


2008 FOREST HEALTH SURVEY

Pioneer Park, Mercer Island, WA

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PIONEER PARK FOREST HEALTH SURVEY REPORT

EXECUTIVE SUMMARY

Pioneer Park, which covers 114 acres in the south part of Mercer Island, is the largest open space area within the city. The preservation and fostering of forest health of the park is a priority for the City of Mercer Island and the Open Space Conservancy Trust. In 2008, the City of Mercer Island, in conjunction with Seattle Urban Nature (SUN), mapped habitat types and conducted a vegetation inventory in Pioneer Park. The goals of the project were to:

1) provide an inventory of native and invasive species in the park
2) compare the success of previous management efforts
3) create a management plan based on collected data
4) estimate the time and cost necessary to meet the set goals

Four forested habitat types were mapped in the park: conifer forest, conifer/ deciduous mixed forest, riparian forest and landscaped forest. To study these habitats, 56 1/10th acre rectangular vegetation plots were established throughout the forested natural areas of Pioneer Park. Within these plots, information about trees, shrubs, vines, herbaceous plants, snags and downed wood was recorded.

The overall quality of the shrub and herbaceous vegetation throughout the park was found to be in good condition. Native shrubs and herbaceous species outnumbered their non-native invasive counterparts in both species diversity and percent cover. The quality and quantity of dead and downed wood in the park was comparable to other Seattle-area urban forests, and is sufficient to support a variety of wildlife species within the park.

Results of the study also show that there are serious threats and concerns to the ecological integrity of the forests at Pioneer Park. Large populations of regenerating invasive trees (English holly and cherry laurel) cover the forest floor while English ivy, an invasive vine, was found growing on 20% of the native canopy trees. In addition, there are very few naturally regenerating conifer trees, suggesting that without active management, the conifer-dominated canopy may be lost and replaced by canopy gaps and native deciduous trees in the near future.

The current management strategy, adopted from the 2003 Forest Management Plan, involves intensive removal of existing invasive species and native tree planting. While this strategy has been effective, it lacks the flexibility needed to target specific urgent forests health issues. A new management strategy is proposed that allows the flexibility necessary to target a range of issues such as key invasive species eradication and long-term planning for the future structural diversity of the forest. The new management strategy prescribes immediate removal of English ivy from canopy trees, eradication of the invasive plants English holly and cherry laurel, and planting of disease-resistant conifer trees in a two stage approach.

Management using the strategy recommended by this report has been organized into a 20 year plan. The cost of this preferred 20 year plan ($3,580,000) is estimated to be similar to the cost of achieving similar goals using the current strategy ($3,730,000)

established in the 2003 Forest Management Plan. The preferred 20 year plan would substantially increase the likelihood of long-term ecological sustainability by allowing managers to initially focus management priorities on immediate threats affecting forest health. However, current funding ($55,000 per year from CIP for Pioneer Park) and new funding ($77,000 per year from Proposition No. 2 - Levy for Park Operations and Maintenance) is not sufficient to achieve the preferred plan.

Therefore, a restricted budget management strategy was developed that, while based on the preferred 20 year plan, stays within the currently available budget. In order to accommodate this budget, the timing of management activities was changed and some follow-up maintenance reduced. These changes are likely to compromise the effectiveness of the recommendations, as priority activities, such as holly and laurel removal, tree planting, and ivy ring creation will take longer to complete. The budget-restricted plan also requires 25 years of management to achieve comparable levels of forest health set in the original plan (20 years). If additional funding becomes available in future years, priority management activities can be accelerated to rates comparable to the preferred plan.

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1. INTRODUCTION

1.1. Purpose of study

In June 2008, the City of Mercer Island City Council funded a forest health survey in Pioneer Park. This study was proposed in response to several questions posed by the Trustees of the Open Space Conservancy Trust. The primary aim of the forest health study is to assess the feasibility of accomplishing goals set forth in the 2003 Pioneer Park Forest Management Plan (PPFMP) within reasonable funding and time constraints. Specifically, the study was designed to:

1) establish a baseline assessment of native and invasive species cover in the park
2) compare the success of various management efforts
3) estimate the time and cost necessary to meet the set goals

See Appendix A for a complete list of the 2003 PPFMP goals.

1.2. Site location and context

A comprehensive overview of Pioneer Park can be found in the Pioneer Park Forest Management Plan, adopted in 2003.

1.2.1. Area description

Pioneer Park is located in the south end of Mercer Island in King County, Washington, and consists of approximately 114 acres of public land. The park is split into three, nearly equal-sized contiguous units, divided by Island Crest Way and Southeast 68th Street. These units are appropriately referred to as the northwest (NW), northeast (NE), and southeast (SE) quadrants.

Of the total 114 acre area, approximately four acres are considered landscaped forest. These areas, which are primarily composed of mowed grass and large trees, are a transition landscape feature between busy roads and the non-landscaped forest. The remaining 110 acres of the park are non-landscaped forests, managed for native ecosystem function (current management is described in Section 1.4). Parking at Pioneer Park is limited to informal turnouts on roadsides, and a portable latrine, located at the southeast corner of the NW quadrant, serves as the park's only restroom. There are no formal facilities within the park. The park, as a whole, has 6.9 miles of trails (Map 1). The primary use of the park is recreational: walking, running, and horseback riding. Hiking and bicycling are allowed on all the trails, however horseback riding is allowed only on the Horse and Fire Station Trails of the NW quadrant and throughout the SE quadrant, a total of 3.5 miles of trail.

1.2.2. Hydrology

Most of the land at Pioneer Park is relatively dry upland. However, the northeast part of the NE quadrant contains several diverse hydrologic features. A ravine with a small perennial stream enters the NE quadrant at the center of the north border (Map1). The drainage then curves to the east and drains near the park's northeast entrance. The stream enters a culvert as it exits the park. Also in the northeast section of the NE quadrant are several naturally occurring seeps. These outlets of groundwater support populations of unique plant species such as skunk cabbage (*Lysichiton americanus*) and

devils club (*Oplopanax horridus*). The north central part of the NW quadrant contains a region with poorly drained soils, which has resulted in high densities of water-loving shrubs such as salmonberry (*Rubus spectabilis*).

1.2.3. Geology and soils

The soil and topographic features at Pioneer Park owe their development largely to glacial activity within the past 10,000 years. Higher areas and ridges in the topography were left after glaciers gouged troughs and deposited sediment. The elevation drops 45m (150') from the rim of the adjacent upland area in the park's NE quadrant to the bottom of the ravine. Slopes in the ravine area of the NE quadrant can exceed 30 degrees.

The soils of Pioneer Park, as the result of glacial activity, are sandy and gravely. However, some areas of the park have a relatively shallow, cemented substratum which prevents soil drainage and results in areas of wet soil. Other areas, which do not have this drainage barrier, have relatively dry soils as a result of its coarse texture. A more detailed description of the soils at Pioneer Park can be found in the "Soil -The Park's Foundation" section of "Pioneer Park: A Natural History" (Mercer Island Parks and Recreation Department, 1990).

1.3. Site use history

The first documented management of the land which is now occupied by Pioneer Park was in the late 1800s when the area was logged (Gellantly, 1989). Since the logging activities of the late 1800s and early 1900s, no large-scale alterations have been made to this land. The land was held privately until 1931, when it was willed to the University of Washington. The park was then bought by the newly incorporated City of Mercer Island in 1964, following passage of a bond. Despite several attempts to turn parts of the park into a golf course, Pioneer Park has remained intact since becoming a park. The construction of a formal trail system is the only major change to the park since its creation. In 1992, the City of Mercer Island chartered the Open Space Conservancy Trust to oversee the preservation of Pioneer Park and ensure that all uses of and improvements to the park "shall not change its character or impair any of its ecological, scenic, aesthetic, or natural attributes" (Mercer Island Open Space Conservancy Trust & City of Mercer Island Parks and Recreation Department, 2003).

1.4. Current vegetation management practices

Starting in 1997, the City of Mercer Island began various restoration projects within Pioneer Park. The 2003 Pioneer Park Forest Management Plan outlined a preferred management plan, the "Purely Native" scenario, which focused on "aggressive control of invasive, non-native plants" and "dispersed planting of evergreen and deciduous overstory species". What has been adopted since is a strategy that incorporates the complete weed removal aspects of that plan with a more intensive planting regime than the plan stated. Today, these activities continue, with sections of the park receiving varying levels of treatment. For the purposes of this survey, these activities have been split into three main groups: *control, selective treatment,* and *comprehensive treatment*.

Control areas are those that have not received any organized effort to eradicate invasive plants or plant trees and shrubs. Areas that have received *selective* treatment are those in which one or more specific type of restoration effort has taken place. *Selective*

treatments may include tree planting, Himalayan blackberry (*Rubus armeniacus*) removal, Himalayan blackberry knockdown, creation of English ivy (*Hedera helix*) rings, holly (*Ilex aquifolium*) and cherry laurel (*Prunus laurocerasus*) removal or ivy removal. While *selective* treatment is not considered a viable, complete strategy for creating a healthy forest on its own, *selective* treatment methods can yield effective results as part of a larger management strategy. In this paper, *selective* treatment areas are used to assess the effectiveness of a given treatment in the continuum from *control* areas to *comprehensive* areas. *Comprehensive* treatment includes both removal of all non-native species **and** planting of native conifer trees. A condensed description of *comprehensive* removal is described below. For a thorough description of management activities, can be found in Appendix F.

The removal of non-native species includes:

- Himalayan blackberry– roots dug up from the forest floor, and biomass piled and left to compost on site,
- English ivy– roots dug up, and biomass piled and left to compost **and** ivy growing on trees severed at base and removed from tree trunk to approximately four feet high,
- Other non-native, invasive small shrubs and herbaceous plants - roots dug up, and biomass piled and left to compost or removed from site
- Cherry laurel, English holly and other non-native, invasive shrubs and small trees – stems girdled and treated with glyphosate herbicide

Follow-up weed removal is done at *comprehensive* treatment sites for two years. This work, which uses the methods described above, is completed at least once during the late spring or summer.

Following initial removal, *comprehensive* treatment areas are inter-planted with native trees and shrubs. The density of the plantings varies from 3’ spacing for shrubs to 8’ to 15’ spacing for trees. Shrub species vary, but tree species consist mostly of native conifers.

2. STUDY METHODOLOGY

Methods used in this study were adapted from established methodologies created by Seattle Urban Nature (Seattle, WA). Execution of this study has been done in close coordination and consultation with Seattle Urban Nature. This organization has preformed similar vegetation studies using these forest survey methodologies throughout the greater Seattle area. Many of following methodology descriptions in this section represent direct references from these reports.

2.1. Habitat and treatment delineation

At the onset of this study, Pioneer Park was split into zones reflecting the composition of the forest canopy, associated understory species, and topography. With the aid of aerial orthoimagery and topography maps, the boundaries between zones were delineated and ground-truthed in the field. This information was then used to create a GIS base layer representing the spatial arrangement of habitat types throughout the park. The resulting habitat types identified were conifer forest, mixed conifer-deciduous forest, riparian forest, and landscaped forest. Map 1 shows the delineation of the four forest habitat types at the park and Table 1 shows the corresponding acreage of each habitat type.

Map 1. Locations of habitat zones delineated in Pioneer Park, Mercer Island, WA

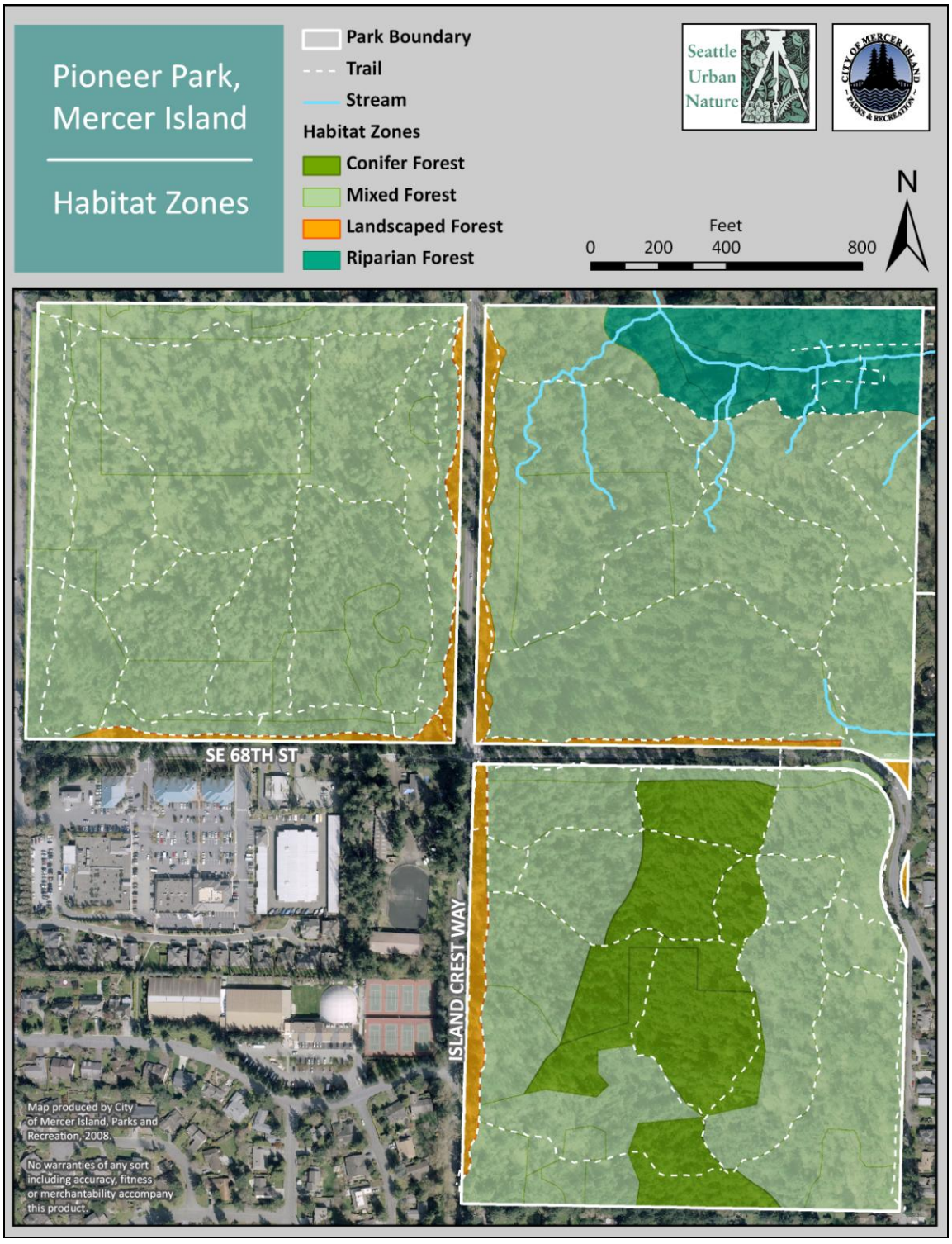


Table 1. Total acreage of each forest habitat type in Pioneer Park, Mercer Island, WA

Forest Habitat Type	Area (acres)	Percent of total area	Number of plots sampled
Conifer Forest	28.0	24.4	6
Mixed Conifer/ Deciduous Forest	71.2	62.4	47
Riparian	10.8	9.5	3
Landscaped Forest	4.2	3.7	0
Total Park	114.2	100	56

Previously established treatment areas were mapped using a GPS unit, from which a GIS layer was created. Three treatment types were incorporated into the map: *comprehensive, selective,* and *control*. Map 2 shows the delineation of the three treatment types at the park and Table 2 shows the corresponding acreage of each treatment.

2.2. Sampling intensity

With the aim of sampling five percent of the park, 56 one-tenth acre plots were surveyed during the summer of 2008. The total coverage of these plots is 5.6 acres, or 5.1% of the non-landscaped areas of the park (110 acres). Areas of the park designated as 'landscaped forest', generally found near the roadways, were not included in the survey (Map 1).

2.3. Transect layout

Plots were distributed proportionately among all habitat types and randomly located within a particular habitat. Plots were also situated to correspond to management treatment locations (Map 2). Of the total 56 plots, six were located in conifer forest, 47 in mixed conifer/deciduous forest and three in riparian forest.

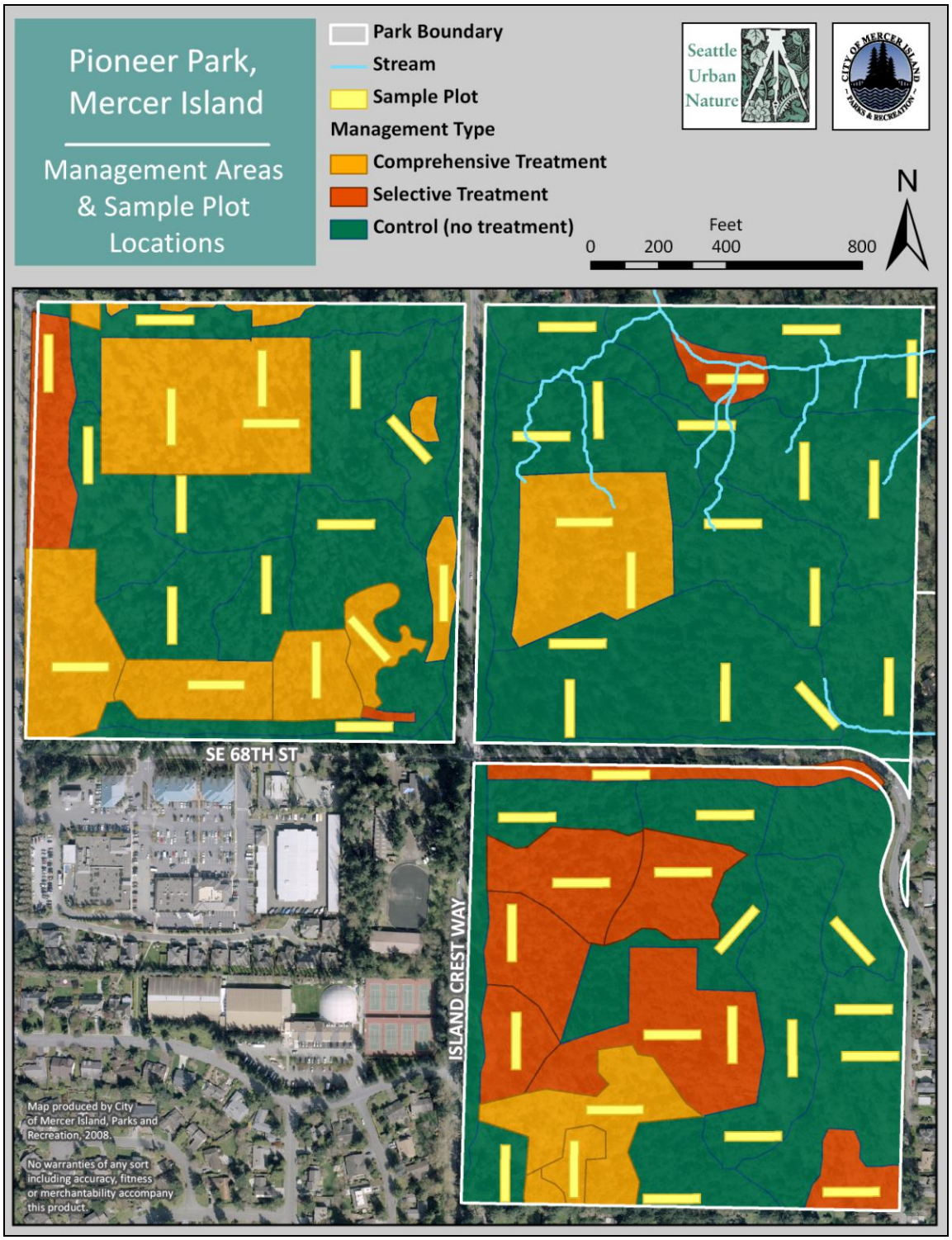
The plots are rectangular and measure 26.2 feet (8 meters) wide and 164 feet (50 meters) long. These dimensions cover an area of approximately 0.1 acre, which has been a standard measure in recent vegetation management plans in the Seattle area (Jones and Stokes, 2002; Sheldon Associates, Inc., 2003; Seattle Urban Nature, 2006).

Long rectangular plots provide more accurate sampling of the naturally occurring variation that occurs within clumped distributions of plant species, thereby producing more accurate estimates than round or equal-sided plots, particularly in regard to

Table 2. Current total acreage of each management practice in Pioneer Park, Mercer Island, WA

Management Type	Area (acres)	Percent of total area	Number of plots sampled
Control	75.0	65.7	34
Selective	16.7	14.6	10
Comprehensive	22.5	19.7	12
Total Park	114.2	100	56

Map 2. Management areas and 2008 sample plot locations, Pioneer Park, Mercer Island, WA



density-related measurements (Elzinga *et al*, 1998).

The majority of sampling plots in Pioneer Park are oriented along a north/south or east/west axis. If orientation along these axes did not allow the plot to be fully included in a particular habitat type or management unit, the plot was modified to a northwest/southeast or northeast/southwest orientation that would allow the sample to stay within the habitat/management boundary.

The origin of each plot was marked with a 1" x 1" x 4' wooden stake (Stake A) and a 12" rebar stake with a metal, numbered tag, each of which were driven one foot into the ground. Plots were laid out as shown in Figure 1. GPS point locations were recorded at Stakes A and C. Plot bearings and GPS points are listed in Appendix G.

2.4. Assessment procedures

Two general categories of attributes, tree density and vegetation cover, were recorded at each plot. Average slope and aspect were also recorded for each plot.

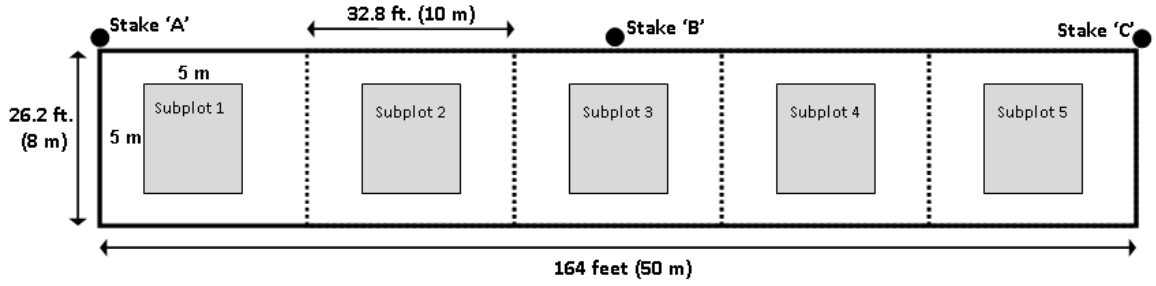
2.4.1. Tree density

All trees with trunks originating within the one-tenth acre plot were identified and counted, including non-native tree species. Trees on the edge of the plot were included only if more than half of the rooted trunk occurred in the plot. Height and diameter at breast height (DBH; measured at 4.5 feet above ground) were recorded for each tree. In addition, trees were assessed for colonization by English ivy. For trees less than 4.5 feet in height, average stem diameter was recorded to the nearest 0.5 inch.

Tree density was considered a key measure in this survey, as it allows for the analysis of several aspects of functionality, including tree regeneration, forest structure, conifer to deciduous ratios and the presence and frequency of exotic tree species.

Snags and coarse woody debris (CWD) greater than five inches in diameter, consisting of downed logs and stumps, were measured and placed into one of three decay classes: I, II or III. Decay class I indicates a branch or trunk that has recently died and is still firm, and frequently has intact bark and branches. Decay class III indicates wood that is in an advanced state of decay, with crumbling wood and extensive epiphytes, and usually has no remaining bark or branches. Decay class II provides an intermediate designation which characterizes wood between these two extremes. CWD dimensions were used to calculate estimates of downed wood volume per acre.

Figure 1. Layout of sampling plots in Pioneer Park, Mercer Island, WA



2.4.2. Vegetation cover

All plant species occurring in or overhanging the sample plot boundaries were identified and percent cover visually estimated for each species. Estimations of vegetation cover were made by dividing the sample plot into five equally-sized quadrats (10 m x 8 m). A 5 meter by 5 meter subplot was randomly placed within each quadrat (see Figure 1), and percent cover of each species was visually estimated for each subplot. The total area covered by the subplots represents 31% of the entire sample plot (400 m^2). Estimates from the five subplots were combined to derive an estimate of cover for the entire sample plot. Species present in trace amounts were given a minimum value of 0.1% cover, which allows for a comprehensive floristic survey of each plot location.

2.5. Data collection and management

Data collection was conducted by two ecologists at the City of Mercer Island, with training and assistance from staff ecologists at Seattle Urban Nature. Data was recorded using a Compaq iPAQ PDA. Information from the PDA was transferred to a Microsoft Access Database, and analyzed using Microsoft Excel. Maps were produced using ESRI ArcMap version 9.2.

3. RESULTS AND FINDINGS

This section contains a summary and analysis of the vegetation and dead wood that occurs in Pioneer Park. These attributes of the forest are divided into six main sections: overstory tree composition and structure (Section 3.2), regenerating tree composition and structure (Section 3.3), shrub composition and diversity (Section 3.4), herb, vine and grass composition and diversity (Section 3.5), snags (Section 3.6), and coarse woody debris (Section 3.7).

3.1. Park-wide vegetation trends

3.1.1. Species distribution

A total of 118 plant species were found in Pioneer Park during the 2008 survey (Appendices B through E). This list includes 26 tree species (15 native, 10 non-native, 1 undetermined); 29 shrub species (19 native, 9 non-native, 1 undetermined); and 63 herbaceous, grass, and vine species (30 native, 24 non-native, 9 undetermined). Occurring throughout the park are a few noteworthy invasive, non-native species. These species include the tree English holly (King County Noxious Weed of Concern, 2008), the shrubs Himalayan blackberry (King County Noxious Weed of Concern, 2008) and cherry laurel (King County Noxious Weed of Concern, 2008), the vine English ivy (King County Non-Designated Noxious Weed, 2008), and the herbaceous yellow archangel (*Lamiastrum galeobdolon*) (King County Non-Designated Noxious Weed, 2008).

3.1.2. Vegetation by habitat types

Three forest types were identified at Pioneer Park based on canopy density of conifer and deciduous trees, as well as proximity to water courses and topography. Both conifer forests and mixed conifer/deciduous forests occur in flat to moderate topography, with conifer forests distinguished by a higher ratio of conifer to deciduous trees. The conifer forest areas also tend to have understory species that are shorter in stature and more tolerant of dry conditions than those of the mixed forest. The riparian forests have an

overstory and understory similar to the mixed conifer/deciduous forest, but occur near watercourses. These areas are often dominated by plants associated with water, and tend to have steeper topography. Landscaped forests include areas of managed vegetation, often with mown grass, on the street edge of the park. No study plots were located in the landscaped forest areas.

Detailed descriptions of vegetation differences between habitat types can be found in Sections 3.2 through 3.5.

3.1.3. Vegetation by management treatments

In general, vegetation varied between the three management treatment categories: *control, selective,* and *comprehensive.* Areas under *comprehensive* treatment result in far fewer invasive non-native regenerating trees, shrubs, and herbaceous plants. Additionally, the *comprehensive* treatment areas have a much higher density of regenerating conifer trees compared to the other treatments. *Selective* treatment areas differ from *control* areas by having slightly fewer non-native regenerating trees. However, *selective* treatment areas do not have appreciably different levels of non-native invasive shrubs, herbaceous plants or regenerating conifer trees compared to the *control* areas.

3.2. Overstory tree composition and structure

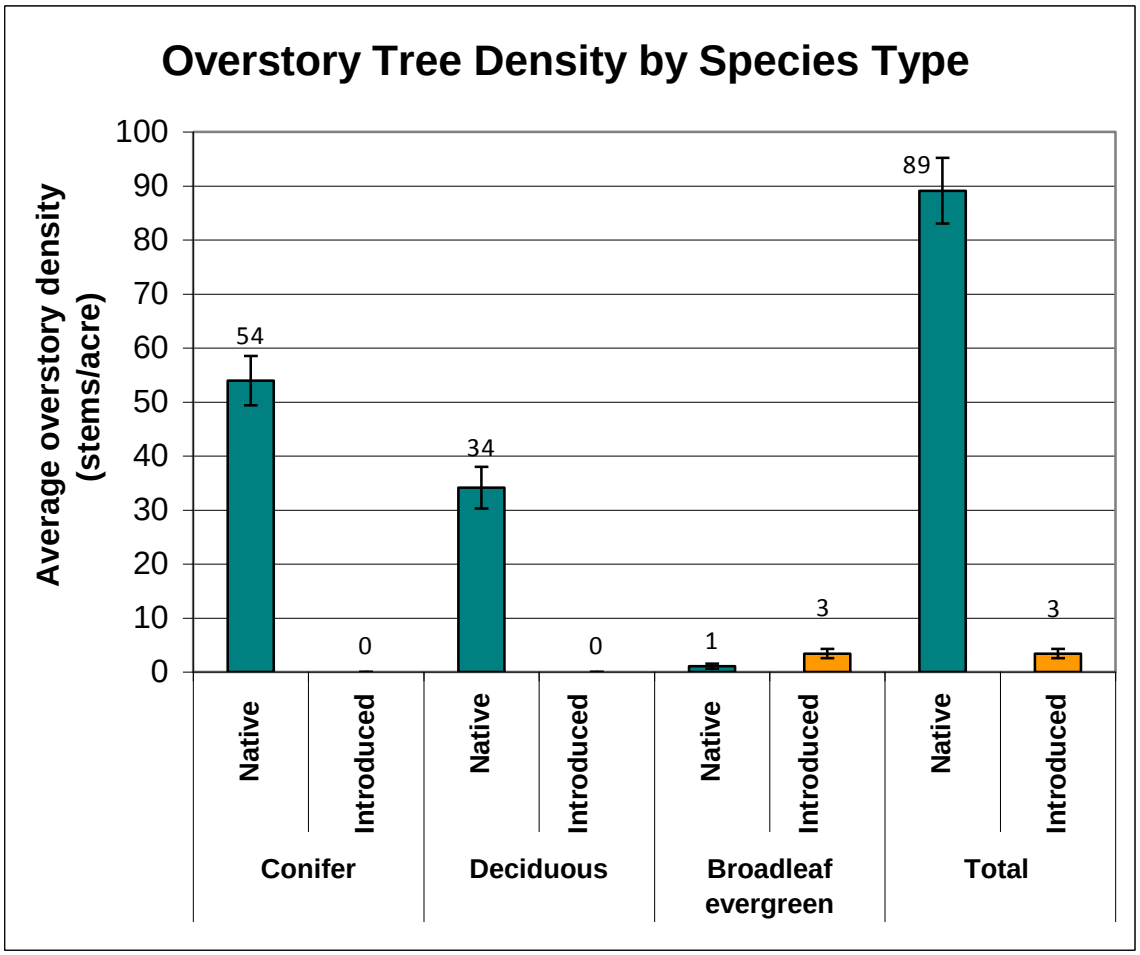
3.2.1. Summary

In this study, trees over 5 inches DBH were considered in the analysis of overstory tree composition and structure. In all habitat types identified in Pioneer Park the dominant overstory tree type is the native conifer, which makes up 58.3% of all overstory trees. Native deciduous trees are the second most common tree type, and account for 36.8% of large trees. Both native and introduced broadleaf evergreen trees make up smaller portions of the overstory tree composition (1.2% and 3.7%, respectively) (Figure 2). An "overstory composition by treatment" section is not included due to the fact that treatments do not affect overstory composition.

Douglas-fir (*Pseudotsuga menziesii*) is the most common conifer species, found in 84% of plots, while western hemlock is found in 45% of plots. Big leaf maple and red alder are found in 57% of sample plots. Other species found regularly as large trees include western red cedar (*Thuja plicata*), madrone (*Arbutus menziesii*) and English holly (Appendix B).

English holly, the only non-native tree which met overstory tree criteria, accounts for only 3.7% of the total density (Figure 2), but was found in 25% of sample plots. Despite its proportionally low density of 3 stems/acre, the presence of large English holly trees is a concern. This species is a prolific seeder, and these mature trees are largely responsible for the continued and constant growth of new English holly plants. The effects of the high seeding rate can be seen in the composition of regenerating trees in Pioneer Park, the vast majority of which are English holly (see Section 3.3).

Figure 2. Density of overstory trees by species type, Pioneer Park, Mercer Island, WA. Bars represent ±1 standard error.



Forest development in the Puget Sound area

The development of Puget Sound area lowland forests following disturbance such as logging or fire is thought to be a three-step process in terms of overstory tree composition. Fast growing native deciduous trees, such as big leaf maple and red alder, become established in areas of mature forest that have been cleared by such disturbances. Following, and concurrent with, the 70-150 year life-cycle of these deciduous trees, native conifers become established in the forest. Of the native conifers, the most dominant in younger forests (<250 yrs old) is Douglas-fir, known for growing relatively fast in open areas (Franklin *et al*, 2002). Growing slowly and steadily in the shade created by Douglas-fir are western hemlock (*Tsuga heterophylla*) and western red cedar, both of which have the ability to eventually surpass Douglas-fir in height and dominate a mature old-growth forest (Franklin *et al*, 2002).

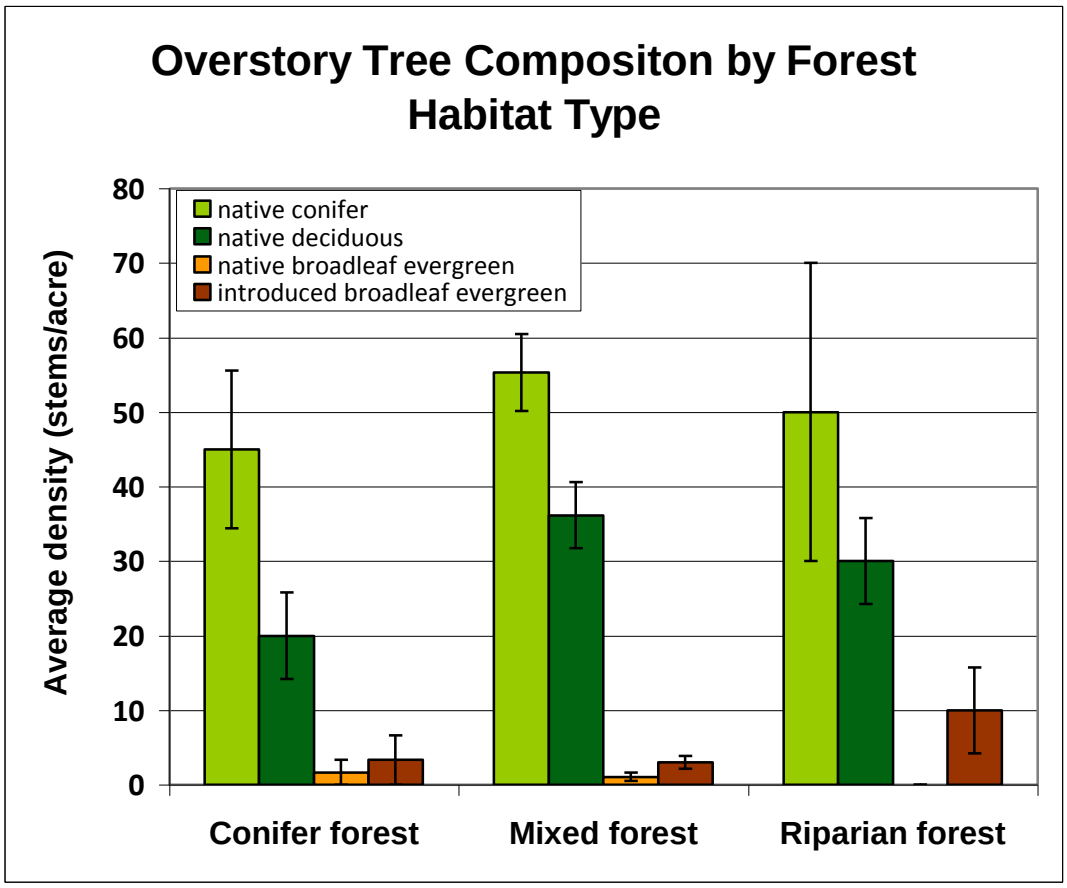
Overstory tree composition varies by forest type (Table 3, Figure 3). Mixed conifer-deciduous forests and riparian forests have a lower ratio of conifer to deciduous (1.53:1 and 1.67:1 respectively) than the conifer forest category (2.25:1). The ratios of conifer to deciduous trees in the overstory in mixed and riparian forests are very similar.

Table 3. Conifer and deciduous overstory tree densities in habitat types of Pioneer Park, Mercer Island, WA

Forest Habitat Type	Native conifer tree density (stems/acre)	Native deciduous tree density (stems/acre)	Ratio of conifer to deciduous trees
Conifer	45	20	2.25
Mixed conifer / deciduous	55.3	36.2	1.53
Riparian	50	30	1.67

The relatively high proportion of large native conifers suggests that the forest may be progressing past the deciduous-dominated stage of forest development. However, the abundance of Douglas-fir in overstory trees (42%), compared to that of western hemlock (12%) and western red cedar (4%), indicates that the forest overstory is still developing and has not yet reached maturity (Appendix B).

Figure 3. Composition of overstory trees by forest habitat type, Pioneer Park, Mercer Island, WA. Bars represent ±1 standard error.



3.2.2. Overstory tree density

Overall, Pioneer Park has an average of 93 overstory trees per acre. Table 4 shows values for forested natural areas in the Seattle area which have a similar history of disturbance within the past 100 years. Because previous assessments of Pioneer Park have classified its forest as a Western Hemlock Forest (Mercer Island Parks and Recreation Department, 1990), results from Pioneer Park are also compared to those of a typical Pacific Northwest western hemlock old-growth forest (Table 4).

Table 4 demonstrates that the overall density of the forest in Pioneer Park is similar to densities of other regional urban parks and suburban natural areas. However, it is much lower than that of an old-growth forest of comparable composition, which suggests that the forest is less productive, possibly due to past logging, a lack of continuous conifer regeneration, and/or the fungal pathogen laminated root rot (see Section 3.2.4).

3.2.3. Structure

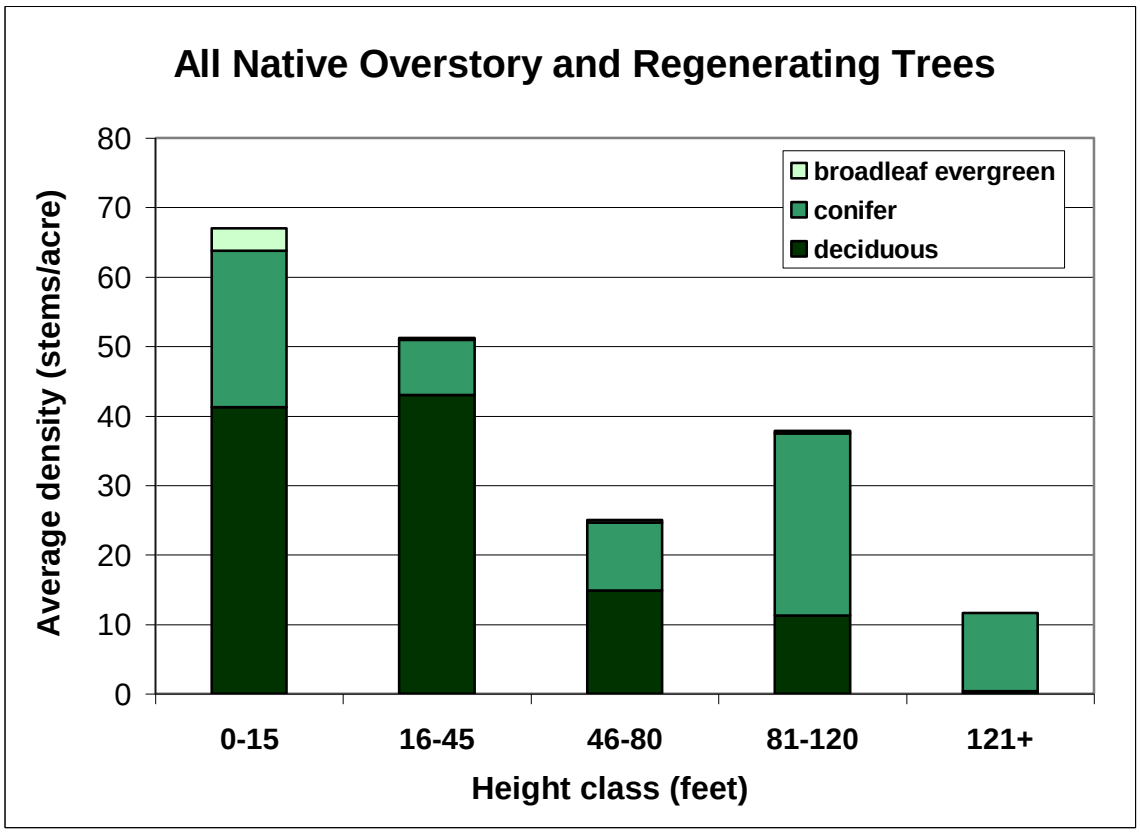
The forest canopy of Pioneer Park has a relatively high structural diversity as a result of variation in tree species and height. The distribution of trees in height classes lends insight into how structurally diverse the canopy is and which species are emerging into the canopy. At Pioneer Park, the majority of native trees in the lower (0'-15' and 16'-45') height classes are native deciduous trees (Figure 4), the majority of which are big leaf maple and red alder. The mid-strata height category of 46'-80' contains an approximately even mix of native conifer and native deciduous trees. The canopy overstory height classes (81'-120' and 121'+) are dominated by native conifer trees, the majority of which is Douglas-fir. The large group of conifer trees in the 81' to 121'+

Table 4. Comparison of overstory tree density and composition at study sites in Seattle-area urban forests

Study site	Years since disturbance (approx.)	Overstory tree density (stems/acre)	Density of native conifer (% of total)	Percent Douglas-fir of total density
Shadow Lake, King Co., WA* (SUN, 2008c)	70-90 years	125	86 (69%)	23%
Boeing Creek, Shoreline, WA* (SUN, 2008a)	110 years	114	81 (71%)	21%
Deadhorse Canyon, Seattle, WA* (SUN, 2005)	110 years	88	15 (17%)	2%
Hamlin Park, Shoreline, WA* (SUN, 2008b)	100 years	113	40 (35%)	14%
Old-growth western hemlock forest, Cascade Range ** (Franklin *et al*, 1981)	250 years	156	-	32%
Pioneer Park, Mercer Island, WA	110 years	93	54 (58%)	42%

* Study sites sampled and analyzed by Seattle Urban Nature (SUN) using methods comparable to those of the Pioneer Park Forest Health Survey. Values reported are those of **mixed conifer/deciduous forests**.
Values reported are those of **conifer forests.

Figure 4. Average density of tree heights across all plots, Pioneer Park, Mercer Island, WA



height classes likely became established following the last logging of the area around 1915. Introduced canopy tree species were not addressed in these diameter and height comparisons because it is assumed that these species will be removed in the future and therefore not contribute to the forest structure.

3.2.4. Disease

As the forest in Pioneer Park continues to develop, it also faces the effects of laminated root rot (*Phellinus weirii*). While there are several fungal diseases that currently affect overstory trees in Pioneer Park, laminated root rot is the most active and destructive. This naturally-occurring fungus causes the roots of healthy, mature Douglas-fir and western hemlock to decay, resulting in treefall and death within 5-20 years (Mercer Island Open Space Conservancy Trust & City of Mercer Island Parks and Recreation Department, 2003). The fungus, which occurs in all three quadrants of Pioneer Park, spreads from tree to tree via root contact, and can survive in large stumps for over 50 years. The result of laminated root rot is a matrix of gaps in the forest, which reach 2.5 acres in size. While gaps and forest heterogeneity are considered good for forest structure and wildlife habitat, these openings can create prime sites for growth of invasive shrubs such as Himalayan blackberry. Additionally, trees infected with laminated root rot can be a safety hazard due to their tendency to fail while still appearing relatively healthy. For more information on tree diseases in Pioneer Park see Appendix E (pp.55-84) in the 2003 Pioneer Park Forest Management Plan.

3.3. Regenerating tree composition and structure

3.3.1 Summary

In this study, trees with a DBH of 5 inches or less are considered to be regenerating trees. In the 56 plots sampled in Pioneer Park, 24 species of regenerating tree were identified (Appendix C). The average density of regenerating trees was 1038 stems/acre. The majority of these trees were English holly, which was found in 86% of the plots and averaged 899 stems/acre (Figures 5 and 6). Native tree species only contributed 10% of the regenerating tree density, with 104 stems/acre. Of these native trees, big-leaf maple is the most common, found in 77% of the plots and contributing 46.9% of the native regenerating tree density (Figure 7). Native conifer regeneration is low, with an average of 23.8 stems/acre (2.3% of the total regeneration and 20.7% of native tree regeneration).

Comparisons made with other Puget Sound urban forested areas show that forest regeneration in Pioneer Park faces many challenges (Table 5). English holly density is much higher than in other regional urban parks and suburban natural areas, while native conifer regeneration is very low. Although the density of introduced deciduous species, such as European mountain ash (*Sorbus aucuparia*), is not as high as that of Hamlin Park in Shoreline, these trees are regenerating faster than native conifers and may pose a future threat to the forest structure. Native deciduous trees are regenerating well

Figure 5. Mean density of regenerating trees across all plots, Pioneer Park, Mercer Island, WA

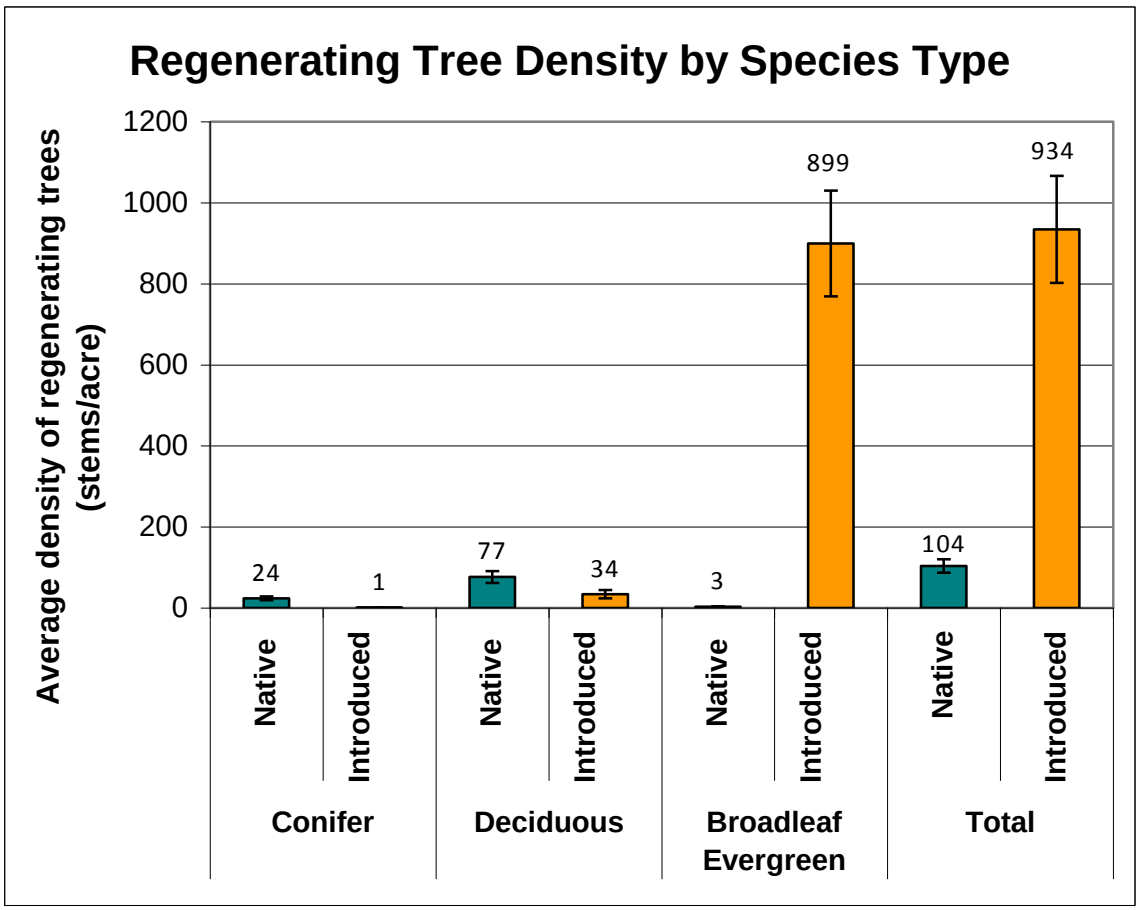


Figure 6. Regenerating tree composition by species type, Pioneer Park, Mercer Island, WA

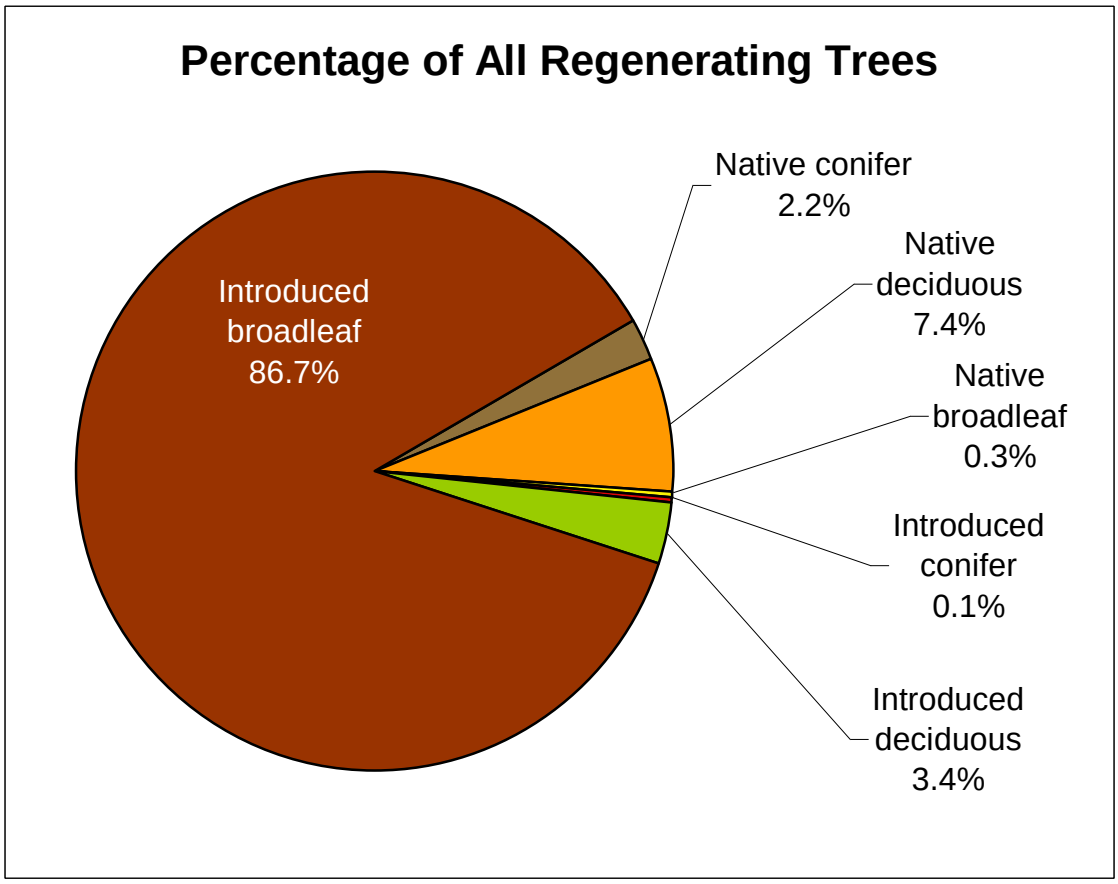
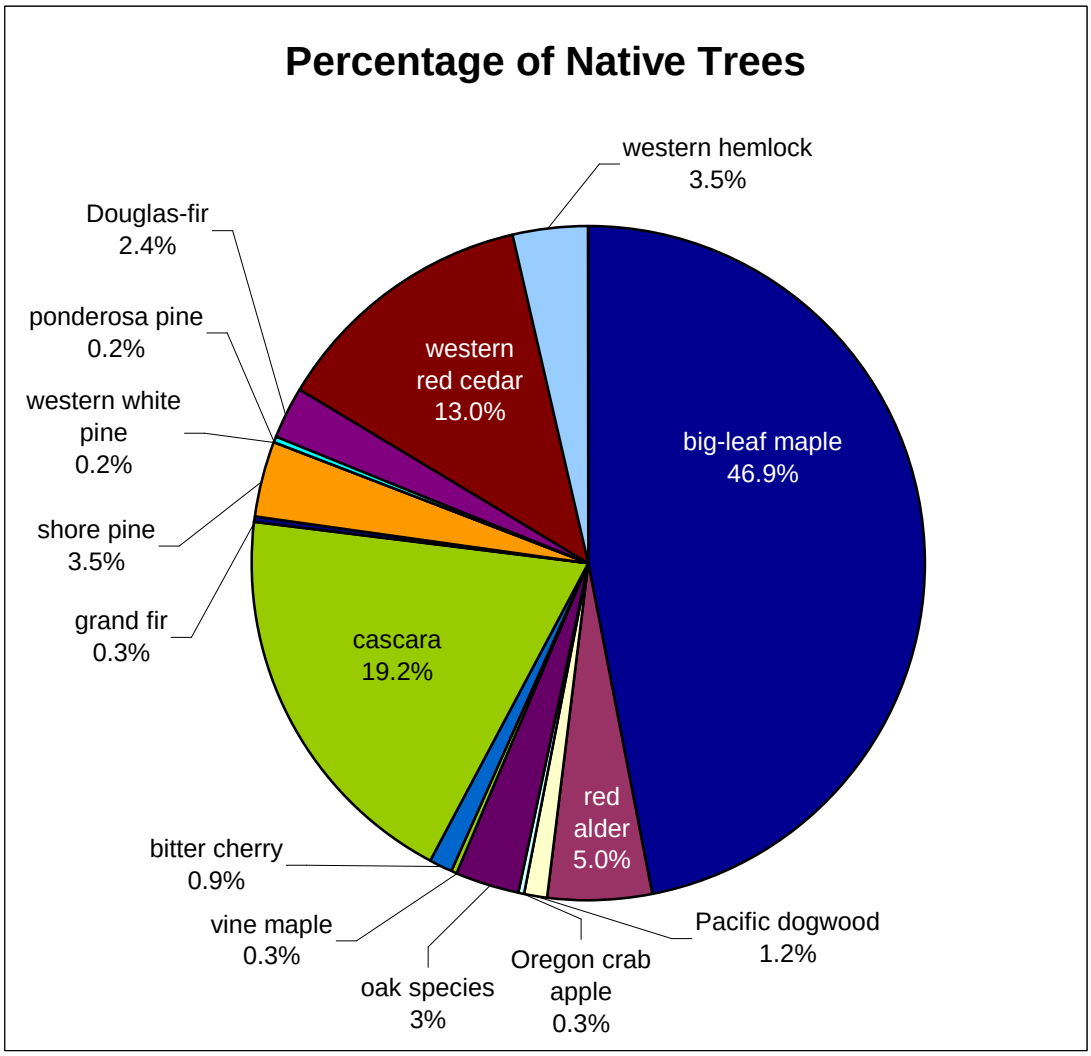


Table 5. Comparison of regenerating tree densities at study sites in Seattle-area urban forests

Area	Native conifer (stems/ acre)	Native deciduous (stems/ acre)	Introduced deciduous (stems/ acre)	Introduced broadleaf evergreen (stems/acre)
Boeing Creek, Shoreline, WA* (SUN, 2008a)	120	53	50	151
Hamlin Park, Shoreline, WA* (SUN, 2008b)	143	11	294	789
Deadhorse Canyon, Seattle, WA* (SUN, 2005)	61	39	13	243
South Woods, Shoreline, WA* (SUN, 2007)	57	99	136	3646
Pioneer Park, Mercer Island, WA	**24**	77	34	899

* Study sites sampled and analyzed by Seattle Urban Nature (SUN) using methods comparable to those of the Pioneer Park Forest Health Survey.

Figure 7. Native regenerating tree composition by species, Pioneer Park, Mercer Island, WA

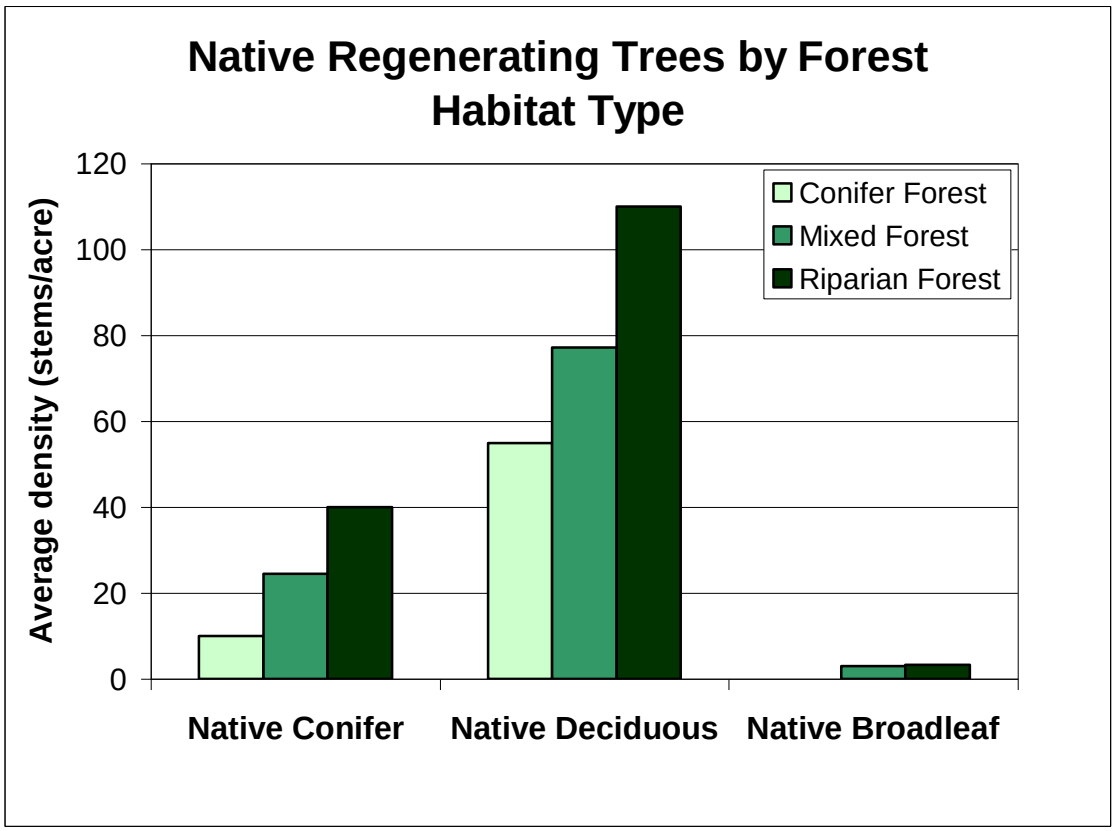


overall. However, in order to maintain the current overstory ratio of conifer to deciduous trees, native conifers should be present at three times the density of deciduous trees (Table 4).

3.3.2 Regenerating tree composition by habitat

The density of regenerating trees vary by habitat type. Conifer forest areas have the lowest densities of all categories of regenerating native trees, ten native conifer stems/acre and 55 native deciduous stems/acre (Figure 8). The mixed forest areas have a moderate amount of regenerating native trees, 25 native conifer stems/acre, 77 native deciduous stems/acre, and 3 native broadleaf stems/acre. The riparian forests have the greatest density of native regenerating trees, 40 stems/acre of native conifer, 110 stems/acre of native deciduous, and 3 stems/acre of native broadleaf trees. The exceedingly low density of regenerating native conifer and other trees in conifer forests are of particular note. The particularly low density of regenerating trees in the conifer forest stands may be the result of few seed producing canopy trees in the area that have the ability to grow in the shade of Douglas-fir.

Figure 8. Density of native regenerating trees by forest habitat type, Pioneer Park, Mercer Island, WA



3.3.3 Regenerating tree composition by treatment

Both *selective* and *comprehensive* treatments appear to decrease the density of non-native regenerating trees. Introduced broadleaf tree density shows a marked decrease in both treatment types, from 112 stems/acre in *control* plots to 91 stems/acre in areas with *selective* treatment and 55 stems/acre with *comprehensive* treatment (Figure 9). Introduced deciduous tree density also varies by treatment: density in *control* plots averaged 5 stems/acre while *selective* and *comprehensive* areas contained only 2 and 0.1 stems/acre, respectively (Figure 9).

Because the current regeneration of trees will determine the makeup of the future overstory, the extremely low density of native conifers is of particular concern. Tree-planting efforts over the past six years have been successful in increasing the density of native coniferous trees (Figure 10). However, with an average of 45 regenerating conifers per acre, planted areas are still relatively sparse. The composition between planted and unplanted areas also differs (Figure 11). Planted areas have a higher number of species, due to a focus on diversifying the suite of young conifer species to include those that are less susceptible to laminated root rot. A look at regenerating conifers in unplanted areas, however, shows that there is some natural western red cedar recruitment.

Figure 9. Density of all regenerating trees by treatment type, Pioneer Park, Mercer Island, WA. Bars represent ±1 standard error.

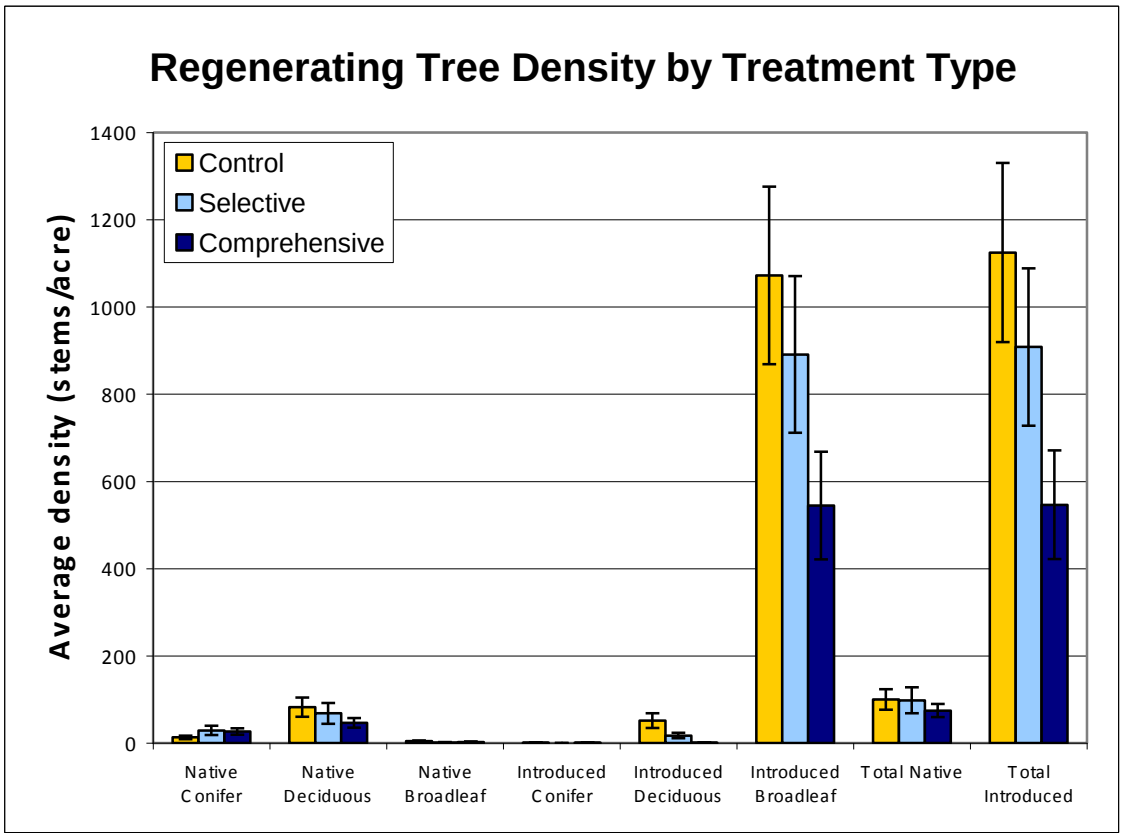


Figure 10. Density of regenerating conifer trees in planted and unplanted areas, Pioneer Park, Mercer Island, WA. Bars represent ±1 standard error.

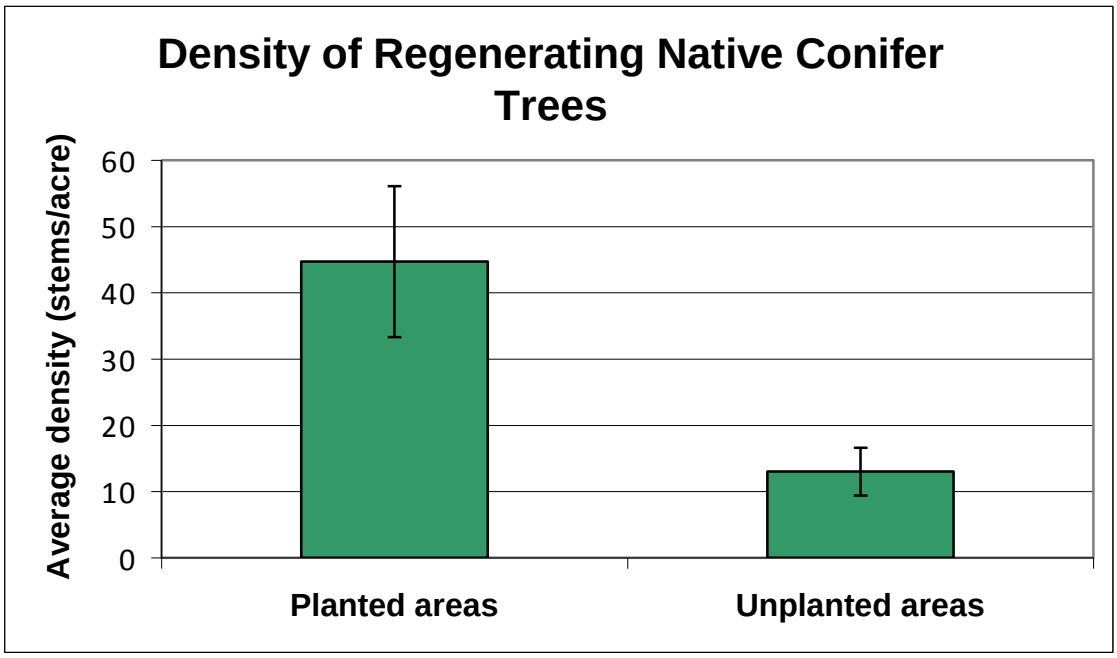
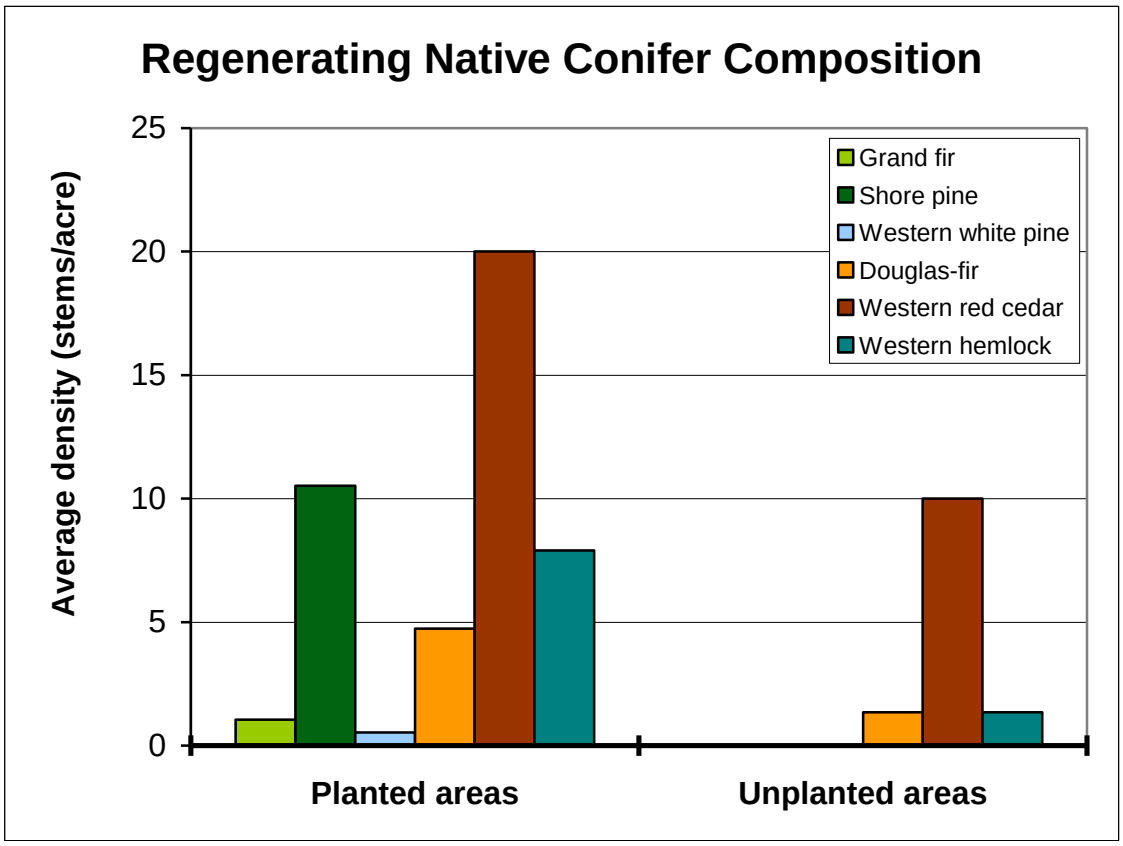


Figure 11. Composition of native conifer regeneration, Pioneer Park, Mercer Island, WA



3.4. Shrub composition and diversity

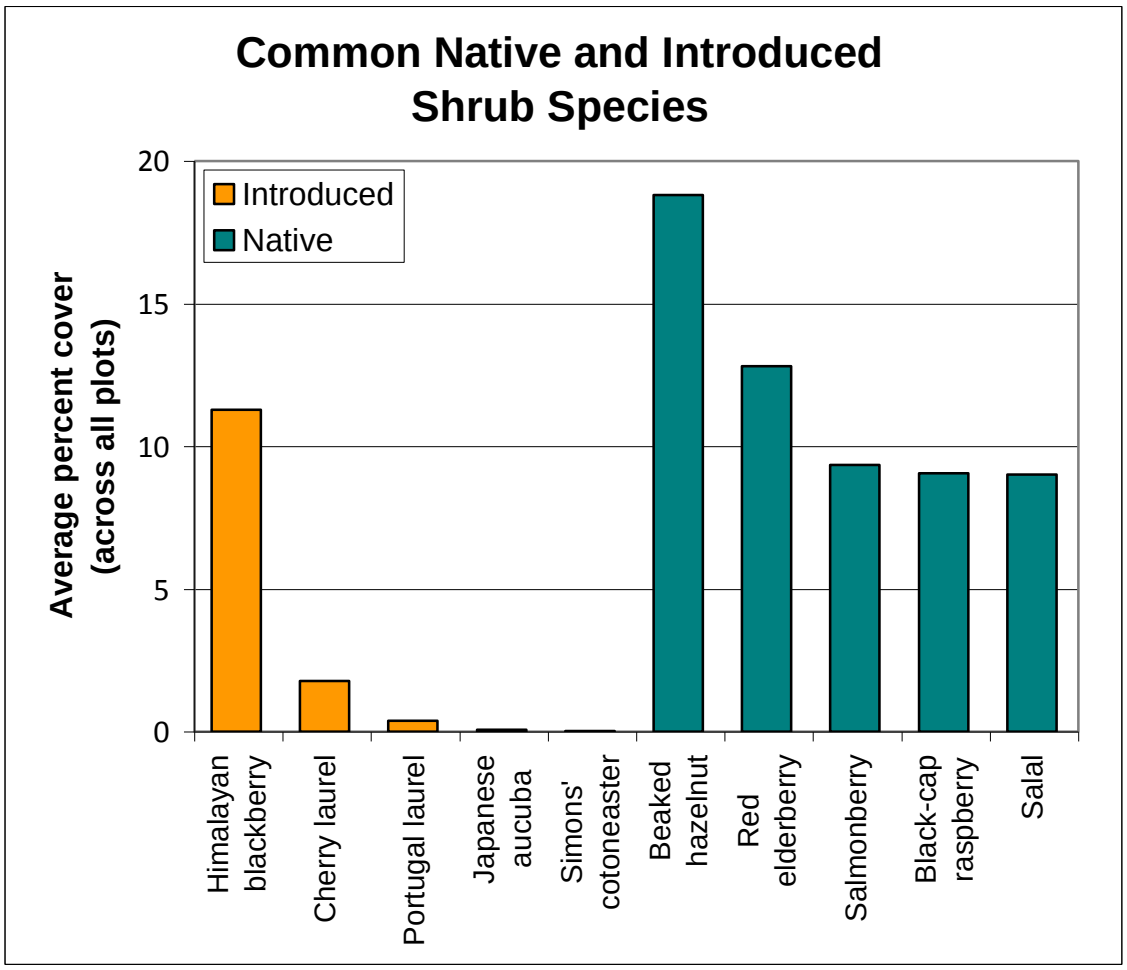
3.4.1. Summary

Twenty-nine species of shrubs were found across the 56 plots sampled in Pioneer Park. Of these, nine are identified as non-native (13.6% cumulative cover), 19 as native (81.6%) and one unidentified shrub. The most commonly found native shrubs, low Oregon grape (*Mahonia nervosa*) and red elderberry (*Sambucus racemosa*), were found in 96% and 93% of the plots, respectively. The shrubs with the highest average cover across all the plots are beaked hazelnut (*Corylus cornuta*) (18.8%) and red elderberry (12.8%) (Figure 12). Himalayan blackberry is the most common introduced plant, found in 76.8% of the plots, with an average cover of 11.3% across all plots (and 14.7% average cover in the plots where it was found).

3.4.2. Shrubs by habitat type

Dominant shrub species and density vary by forest type. The wetter riparian forest areas are dominated by the moisture-loving salmonberry (18.1%) and also include a relatively large (5.7%) cover of the wet-soil indicator plant devils club (Table 6). The mixed forest area has a drier mix of shrubs of moderate cover which include beaked

Figure 12. Mean cover of most common shrubs across all plots, Pioneer Park, Mercer Island, WA



hazelnut (18.6%), red elderberry (14.2%), and Himalayan blackberry (11.1%). The conifer forest areas, with the driest soils at Pioneer Park, had a high cover of the shrub species beaked hazelnut (29.5%), trailing blackberry (*Rubus ursinus*) (23.5%) and salal (*Gaultheria shallon*) (23.4%).

Table 6. Four most common shrubs in each habitat type, Pioneer Park, Mercer Island, WA

Forest habitat type	Conifer Forest	Mixed Forest	Riparian Forest
1st most common shrub (% cover)	Beaked hazelnut (29.5%)	Beaked hazelnut (18.6%)	Salmonberry (18.1%)
	Trailing blackberry (23.5%)	Red elderberry (14.2%)	Red elderberry (7.7%)
	Salal (23.4%)	*Himalayan blackberry (11.1%)	*Himalayan blackberry (7.1%)
4th most common shrub (% cover)	*Himalayan blackberry (14.9%)	Salmonberry (9.9%)	Devils club (5.7%)

***** Invasive, non-native species

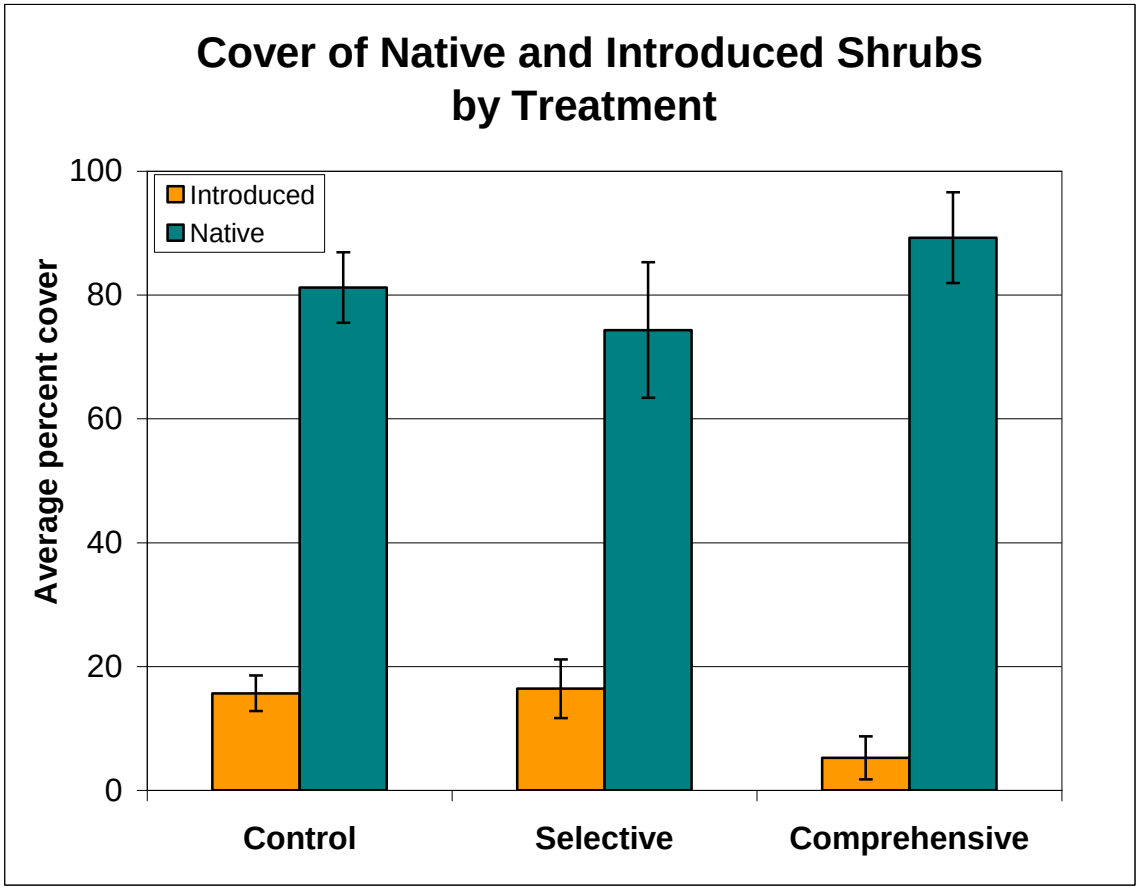
3.4.3. Shrub cover by treatment

In general, native shrubs are far more dominant than introduced shrubs in Pioneer Park. Overall, native shrubs have an average cover of 81.6%, while introduced shrubs cover only 13.6%. Introduced shrub cover is similar in *control* (15.6%) and *selective* (16.4%) treatment areas, but lower in areas with *comprehensive* treatment (5.2%) (Figure 13). Native shrub cover is slightly higher in *comprehensive* treatment areas than either *selective* treatment or *control* areas. Himalayan blackberry, the most prevalent non-native shrub, has an overall cover of 12.7% in *control* areas and 13.9% in *selective* treatment areas, while areas that received *comprehensive* weed removal have only 5.2% cover of Himalayan blackberry.

While Himalayan blackberry is the dominant invasive shrub in Pioneer Park, several others were found in the survey plots. Although they do not currently dominate the forest understory, they have the potential to spread rapidly and compete with native vegetation if left unchecked. Cherry laurel, a large tree-like shrub, was found in 43% of the plots, indicating that it is already widespread and is likely impacting the growth of native shrubs and trees. Spurge laurel (*Daphne laureola*), cutleaf blackberry (*Rubus laciniatus*) and one-seed hawthorn (*Crataegus monogyna*) are also present in the park and may become problems in the future.

A complete list of shrubs and coverage can be found in Appendix D.

Figure 13. Mean cover of introduced and native shrubs by treatment type, Pioneer Park, Mercer Island, WA



3.5. Herb, vine and grass composition and diversity

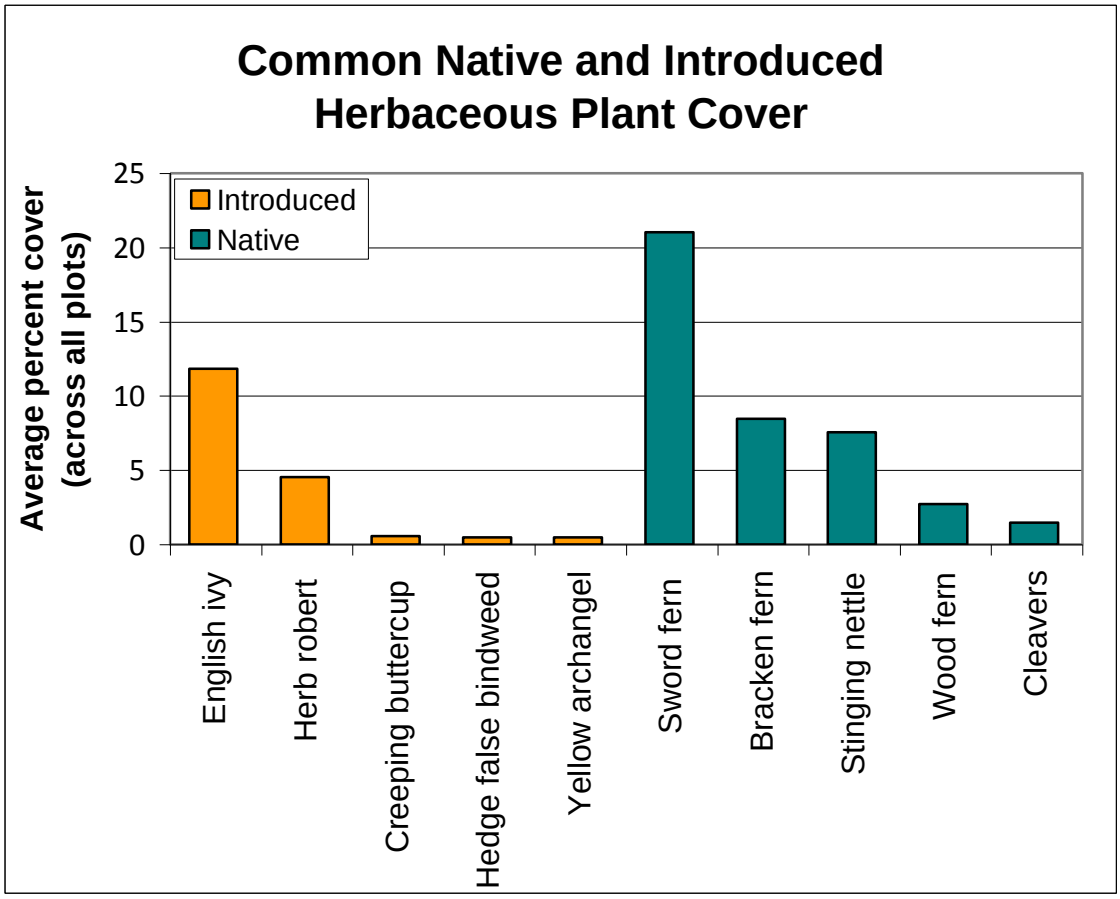
3.5.1. Summary

A total of 63 herbaceous species were found in the sample plots at Pioneer Park. Of these, 30 species are native (44.4% cumulative cover), 24 are non-native (19.1%) and nine are of unknown origin. The invasive species English ivy, as well as the native sword fern (*Polystichum munitum*), are present in every sample plot. Herb Robert (*Geranium robertianum*), a Class B Non-designated Noxious Weed in King County, is present in 94.6% of plots, with an average cover of 4.5% across all plots (Figure 14). Also found throughout the park are wood fern (*Dryopteris expansa*) and bracken fern (*Pteridium aquilinum*), each of which are present in 84% of the plots.

Several other native herbaceous species of interest were also found in the sample plots. Pacific trillium (*Trillium ovatum*), a well-known lily species, was found in 68% of the plots, while vanilla leaf (*Achlys triphylla*), a less common wildflower, was found in 40% of plots. Youth-on-age (*Tolmiea menziesii*) and foam flower (*Tiarella trifoliata*) were also found in over 5% of plots. Wild ginger (*Asarum caudatum*), which has been recorded in previous surveys of Pioneer Park vegetation, was not found in any of the sample plots.

A complete list of herbaceous species and percent coverage can be found in Appendix E.

Figure 14. Mean cover of most common herbaceous species across all plots, Pioneer Park, Mercer Island, WA



3.5.2. Herbaceous species across habitat types

At 105% cover, the riparian forest areas has the greatest total herbaceous matter. This high percent cover reflects the overlap between many individual species, and is the result of wetter conditions that allow for the growth many herbaceous plants. The most common herbaceous species in the riparian forest areas are sword fern (45% cover), lady fern (11%), stinging nettle (Urtica dioica) (10%), and English ivy (9%).

The mixed forest areas, with an average of 65% cover, have a moderate amount of total herbaceous cover. These areas typically have drier soils than the riparian forest areas. The most common herbaceous species in the mixed forest areas are sword fern (21% cover), English ivy (13%), stinging nettle (8%), and bracken fern (8%). Conifer forest areas have an average of 38% total herbaceous cover, the lowest of the three habitat types. These areas generally have the most well drained/dry soils, which create a more stressed environment for herbaceous species. The most common herbaceous species in the conifer forest areas are bracken fern (15% cover), sword fern (11%), English ivy (7%), and herb Robert (3%).

3.5.3. Herbaceous species across treatment types

In comparing treatment effects on herbaceous cover, *comprehensive* treatment areas have a higher ratio of native to introduced species coverage than both the *control* and *selective* treatment areas (Figure 15). Cover of the five most common introduced species were compared by treatment type (Figure 16). English ivy and herb Robert are more prevalent in both the *control* and *selective* treatment areas than the *comprehensive* areas. Additionally, the other three most prevalent herbaceous species (creeping buttercup (*Ranunculus repens*), hedge false bindweed (*Calystegia sepium*), and yellow archangel) are not found in *comprehensive* treatment areas at all. This absence may be attributable to the effectiveness of *comprehensive* weed removal, or may indicate that these weeds were never found in these plots.

Figure 15. Mean cover of introduced and native herbaceous plants by treatment type, Pioneer Park, Mercer Island, WA

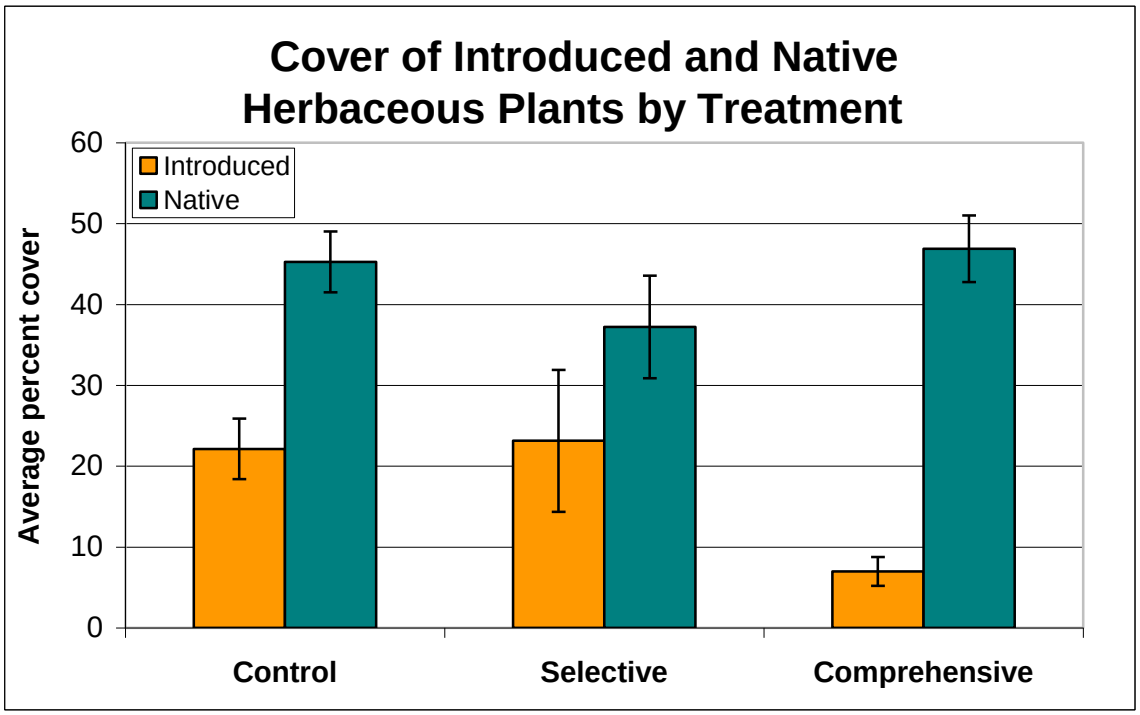


Figure 16. Mean cover of most common invasive herbaceous species by treatment type, Pioneer Park, Mercer Island, WA

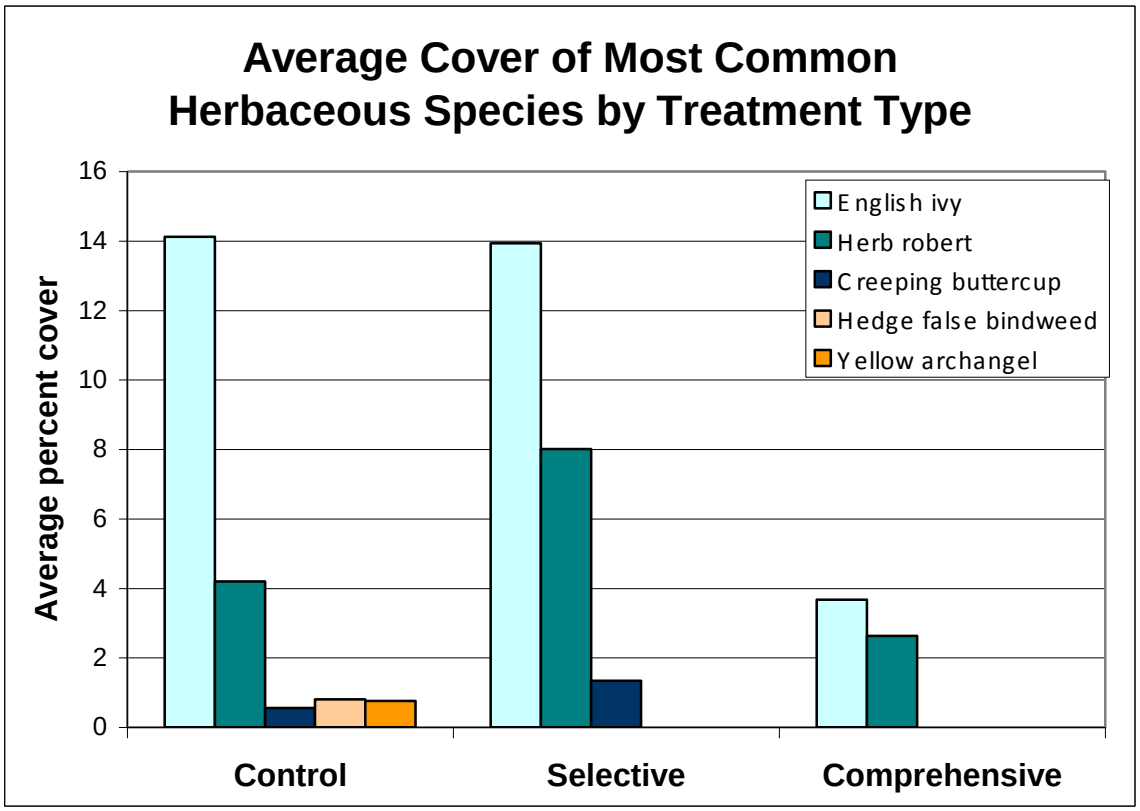
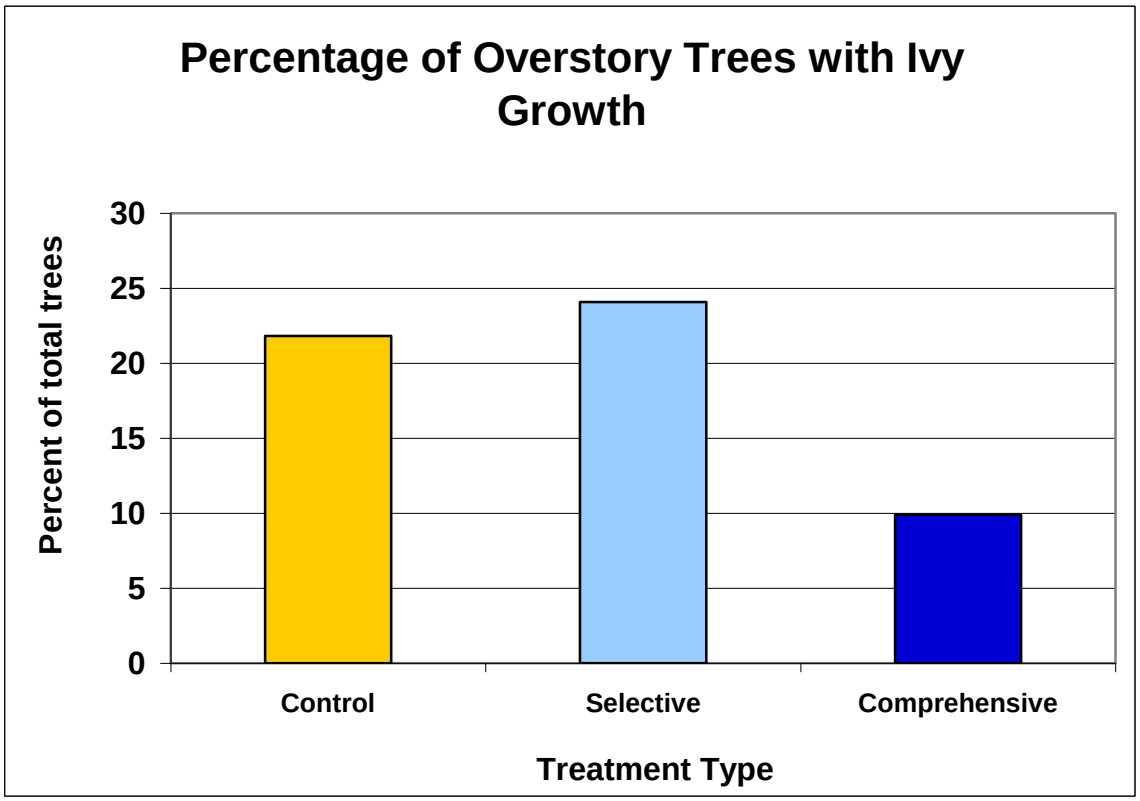


Figure 17. Percent of overstory trees with ivy growth, by treatment type, Pioneer Park, Mercer Island, WA



3.5.4. Ivy growth on overstory trees

While English ivy is a generally a low growing herbaceous plant, it has the ability to climb high in the canopy on mature trees. This growth of English ivy leads to stress, diminished growth, and eventually death of trees due to its weight and competition for light and water. Additionally, English ivy does not produce seed as a ground cover but does produce seed as it reaches into tree crowns. The presence of ivy in the canopy of trees leads to even more ivy in the park due to the production of seeds. Areas that received the *comprehensive* treatment had a greatly reduced percent of overstory trees with ivy growth (10%) as opposed to the *control* (22%) and *selective* (24%) treatments (Figure 17).

3.6. Snags

3.6.1. Background

Standing dead wood is an important component of all forests. These snags provide habitat for wildlife, insects, fungi and plants, and store nutrients, which are slowly released into the forest floor. In the Pacific Northwest, sixty-nine species of animals commonly use cavities carved out of these tree remnants (Boyland and Bunnell, 2002), and the presence of snags is particularly essential for populations of cavity nesting birds. In addition, birds use these pieces of wood as perches and as sources of insects for food.

3.6.2. Summary

Overall, Pioneer Park contains a healthy amount and quality of standing dead wood. Pieces of wood considered snags in this study were at least 5 inches DBH and at least 6 feet tall. Snags were found in 43 of the 56 plots (77%), with an average density of 20.2 snags/acre. The average height of a snag in Pioneer Park is 30 ft tall, with 24.8% of snags (5 snags/acre) taller than 40 ft (Figure 18). The diameters of snags range from 5-35 inches, and 3.2 snags per acre (15% of snags) are larger than 20 inches in diameter (Figure 19). Snags in Pioneer Park were found in all stages of decay, although most snags were categorized as Decay Class II.

Figure 18. Average snag density and height class by decay class, Pioneer Park, Mercer Island, WA

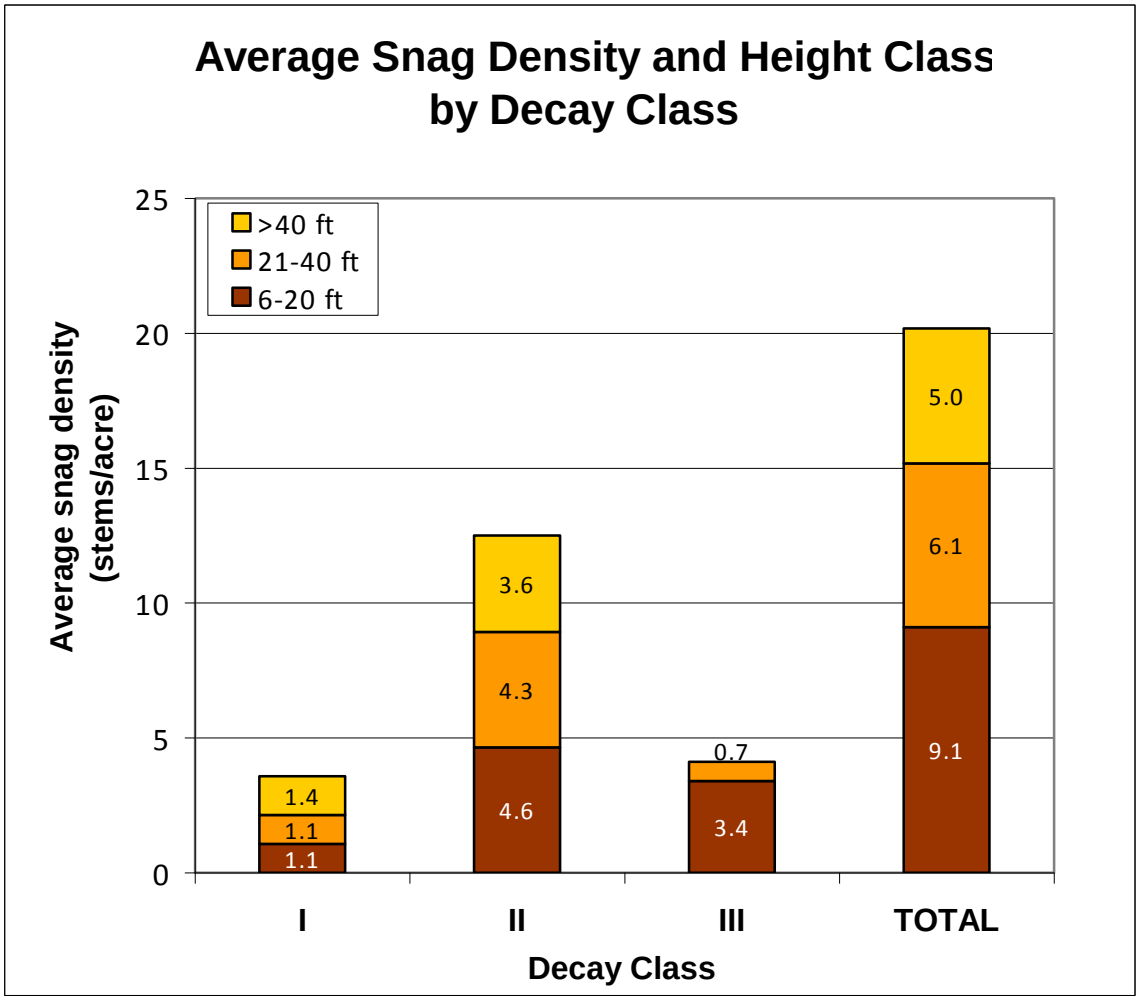
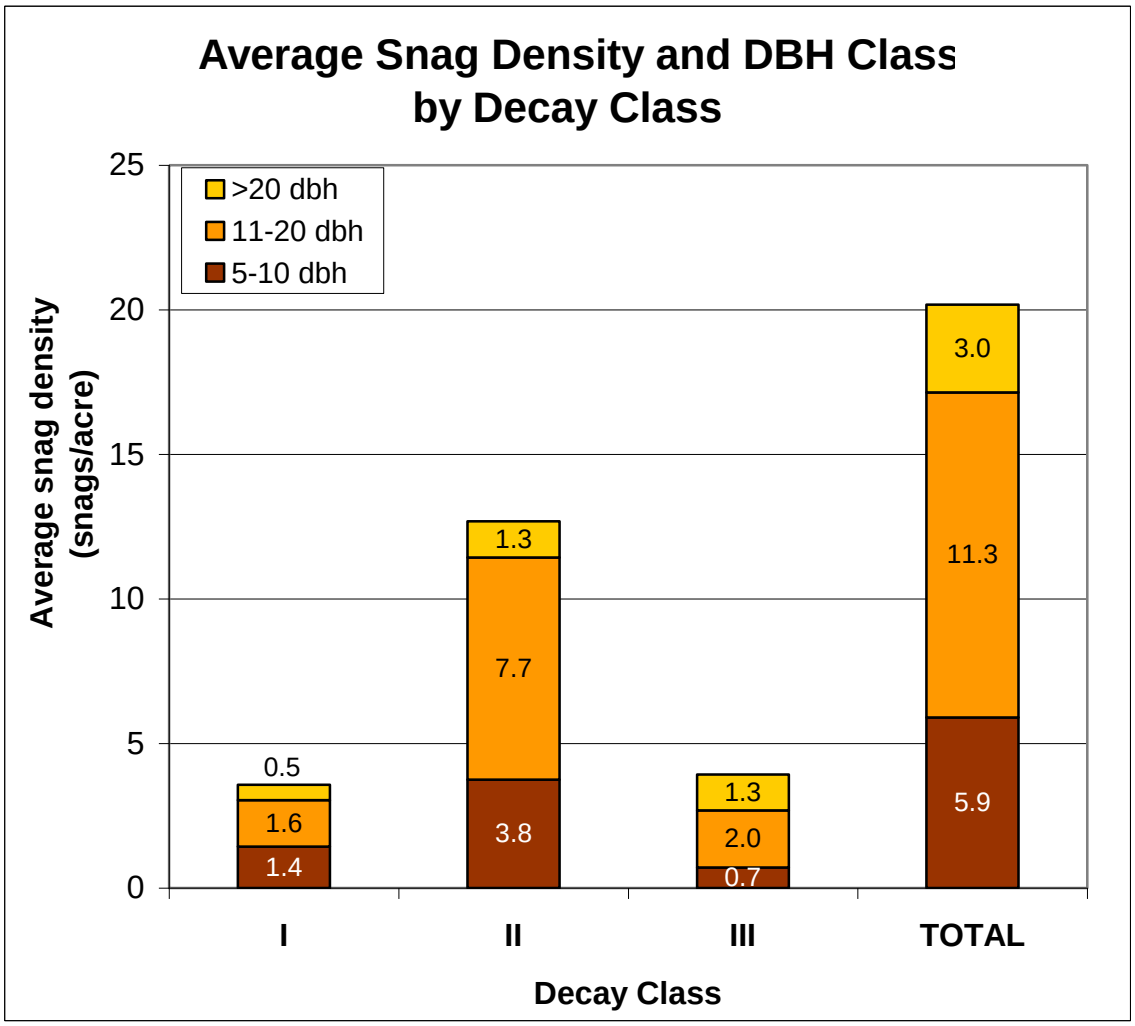


Figure 19. Average snag density and DBH class by decay class, Pioneer Park, Mercer Island, WA



The snags found in this study have a great deal of variation in size, decay and height. This type of diversity is extremely important for the support of all species that rely on certain conditions of standing dead wood. Boyland and Bunnell (2002) suggest that in order to sustain populations of cavity nesting birds, forests in the Pacific Northwest should contain at least 0.8-1.2 snags/acre larger than 20 inch DBH, and 4-8 snags/acre smaller than 20 inch DBH. Pioneer Park easily meets both of these criteria. Boyland and Bunnell (2002) also assert the importance of snags that are wide (to accommodate an adult and several young birds) and tall (to minimize interference by predators). In Pioneer Park, snags above 40 ft. tall average only 15.8 inches in diameter, and only three snags were found that exceeded 20 inches in diameter.

Table 7 shows how characteristics of snags in Pioneer Park compare to those of other urban forested areas in the Seattle area. The overall density and the average diameter of snags in Pioneer Park are slightly lower than other areas, while the average height is similar.

Table 7. Comparison of snag characteristics in Seattle-area urban forests (conifer-deciduous mixed forest type)

Area	Snag density (snags/acre)	Average height (ft.)	Average diameter (in.)	Snags over 20 in. diameter (snags/acre)
Shadow Lake, King Co., WA* (SUN, 2008c)	32	27	13.1	3
Boeing Creek, Shoreline, WA* (SUN, 2008a)	21	40	18.5	6
Deadhorse Canyon, Seattle, WA* (SUN, 2005)	14	24	21	3
Hamlin Park, Shoreline, WA* (SUN, 2008b)	65	36	9.6	0
Pioneer Park, Mercer Island, WA	20	30	12.9	3

* Study sites sampled and analyzed by Seattle Urban Nature (SUN) using methods comparable to those of the Pioneer Park Forest Health Survey.

3.7. Coarse woody debris

3.7.1. Background

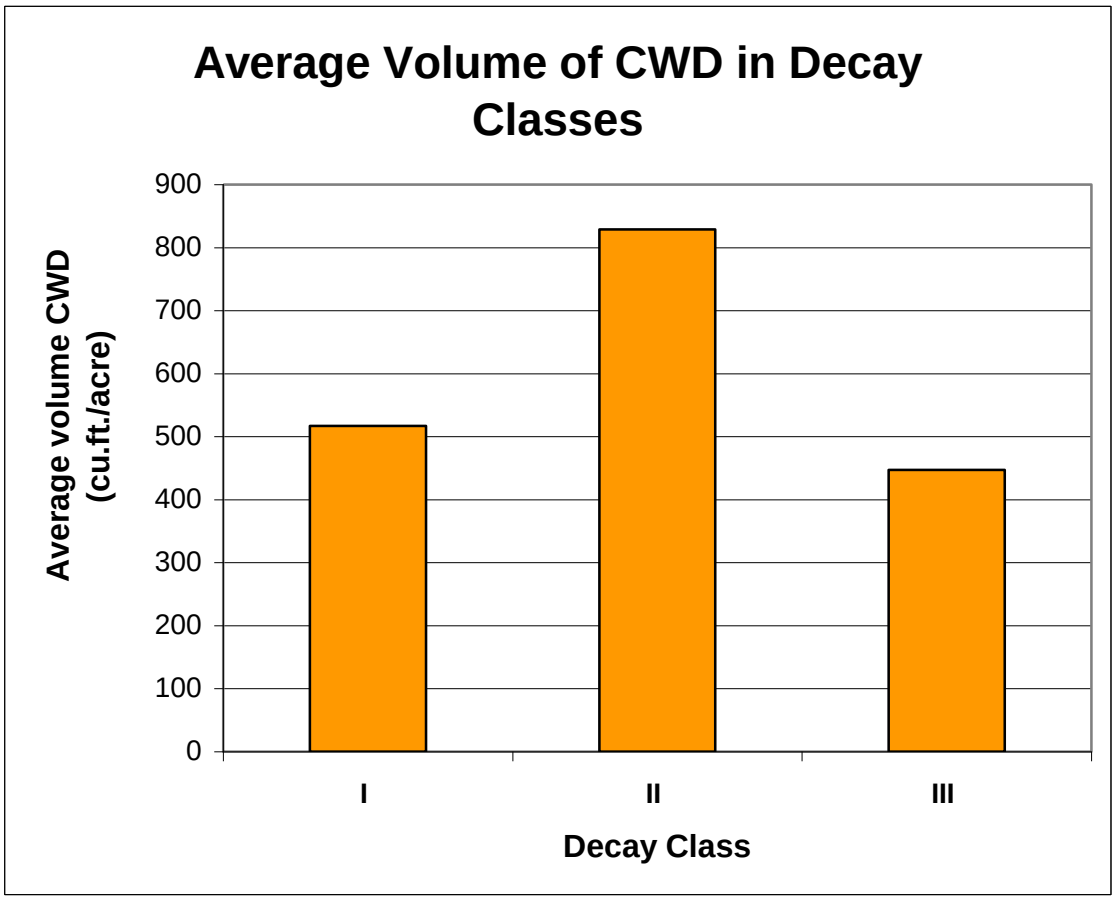
Coarse woody debris has become a focus of forest health and management over the last decade, as its benefits and services have been recognized. The importance of CWD in Pacific Northwest forests is difficult to overestimate, given its role in the lifecycles of forest flora and fauna.

Decaying pieces of wood in the forest often serve as 'nurse logs', areas where shade-tolerant conifers can more easily regenerate, due to the nutrient-rich, moist substrate, and reduced competition with other vegetation (Franklin *et al*, 1981; Stevens, 1997). Tree regeneration is often higher on coarse woody debris than in surrounding soil areas, and these saplings often have a higher growth rate (Franklin *et al*, 1981). For these reasons, the process of habitat renewal can be faster in areas where coarse woody debris has been left in place (Stevens, 1997).

Because decaying wood absorbs and retains water, CWD often serves as a sought-after microhabitat for animals during dry periods. These pieces of wood provide sites for burrows, nests and dens, as well as travel corridors through dense understory vegetation, for a variety of small mammals (Stevens, 1997). They also provide protection and moisture for amphibians, and habitat for arthropods and decomposers.

These logs also contribute to the health of the ecosystem indirectly: CWD contains pools of nutrients that are slowly released into the forest floor and made available to vegetation. Large pieces of wood serve as long-term storage for large amounts of carbon.

Figure 20. Volume of CWD per acre, by decay class, Pioneer Park, Mercer Island, WA



3.7.2. Summary of coarse woody debris results

Coarse woody debris on the forest floor was only considered in this study if it had a diameter of 6 inches or greater. CWD was found in all but one study plot at an average density of 127 pieces per acre. The average piece of CWD has a length of 15.5 feet and a diameter of 12.1 inches. Coarse woody debris was found in all stages of decay, and almost half of the volume of wood was classified as Decay Class II (Figure 20). A healthy forest, such as this, will have a good proportion of its CWD in each decay class.

The average volume of CWD in the park, 1793 ft^3 per acre, is midway between values for other similar parks in the area (Table 8). Values for unmanaged forests of similar age in the Pacific Northwest range from 1325 to 2359 ft^3 per acre, with a mean of 1774 ft^3 per acre (Spies and Franklin, 1991). Although the volume of downed wood needed to create a 'healthy' forest is difficult to calculate, the proximity of values in Pioneer Park to those of unmanaged forests indicates that this park currently contains an adequate amount of CWD to support local wildlife.

Table 8. Comparison of CWD characteristics in Seattle-area urban forests (mixed conifer-deciduous forest type)

Area	Average number of pieces per acre	Average volume (ft^3/acre)	Average diameter (in.)
Shadow Lake, King County, WA* (SUN, 2008c)	130	2774	11.8
Boeing Creek, Shoreline, WA* (SUN, 2008a)	-	1022	11
Deadhorse Canyon, Seattle, WA* (SUN, 2005)	-	2390	16.5
Hamlin Park, Shoreline, WA* (SUN, 2008b)	128	611	7.8
Pioneer Park, Mercer Island, WA	127	1793	12.1

* Study sites sampled and analyzed by Seattle Urban Nature (SUN) using methods comparable to those of the Pioneer Park Forest Health Survey.

4. MANAGEMENT RECOMMENDATIONS

The recommended management strategies that have been developed for this park are a product of study results and professional experience with similar restoration efforts. These recommendations differ from those of the 2004 City of Mercer Island Open Space Vegetation Plan. The 2004 plan, which guides open space vegetation management in all Mercer Island parks except Pioneer Park, suggests that weed removal priorities should be directed towards the removal of small outlier populations (nascent foci) of a given weed before focusing on larger, dense patches. Due to the healthy cover of native shrubs throughout Pioneer Park, it is not expected that large areas of the park will be invaded by outlying populations of non-native shrubs and herbaceous plants in the years before these weeds are addressed in the new management plan. Therefore the nascent foci strategy will not be used in this plan and instead a complete removal strategy will be employed.

4.1. Review of Management Practices, 2003 – 2008

The goal of the strategy set forth in the 2003 Forest Management Plan is to attain a "healthy forest" using passive, natural regeneration whenever possible. This strategy includes one round of tree planting consisting of primarily native conifer trees. The tree planting occurs throughout the park only as needed, including forest gaps and areas with sparse natural regeneration of any native trees (either conifer or deciduous).

To reach the point of requiring only light annual maintenance, an area must undergo a three year cycle of treatment which includes three years of intensive weed removal and tree planting, where needed, in the first year. This management, referred to as *comprehensive* treatment, prioritizes treatment by area. Treatment in one or more areas of the park is begun before another area is addressed. Generally, areas not receiving *comprehensive* treatment either remain untreated until they can receive *comprehensive* treatment, or receive a small amount of treatment (*selective*), such as tree planting or blackberry brush-cutting.

An advantage of this methodology is that once an area has gone through a complete three-year cycle of treatment, it is considered "finished" and only requires annual maintenance. Unfortunately, it delays focus on particularly troublesome park-wide issues, such as English ivy on large trees and low conifer regeneration, which will affect the health of Pioneer Park's forests for years (Appendix H).

4.2. Overview of 2008 Forest Health Plan

The 2008 Forest Health Plan has the goal of attaining a healthy and sustainable forest based on the findings of the 2008 FHS study. The methodology of this plan is outlined in Sections 4.3 though 4.5.

The strategy prioritizes specific issues throughout the park that will have the greatest impact on the future structure of the forest. Treatment of an entire forest health issue occurs throughout the park before treatment of the next most pressing issue. This gives managers the ability to prioritize management activities based on ecological need, and adjust timing of particular tasks in accordance to available funding levels. As proposed, the workload and cost of this plan has been distributed relatively evenly over the next twenty years (see Section 4.3).

4.3. Continuation of *comprehensive* treatment

The areas currently undergoing *comprehensive* treatment have received a significant investment of both time and money over the past seven years. For this reason, it is our recommendation that invasive removal and other maintenance activities in the 17.1 acres receiving *comprehensive* treatment continue through the three-year schedule of maintenance. Once these three years of intensive management are completed, lower-intensity yearly maintenance should continue to aid the growth of new trees. This maintenance is expected to be required for approximately 20 years.

4.4. Management of large woody debris

Because dead and decaying wood plays a vital role in the regeneration of trees and the preservation of plant and animal diversity of Pioneer Park, CWD and snags should be kept in place whenever possible. In addition, wood from living trees or snags that are cut due to safety concerns should be left within the park. Special efforts should be made to retain tall, large diameter snags.

4.5. New management strategy (in order of priority)

4.5.1. Short-term objectives

1) Remove English holly and cherry laurel

English holly is the most common tree found in Pioneer Park (Map 3). Its ability to form dense thickets and grow in virtually any environment makes this species a major competitor of native vegetation for light, nutrients and water. If possible, a given area should be swept clean of all English holly, regardless of size, by herbicide treatment. Larger plants (with a diameter of one inch or more) should be frilled at a height of one foot and treated with 100% concentration glyphosate applied immediately to the fresh wound of the tree. Smaller trees and seedlings (all specimens with a diameter less than one inch) of English holly should

Map 3. Regenerating English holly density in Pioneer Park, Mercer Island, WA

be cut at a height of one foot and receive an immediate 100% concentration glyphosate application on the cut stem.

Because it is spread easily by seed and will continue to invade new areas, the control of mature specimens of English holly is the highest priority. If time or budgets do not allow for removal/treatment of all sizes of English holly, older specimens, with a diameter of one inch or more, should be removed first as they are more likely to contribute new propagules to the environment.

The same control measures should be used for cherry laurel.

2) Plant conifers and maintain

Over the next 100 years the composition of the forest canopy in Pioneer Park will continually change, due in part to forest diseases. A relatively high percent of existing overstory Douglas-fir will become infected with laminated root rot (LRR) and fall to the forest floor. In order to prevent the rapid colonization of these new forest gaps by native deciduous trees or invasive tree species, it is important that young conifers be planted early. At Pioneer Park, native conifers suitable for planting in LRR gaps include the LRR-resistant western red cedar and the LRR-tolerant shore pine (*Pinus contorta* var. *contorta*) and western white pine (*Pinus monticola*). While Douglas-fir and western hemlock will not be actively removed, planting these species is not encouraged due to their susceptibility to LRR. With widespread planting of LRR -resistant and -tolerant conifer species, the historic conifer tree character of Pioneer Park will be preserved, while the naturally-occurring laminated root rot fungus persists in the forest.

Based on densities found in comparable mature forests (Table 4), the desired stem density for overstory trees in Pioneer Park is approximately 150 trees/acre. The structure of this forest is ideally a multi-aged conifer stand, with a small percentage of native deciduous trees. Because Pioneer Park currently supports a robust population of young deciduous trees, planting efforts should focus primarily on the aforementioned conifer species.

Given the target density, regenerating conifers should be planted at a density of 200 to 400 trees/acre (Sound Native Plants, 2006), depending on site quality. This initial planting density will ensure good survival while allowing for natural attrition and thinning. However, in order to achieve a forest stand that contains trees of varying ages, we recommend that tree planting be completed in two phases:

- Phase 1 (short term): Plant at approximately 200 trees/acre density, including existing regenerating conifers.

- Phase 2 (long term, 20-30 years later): Plant at approximately 110 trees/acre density, *excluding* existing regenerating conifers (see section 4.3.3)

Overplanting to account for natural mortality will save time and cost of future planting. However, if mortality rates are lower than expected, future thinning may be required. Thinning forest understory plantings requires additional expense, and the removal of young, healthy trees may cause public concern. (K. Moller, Seattle Parks Urban Forester, Personal communication, 7 October, 2008).

Although trees planted at Pioneer Park should primarily consist of conifer species, these plantings may be supplemented and diversified by adding under-represented native broadleaf species that are well-suited to particular habitat types. In the conifer forest habitats, the addition of cascara, pacific dogwood and madrone will diversify the overstory canopy. Mixed forest areas will benefit from the addition of young madrone trees, and riparian forest habitats should also receive several broadleaf species, such as bitter cherry (*Prunus emarginata*), cascara (*Frangula purshiana*), Oregon ash (*Fraxinus latifolia*), pacific dogwood (*Cornus nuttallii*), and paper birch (*Betula papyrifera*). The planting of these non-dominant native broadleaf trees should be limited to 10% of any given planting to ensure that the desired conifer species thrive.

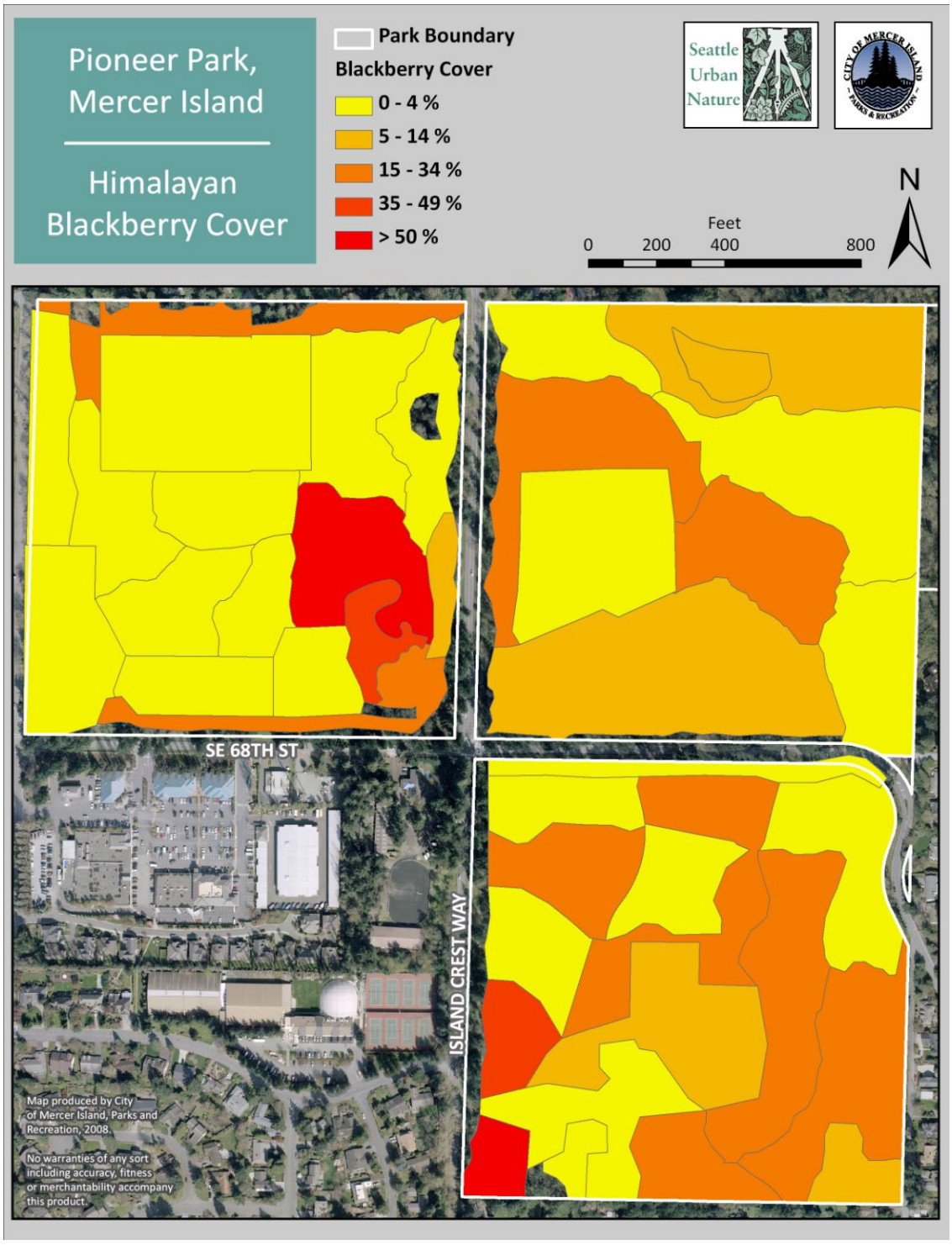
Himalayan blackberry control

In preparation for planting, vegetation will be cleared to allow light to reach the newly planted trees. This vegetation clearing will include removal or cutting back of both invasive species (such as English ivy and Himalayan blackberry) and native species (such as sword fern and low Oregon grape). This clearing should be completed no more than four weeks before planting to ensure that the vegetation has not grown back.

In areas such as forest gaps, where dense patches of Himalayan blackberry dominate, the area will need to be cleared of all canes by brush cutting or "knock down". This process involves cutting all blackberry canes in the area to a height of one foot using mechanized equipment and allowing the cut material to decompose on site. This relatively quick method of clearing these areas does not remove the root material but, rather, over time exhausts the plant's underground resources by restricting photosynthesis. It also may allow native vegetation surrounding the Himalayan blackberry to expand.

Priority Himalayan blackberry removal areas are indicated in Map 4. Overall, complete elimination of Himalayan blackberry is a lower priority than the treatment of English holly, cherry laurel, and English ivy because, unlike these species, growth of blackberry can be suppressed with increased shade. As portions of the forest become shadier following the planting of conifer trees, density and spread of Himalayan blackberry will be kept at a minimum.

Map 4. Himalayan blackberry cover in Pioneer Park, Mercer Island, WA



New trees should be planted in the fall or early winter only, to allow for adequate rooting before the dry months of the year. We recommend 2-gallon planting stock, as these trees generally have developed root systems, and are tall enough to be re-located for maintenance (if flagged). If possible, planting stock should be obtained from a local seed source.

Maintenance should be performed on trees once per summer, for two years following planting. This maintenance will include the removal of all vegetation within a 5 foot diameter of each tree. Removing these plants, and their roots, will reduce the competition for light, water and soil nutrients. Because these trees will not be irrigated, the reduction of competition is especially important to the survival of these saplings.

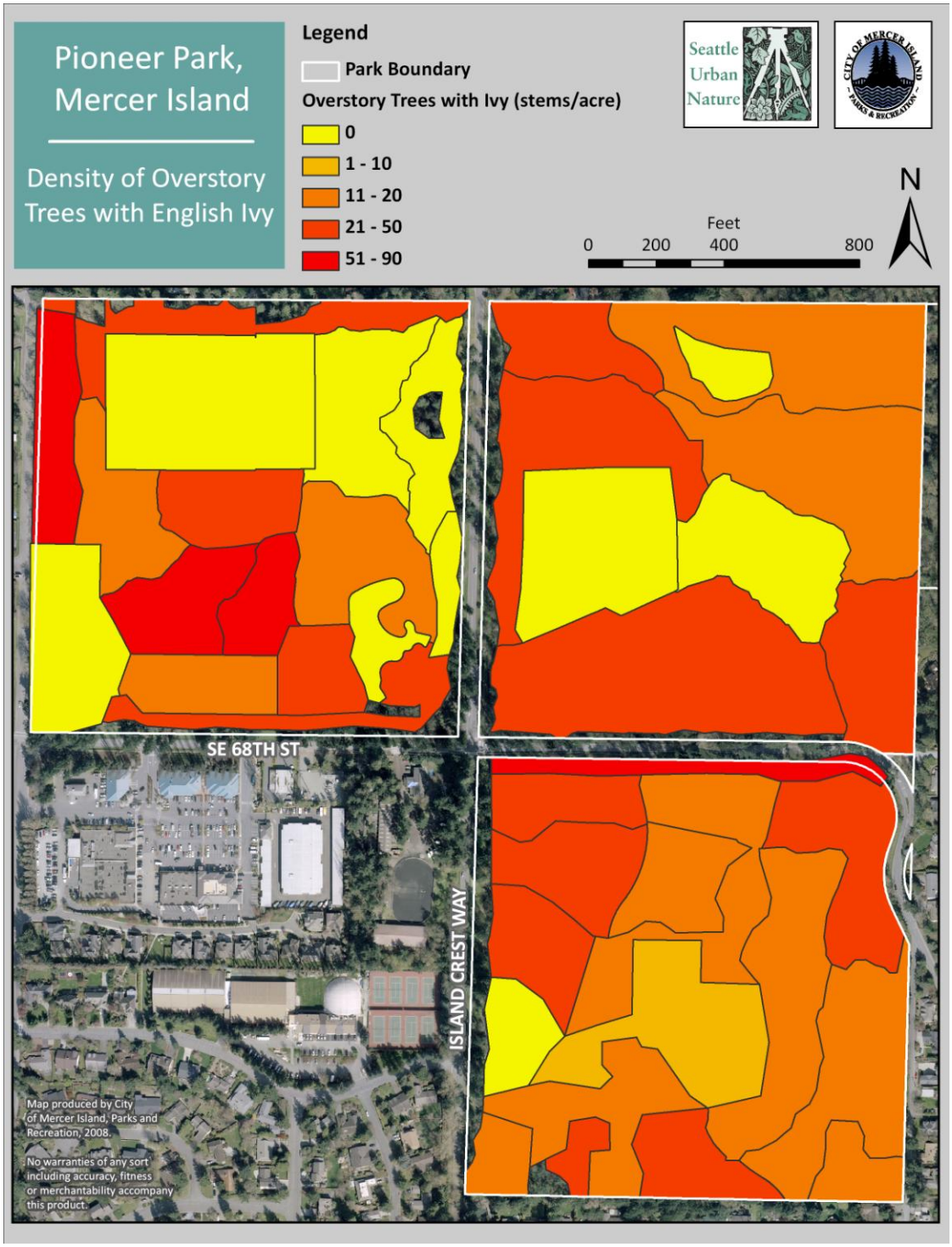
While the shrub component of the forest is very important, the planting of shrubs is not a priority for several reasons. First, there already exists a good diversity and density of native shrubs (Figure 12). Second, the future knockdown and removal of Himalayan blackberry may open space in the forest into which native shrubs will continue to move, given ongoing maintenance.

3) Remove English ivy from trees

The removal of English ivy from trees is a critical step in improving the health of Pioneer Park. On very small trees the entire mass of ivy is removed from the plant. On large trees, where ivy has grown high into the tree, the stems of ivy are severed at approximately four feet from the ground. In both cases, the ivy stems and root mass are cleared within a three foot ring around the base of the tree. This technique, known as creating “ivy rings”, causes the ivy on large trees to dry out and slowly die. Although the ivy dies relatively quickly, it can take up to 20 years for the dead ivy biomass to fall out of the tree. The creation of ivy rings greatly reduces the weight and shading on the tree canopy, and decreases the competition for soil resources, within weeks.

Because English ivy is evergreen, ivy ring creation can be performed any time of the year. Areas of Pioneer Park with a high density of ivy-covered trees should be given first priority in control (Map 5).

Map 5. Density of overstory trees with English ivy growth in Pioneer Park, Mercer Island, WA



4.5.2. Mid-term objectives

1) Remove herbaceous weeds from forest floor

This goal targets aggressive non-native groundcover species such as English ivy, yellow archangel, hedge false bindweed, and herb Robert. In areas where these species occur in dense monocultures, control using a foliar-application of glyphosate herbicide at the manufacturer's recommended concentration is advised. In areas near existing native plants, young conifer trees, or watercourses, manual removal is recommended. Pulled plant material can be left on site in large piles atop tree branches, elevating the pile several inches above the ground, which will promote degradation. Follow-up removal of these plants will occur once every three years.

2) Monitor and remove new invasions

Pioneer Park is currently home to several invasive species which require significant economic resources for management and pose immediate threats to the ecological health of the forest. Other invasive plants, such as yellow archangel and cherry laurel, have the potential to greatly increase their presence in the park. However, there are many other invasive species found in the Pacific Northwest which have not yet become problems in the park. Such species include Scotch broom (*Cytisus scoparius*), knotweed (*Polygonum cuspidatum*), garlic mustard (*Alliaria petiolata*), and reed canarygrass (*Phalaris arundinacea*). Preventing invasions by these species is the most effective and resource-efficient method of controlling these plants. Therefore, a systematic monitoring program of the areas that are likely to host such invasions is strongly recommended. This monitoring should be done every-other year in late spring, when the greatest numbers of plants are growing concurrently. The three general locations in the park where plant invasions are likely to occur are at the park boundaries with private residences, along the stream corridor, and alongside trails.

Boundary search
Many of the non-native species that become a problem in public wildland parks are plants that have spread from horticultural plantings on adjacent properties. Because four edges of Pioneer Park directly border private residential property, these boundaries must be monitored for potential invasive plants. Each year, a search of the boundary between Pioneer Park and private properties should be made to identify new species. This search should cover a 50' wide swath from the park boundary line inward. The important boundaries for this search are the north edge of the NW quadrant, the north and east edges of the NE quadrant, and the south edge of the SE quadrant. Monitors should carry a GPS unit to record the location of new invasions, and hand tools and bags, used to remove small invasive populations, if time permits. Larger population of newly discovered invasive plants should be eliminated from park property as soon as possible.

Stream corridor search
Stream corridors provide a unique opportunity for new non-native plant invasions. Plants can move as seeds and vegetative material, making their way into the park by flowing downstream. Invasive, non-native water-loving plants such as

knotweed, reed canarygrass, and bittersweet nightshade (*Solanum dulcamara*) are uniquely adapted to wet areas and are especially difficult to remove once established. In monitoring the stream corridor, a 100' wide search (50' on each side of the stream) is recommended.

Trail edge search
New plant invasions often occur along trail edges because these areas of the park receive the most use by park visitors. Invasive plant seeds can enter the park through attachment to clothing, shoes, pet hair, pet paws, and horse waste. A regular survey of all park trails is recommended to monitor for potential new plant invasions. Because trail corridors are observed more often than the park's streams or boundaries, it is only necessary to monitor a 10' swath on either side of the trail.

3) Permanent survey plot monitoring

Permanent survey plots, first established for the 2008 Forest Health Survey, will be revisited every ten years. This monitoring will use the same sampling techniques described in Section 2 of this report. With each data collection, new information will be available regarding existing forest conditions, effectiveness of treatments, and trends in vegetation over time. Ideally, this survey will be conducted in the same season in which the initial study was conducted (early June through August) so that data are comparable. Plots can be located using maps from the original survey as well as geographic coordinates (Appendix G).

4.5.3. Long-term objectives

1) Second phase conifer planting

The second phase of conifer planting will take place 20-25 years after the implementation of this plan. As in the first phase of planting, most trees will be LRR-resistant conifer species, with a small proportion of native broadleaf species. Trees will be planted at a density of 100 stems/acre, filling in the spaces between existing trees and replacing previous planted trees that have not survived.

Similar maintenance should be performed on these newly planted trees, to ensure a high percentage of survivorship and the creation of a healthy multi-aged stand.

4.6. Budget-restricted management alternative

An alternative management strategy was developed that, while based on the 2008 Forest Health Plan, stays within Mercer Island Parks' annual budget for work at Pioneer Park ($132,000). In order to accommodate this budget, the timing of management activities was changed and some follow-up maintenance reduced. These changes are likely to compromise the effectiveness of the recommendations, as priority activities, such as holly and laurel removal, tree planting, and ivy ring creation will take longer to complete. The budget-restricted plan also requires 25 years of management to achieve comparable levels of forest health set in the original plan (20 years).

4.6.1 Specific modifications to 2008 Forest Health Plan

In the modified plan, initial holly and laurel treatment is spread over six years rather than five, and follow-up treatment of holly and laurel occurs every six years rather than every five. Initial tree planting occurs over 13 years rather than five years, and only one round of annual maintenance occurs on the planted trees rather than the two years recommended in the original plan. Ivy ring creation begins in the fifth year of the project in the budget-restricted plan, rather than the first year, and stretches the activity over ten years rather than five years. Two cycles of ivy ring maintenance occurs in the modified plan rather than three cycles.

Ground ivy treatment occurs seven years later in the budget-restricted plan and is spread out over six years rather than five. Additionally, there is one fewer cycle of ground ivy maintenance in this revised plan. Four rounds of boundary search and destroy are included in this plan (once every four years, starting at year 11) compared to eight rounds (every other year, starting at year 6) in the 2008 Forest Health Plan. The second phase of tree planting takes place over 11 years rather than five years.

4.7. Cost estimates

Three condensed budgets are presented in the appendices. Appendix I estimates the cost of implementation for the 2008 Forest Health Plan, the details of which are presented in Sections 4.2 through 4.5. This plan is projected to cost approximately $3.58 million over the next 20 years. For comparison purposes, Appendix J presents the costs expected for continuation of the 2003 Forest Management Plan, with a total cost of approximately $3.73 over 20 years. The budget-restricted version of the 2008 Forest Health Plan costs is presented in Appendix K. This budget and the corresponding management schedule are revised to limit annual spending on Pioneer Park management to approximately $132,000, the current amount allocated to these activities, and costs are projected over the next 25 years. All strategies include the completion of management activities in the current *comprehensive* treatment areas (Sections 1.4 and 2.1).

Costs are calculated based on unit costs of contracted work within Mercer Island Parks between 2006 and 2008. There are very few estimates of unit costs for annual maintenance once initial weed removal or planting has occurred. Because of this, long term unit costs for maintenance are educated guesses at best. Budgets are projected through 2028 or 2033, depending on the plan, when the forest is expected to have attained a stable, healthy state, requiring minimal further maintenance.

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Appendix A. Pioneer Park Forest Management Plan goals

(From: Mercer Island Open Space Conservancy Trust & City of Mercer Island Parks and Recreation Department, 2003):

1. Pioneer Park will remain a healthy, sustainable native forest

2. The soils of the park are the foundation for all life in the park. Therefore, they will be preserved, along with the living organisms and soil-building processes found there.

3. The forest will consist of plant species native to the Puget Sound basin. Plants native to the coastal northwest, but not endemic to the Puget Sound basin may be used, limited to sites where locally native species cannot perform a landscape function necessary for forest management.

4. Natural regeneration will be the primary mechanism for managing the forest vegetation, since this achieves ecological restoration with lower levels of input and disturbance. Plantings will be used where native regeneration is not sufficient to achieve plan goals.

5. Diversity of structure and composition will be managed. Too much or too little diversity impacts habitat, aesthetics, pest control, and management efficacy. Activities that increase diversity should not introduce excessive randomness to the forest composition.

6. Habitat will be preserved and enhanced to maintain the park's population of native animals, including, but not limited to, mammals, birds, reptiles and invertebrates.

7. The riparian environments within the park will be managed as in Goal 6 and also avoid adverse impact to aquatic habitat downstream from the park.

8. Invasive non-native plants will be controlled to achieve plan goals.

9. Park vegetation will not pose an unreasonable hazard to park users, adjacent streets or neighboring properties.

10. The vegetation in the park will be managed to enhance park users' passive enjoyment of a native forest setting.

11. Members of the Mercer Island community find ways to actively participate in the restoration projects under the leadership of the Open Space Conservancy Trust.

12. The City of Mercer Island will manage the forest under the leadership of the Open Space Conservancy Trust.

Appendix B. Frequency and density of overstory tree species in Pioneer Park

Species	Common Name	Native/ Introduced	Percentage of Plots Found	Average Density (stems/ plot)	Percentage of Native Density	Percentage of Total Density
Acer macrophyllum	big-leaf maple	native	57.1	15	16.9	16.4
Alnus rubra	red alder	native	57.1	15	16.4	15.8
Arbutus menziesii	madrone	native	8.9	1	1.2	1.2
Cornus nuttallii	dogwood	native	7.1	1	1	1
Ilex aquifolium	English holly	introduced	25	3		3.7
Prunus emarginata	bitter cherry	native	3.6	3	3.2	3.1
Pseudotsuga menziesii	Douglas-fir	native	83.9	39	43.7	42.1
Rhamnus purshiana	cascara	native	7.1	1	1	1
Taxus brevifolia	yew	native	1.8	0.2	0.2	0.2
Thuja plicata	western red cedar	native	25	4	4.4	4.2
Tsuga heterophylla	western hemlock	native	44.6	11	12	11.5

Appendix C. Frequency and density of regenerating tree species in Pioneer Park

Species	Common name	Native/ Introduced	Percent of Plots Where Found	Average Density (stems/plot)	Percentage of Native Trees	Percentage of Total Trees
Abies grandis	grand fir	native	1.8	0.04	0.3	<0.1
Acer circinatum	vine maple	native	1.8	0.04	0.3	<0.1
Acer macrophyllum	Big-leaf maple	native	78.6	4.8	46.9	4.7
Acer palmatum	Japanese maple	introduced	1.8	0.02	--	<0.1
Acer saccharinum	silver maple	introduced	1.8	0.07	--	<0.1
Alnus rubra	red alder	native	7.1	0.5	5	0.5
Cornus nuttalii	Pacific dogwood	native	3.6	0.1	1.2	0.1
Ilex aquifolium	English holly	introduced	85.7	89.9	--	86.6
Malus fusca	Oregon crab apple	native	3.6	0.04	0.3	<0.1
Malus sp.	apple	introduced	3.6	0.04	--	<0.1
Pinus contorta	shore pine	native	3.6	0.4	3.5	0.3
Pinus monticola	western white pine	native	1.8	0.02	0.2	<0.1
Pinus ponderossa	ponderosa pine	native	1.8	0.02	0.2	<0.1
Prunus avium	sweet cherry	introduced	9	0.4	--	0.4
Prunus cerasifera	cherry plum	introduced	1.8	0.02	--	<0.1
Prunus emarginata	bitter cherry	native	3.6	0.09	0.9	<0.1
Prunus sp.	plum	introduced	5.4	0.1	--	0.1
Pseudotsuga menziesii	Douglas-fir	native	10.7	0.3	2.4	0.2
Quercus sp.	oak	native	19.6	0.3	3.1	0.3
Rhamnus purshiana	cascara	native	60.7	2	19.2	1.9
Sequoia sempervirens	coast redwood	introduced	7.1	0.1	--	<0.1
Sorbus aucuparia	European mountain ash	introduced	39.3	2.9	--	2.8
Thuja plicata	western red cedar	native	41.1	1.3	13	1.3
Tsuga heterophylla	western hemlock	native	19.6	0.4	3.5	0.3

Appendix D. Frequency and cover of shrub species in Pioneer Park

Species	Common Name	Native/ Introduced	Percent of Plots Where Found	Avg. Cover Where Found	Avg. Cover Across All Plots
Acer circinatum	vine maple	native	5.4	2.5	0.1
Aucuba japonica	Japanese laurel	introduced	3.6	2.0	<0.1
Corylus cornuta	beaked hazelnut	native	83.9	22.4	18.8
Cotoneaster simonsii	Simons' cotoneaster	introduced	3.6	0.9	<0.1
Crataegus monogyna	oneseed hawthorn	introduced	1.8	0.02	<0.1
Daphne laureola	spurgelaurel	introduced [1]	1.8	0.02	<0.1
Gaultheria shallon	salal	native	73.2	12.3	9.0
Holodiscus discolor	oceanspray	native	26.8	6.1	1.6
Lonicera involucrata	twinberry	native	1.8	0.02	<0.1
Mahonia aquifolium	tall Oregon grape	native	3.6	0.1	<0.1
Mahonia nervosa	low Oregon grape	native	96.4	7.1	6.8
Oemeleria cerisformis	Indian plum	native	85.7	6.4	5.5
Oplopanax horridus	devil's club	native	12.5	8.4	1.1
Prunus laurocerasus	cherry laurel	introduced [1]	42.9	4.1	1.8
Prunus lusitanica	Portugal laurel	introduced	8.9	4.2	0.4
Ribes lacustre	prickly currant	native	1.8	2.6	<0.1
Rosa gymnocarpa	baldhip rose	native	10.7	1.6	0.2
Rosa pisocarpa	cluster rose	native	1.8	3.6	<0.1
Rubus armeniacus	Himalayan blackberry	introduced [2]	76.8	14.7	11.3
Rubus laciniatus	cutleaf blackberry	introduced [2]	5.4	0.05	<0.1
Rubus leucodermis	whitebark raspberry	native	76.8	11.8	9.1
Rubus parviflorus	thimbleberry	native	16.1	2.1	0.3
Rubus spectabilis	salmonberry	native	62.5	15.0	9.3
Rubus ursinus	creeping blackberry	native	85.7	5.8	4.9
Sambucus racemosa	red elderberry	native	92.9	13.8	12.8
Symphoricarpos albus	common snowberry	native	1.8	19.2	0.3
Ulmus americana	American elm	introduced	1.8	1.6	<0.1
Unknown shrub	Unknown shrub	--	1.8	4.8	<0.1
Vaccinium parvifolium	red huckleberry	native	75.0	2.0	1.5

[1] Invasive species which are currently listed as Non-Designated Noxious Weeds by the King County Noxious Weed Program (King County, 2008)
[2] Invasive species which are currently listed as Noxious Weeds of Concern by the King County Noxious Weed Program.

Appendix E. Frequency and cover of herb, fern and grass species in Pioneer Park

Species	Common Name	Native/ Introduced	Percent of Plots Where Found	Avg. Cover Where Found	Avg. Cover Across All Plots
Achlys triphylla	vanilla leaf	native	39.3	0.8	0.3
Actaea rubra	red baneberry	native	3.6	0.4	<0.1
Adiantum pedatum	northern maidenhair	native	3.6	1.1	<0.1
Agrostis sp.	bentgrass	-	3.6	2.9	0.1
Aira caryophyllea	silver hairgrass	introduced	1.8	4.2	0.1
Ajuga reptans	common bugle	introduced	1.8	0.1	<0.1
Athyrium filix-femina	common ladyfern	native	19.6	4.5	0.9
Bromus vulgaris	Columbia brome	native	1.8	0.2	<0.1
Calystegia sepium	hedge false bindweed	introduced [2]	3.6	13.6	0.5
Cardimine hirsuta	hairy bittercress	introduced	3.6	0.6	<0.1
Carex sp.	sedge	native	5.4	0.2	<0.1
Circaea alpinum	enchanter's nightshade	native	21.4	0.5	0.1
Cirsium vulgare	bull thistle	introduced [1]	1.8	0.02	<0.1
Claytonia sibirica	Siberian springbeauty	native	23.2	0.3	0.1
Crepis capillaris	smooth hawksbeard	introduced	1.8	0.3	<0.1
Dryopteris expansa	wood fern	native	83.9	3.3	2.7
Epilobium angustifolium	fireweed	native	1.8	0.02	<0.1
Epilobium ciliatum	fringed willowherb	native	16.1	0.4	0.1
Equisetum sp.	horsetail	-	5.4	4.9	0.3
Galium aparine	stickywilly	native	41.1	3.6	1.5
Geranium robertianum	herb robert	introduced [1]	94.6	4.8	4.5
Geum macrophyllum	largeleaf avens	native	12.5	0.1	<0.1
Hedera helix	English ivy	introduced [1]	100.0	11.9	11.9
Hieracium albiflorum	white hawkweed	native	3.6	0.02	<0.1
Hypericum androsaemum	sweet-amber	introduced	1.8	0.4	<0.1
Hypericum sp.	St. Johnswort	-	1.8	0.02	<0.1
Hypochaeris radicata	hairy cat's ear	introduced	1.8	0.02	<0.1
Impatiens capensis	jewelweed	introduced	1.8	1.0	<0.1
Juncus sp.	rush	-	1.8	0.2	<0.1
Lactuca serriola	prickly lettuce	introduced	1.8	0.02	<0.1
Lamiastrum galeobdolon	yellow archangel	introduced [1]	3.6	13.0	0.5
Lapsana communis	common nipplewort	introduced	28.6	1.3	0.4
Lonicera ciliosa	orange honeysuckle	native	17.9	0.2	<0.1
Lunaria annua	annual honesty	introduced	3.6	0.1	<0.1
Luzula parviflora	smallflower woodrush	native	1.8	0.02	<0.1
Lysichiton americanus	American skunkcabbage	native	1.8	4.2	0.1
Maianthemum dilitatum	false lily of the valley	native	1.8	1.2	<0.1
Maianthemum racemosum	feathery false lily of the valley	native	1.8	0.2	<0.1
Mycelis muralis	wall-lettuce	introduced	50.0	0.5	0.3
Osmorhiza berteroi	sweetcicely	native	16.1	0.6	0.1
Plantago major	common plantain	introduced	1.8	7.0	0.1
Poa sp.	bluegrass	-	1.8	0.02	<0.1
Polypodium glycyrrhiza	licorice fern	native	12.5	0.3	<0.1
Polystichum munitum	sword fern	native	100.0	21.0	21.0
Prunella vulgaris	common selfheal	native	1.8	0.2	<0.1
Pteridium aquilinum	western brackenfern	native	83.9	10.1	8.4
Ranunculus repens	creeping buttercup	introduced [2]	10.7	5.4	0.6
Rumex obtusifolius	bitter dock	introduced	3.6	0.1	<0.1
Scirpus microcarpus	panicled bulrush	native	21.4	0.5	0.1
Senecio sylvaticus	woodland ragwort	introduced	1.8	0.02	<0.1
Solanum dulcamara	climbing nightshade	introduced [2]	14.3	0.5	0.1
Sonchus oleraceus	common sowthistle	introduced	1.8	0.4	<0.1

Appendix E (continued)

Species	Common Name	Native/ Introduced	Percent of Plots Where Found	Avg. Cover Where Found	Avg. Cover Across All Plots
Stachys chamissonis	coastal hedgenettle	native	1.8	0.04	<0.1
Stellaria sp.	starwort	-	14.3	0.7	0.1
Taraxacum officinale	common dandelion	introduced	3.6	0.1	<0.1
Tiarella trifoliata	threeleaf foamflower	native	10.7	1.2	0.1
Tolmeia menziesii	youth-on-age	native	5.4	7.6	0.4
Trillium ovatum	Pacific trillium	native	67.9	0.6	0.4
Unknown grass sp.	Unknown grass	-	21.4	0.9	0.2
Unknown herb	Unknown herb	-	5.4	0.1	<0.1
Urtica dioica	stinging nettle	native	80.4	9.4	7.6
Vicia sp.	vetch	-	3.6	0.04	<0.1
Vinca minor	common periwinkle	introduced	1.8	14.6	0.3

[1] Invasive species which are currently listed as Non-Designated Noxious Weeds by the King County Noxious Weed Program (King County, 2008)
[2] Invasive species which are currently listed as Noxious Weeds of Concern by the King County Noxious Weed Program.

Appendix F. Management Guidelines for 2006-2008

Project Activity	Scope	Performance Objectives
1. Comprehensive invasive removal	Within the defined area, selectively remove the roots and tops of all non-native plants, *including* herb Robert (*Geranium robertianum*). Exception is holly and laurel greater than 1" diameter. Avoid damage to all other native vegetation. Pile invasives on cardboard sheets to prevent resprouting. Areas that are greater than 50 square feet (4.6 m^2) in size with no visible native plants may be cleared with hand-held power equipment. With approval from the Park Arborist, glyphosate herbicide with adjuvant may be used on English ivy according to label directions in lieu of hand pulling. Application under direct supervision of licensed pesticide applicator, conforming to all applicable regulations. Provide copies of pesticide application records.	Less than 22 lbs (10 kg) of living invasive plant material remaining per 100 sq ft. In areas of herbicide treatment, dieback of ivy leaves AND greater than 90% of ground area showing failure in ivy regrowth during the following spring. **No** herb Robert (*Geranium robertianum*) to remain.
2. Comprehensive invasive removal, no herbicide	Within the defined area, selectively remove the roots and tops of all non-native plants, *including* herb Robert (*Geranium robertianum*). . Exception is holly and laurel greater than 1" diameter. Avoid damage to all other native vegetation. Pile invasives on cardboard sheets to prevent resprouting. Areas that are greater than 50 square feet (4.6 m^2) in size with no visible native plants may be cleared with hand-held power equipment.	Less than 22 lbs (10 kg) of living invasive plant material remaining per 100 sq ft. **No** herb Robert (*Geranium robertianum*) to remain.
3. Herbicide holly and laurel	Within the defined area: 1. For all standing laurel (*Prunus laurocerasus*) and holly (*Ilex aquifolium*) less than 1" diameter at 6" above ground, cut the tree down to a stump 1 foot high. Cut all branches to lengths 18" or less and compact into piles no larger than 1 cubic yard. Apply glyphosate herbicide at the label-recommended rate to the **freshly cut** stump. 2. For all holly and laurel greater than 1" diameter at 6" above ground, do not cut the tree down, but instead clear branches necessary to access the main trunk(s). Apply glyphosate herbicide by injection at the recommended rate. Application under direct supervision of licensed pesticide applicator, conforming to all applicable regulations. Provide copies of pesticide application records.	Dieback of leaves beginning within 2 months following treatment AND greater than 90% of canopy showing failure to regrow during the following spring.
4. Holly and laurel sprout removal	In the defined area, cut and pile all holly (*Ilex aquifolium*) and laurel (*Prunus laurocerasus*) sprouts at stumps or ground level, wherever the growth point occurs. Piles should be well compacted and be no larger than 1 cubic yard.	Less than 1 foot (0.3 m) live terminal growth of holly or laurel per 100 sq ft
5. Ivy survival rings	Within the defined area, cut ivy vines in all trees at chest height and remove all vegetation from that point on the base of the tree downward, extending out to 3' in all directions from the base of the tree. Grub out surface roots of all invasive plants at the base of the tree.	Tree trunk is fully visible; less than 1.1 lbs (0.5 kg) of living invasive plant material within 3' of the tree.

Project Activity	Scope	Performance Objectives
6. Second year invasive removal	Within the defined area, selectively remove the roots and tops of all non-native plants, including herb Robert (*Geranium robertianum*). Treat holly and laurel as above in Activity #3. Avoid damage to all other native vegetation. Pile new debris on existing old piles. Glyphosate herbicide with adjuvant may be used on English ivy regrowth according to label directions in lieu of hand pulling in areas permitted by MI Parks & Recreation staff member.	Less than 2.2 lbs (1.0 kg) of living invasive plant material remaining per 100 sq ft, including areas of herbicide treatment. **No** herb Robert (*Geranium robertianum*) to remain.
7. Selective herbicide herbaceous weeds	Within the defined area, apply glyphosate herbicide in early summer to herbaceous weeds. Application under direct supervision of licensed pesticide applicator, conforming to all applicable regulations. Provide copies of pesticide application records.	Marker dye used to verify application. Less than 5% of the ground area containing living herbaceous weeds one month following treatment.
8. Third year invasive removal	Within the defined area, selectively remove the roots and tops of all non-native plants, including herb Robert (*Geranium robertianum*). Treat holly and laurel as above in Activity #3. Avoid damage to all other native vegetation. Pile new debris on existing old piles.	Less than 1.1 lbs (0.5 kg) of living invasive plant material remaining per 100 sq ft, including areas of herbicide treatment. **No** herb Robert (*Geranium robertianum*) to remain.
9. Tree planting maintenance	Within the defined area, cut all blackberry growth currently 2' or taller to the ground. Cut back any other vegetation within 4' **around *and* above** tree seedlings. Re-mulch with 1" native leaf litter.	Less than 2oz (54g) living plant material within 4' of any tree seedling. Blackberry height less than 2' everywhere else.
10. Understory planting	Within the defined area, plant provided native tree seedlings to achieve a 15' average spacing between trees (existing and planted). Where appropriate, plant provided native understory shrubs to achieve a 3' average spacing between shrubs (existing and planted).	Stocking density of 200 trees (existing and planted) per acre. Tree planted according to detail (Section 10 below).
11. Holly and laurel stump-cut	Within the defined area, cut all holly (*Ilex aquifolium*) and laurel (*Prunus laurocerasus*) greater than 1" diameter at 6" above ground to 4' tall stump. Scatter debris such that it does not smother native vegetation and lies in ground contact.	
12. Mound planting	Within the defined area, harvest native soil from surrounding area to form planting mounds 7" high with sloped edges extending out 18" in all directions from center. Plant provided native tree and shrub seedlings into created mounds. Mulch mounds with provided mulch.	Plant trees and shrubs with root flares emerging just at soil level at top of mound. Tree and shrub planted according to detail (Section 11 below).
13. Knotweed herbicide injection	Within the defined area, inject knotweed (*Polygonum cuspidatum & Polygonum cuspidatum x sachalinense*) stems 1" or larger with glyphosate herbicide at the label-recommended rate. Apply spray paint marker to each injected stem. Application under direct supervision of licensed pesticide applicator, conforming to all applicable regulations. Provide copies of pesticide application records.	Less than 50% survival rate of injected stems following Spring.

Project Activity	Scope	Performance Objectives
14. Water and weed	Within the defined area, selectively remove the roots and tops of all non-native plants, *including* herb Robert (*Geranium robertianum*). Avoid damage to all other native vegetation. Pile invasives on cardboard sheets to prevent resprouting. Apply water to recently-planted native plants to achieve soil saturation to 8" depth.	Less than 2oz (54g) living plant material within 4' of any tree seedling. Apply water to achieve soil saturation to 8" depth.
15. Sheet mulching	Within defined area, brush cut or mow invasive plants to remove tops. Avoid damage to native vegetation. Cover cleared areas completely with 3/8" (1cm) (typically 2 layers) cardboard, working around existing native plants. Cover cardboard with minimum 4" provided mulch.	No invasive re-growth through mulch for one year.

Appendix G. Plot locations and bearings in Pioneer Park

Park Quadrant	Plot #	Stake at 0 m (A)		Stake at 50 m (C)		Plot bearing
		Latitude	Longitude	Latitude	Longitude	
SE	1	47.538518	-122.216671	47.538567	-122.217311	270
SE	2	47.538940	-122.221046	47.538468	-122.221017	180
SE	3	47.538575	-122.219467	47.538591	-122.218801	90
SE	4	47.539024	-122.218496	47.539074	-122.21780	90
SE	5	47.539274	-122.220126	47.539294	-122.219449	90
SE	6	47.539980	-122.220975	47.539507	-122.220967	180
SE	7	47.539886	-122.219413	47.439928	-122.218743	90
SE	8	47.540127	-122.217186	47.540141	-122.216528	90
SE	9	47.540753	-122.217414	47.540485	-122.216630	135
SE	10	47.540825	-122.218098	47.540525	-122.218589	225
SE	11	47.540850	-122.221039	47.540429	-122.221029	180
SE	12	47.541586	-122.220384	47.541613	-122.221064	270
SE	13	47.540948	-122.220093	47.540950	-122.220748	270
SE	14	47.541891	-122.219451	47.541775	-122.220093	270
NE	15	47.542365	-122.218610	47.542799	-122.218600	0
NE	16	47.542972	-122.220765	47.542960	-122.220076	90
NE	17	47.544014	-122.220648	47.544004	-122.219980	90
NE	18	47.543967	-122.218780	47.543911	-122.218137	90
NE	19	47.544661	-122.221213	47.544614	-122.220546	90
NE	20	47.545585	-122.220888	47.545589	-122.220192	90
NE	21	47.544797	-122.219233	47.544763	-122.218615	90
NE	22	47.545132	-122.218720	47.545108	-122.218127	90
NE	23	47.545594	-122.217533	47.545554	-122.216814	90
NE	24	47.544476	-122.216772	47.544063	-122.216751	180
NE	25	47.542952	-122.216557	47.542517	-122.216543	180
NW	26	47.542248	-122.222587	47.542238	-122.223254	270
NW	27	47.543109	-122.222047	47.543577	-122.222082	0
NW	28	47.543942	-122.222769	47.543931	-122.223440	270
NW	29	47.542698	-122.225916	47.542710	-122.226578	270
NW	30	47.542584	-122.224369	47.542605	-122.225028	270
NW	31	47.543540	-122.224115	47.543105	-122.224100	180
NW	32	47.543275	-122.225227	47.542831	-122.225224	180
NW	33	47.544178	-122.226190	47.544618	-122.226217	180

Appendix G (continued)

Park Quadrant	Plot #	Stake at 0 m (A)		Stake at 50 m (C)		Plot bearing
		Latitude	Longitude	Latitude	Longitude	
NW	34	47.545335	-122.226704	47.544891	-122.226688	180
NW	35	47.544281	-122.225049	47.543839	-122.225063	180
NW	36	47.545541	-122.225843	47.545564	-122.225191	90
NW	37	47.544977	-122.225170	47.544523	-122.225177	180
NW	38	47.545278	-122.223087	47.544827	-122.223066	180
NW	39	47.545287	-122.224177	47.544833	-122.224200	180
NW	40	47.544703	-122.223775	47.544691	-122.224425	270
NW	41	47.544401	-122.222245	47.544713	-122.222706	315
NW	42	47.542830	-122.222666	47.543149	-122.223117	315
NW	43	47.542509	-122.223508	47.542965	-122.223514	0
NE	44	47.543257	-122.219773	47.543723	-122.219772	0
NE	45	47.542265	-122.220515	47.542721	-122.220486	0
NE	46	47.542256	-122.217252	47.542595	-122.217792	315
NE	47	47.543110	-122.217637	47.543568	-122.217641	0
NE	48	47.545506	-122.215902	47.545096	-122.215930	180
NE	49	47.545038	-122.220268	47.544588	-122.220261	180
NE	50	47.544205	-122.217984	47.544610	-122.217911	0
SE	51	47.541583	-122.218226	47.541556	-122.218906	270
SE	52	47.541092	-122.218666	47.541115	-122.219417	270
SE	53	47.540052	-122.218397	47.539589	-122.218364	180
SE	54	47.539644	-122.216387	47.539652	-122.217082	270
SE	55	47.539624	-122.217655	47.540053	-122.217649	0
SE	56	47.538487	-122.220438	47.538944	-122.220419	0

Appendix H. Comparison of management plan strategies

	2003 Forest Management Plan	2008 Forest Health Plan
Location of planted trees	Focused in forest gaps and areas with low regeneration	Throughout entire park
Future forest canopy composition	Mixed conifer and deciduous	Mostly conifer, some deciduous
Future forest structure (conifer)	Two-tiered	Multi-tiered
Ongoing invasive plant searches	No	Yes
Completion of in-progress comprehensive treatment	Yes	Yes
Prioritizes treatment of most ecologically critical issues	No	Yes
Total cost (next 20 years)	$3.73 million	$3.58 million
Flexibility in budgeting	Lower flexibility	High flexibility (Adjust for priorities in management)

Appendix I. Cost analysis for 2008 Forest Health Management Plan

2008 FOREST HEALTH SURVEY PLAN	Acres	Square feet	Average cost per square foot	Years	TOTAL COST
STAFF SALARY					
Partial funding for project manager			$10,000.0000	20	$200,000.00
ALREADY COMPLETED Three years intensive treatment completed					
Annual maintenance	6.6	287496	$0.0350	5	$50,311.80
Annual maintenance	6.6	287496	$0.0250	15	$107,811.00
TWO YEARS COMPLETED					
3rd year removal	9.6	418176	$0.0532	1	$22,246.96
Annual maintenance	9.6	418176	$0.0350	5	$73,180.80
Annual maintenance	9.6	418176	$0.0250	14	$146,361.60
ONE YEAR COMPLETED					
2nd year removal	0.9	39204	$0.0634	1	$2,485.53
3rd year removal	0.9	39204	$0.0532	1	$2,085.65
Annual maintenance	0.9	39204	$0.0350	5	$6,860.70
Annual maintenance	0.9	39204	$0.0250	13	$12,741.30
NOT YET STARTED					
Holly/laurel herbicide treatment	93	4051080	$0.0600	1	$243,064.80
Holly/laurel removal (maintenance)	93	4051080	$0.0600	1	$243,064.80
Holly/laurel removal (maintenance)	93	4051080	$0.0400	2	$324,086.40
Tree planting labor (15' spacing)	93	4051080	$0.0600	1	$243,064.80
Tree cost (15' spacing)	93	4051080	$0.0311	1	$125,988.59
Tree planting maintenance (two years)	93	4051080	$0.0638	2	$516,917.81
Ivy ring creation	93	4051080	$0.0209	1	$84,667.57
Ivy ring maintenance (every 2 years)	93	4051080	$0.0070	3	$85,072.68
Ivy ring maintenance (every 2 years)	18	784080	$0.0070	1	$5,488.56
Ground ivy (and other herbaceous weeds) treatment	93	4051080	$0.0100	1	$40,510.80
Ground ivy (and other herbaceous weeds) 2nd year treatment	93	4051080	$0.0070	1	$28,357.56
Ground ivy (and other herbaceous weeds) maintenance	93	4051080	$0.0050	2	$40,510.80
Ground ivy (and other herbaceous weeds) maintenance	37	1611720	$0.0050	1	$8,058.60
Boundary/stream search and destroy	7.2	313632	$0.1000	8	$250,905.60
Phase 2 tree planting labor (20' spacing)	110	4791600	$0.0500	1	$239,580.00
Phase 2 tree cost (20' spacing)	110	4791600	$0.0200	1	$95,832.00
Tree planting maintenance (two years)	110	4791600	$0.0400	2	$383,328.00
			TOTAL PROJECT COST		$3,582,584.72

Appendix J. Cost analysis for 2003 Forest Management Plan

2003 FOREST MANAGEMENT PLAN	Acres	Square feet	Average cost per square foot	Years	TOTAL COST
STAFF SALARY					
Partial funding for project manager			$10,000.00	20	$200,000.00
ALREADY COMPLETED Three years intensive treatment completed					
Annual maintenance	6.6	287496	$0.0350	5	$50,311.80
Annual maintenance	6.6	287496	$0.0250	15	$107,811.00
TWO YEARS COMPLETED					
3rd year removal	9.6	418176	$0.0532	1	$22,246.96
Annual maintenance	9.6	418176	$0.0350	5	$73,180.80
Annual maintenance	9.6	418176	$0.0250	14	$146,361.60
ONE YEAR COMPLETED					
2nd year removal	0.9	39204	$0.0634	1	$2,485.53
3rd year removal	0.9	39204	$0.0532	1	$2,085.65
Annual maintenance	0.9	39204	$0.0350	5	$6,860.70
Annual maintenance	0.9	39204	$0.0250	13	$12,741.30
NOT YET STARTED					
1st year removal	93	4051080	$0.0900	1	$364,597.20
Tree planting labor (15' spacing)	93	4051080	$0.1380	1	$559,049.04
Tree cost (15' spacing)	93	4051080	$0.0311	1	$125,988.59
2nd year removal	93	4051080	$0.0634	1	$256,838.47
3rd year removal	93	4051080	$0.0532	1	$215,517.46
Annual maintenance	93	4051080	$0.0290	13	$1,527,257.16
Annual maintenance	43	1873080	$0.0290	1	$54,319.32
			TOTAL PROJECT COST		**$3,727,652.59**

Appendix K. Cost analysis for Budget Restricted 2008 Forest Health Survey Plan

2008 FOREST HEALTH SURVEY PLAN - BUDGET RESTRICTED	Acres	Square feet	Average cost per square foot	Years	TOTAL COST
STAFF SALARY					
Partial funding for project manager			$10,000.0000	25	$250,000.00
ALREADY COMPLETED Three years intensive treatment completed					
Annual maintenance	6.6	287496	$0.0350	5	$50,311.80
Annual maintenance	6.6	287496	$0.0250	20	$143,748.00
TWO YEARS COMPLETED					
3rd year removal	9.6	418176	$0.0532	1	$22,246.96
Annual maintenance	9.6	418176	$0.0350	5	$73,180.80
Annual maintenance	9.6	418176	$0.0250	19	$198,633.60
ONE YEAR COMPLETED					
2nd year removal	0.9	39204	$0.0634	1	$2,485.53
3rd year removal	0.9	39204	$0.0532	1	$2,085.65
Annual maintenance	0.9	39204	$0.0350	5	$6,860.70
Annual maintenance	0.9	39204	$0.0250	18	$17,641.80
NOT YET STARTED					
Holly/laurel herbicide treatment	93	4051080	$0.0600	1	$243,064.80
Holly/laurel removal maintenance	93	4051080	$0.0600	1	$243,064.80
Holly/laurel removal maintenance	93	4051080	$0.0400	2	$324,086.40
Tree planting labor (15' spacing)	93	4051080	$0.0600	1	$243,064.80
Tree cost (15' spacing)	93	4051080	$0.0311	1	$125,988.59
Tree planting maintenance (one year)	93	4051080	$0.0638	1	$258,458.90
Ivy ring creation	93	4051080	$0.0209	1	$84,667.57
Ivy ring maintenance (every 2 years)	93	4051080	$0.0070	2	$56,715.12
Ground ivy (and other herbaceous weeds) initial treatment	93	4051080	$0.0100	1	$40,510.80
Ground ivy (and other herbaceous weeds) 2nd year treatment	93	4051080	$0.0070	1	$28,357.56
Ground ivy (and other herbaceous weeds) maintenance	93	4051080	$0.0050	1	$20,255.40
Ground ivy (and other herbaceous weeds) maintenance	62	2700720	$0.0050	1	$13,503.60
Boundary/stream search and destroy	7.2	313632	$0.1000	3.75	$117,612.00
Phase 2 tree planting labor (20' spacing)	110	4791600	$0.0500	1	$239,580.00
Phase 2 tree cost (20' spacing)	110	4791600	$0.0200	1	$95,832.00
Tree planting maintenance (one year)	110	4791600	$0.0400	1	$191,664.00
			TOTAL PROJECT COST		$3,093,621.19