# City of Mercer Island
# Open Space Vegetation Plan
# 10-year Evaluation and Update

Adopted by City Council

March 30, 2015

**City of Mercer Island**

**Parks and Recreation Department**

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The authors would also like to appreciate the hundreds of workers and thousands of volunteers that have made the restoration of the open space possible.

# List of Abbreviations and Definitions

**DBH**: Diameter at breast height

**FHS**: Forest Health Survey (2008, City of Mercer Island)

**m**: meter(s)

**m2**: square meters

**ft** or ′: feet

″: inches

**OS**: Open space

**OSVM**: Open Space Vegetation Management Plan

**PPFMP**: Pioneer Park Forest Management Plan

**TPA**: Trees per acre

**Overstory** (used interchangeably with "canopy trees"): the larger forest trees (greater than 5″ diameter at breast height) that create the forest canopy.

**Puget lowlands**: a physiographic province consisting of low-elevation land in western Washington between the Cascade mountains on the east and the Olympic Mountains and Willapa hills on west.

**Regeneration/regenerating tree**: young trees, including seedlings and saplings. In the 2014 study this included trees less than 5″ diameter at breast height.

**Understory** (used interchangeably with "herb and shrub layers"): the vegetation below the forest canopy that includes shrubs, herbs, grasses, and seedling and sapling trees (less than 5″ diameter at breast height).

**Woody debris**: remains of dead trees, either standing (stumps, snags) or fallen (logs)

# Executive Summary

This report provides Mercer Island City Council a comprehensive status report on the condition of the city's open space vegetation. It revisits the original goals of the 2004 Open Space Vegetation Plan and recommends modifications and improvements to achieve sustainable and resilient forest landscapes.

Urban forests provide many benefits to people, wildlife, and ecosystems, but they must be actively maintained to avoid deterioration. Mercer Island benefits from a robust open space system covering more than 300 acres, but substantial invasion by exotic plants and canopy deterioration from root pathogens pose serious threats to the open space vegetation and the associated ecological services. In 2004, more than 50% of open space was heavily invaded by exotic plants. English holly and other invasive trees were common. In 2004 the city created an Open Space Vegetation Management (OSVM) Plan that identified major threats to the parks system, set work priorities based on research and public involvement, and outlined restoration goals for the open spaces.

From 2004 to 2014 staff of the Parks and Recreation Department managed a systematic restoration program to reduce invasive plant species, revegetate areas of bare soil, and plant native plants, particularly coniferous trees, to improve forest cover. Over this time, 43,000 native plants were planted (covering more than 50% of the open space area), citizens volunteered more than 46,000 hours in 551 restoration events, and over 100 acres of trees were freed from climbing ivy.

## 2014 OSVM Study

The 2004 OSVM plan stipulated that the plan and progress should be evaluated after 10 years. The Open Space Vegetation Management Plan Evaluation Report contained in this document is the result of this evaluation process. In summer of 2014 a field study was undertaken to quantify the abundance of native and invasive plants in the overstory (mature tree layer) and understory (shrub and herb layer) of Mercer Island open spaces. The results allow comparison with previous conditions and provide a baseline for future comparisons.

- Mercer Island open spaces have an average of 85 native Trees Per Acre ('TPA'; 50 TPA deciduous, 33 TPA conifer, and 2 TPA Pacific madrone). Canopy density in Pioneer Park is not statistically different between the 2008 Forest Health Survey and the 2014 open space study.
- In Pioneer Park, large English holly trees decreased from 3 TPA to 1 TPA between 2008 and 2014. Most of the remaining canopy trees are holly that have resisted treatments.
- The density of invasive tree regeneration (seedlings and saplings), which was extremely high in a 2008 Forest Health study (910 TPA), remains very high in 2014 (666 TPA) despite the decreased density of exotic trees in the canopy.

- Native conifer regeneration across all open spaces in 2014 is 78 TPA. Nearly all of these were planted. In Pioneer Park, native conifer density was probably near zero in 2004. It increased to 24 TPA in 2008 and to 69 TPA in 2014.
- Total exotic plant cover in the open space understory (shrubs and herbs) decreased from 58.4% in 2004 to 31.7% in 2014. In that same decade, two of the most important invaders, English ivy and Himalayan blackberry, decreased from 21% to 17% and 26% to 7% respectively.

Overall, the study showed that, while root rot and tree senescence are known problems in the park system, canopy cover hasn't declined precipitously (at least in Pioneer Park) in the last half of the decade. Tree densities are lower than wildland systems and somewhat lower than other Puget lowland open spaces. Efforts to control invasive trees have been moderately successful, although effective permanent control of holly is still challenging. Conifer planting has been highly successful in creating a new cohort of conifers across the park system, but invasive tree regeneration still poses a serious problem for the urban forest. Understory invasive control has had significant and substantial effects in reducing shrub and herb invaders such as English ivy and Himalayan blackberry.

## Management Goals, Objectives and Levels of Service

The 2004 OSVM plan focused on maintaining functional benefits derived from Mercer Island's open space and noted that native canopy trees, regenerating conifers, and native understory vegetation were critical factors in maintaining these benefits. To facilitate discussion and restoration planning, a more detailed description of 'desired future conditions' in our urban forest is included in this update. These optimal conditions are characterized by:

1. Primarily native vegetation with few invasive species
2. High structural diversity (including trees, shrubs, herbs, and large woody debris)
3. Uneven age distribution of trees (i.e. seedlings, saplings, and more mature trees present)
4. High biological diversity, and in particular:
    a. Mixture of native coniferous and deciduous canopy trees
    b. Diverse native understory
5. Landscape-level diversity: areas of differing vegetation, soils, and topography
6. High quality aquatic resources
7. Healthy soils
8. Safe trails and access routes for human users
9. High level of investment, involvement, and interest by human users

These characteristics replace the action-oriented objectives of the 2004 plan. It is understood that, due to limited resources, these conditions will not be achievable across the entire open space system, but these characteristics will guide restoration in prioritized areas and to the extent that funding allows. Updated goals for Mercer Island open spaces are:

1. Maintain the functional benefits of open space vegetation.
2. Foster resilient plant communities that can recover from disturbances and adapt to climate change.
3. Implement work based on the value of these functional benefits, the community's priorities for the open space properties, and the condition of the vegetation found there.
4. Maximize the return on available funding through volunteers, matching grants, and donations.

The addition of Goal 2 reflects a special concern for planting trees that we expect to be alive through the next century and the expectation that open spaces will need to transition to more stable condition to require less intensive management in the long-term.

**Prioritize Work Areas for Levels of Service**

Going forward, work areas within parks will be prioritized for restoration work relative to their potential for reaching desired future conditions and dependent on the presence of resilient landscape attributes (such as aquatic resources) within those areas. Work areas will be assigned to one of three levels of restoration service:

- Ecological resilience areas: restoration will focus on restoring/maintaining a diverse and resilient native understory and overstory.
- Canopy retention areas: restoration will focus on preserving and replacing tree canopy.
- Horticultural management: planting and maintenance will be driven by functional and aesthetic needs

## Management Recommendations

Recommendations were made based on the results of the 2014 field study, the desired state of the open space forests, discussions with regional experts, and consideration of the growing effects of climate change on the parks system. First, it is recommended that the city continue the current program of native tree planting and invasive species removal, as this program has been successful in producing a substantial conifer cohort and releasing native plants from competition across a substantial portion of the open space system. Prioritization of new areas to be restored will be guided in part by further recommendations below.

**Improve restoration techniques**

Restoration practices will be modified to reflect experience from the last decade and expected conditions in the next decade. The expected changes are these:

- Staff will begin summer watering for susceptible first-year tree plantings, because increasingly droughty summers are expected to negatively affect establishing trees.
- Where invasive plants are well established, staff will budget for additional years of invasive removal (beyond the 3 years prescribed in the original plan).

- To improve holly treatment success, staff will increase collaboration with other regional managers, increase use of imazapyr injection (which appears to be more effective than past treatments), and create a framework to better monitor and compare results among treatment methods.
- To better understand how restored areas may eventually transition to stable, beneficial vegetation, staff will assess promising maintenance approaches. These include:
  - below and above-ground removal (comprehensive maintenance)
  - mulching
  - repeated "invasive knockdown" (removing aboveground portions only)
  - "search and destroy" sweeps to find and remove small patches of invasive vegetation.

**Climate adaptation plan**

Parks and Recreation staff will also begin to implement an open space climate adaptation strategy, which is aimed at increasing resilience in the urban forest ecosystem. Currently the adaptation strategy centers on six broad prescriptions suggested by the scientific literature on climate change and resilience. These ideas will help guide and prioritize restoration work over the next ten years:

1. Strengthen adaptive management by including more experimental approaches, updated scientific information, and careful monitoring: In the face of a rapidly changing climate and uncertainty about how ecological systems will respond to manipulations and disturbances, it is important to allocate resources to monitoring, gathering information, and assessing effectiveness of restoration techniques and materials.
2. Manage for biological diversity, which provides resilience in the face of disturbance and climatic variability.
3. Provide special protection for bottomlands, wetlands and waterways, which are especially critical resources in times of drought and may serve as climate refugia.
4. Identify and protect other geologically or topographically unique areas, as these could provide refugia as climate changes. Landscape diversity will be important to conserving biological diversity and resilience. Such areas might include, for instance, steep north-facing slopes and ravines.
5. Improve risk assessment in relation to threats expected to increase with climate change. Enhanced risk assessment and monitoring of ecosystem health will also improve early detection of related public safety issues such as hazard trees or areas prone to slides.
6. Manage for asynchrony and use establishment phase to reset succession: In the event of major disturbances to the urban forest canopy on Mercer Island (fires, large blow-down areas), reforestation should be approached as an opportunity to increase diversity of native forest patches (for instance, by including a diversity of shade intolerant native trees).

Following these principles above, the city is considering specific climate adaptation actions, including diversification and more careful monitoring of native tree provenances and increased monitoring for hydrologic stressors such as erosion, flooding, or drought in the open spaces. Staff have also described and considered a number of actions that could be taken under certain future circumstances to improve resilience, including conservative use of more southern pacific coast native plant species that may be pre-adapted to warmer climates (assisted migration).

**Ravine restoration and watercourse stabilization**

Ravine landscapes have a biological resiliency that make them central to the climate adaptation strategy. The City's current watercourse stabilization program does not address minor erosion and small scale stabilization in ravines. Nevertheless, assessing and correcting drainage in stream channels and the associated steep slopes would contribute to the long term health of the ravine ecosystems. Work such as correcting residential drainage, piping street outfalls to the watercourse, and installing bioengineering in stream channels may be warranted. A work item for the Open Space program will be to conduct this assessment in 2015 and 2016 and work with the Maintenance Department on a recommended approach for the resulting issues.

**Public involvement**

As conditions change and new science becomes available, the city will adapt its strategies for achieving this plan's goals and objectives. Staff will continue to look to the guidance of the Open Space Trust Board in decisions regarding Pioneer Park and Engstrom Open Space. Although this board is specifically chartered to guide management of Pioneer Park and Engstrom Open Space, the recommendations from this body will be taken into consideration by the Parks Director and city staff in making decisions relating to the rest of the parks system.

Public involvement and education will continue to be a central goal of the open space team going forward. As in the past, the staff will contract with volunteer management organizations to organize restoration volunteer events, and city staff will encourage and help to facilitate other volunteer and education projects by organizations such as Boy Scouts, Washington Native Plant Society, and local schools. Additionally, the city plans to launch a campaign to educate the public about the negative effects of landscaping with certain invasive plants such as English holly.

# 1. Introduction

## 1.1 Context of the 10-year evaluation

Urban forests provide a wide array of benefits to people, including (adapted from Green Futures Research and Design Lab, 2013):

- recreational and aesthetic experiences
- provision of habitat for animals and plants
- reduction in air pollution
- summer cooling through shading and evapotranspiration
- reduction of runoff and flood mitigation
- urban noise reduction
- increased property values

Unlike wildland forests, urban forests also must be actively maintained by humans. Human interventions are needed in most urban forests to maintain attributes that increase sustainability and resilience of the forest, conserve biodiversity, and increase benefits to humans, including adequate canopy cover, a mix of tree ages and species, and a predominance of native vegetation (Clark et al. 1997).

The City of Mercer Island is fortunate to have a high cover of urban forest relative to many cities in the Puget lowland (Green Futures Research and Design Lab, 2013). However, studies commissioned by the Mercer Island Parks and Recreation Department in 2003 and 2004 showed that nearly half (43%-45%) of the open space on the island was heavily invaded by exotic plants, a situation that could lead to a loss of forest cover, biological integrity, and the many benefits that arise from the city's open spaces (City of Mercer Island Parks and Recreation 2004).

In response to these studies, the Mercer Island city council authorized the Parks and Recreation Department to develop the 2004 Mercer Island Open Space Vegetation Management (OSVM) Plan, which integrated citizens' priorities, CityGREEN analysis of urban forest benefits, and analysis of the costs of restoration tasks over a 20 year period. The OSVM plan assigned three levels of restoration service to the parks. Pioneer Park was assigned the highest level (A) which entailed planting of diverse native plants and comprehensive removal of understory invasive plants. Five large parks were assigned the next lowest level (B), which entailed planting native trees, clearing weeds around trees, and removal of invasive plants in areas with good native vegetation cover. Nine parks were assigned the lowest level (C) which simply avoided canopy loss through ivy removal. In the following years funds were allocated to elevate several level C parks to level B and to provide level A treatment to the unique resource of Ellis Pond OS.

The Pioneer Park Forest Management Plan (PPFMP), written in 2003 and amended in 2009, added detail to the management goals and approaches to be used in the largest open space, Pioneer Park. These detailed prescriptions and strategies for restoration provided in the PPFMP have served as a template for the work in the other Mercer Island open spaces.

Additionally, the PPFMP stressed the importance of adaptive management in restoration, recognizing that new research, accumulated experience with on-site restoration, and changing conditions in open spaces require practitioners to change practices and even restoration goals.

## 1.2 Restoration progress, 2004 – 2014

From 2004 to 2014 staff of the Parks and Recreation Department developed and managed a systematic restoration program with the aim of reducing invasive plant species, revegetating areas of bare soil, and planting native plants, particularly coniferous trees, to improve forest cover. Over the course of the decade more than 40,000 native plants were planted across 161 acres (52% of the open space area, Fig. 1). About 90% of the open space area (260 acres) received some kind of restoration treatment. Citizens volunteered more than 36,000 hours through individual projects, collaborations with regional non-profits and local schools, and in the course of 440 volunteer restoration events (Table 1).

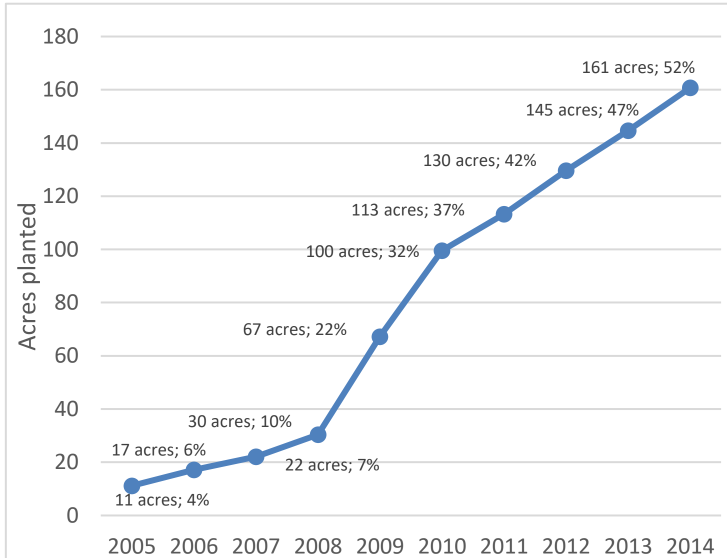


**Figure 1: Cumulative acres and percentage of Mercer Island's open space area planted with native plants from 2005-2014.**

In 2008 a Forest Health Survey (FHS, Peterson and Sommargren 2008) gathered detailed information on the structure, composition, and ecological attributes of vegetation in Pioneer Park. This survey showed that native vegetation was dominant in Pioneer Park, but invasive exotic species were still widely distributed and were abundant in some areas of the park. Invasive trees, especially English holly (*Ilex aquifolium*), were shown to be a significant threat. Restoration plantings up to that time were shown to have initiated a cohort of conifers to replace aging canopy, bringing densities of young conifers up to 24 trees per acre. This quantitative assessment helped to guide the approach to restoration in Pioneer Park from 2008 to 2014 and informed restoration choices across the larger open space system. Additionally, it provided a quantitative baseline for future assessments of change and progress in Pioneer Park.

As shown in Table 1, funding for open space work generally increased over the first six years, then leveled off for the two most recent biennia. City Council started out funding the Open Space Vegetation Plan's recommended level, but subsequently provided additional funding to raise the level of service for the lowest priority open spaces with the goal that all identified open space properties would be managed to maintain current (2004) function. In 2008, voters approved a parks maintenance levy that included an annual $65,000 for open space vegetation and $77,000 specifically for Pioneer Park forest management. This coincided with a significant economic recession that provided a favorable bidding climate. These two factors greatly increased the pace and extent of forest restoration. Contracting costs recovered in the subsequent biennia.

**Table 1: Restoration progress and effort from 2004 to 2014**

| Number of... | 2005-2006 | 2007-2008 | 2009-2010 | 2011-2012 | 2013-2014 | Total |
|---|---|---|---|---|---|---|
| Trees Planted | 3,799 | 2,404 | 12,947 | 5,705 | 6,262 | 31117 |
| Shrubs planted | n/a | 2,066 | 2,027 | 3,027 | 5407 | 12527 |
| Ivy survival rings created | 2233 rings | 30.4[a] | 37.4 | 21.5 | 54.9 | 114 |
| Total acres worked | 88.3 | 99.2 | 204 | 139 | 145 | 260 (89%) |
| Volunteer events | 125 | 92 | 109 | 114 | 111 | 551 |
| Volunteers | 1,312 | 2,089 | 4,148 | 6,496 | 3104 | 17,149 |
| Volunteer hours | 2,260 | 8,370 | 13,547 | 12,684 | 10,006 | 46,867 |
| Total expenditure ($1000s) | 276 | 665 | 761 | 780 | 862 | 3,344 |

a: numbers presented for years after 2006 represent acres treated

## 1.3 The Mercer Island open space system

The Mercer Island Open Space system represents areas of the Mercer Island parks system that are "under public ownership set aside for preservation of significant natural resources, open space and visual aesthetics/buffering" (City of Mercer Island 2014). Open spaces are less intensively managed than other park areas, largely shaped by natural processes, and in most cases forested. The open space system comprises 307 acres spread across 22 park areas from Luther Burbank Park at the northern tip of Mercer Island to Clarke Beach Park, near the southern tip. The individual open spaces vary substantially in size, from 118 acre Pioneer Park to 0.9 acre Secret Park. Aubrey Davis Park, situated over the Interstate 90 corridor, is managed according to a separate agreement in cooperation with Washington State Department of Transportation and is excluded from this study and management plan.

Open spaces vary widely in ecological character as well. Forest canopy ranges from relatively old second growth forest with low levels of human disturbance (parts of Pioneer Park) to highly disturbed areas characterized mostly by exotic overstory and understory (parts of Luther Burbank Park). Much of the island is set on thin and droughty soils, but moist areas and small wetlands provide ecologically important diversity in topographical depressions, along stream systems, and in areas where Pleistocene clays create perched water tables near the soil surface.

# 2. Open Space Vegetation Survey (2014 OSVS)

## 2.1 Study purpose

The 2004 OSVM plan called for evaluation and revision of the management plan on a ten-year cycle, based on follow-up studies of canopy cover and invasion. In accordance with this provision, a vegetation study was carried out in the summer of 2014, forming the basis of the 2014 evaluation of the Mercer Island Open Space Management Plan. The goals of the 2014 study, driven in large part by the management concerns identified in the 2004 and 2008 vegetation studies, were:

For the overstory:

1) Quantify density and conifer/deciduous composition of native overstory across the Mercer Island open space system.
2) Evaluate the degree of English ivy colonization of tree trunks in open spaces
3) Characterize abundance and composition of exotic overstory trees
4) Compare Pioneer Park composition and densities to 2008 FHS.

For regenerating trees:

5) Quantify density of native regeneration by type (conifer, deciduous, madrone)
6) Quantify densities of exotic trees by species
7) Compare Pioneer Park densities to those of 2008 FHS study.

For understory:

8) Quantify cover of exotic species (especially English ivy, Himalayan blackberry and Robert's geranium)
9) Evaluate composition, cover, and diversity of native species
10) Compare system-wide results from 2004 OSVM study and Pioneer Park results from 2008 FHS.

## 2.2 Approach and methods

This study was based upon stem counts and visual quantification of native and invasive species cover in 577 plots of two different types spread across the open spaces of the island. Observations of herb, shrub, and seedling cover by species were made in 435, 5×5 meter (m) plots and observations of tree regeneration, density, and degree of ivy invasion were made in 142, 10×40 m plots. The study methods are comparable to standard methods used by Seattle Urban Nature for other parks in the Puget Lowlands region and with those of the 2008 Forest Health Study in Pioneer Park. Though slightly different in approach and scope, they are also compatible with the methods of the 2004 OSVM study. The results of this study indicate the level of progress made since the previous studies and provide updated information on the presence, abundance, and spatial distribution of native and exotic species in the open space system. Importantly, the study provides a rigorous baseline for evaluation of future improvements and challenges.

## Plot allocation

All portions of Mercer Island parks considered open space were delineated in ArcGIS (ESRI 2010) using existing shapefiles from Mercer Island parks databases and visual inspection of orthophotos. For the purpose of this study, open spaces were considered all park areas, mostly forested, with a low level of vegetation management (not mowed or intensively landscaped).

Desired samples sizes for small and large plots were determined based on standard deviations from 2008 Forest Health Survey data using standard equations from Elzinga et al (1998). A grid of points (160' spacing, created using ArcGIS *fishnet* tool) with a random origin was overlaid on the resulting open space layer and 5×5 m understory sampling plots allotted to each open space where grid points fell (Figs. 2, 3). Plots that fell within a 5 m buffer of park edge were excluded to ensure all portions of plots fell within open spaces. A separate grid (300' spacing) provided origins for overstory tree transects (Fig. 3), and used for the largest parks. For smaller parks, where the wide dispersal of the tree-plot grid did not provide reliable park-by-park representation, randomly-located points were generated within each park to provide area-proportionate samples. From each origin point, 10×40 m rectangular transects were randomly assigned an ordinal compass bearing (NESW). In cases where the randomly-assigned bearing was not contained in the open space, the next default bearing was 180° from the original (to maintain assigned orientation if possible) followed by 90°, 270°, and finally non-ordinal directions that would allow inclusion in the polygon).

A grid design was chosen because it is statistically viable (Krebs, 2014) and provides several advantages, including ease of layout, improved efficiency for field sampling, assurance of sufficient spatial dispersion of plots throughout open space polygons (such that no major areas of parks were under-sampled), reduction of spatial autocorrelation among plots, and allowance for accurate compass navigation among plots in the event of inability to acquire GPS signals. Systematic (e.g. grid) sampling has the potential for biased results in certain cases where the grid parallels environmental gradients that have periodicity (Krebs, 2014). To mitigate for this possibility, aerial photos and topographical data were examined to rule out such biases, and the number and patterns of plots near the edges of rectilinear parks were analyzed to make sure that these plot edges (which have the potential to align with the sample grid) were not over-represented or under-represented in the systematic sample relative to a random sample. The grid sample was found to represent edge habitat very similarly to a random sample, and, for tree transects, randomization of transect bearings added an extra dimension of randomization to mitigate possible edge bias.

### Statistical treatment of small parks

In order to efficiently produce rigorous data characterizing the overall park system (and large, high priority parks), plots were allocated on an area-weighted basis rather than equalized by park. This means that smaller parks were allotted fewer samples, and metrics for these parks are less rigorous and statistically valid. For statistical meaningful analysis and summarization, data from the smallest 10 parks have been amalgamated in some cases. In other cases, the small sample still provides meaningful indications of ecological conditions and composition in these parks, and data has been broken down by park. However, the reader should be cognizant of the increased uncertainties associated with smaller sample sizes in these cases.

## Sampling protocol:

Using GPS, a field technician navigated to each gridpoint and laid out a 5×5 m plot (16.2 ×16.2 ft, 25 m$^2$) with the SE corner at the gridpoint. In some cases when GPS signal was insufficient for navigation, plots were located using compass bearings and pacing of appropriate distances. Because trails are a permanent aspect of Mercer Island open spaces and are potentially important corridors for introduction and establishment of invasive species (Nemec et al. 2011, Wells et al. 2012), samples were allowed to fall across and include trails such that trail areas were sampled in proportion to their footprint in the park system.

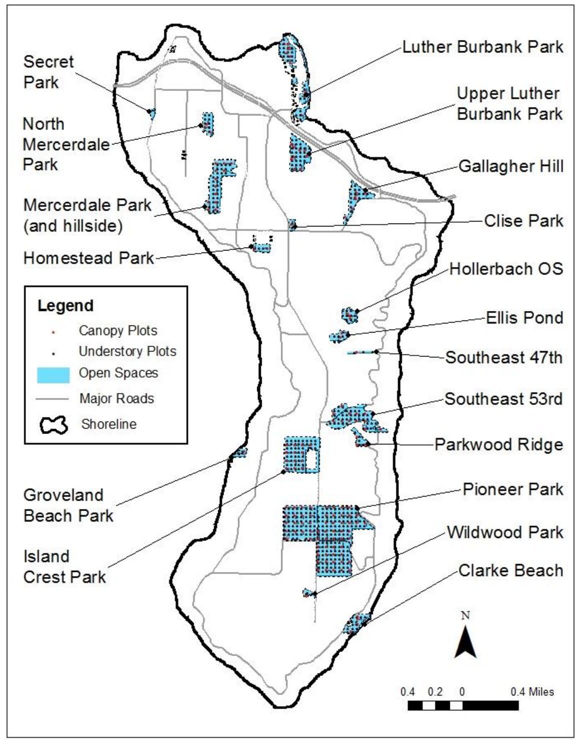


**Figure 2: Map of sampled Mercer Island open spaces**

In each 5×5 m plot these metrics were estimated visually (for parts of plants overhanging plot, whether rooted in the plot or not):

- Percent cover of all herbs, shrubs, and tree seedlings (less than 1" DBH)
- Aggregated cover of bryophyte layer
- Percent overstory canopy cover (from trees >5" DBH) directly overhead
- Percent sapling cover
- Evidence of restoration work (coded as N=none, P= planting, IR=Ivy rings, ST=invasive shrub treatment (frilling, cutting, herbicide), BR=invasive knockdown/Blackberry Removal)
- Intersection with trail (Coded as: 0=>1 m from trail, 1=0-1 m from trail, 2=intersecting trail)

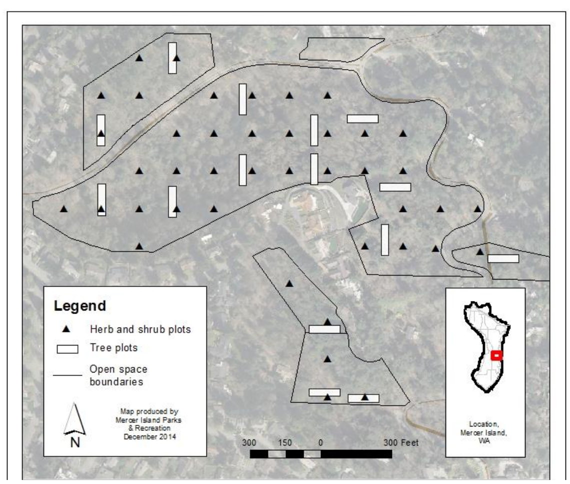


**Figure 3: Example of understory and overstory plot layout**

- For a subset of parks, a qualitative soil index (from 1 (extremely poor) to 4 (excellent))

In each 10×40 m plot (400 $m^2$, approximately 1/10th acre), stems were counted for:

- All native trees with DBH > 5", categorized as deciduous, conifer, or evergreen broadleaf, and assigned to 4 ivy invasion categories:
    - 1: No ivy on trunk
    - 2: Basal ivy (0-3ft)
    - 3: Moderate: ivy 3-15 ft up trunk
    - 4: Extensive: ivy >15 ft up trunk
- Trees with multiple main trunks were counted as a single tree if they diverged above ground level. Trees were considered in the plot if the trunk center was inside the perimeter of the plot.
- Number of overstory (>5" DBH) non-native tree trunks by species.
- Number of saplings (>1" DBH and <5" DBH): exotic species identified to species and natives identified as conifer, deciduous, or evergreen broadleaf.

In a 10×10 m plot nested within each tree plot:

- Native tree seedlings <1" DBH were counted and designated as conifer, deciduous, or broadleaf evergreen.
- Non-native tree seedlings were counted and identified by species.

## Data management, species categorization, and analysis

Data were taken on field data forms and entered promptly into an Excel database for analysis. An ACCESS database used for 2008 FHS was updated for use in categorizing species data. An attempt was made to categorize and analyze the cover of trees and tree-like shrubs 1) to make ecologically meaningful measurements of native and exotic cover within vegetation layers, 2) to create metrics comparable to Seattle Urban Nature's (SUN) data on regional parks, and 3) to create metrics that could be accurately compared to 2004 and 2008 Mercer Island studies. To this end, certain tree-like shrubs were treated as trees in the island-wide analyses (following lead of SUN). These include: cherry laurel (*Prunus laurocerasus*), Portuguese laurel (*Prunus lusitanica*), oneseed hawthorn (*Crataegus monogyna*), black hawthorn (*C. douglasii*), common apple and Pacific crabapple (*Malus domestica* and *M. fusca*), and vine maple (*Acer circinatum*). When comparing tree regeneration to 2008 FHS (where these species were considered shrubs), these species were omitted to make the most accurate possible comparison. Tree seedlings and tree-like shrub seedlings can have substantial effects on understory ecology where they are abundant. In particular, holly, laurels, and other root-sprouting trees/shrubs can create shrubby thickets after control efforts damage larger stems. Inclusion of these species in the herb/shrub layer cover data will give Mercer Island natural resources managers better data on the effects of these species on the understory going into the future.

# 3. Results

The 2014 vegetation study shows substantial improvement in some aspects of park health as it relates to invasive species. It also shows that invasive vegetation continues to be a critical problem in the park system. These are arranged here first according to vegetation structural/functional layers, then by issues of interest and concern within each layer. These categories are as follows:

1. Overstory: native composition and invasive species
2. Regenerating trees: levels of native conifers, deciduous, and exotic trees
3. Understory: native composition and abundance of exotic species

## 3.1 Overstory

**Native composition and density**

Based on the overstory data from 2014, Mercer Island's open spaces are stocked with 85 native trees per acre (TPA), of which 33 (39%) are conifers, 50 (59%) are deciduous, and 1.7 (2%) are evergreen broadleaf (madrone).

The individual parks vary substantially in their total density and composition (Fig. 4). Pioneer Park native tree density (85 TPA) matches closely the island average, but in Pioneer Park conifers (46 TPA) are more numerous than deciduous (37 TPA). These densities trend slightly lower but are not statistically different from the densities calculated from the 2008 Forest Health Survey (FHS, Fig. 5).

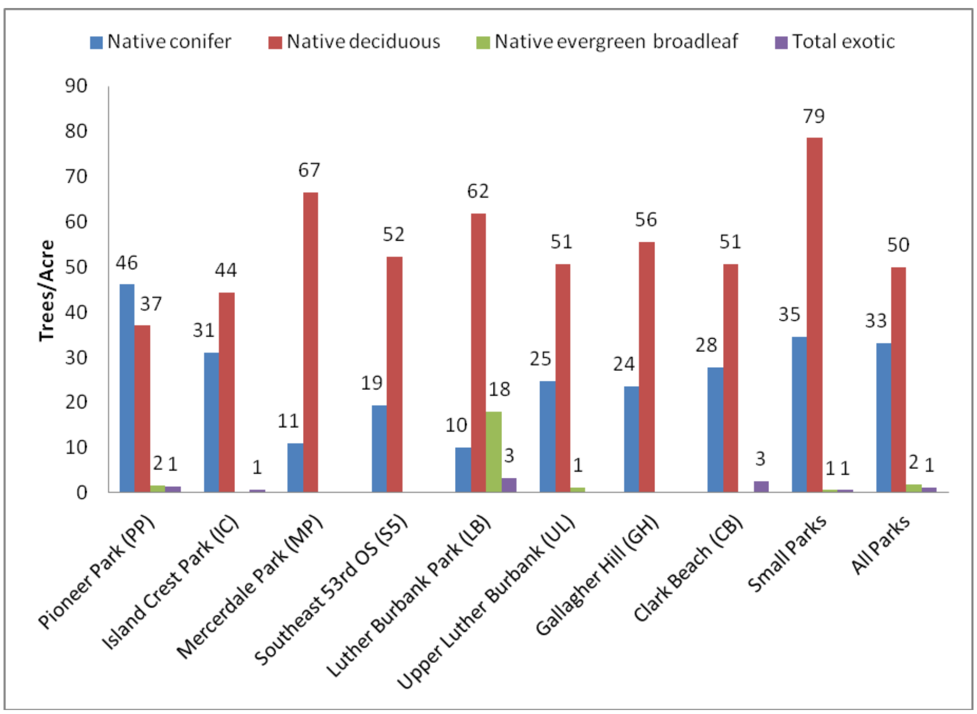


**Figure 4: Overstory tree densities, Mercer Island open spaces**

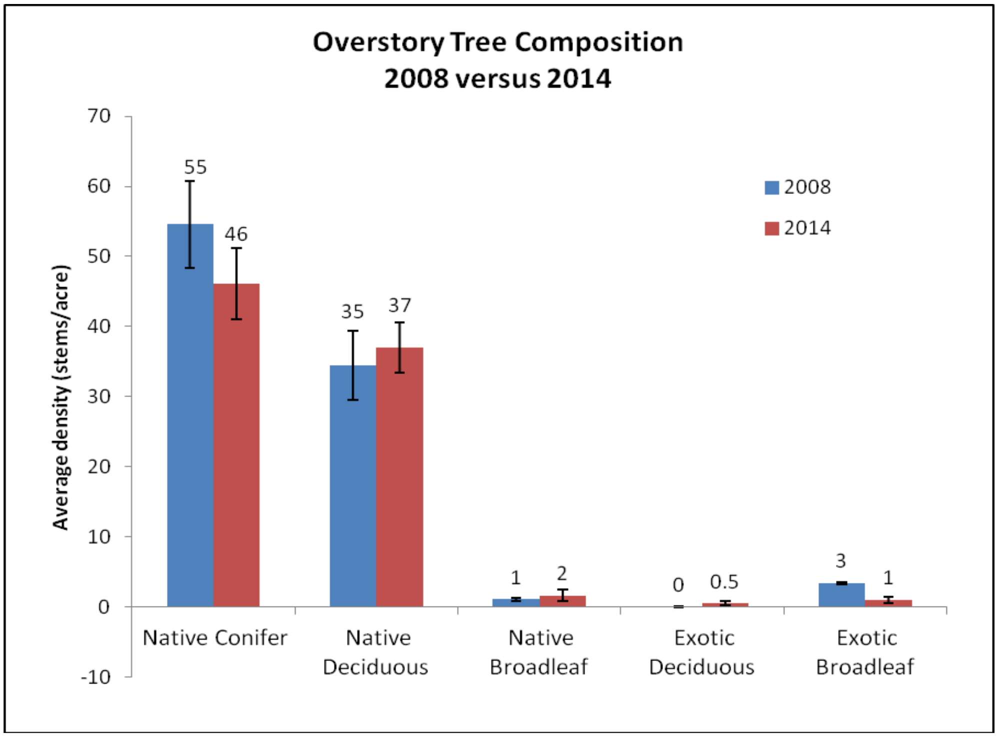


**Figure 5: Overstory tree density by group, 2008 versus 2014**

Island Crest Park has somewhat lower native overstory tree density (75.5 TPA), and is more deciduous (31 TPA conifer, 44 TPA deciduous). Most of the other large parks (arbitrarily defined here as 7 acres or larger) show densities from 70-80 TPA, and are still more deciduous in character. Mercerdale Park and Luther Burbank Park are the most deciduous-dominated (with only ~10 conifers per acre), while Upper Luther Burbank Park, Gallagher Hill, and Clarke Beach are only moderately more deciduous in character than Island Crest Park. The data show the smaller parks to be still more variable in density and composition (partly due to smaller sample sizes, but also likely due to widely varying conditions and histories in these parks). Ellis Pond, Hollerbach Open Space, Groveland Park and Wildwood Park all have tree densities well over 100 TPA, and all but Groveland are heavily dominated by deciduous trees. These densities generally reflect a greater density of younger, smaller deciduous trees in these parks, as compared to the more mature forests of Pioneer Park and Island Crest Park. Clise Park and Parkwood Open Space are less densely stocked.

A number of exotic trees (and large shrubs) are found in Mercer Island Open Spaces, including: English holly (*Ilex aquifolium*), cherry laurel (*Prunus laurocerasus*), one-seed hawthorn (*Crataegus monogyna*), European mountain ash (*Sorbus aucuparia*), bird cherry (*Prunus avium*), Portuguese laurel (*Prunus lusitanica*), cherry plum (*Prunus cerasifera*), Japanese maple (*Acer palmatum*), common apple (*Malus domestica*), silver maple (*Acer saccharinum*), redwood (*Sequoiadendron sempervirens),* and horse chestnut (*Aesculus hippocastanum*) (see Fig. 6). Total exotic trees (including all species listed above) comprise 1.5 TPA across all open spaces studied in 2014, and 1.5 TPA in Pioneer Park. Due to the sparse distribution, sampling captured overstory exotics only in Luther Burbank (1 TPA), Clarke Beach (2.5 TPA), and Homestead Park (5 TPA). English holly in particular has been recognized by the Parks and Recreation department as a threat to the character and function of the native vegetation of the island's open spaces. Holly was specially targeted as a troublesome invasive in the 2004 OSVM plan and a program was initiated to girdle or frill and apply herbicide to kill these and other high frequency invasive trees and shrubs. In the 2008 FHS, overstory (>5" DBH) holly individuals persisted in Pioneer Park at densities of 3 TPA. 2014 data show a more than two-thirds reduction of holly (to 0.8 TPA) in Pioneer Park. English holly is remarkably resilient to physical and chemical damage, and nearly all of the remaining overstory trees are weakened individuals that have survived treatment efforts. Despite substantial success in reducing mature invasive trees, the problem of regeneration persists, and is considered further below.

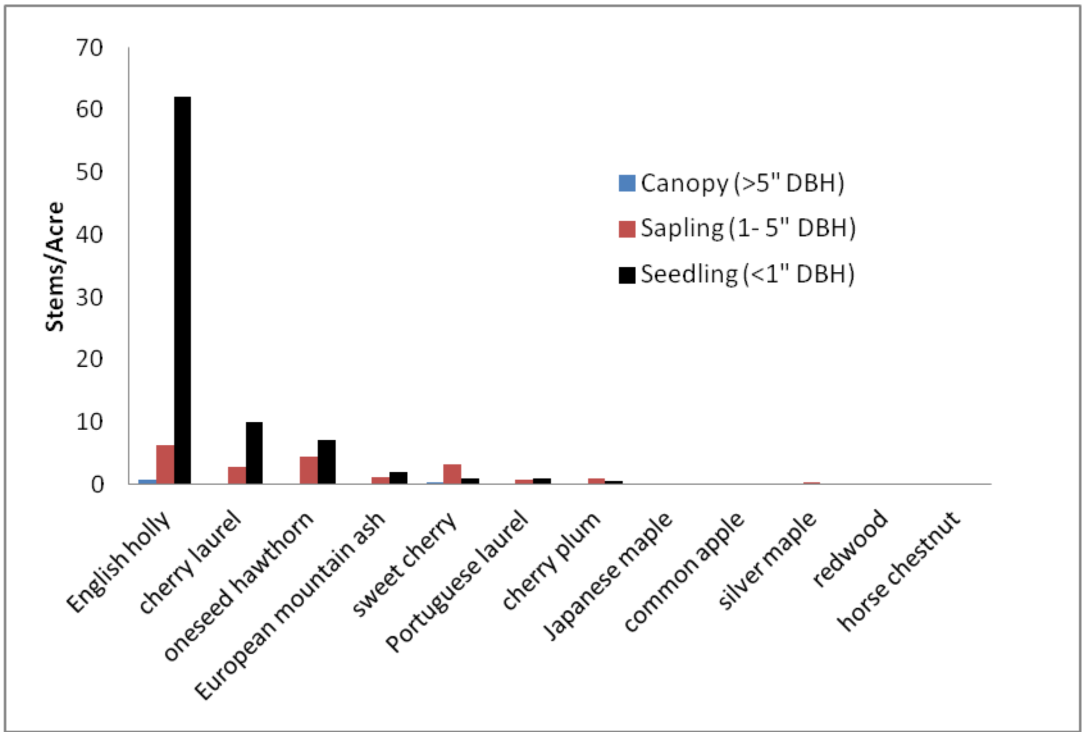


**Figure 6: Frequency of invasive trees and large shrubs (in three size classes) across plots in Mercer Island Open Spaces**

## Ivy on trees

Overall, 45% of trees in Mercer Island open spaces have ivy colonizing their trunks (Fig. 7). Of all trees, 21% only have ivy lower than 3' up the trunk (hereafter, "basal"), 14% have infestations reaching 3 to 15' up the trunk ("moderate"), and 10% have ivy climbing over 15' ("substantial"). This estimate of proportion of trees infested with ivy is comparable to the 2004 island-wide estimate of 48% infestation (with 21%, 9%, and 18% assigned to basal, moderate, and substantial infestation categories, respectively). The 2004 study included rights-of-way in addition to parks and open spaces, and the parks/open spaces-only estimate from that study is somewhat lower (37.5%). However, it should be cautioned that the 2004 ivy invasion estimate based on parks only cannot be considered statistically rigorous, as it only includes 32 trees in 10 plots across the island's open spaces (the 2014 estimate is based on 1,202 trees in 143 tenth-acre plots). In addition, it is not certain whether the standards for selecting and categorizing trees are strictly compatible between these studies. Anecdotal information from early years of the invasive vegetation control program suggests that substantial progress has been made. In 2005 it was recorded that nearly all trees in Southeast 53rd OS had some ivy infestation, with many heavily affected (City of Mercer Island 2004). Today approximately 50% of trees have some ivy in this park, and only 15% are infested over 15 feet.

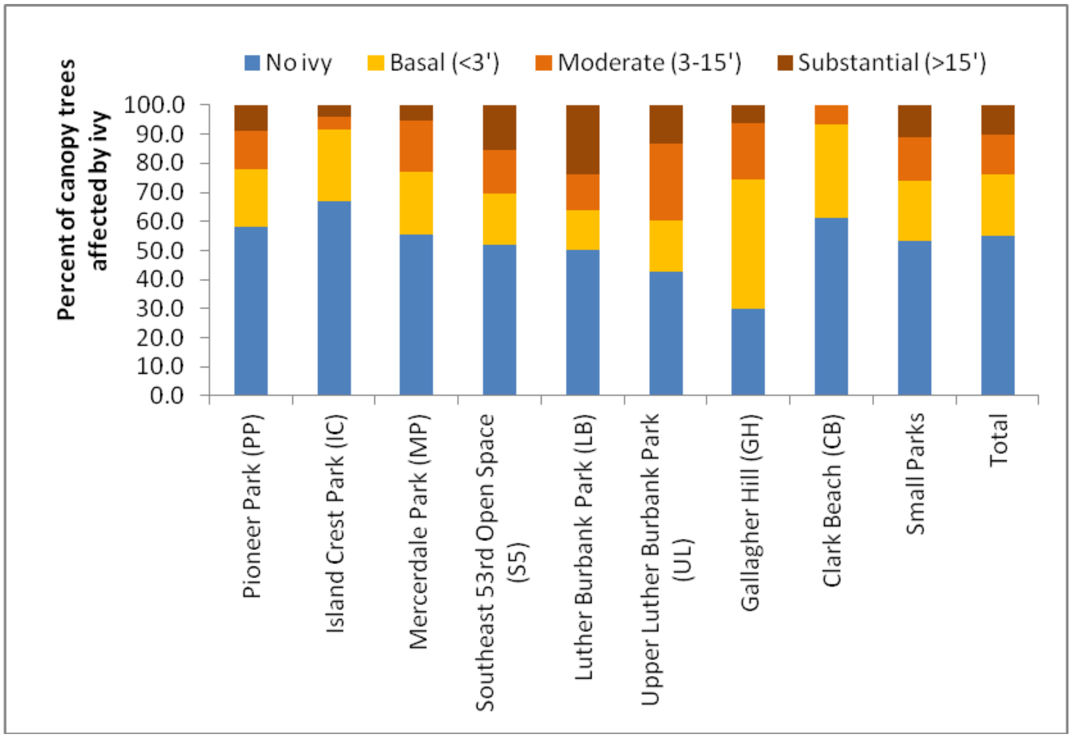


**Figure 7: Levels of ivy infestation in parks of Mercer Island, WA**

Based on the 2014 study, large and small parks are similar in their overall levels of invasion, but within these categories individual parks vary substantially. Pioneer Park is slightly better than average for the system, with 41.9% of trees having some ivy invasion, and 19.8%, 13.1%, and 9% of trees having basal, moderate, and substantial infestations, respectively. Among the larger parks, Island Crest and Parkwood Ridge Open Space are best off (with 33% and 39% of trees having any ivy, respectively). Upper Luther Burbank and Gallagher Hill are most affected, with 57% and 70% of trees affected, respectively. Not surprisingly, smaller parks are more variable, with Ellis Pond (3.2% affected), Clise Park (12.5%) and Parkwood Ridge (20%) least affected, and Southeast 47th Street Open Space (100%), Hollerbach Open Space (70%), and Homestead Park (67%) most affected. Across all parks, most affected trees have only basal infestations, but in a few parks the pattern of invasion is different. In Southeast 47th and Luther Burbank Park, severely invaded trees make up the largest proportion of invaded trees. Southeast 53rd street Open Space also has relatively high proportion of severely invaded trees among the trees that are affected in that park.

## 3.2 Regenerating trees

**Native tree densities**

Tree regeneration is an important measure of the health, trajectory, and sustainability of a forest ecosystem. Previous studies and assessments of Pioneer Park have indicated that levels of native conifer regeneration are extremely low and that this lack of regeneration posed a threat to the character of the forest and the ecological and human benefits that derive particularly from mature conifer trees. To make up for the lack of natural regeneration, Mercer Island Parks and Recreation began a systematic planting program, focused on establishing a cohort of young shade-tolerant conifers that could replace aging or diseased trees as they died. Without this intervention there is concern that, at best, native deciduous trees (primarily maples) will gradually fill in canopy gaps and replace aging conifers, thereby losing the environmental benefits associated with sufficient conifer cover. At worst, without under-planting conifers, understory invasive species and exotic trees would gradually replace native trees as gaps are created. This would degrade even further the benefits provided by a native mixed (conifer/deciduous) forest. Both the 2008 Pioneer Park FHS and the 2014 OSVM survey gathered data on seedling (<1" DBH) and sapling (1" to 5" DBH) size trees to monitor the changes in the densities of growing trees in Mercer Island's urban forests. In the discussion below, seedling and sapling categories are combined to produce a single metric (regenerating trees) for each tree type.

The 2008 FHS showed that six years of conifer planting in portions of Pioneer Park had brought regenerating conifer densities up to 45 TPA in the planted areas (compared to 12 per acre in unplanted areas). Average density across the entire park was raised to 24 TPA, still substantially lower than other urban parks in the region (Peterson and Sommargren, 2008). Planting continued across expanding portions of the park from 2008 to 2014, and 2014 survey data show that the regenerating conifer density averaged across all of Pioneer Park is 69 TPA (Figs. 8 and 9). Conifer regeneration in areas of Pioneeer Park planted by fall 2014 (approximately 70% of the park) reached 101 TPA, up from 31 TPA across that same area in 2008 (Fig. 9). Unplanted areas had 25 TPA, statistically indistinguishable from the 2008 levels. The 2014 density is mid-range for the group of urban Puget Lowland parks that served as points of comparison in the 2008 FHS.

Regenerating conifer density island-wide is 78 TPA, slightly higher than Pioneer Park. The large parks vary substantially in their densities. Island Crest Park, Southeast 53rd Open Space, and Luther Burbank all have relatively low densities of young conifers (approximately 60 TPA), whereas Upper Luther Burbank, Mercerdale Park, Gallagher Hill, and Clarke Beach (in order of increasing density) all have more than 100 TPA. The smaller parks together match the island-wide average (Fig. 5).

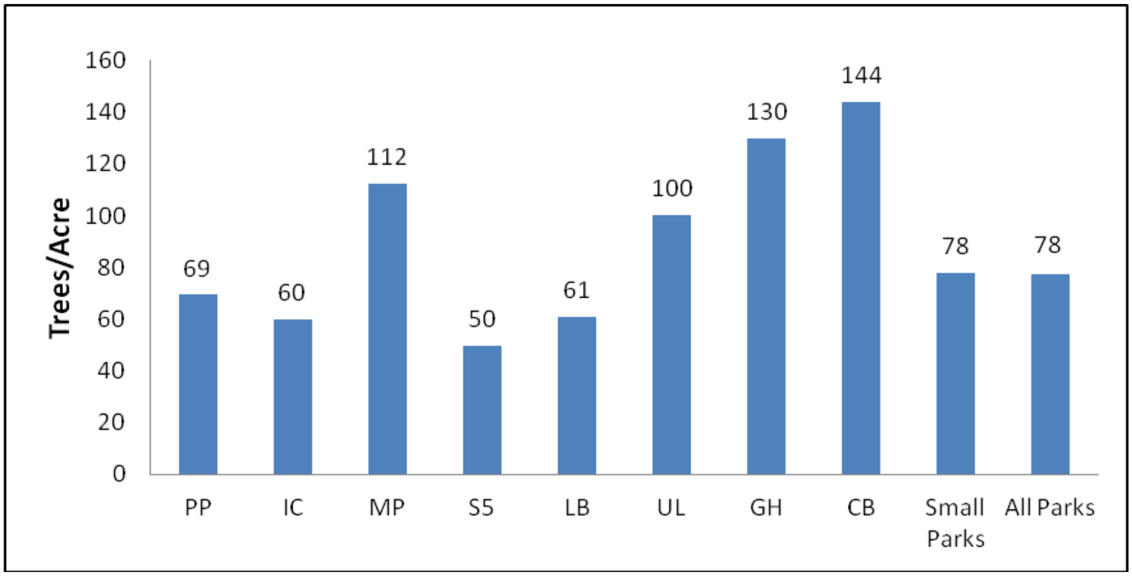


**Figure 8: Conifer regeneration (trees <5"DBH) mean density across 19 parks, Mercer Island, WA**

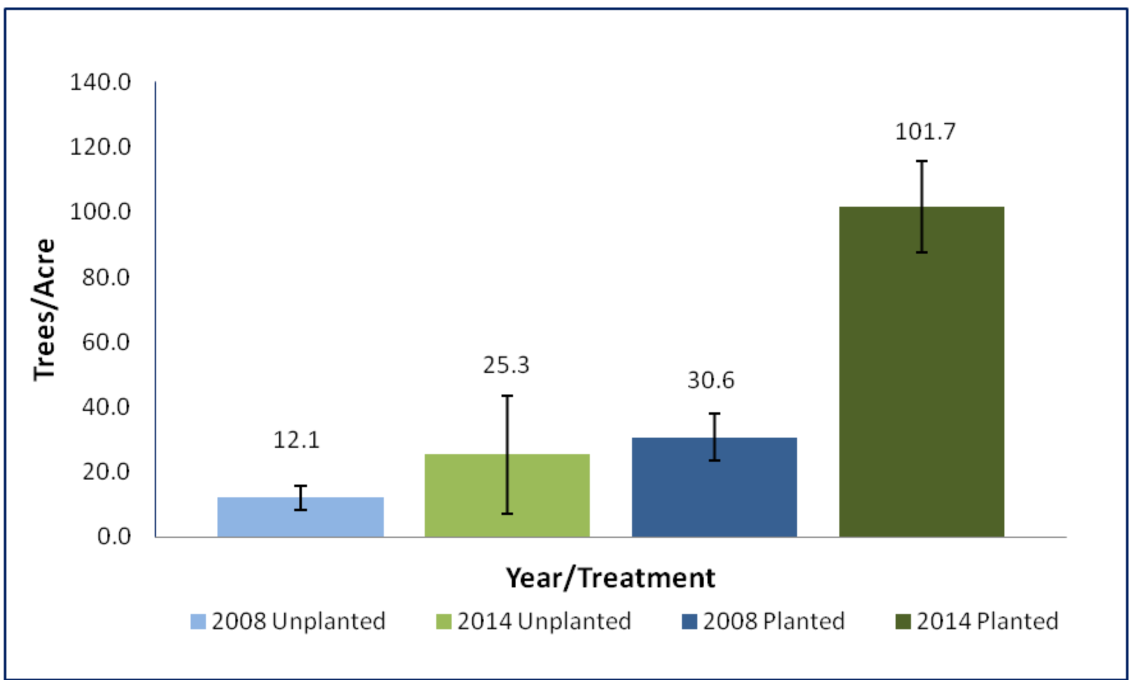


**Figure 9: Pioneer Park conifer regeneration (<5"DBH), 2008 and 2014, in areas planted or unplanted as of 2014**

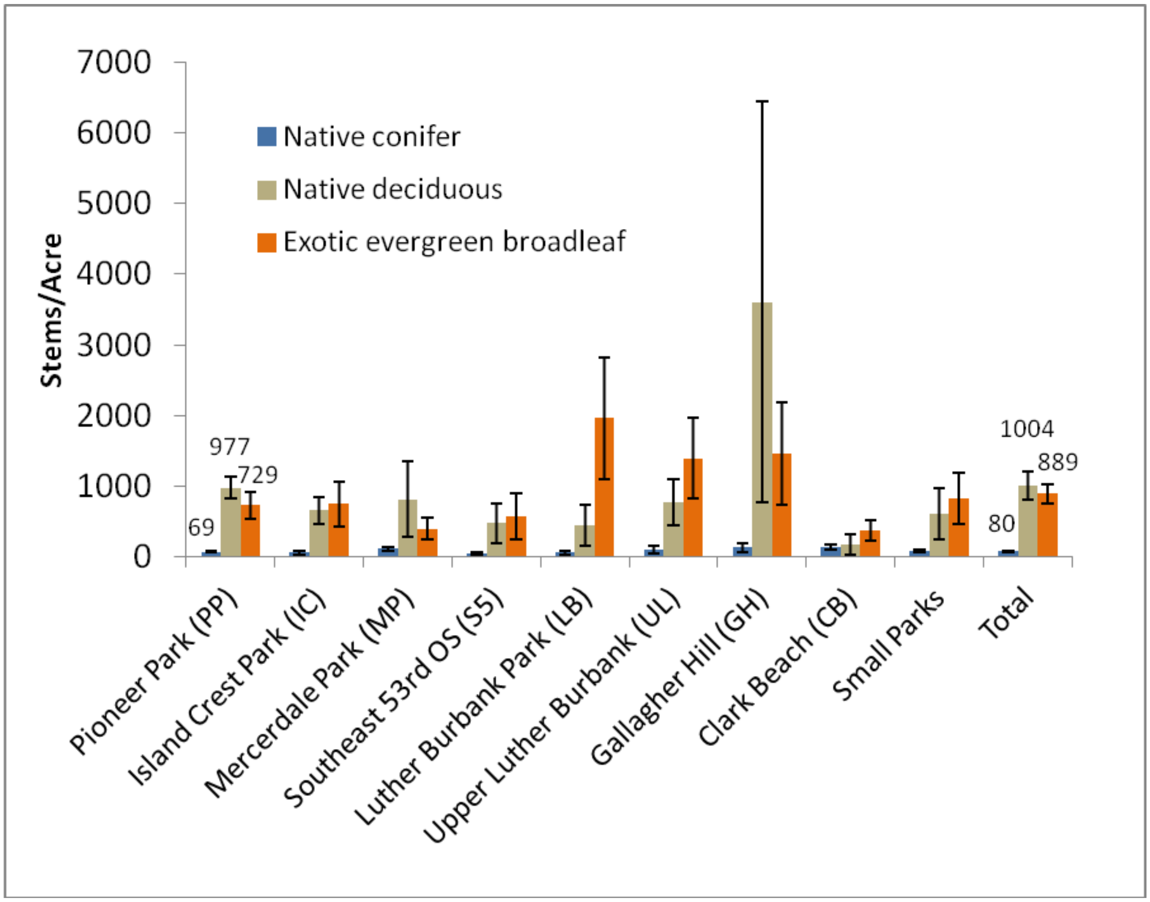


**Figure 10: Regeneration (<5"DBH) of major groups of native and exotic trees across large parks of Mercer Island, WA**

Average deciduous regeneration across all surveyed open spaces in 2014 is more than tenfold greater than conifer regeneration, with a mean of 1004 TPA. This regeneration is primarily 1$^{st}$ or 2$^{nd}$ year bigleaf maple germinants, and is spatially patchy both within and between parks (Fig. 10). Of the large parks, Pioneer Park has the highest levels (977 TPA) with the exception of Gallagher Hill Open Space where a single recently disturbed plot with densely germinating maples drove the average densities up to 3600 TPA. Southeast 53$^{rd}$ St. OS, Luther Burbank Park, and especially Clarke Beach Park stand out as having comparatively low levels of deciduous regeneration, although these levels are still well above levels of conifer regeneration.

Comparison of 2008 FHS and 2014 OSVM survey data shows more than ten-fold higher levels of deciduous regeneration in 2014 (977 TPA) than in 2008 (78 TPA) in Pioneer Park (Fig. 11). In 2008 most plots had densities equivalent to 50-100 TPA and none greater than 700 TPA, whereas in 2014 over 30% of plots have densities equivalent to over 1000 TPA. Examination of spatial patterns of seedling density from both years do not indicate that recent soil disturbance from invasive removal or planting is a likely cause of increased germination, rather it seems likely that climate-related variability in seed production led to the greater density of seedlings observed in 2014. Variability in seed production by somewhat shaded bigleaf maples has been remarked upon by some researchers (Fryer, 2011).

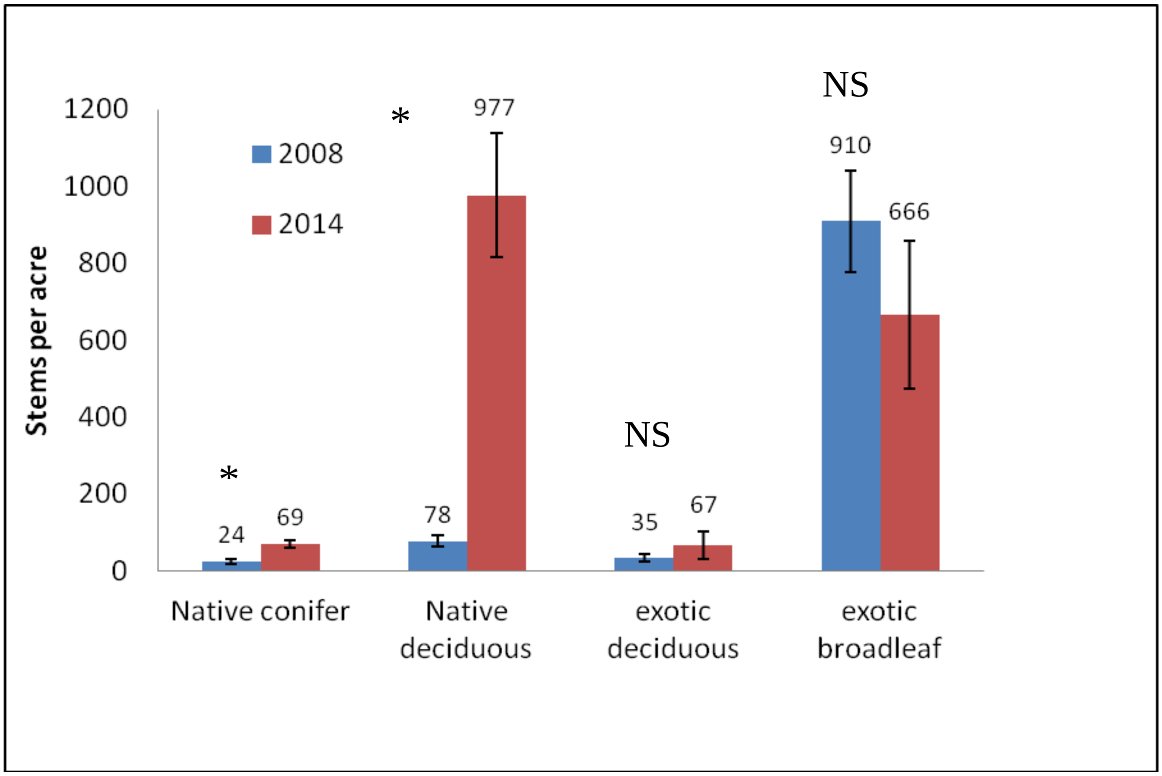


**Figure 11: Comparison of regeneration of major native and exotic tree groups in 2008 versus 2014, Pioneer Park, Mercer Island, WA**

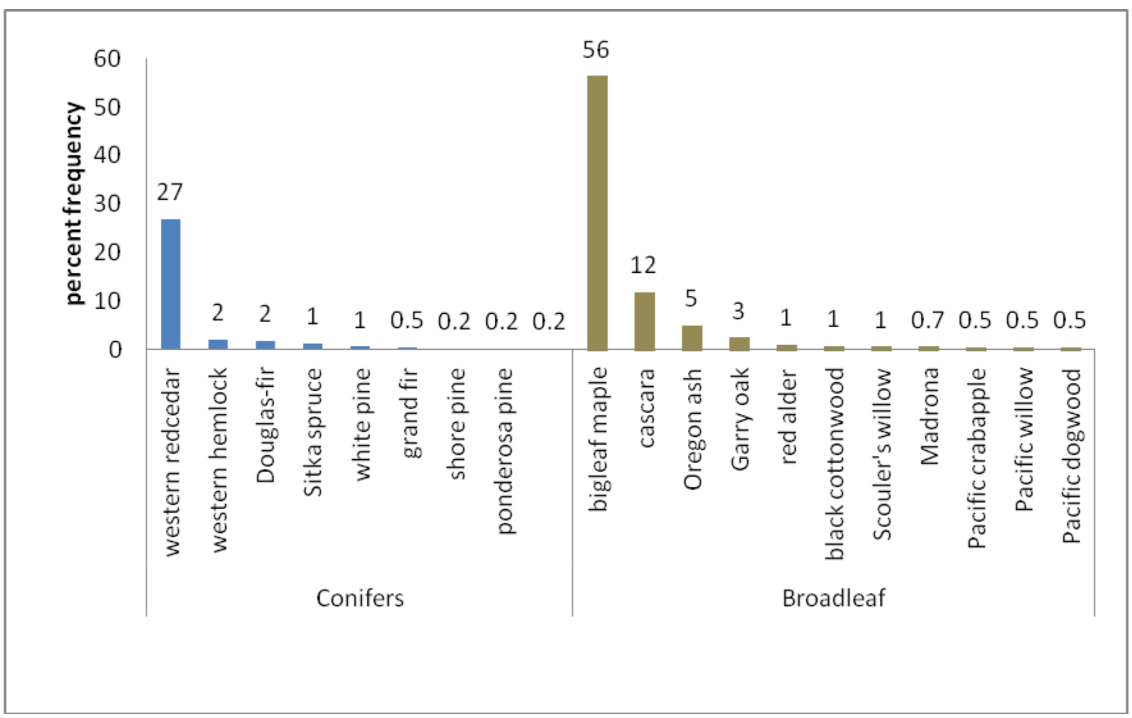


**Figure 12: Frequency of native tree seedling (<1"DBH) occurrence in 25m[2] plots across 19 Mercer Island open spaces (N=435).**

## Native Tree composition

Western redcedar is the most frequently occurring conifer seedling across the open space system (occurring in 27% of the 435 understory plots and in nearly every park sampled, Fig. 12). This regeneration-layer dominance is primarily a result of extensive planting of this species, which has been favored for its shade tolerance, longevity, and resistance to laminated root rot. In a few places this species was also found to be regenerating naturally through layering (rooting of branches in ground contact). Western hemlock, Douglas-fir, and Sitka spruce are the next most frequently found, but each is found in only 1 to 2 percent of plots. As in 2008, very few instances of apparent natural conifer regeneration were observed during the survey.

Bigleaf maple was the most frequently encountered deciduous seedling (56% of plots), and was observed with over twice the frequency of the next most common seedling (western redcedar). Bigleaf maple regeneration was observed at relatively high densities (>300 seedlings/acre) across most of the parks, with the exception of North Mercerdale and Luther Burbank Parks, where frequency of maple seedlings was quite low. Cascara seedlings (12% frequency) were found in patches across a number of parks, but were by far the most common in Pioneer Park and southern Island Crest, where germination is prolific in small gaps near parent trees. Oregon ash, which was found in 5% of plots, was primarily observed regenerating where mature ash stands were important components of the forest, namely Luther Burbank Park, Mercerdale Park, and Clarke Beach Park.

## Exotic Tree Regeneration

English holly invasion of Mercer Island parks was identified as a potential problem as early as 1996 in an overview study of Pioneer Park by Dr. Sara Reichard (Appendix D of Pioneer Park Management Plan). The 2008 Forest health survey provided quantitative data, and showed levels of regeneration of this invasive evergreen broadleaf tree to be very high (910 trees/acre). The new survey shows that the mean density in Pioneer Park is now 666 TPA (Fig. 11). While the decrease in mean numbers since 2008 may be indicative of a declining trend, the difference is not statistically significant (due to the highly patchy distribution and high standard error). The 2014 densities remain extremely high relative to native regeneration and relative to other open spaces in the region (Fig. 13). Inclusion of cherry laurel and Portuguese laurel, two other invasive evergreen broadleaf trees, brings the density of this group of invasive trees up to 729 TPA in Pioneer Park, and 889 TPA across all open spaces.

Densities of regenerating exotic evergreen broadleaf trees are substantial even in the least-affected large open spaces, Clarke Beach Park (379 TPA) and Mercerdale Park/Hillside (398 TPA). Luther Burbank Park (1964 TPA), Upper Luther Burbank Park (1396 TPA), and Gallagher Hill (1453 TPA) have the highest levels of invasion among the larger parks (>7 acres). Of the smaller parks, Groveland Park stands out, having the highest levels of invasion of any park (1965 TPA), followed by Homestead Park (1453 TPA) and Hollerbach OS (1396 TPA). English Holly makes up by far the majority (83%) of exotic evergreen broadleaf regeneration across the parks system, followed by cherry laurel (15%), and more distantly by Portuguese laurel (2%, Fig. 6). These species can propagate both by seed (dispersed by birds) and vegetatively by growth of root sprouts, which spread out from established individuals. Across all open spaces the majority (64%) of regenerating holly stems are root sprouts, often from previously cut or treated stems. In two parks with the highest levels of holly regeneration, Upper Luther Burbank Park and Gallagher Hill (as well as in Southeast 53$^{rd}$ OS) over 90% of regenerating holly stems are from root sprouts. In the remaining parks (excluding Pioneer Park where this data was not collected), the numbers of new seedlings and root sprouts were approximately even. These proportions have some impact on the potential for holly control in the parks.

Exotic trees appear to have been established longer in some parks than in others. Although density of regeneration in Pioneer Park is only moderate relative to the other Mercer Island parks, it is notable that over 17% of the regeneration in this park is in the sapling size class (greater than 1" DBH), whereas the other highly invaded parks (Gallagher Hill, Upper Luther Burbank, and Luther Burbank) have more young (seedling) regeneration, with only 2-3% in the sapling size class.

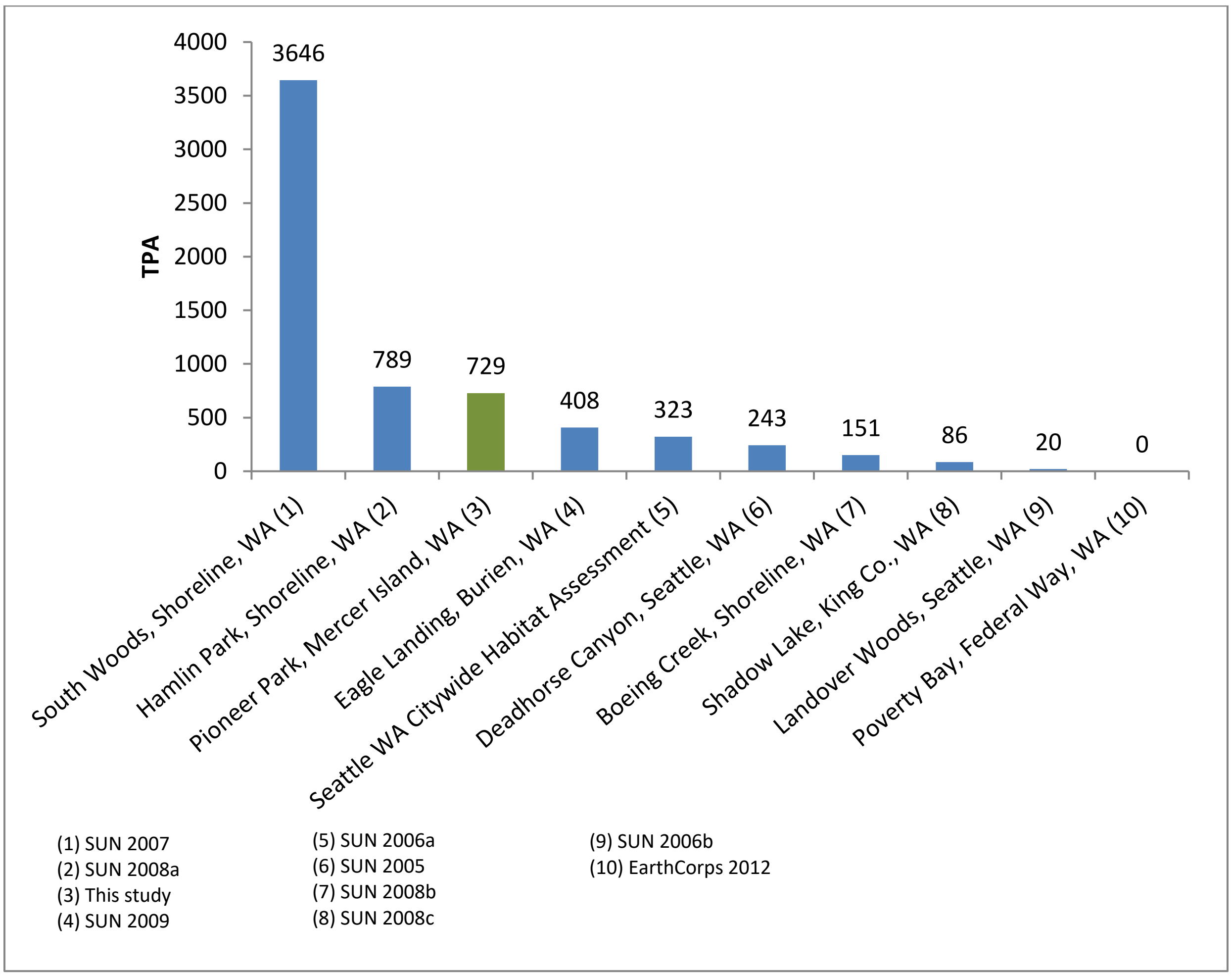


**Figure 13: Density of exotic evergreen broadleaf tree regeneration in 10 regional open spaces.**

Exotic deciduous tree regeneration is substantially lower than holly and laurel, but regeneration of invasive trees such as one-seed hawthorn, European mountain ash, sweet cherry, and cherry plum are still a concern in certain areas. Island-wide, densities of regenerating exotic deciduous trees are 60 TPA. Regeneration is highest in Pioneer Park (67 TPA), Luther Burbank Park (76 TPA), and Clarke Beach (63 TPA). In Pioneer Park these are mostly European mountain ash with some sweet cherry, while in Luther Burbank the numbers overwhelmingly represent one-seed hawthorn, where a relatively high proportion have attained at least sapling size. Clarke Beach has both cherry plum and some one-seed hawthorn.

## 3.3 Understory

As observed in previous studies of exotic species on Mercer Island and similar urban environments in the Puget Sound Area, exotic species are ubiquitous and contribute much of the vegetation cover in open spaces. Exotic species made up 69 out of a total of 178 species (39%) observed in the 2014 survey, and 99.1% of the 435 herb-layer plots had at least one exotic species present in them. Across all of the open spaces sampled in 2014, average total cover of all non-native species was 31.9 (±1.7) %. This is substantially less than the 2004 estimate of 58.4 (±1.8)% (Fig. 14). The primary invasive species found in the 2014 survey included the same species found in the 2004 survey, although abundance of these species was different between the studies. The three most abundant exotic plants in 2014 were: English Ivy, Himalayan blackberry, and Robert's geranium. English ivy cover decreased significantly since the restoration period began, from 21% to 17%. Blackberry decreased from 26% to 7% and English holly from 6% to 0.7%. Robert's geranium increased slightly from 0.1% to 2.1% cover (Fig. 14).

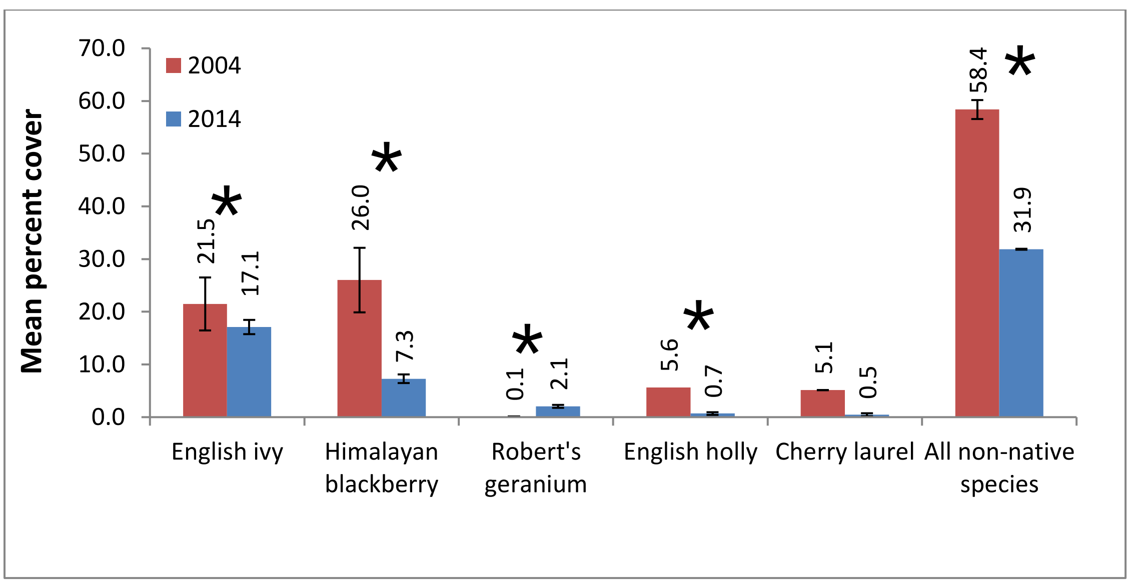


**Figure 14: Comparison of cover of invasive species (2004 versus 2014) in Mercer Island open space. Asterisks signify statistically significant differences among years.**

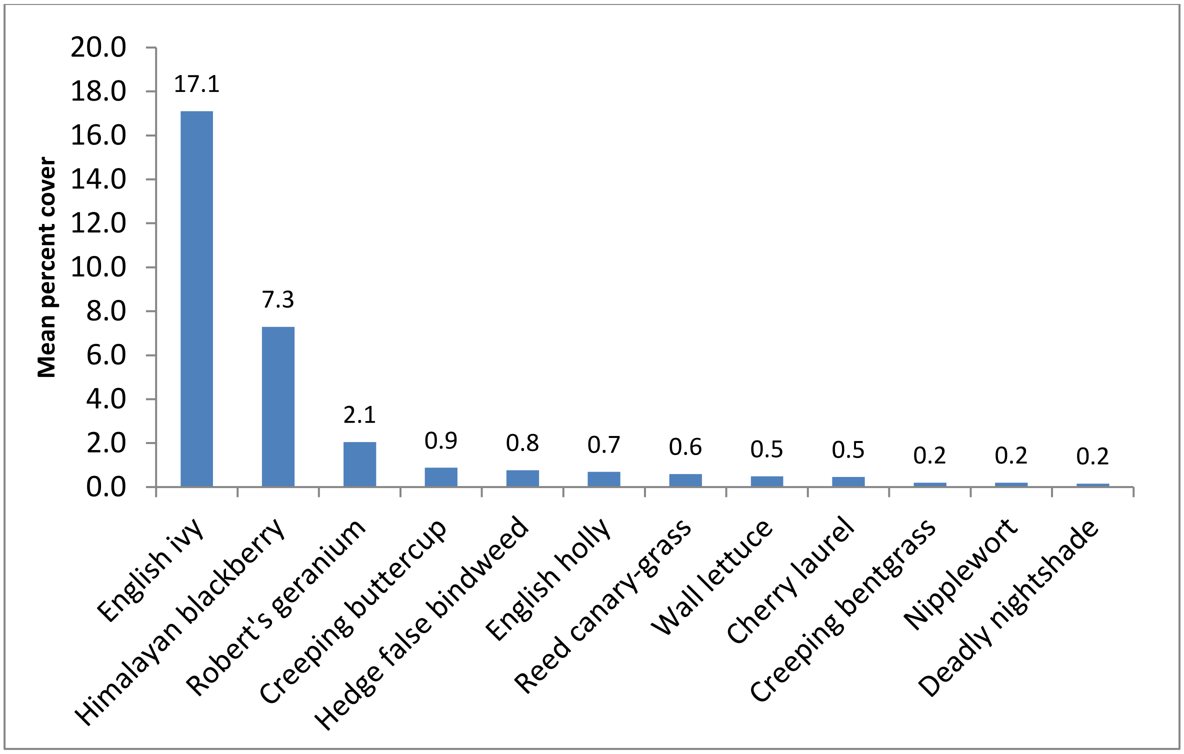


**Figure 15: Mean cover of 12 top invasive plants across Mercer Island open spaces**

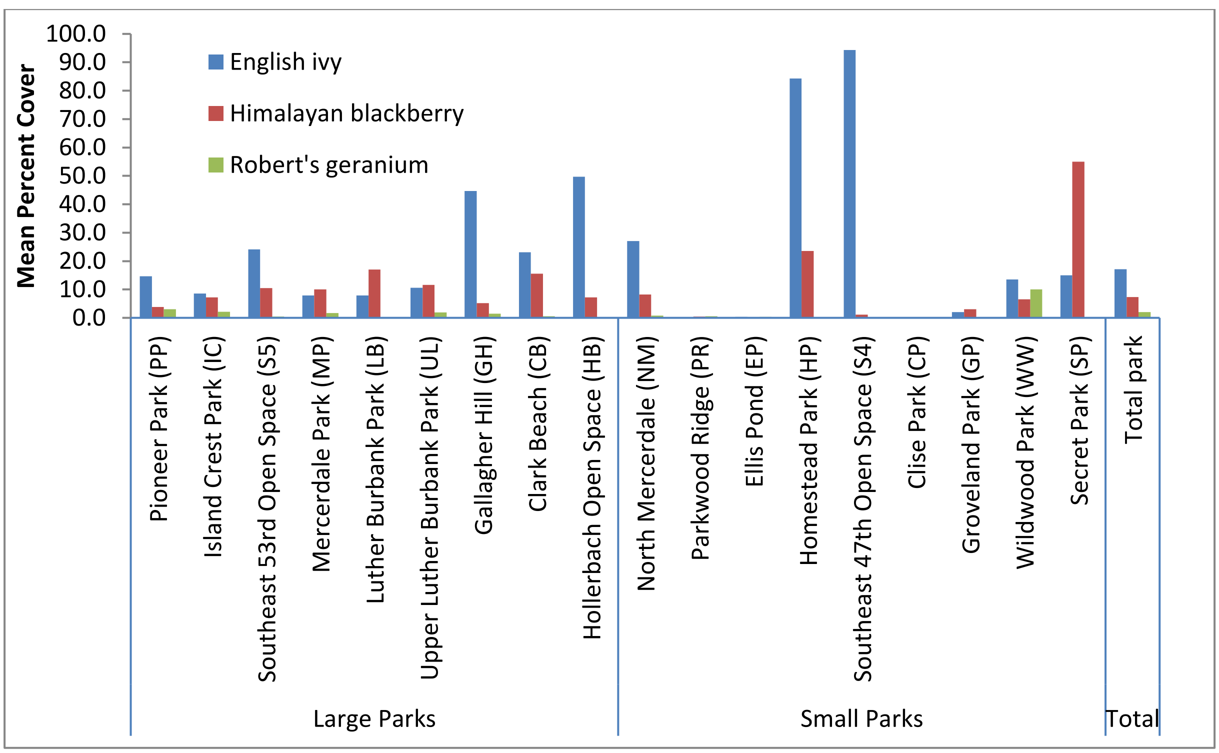


**Figure 16: Mean cover of three major invasive plants in Mercer Island open spaces**

The 2014 study shows that total invasive cover varies substantially by park (Figs. 15, 16, 17). Among larger parks, mean total exotic cover is lowest in Island Crest Park (20%) and Pioneer Park (24%) and highest in Gallagher Hill (72%) and Clarke Beach (59%). The variation is even more dramatic among small parks, with Parkwood Ridge, Ellis Pond, and Clise Park each having less than 3% mean cover while Homestead Park and Southeast 47th are both over 95% mean exotic cover. (Note that the *proportion* of total plant cover made up by exotics is lower than this in each case, as total plant cover adds up to over 100%). Although English Ivy (*Hedera helix*) is the exotic species with greatest frequency (86%) and cover (17%) by a large margin, the relative contribution of other weeds varies by park. Himalayan blackberry (*Rubus armeniacus*) is more important in Island Crest than Pioneer Park (7% vs. 4%) and has greater cover than ivy in Mercerdale, Luther Burbank, Upper Luther Burbank, and Secret Park. Creeping buttercup (*Ranunculus repens*), hedge false-bindweed (*Calystegia sepium*), English holly, Reed canarygrass (*Phalaris arundinacea*), wall lettuce (*Mycelis muralis*), Cherry laurel, creeping bentgrass (*Agrostis tenuis*), nipplewort (*Lapsana communis*), and deadly nightshade (*Solanum dulcamara*) were, in decreasing order of mean cover, the next most important weeds of the herb/shrub layer after ivy, blackberry, and Robert's geranium. Although these and other lower-abundance weeds contributed much less cover than the top three weeds on average, they each dominate in some areas of the park system and, in a few cases, have relatively high abundance overall in particular parks. For instance, hedge false-bindweed represents over 10% of total cover across all plots in Clarke Beach Park, reed canarygrass has nearly 9% cover across plots in Luther Burbank Park, and creeping buttercup has over 5% mean cover in Mercerdale Park. Additional details on invasive species presence and native composition and structure can be found in the site descriptions in Appendix B.

Nascent invaders and species with invasive potential

Several exotic species were observed in the 2014 survey that warrant further monitoring or consideration. A few are known invasives that are increasing their distribution on the island. Old man's beard (*Clematis vitalba*) is a class C noxious weed in Washington State. It is a common and pernicious invasive in the greater Seattle area, overgrowing shrubs and herbs and threatening forest cover when it climbs high into trees. This species had not been recorded from Mercer Island prior to this study, but has now been found at several locations in Mercerdale Park and one location in North Mercerdale Park. Staff have begun work on controlling this species.

Jewelweed (*Impatiens capensis*) is listed on the Washington State Weed Control Board Monitor list and listed by King County as a weed of concern. It has been spreading on the island for several years, and new locations in Mercerdale Park, Gallagher Hill, and Luther Burbank Park were observed in the 2014 survey. In addition, firethorn (*Pyracantha*), foxglove (*Digitalis purpurea*), spurge laurel (*Daphne laureola*), common bugle (*Ajuga reptans*), reed canarygrass, Japanese laurel (*Aucuba japonica*), and two species of bamboo represent potential invaders that staff will continue to work on controlling and monitoring.

Staff will also be monitoring a few unusual exotic species that appear to have naturalized in the parks and have some potential to be invasive. These include mock Indian strawberry

(*Duchesnea indica*) in moist areas of NW Pioneer Park and Upper Luther Burbank, unconfirmed populations of an invasive orchid (*Epipactis helleborine*) in North Mercerdale Park, and an unusual exotic sedge (*Carex sylvatica*) in Clarke Beach Park.

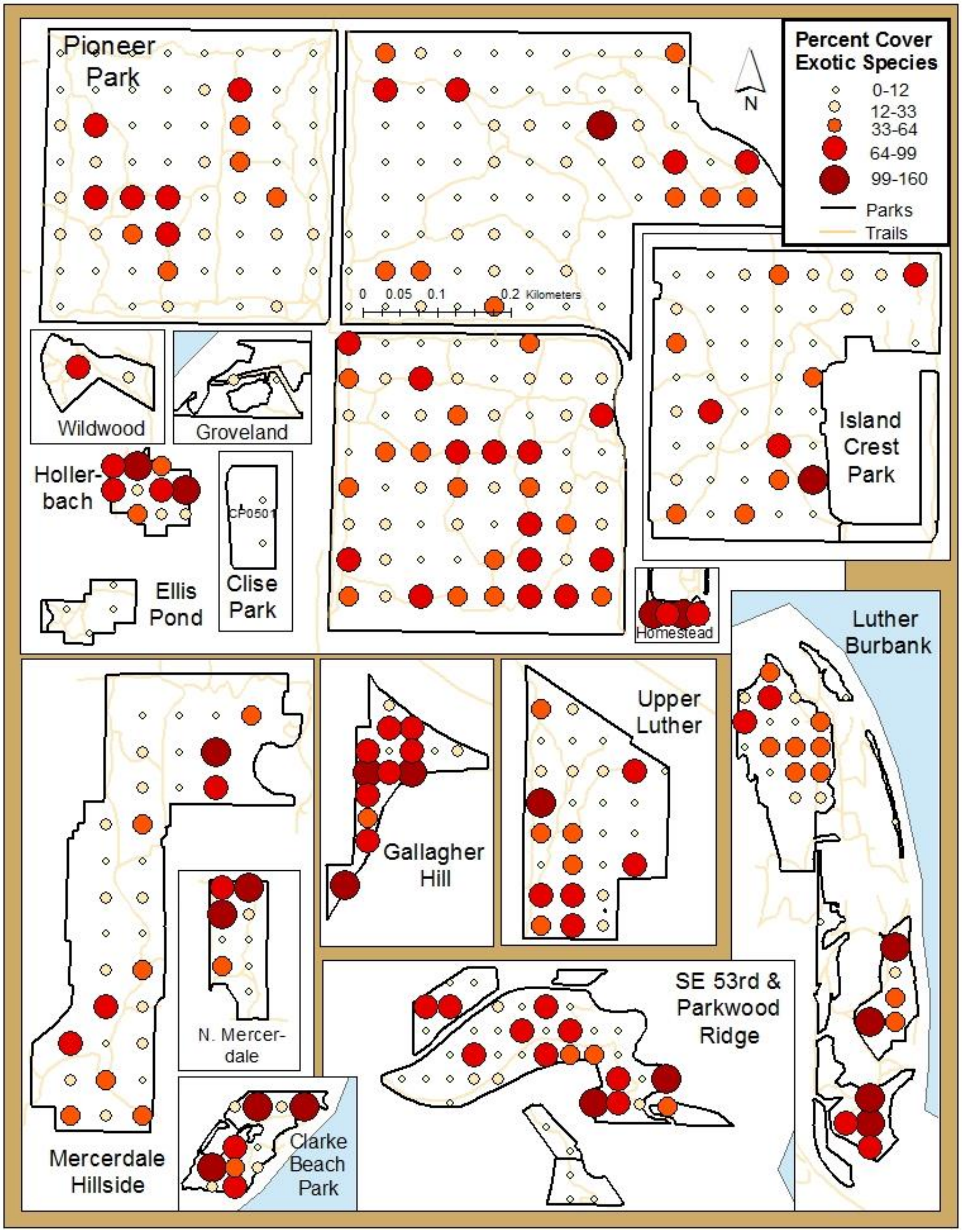


**Fig. 17: Percent cover of exotic plants in 25m2 plots in 17 open spaces on Mercer Island**

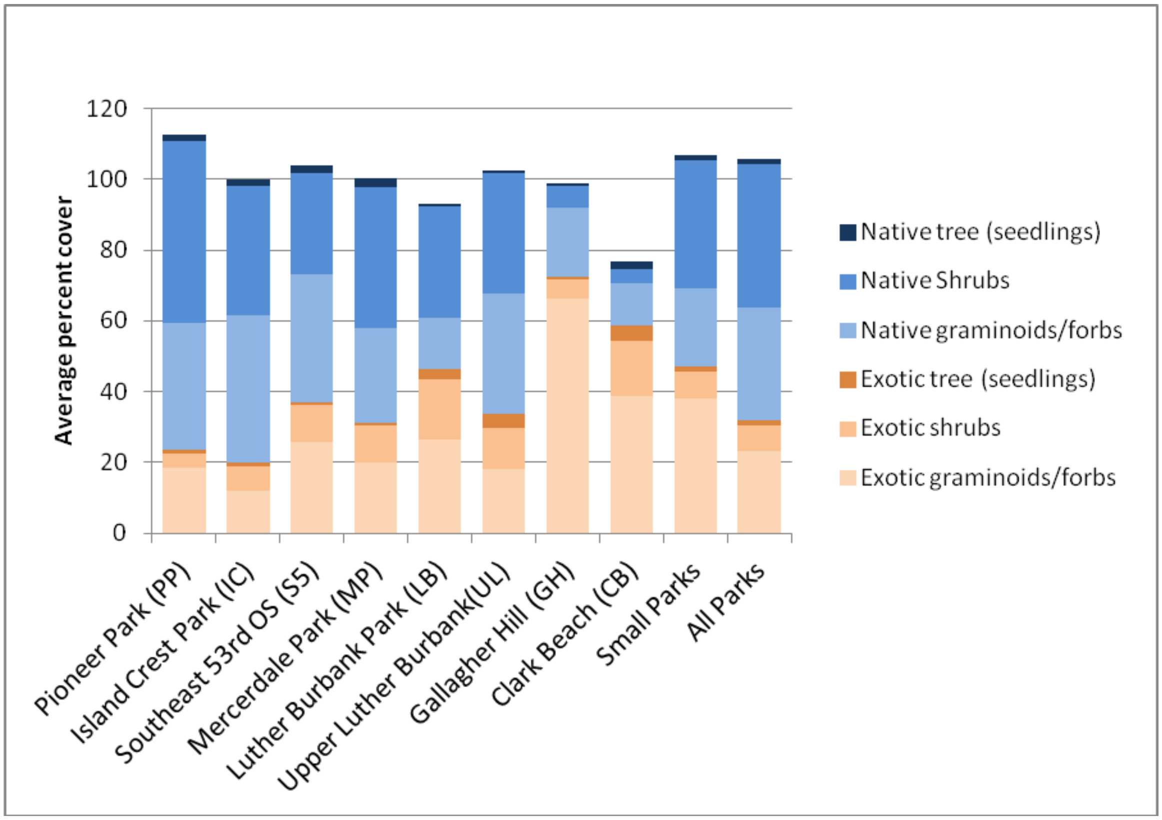


**Figure 18: Mean cover of exotic and native vegetation types in Mercer Island open spaces**

## Plant Richness and Diversity

Despite the urban surroundings of Mercer Island's parks, the park system supports a diverse assemblage of over 100 native plant species. The proportion of plant cover made up by native species across the park system is 70%, and on average 67% of the species in each plot are native. Species diversity, like degree of exotic invasion, varies among parks. Among large parks, Pioneer Park has the highest total mean species richness per plot (15 species/plot), the highest proportion of cover made up by native species (80%), and the highest proportion native richness per plot (76%). Island Crest and Southeast 53rd were the next most native-dominated large parks, and Gallagher Hill, Luther Burbank, and Clarke Beach were the least native in character. The small parks were somewhat less native-dominated on average, but varied widely from highly native Parkwood Ridge, Ellis Pond, Clise Park, and Groveland Park (all of which had proportions of native cover near or over 90%) to highly invaded Homestead Park, Southeast 47th, Wildwood park, and Secret Park (all of which had proportions of native cover below 30%).

Considering plant species richness at a larger spatial scale – the number of species supported by each park, rather than the mean number found in 25m$^2$ plots – Pioneer Park still has the greatest richness (98 species total, 66 native). This is not surprising given the much greater size of this park relative to the other parks in the system, but once again underscores the importance of this park for local biodiversity. Island Crest, Luther Burbank, and Southeast 53rd follow Pioneer Park in number of native species supported (56, 50, and 48, respectively). Although nearly half of its species are non-native, Luther Burbank Park has a very high richness of total (93) and native (50) species. Species-area accumulation curves show that it, along with Island Crest and Southeast 53rd are more species-rich per unit area than Pioneer Park, probably due to their greater topographical variation and the presence of relatively large wet areas within these parks. Several small parks are also notable for their high richness of native species given their size, particularly Ellis Pond (28) and Parkwood Ridge (30).

**Native Composition**

Sword fern (*Polystichum munitum*), stinging nettle (*Urtica dioica*), bracken fern (*Pteridium aquilinum*), wood fern (*Dryopteris expansa*), and lady fern (*Athyrium filix-femina*) are the most dominant herbaceous species in Mercer Island Parks. Sword fern, which prefers deep, mesic soils, is by far the most widely distributed and dominant herbaceous species in Mercer Island open spaces (19.4% cover overall). This species has the greatest mean cover in all individual parks except Clarke Beach (where giant horsetail, *Equisetum telmateia*, is more dominant) and in the single invasive-dominated plot of Secret Park. In Pioneer Park, drought-tolerant bracken fern is second highest in average cover, inhabiting the areas with drier soils, whereas Island Crest, Southeast 53rd, and Upper Luther Burbank are more nettle-dominated, indicating more areas of rich moist soil in those sites. Giant horsetail, an indicator of seasonal moisture and exposed mineral soil, contributes substantial cover in Mercerdale Park/Hillside and Luther Burbank Parks.

Hazelnut (*Corylus cornuta*), salmonberry (*Rubus spectabilis*), elderberry (*Sambucus racemosa*), salal (*Gaultheria shallon*), and trailing blackberry (*Rubus ursinus*) are the native shrubs with the greatest cover across the open spaces. Hazelnut has the greatest mean cover in all of the large parks except Southeast 53rd OS, Luther Burbank and Gallagher Hill. Salmonberry (characteristic of moist, disturbed, often alluvial soils) dominates in wet Southeast 53rd SO and Gallagher Hill, while the more widely-tolerant snowberry (*Symphoricarpos albus*) has slightly higher cover than hazelnut or salmonberry in Luther Burbank. Trailing blackberry and elderberry have lower levels of average cover across the park system, but are the most frequently encountered shrubs (in 64% and 53% of plots, respectively).

**Areas and species of special ecological importance**

Several areas and landforms stand out as being of particular importance in the island open spaces. As noted in the PPMP and shown by numerous studies, wetlands, riparian areas, and aquatic resources are hotspots of ecological function and biological diversity. These areas provide critical habitat for many animal species and support a diverse and distinctive suite of plant species. They also contribute disproportionately to ecosystem services such as pollution abatement, erosion control, flood control, and nutrient transformation. Additionally, wetlands and riparian areas buffer critical aquatic resources that support sensitive species such as salmon (Apostol and Berg, 2006). In Mercer Island open spaces, plant diversity was found to be higher in these wet soil areas, and a number of locally relatively uncommon species are found mostly or entirely in these areas. These include starflower (*Trientalis borealis*), devil's club (*Oplopanax horridus*), slightstemmed miterwort (*Mitella caulescens*), and skunk cabbage (*Lysichiton americanum*). These wet areas are likely to become still more critical to ecosystem health as climate change accelerates and summer drought becomes more extreme.

Other plant species that were observed in the 2014 survey which are relatively sensitive to disturbance or uncommon in urban forests are trillium (*Trillium ovatum*), vanilla leaf (*Achlys triphylla*), and wild ginger (*Asarum caudatum*).

## 3.4 Discussion

The picture presented of Mercer Island parks is a complex one, involving varying levels of 69 exotic plants across 18 very different open spaces. A number of informative trends can be drawn out, however, and will hopefully be instructive for planning future allocation of restoration efforts.

A thorough examination of the health and structure of the open space forest canopy is beyond the scope of this study, but a few important patterns are observable. Overstory density across the open space system is perhaps lower than is ideal, but appears to have changed little (at least in Pioneer Park) since 2008. Root rot plays a part in making the canopy tree densities relatively low, which in turn contributes to the problem of sun-loving invasive plants such as blackberry in the understory. Pioneer Park is unusual in its abundance of conifers; most of the remaining parks are somewhat to heavily deciduous in character. The high overall densities in some parks reflect relatively well-stocked forests, but also reflect the closer spacing of younger, smaller trees in many parts of the park system. **Conifer planting has been highly successful in creating a new cohort of conifers across the park system**, which will bring new ecological benefits especially to these deciduous-dominated parks in the coming decades.

Spatial and statistical analysis of ivy cover in the understory shows that **ivy control efforts have been effective**, and partly as a consequence of these efforts, few trees have substantial or severe ivy infestations that threaten their stability or photosynthetic capabilities. **However, a large proportion of trees still have some level of ivy infestation**, and field observations indicated that ivy seed rain continues to be quite heavy.

**Invasive trees are another critical issue** that will require continued action. Past rounds of treatment have produced substantial change in the densities of mature exotic trees across the island, and the brown "deserts" under dozens of now leafless holly and laurel trees, where the trees had shaded out all other species while they were alive, illustrate clearly the kind of forest we are avoiding by treating these trees. However, holly in particular is difficult to treat effectively, and more work is needed to improve procedures given the continued seed rain from exotic broadleaf evergreen trees. Where most regeneration is from root sprouts (e.g. nearly all regeneration in Gallagher Hill OS), there is an opportunity to develop and improve new effective protocols for controlling thickets of regenerating holly. Where germinating seeds are more important sources (Mercerdale Park, Luther Burbank, Island Crest Park) means of control may be more elusive (see Management Recommendations, Section 5.2).

The 2014 survey shows that there is still a wealth of native plant diversity on the island. Over 100 native plants were captured in survey plots, and native plants still dominate 75% of those plots. Past restoration work has reduced cover of exotic species. Certain areas are still heavily invaded by ivy, blackberry, and other invasive plants (see maps of invasion hotspots in Appendix D). Completion of planned restoration activities in new park areas over the coming decade will reduce the burden of exotic species in these areas. It is important to understand that eradication of exotic and invasive species in Mercer Island Parks is not attainable as long as there are seed sources in the surrounding landscape. The best that is possible is effective continued control efforts and management of park natural vegetation to best compete with invaders.

# 4. Management Goals and Objectives

## 4.1 Original (2004) OSVM plan objectives

The 2004 OSVM plan took a functional approach to open space. It rated all open space properties on certain functions, some of which were quantifiable – erosion control, storm water buffering, air pollution abatement – and some that were subjective – habitat, urban design, recreation value.

Original plan goals were:

1. Maintain the functional benefits of open space vegetation to the extent that available resources allow.
2. Implement work based on the value of these functional benefits, the community's priorities for the open space properties, and the condition of the vegetation found there.
3. Maximize the return on available funding through volunteers, matching grants, and donations.

Management objectives supporting the plan goals were focused on maintaining tree canopy, reducing invasive vegetation, and improving/maintaining wildlife habitat while controlling erosion. They were prioritized as follows:

1. Revegetate bare (eroded) areas on slopes
2. Remove ivy vines growing up trees
3. Maintain existing restoration project areas
4. Foster trees and woody debris in riparian and shoreline habitats
5. Plant native trees (especially conifers) where needed
6. Selectively weed invasives from native understory
7. Clear invasive dominated areas and foster native regeneration on slopes <30%
8. Control invasives and replant natives on slopes >30%

The plan laid out a 20 year timeframe in which to achieve plan goals. It was not stated in the plan, but perhaps assumed that after 20 years the open space would be in a stronger position such that a lower level of investment would sustain the open space functions into the future.

After ten years of implementation, Parks and Recreation staff have a much better understanding of the dynamics of the restoration process. In this plan update, we are considering what it will take to transition to a more stable condition (see Section 5.4 below).

## 4.2 Desired Future Conditions

In the coming decades the restoration program will need to balance the expansion of restoration treatments into new park areas against the requirements of transitioning the large areas already restored to a more stable condition. In addition, the parks system will be increasingly impacted by climate change. A more nuanced discussion of the desired future conditions of the open space system on Mercer Island will facilitate these decisions.

Desired future conditions are those that will best allow the open space system to provide benefits such as wildlife habitat, recreation, erosion control, summer cooling, storm water reduction, and pollution abatement. Importantly, the desired forest is resilient to disturbances, especially the changes projected by climate models for the next century, a consideration that is elaborated upon further in Management Recommendations, Section 5.5.

The ideal (desired) urban forest has these characteristics:

1. **Primarily native vegetation**: Exotic plants have been shown in many cases to decrease wildlife habitat value, erosion control, structural diversity, aesthetic value, and other ecosystem benefits (Charles and Dukes 2007, Clark et al. 1997).
2. **High structural diversity**, and in particular:
    a. **Dense tree canopy cover**, including large native trees: many of the benefits of open spaces are derived from the ecological functions of trees (shade, wind-blocking, transpiration, provision of vertical structure) (B.C. 2010).
    b. **Structurally diverse understory** of native shrubs, herbs, ferns, and mosses: this is important for supporting wildlife diversity (Marzluff and Rodewald 2008) as well as for recreation/aesthetic appreciation (Fuller et al. 2007).
    c. **Substantial standing and fallen woody debris**: this is critical habitat for birds, mammals, amphibians, and invertebrates, as well as providing germination sites for native plants.
3. **Uneven age distribution of trees**: A mix of mature and regenerating trees is needed to provide benefits in the present and in the future (Clark et al. 1997).
4. **High biological diversity**, and in particular:
    a. **Mixture of native coniferous and deciduous canopy trees**: Coniferous trees are important because they live longer, grow larger, continue to metabolize and provide ecological services during the wet winter season, and are consistent with the ecological heritage of the region (B.C. 2010). Additionally, a diverse overstory is likely to be more resilient to disease, climate change, and other disturbances (Clark et al. 1997, Walker and Salt 2012).
    b. **Diverse native understory** (herb and shrub layer): Diversity improves wildlife habitat, but also improves regeneration opportunities for trees.
5. **Landscape-level diversity** (patchiness): Having areas that are characterized by different soil or vegetation conditions better supports wildlife, provides more interesting recreational experiences (Fuller et al. 2007), and creates a more resilient landscape (Hunter et al. 1998).

6. **High quality aquatic resources**: Streams, wetlands, ponds, and shorelines dominated by native vegetation are critical wildlife habitat, and also recharge aquifers, purify water, reduce flooding risks, and improve aesthetic values (Mitch and Gosselink 2000).
7. **Healthy soils**: regeneration and growth of vegetation and complex wildlife food webs both depend on healthy un-compacted soils with sufficient organic material (Gurevitch et al. 2006).
8. **Safe trails and access routes for human users**: this element is important for user safety as well as for reducing unwanted recreational impacts to off-trail areas.
    a. Trail maintenance: well-maintained trails are critical for safety and recreation
    b. Regular assessment and monitoring for hazards, including hazard trees: This is important to maintaining a safe open space system.
9. **High level of investment, involvement, and interest by human users**: Although this is arguably not an attribute of the forest itself, it is a crucial factor in sustaining funding and management of the urban forest, without which the ecological system is unsustainable (Clark et al. 1997).

Despite on-going funding for restoration work on Mercer Island, complete restoration of the open space system to these desired future conditions is not a realistic goal. The urban environment is stressful to vegetation, natural tree regeneration is poor in this environment, and exotic species constantly re-invade park areas due to ongoing seed rain from surrounding areas and from the existing seedbank. However, the characteristics of the ideal open space vegetation provide a more refined set of objectives for management work.

Given limited resources and the uncertainty of the effects of climate change, we propose modifying the plan goals as follows:

1. Maintain the functional benefits of open space vegetation.
2. <u>Foster resilient plant communities that can recover from disturbances and adapt to climate change.</u>
3. Implement work based on the value of these functional benefits, the community's priorities for the open space properties, and the condition of the vegetation found there.
4. Maximize the return on available funding through volunteers, matching grants, and donations.

## 4.3 Levels of Service

The 2004 OSVM plan set priorities for open space restoration based on staff evaluation of functional benefits and a public benefit-rating exercise. As noted in Section 1.1, the plan set the highest level of service (Level A) to Pioneer Park, which would be managed according to the Pioneer Park Forest Management Plan. Mercerdale Park and Hillside, Upper Luther Burbank, Ellis Pond, Island Crest Park and SE 53rd Open Space were set as 2nd priority and assigned a lower level of restoration service (Level B), in which new trees would be planted to maintain canopy, all invasive species would be removed around trees, and new invasions would be removed in more intact areas of vegetation. Initially, 9 remaining parks were rated 3rd priority and assigned a lower level of maintenance (Level C). Beginning in 2005, however, the City Council opted to increase funding to bring all parks up to at least level B service. Some flexibility was built into the prioritization according to levels of community participation in restoring neighborhood parks.

As in the original OSVM plan, different open space areas will receive different levels of restoration service. Unlike in the 2004 plan where entire parks were assigned service levels, service levels will be assigned to landscape units within parks depending on the function and attributes of those individual units. Going forward, three levels of service have been re-defined to better reflect their functional objectives:

Ecological resilience: Areas with high ecological function or high potential for restoration to a complex native plant community will receive restoration services focused on enhancing and maintaining a high level of ecological function and resilience. In these areas, trees will be planted to facilitate canopy development, invasive trees will be removed, and invasive shrubs and herbs will be controlled to maintain a native-dominated understory.

Canopy retention: Areas where restoration of a complex native understory would be prohibitively difficult will receive restoration services focused on canopy preservation and replacement. In these areas, invasive trees will be removed, ivy rings will be periodically created to preserve tree health. New trees may be planted to ensure future canopy recruitment in some canopy retention areas.

Horticultural management: Some areas with particular functions of public access and use will receive services focused on maintaining appropriate horticultural function and aesthetics. These include areas such as certain trailheads and road edges where maintenance activities such as pruning, mulching, and replacement of damaged plants may be carried out to maintain a more landscaped aesthetic.

The management recommendations below provide some guiding principles for prioritizing restoration activities (see Section 5.1) as well as improving the efficacy and sustainability of our approach to open space restoration.

# 5. Management Recommendations

The results from the 2014 Open Space Survey provide a picture of the condition of the island's open spaces and an assessment of the progress that has been made in combating invasive species and loss of forest function over the last ten years. The Parks & Recreation management team recommendations for open space management strategies for the coming decade are based in part on this survey information and on the associated evaluation of the open space vegetation program's performance. The recommendations are also based on careful consideration of the likely effects of increasing global temperatures, changing seasonal precipitation, and increased climatic variability on Mercer Island's parks, both in the coming decade and beyond. Staff reviewed restoration practices in light of their effectiveness over the last decade and conducted literature reviews to determine how practices could be improved given advances in technology and research. The process was also informed by targeted discussions between staff and a number of local and regional experts in urban restoration and ecology.

## 5.1 Prioritization of open space areas

Going forward, open space areas will continue to be prioritized to receive varying levels of restoration service, but this prioritization will be based on a finer-scale consideration of landscape attributes within as well as between parks. Landscape elements will be evaluated based on the potential for reaching desired future conditions described in Section 4.2 and the potential for climate resilience (Section 5.5). Specifically, the following factors will influence the level of restoration effort expended in a given open space area:

1. Wet areas, riparian areas, and shorelines will be considered specially for higher levels of service and for restoration actions that would improve their function for habitat, erosion control, and storm water buffering. These target areas may include:
    a. Engstrom OS ravine and stream areas
    b. Southwestern Island Crest Park wet areas
    c. SE 53rd OS wetlands
    d. Streamside and wetland portions of Hollerbach OS
    e. Portions of Parkwood Ridge
    f. Wet areas in southwest and northern Mercerdale Hillside
    g. Luther Burbank wetlands
    h. Upper Luther Burbank ravine, riparian, and stream areas
    i. Gallagher Hill stream areas
    j. Shoreline areas in Clarke Beach Park
2. Areas with substantial presence of mature or old-growth trees, which can provide exceptional habitat and aesthetic benefits, will be considered for higher levels of service.
3. North-facing ravine areas in Upper Luther Burbank, Gallagher Hill OS, SE 53rd OS, Hollerbach OS, Island Crest Park, and Pioneer Park/Engstrom could be evaluated as cool micro-environment areas with potential as future climate refugia. Some extra restoration activities could result from this evaluation.

4. Certain areas throughout the open space system may be considered optimal for inclusion in trials of new mixes of seed provenances, or other adaptive management trials regardless of their initial prioritization. Results of summer watering trials or seed provenance trials will be more robust and dependable if test planting areas are distributed across a range of topography and soil and vegetation types.
5. Search and destroy efforts, aimed at removing scattered individuals or nascent invasive foci, will be focused most strongly on the most pristine areas within the parks. However, these efforts may be especially effective or informative when used in other areas:
    a. Where concentrations of fruiting invasive species (especially holly) pose a seed pressure threat to the more pristine open space areas
    b. Where invasive species conditions are appropriate to try new techniques (e.g. where especially dense thickets of holly provide targets to try techniques of controlling holly regrowth)
6. High levels of public investment and involvement may merit higher levels of service.

## 5.2 Continue native planting and invasive control programs

The 2014 survey shows us that the invasive removal and planting programs of the last 10 years have made substantial progress in releasing native vegetation from competition (see Section 3.3) and providing a cohort of young trees to replace aging and root-rot susceptible trees across more than half of Mercer Island's open space forests (see Section 3.2). These programs will be continued over the coming years, completing planned cycles of invasive control and planting work in the island's open spaces.

## 5.3 Improve restoration techniques

### Tree planting survivorship

Each year the program plants thousands of native trees in open space to provide canopy regeneration. Survivorship of these plantings ranges widely. On some sites, one and two year survivorship is high (80%+) while on others it is low (20%). In many cases, year-to-year survivorship is closely tied to weather patterns, such as drought or periodic summer rainfall. Over the last few years, planting techniques have been improved, including substantial watering at the time of planting and top dressing planting circles with thick mulch (either leaf litter or arborist chips).

**Likely modifications to current practices:**

- Develop and implement a new watering plan to improve survivorship of plantings during their first summer after installation.

**Potential modifications to current practices:**

- Use mycorrhizal inoculants to improve root-soil water relationships.

### Restoration site cycles

Initial planning for open space work assumed that a three year restoration cycle would result in conditions that would allow the plant communities' natural resilience to continue displacing invasive plants. In practice, very few sites are able to continue unmaintained after three years. Minor amounts of invasive removal in years 4 and 5 are often needed to prevent invasive plants from returning to former levels. Furthermore, restoration sites that are “completed” need occasional maintenance beyond the initial cycle to stem the reestablishment of invasive plants from root fragments, the existing seed bank or new seed rain.

**Likely modifications to current practices:**

- Budget for maintenance in cycle years 4 and 5, as well as periodic renovation depending on site conditions.

**Potential modifications to current practices:**

- Use targeted herbicide applications to accelerate control of invasive species (within the accepted integrated pest management program).
- Implement multi-year rest cycles for selected sites to observe new equilibrium state of native/invasive plant components

## Holly control

Control of holly and other evergreen broadleaf trees/shrubs remains a critical issue in the Island's open spaces. Exotic evergreen broadleaf regeneration remains very high, mature holly survives mechanical and herbicide treatment to an exceptionally high degree, and resulting thickets of re-growth may be even more difficult to treat effectively. Combating holly will require a continued expenditure of resources and will entail further investigation and collaboration with other regional managers to identify the best practices. These practices may differ in areas where root sprouts are the major source of new holly trees (Gallagher Hill, Upper Luther Burbank, and Southeast 53$^{rd}$ OS) versus where new germination is the major source (e.g. Mercerdale Park, Luther Burbank, Island Crest Park). Likely and potential actions to improve exotic broadleaf evergreen treatment success include:

**Likely modifications to current practices:**

- Increase collaborative problem-solving with other regional managers to improve holly control strategies.
- Improve monitoring of treatment efficacy in future rounds of treatment, focusing in part on protocols that will kill spreading root-sprout thickets.
- Require contractors and City crew to use EZ-Ject application of imazapyr for holly control, which initial data indicate is more rapid and effective than glyphosate and frilling treatment (Salisbury 2013).
- Launch a public education campaign to replace holly and laurel in private landscapes with native species or suitable horticultural species, especially near parks with high rates of new germination.
- **Potential modifications to current practices:** Seed trap installations in or near areas most heavily-affected by new seed deposition and germination.

## Genetic provenance of tree seedlings

To date, the trees planted in open space have come from a variety of genetic provenances around the Puget Sound area. Nurseries that grow native trees know that a major part of their market is urban restoration. However, the companies doing seed propagation are mostly growing for timber companies. Nurseries will often take what they can from the large propagators. Since most of the timberland is at higher elevations or more inland, the provenances of these trees are not ideal for this low-elevation maritime location. It has been difficult to get growers who adhere to good genetic management practices.

With the increased focus on genetic provenance as part of a climate adaptation strategy (see below) it is important that we are able to plant the genetic provenances that research suggests will be most adapted to future climate scenarios. Several provenances may be used to increase diversity and improve long term survival prospects.

**Likely modifications to current practices:**

- Require seed provenance documentation with plant orders.
- Track the locations of various seed provenances of trees planted in restoration sites. Monitor and record establishment success correlations with seed provenance.
- Contract with a commercial nursery to grow the seed provenances for native tree species that we need for good genetic management and to anticipate future climate change.

## Root disease management

Root disease is contributing to the attrition of mature trees in open space. The 2004 plan did not address the need this presents. It was assumed that planting disease resistant species would handle the problem. The Hanukkah Eve

### *Box 1: Seedzones and provenance*

*Horticulturalists, foresters, and ecologists have long known that traits of individuals and populations of plant species vary geographically. Toward the middle of the 20th century foresters began to formally recognize that trees grown from locally-sourced seeds were substantially better-adapted to local condition, leading to the creation of "seed zones" (see below) to guide selection of suitable planting material . Now, as foresters and ecologists consider the implications of climate change, many suggest that future forest resiliency may be increased by planting some proportion of nursery stock derived from outside the local seed zone, especially from warmer areas or areas with present climates similar to projected future climates in the planting area, so that tomorrow's trees may be 'pre-adapted' to the rapidly changing climate.*

*Below are some definitions of related terms (modified from the Dictionary of Forestry, Society of American Foresters, 1998):*

***Population:** a group of similar individuals sharing a common gene pool and occupying a particular geographic area.*

***Provenance**: the original geographic source of seed, pollen, or propagules (often given in terms of seed zones, see below).*

***Genotype**: 1) an individual's hereditary (genetic) constitution, or 2) individual(s) characterized by a certain genetic constitution.*

***Seed zone**: a designated area, usually with definite topographic bounds, climate, and growing conditions, containing trees with relatively uniform genetic composition as determined by testing traits of progeny of various seed sources.*

windstorm in December 2006 exposed the extent and severity of the problem. In the following eight years City staff and the Open Space Conservancy Trust have considered numerous ways to mitigate the impacts of root disease. Despite this work, there remain few other management choices that represent a reasonable approach for an urban open space.

**Likely modifications to current practices:**

- Public education about root diseases
- Treating cut stumps of diseased trees with borax

**Potential modifications to current practices:**

- Stump removal at the margins of root disease pockets to reduce transmissions of disease to healthy trees
- Use of competitive fungi such as *Trichoderma* to provide trees defense against certain disease.
- Mapping and monitoring root disease centers

## 5.4 Transition sites to a more stable condition

Restoration temporarily reduces the stability of the plant community on a site. The clearing of invasives and planting of trees exposes bare earth and stimulates germination of dormant seeds lying in the soil. This favors weed species, both native and exotic. Most sites have several flushes of weed growth following the first round of invasive removal.

One of the major objectives for the following decade is to explore and evaluate maintenance regimes that lead to maximum stability of native vegetation over time with minimum cost. Current practice has been three years of invasive plant removal maintenance in comprehensive removal areas. In addition, other procedures or "tools" in the restoration toolbox have been used in various contexts based on project goals. These include:

1. Dense understory planting to establish native cover and compete with invasive species
2. additional years of "removal maintenance": belowground and aboveground portions of all herbaceous and shrubby weeds are removed
3. Increased use of mulches to reduce weed regrowth
4. "invasive knockdown": only aboveground portions removed with clippers or weed-eaters
5. "search and destroy": rapid sweeps of large areas to target small patches or individual plants for manual or chemical control

The 2004 plan addressed invaded forest conditions that had evolved over the 130 years since European settlement. It was recognized at the time to be a temporary plan, one that would not go on indefinitely. The goal over the next ten years is to transition open space project sites to a lower level of maintenance. In high priority areas where the goal has been to restore diverse and native-dominated plant communities, maintenance will eventually consist of periodic sweeps to reduce new invasions. In canopy-prioritized areas non-native understory vegetation is expected to remain a component of the forest, but periodic treatments will maintain ivy-free tree trunks, control invasive trees, and eliminate foci of newly encroaching invasive species (e.g. knotweed, jewelweed, old man's beard). In horticultural management areas (as defined in Section 4.3 above) a somewhat more frequent cycle of maintenance may include mulching, pruning, and planting. It is unlikely that all open space will be "stable" by 2024. Invasive plants will continue to grow in open space. Therefore, part of this goal will be to determine what levels of certain invasives are part of each plant community.

## 5.5 Develop an open space climate adaptation strategy

The 2004 plan predated much of the current knowledge about climate change. An enormous body of scientific work has been published since. The plan assumed that the climate would be static and that native plants were adapted to grow in our open spaces. While this assumption still may be true for a majority of native plant species, there are likely to be exceptions, most notably in tree species.

The need to rethink our approach is evident in the current information. The most challenging issue is the great uncertainty that climate change poses. The general predictions by UW Climate Impacts Group are for a slightly warmer, slightly wetter climate in the coastal Pacific Northwest. The warming will be characterized more by higher minimum temperatures than by higher maximum temperatures. Importantly, the projected increases in precipitation will likely be focused on the already wet winter months, while the already dry western Washington summers are likely to become still drier. At the same time, higher temperatures will increase plants' needs for water. The Pacific Northwest avoids the more extreme changes that will impact other parts of the world, but these predictions of greater variability in climate with longer drought episodes is a concern for urban forests. These conditions will stress plant communities, especially trees (Climate Impacts Group 2009).

Regional climate change is compounded by microclimate changes that have already occurred in open space. The microclimate in the open space on Mercer Island changed when development occurred on the island. Trees were cut down, ground was exposed, pavement was installed, and land was drained. The open space became warmer and drier. The forests became remnants of what was once continuous forest canopy. The edges of these remnants became exposed to sun and wind. These so-called "edge effects" extend for up to three tree lengths into the forest, impacting most of the open space acreage. These changes due to urban development will compound the climate changes that are projected for the next 100 years. For example, if residential development caused a three degree Fahrenheit rise in average air temperature in open space, and the local air temperature is expected to warm by five degrees in the next one hundred years, this could mean a total temperature rise of eight degrees Fahrenheit.

In the next decade Parks and Recreation staff will introduce new strategies for climate adaptation in response to a wealth of new information on climate projections, plant genetics, and climate change adaptation. Many of the strategies described in this document are aimed to increase the resilience of Mercer Island open space vegetation to current stressors and to disturbances and stresses we foresee as important in the coming decades. (For a discussion of the concept of resilience, see Box 2). As we set goals for the next ten years, we must consider that our actions, particularly tree planting, will play a part in determining the function and resilience of our forests over much longer timeframes (a century or more). Recommendations below are divided between those that most closely pertain to shorter versus longer time-frame objectives, but it is important to note that objectives for these two time-frames are inter-dependent and that most actions have effects spanning both periods.

***Box 2: Resilience***

**Resilience** has become a central concept in planning for sustainability in human-built and natural systems, especially in the context of climate change.

Ecological resilience has been defined as: "the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity (Walker and Salt 2012)".

Many natural systems are able to self-organize and recover from a variety of disturbances – they are resilient. However, it is possible for systems to lose their resilience when their components or the conditions in which they exist are changed too much, such as when forests are fragmented, or too many fish are harvested from an aquatic ecosystem. When this happens, the system crosses a **threshold**, and may then enter an **alternative stable state**, one which is characterized by a different set of species, exhibits new characteristics, and resists efforts to return to the original state.

When managing systems to maintain or boost their resilience, it is important to consider what *attributes* of a system one desires to make more resilient (Brand and Jax 2007). It may be desirable that populations of certain species persist in the landscape for habitat, cultural, or aesthetic reasons. Alternatively, it may be acceptable that species change in abundance after a disturbance as long as the ecological functions (such as carbon sequestration, habitat provision, or productivity) provided by the mix of species is maintained. In many cases, it is ecological services to humans (such as shade, pollution amelioration, storm-water reduction, or aesthetics) that we wish to make more resilient.

Planning for climate change resilience is particularly tricky, because climatic warming and changes in seasonal precipitation are not comparable to a passing disturbance like a forest fire; climate change will manifest as incremental change of the climatic baseline, punctuated by passing disturbances. Ecological communities cannot be expected to "return to normal" once climate change passes. For this reason, some ecologists suggest that we need to help ecosystems to *re-organize and respond* to climate-related environmental change rather than attempting to improve their *resistance* to such changes. As an example, Mercer Island lies in the western hemlock climax zone, where western hemlock is considered to be the tree that will naturally become dominant as a forest matures. The forest ecologist Jerry Franklin (pers. comm.) suggests that hemlock may decline as summers become drier, changing the ecological identity of these regional forests. However, well-adapted genotypes of native species such as Douglas-fir, western white pine, and cedar will likely continue to provide native conifer cover and structure to maintain the characteristics and functions of our native forests. For Mercer Island open spaces, a meaningful conception of resilience may be the degree to which these forests can retain desired ecological structures, functions, and services even while some aspects of their identity slowly change.

**Definitions:**

**Threshold**: a level of a controlling factor beyond which the feedbacks in a system change

**Alternative stable states**: states or conditions of an ecosystem (e.g. number and type of species, organization, physical conditions) that are resistant to change (resilient) unless pushed beyond a certain *threshold* by a significant perturbation. Once over the threshold, the system may exhibit new feedback patterns and fall into a new configuration or condition which is resistant to further change.

References:
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Brand, F. S., and K. Jax. 2007. Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. Ecology and Society 12(1): 23. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art23/

## The short term (10-20 years): building capacity for adaptive management

In the near-term, the assumptions and goals of the 2003 Pioneer Park Forest Management Plan and 2004 Open Space Vegetation plan will continue to be relevant and the overarching strategies to attain these goals will likely continue to be effective. However, even during this time period, climatic variability will likely be greater and extreme weather events more frequent than in the preceding decades (IPCC 2007, Kim et al. 2014). These upcoming decades represent a time to build a vision and a set of tools to practice forest management in a variable and changing climate. Carrying out successful restoration projects in an increasingly uncertain world will require a level of informed adaptive management beyond what has been pursued in the past.

In the face of greater uncertainty about climate conditions from year to year, we will need to be more open to testing and carefully monitoring the efficacy of different restoration approaches.

**Selecting the most effective methods of ecological restoration in a changing and more uncertain climate will require allocation of a somewhat larger proportion of resources to project design, new plant materials, testing, project monitoring, and data analysis. Re-allocating resources to a data-based adaptive management approach will likely reduce expensive failures further down the road.**

## The long-term (50-100+ years): new tools and strategies

Land managers have traditionally used knowledge of historical plant community composition and the historical range of variability in ecosystems to inform restoration and management activities. To the same end, restoration ecologists identify relatively undisturbed "reference ecosystems" to guide development of restoration targets (SER 2004). With climate change, these historical vegetation patterns and compositions must be treated as increasingly uncertain guides. The major ecological changes expected in the coming century will require that land managers focus their efforts more on cultivating functional and resilient ecosystems – systems that can change along with the changing climate but retain their function and identity (see Box 2).

**The literature on ecological restoration, conservation, and climate change suggests several overarching principles that are likely to increase landscape resilience. The 6 concepts listed below are drawn from this literature and form the foundation for our climate adaptation strategy. These principles will help guide restoration work and mitigate the loss of ecological functions and benefits on Mercer Island as climate changes.**

1. **Strengthen adaptive management by including more experimental approaches and careful monitoring** (Seppälä et al. 2009). This concept was also discussed above as a tool for improving short term success. Despite the growing popularity of urban restoration programs, urban ecological restoration is a young science dealing with a landscape of rapid social and environmental change. Best practices are still evolving, and for many activities there is relatively little published

research to inform our work. To accelerate the learning process, restoration practitioners must design experimentation and evaluation into restoration projects and work to share information.

2. **Manage for diversity, which provides resilience in the face of disturbance and climatic variability** (Tilman et al. 1997, see also Box 2). This is especially critical given that forest insects and pathogens are predicted to be a major cause of ecosystem disruption in the coming century and may severely impact one or another individual species (Little et al. 2010). Increasing or maintaining a diversity of species, habitat types, and spatial heterogeneity has been a priority in Mercer Island restoration and will be a very high priority in the coming decade.

3. **Provide special protection for bottomlands, wetlands and waterways, which are especially critical resources in times of drought and may serve as climate refugia** (Seavy et al. 2009). Protection of aquatic resources is emphasized in both the 2004 OSVM plan and the 2008 Pioneer Park Forest Plan. With climate change impacts as an increasingly pressing concern, protection of these areas will be an even higher priority moving forward. Particular emphasis will be given to developing good methods for invasive species control in these areas, and areas of potential erosion will be prioritized for assessment and stabilization.

4. **Identify and protect other geologically or topographically unique areas, as these could provide refugia as climate changes** (Hunter 1988). Due to its small size, Mercer Island has a limited number of topographically or geologically unusual areas, but this recommendation would apply to wet depressions and stream corridors (as discussed in #3 above). Additionally, steep, north-facing slopes and ravines will be assessed as possible mini-refugia as climate changes, and special restoration efforts might be prioritized in these areas.

5. **Improve risk assessment (B.C. 2010) in relation to threats expected to increase with climate change** (drought and attendant canopy tree death, flooding, erosion, root rot, fire). The interaction between ecological change and public safety and health is important. Enhanced monitoring of ecosystem health (see point #1), which will improve early detection of ecological disturbances such as erosion and increased tree mortality, will also enhance early detection of related public safety issues (such as hazard trees or areas prone to slides).

6. **Manage for asynchrony and use establishment phase to reset succession.** Severe climatic events such as fire, drought or storms often cause widespread die-off which restarts succession and reduces diversity. This becomes an opportunity to promote diverse age classes and species mixes to reset the ecological trajectory of a landscape (Millar et al. 2007). Disasters such as major wind-storms could potentially open up large canopy gaps in Mercer Island open spaces. Fire has historically been uncommon in west-side forests and urban firefighting efforts further reduce chances of spreading forest fires, but climate projections indicate that western Washington forests may become more fire-prone in the coming

decades. Loss of a large area of canopy from one of these disturbances would negatively affect the Island's open spaces and the services they provide. However, some positive results could be achieved if subsequent replanting was undertaken with this directive in mind. The diversity of trees used in restoration has been somewhat constrained by a necessary focus on shade-tolerant species that will survive and grow well under the existing canopy. The process of restoring such a disturbed are would present an opportunity to establish patch diversity by establishing some stands composed of less shade-tolerant species such as Douglas-fir (used sparingly due to susceptibility to root rot), shore pine, and western white pine.

**In addition to identifying broad principles that will improve ecological resilience, parks staff have evaluated a set of more specific climate adaptation actions that have the potential for mitigating one or more expected ecological effect of climate change.** Expected climate effects include: increased summer drought stress (CIG 2009) and associated seedling mortality, increased forest pathogen and insect damage associated with increased drought (Little et al. 2010), increased winter rain (CIG 2009) and associated erosion, and increased climate variability/storminess (IPCC 2007). Maladaptation of tree species to climate is another major concern. Regional projections for the Pacific Northwest indicate that, as temperatures rise over coming century, native tree species and varieties may become maladapted in large parts of their current distribution (Kim et al. 2012, Rehfeldt et al. 2014). Plants have "migrated" and plant communities changed during major climate fluctuations in the past (Davis 1994), but studies indicate that the rate of climatic change in the coming centuries will likely outstrip the abilities of trees to colonize new areas (Iverson et al. 2004).

The adaptation actions assessed by staff are shown in Table 2 below. They have been divided into three categories according to the feasibility, risk, and overall potential for positive impact on Mercer Island open spaces. Note that Activity 3 is one form of "assisted migration", a type of adaptive strategy which bears further consideration as an option for Mercer Island open spaces and is discussed further below (also see Table 3). Actions in categories 2 and 3 are not being considered for use at this time given their associated risks and uncertainties.

**Table 2: Climate adaptation: example activities considered for Mercer Island open spaces**

| Activity | Context or "trigger" for use | Risks/costs |
|---|---|---|
| Category 1: Feasible, low-risk activities with high probability of positive results: staff plans to incorporate these activities into restoration work in coming years and to monitor effects. | | |
| 1) Summer follow-up watering of tree plantings | Planned near-term implementation | No known risks, moderate cost |
| 2) Protect mature trees and stands from additional hydrologic and microclimatic changes | Monitor adjacent properties for potential impacts from development | No known risks, will require working with adjacent property owners |
| 3) Incorporation of diverse, warm or dry-tolerant provenances* of native trees into planting stock | Planned near-term implementation | Some risk of maladaption to current climate (but still favorable as compared to risk of inaction) |
| Category 2: Moderate feasibility, risk, and probability of success. These activities are supported by research and may be used in certain conditions or in the case of certain triggering events. | | |
| 4) Mycorrhizal inoculation of planting materials | Could be used in event of repeated failure of tree establishment in some areas | Poorly understood, but not likely to involve significant risk |
| 5) Use El Nino/Southern Oscillation (ENSO) forecasts to guide timing and scope of restoration work during a given year. | Continued difficulty with performance of restoration plantings | Forecasts are not good predictors of actual weather conditions. May increase logistics and reduce ability to plan projects for other adaptive strategies |
| 6) Thinning of forest stands to improve vigor | Could be used in event of clear, imminent threat of major damage from certain forest pathogens/insects. Not a preferred action due to risks. | Substantial risk of negative impacts from canopy reduction, soil compaction, and other associated disturbances |

| Category 3: Low feasibility, high risk, or uncertain success. These activities would require more support from research as well as presence of certain triggers before use. | | |
|---|---|---|
| 7) Soil renovation | Small, high-impact planting areas where other measures have failed to establish plants | No/low risk, high cost |
| 8) Root rot fungal competitor treatments | Additional research establishing effective treatments | Poorly understood risks of disturbing soil biota/fungal ecology |
| 9) Stump removal to decrease root rot spread | Additional research demonstrating effectiveness and/ or worsened impacts of root rot on parks | Risks of soil compaction and disturbance, high cost |
| 10) Improve drainage in flood-prone open space areas | Evidence of substantial flood damage to open space plant communities | Risk of soil compaction and disturbance, negative impacts of hydrological alteration |
| **see Box 1* | | |

**Assisted Migration**

One of the most discussed strategies for climate change adaptation in ecological systems is "assisted migration", in which species or genetic populations that have not been considered historically native in an area (hereafter, "novel plant material") are introduced in order to improve ecosystem function or preserve the species. Assisted migration seeks to facilitate the natural process by which species or genetic types within a species colonize new ranges as climate changes. Assisted migration activities can range from subtle changes in the genetic stock used for native species plantings (as in Category 1 activity above) to more radical changes in the species used in restoration. The table below outlines this gradient of actions.

**Table 3: Plant materials scenarios for climate change adaptation in Mercer Island Open Spaces**

| Deviation from native composition | Possible plant material scenarios for climate change adaptation | Example | Context for use |
|---|---|---|---|
| None | Plants with wide environmental tolerances | Western redcedar (*Thuja plicata*) | Currently in use |
| Minor or none | Trees native to the Puget lowlands, but not historically known on Mercer Island | western white pine (*Pinus monticola*) | Currently used in habitat areas where other native species are poorly adapted |
| Minor | Western Washington native species derived from seed zones/provenances (see Box 1) better adapted to projected future climates on Mercer Island | Douglas-fir (*Pseudotsuga menziesii*) seedlings from warmer/ drier seed zones | Planned inter-planting with local seed provenances to evaluate adaptation to changing climate |
| Moderate | Pacific Northwest native species that are not now native (or uncommon in) Puget lowlands but are well adapted to projected future climates | Ponderosa pine (*Pinus ponderosa*) | Currently in limited use in park areas with special requirements, potential for use in limited drought and disease-prone areas |
| Major | "neo-native" species that are not Pacific Northwest natives currently, but may have existed in PNW over geologic time | coast redwood (*Sequoia sempervirens*) | Currently in limited use in areas with special requirements, potential for use in disease-prone areas |

**Assessing and mitigating risk**

Design of a forest adaptation strategy must balance risks of various types:

Inaction (continuation of practices without modifications related to climate change) incurs risks:

- establishment failures of plantings as climate events surpass tolerances of native genotypes
- death of more mature trees and loss of canopy cover
- negative impacts on vegetation or wildlife if timing of biological processes (phenology) changes and disrupts symbioses, food webs or competitive balance

- poor understanding of responses to such events given failure to increase monitoring or experimental approaches

Assisted migration approaches (from minor to major, as in Table 3) also incur some risk:
- near-term failure of seedlings that are adapted to warmer/drier climates
- long-term failure of more mature "novel" trees (and resulting loss of canopy) if climate does not track projections
- unintended negative interactions between novel genotypes/species and native species (competitive imbalances, disease introduction)

However, there are ways to mitigate some of the risks inherent in adaptation strategies:
- A bet-hedging, diversity-based approach can reduce the chances of future forest loss (either from die-off of current native genotypes or of new introduced genotypes). This approach would entail inter-planting small proportions of new genotypes with currently accepted plants to provide adaptive diversity and resilience against a range of potential climate conditions (Williams and Dumroese 2013).
- Risks of ecological mis-match, invasiveness, or transplant failure are limited by the constrained suite of species/genotypes being considered by staff. Most options being considered are native to the region and/or common as plantings within regional open spaces (even the most extreme example of assisted migration above, redwood, has been successfully planted on Mercer Island and widely throughout the Seattle area without known negative ecological consequences. It also has a history as a native species in the distant past).
- Careful and conservative selection of seed lots can further mitigate risk: a number of tools, based on climate models, are now available to select future-climate-adapted seed provenances of native species. Appendix E contains updated seed provenance zones for Washington State.
- Careful monitoring of mortality and success of native and novel genotypes/species will allow for rapid re-assessment of novel genotypes that may not be right for outplanting on Mercer Island and will facilitate re-direction to different options.
- Parks staff have begun the process of considering specific provenances of native trees to add to the genetic diversity and resilience of our forest. Staff have also begun systematic consideration of potential climate-resilient "neonatives" that could be used in the limited contexts or under the "trigger" scenarios described in Table 3.

## 5.6 Coordinate ravine restoration and watercourse stabilization

One of the issues that came out of the climate change research and the public meetings was the coordination of watercourse stabilization and restoration. Watercourses are priority landscapes for restoration because of their expected resiliency to climate change.

Certain ravine properties with watercourses are managed jointly with Maintenance Department. Coordination of stabilization work with open space restoration has been successful in Gallagher Hill and Upper Luther Burbank Park. However, channel conditions in two other ravine systems are not as degraded - SE 53rd Open Space and Hollerbach Park – and may not qualify these ravines for stabilization projects in the near future. Nevertheless, assessing and correcting drainage in stream channels and the associated steep slopes would contribute to the long term health of the ravine ecosystem. Ravines are a priority landscape in the plan update. Work such as correcting residential drainage, piping street outfalls to the watercourse, and installing bioengineering in watercourses may be warranted. A work item for the Open Space program will be to conduct this assessment in 2015 and 2016 and work with the Maintenance Department on a recommended approach for the resulting issues.

## 5.7 Public policy and decision making for adaptive management

The scientific knowledge base related to climate change and forest management is still relatively limited. Over the next twenty years there will be more research that can inform the decisions we will need to make. City staff expect to revise and refine the strategy regularly as new information becomes available. The nature of the decisions also requires subjective judgment and interpretation of community values. Generally, public policy is set through legislative action of the Mercer Island City Council, in conjunction with the City Manager and the respective departments. The Mercer Island City Council also has boards and commissions that apply public policy and make administrative decisions as well as policy recommendations to City Council.

In the case of certain open space, the City Council has commissioned the Open Space Conservancy Trust with the ownership of Pioneer Park and Engstrom Open Space. This board is a valuable resource because the members gain expertise in the topic of forest management during their four year terms. However, it is not the intent of Council to expand their charter to other open space properties.

Nevertheless, it is consistent with the Open Space Plan to use recommendations and decisions from the Open Space Conservancy Trust to inform standards of care for other open space in the City. The Trust properties receive the highest level of service according to the plan. It follows that lower levels of service could then be defined for other properties by the Director of Parks and Recreation.

## 5.8 Public involvement and education

Public involvement and education continues to be an important goal. Volunteer participation in restoration events both augments the amount of restoration work that can be done each year, and, more importantly, helps citizens to develop a better understanding of and investment in their parks system. The parks department will continue to contract with volunteer management organizations which have the expertise and organizational infrastructure to bring in a diverse group of volunteers on a weekly basis.

The natural resources staff will continue to develop other programs, events, and projects that improve outreach while fostering stewardship. These include projects such as Boy

Scout community projects (often related to trail or parks infrastructure construction) and student restoration projects (such as the restoration collaboration between elementary school students and the Washington Native Plant Stewards). Staff will continue to take advantage of the opportunities presented by festivals and gatherings to reach out and educate the community about the natural resources programs (as exemplified by information provided at Mercer Island Summer Celebration!).

Finally, a new initiative in this plan is to undertake a targeted outreach and education campaign related to the effect of invasive trees and shrubs in private landscaping. There has been some public education around ivy as an undesirable plant for private landscaping, but cherry laurel and holly are less familiar to the public as invasive species. The purpose of the proposed campaign is to increase public understanding of the link between seed sources (mature fruiting plants) on private lands and the continued invasion in public parks, with the ultimate goal of convincing landowners to replace these invasive plants with native or less aggressive introduced species. Planning for this educational campaign is still in early stages, and a more detailed plan will be developed over the course of the coming biennium.

## 5.9 Summary of recommendations

- Prioritization of open space areas (Section 5.1)
    - Broad prioritization of open spaces remains the same, but wet areas in several parks, areas with large or old-growth trees, and north-facing ravine areas will be evaluated for higher levels of service.
    - Areas throughout the open space system will be scoped for inclusion in trials of new seed provenances, watering, and holly treatment.
- Continue planting and invasive species maintenance activities to provide conifer regeneration in most remaining areas of the parks system and to free native vegetation from competition (Section 5.2).
- Improve restoration techniques (Section 5.3)
    - Incorporate summer watering into first year's planting protocol.
    - Allow for longer invasive species removal maintenance cycles (4-5 years where necessary) and periodic renovation of treated areas.
    - Explore alternatives for holly treatment: collaborate with other regional managers to share knowledge, increase use of effective EZ-ject treatment with Imazapyr, and more consistently monitor treatment effectiveness.
- Transition sites to more stable condition (Section 5.4)
    - Explore and assess relative efficacy of maintenance options for restored areas (options to compare include: longer removal maintenance, mulching, invasive knockdown, and "search and destroy" sweeps)
- Develop an open space climate adaptation strategy (Section 5.5)
    - Improve the basis for adaptive management. Begin placing more emphasis on monitoring project outcomes and learning from treatment comparisons.

    - Use several guiding climate change principles (such as adaptive management, biotic diversity, landscape diversity, and risk assessment) to help guide and prioritize restoration work over the next 10 years.
    - Systematically monitor for and address hydrological stress or disturbances (drought or erosion) in the parks system.
    - Incorporate a greater diversity of seed provenances of native trees into planting stock, particularly warm/dry area provenances. Monitor survival of different provenances in experimental areas.
    - As necessary, consider other climate change adaptation actions and plant materials in Tables 2 and 3 in order to improve land management outcomes and increase resilience.
- Coordinate ravine restoration and watercourse stabilization (Section 5.6)
- Public policy and decision making for adaptive management (Section 5.7)
    - Oversight and expertise from the Open Space Conservancy Trust board will continue to guide actions and policy for Pioneer Park and Engstrom Open Space, but will also help to inform decisions made by the Director of Parks and Recreation pertaining to other open spaces.
- Public involvement and education (Section 5.8)
    - Continue to cultivate a rich public involvement and education component within the open space program to allow the community to fully appreciate and share in the upkeep of their park system.
    - Launch public education campaign to reduce landscape use of invasive shrubs.

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# Appendix A: Summary Table of Open Space Characteristics and Vegetation

| | | Large Parks (>7 acres) | | | | | | | | Small Parks | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Park** | **Pioneer Park/ Engstrom** | **Island Crest Park** | **SE 53rd OS** | **Mercerdale Park** | **Luther Burbank Park** | **Upper Luther Burbank** | **Gallagher Hill** | **Clarke Beach Park** | **Hollerbach OS** | **North Mercerdale Hillside** |
| **Acres** | **Acres (park)** | 127.4 | 38.9 | 26.2 | 30.8 | 54.5 | 18.1 | 11.3 | 9.1 | 5.2 | 6.2 |
| | **Acres (Open Space)*** | 127.4 | 31.2 | 26.2 | 25.1 | 27.2 | 18.1 | 11.3 | 7.7 | 5.2 | 6.2 |
| | **Acres (Sampled space)** | 121.3 | 30.4 | 26.2 | 24.7 | 20.1 | 18.1 | 11.3 | 7.0 | 5.2 | 6.2 |
| **Plots** | **Number, herb plots** | 196 | 46 | 37 | 31 | 29 | 28 | 15 | 11 | 10 | 9 |
| | **Number, tree plots** | 61 | 13 | 12 | 12 | 10 | 9 | 6 | 4 | 2 | 3 |
| **Canopy** | **TPA Native** | 85 | 75 | 72 | 78 | 90 | 76 | 79 | 78 | 78 | 105 |
| | **TPA exotic** | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 |
| | **Conifer:Deciduous** | 1.2 | 0.7 | 0.4 | 0.2 | 0.2 | 0.5 | 0.4 | 0.6 | 1.9 | 0.0 |
| | **Percent of trees with ivy** | 42 | 33 | 48 | 45 | 50 | 57 | 70 | 39 | 70 | 42 |
| | **Percent with ivy >15'** | 9 | 4 | 15 | 5 | 24 | 13 | 6 | 0 | 9 | 3 |
| **Regeneration** | **Regenerating conifers/acre** | 69 | 60 | 50 | 112 | 61 | 100 | 130 | 144 | 51 | 138 |
| | **Regenerating Exotic trees/acre** | 797 | 758 | 571 | 432 | 2041 | 1397 | 1487 | 443 | 796 | 78 |
| **Understory** | **Total exotic cover** | 24 | 20 | 37 | 31 | 46 | 34 | 72 | 59 | 61 | 42 |
| | **Percent cover ivy** | 15 | 9 | 24 | 8 | 8 | 11 | 57 | 23 | 50 | 27 |
| | **Percent blackberry** | 4 | 7 | 10 | 10 | 17 | 12 | 5 | 16 | 7 | 8 |
| | **Other primary invaders** | holly, wall lettuce | holly, wall lettuce | laurel, bindweed | creeping buttercup, wall | reed canary-grass, | cherry laurel, nightshade | bindweed, creeping buttercup | bindweed, nipplewor t | laurel, holly | bindweed |
| | **Site native diversity** | 66 | 56 | 48 | 35 | 50 | 37 | 33 | 22 | 37 | 26 |
| | **Mean plot native diversity** | 11 | 10 | 8 | 8 | 5 | 9 | 7 | 5 | 9 | 6 |

| | | Small Parks (Cont'd) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Park | Parkwood Ridge | Ellis Pond | Homestead Park | SE 47th OS | Clise Park | Groveland Park | Wildwood Park | Secret Park | All Parks |
| Acres | Acres (park) | 3.8 | 4.0 | 11.1 | 1.5 | 1.7 | 3.1 | 3.0 | 0.9 | 327.5 |
| | Acres (Open Space) | 3.8 | 4.0 | 3.7 | 1.5 | 1.7 | 2.6 | 1.9 | 0.9 | 305.6 |
| | Acres (Sampled space) | 3.8 | 4.0 | 3.5 | 1.4 | 1.6 | 1.6 | 1.7 | 0.7 | 270.3 |
| Plots | Number, herb plots | 5 | 4 | 4 | 3 | 2 | 2 | 2 | 1 | 412 |
| | Number, tree plots | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 132 |
| Canopy | TPA Native | 67 | 157 | 137 | 162 | 81 | 192 | 162 | NA | 85 |
| | TPA exotic | 0 | 0 | 5 | 0 | 0 | 0 | 0 | NA | 1 |
| | Ratio Conifer:Deciduous | 1.5 | 0.3 | 0.1 | 0.1 | 0.6 | 2.2 | 0.2 | NA | 0.6 |
| | Percent of trees with ivy | 20 | 3 | 67 | 100 | 13 | 58 | 56 | NA | 45 |
| | Percent with ivy>15' | 0 | 0 | 0 | 94 | 0 | 0 | 19 | NA | 10 |
| Regeneration | Regenerating conifers/acre | 94 | 96 | 0 | 0 | 81 | 162 | 40 | NA | 80 |
| | Regenerating Exotic trees/acre | 57 | 824 | 1775 | 283 | 647 | 101 | 5745 | NA | 937 |
| Understory | Total exotic cover | 2 | 3 | 121 | 96 | 2 | 7 | 46 | 85 | 32 |
| | Percent cover ivy | 0 | 0 | 84 | 94 | 0 | 2 | 14 | 15 | 17 |
| | Percent blackberry | 0 | 0 | 24 | 1 | 0 | 3 | 7 | 55 | 7 |
| | Other primary invaders | wall lettuce | wall lettuce | bindweed | holly | holly | bindweed | creeping buttercup | holly | creeping buttercup |
| | Site native diversity | 30 | 28 | 10 | 10 | 7 | 12 | 10 | 6 | 106 |
| | Mean plot native diversity | 12 | 10 | 5 | 5 | 6 | 7 | 5 | 6 | 9 |

# Appendix B: Descriptive Summary of Open Space Condition

## Large Parks:

**Clarke Beach Park:**

**Resources description:** This park has severely disturbed soils and a history of invasive species establishment, but also shows substantial restoration progress. Overall, restoration work has reduced invasive cover, but also left total vegetation cover low. On the other hand, restoration plantings have produced some of the highest conifer densities among our parks. Some areas of native shoreline vegetation provide important aquatic/lakeside habitat.

**Exotic vegetation:** Exotic species cover is still fairly high in this park, but restoration work has reduced their cover and, in particular, achieved low levels of ivy on trees. Bindweed and creeping buttercup are more important weeds in this park than elsewhere. Extensive clusters of holly and cherry laurel continue to be treated. The unusual non-native sedge *Carex sylvatica* is found along trails here.

**Gallagher Open Space:**

**Resources description:** This park has ecological functions in protecting the water quality and modifying runoff from the stream that runs through the central ravine, and it provides an important visual, sound, and air quality buffer between the freeway and residential areas. Additionally, restoration plantings and weed removal have allowed for higher than average levels of native conifer and hardwood regeneration.

**Exotic vegetation:** This park is arguably the most heavily invaded park in the system. The southern “limb” has disturbed soils and is densely invaded by ivy, holly, and cherry laurel. Bindweed, Robert’s geranium, and creeping buttercup all encroach from the roadside. *Daphne laureola*, *Cotoneaster bullatus*, sweet cherry, and foxglove are also present. A vigorous stand of spreading *Sasa*-type bamboo is of particular concern in the central part of this southern strip. Soil and vegetation are much less disturbed in the northern part of the park, and restoration efforts are clearly visible. The north area, particularly the ravine, is densely ivy-affected. Cherry laurel and holly are scattered, and some have not yet been treated. The planted area at the northwestern tip is affected by bindweed.

**Island Crest Park**

**Resources description:** Like Pioneer Park, this park represents exceptional ecological value due to its large size, more mature forest, and relatively undisturbed soils. In addition, it has lower levels of ivy on trees and overall invasive cover than other large parks and somewhat higher proportion of conifers than other large parks (other than Pioneer Park). Finally, the mosaic of wet areas in the southwest corner represents an important biological and hydrological resource.

**Exotic vegetation:** This park has lower levels of invasion than many in the system (it included some of the few plots island-wide with no exotic species), but there are areas with substantial presence of invasives. Ivy cover is substantial in patches in the northwest corner and along north edge of the park. Along the park's west edge blackberry is occasionally dense in canopy gaps and holly is patchily dense. Very high levels of holly regeneration were found near treated (but living) thickets in south-central area. Cherry laurel is abundant in northeastern corner. The wetlands in the southwestern area are moderately invaded by less common exotics, including bull thistle, deadly nightshade, and hairy cat's ear.

**Luther Burbank**

**Resources description:** This park is considered one of the gems of the Mercer Island Park system, and has many cultural and ecological resources including extensive shoreline habitat (much of which features restored native vegetation), open and scrub-shrub wetlands, and many well-loved recreational park areas. The wetlands provide habitat for plants with restricted habitat needs (cattail, bulrush, soft rush, slough sedge, mild waterpepper (*Polygonum hydropiperoides*), and marsh seedbox (*Ludwigia palustris*)). These areas provide critical habitat for birds, and the north point of the island also provides eagle habitat.

**Exotic vegetation:** Luther Burbank is one of the most invaded Mercer Island parks, with the highest densities of exotic trees and highest levels of exotic tree regeneration. Most of the upland forest is heavily invaded by one-seed hawthorn (*Crataegus monogyna*), and holly and cherry laurel are abundant. Both wetland areas are invaded by reed canarygrass, and the southern wetland is additionally invaded by nightshade, yellow flag iris, and blackberry (around the perimeter). Cotoneaster species and wayfaring tree (*Viburnum lantana*) are commonly found in the upland areas especially east of the south meadow, and Scotch broom is occasional.

**Mercerdale Park and Hillside**

**Resources description:** This long park includes modest wetland areas in the northern and southern portions which support less common forest types (cottonwood and Oregon ash). Soils and vegetation are more disturbed than Pioneer Park or Island Crest, but still support substantial healthy native vegetation and at least one less-common woodland species: wild ginger (*Asarum caudatum*). The hardwood-dominated forest has relatively low levels of ivy invasion.

**Exotic vegetation:** Although overall levels of cover by invasive species are only moderate in this park, a wide variety of exotic species are present. Dense stands of holly and cherry laurel have been treated but, in many cases, persist along the southern and western edges. Blackberry and bindweed have been repeatedly controlled in the southern quarter, and unusual exotic species such as firethorn (*Pyracantha*), velvetgrass (*Holcus lanatus*) and large periwinkle (*Vinca major*) are occasional. Importantly, both *Clematis vitalba* (in three places along the southern half of the trail) and *Impatiens capensis* (in drainage above 34$^{th}$ St.) were observed here.

**Pioneer Park**

**Resources description:** Pioneer Park comprises the largest and least-disturbed forest areas on Mercer Island. Soils are relatively healthy, and the forest is likely more similar to pre-settlement forests than other open spaces. Conifers are dominant over deciduous trees, unlike other parks. More plant species are found here than in other smaller parks, and with the inclusion of Engstrom Open Space, this park provides important topographic, soil moisture, and habitat diversity.

**Exotic vegetation:** Compared with the rest of the open spaces on island, Pioneer Park has relatively low levels of invasion. Ivy is the most important invader, and levels are slightly higher than in most of the other large parks. Blackberry is the next most important, but due to a more mature canopy cover, its cover is lower than in most other parks. Large sweet cherry, cherry laurel, and holly are still found in the park, despite some success in controlling these species. Invasive species are found in all quadrants, but cover of exotic species (herbs, shrubs, and regenerating trees) in the southeast quadrant is approximately twice that in the northern quadrants.

**Southeast 53rd Open Space**

**Resources description:** This park contains large wetland areas with some less-common species and habitat types (wild ginger, columbine, deer fern, devil's club). Massive cedar snags, logs, and stumps likely are mementos of pre-settlement forests and enhance habitat and aesthetic value of the park.

**Exotic vegetation:** Ivy is substantial in the portion of this park north of 53rd St. NE, with notable regrowth of treated holly stands and a significant garden encroachment. The western portion of the main park has remnant patches of ivy (many controlled this season) and relatively abundant re-sprouting cherry laurel. Impatiens and knotweed were observed along stream in west-central portion. In the eastern portion of the site ivy is patchy on trees where it has grown back from ivy-rings, and, along the road way slopes, blackberry is dense. Where this blackberry has been knocked back, the slopes are more susceptible to erosion and would be good candidates for native plantings to stabilize and compete with blackberry.

**Upper Luther Burbank:**

**Resources description:** The streams that dissect this park and the associated small riparian wetland areas are important resource features. The park serves to buffer these resources and improve water quality, modulate their hydrology, and provide critical riparian plant and animal habitat. Erosion along the southern ravine should be noted as a threat to water quality and habitat. The moist air and soil environments support luxurious moss and licorice fern growth on trees as well as a number of less common species, including scouring rush (*Equisetum hyemale*), Henderson's sedge (*Carex hendersonii*), woodrush (*Luzula parviflora*), maidenhair fern (*Adiantum pedatum*), and American speedwell (*Veronica americana*).

**Exotic vegetation:** Invasion is moderate at this site overall. The north-west ravine has substantial ivy and holly invasion, including some untreated and robust holly trees. The northern strip along the freeway and southeastern and southwestern corners have substantial blackberry presence. Holly is densely seeded in many areas, and thickets of holly and cherry laurel are scattered throughout. Exotics of note are reed canarygrass in the eastern stream bed and Indian strawberry (*Duchesnea indica*) in the south-central ravine area. The latter is an unusual introduced species, but it is unknown whether it poses an invasive threat.

## Small Parks:

### Clise Park

**Resources description**: This small park has little in the way of special resource elements, but is dominated by native vegetation, particularly Indian plum.

**Exotic vegetation:** is invaded by ivy only at a low level, with most tree trunks free of it. A number of invasive trees and shrubs, including sweet cherry, *Daphne laureola* and cherry laurel, are moderately common.

### Ellis Pond

**Resources description:** This park contains the only year-round pond on the island as well as habitat types and plant communities that are unique on Mercer Island. Unique or unusual vegetation types include Pacific crabapple (*Malus fusca*) bottomland to the east of Ellis Pond and *Spiraea*/Dogwood (*Cornus nuttallii*) thickets to the north. Additionally, a number of other species that are not commonly found in other areas on Mercer Island exist there including: cow parsnip (*Heracleum maximum*), American brooklime (*Veronica americana*) and devil beggarticks (*Bidens frondosa*, of uncertain nativity in WA).

**Exotic vegetation:** Relative to other park areas, it is not extensively invaded by exotic vegetation. Exotic species concerns include creeping buttercup (*Ranunculus repens*), English holly (especially in the northern wetlands, where is appears to be seeding in prolifically), and cherry laurel.

### Groveland Beach Park:

**Resources description:** This open space has a heavy cover of mature conifer trees in the northern area and includes beach.

**Exotic vegetation:** Ivy is well controlled in the eastern (upslope) portion, but more problematic on slopes and below. Himalayan blackberry is advancing in the south east corner and the central portion of the park has blackberry, creeping buttercup, and bindweed. Daphne laureola and cherry laurel are common in northern slope area.

### Hollerbach Open Space

**Resources description** contains wetland species, such as deer fern (*Blechnum spicant*), coltsfoot (*Petasites frigidus*), maidenhair fern (*Adiantum pedatum*), and *Equisetum hyemale*, that are uncommon in other areas of the island. The difficulty of access, rugged and wet terrain, large size of some of the trees, and extensive large woody debris all make this small park relatively "wild" despite its small size, which may contribute to its habitat (and aesthetic) value. The wetland areas contribute to wildlife and bird habitat and provide ecological services of erosion control and aquifer recharge. The moist microclimate, paired with the high level of coarse woody debris, makes this park one of the few areas on the island of successful natural conifer regeneration (mostly hemlock). Some erosion is notable on the steep and moist slopes.

**Exotic vegetation:** Hollerbach is heavily invaded by ivy, blackberry, cherry laurel, Portuguese laurel, and holly. Ivy on tree trunks is moderate, with few trees invaded into the canopy. The extensive fallen wood indicates that forest health may be compromised by root rot diseases, and the resulting gaps play a part in the invasion of sun-loving exotic species noted below.

**Homestead Park**

**Resources description:** Although small, this park still has potential importance due to its wetland's effects on aquifer recharge, water quality, and runoff. It is a visual and sound buffer between school, ballfield, transportation, and residential land uses.

**Invasive vegetation:** Homestead is heavily invaded by ivy, holly, cherry laurel, sweet cherry, and blackberry. Control attempts are making headway with these woody invaders. *Daphne laureola* is also present. Bindweed and creeping buttercup have substantially invaded wet areas on west side.

**North Mercerdale Park**

**Resources description:** The vegetation of this small park is not exceptional, but the park includes some wet areas and a small ponded area which have hydrological importance, and the park acts as a buffer between the town center area and the residential areas above.

**Exotic vegetation:** This park is relatively heavily invaded, with some areas dominated by ivy or blackberry. Sweet cherry (recently treated) is abundant in the south-end hillside. One of the few known occurrences of invasive clematis (*C. vitalba*) known on the island was observed in the northwest portion near the upper trail. Jewelweed (*Impatiens capensis*) was also controlled in the wet seep slope above the small pond.

**Parkwood Ridge Open Space:**

**Resources description:** This is a relatively healthy open space, with a diversity of plant species and habitats. The stream corridor is relatively healthy, and a number of less common plants were found here (waterleaf, soft rush, woodrush)

**Exotic vegetation:** Trailside weeds such as Robert's geranium and nipplewort are common and periwinkle (*Vinca minor*) is encroaching the upper portions from landscaping in neighboring parcels.

**Southeast 47th Open Space**

**Resources description:** Consisting of a narrow steeply-sloped strip of land buffering a small watercourse, this open space likely provides important functions of aquifer recharge, erosion control, and water quality improvement.

**Exotic vegetation:** This park is heavily invaded throughout by English ivy (with most tree stems in the lower portion invaded into the canopy). Additionally, the upper portions (where some ivy control appears to have been undertaken) are invaded extensively by Robert's geranium and bindweed. English holly and cherry laurel are common in the lower two thirds of the park, and have not been recently been controlled (some are fruiting).

**Wildwood Park:**

**Resources description**: This small park includes wet areas and is valued by adjacent landowners, who contribute to its restoration.

**Exotic vegetation:** Invasive species presence is high in this park, with holly, ivy, reed canarygrass all present.

# Appendix C: Cover and Frequency of Plant Species

**Appendix C, Table 1: Native herbs and graminoids captured in 25m2 plots**

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Achlys triphylla** | vanilla leaf | ACTR | 0.33 | 8.51 |
| **Adiantum aleuticum** | maidenhair fern | ADPE | 0.01 | 1.15 |
| **Alisma triviale** | northern water plantain | ALPL | 0.00 | 0.46 |
| **Asarum caudatum** | wild ginger | ASCA3 | 0.00 | 0.23 |
| **Athyrium filix-femina** | ladyfern | ATFI | 1.15 | 19.77 |
| **Bidens frondosa** | leafy beggar-ticks | BIFR | 0.00 | 0.23 |
| **Blechnum spicant** | deer fern | BLSP | 0.01 | 0.46 |
| **Bromus vulgaris** | Columbia brome | BRVU | 0.03 | 11.95 |
| **Carex hendersonii** | Henderson's sedge | CAHE | 0.01 | 0.23 |
| **Carex leptopoda** | taperfruit shortscale sedge | CALE24 | 0.08 | 13.79 |
| **Carex obnupta** | slough sedge | CAOB | 0.00 | 0.23 |
| **Chamerion angustifolium** | fireweed | EPAN | 0.00 | 0.46 |
| **Circaea alpina** | small enchanter's nightshade | CIAL | 0.08 | 11.72 |
| **Claytonia sibirica** | Siberian miner's lettuce | CLSI | 0.11 | 15.86 |
| **Dicentra formosa** | western bleedingheart | DIFO | 0.00 | 0.69 |
| **Dryopteris expansa** | wood fern | DREX | 1.34 | 33.79 |
| **Eleocharis palustris** | common spike rush | ELPA | 0.01 | 0.23 |
| **Epilobium ciliatum** | fringed willowherb | EPCI | 0.02 | 8.97 |
| **Equisetum arvense** | common horsetail | EQAR | 0.07 | 0.46 |
| **Equisetum hyemale** | scouringrush horsetail | EQHY | 0.08 | 0.46 |
| **Equisetum telmateia** | giant horsetail | EQTE | 1.15 | 13.56 |
| **Fragaria chiloensis** | beach strawberry | FRCH | 0.00 | 0.46 |
| **Fragaria vesca** | woodland strawberry | FRVE | 0.00 | 0.46 |
| **Fragaria virginiana** | wild strawberry | FRVI | 0.00 | 0.23 |
| **Galium aparine** | cleavers | GAAP | 0.26 | 28.28 |
| **Galium trifidum** | small bedstraw | GATR | 0.02 | 4.83 |
| **Geum macrophyllum** | bigleaved avens | GEMA | 0.15 | 14.02 |
| **Glyceria striata** | tall mannagrass | GLEL | 0.02 | 0.69 |
| **Hydrophyllum tenuipes** | Pacific waterleaf | HYTE | 0.00 | 0.23 |
| **Leersia oryzoides** | rice cutgrass | LEOR | 0.00 | 0.23 |
| **Lonicera ciliosa** | orange honeysuckle | LOCI | 0.06 | 4.60 |
| **Lonicera hispidula** | hairy honeysuckle | LOHI | 0.04 | 0.92 |
| **Ludwigia palustris** | marsh seedbox | LUPA | 0.02 | 0.23 |
| **Luzula parviflora** | smallflowered woodrush | LUPA4 | 0.00 | 1.15 |
| **Lysichiton americanus** | skunk cabbage | LYAM | 0.07 | 1.61 |
| **Mitella caulescens** | slightstemmed miterwort | MICA5 | 0.00 | 0.23 |
| **Nemophila parviflora** | smallflower nemophila | NEPA | 0.05 | 5.98 |
| **Oenanthe sarmentosa** | water parsley | OESA | 0.01 | 0.69 |
| **Osmorhiza berteroi** | sweet cicely | OSBE | 0.07 | 15.17 |
| **Polygonum hydropiperoides** | mild waterpepper | POHY | 0.04 | 0.69 |
| **Polypodium glycyrrhiza** | licorice fern | POGL | 0.03 | 7.36 |

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Polystichum munitum** | sword fern | POMU | 19.42 | 88.97 |
| **Prunella vulgaris** | common self heal | PRVU | 0.00 | 0.46 |
| **Pteridium aquilinum** | bracken fern | PTAQ | 2.57 | 34.71 |
| **Schoenoplectus tabernaemontani** | soft-stemmed bulrush | SCTA | 0.05 | 0.23 |
| **Scirpus microcarpus** | small-seeded bulrush | SCMI | 0.03 | 1.15 |
| **Stachys chamissonis var. cooleyae** | hedgenettle | STCO | 0.02 | 1.38 |
| **Stellaria crispa** | crisp sandwort | STCR | 0.07 | 12.18 |
| **Streptopus amplexifolius** | clasping twistedstalk | STAM | 0.00 | 0.23 |
| **Tellima grandiflora** | fringecup | TEGR | 0.11 | 6.44 |
| **Tiarella trifoliata** | foamflower | TITR | 0.05 | 3.45 |
| **Tolmiea menziesii** | piggy-back plant | TOME | 0.42 | 6.67 |
| **Trientalis borealis ssp. latifolia** | starflower | TRBO | 0.00 | 2.07 |
| **Trillium ovatum** | trillium | TROV | 0.16 | 21.61 |
| **Typha latifolia** | cattail | TYLA | 0.11 | 0.23 |
| **Urtica dioica** | stinging nettle | URDI | 3.42 | 46.67 |
| **Veronica americana** | American Speedwell | VEAM | 0.00 | 1.15 |
| **Vicia americana** | American vetch | VIAM | 0.01 | 3.22 |

## Appendix C, Table 2: Herbs and graminoids of uncertain nativity captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Juncus effusus** | soft rush | JUEF | 0.07 | 0.92 |
| **Juncus sp.** | rush | Juncus sp. | 0.00 | 0.23 |
| **Viola sp.** | violet | Viola sp. | 0.00 | 0.46 |

## Appendix C, Table 3: Non-native herbs and graminoids captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Agrostis capillaris** | creeping bentgrass | AGTE | 0.20 | 2.53 |
| **Agrostis stolonifera** | creeping bentgrass | AGST | 0.13 | 1.61 |
| **Bromus diandrus** | ripgut brome | BRRI | 0.00 | 0.23 |
| **Calystegia sepium** | hedge false bindweed | CASE1 | 0.77 | 6.90 |
| **Cardamine hirsuta** | hairy bittercress | CAHI | 0.10 | 16.32 |
| **Cirsium arvense** | Canada thistle | CIAR | 0.01 | 0.46 |
| **Cirsium vulgare** | bull thistle | CIVU | 0.00 | 0.23 |
| **Clematis vitalba** | wild clematis | CLVI | 0.04 | 0.23 |
| **Cyclamen sp.** | cyclamen | Cyclamen | 0.00 | 0.23 |
| **Digitalis purpurea** | foxglove | DIPU | 0.00 | 0.46 |
| **Duchesnea indica** | Indian strawberry | DUIN | 0.00 | 0.23 |
| **Elymus repens** | quackgrass | AGRE | 0.08 | 1.15 |
| **Geranium robertianum** | herb Robert | GERO | 2.05 | 64.83 |
| **Hedera helix** | English ivy | HEHE | 17.11 | 86.44 |
| **Holcus lanatus** | velvetgrass | HOLA | 0.00 | 0.46 |
| **Hypericum androsaemum** | sweet amber | HYAN8 | 0.00 | 0.46 |
| **Hypericum perforatum** | St. John's wort | HYPE | 0.00 | 0.23 |
| **Hypochaeris radicata** | hairy cat's-ear | HYRA | 0.00 | 0.23 |
| **Iris pseudacorus** | yellow flag iris | IRPS | 0.07 | 0.23 |
| **Lapsana communis** | nipplewort | LACO | 0.20 | 22.76 |
| **Lathyrus latifolius** | perennial pea | LALA | 0.00 | 0.46 |
| **Lotus corniculatus** | bird's-foot trefoil | LOCO | 0.00 | 0.69 |
| **Lunaria annua** | annual honesty | LUAN | 0.00 | 0.23 |
| **Mycelis muralis** | wall-lettuce | MYMU | 0.49 | 44.14 |
| **Phalaris arundinacea** | reed canarygrass | PHAR | 0.59 | 2.53 |
| **Plantago major** | broad-leaved plantain | PLMA | 0.01 | 1.61 |
| **Poa annua** | annual bluegrass | POAN1 | 0.04 | 0.69 |
| **Poa trivialis** | rough bluegrass | POTR2 | 0.01 | 2.07 |
| **Ranunculus repens** | creeping buttercup | RARE | 0.88 | 9.66 |
| **Rumex crispus** | curly dock | RUCR | 0.00 | 0.46 |
| **Rumex obtusifolius** | bitter dock | RUOB | 0.01 | 1.38 |
| **Solanum dulcamara** | deadly nightshade | SODU | 0.16 | 4.37 |
| **Sonchus oleraceus** | common sowthistle | SOOL | 0.00 | 0.23 |
| **Stellaria media** | chickweed | STME | 0.00 | 1.38 |
| **Tanacetum parthenium** | feverfew | TAPA6 | 0.00 | 0.23 |
| **Taraxacum officinale** | dandelion | TAOF | 0.01 | 5.06 |
| **Trifolium pratense** | red clover | TRPR | 0.00 | 0.46 |
| **Veronica serpyllifolia** | thymeleaf speedwell | VESE | 0.05 | 1.84 |
| **Vicia hirsuta** | hairy vetch | VIHI | 0.00 | 0.23 |
| **Vicia sativa** | garden vetch | VISA | 0.00 | 0.23 |
| **Vinca major** | bigleaf periwinkle | VIMA | 0.00 | 0.23 |
| **Vinca minor** | common periwinkle | VIMI2 | 0.00 | 1.38 |

## Appendix C, Table 4: Native shrubs and shrubby trees captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Acer circinatum** | vine maple | ACCI | 0.18 | 4.83 |
| **Amelanchier alnifolia** | serviceberry | AMAL | 0.00 | 0.46 |
| **Cornus sericea** | red-osier dogwood | COSE | 0.22 | 1.15 |
| **Corylus cornuta** | beaked hazelnut | COCO | 11.91 | 32.18 |
| **Crataegus douglasii** | Pacific hawthorn | CRDO | 0.00 | 0.92 |
| **Gaultheria shallon** | salal | GASH | 4.06 | 32.87 |
| **Holodiscus discolor** | oceanspray | HODI | 0.37 | 3.22 |
| **Lonicera involucrata** | twinberry | LOIN | 0.03 | 0.69 |
| **Mahonia aquifolium** | tall Oregon grape | MAAQ | 0.08 | 2.07 |
| **Mahonia nervosa** | low Oregon grape | MANE | 2.69 | 45.52 |
| **Malus fusca** | western crabapple | MAFU | 0.00 | 0.46 |
| **Oemleria cerasiformis** | Indian plum | OECE | 2.85 | 47.59 |
| **Oplopanax horridus** | devil's club | OPHO | 0.64 | 3.91 |
| **Philadelphus lewisii** | Lewis' mock-orange | PHLE | 0.00 | 0.46 |
| **Physocarpus capitatus** | Pacific ninebark | PHCA | 0.03 | 0.92 |
| **Rhododendron macrophyllum** | western rhododendron | RHMA | 0.00 | 0.46 |
| **Ribes lacustre** | swamp gooseberry | RILA | 0.02 | 1.15 |
| **Ribes sanguineum** | red-flowering currant | RISA | 0.00 | 0.46 |
| **Rosa gymnocarpa** | baldhip rose | ROGY | 0.13 | 2.30 |
| **Rosa nutkana** | Nootka rose | RONU | 0.01 | 0.23 |
| **Rosa pisocarpa** | clustered wildrose | ROPI | 0.16 | 1.38 |
| **Rubus leucodermis** | blackcap | RULE | 0.06 | 4.14 |
| **Rubus parviflorus** | thimbleberry | RUPA | 0.10 | 2.99 |
| **Rubus spectabilis** | salmonberry | RUSP | 6.14 | 30.57 |
| **Rubus ursinus** | creeping blackberry | RUUR | 3.96 | 64.14 |
| **Salix lucida ssp. lasiandra** | Pacific willow | SALU | 0.01 | 0.46 |
| **Salix scouleriana** | Scouler's willow | SASC | 0.01 | 0.69 |
| **Sambucus racemosa** | red elderberry | SARA | 5.55 | 53.10 |
| **Spiraea douglasii** | hardhack | SPDO | 0.04 | 0.92 |
| **Symphoricarpos albus** | snowberry | SYAL | 0.79 | 5.98 |
| **Vaccinium parvifolium** | red huckleberry | VAPA | 0.63 | 16.32 |

## Appendix C, Table 5: Non-native shrubs captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Aucuba japonica** | Japanese laurel | AUJA | 0.00 | 0.23 |
| **Cotoneaster bullatus** | hollyberry cotoneaster | COBU | 0.00 | 0.23 |
| **Cotoneaster simonsii** | Simons cotoneaster | COSI | 0.02 | 1.38 |
| **Daphne laureola** | spurge laurel | DALA | 0.00 | 1.15 |
| **Ligustrum vulgare** | European privet | LIVU | 0.02 | 0.23 |
| **Pyracantha sp.** | firethorn | Pyracantha sp. | 0.03 | 0.23 |
| **Rubus armeniacus** | Himalayan blackberry | RUDI | 7.29 | 54.02 |
| **Rubus laciniatus** | evergreen blackberry | RULA | 0.00 | 0.46 |
| **Sonchus asper** | spiny sowthistle | SOAS | 0.00 | 0.92 |
| **Umbellularia californica** | California laurel | UMCA | 0.00 | 0.23 |
| **Viburnum lantana** | wayfaringtree | VILA | 0.00 | 0.46 |
| **Viburnum opulus** | European cranberrybush | VIOP | 0.00 | 0.23 |

## Appendix C, Table 6: Native trees captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Abies grandis** | grand fir | ABGR | 0.01 | 0.46 |
| **Acer macrophyllum** | big-leaf maple | ACMA | 0.55 | 56.32 |
| **Alnus rubra** | red alder | ALRU | 0.01 | 1.15 |
| **Arbutus menziesii** | Pacific madrone | ARME | 0.01 | 0.69 |
| **Betula papyrifera** | paperbark birch | BEPA | 0.00 | 0.23 |
| **Cornus nuttallii** | Pacific dogwood | CONU | 0.00 | 0.46 |
| **Frangula purshiana** | cascara | RHPU | 0.07 | 11.95 |
| **Fraxinus latifolia** | Oregon ash | FRLA | 0.06 | 5.06 |
| **Picea sitchensis** | Sitka spruce | PISI | 0.02 | 1.38 |
| **Pinus contorta** | shore pine | PICO | 0.00 | 0.23 |
| **Pinus monticola** | western white pine | PIMO | 0.01 | 0.69 |
| **Pinus ponderosa** | ponderosa pine | PIPO | 0.00 | 0.23 |
| **Populus balsamifera ssp. trichocarpa** | black cottonwood | POTR | 0.00 | 0.92 |
| **Pseudotsuga menziesii** | Douglas fir | PSME | 0.01 | 1.84 |
| **Quercus garryana** | Garry oak | QUGA | 0.01 | 2.53 |
| **Thuja plicata** | western red cedar | THPL | 0.66 | 26.90 |
| **Tsuga heterophylla** | western hemlock | TSHE | 0.03 | 2.07 |

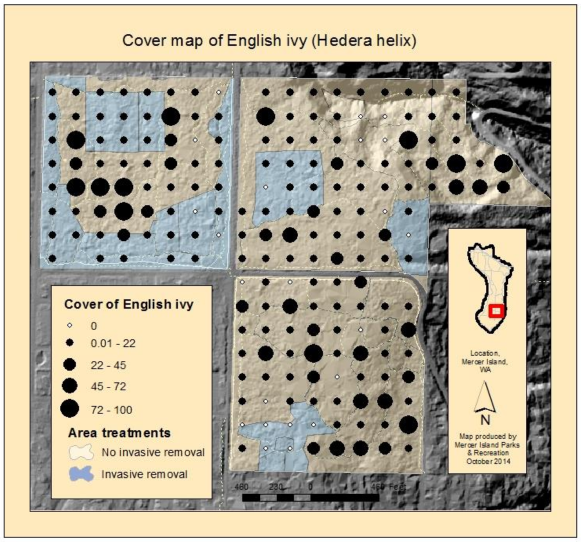
## Appendix C, Table 7: Non-native trees captured in 25m2 plots

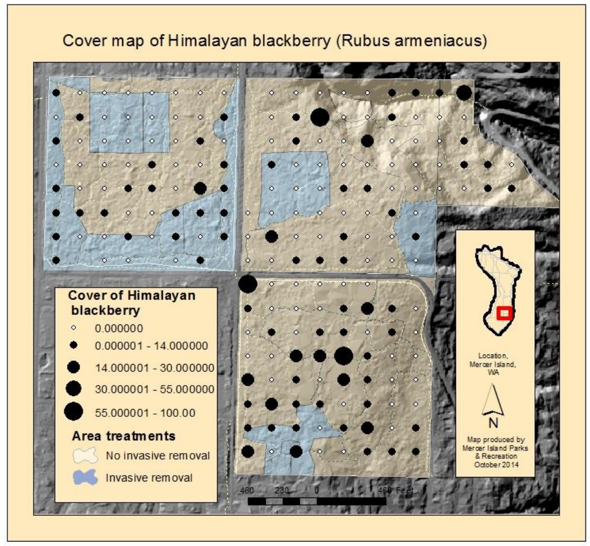
| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Acer palmatum** | Japanese maple | ACPA | 0.00 | 0.46 |
| **Acer saccharinum** | silver maple | ACSA | 0.01 | 0.23 |
| **Aesculus hippocastanum** | horse chestnut | AEHI | 0.00 | 0.46 |
| **Calocedrus decurrens** | incense cedar | CADE27 | 0.02 | 0.23 |
| **Crataegus monogyna** | one-seed hawthorn | CRMO | 0.04 | 3.68 |
| **Ilex aquifolium** | English holly | ILAQ | 0.69 | 45.52 |
| **Juglans nigra** | black walnut | JUNI | 0.01 | 0.46 |
| **Malus domestica** | domestic apple | MADO | 0.01 | 0.23 |
| **Prunus avium** | sweet cherry | PRAV | 0.03 | 4.14 |
| **Prunus cerasifera** | cherry plum | PRCE2 | 0.03 | 1.38 |
| **Prunus laurocerasus** | cherry laurel | PRLA | 0.46 | 14.94 |
| **Prunus lusitanica** | Portugal laurel | PRLU | 0.01 | 6.44 |
| **Quercus sp.** | oak | Quercus sp. | 0.00 | 1.15 |
| **Sequoia sempervirens** | coast redwood | SESE | 0.04 | 0.46 |
| **Sorbus aucuparia** | European mountain ash | SOAU | 0.10 | 7.82 |

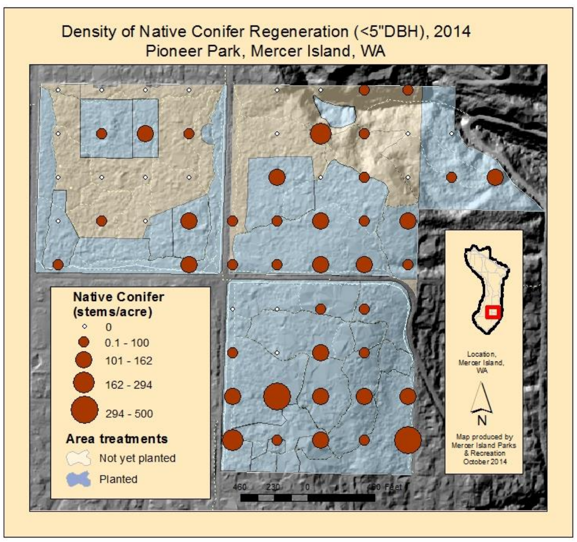
## Appendix C, Table 8: Unidentified species captured in 25m2 plots

| Scientific name | Common name | Abbreviation | Average Cover across all plots | Percent of plots where found |
|---|---|---|---|---|
| **Poaceae** | Unidentified grass | Poaceae | 0.03 | 4.60 |
| **Unidentified herb** | Unidentified herb | UnIdherb | 0.00 | 0.92 |
| **Unidentified seedling** | Unidentified seedling | UnIdseedli | 0.00 | 1.61 |

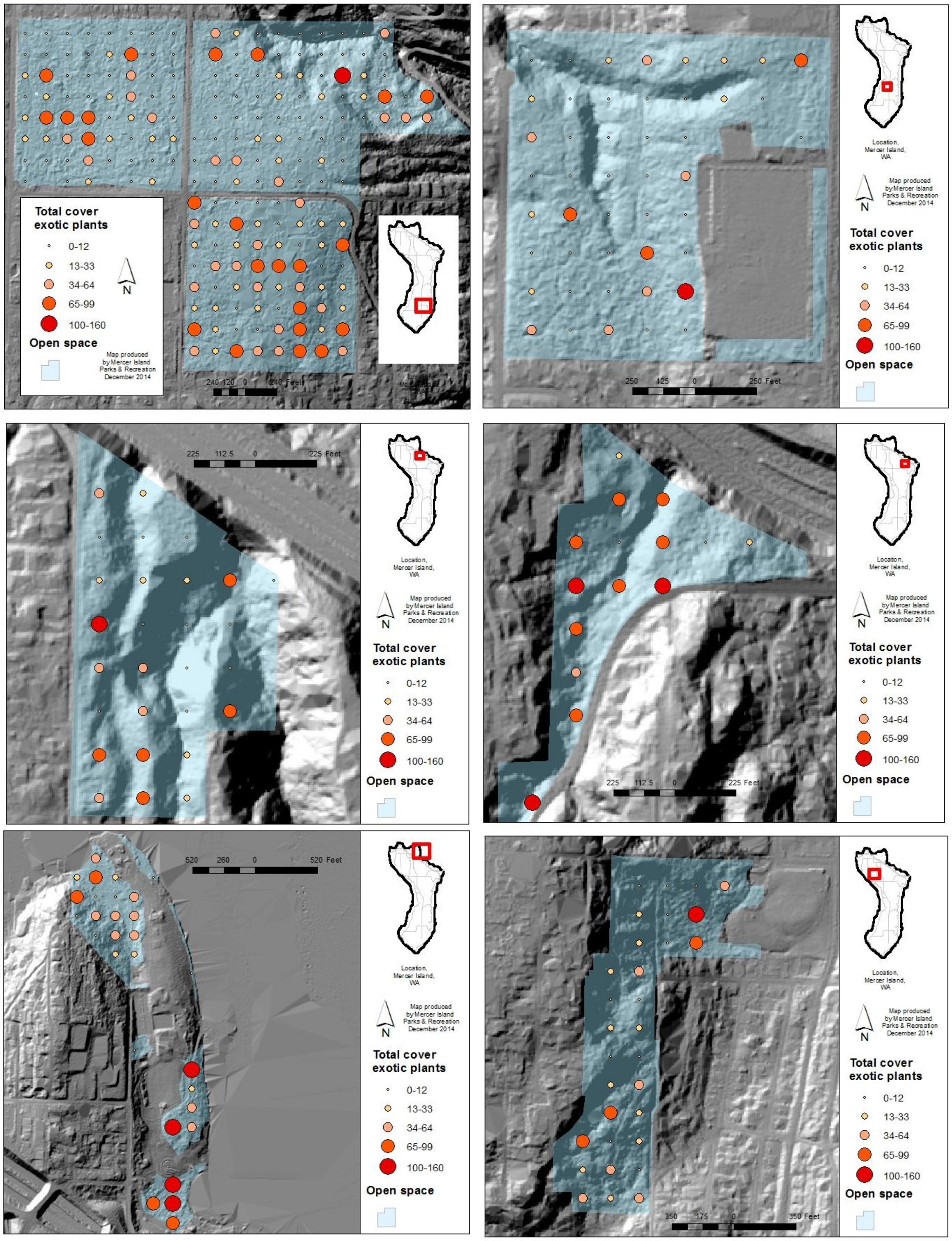
# Appendix D: Plant and Vegetation Maps

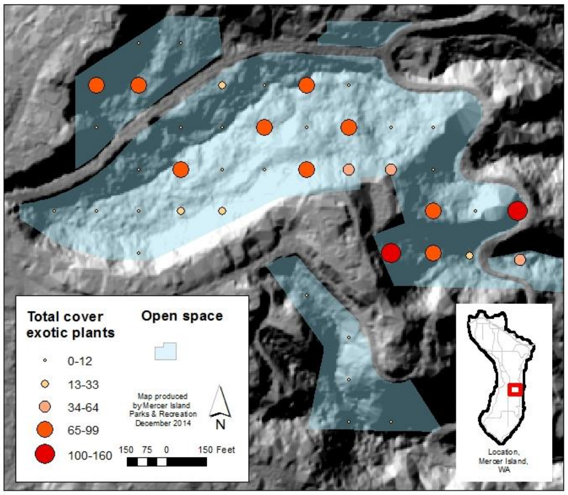


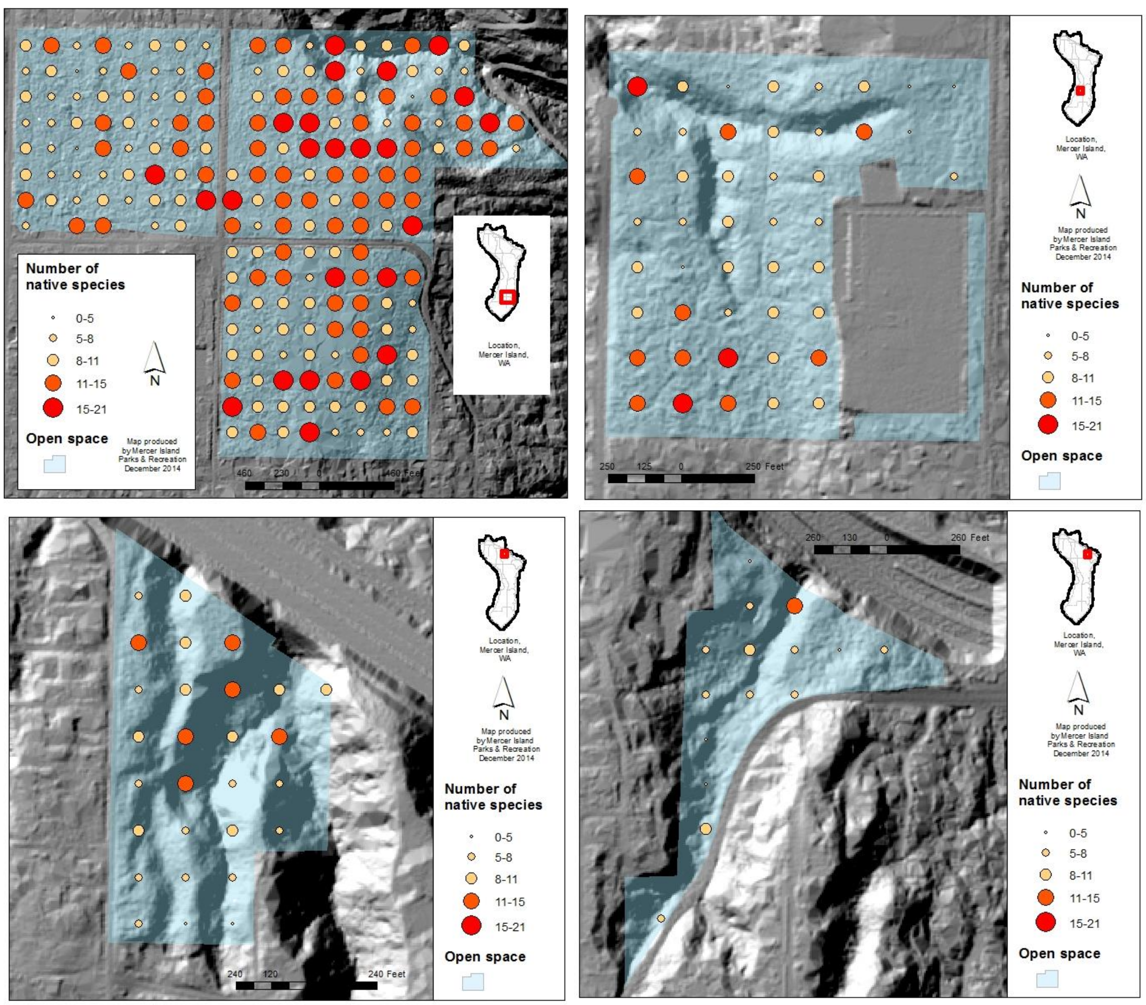



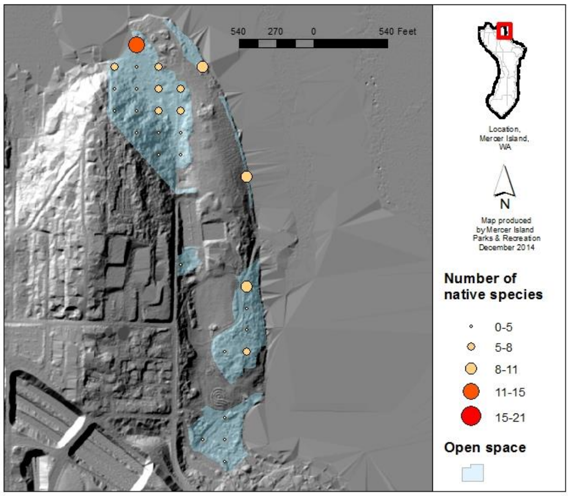
Total cover of exotic plants in major open spaces of Mercer Island, WA.

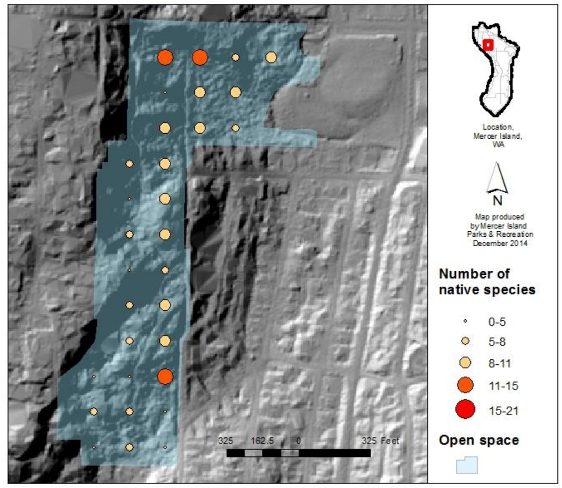


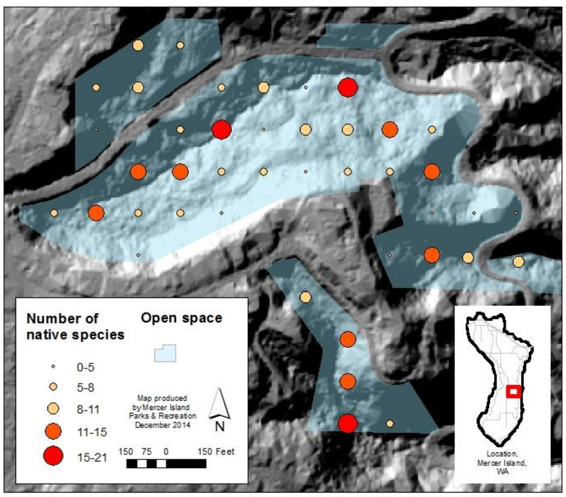


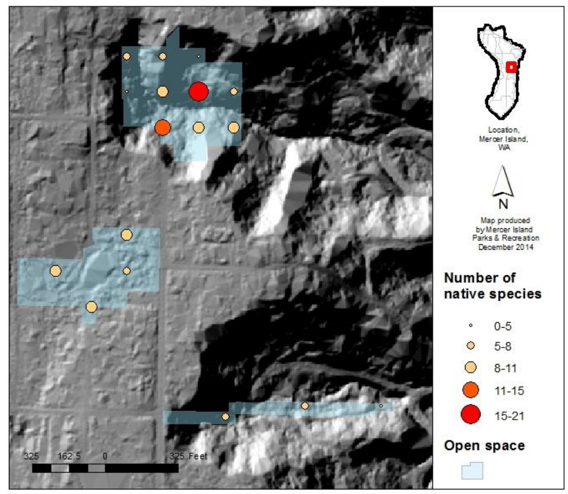

Native plant species richness in large open spaces of Mercer Island, WA.




540 270 0 540 Feet
Location, Mercer Island, WA
N
Map produced by Mercer Island Parks & Recreation December 2014
Number of native species
0-5
5-8
8-11
11-15
15-21
Open space

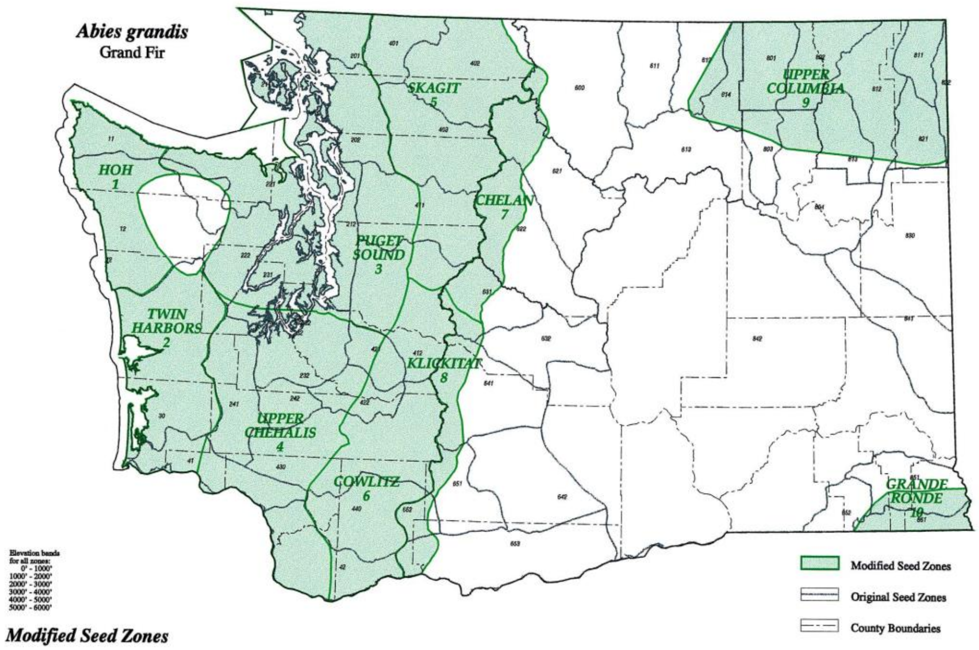

325 162.5 0 325 Feet
Location, Mercer Island, WA
N
Map produced by Mercer Island Parks & Recreation December 2014
Number of native species
0-5
5-8
8-11
11-15
15-21
Open space

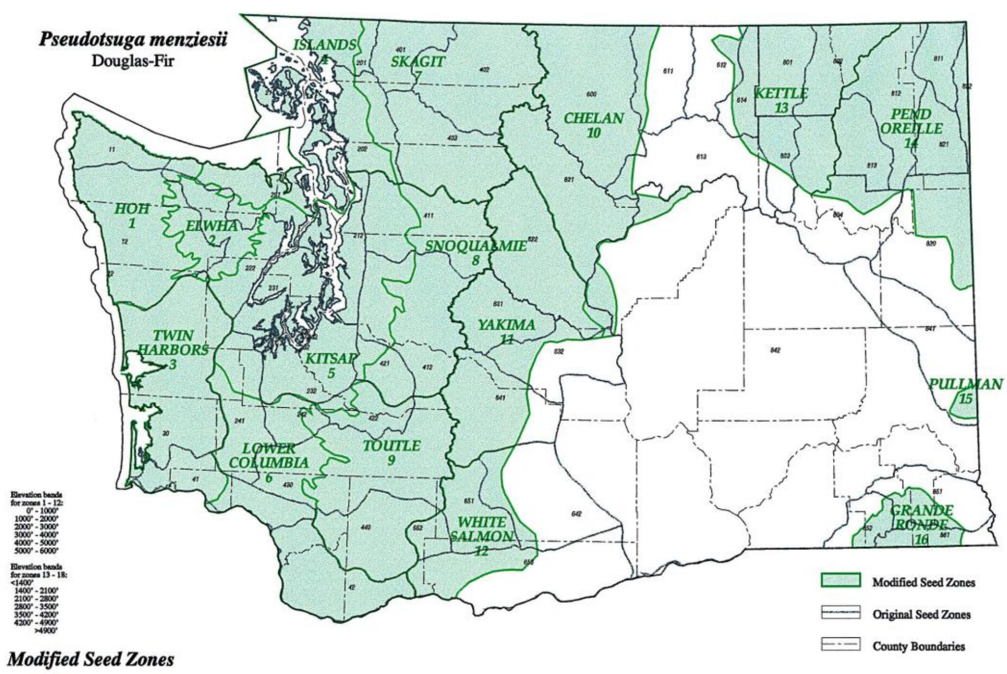

Number of native species
0-5
5-8
8-11
11-15
15-21
Open space
Map produced by Mercer Island Parks & Recreation December 2014
N
150 75 0 150 Feet
Location, Mercer Island, WA

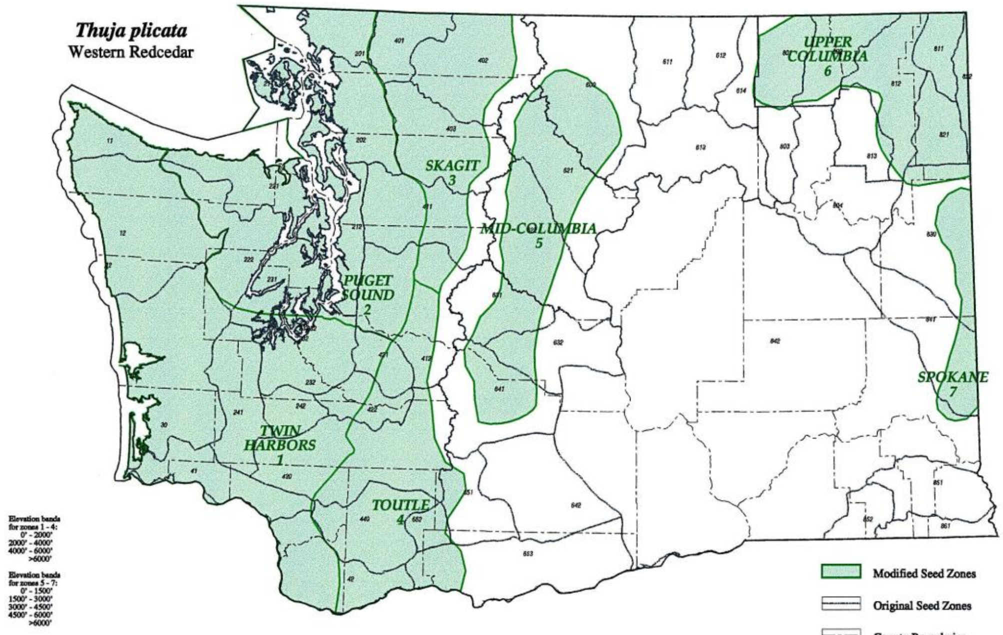

Location, Mercer Island, WA
N
Map produced by Mercer Island Parks & Recreation December 2014
Number of native species
0-5
5-8
8-11
11-15
15-21
Open space
325 162.5 0 325 Feet

# Appendix E: Selected Updated Washington State Seed Provenance Zones

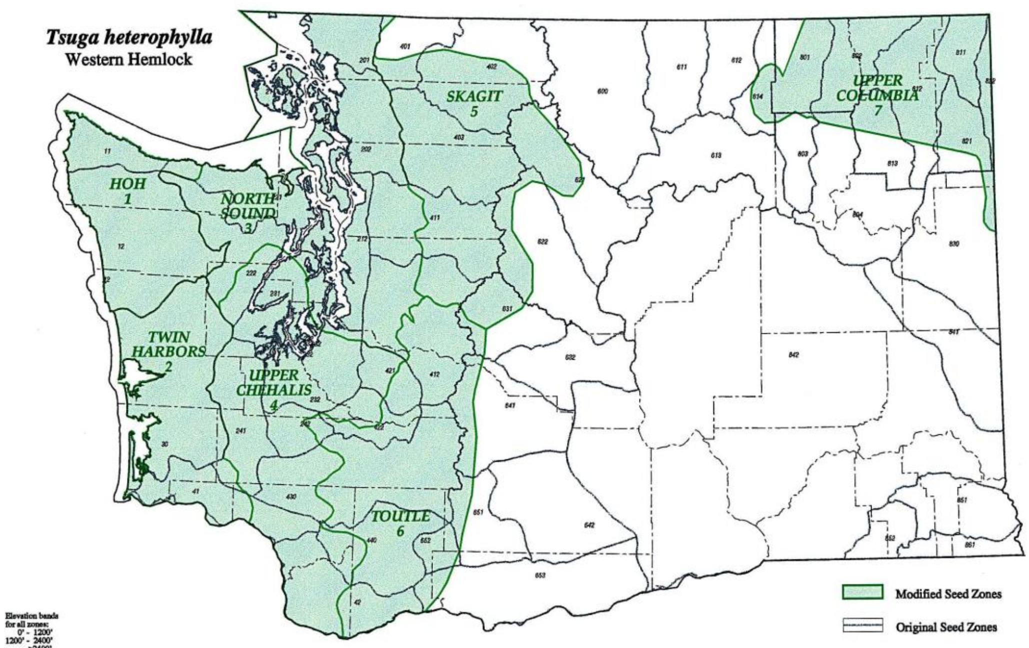
(Randall, W. K. and P. Berrang. 2002. Washington Tree Seed Transfer Zones. Washington State DNR.)






***Modified Seed Zones***




***Modified Seed Zones***

# Appendix F: Comments from Expert Advisors

## *Appendix F, Part 1: Summary of Verbal Comments from Dr. Jerry Franklin (Professor Emeritus, University of Washington)*

**Restoration plantings:**
Dr. Franklin encouraged use of a diverse palette of native species in restoration plantings, including hardwoods (which may be more resilient to climate change in certain ways, and which may allow higher levels of soil moisture).

He suggested that maple, cottonwood, and ash are good elements to encourage, while alder may have the negative effect of increasing soil N and providing more advantage to nitrogen-loving invasive species.

Dr. Franklin suggested that a relatively high proportion of western redcedar may be a good choice for climate resilience, as it seems quite tolerant of varying atmospheric moisture content as long as it can find soil moisture. It also will cast a deep shade that may help outcompete invasive understory species. Cedar will also tend to increase soil pH.

Hemlock may be more sensitive to decreasing atmospheric moisture (as summers become drier), so this species may become less well adapted to local climates. Dr. Franklin believes that Douglas-fir will continue to do well in the region.

Another species Dr. Franklin would include to increase diversity would be western white pine, which will be relatively drought tolerant and can be seen to be more shade tolerant than some think.

**Climate, provenances, and assisted migration:**
Regarding experimentation with various provenances of native species, Dr. Franklin is supportive of trying those from warmer, drier areas (especially to the south), although he notes that even local populations of native conifers are likely to have a high degree of genetic diversity (and adaptability) contained within them.

He is generally supportive of adaptive migration actions using native species, and has encouraged western Oregon groups to consider using California black oak in restoration. He concedes that there are not a large number of good candidates for this region, however. He offers chinkapin (*Castanopsis chrysophylla*) as one option, noting that it has arborescent forms in certain conditions and provides good wildlife habitat and forage.

Dr. Franklin notes that monitoring of soil moisture is one area that could be helpful in understanding climate effects, and his team is using a type of cosmic ray scattering detector to create soil moisture estimates integrated over 10+ acres.

He also points out that fire may become a more frequent disturbance in Western Washington, guessing that fire return intervals that were once 250-300 (to 400) years may become half that with climate change.

### *Appendix F, part 2: Written Comments from Clay Antieau (Scientist, Seattle Public Utilities)*

***Mr. Antieau provided these comments in response to an earlier summary of the updated Open Space Vegetation Management Plan. In some places [bracketed] notes have been inserted to clarify the part of the plan being discussed.***

Hi Paul, Matthew:

I appreciate the opportunity to comment on Mercer Island's Open Space Vegetation Plan 10-Year Evaluation (n.d.) and your queries concerning climate change and the future of Mercer Island's urban forest. Your implementation of the City's forest and vegetation management plans is commendable in being objective-driven, data-focused—and adaptive, as you now contemplate your 10-year track record in forest management. I had a few comments and suggestions, and appreciate your patience in awaiting my response. I prefer the written response because I can cite relevant literature, more carefully hone my speaking points, etc. I'd still be pleased to also discuss in person if desired.

Regards,
Clay
206-233-3711
January 23, 2015

## On the Report Itself

- Add date of publication/issuance.
- Include references.
- Number report sections and include page numbers for easier referencing and discussion.
- "Note that Activity 2…" I believe should be "Note that Activity 3…."
- Report mentions mortality; would be useful to briefly summarize or describe the numbers, if available
- I enjoyed that invasive trees occurred at "666 stems/ac"—a potential satanic reference!
- The report is silent or unclear on several forest management considerations that may be critical to understanding trends in forest health and in informing potential management actions: 1) prioritization; 2) soil compaction; 3) mechanisms of conifer regeneration; and 4) evergreenness as a restoration strategy.

## Prioritization

I'm a strong advocate for strategic restoration planning. Thus, in my review, the report was not clearly insofar as Mercer Island's strategic planning that prioritizes natural areas based on ecological health and natural resource functioning. Prioritization would be used to determine protection, enhancement, and restoration priorities for projects and management actions in a resource-limited world. In other words, don't spread yourself too thinly: prioritize. For example, I like the long-term focus, simplicity, and strategy of the Bradley Method of Ecological Restoration (Bradley, Joan. 1971. Bush Regeneration: The practical way to eliminate exotic plants from natural reserves. The Mosman Parklands and Ashton Park Association, Mosman (Sydney), New South Wales. 15 pp.): 1) Prevent degradation of good areas; 2) Improve the next best area; always work from good to bad; cautiously move into really bad areas (do not overclear!); 3) Hold the advantage gained; 4) Disturb soil as little as possible; restore it to its natural condition; 5) Allow the rate of regeneration to dictate the rate of clearing. While it may not be politically popular, a prioritization effort may result in some low quality natural areas being consciously dropped from restoration interventions, or subjected to less or different intervention.

## Soil Compaction

The report mentions soil compaction very briefly. Effects of soil compaction are rarely considered in ecosystem restoration, but the science demonstrates that even moderate compaction can have significant adverse effects on soil flora and plant growth. I'm impressed from my own stewardship experiences at Discovery Park in Seattle that people and dogs travel everywhere off-trail, which leads to ecologically important but unconsidered (from the management side) soil compaction over short period of time. Even stewardship activities (whether volunteers or paid contractors) can result in long-lasting, adverse legacies of soil compaction.

There's a body of scientific literature associated with forest management and mine reclamation that documents important effects of soil compaction on plant growth and soilfoodwebs. The upshot is that: 1) soil productivity and physical characteristics are crucial to an ecosystem's overall functioning; 2) once compacted, soils take a very long time (if ever) to return to "pre-compaction" physical, chemical, and biological conditions; and 3) excessively compacted soils typically require interventions in the form of physical ripping and incorporation of wood. Deborah S. Page-Dumroese (http://forest.moscowfsl.wsu.edu/people/smp/ddumroese.html) and Stephen Schoenholtz (http://water.vwrrc.vt.edu/) would be your main North American scientific experts on soil compaction. A small sampling of relevant literature would include:

M.P. Amaranthus, D. Page-Dumroese, A. Harvey, E. Cazares, and L.F. Bednar. 1996 (May). Soil compaction and organic matter affect conifer seedling nonmycorrhizal and ectomycorrhizal root tip abundance and diversity. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Research Paper PNW-RP-494.

Curran, M.P., R.L. Heninger, D.G. Maynar; and R.F. Powers. 2005. Harvesting effects on soils, tree growth, and longterm productivity. In: Productivity of Western Forests: A forest products focus. Tech. Editors: C. A. Harrington and S.H. Schoenholtz. Gen Tech Rep. GTR-PNW642. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. pp. 3-17.

Froehlich, H.A., D.W.R. Miles, and R.W. Robbins. 1985. Soil bulk density recovery on compacted skid trails in central Idaho. Soil Sci. Soc. Am. J. 49: 1015-1017.

J. L. Torbert and J. A. Burger. 1990. Tree survival and growth on graded and ungraded minesoil. Tree Planters Notes (Spring): 3-5.

Elseroad, A. C. 2001. Forest roads in northern Arizona: Recovery after closure and revegetation techniques. Master's thesis, Northern Arizona University, Flagstaff.

It may be useful to measure soil compaction in future monitoring and/or determine ways to prevent or discourage off-trail trespass.

## Conifer Regeneration in Pacific Northwest Moist Maritime Forests

In discussing conifer regeneration, it's critical to understand the mechanism(s) of natural regeneration.

The main point here is that more than 90% of natural regeneration of western hemlock, redcedar, and Sitka spruce occurs on down wood and stumps—not on mineral soil or duff (why this is the case is not altogether clear). Thus, if a forest stand suffers a legacy of reduced or no volumes of down wood, then there will be a concomitant lack of conifer recruitment. Other reasons could also explain a general absence of conifer regeneration, e.g, lack of mycorrhizal associates, lack of seed source, etc. See, for example:

Beach, E. W., C. B. Halpern. 2001. Controls on conifer regeneration in managed riparian forests: effects of seed source, substrate, and vegetation. Canadian Journal of Forest Research 31, 471-482.

Gray, A.N. and T. A. Spies. 1997. Microsite controls on tree seedling establishment in conifer forest canopy gaps. Ecology 78: 2458–2473.

Christy, J.E. and R.N. Mack. 1983. Variation in demography of juvenile Tsuga heterophylla across the substratum mosaic. Journal of Ecology 71: 75–93.

It may be useful in future monitoring efforts to document characteristics and volumes of down wood and standing dead wood in some of your green spaces to inform understandings of natural regeneration. There are a number of published methods for sampling such wood.

In conjunction with this down-wood/regeneration relationship, we know that gap creation is critical in recruiting those regenerating conifers (whether naturally regenerated or planted) into upper canopies. I've been in discussion with Seattle Parks on this topic of accelerating conifer regeneration in Seattle green spaces through underplanting, individual conifer release, and prescriptions for gap creation or general thinning-from-above. In particular, I feel strongly that thinning-from-above is a critical (but neglected or overlooked) aspect of urban forest restoration. There's been research in WA and OR related to underplanting alder stands; the general conclusion has been, at least, "underplanting is not successful without generous overhead canopy thinning." Green Seattle Partnerships' strategy on underplanting has been "Underplant without thinning and assume the underplanted conifers will grow as the alder/maple canopy decays." We now understand this is not a successful strategy due to the lack of light reaching the groundstory and the increasingly aggressive invasive understories in these forests. However, so far, killing trees to ensure native conifer recruitment has been a difficult (impossible?) challenge for Seattle Parks to implement—for the obvious socio-political reasons.

## Evergreenness as a Tool for Increasing Resilience and Resistance to Invasive Species

In the Moist Maritime Pacific Northwest, evergreenness is a known adaptive strategy for plants (both native and non-native) to compete successfully in our mild winter-wet, summer-dry climate. However, previous land uses and disturbance events have resulted in a loss of native evergreenness in forested ecosystems throughout the Northwest, particularly in urban areas. An effect of that loss of evergreenness is an increased susceptibility of these forested ecosystems to invasion of non-native, invasive, broadleaf evergreen species. While restoration efforts often attempt to restore native evergreenness to upper (tree) canopies, evergreenness in shrub and ground canopies is often overlooked. The report focuses on the establishment of conifer species, but does not describe attempts to restore evergreenness to shrub and groundstories, which may be as important, or more so, then establishing conifer tree canopies for purposes of building resistant and resilient forest ecosystems. The report mentions using "deciduous trees and shrubs…to fill in and diversify deficient understory and overstory." There should be a distinct emphasis on evergreen species in forest restoration, in my opinion.

**A few specific issues we are particularly interested in:**

1. *On Mercer Island we are considering several changes to restoration practice to deal with summer dry spells and to reduce invasive plant re-growth (for instance: summer watering of newly planted trees and longer cycles of weeding maintenance). Have you experimented with different degrees of planting and invasive removal maintenance in your urban restoration projects?*

I believe forest restoration practitioners (including myself!) have historically underestimated just how long-term forest restoration is; we're just now realizing this effort takes more than just a couple of years, considering the substantial effects of soil compaction, competition from invasive and native species, vandalism, depauperated soilfoodwebs, absence of soil organic matter (including wood in and on the soils), and numerous other adverse legacies of previous land use and human disturbance. I have volunteer steward sites now approaching 10 years old that continue to require intervention for invasive species and mountain beaver, for example. I have not experimented with different degrees of planting and invasive removal in my urban stewardship projects. However, I'll say that over the years I've come to rely on a dense planting in a small area (rather than a sparse planting in a large area) to achieve quickest cover (for purposes of discouraging invasive species) and to establish "nuclei of micro-climatic change" (where the dense planting begins to positively affect immediately adjacent areas through shading, competition, seed rain, etc. That strategy also makes maintenance a bit easier because there's not as much ground to cover and somewhat addresses the commonly seen "weed vacuum" phenomenon mentioned in the report (removing *Ilex* results in subsequent invasion by *Calystegia*).

I also strongly advocate for incorporating (arborist) wood chips into the soil as part of the planting process. I typically add one five-gallon bucket of wood chip to each of my planting holes (whether 1, 2, or 5 gallon containerized stock) and thoroughly mix the chips into the soil of the planting hole. When I do a planting "bed," I add as much wood chip as I can and then coarsely incorporate it in by hand with spade or fork. For larger projects, wood chips can be incorporated using tracked vehicles or other construction equipment. As I understand mycorrhizal fungi, most (all?) of them are species that decompose wood but are also able to form close associations with plant roots to supplement their diets. SO, if there's wood to eat in the soil, the fungi develop on that food source first (as decomposers) and then can eventually and simultaneously find their way to plant roots (where they can be mycorrhizal)- thus kick-starting a fungal-based soilfoodweb. The mass of wood chip in the planting hole encourages the fungal mycelia to go far and wide in search of nutrients and moisture, thus benefitting the plant that has formed a mycorrhizal relationship with the fungi. The wood mass also physically acts to hold moisture (like mini-sponges), which benefits the plants directly, of course.

I've also found that conducting restoration in shade is not productive. Without good light penetration to the understory, planted materials typically just sit and eventually die (with the exception of a few iron-clad species such as *Polystichum munitum* and *Rubus spectabilis*. I therefore attempt to "thin-from-above" (if possible) to get light to the groundstory, plant in existing forest gaps, and/or concentrate on forest edges or areas immediately adjacent to forest edges. Using that strategy, I obtain less mortality of planted stock and then faster establishment and growth of that stock.

2. *You have worked both in urban restoration and on large forestry projects for SPU where climate is being explicitly considered – do you have ideas for improving climate resiliency of urban forests?*

Great question! Generally, the effects of climate change on dry-region forests are predicted to involve decline or other biotic changes in response to projected increases in the frequency and severity of drought. Principles used in managing for climate change are as your report generally outlines them. I might add a few elaborations:

[Table 2] Category 1, Activity 1: consider use of wood chip in planting hole at time of planting to created minireservoirs of moisture and encourage mycorrhizal associations (see discussion above).

[Table 2] Category 1, Activity 2: a) consider establishing and enforcing disinfection protocols to minimize likelihood of transporting diseases from site to site (see discussion below); b) consider addressing soil compaction by discouraging off-trail trespass and minimizing crew visits.

[Table 2] Category 1, Activity 3: I'd go full speed ahead on this one. Minor risk with potential strong upside.

[Table 2] Category 2, Activity 4: The body of research on this suggests mycorrhizal inoculation is neither effective nor required [spores of most fungi are everywhere, they just something to eat (wood or sugars from plant roots)].

[Table 2] Category 3, Activity 7: I believe this is a Category 1 activity. For me, it's been an effect way to obtain a foothold in invaded areas or to introduce biological diversity. No or low risk.

In terms of <u>assisted migration</u>, I'd have no reservation in including in restoration efforts in King County those species native to King County but not necessarily to the restoration site). For example, at Discovery Park, I've been using *Acer glabrum*, *Quercus garryana*, and *Populus tremuloides* as three species not native to the Park but native to King County. I consider these very useful as drought tolerant, competitive species in view of the potential effects of climate change. Previously introduced to Discovery Park, *Pinus ponderosa* is now naturalizing and appears well adapted to the Park's droughty, infertile, sandy soils (except that it's subject to a defoliating needle disease suspected to be *Elytroderma deformans*). Likewise, *Chamaecyparis lawsoniana* is now naturalizing and is well adapted to Park conditions. Both species are "gentle" invaders and don't seem to have much impact in terms of displacing native species, etc. This all leads to a discussion of "novel ecosystems" and the City's appetite for pursuing or tolerating such.

I also suggest the City should consider literally starting over with those natural areas that are so far-gone in terms of quality, biological diversity, and ecosystem functioning (due to invasive species, loss of tree canopy, etc.) as to be unrestorable (Seattle has plenty of these!). In those cases, remediation would include complete removal of vegetation, soil improvement interventions as needed, addition of down wood, and replanting. Considering their location and size, these areas might be contemplated for planting primarily to non-native but North American coniferous species such as *Calocedrus decurrens*, *Sequoia sempervirens*, *Sequoiadendron gignateum*, *Pinus ponderosa, Abies bracteata*, *Juniperus occidentalis*, *Taxodium ascendens, …*as a diversity hedge against climate change and/or for their commodity value—part of the City's adaptive management program.

In terms of adaptive management, a key but oft-overlooked element is carefully designing your work in such a way as to be able to answer specific management questions. That can be experimental (in the strict sense) but does not necessarily have to be. One fundamental aspect of adaptive management is having good baseline information as might be obtained from permanent forest monitoring plots. Two experts have assisted Seattle Public Utilities in advancing the formal adaptive management program that was part of commitments made in the Cedar River Habitat Conservation Plan. Steve Ralph might be considered a local or regional expert in adaptive management as it relates to conservation planning, particularly for fish species. Dr. Steven Yaffee is distinctly a global expert on adaptive management in natural systems and in other contexts as well. We had excellent experiences with both. Might be good to have conversations with either or both. Contact info below.

Stephen (Steve) Ralph Stillwater Sciences, Inc.
1314 NE 43rd St.
Suite #203, Seattle, WA 98105
ralph@stillwatersci.com
206-632-0107

Dr. Steven Yaffee
University of Michigan
School of Natural Resources and Environment
yaffee@umich.edu
734-763-5451
www.snre.umich.edu/profile/yaffee

3. *Do you have experience with working on root rot pockets in urban areas? Any prescriptions?*

As I understand the literature and recommendations from industry and academics, there's really not much a manager can do to manage root rot pockets. Forest ecologists would point out that such disease is responsible for creating important canopy gaps, an ecological process that leads to increased plant and animal use and diversity. I'd recommend continuing to plant shade tolerant and root rot resistant (or less susceptible) conifers and deciduous trees such as *Acer macrophyllum*, *Acer circinatum*, *Alnus rubra*, *Rhamnus purshiana*, *Thuja plicata*, *Tsuga heterophylla*, *Picea sitchensis*…. I don't recommend creating containment or quarantine belts (and then replanting with deciduous species) because you could go through a lot of trees fast, which is undesirable in our relatively smallish urban green spaces; adding solely deciduous species is counter to invasive species management (see comment, above, on importance evergreenness). I do recommend establishing and enforcing disinfection protocols to assist in reducing likelihoods that soil-borne diseases are transmitted from site to site by tools and footwear.

4. *Have you experimented with various holly removal protocols? Results? Thoughts on how to deal with holly thickets that result from failed/incomplete treatments?*

It sounds like you need initial treatments that are more effective. The report mentions the use of frilling with glyphosate, a technique that did not rate highly in EarthCorps' recent evaluation (EarthCorps 2013). If you haven't already,try frilling with triclopyr. Also, in frilling or girdling treatments, ensure all layered branches have been dug out and cut off; otherwise these survive the frills and girdles and create dense thickets after a couple of years. For holly thickets resulting from failed/incomplete treatments, you might consider foliar applications using glyphosate or triclopyr. Adding isopropyl alcohol to the mix assists in penetrating the holly leaf's (or English ivy, or English laurel, or Portuguese laurel, etc.) thick waxy coating that otherwise prevents herbicidal chemicals from being absorbed.

Personally, for initial treatment, I prefer a non-herbicidal method that involves digging out and cutting off all layered branches and then girdling the main stem using the technique in the attached description. I've used this on many invasive woody species (and non-clonal) having one or a few main stems. The method takes longer to implement than other methods, and target plants take a couple of years to die, but it works and does not require herbicides.

## Appendix F, part 3: Comments from Dr. Su Hyung Kim (Associate Professor, University of Washington)

*Staff contacted Dr. Kim with these questions related to a paper he co-authored on climate effects on seed transfer zones in Washington State:*

1) *In your white paper for Forterra, you show that western redcedar provenances from Toutle seedzone are likely to be better adapted to the Puget trough. Most of the Toutle zone would seem to be cooler and wetter than here. What explains this result?*
2) *What are the likely physiological effects on forest trees from changing climate in the Puget Sound region in the next 50 years?*

Dr. Kim responded by email with these comments:

For your question 1), the predictions were made based on future climate projection from a number of emission scenarios and global climate models. What it predicts is to look for those seed zones in the future climate that are most similar to the current seed zones. Zones are darker if more models agreed (it's like voting among models). So this information should be taken with caution and interpreted with expert opinions like yours.

For question 2), I'm afraid that this isn't something I can give a simple, straightforward answer via an email or even in person. You may consider contacting a forest ecologist such as Prof. Greg Ettl, Tom Hinckley, or David Ford in our school to discuss this topic in the context of our region's forest ecosystems.

Please let me know if you have any other questions. Thank you.

Soo

# Appendix G: Written Public Comments

*This updated OSVM plan was opened for public comment between Jan 15 and Feb 17, 2015. Comments were solicited in the Mercer Island Weekly and by emails to groups of citizens active in parks and environmental issues. A public meeting was held on Feb 5, 2015, to encourage further comments. Comments and meeting attendance roster are included below:*

## Appendix G, Part 1: Comments from Ms. Carolyn Boatsman

February 14, 2015

Dear Mr. West,

I offer the following comments regarding the City of Mercer Island Open Space Vegetation Plan

10-year Evaluation Draft for Public Review.

First, on page 7, the Executive Summary states: "Maintain the functional benefits of open space vegetation to the extent that available resources allow."

I think that the Draft Plan should firmly and positively state goals. The phrase "to the extent that available resources allow" weakens the statement. It is true that the level of support for implementing the Plan may change over time as elected officials determine budget priorities. However, to make this statement in a planning document provides an unnecessary "escape hatch". I would avoid it, revising as follows:

"Maintain the functional benefits of open space vegetation."

Second, on page 52, the Draft Plan states: "Finally, a new initiative in this plan is to undertake a targeted outreach and education campaign related to the effect of invasive trees and shrubs in private landscaping. There has been some public education around ivy as an undesirable plant for private landscaping, but cherry laurel and holly are less familiar to the public as invasive species. The purpose of the proposed campaign is to increase public understanding of the link between seed sources (mature fruiting plants) on private lands and the continued invasion in public parks, with the ultimate goal of convincing landowners to replace these invasive plants with native or less aggressive introduced species. Planning for this educational campaign is still in early stages, and a more detailed plan will be developed over the course of the coming biennium.

I laud the inclusion of this strategy in the Draft Plan and look forward to its implementation.

Thank you for the opportunity to comment.

Sincerely,
Carolyn Boatsman

## Appendix G, Part 2: Comments from Ms. Rita Moore

Paul,
Last week I attended the California Native Plant Society (CNPS) conference on San Jose to learn more about California native plants. (I am helping my son and his wife landscape their San Francisco back yard with California natives.).
In one session a commercial landscaper in CA said they got the best survival results with natives when using water with initial planting. Also sure death was planting too deeply. They dig holes, fill with water then plant halfway, add more water, finish planting and build a basin around the plant and water again. Some plants are never water again after the initial planting.
Some native nurseries are getting better results using mycorrhizal inoculants in their potting soil. Some have also found their potting mixes to be too water retentive causing root roots. Want mycorrhizal growth not bacterial growth in pots with native plants.
**Residents of MI**
Do more to involve residents with wildlife habitat on their own property by adding natives to their landscapes. Can focus on pollinator and bird habitat improvement plus invasive removal.
Do more to get residents to install rain gardens and swales. Look at big effort put into solar for roof tops. We can do this for native plants and invasives too.
Especially focus on residents with wet areas, riparian areas and shoreline or in habitat corridors.
Much more habitat on the island is in private hands rather than on parks.
I know I was involved with the Pioneer Park book update so am biased but I believe this has really valuable information in it for island residents. More people need to know about it.
Promote an alliance with the National Wildlife Federation and it's office in Seattle. They are grated up to do this kind of education.
I plan on attending the
**Plants**
In list of forbs did not see cow parsnip. Of you want some I have a couple that can be dug up. They all came from one plant.
Wildlife
We need a baseline study of the wildlife habitat on the island. As far as I know this has never been done on the island.
**Comment**
When I first moved here in 1999, Gallagher Hill did not have ivy on the trees but there was a lot on the ground. Now it is all over the trees. I strongly believe it is important to restore open space areas, with good habitat, as soon as possible. If you

wait, it becomes more degraded with continued invasive growth and more expensive to restore later.
Really glad to see "pristine" part of parks are a priority. Always believed best habitat should be addressed first since if left shown it will degrade and then cost more to restore.

**Hollerbach Park**

Personally I am very interested in Hollerbech Park riparian and wetland efforts since I am downstream of the park and work done upstream will directly effect me and the stream on my property. November 2013 storm caused serious flooding that took out almost all of the weirs on the stream on my put property and deeply eroded the stream bed.

**Trees selected for planting in parks**

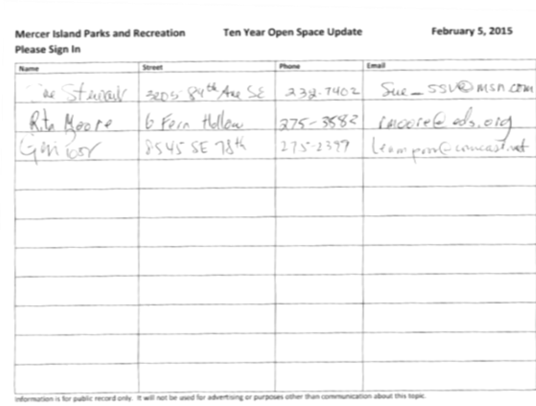
Suggest adding yew trees on the understory mix in or parks. I know there are quite a few on the north side of the ravine in Holler back Open Space. They grow in shade, albeit very slowly.
Rita

## Appendix G, Part 3: Comments from Ms. Sue Stewart

Thanks Paul for this link to your report. I began reviewing it over the weekend and am very impressed. I had read that Open Space management might be hurt by budget concerns. Has that been resolved or still an issue? Thanks also for notice of the open house…I'll hope to see everyone there on February 5th. Best,
Sue Stewart

## Appendix G, Part 4: Public Meeting Attendance

Rita Moore
Sue Steward
Geraldine Poor


Mercer Island Parks and Recreation Ten Year Open Space Update February 5, 2015
Please Sign In

| Name | Street | Phone | Email |
| --- | --- | --- | --- |
| Sue Stewart | 3205 84th Ave SE | 232-7402 | Sue_SSV@msn.com |
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