4.8 million (Figure 11). The most valuable size classes of trees are 12.1"–18" DBH. Because value increases with the size of the tree, even though trees that are between 12.1" and 18" DBH only make up 18% of the population, they account for 34% of the total replacement value. The tree types with the greatest replacement values are red maple (\$1.5 million), and Norway maple (\$1.2 million). These two tree types account for 56% of the total replacement value.

The Bottom Line

Similar to importance value, high replacement values are both a function of the abundance and size of an existing tree type and do not necessarily represent tree types that should be planted in the future.

Figure 10: Potential acres of tree canopy from planting

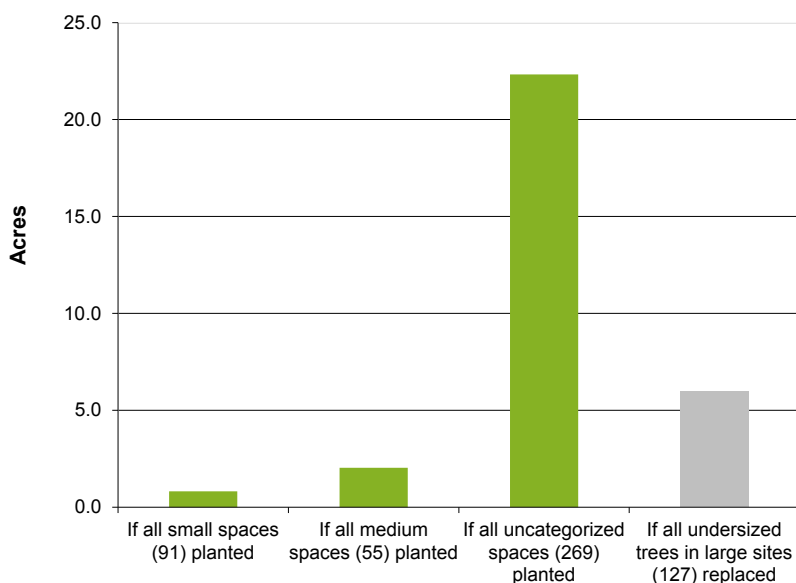
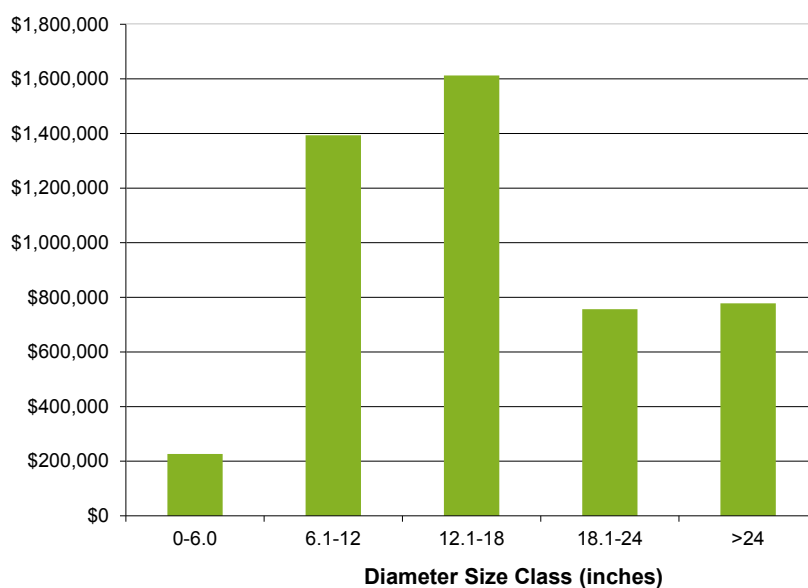


Figure 11: Replacement values by diameter size class



Healthy, diverse, and resilient urban forests have high replacement values as a whole with no one tree type representing a disproportionate amount. In the Pearl District, de-emphasizing tree types that are already over represented in the population will decrease vulnerability to pests and pathogens in the future. The high replacement value for the Pearl's largest trees shows the need to care for and protect the largest, most valuable trees in the neighborhood.

Environmental and Aesthetic Benefits

The amount of environmental and aesthetic benefit a tree may provide over its lifetime is a function of its mature size and longevity. Trees with a larger mature size and longer lifespan such as Douglas-fir or oak will provide significantly greater benefits than small ornamental trees such as dogwoods or snowbells. The calculation indicates the benefits that trees currently provide: as trees grow and the population changes, benefits derived from the various tree types will change within a neighborhood.

The Pearl's street tree population was assessed to quantify the dollar value of annual environmental services and aesthetic benefits provided by trees: aesthetic/property value increase, air quality improvement, carbon dioxide reduction, energy savings, and storm water processing. Calculations were made using iTree Streets. The iTree model relies on tree size and species from the inventory, as well as Portland's current pricing for electricity and natural gas, regional benefit prices for air quality, regional storm water interception costs, and the neighborhood's median home resale value (Zillow 2016).

Results

The Pearl's street trees provide approximately \$329,443 annually in environmental services and aesthetic benefits (Table 8). An average tree in the Pearl provides \$178 worth of benefits annually.

Large form trees produce more benefits on average than smaller trees. Of the most common tree types, elm and deciduous oak provide the highest annual benefits per tree, at approximately \$269 - \$362 per tree (Table 9). Western redcedar and Norway maple also provide a high level of annual benefit between \$232 and \$249. Tupelo and ginkgo provide the least amount of benefits, ranging from \$54 to \$74 annually.



A large form tree like this elm (Ulmus sp.) provides many times more benefits over its lifetime than a smaller form tree would.

Table 8: Valuation of annual environmental and aesthetic benefits

Benefits	Total (\$)	Total (\$) per tree
Aesthetic/Other	\$248,118	\$133.76
Air Quality	\$2,753	\$1.48
CO ₂	\$1,177	\$0.63
Energy	\$43,876	\$23.65
Stormwater	\$33,519	\$18.07
Total	\$329,443	\$177.60

Table 9: Average annual environmental and aesthetic benefits provided by Pearl's most abundant street tree types

Tree Type	Aesthetic/ Property Value	Air Quality	CO ₂ Reduction	Energy Savings	Stormwater Processing	Total (\$) per tree
elm	\$184.32	\$5.89	\$1.57	\$84.52	\$85.63	\$361.93
oak, deciduous	\$228.83	\$1.41	\$0.80	\$23.22	\$15.25	\$269.50
Western redcedar	\$159.54	\$2.27	\$0.81	\$38.73	\$47.75	\$249.10
maple, Norway	\$182.37	\$2.04	\$1.01	\$32.70	\$25.99	\$244.13
linden	\$183.96	\$1.70	\$0.72	\$27.85	\$23.15	\$237.38
katsura	\$167.58	\$1.57	\$0.87	\$36.10	\$26.22	\$232.34
maple, red	\$146.59	\$1.59	\$0.58	\$25.54	\$17.31	\$191.61
ash	\$93.07	\$0.61	\$0.36	\$9.50	\$6.74	\$110.28
hornbeam	\$85.98	\$0.67	\$0.23	\$11.54	\$9.16	\$107.59
pear	\$55.44	\$1.47	\$0.52	\$19.26	\$14.89	\$91.58
honey locust	\$78.49	\$0.42	\$0.32	\$6.86	\$3.89	\$89.98
zelkova	\$74.25	\$0.35	\$0.19	\$7.85	\$5.50	\$88.13
cherry	\$58.10	\$1.03	\$0.38	\$15.61	\$10.84	\$85.96
ginkgo	\$64.65	\$0.35	\$0.27	\$5.70	\$3.30	\$74.27
tupelo	\$48.69	\$0.14	\$0.08	\$3.13	\$2.08	\$54.11

The Bottom Line

Large, empty planting spaces in the Pearl represent not only an opportunity to expand canopy, but also represent thousands of dollars in potential environmental and aesthetic benefits to the Pearl residents. If the Pearl planted all 158 of the available uncategorized and medium planting spaces with appropriately sized trees, in 30 years they will have provided \$558,474 in net benefits. Conversely, if all available uncategorized and medium planting spaces were planted with small form trees, over the same time period they would have only provided \$66,874 in net benefits.

Carefully selecting and planting appropriately sized trees directly impacts the amount of benefits provided by the urban forest. Trees that live longer will always produce more benefits to the community—small form trees have a much shorter lifespan than large form trees and may begin to decline after 30 years, just when large form trees are reaching maturity with decades of benefits to the community to come.

The Future Forest of the Pearl

RECENT PLANTING TRENDS

Different species of trees fall in and out of favor over time due to developments in the nursery industry, tree performance, and personal preferences. Portland's street tree population reflects this history, and by comparing the most recently planted trees to the rest of the population we can infer what that trend may mean for the future.

Ideally, new plantings will be diverse and show increases in the planting of those large form species which maximize environmental and aesthetic benefits. Established trees (>3"DBH) are compared to recently planted trees (≤3" DBH) and those with a change of 2.5% or greater were graphed to illustrate recent trends in planting (Figure 12, 13).

Results

Red maple, Norway maple, and pear, which make up nearly 70% of the Pearl's established street trees as a whole, have been planted far less often in recent years, which will lead to greater long-term species diversity (Figure 12). The steep decline of red maple (-27%) is likely because it is no longer approved for right-of-way planting. Norway maple is also planted far less frequently (-20%) likely due to the listing of the species on the City's nuisance plant list, which means it is no longer permitted for right-of-way planting.

Of tree types that have increased in number, ginkgo and zelkova are seeing the largest increase, with changes of +9.9% and +8.6, respectively. Even with increased plantings of each, both tree types are still below the recommended 5% threshold for a single species (Table 2, Figure 13). Other species trending up include ash (+6.3%), evergreen magnolia (+4.5%), and hawthorn (+4.4%).

The Bottom Line

Recent planting trends show a decrease in popularity of red maple and Norway maple, and this is a positive trend as the *Acer* genus and Sapindaceae family are over represented in the Pearl. Pear also exceeds the species diversity threshold for tree types.

Trees planted more frequently in recent years include diverse species that are new to the neighborhood. Evergreen magnolia and tupelo are non-existent or very uncommon in the established tree population, and will help diversify the Pearl District's urban forest.

Figure 12: Planting trend: Tree types planted less frequently

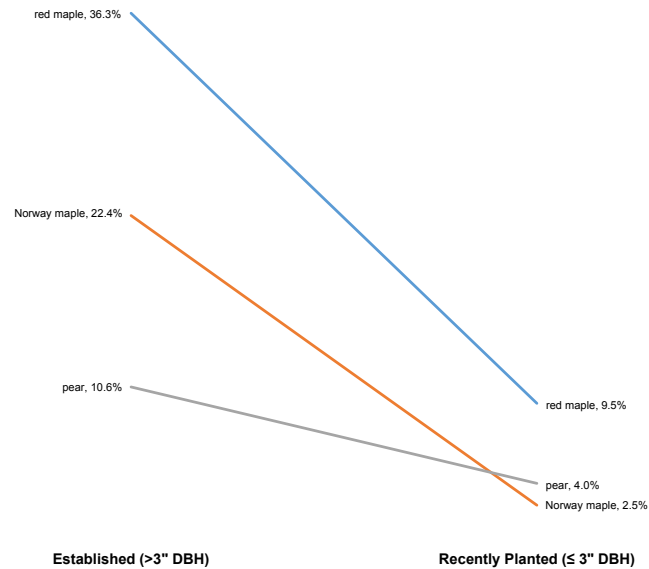
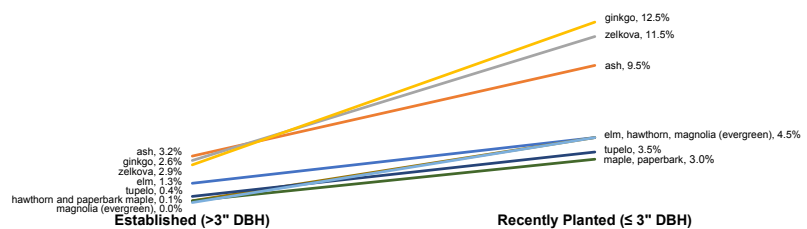


Figure 13: Planting trend: Tree types planted more frequently



TREE COMPOSITION WITHIN LARGE, MEDIUM, AND SMALL PLANTING SITES

Ideally, the mature form of a tree should match the size of its planting site. Appropriately-sized trees maximize benefits to the community while minimizing costly infrastructure conflicts. Table 7 provides an overall picture of undersized trees in the Pearl, however a closer look at where the most recently planted trees have been planted can show whether trends in planting are moving in the right direction. The mature form of recently planted trees ($\leq 3"$ DBH) found in large, medium, and small planting sites was compared to established trees ($> 3"$ DBH).

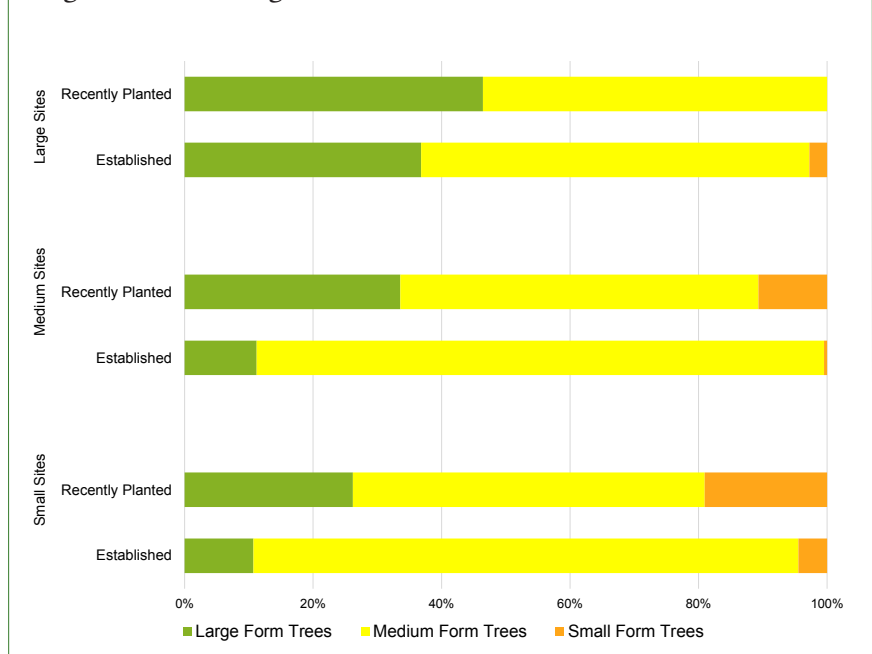
Results

Although the number of recently planted large trees being planted in large sites is increasing, medium form trees still make up the majority of trees being planted in large sites in the Pearl (Figure 14). In medium sites, the planting of medium form trees has decreased while the planting of large form trees has increased. Small form trees make up an increasing proportion in small sites, but medium and large form trees still make up the majority of trees planted in small sites.

The Bottom Line

Recent plantings in the Pearl show that large form trees are increasingly planted in large, medium, and small sites. However, medium form trees still make up a majority of trees planted in all sites. Nearly 54% of recently planted large sites contain medium form trees, and approximately 11% of medium sites are still being planted with small trees. Given that medium sites make up 74% of all sites in the Pearl, this represents a missed opportunity for these sites. Continued efforts to plant appropriately-sized trees in the Pearl's rights-of-way will ensure that tree canopy and its benefits are maximized in over the long-term.

Figure 14: Planting Trend: Mature tree form size shifts



Recommendations

Based on street tree inventory data presented in this report, Urban Forestry staff make the following recommendations for the Pearl District.

PLANTING FOR DIVERSITY AND SIZE

- Reduce dependence on trees in the Sapindaceae family, and specifically trees in the *Acer* genus by planting a diverse array of species, genera, and families. A more diverse urban forest will be more resilient to pests, pathogens, and changing climate conditions. Select species for planting from Urban Forestry's Approved Street Tree Lists (www.portlandoregon.gov/trees/plantinglists).
- Prioritize planting opportunities to plant large, high performing trees that will provide high levels of benefits over their lifetime. These trees would be best planted in the estimated 269 uncategorized planting sites that have been identified for planting (Appendix K).
- Plant trees in all available planting spaces but plant in the smallest spaces last. Trees in small planting spaces provide fewer benefits and are more likely to cause sidewalk and clearance problems in a shorter time frame than if they were planted in larger spaces. However, all plantings help contribute to a neighborhood "tree ethic" and encourage others to plant and maintain street trees. The Pearl's street tree stocking level is 79% and 415 spaces have been identified for planting street trees (Appendix J).
- Seek additional locations to plant large form trees to increase the neighborhood's canopy cover. This includes assessing the right-of-way for concrete removal and installation of new planting sites. With few large sites, creative expansion of existing sites or increased planting in parks, private property, and parking lots may be the only way to significantly increase canopy above the current level of 8%.

YOUNG TREE ESTABLISHMENT AND MAINTENANCE

- Properly water and establish young trees. With 11% of trees being 3" DBH or less, special attention should be paid to this vulnerable population (Appendix E). Small trees represent the future generation of street trees, and early care and training will pay off in future benefits.
- Structurally prune young trees to promote proper form as street trees. This includes removing low limbs for pedestrian and traffic clearance and removing co-dominant leaders. Structural pruning is critical in the first ten years after planting and can prevent future problems and expense. The 33% of trees that are 6" DBH or less should be evaluated for structural pruning needs.
- Educate property owners on how to properly care for young street trees (branch and root pruning, watering, and mulching) in order to reduce and delay future problems and conflicts with infrastructure.



*Planting trees like this uncommon Persian ironwood (*Parrotia persica*) helps to improve the diversity of the urban forest.*

MATURE TREE PROTECTION AND ADVOCACY

- Maintain and care for large, mature trees. Only 6.4% of trees in the Pearl are larger than 18" diameter. Trees provide the most benefits as they reach maturity and tree care is also the most expensive for these large trees. Increasing the level of maintenance of large, mature trees will help prolong their lifespan, reduce hazards, and keep these high value members of the urban forest contributing to the neighborhood.
- Retain existing large trees in fair and good condition. Benefits are lost when older trees are removed and replaced with smaller and younger tree species, due to the time it takes for trees to mature.
- Encourage planning for larger trees as redevelopment takes place in the neighborhood. Wider planting sites and cutouts (>6') will result in larger, healthier, longer-lived trees that provide many times more benefits to the community than smaller trees.
- Promote the importance and benefits of large form species and mature trees within the community.



Large-form trees like this Western redcedar (Thuja plicata) will help maximize environmental benefits in the Pearl over the long term.

REPLACEMENTS - RIGHT TREE, RIGHT PLACE

- Encourage removal and replacement of dead trees and assessment of trees in poor condition. Thirteen percent of the Pearl's trees are dead (17 trees) or in poor condition (318 trees) (Appendix G). Further assessment of trees for hazards by a certified arborist can help with prioritization for replacement.
- Encourage replacement of underperforming species, including undersized trees in large rights-of-way, with higher functioning, appropriately sized trees. In large planting sites, 127 trees have been identified as being too small for their respective site, 10 of which are in poor condition. Furthermore, nearly 65% of trees rated poor are in the *Acer* genus. Given that this genus is already over represented in the street tree population, these trees should be evaluated on an individual basis for replacement.



Large trees will grow healthier and larger when planted in the right space, unlike this linden (Tilia sp.) growing in a small cutout that restricts root growth.

Next Steps: Tree Plans and Tree Teams

The experience of participating in a street tree inventory and the findings in this report will help empower the neighborhood to make informed decisions regarding the management and stewardship of the local urban forest. Street trees are a critical component of a community and the 1,855 street trees and 415 available planting spaces detailed in this report are a good starting point for the neighborhood Tree Team to begin improving and expanding the urban forest.

NEIGHBORHOOD TREE TEAMS

Volunteers who have participated in the Tree Inventory Project are encouraged to form or join a neighborhood Tree Team. A neighborhood Tree Team is a group of volunteers who are interested in addressing the needs of a neighborhood's urban forest through activities such as the inventory, education and advocacy, and year-round stewardship events.

TREE PLANS

Urban Forestry knows that local Tree Teams are the best stewards of their urban forest. Having completed the inventory, they can now use these findings to create a Tree Plan—a customized stewardship plan created and executed by neighborhood Tree Teams for their urban forest.

Tree Plans will include a vision statement, goals, objectives, and recommendations for property owners. Using inventory data, Tree Teams can identify the specific needs of their neighborhood's urban forest and create goals that target these needs.

Once a Tree Plan is established, tree teams can take action toward improving their neighborhood's urban forest, with special access to Urban Forestry's staff and resources.

WORKSHOPS

In the year following the inventory, Urban Forestry will support two stewardship events for each neighborhood that completes a street tree inventory, with staff dedicated to assist tree teams in coordinating the events.

Neighborhoods may host a variety of events, including:

- Tree planting in community spaces
- Tree pruning, with a focus on structural pruning for young trees
- Young tree care
- Educational tree tours and lessons on topics such as species selection for diversity, invasive species recognition and removal, heritage trees, and addressing pests and pathogens
- Programs customized for the neighborhood based upon inventory findings



Young street trees like these oaks (Quercus spp.) benefit greatly from structural pruning in the first ten years after planting.

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Appendix A: Methods

Street trees are defined in this project as woody plants in the public right-of-way with a single or few trunks and a minimum mature size of 15'. In the summer of 2016, street trees adjacent to every tax lot within the neighborhood boundaries were inventoried by Urban Forestry staff.

DATA COLLECTED

Data collected included: tree type identified to species or genus, tree condition, location, size (diameter at breast height), planting site width, planting site type, and presence of overhead high voltage lines.

Tree type: Trees were identified to the genus or species. Six maples were identified to the species level: bigleaf (*Acer macrophyllum*), Japanese (*A. palmatum*), Norway (*A. platanoides*), paperbark (*A. griseum*), red (*A. rubrum*) and silver (*A. saccharinum*) maples. All other maple species were identified as “maple, other.” All dead trees were listed as “unknown” tree type, as identification of these plants was uncertain.

Tree condition: Trees were rated as good, fair, poor, or dead. These general ratings reflect whether or not a tree is likely to continue contributing to the urban forest (good and fair trees) or whether the tree is at or near the end of its life (poor and dead trees). The following guidelines were used:

Good: The tree has strong structure and is healthy and vigorous with no apparent problems. Trunks are solid with no bark damage and the crown is full. Roots show no signs of heaving or visible crossing, and there are no major wounds, decay, conks, or cavities.

Fair: The tree is in average condition. Structural problems may be present, including results of pruning for high voltage electrical lines. Tree may have dead branches and some canopy loss. Wounds are minimal and there is no major decay.

Poor: The tree is in a general state of decline as indicated by major wounds, root heaving, dead limbs resulting in major canopy loss, and/or visible signs of decay indicated by major rot or fungal growth.

Dead: The tree is dead with no live leaves. Dead trees were excluded from data analysis, with the exception of tree condition statistics and total number of trees inventoried.

Tree size: Diameter at breast height (4.5' above ground) was measured with a diameter tape. Measurements of trees with branches, forks, or swelling at 4.5' were taken lower on the tree so a representative size was obtained. Trees with three or fewer multiple stems were measured individually and Urban Forestry staff made final diameter calculations using the formula $\sqrt{(x^2+y^2+z^2)}$. Trees with greater than three multiple stems were measured below branching.

Planting site type: Planting site types were placed into one of the following categories.

Improved sites:

Curbtight: The curb and sidewalk are continuous, and tree is planted adjacent to tax lot.

Cutout: The site is a concrete cutout, also called a tree pit or tree well.

Median: The site is in the middle of the street separated by a curb.

Planting strip: The tree is a planting strip between a curb and a sidewalk.

Swale: The tree is in the middle of a bioswale designed for storm water capture.

Unimproved sites:

Curb only: The site has a curb but no sidewalk.

No curb or sidewalk: The site has no curb or sidewalk.

Other: Sites not falling under above scenarios.

Planting site width: Planting site width was measured for all improved site types except curbtight areas. Planting strips were measured from the inside of the curb to the beginning of the sidewalk and cutouts, medians, and swales were measured from inside edge to inside edge perpendicular to the street. No widths were taken for unimproved planting site types or curbtight areas.

High voltage wires: The presence of high voltage wires above the planting space was recorded.

Stocking level: Planting space size and availability is subject to a number of guidelines, including width of the planting site, presence/absence of high voltage power lines, and distance from conflicts (property lines, stop signs, and underground utilities). Because this project did not inventory all available planting sites, but only sites where trees are currently growing, data for planting site sizes were supplemented with available planting space data collected by Urban Forestry and the Bureau of Environmental Services between 2009 and 2016. These data were compared with existing tree data collected at the same time and used to calculate stocking level. Some industrial, commercial, and multi-family residential areas may have been excluded in the analysis, making this a conservative estimate of available sites.

DATA COLLECTION METHODS

During work days, staff were given a map, a list of trees planted by Friends of Trees in the neighborhood, and an iPhone with the Collector for ArcGIS app, which includes aerial photo and taxlot information. Staff wore safety vests and carried a 2-sided diameter/measuring tape for measuring tree size and site width, and bags for collecting samples.

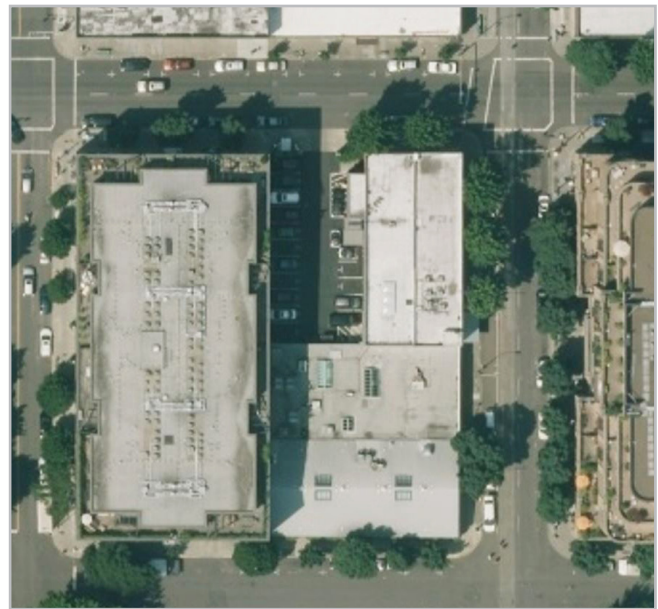
Accuracy was stressed as highly important, and staff consulted each other to verify species identification as questions arose. Data were collected on the Collector for ArcGIS app. Accuracy of data was checked by specialist Urban Forestry staff and corrections were made as necessary. A 10% sample of the final data found species identifications to be more than 95% accurate.

CALCULATION OF BENEFITS AND CANOPY PROJECTION

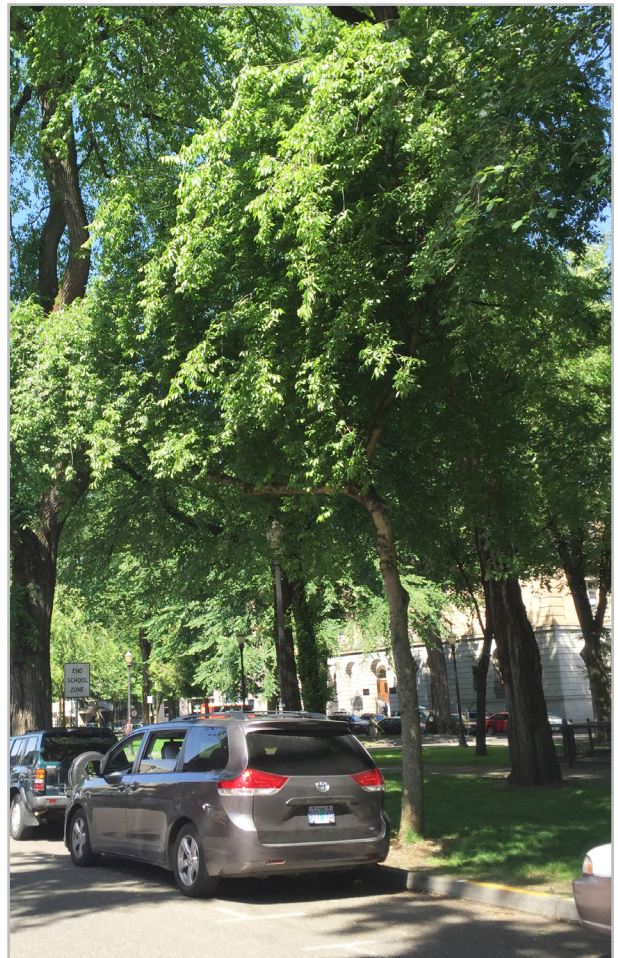
Projected benefits were calculated using 30-year estimates of average annual net benefits provided in the Western Washington and Oregon Community Tree Care Guide (McPherson et al. 2002). Projected canopy cover estimates assume the mature spread of small, medium, and large trees to 20' x 20', 40' x 40', and 60' x 60', respectively. In some cases the data for available planting spaces from the Bureau of Environmental Services (BES) included planting sites that were not categorized by size. Therefore, for the purposes of calculating projected benefits, these spaces were assumed to have a similar proportion of small, medium, and large sites, as were categorized by BES in the neighborhood.

Appendix B: Street trees of Pearl by tree type

Common Name	Scientific Name	Family	# of Trees	% of Total	Mean DBH
ash	<i>Fraxinus</i> spp.	Oleaceae	72	3.9%	5.9
beech	<i>Fagus</i> spp.	Fagaceae	8	0.4%	6.1
cedar	<i>Cedrus</i> spp.	Pinaceae	1	0.1%	2.7
cherry	<i>Prunus</i> spp.	Rosaceae	15	0.8%	8.4
crabapple	<i>Malus</i> spp.	Rosaceae	1	0.1%	7.2
cypress	<i>Cupressus</i> spp.	Cupressaceae	1	0.1%	17.5
elm	<i>Ulmus</i> spp.	Ulmaceae	31	1.7%	23.5
empress tree	<i>Paulownia tomentosa</i>	Paulowniaceae	1	0.1%	7.8
false cypress	<i>Chamaecyparis</i> spp.	Cupressaceae	1	0.1%	0.5
ginkgo	<i>Ginkgo biloba</i>	Ginkgoaceae	68	3.7%	4.2
golden rain tree	<i>Koelreuteria paniculata</i>	Sapindaceae	6	0.3%	8.4
hackberry	<i>Celtis occidentalis</i>	Cannabaceae	1	0.1%	9.4
hawthorn	<i>Crataegus</i> spp.	Rosaceae	11	0.6%	4.2
honey locust	<i>Gleditsia triacanthos</i>	Leguminosae	22	1.2%	4.5
hophornbeam	<i>Ostrya</i> spp.	Betulaceae	2	0.1%	1.6
hornbeam	<i>Carpinus</i> spp.	Betulaceae	123	6.7%	10.7
katsura	<i>Cercidiphyllum japonicum</i>	Cercidiphyllaceae	19	1.0%	13.2
Kentucky coffeetree	<i>Gymnocladus dioica</i>	Leguminosae	1	0.1%	9.5
lilac tree	<i>Syringa reticulata</i>	Oleaceae	5	0.3%	6.2
linden	<i>Tilia</i> spp.	Malvaceae	48	2.6%	10.7
magnolia, evergreen	<i>Magnolia</i> spp.	Magnoliaceae	9	0.5%	1.5
maple, bigleaf	<i>Acer macrophyllum</i>	Sapindaceae	1	0.1%	8.4
maple, Norway	<i>Acer platanoides</i>	Sapindaceae	374	20.2%	11.3
maple, other	<i>Acer</i> spp.	Sapindaceae	7	0.4%	9.9
maple, paperbark	<i>Acer griseum</i>	Sapindaceae	8	0.4%	2.4
maple, red	<i>Acer rubrum</i>	Sapindaceae	617	33.4%	8.8
mountain-ash	<i>Sorbus</i> spp.	Rosaceae	1	0.1%	4.9
oak, deciduous	<i>Quercus</i> spp.	Fagaceae	77	4.2%	8.1
pear	<i>Pyrus</i> spp.	Rosaceae	183	9.9%	7.9
Persian ironwood	<i>Parrotia persica</i>	Hamamelidaceae	4	0.2%	2.6
pine	<i>Pinus</i> spp.	Pinaceae	6	0.3%	9.4
planetree	<i>Platanus</i> spp.	Platanaceae	5	0.3%	7.0
plum	<i>Prunus</i> spp.	Rosaceae	2	0.1%	12.9
poplar	<i>Populus</i> spp.	Salicaceae	9	0.5%	28.0
sweetgum	<i>Liquidambar</i> spp.	Altingiaceae	1	0.1%	12.3
tupelo	<i>Nyssa</i> spp.	Cornaceae	14	0.8%	2.9
unknown (dead)	unknown	unknown	8	0.4%	6.3
Western redcedar	<i>Thuja plicata</i>	Cupressaceae	21	1.1%	14.1
zelkova	<i>Zelkova serrata</i>	Ulmaceae	71	3.8%	5.0
Total			1,847	100.0%	9.2



*Clockwise from left: 1) The flaky, exfoliating bark of a paperbark maple (*Acer griseum*). 2) Construction of high-density buildings is a common sight in the Pearl, particularly in the northernmost portion of the neighborhood. 3) In areas like the Pearl, it is possible to have a high street tree stocking level but low canopy due to large building footprints.*



*Clockwise from top left: 1) A section of streetcar track bordered by pears (*Pyrus* spp.) at left, and zelkova (*Zelkova* spp.) at right. Both are in the top 10 most abundant tree types in the Pearl. 2) An established hackberry (*Celtis occidentalis*) growing on the North Park Blocks. 3) Proper maintenance like pruning can help reduce vehicle damage to trees.*

Appendix C: Street trees of Pearl by size



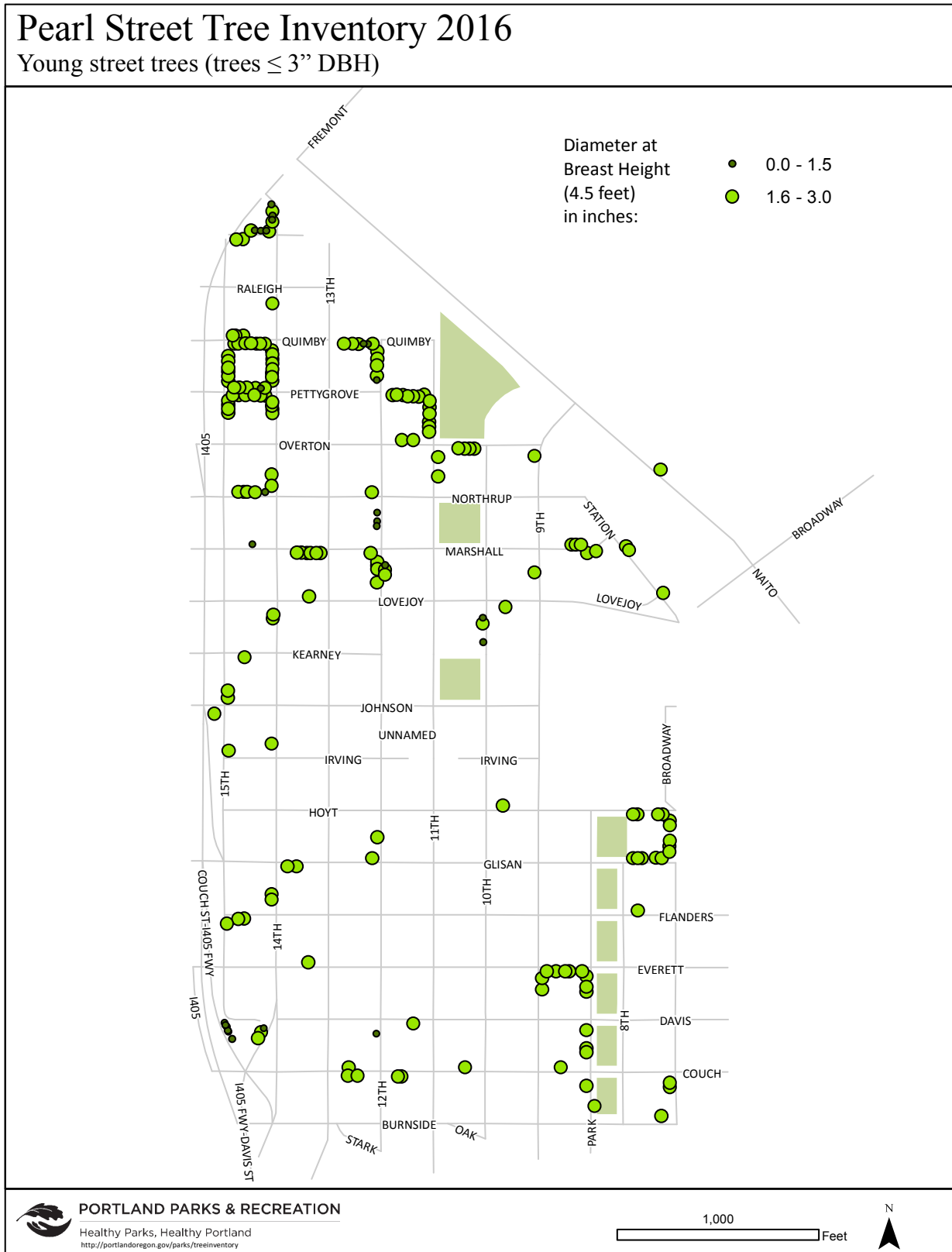
Appendix D: Vulnerability to key pests

Pearl Street Tree Inventory 2016

Vulnerability to key pests



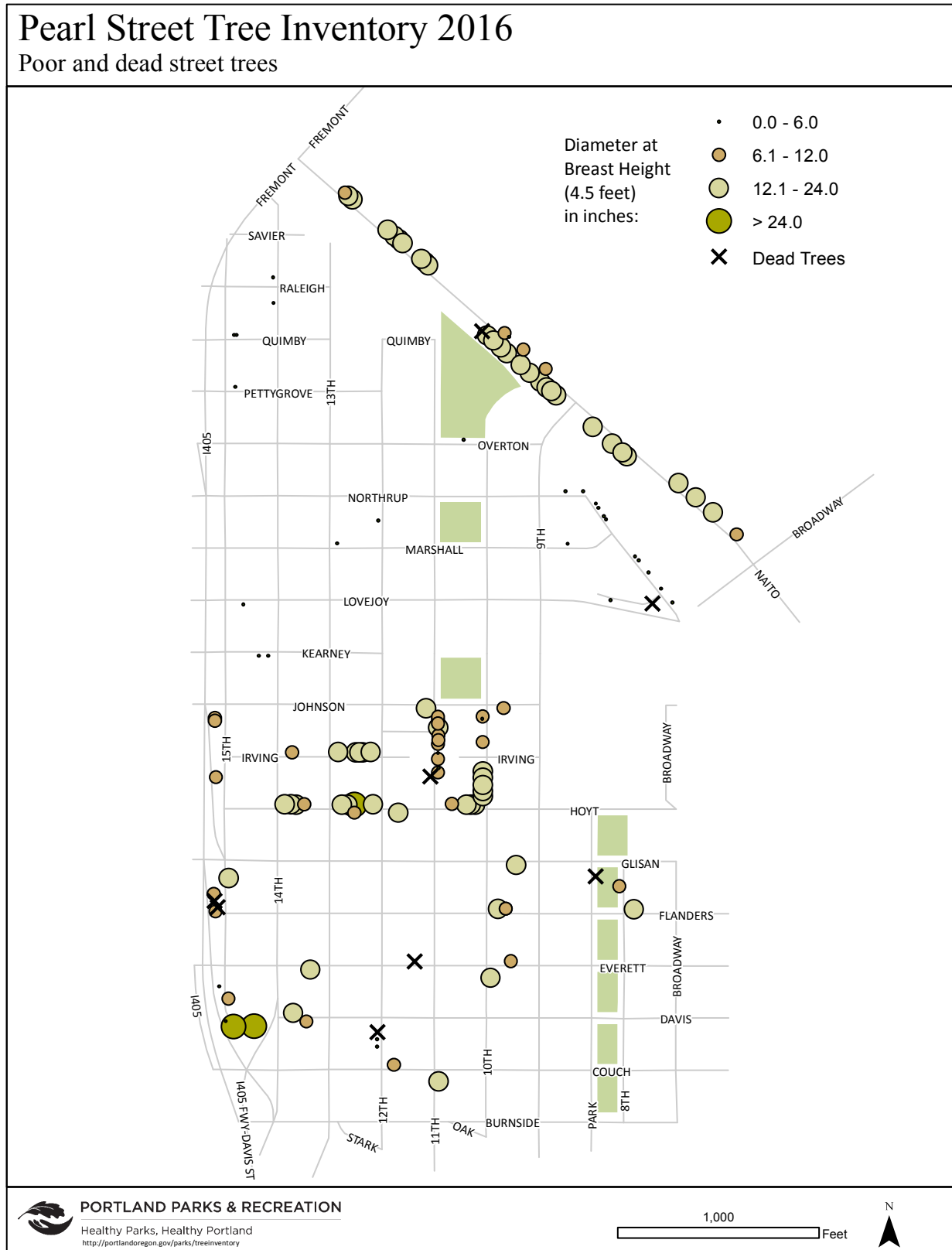
Appendix E: Young street trees (trees ≤ 3" DBH)



Appendix F: Large street trees (trees > 24" DBH)



Appendix G: Poor and dead street trees



Appendix H: Planting site types

Pearl Street Tree Inventory 2016

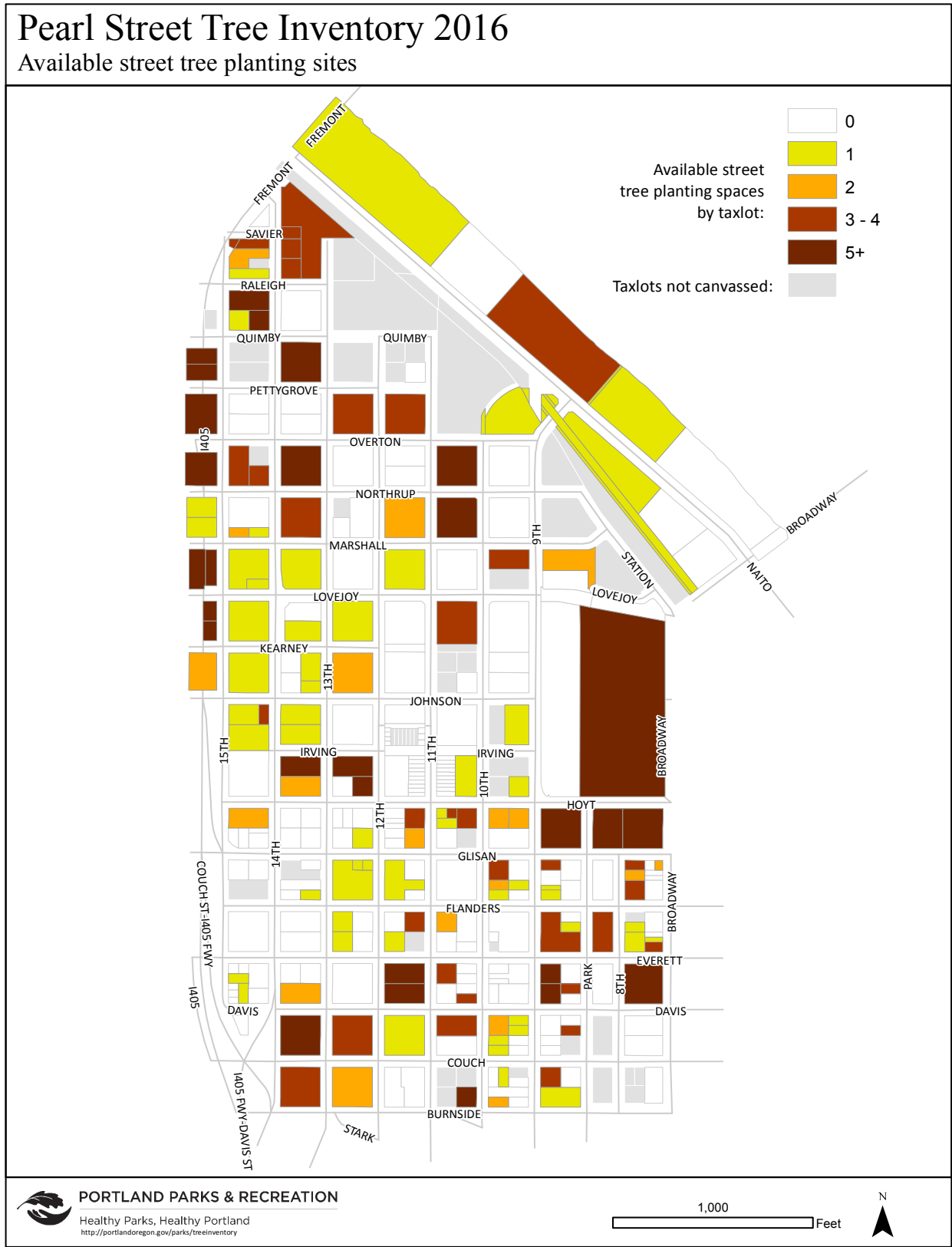
Planting site types



Appendix I: Planting site sizes



Appendix J: Available street tree planting sites



Appendix K: Priority street tree planting sites

