The State of Seattle's Conifer Forests

Seattle Urban Nature

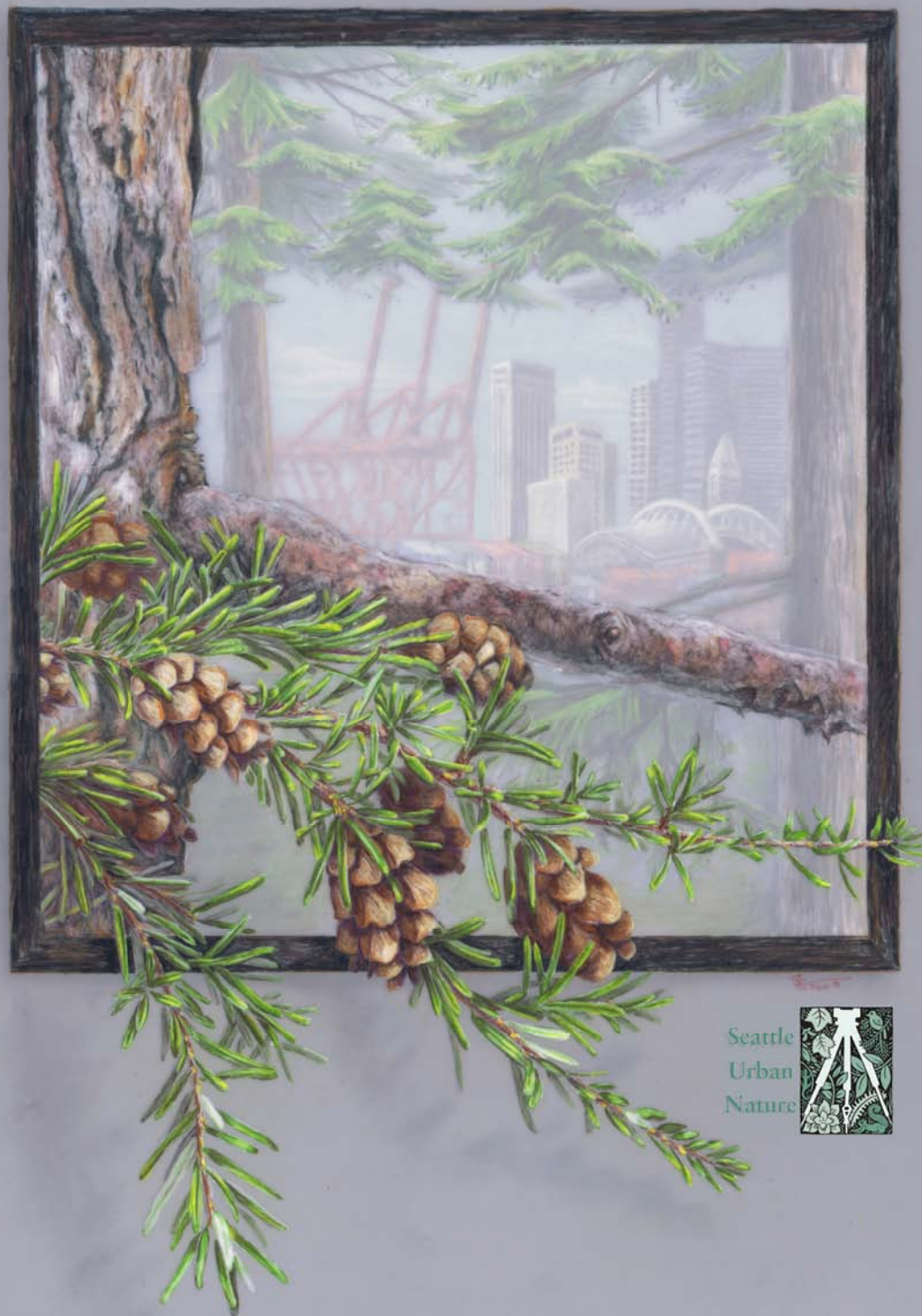2009

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Introduction

Substantial evidence demonstrates that urban forests in the Puget Sound region are in decline. According to the 2006-2007 Green Seattle Partnership (GSP) 20 year Strategic Plan, "within 20 years, 70% of Seattle's forested parkland will be an ecological 'dead zone' where invasive plants predominate, where trees are dead or dying, and where native wildlife habitat is gone." As invasive plants take over urban forests, habitat for native species is degraded, trees critical for storm water retention and carbon sequestration are lost, and other important ecosystem services are compromised.

Over the past ten years there has been a growth in public awareness that urban forest restoration is necessary in order to preserve and protect this important public resource. In Seattle last year the GSP reported that over 78,000 hours were devoted to restoration, which involved thousands of volunteers. With such an intensive investment of both time and money, it is imperative that restoration practitioners use their time and resources effectively to improve the ecological health of our urban forests. Therefore, it is necessary to understand the overall ecological health of the forests and gauge the magnitude of existing threats. Seattle Urban Nature (SUN) is addressing this need through our Citywide Habitat Assessment (CHA) for Seattle.

This report is part of the CHA, an on-going effort to assess the condition of all forest types on public lands within the city. This report provides a comprehensive analysis of the existing condition of conifer forested habitat in Seattle's parks and open spaces. While less-disturbed conifer forests have been evaluated in Western Washington (Chappell, 2004), little information presently exists describing urban conifer habitats. It is intended that this information will help us, as a community, to better understand our urban forests and will help support a sustained effort to restore and preserve these locally rare habitats. Funding for this report came from a Washington Department of Natural Resources Community Forestry Assistance grant, the Bullitt Foundation and individual donors.

History and Ecology of Conifer Forests

Less than 200 years ago, majestic conifer forests dominated the landscape of the Puget Sound region and the Pacific Northwest. Prior to the arrival of European settlers in the 1850s, the Puget Sound region was dominated by old-growth Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) forests (Kruckeberg 1991). These forests were home to Native Americans and the native plants and wildlife they relied on for food and shelter. The loss of conifer trees through wide-scale logging over the past 150 years has altered the succession of forests in much of the region from forests composed of long-lived conifer to forests composed of short-lived deciduous trees, with low levels of conifer regeneration within

(top) Sun shines through the tall conifer trees; (bottom) a frog rests on a moss covered log.

Seattle and other urban areas (GSP 20 year strategic plan). In 1999-2000, Seattle Urban Nature (SUN) conducted the Seattle Public Lands Habitat Survey, a citywide vegetation inventory on 8,000 acres of public lands and open space in Seattle. The results of this survey showed that only 11% of the city's public forests are dominated by conifers, whereas nearly 70% of forests are now deciduous (SUN 2000).

A drastically altered forest ecosystem, where deciduous trees have replaced conifer trees, has many ramifications for forest health. Evergreen conifer trees can live more than 1,000 years. Deciduous trees tend to have much shorter lifespans, on the order of a century or less, and many big-leaf maples (*Acer macrophyllum*) and red alders (*Alnus rubra*) in Seattle's forests are now reaching the end of their years. In addition, regeneration levels of conifer trees are often very low in urban forests due to a number of factors including lack of seed sources, lack of coarse woody debris (downed wood) and competition with human-introduced invasive species.

Conifer forests provide a variety of vital ecosystem services. Stormwater retention is one of the many valuable ecosystem services provided by forests in urban areas. As impervious surface increases, so does the amount of stormwater runoff that is diverted into streams and other water bodies, and increases the demand on wastewater treatment facilities. Forests play a vital role in intercepting and slowing precipitation and storm water in urban areas. Most of the precipitation in the Pacific Northwest occurs during the winter months when conifer forests are actively growing but deciduous trees are dormant. Evergreen trees therefore intercept more rain than deciduous trees.

Conifer forests provide important habitat for Douglas squirrels (Tamiasciurus douglasii).

Other important ecosystem services provided by conifer forests include:

- Regulating and improving air quality in urban areas by producing oxygen, taking up carbon dioxide from the atmosphere, and removing pollutants and particulates from the air year-round.
- Improving water quality in urban areas by filtering pollutants from water and preventing sediments from entering streams and degrading salmon habitat.
- Preventing erosion on steep slopes by anchoring the soil with deep roots.
- Reducing global warming by storing carbon in woody tissues for the lifetime of a tree (conifers can live for more than 1,000 years whereas deciduous trees live about 100 years).
- Providing visual and noise buffering for residential areas from busy roads and industry.

The Pacific Northwest is home to over 20 different species of native conifers, growing from sea-level to timberline (Arno & Hammerly 1977). Native conifer species found in Seattle include Douglas-fir, grand fir (*Abies grandis*), Pacific yew (*Taxus brevifolia*), shore pine (*Pinus contorta*), western hemlock, western red cedar and western white pine (*Pinus monticola*). These trees provide habitat for a wide variety of birds, insects and wildlife. Conifer seeds are an important food source for small mammals such as Douglas squirrels, mice, voles, shrews and chipmunks as well as birds such as the pine siskin, song sparrow, golden-crowned sparrow, white-crowned sparrow, red crossbill, dark-eyed junco, and purple finch. The needles and bark provide browse for black-tailed deer, elk, blue grouse and porcupines (FEIS).

Due to the historical and ecological importance of conifer forests and their rapid decline in our region, it is vital to restore the remaining fragments still present on public lands, as well as look for opportunities to acquire and protect the remaining intact conifer forests that occur on private lands. The 1999-2000 Seattle Public Lands Habitat Survey shows that conifer forests cover approximately 293 acres, accounting for slightly more than 10% of Seattle's roughly 2,800 acres of forested habitat (Table 1).

Forest Type	Acres	Percent
Conifer/Madrone Mixed Forest	52.0	1.9%
Conifer/Deciduous Mixed Forest	361.5	13.2%
Conifer Forest	**290.9**	**10.6%**
Deciduous/Madrone Mixed Forest	50.9	1.9%
Deciduous Forest	1865.5	68.2%
Madrone Forest	25.3	0.9%
Palustrine Forested Wetland	69.3	2.5%
Riparian Forest	21.3	0.8%
Total	**2736.7**	

Table 1. Forest type, cumulative acreage, and percent of each type present in Seattle's public urban forests (from SUN's 1999-2000 survey). Forest types presented in this report are highlighted in red.

Citywide Habitat Assessment (CHA)

In 2005, SUN launched a citywide forest monitoring program known as the Citywide Habitat Assessment (CHA) to monitor improvements or declines in the state of Seattle's urban forests. This assessment builds on data collected during SUN's 1999-2000 Seattle Public Lands Habitat Survey, which provided vegetation information for 8,000 acres of public lands throughout Seattle (see http://www.seattleurbannature.org/Survey/background.html for more information). The aim of the CHA is to implement a long-term monitoring program using a repeatable, accurate methodology that measures specific indicators of forest function and health.

Western trillium (Trillium ovatum) flowers.

The goals of the CHA are to:

1) Provide an understanding of the structure and function of each of the eight forest types in Seattle
2) Understand the threats to the health of these forests and monitor conditions throughout time
3) Disseminate information gathered in an easy to understand form to managers, stewards & the public.

The first step in this process is to establish and sample baseline assessment plots in each of the eight forest types identified in the 1999-2000 survey (see Table 1). Two previous reports from this effort have been published: Information about conifer/deciduous mixed forests in Seattle (available at: http://www.seattleurbannature.org/Projects/citywide.html) and "The State of Seattle's Madrone Forests" (available at: http://www.seattleurbannature.org/Projects/2008_State_of_Madrones.pdf), which discusses conifer/madrone, deciduous/madrone and pure madrone forests.

In this report, baseline information on the state of pure conifer forests in Seattle will be presented. To date, three out of eight forest types remain to be sampled: riparian forests, forested wetlands and deciduous forests, the most widespread forest category within the city. Once data for all eight forest types are collected, a "report card" will be released that summarizes and compares the health, existing conditions, and potential threats to all forested habitat types found on Seattle's public lands. Currently, information about forest health and findings for madrone forests and conifer/deciduous mixed forests are available in the individual reports described above. Ultimately, SUN envisions that these plots will be revisited and future data will provide trend information on the health of Seattle's forests.

View of a 0.1 acre vegetation assessment plot in a conifer forest.

Sampling in Conifer Forests

In order to ensure that the beauty and ecological diversity of Seattle's conifer forests remain for future generations, it is important to understand their current condition and monitor the health of these habitats over time. In an effort towards these goals, SUN established and sampled permanent assessment plots throughout the conifer forests on public land in 2008. A total of 16 plots were sampled in these forests (Map 1). This approximately translates to a 0.5% sampling intensity for the study area. Plots locations were randomly placed on public lands in conifer forests throughout the city.

The sampling unit for this survey consisted of a 164.04 foot (50 meter) x 26.25 foot (8 meter) plot. Plots were marked with a wooden stake and GPS coordinates were recorded. Data recorded at each plot included the species, height and diameter of all live and dead (snags) trees present. All coarse woody debris (CWD) (downed wood) greater than five inches in diameter was also recorded. Shrub, herbaceous, and vining plant species were identified within each plot and percent cover was recorded for each species. Further information about the methods used in this survey is available in our report: "Methodology to Assess Habitat Conditions on Public Land in Seattle" (SUN, 2006).

Conifer Habitat Overview

Seattle's conifer forests vary considerably in both structure and composition across the city. Mature forests that were not logged or that were selectively logged remain in places like Schmitz Park in West Seattle and Seward Park in southeast Seattle. These forests are dominated by Western red cedar (*Thuja plicata*) and Western hemlock (*Tsuga heterophylla*) trees, long-lived and shade tolerant species that dominate old-growth conifer forests in the Pacific Northwest. In areas that were logged at the beginning of the century and where sufficient seed source remained, conifer forests are most commonly dominated by Douglas-fir (*Pseudotsuga menziesii*) trees, which thrive in sunny open areas. Some notable Douglas-fir forests in the city are located in Seward Park, Llandover Woods and Carkeek Park in Northwest Seattle, Westcrest and Fauntleroy Parks in West Seattle, Northacres Park in North Seattle, and Discovery Park. A number of conifer forests that were mapped during the 1999-2000 survey include small fragmented areas planted with conifers. While these areas are dominated by a conifer overstory, they do not necessarily provide the functions of an intact forest habitat, and are heavily invaded with invasive species and have little native plant cover. Examples of these areas constitute plantings along the I-5 corridor (see Map 1).

Conifer forests mapped during the 1999-2000 Seattle Public Lands Habitat Survey

During the 1999-2000 survey, SUN mapped habitats and collected vegetation information for 8,000 acres of public lands throughout Seattle. As a result of this survey, a total of 81 distinct conifer forests were mapped across the city, spanning 291 acres (Map 1). These forests are located in a total of 31 parks and open spaces within the city. Much of Seattle's public land that is currently dominated by deciduous forests (more than 1,800 acres) was likely historically conifer dominated. A primary goal of long-term urban forest restoration in our area is to increase conifer regeneration in these deciduous dominated systems. A concerted citywide effort is now underway to underplant these forests with conifer seedlings, providing for the next generation of conifer forests.

2008 Conifer Forest Assessment

In 2008, 16 permanent plots were established in forested public lands that were classified as conifer forests during the 1999-2000 survey. Small, fragmented areas less than 0.5 acre were not included in this survey. A total of 97 plant species were recorded during this inventory: 65 native, 30 non-native, and two that were not identified to species. The most common overstory tree species associated with conifer forests in Seattle is Douglas-fir, with smaller amounts of western hemlock and western red cedar. In the sampled conifer forests in Seattle, overstory conifer trees are found at an average density of 103 trees per acre (Figure 1). However, conifer trees are regenerating at only 20 trees per acre in the sampled plots, and are greatly outnumbered by English holly (*Ilex aquifolium*) and other invasive tree species (Figure 2).

On average, the well-developed shrub layer of the conifer forests is dominated by beaked hazelnut (*Corylus cornuta*), creeping blackberry (*Rubus ursinus*), salal (*Gaultheria shallon*), and low Oregon grape (*Mahonia nervosa*) (Figure 3). The somewhat sparse herbaceous layer is generally dominated by sword fern (*Polystichum munitum*) (Figure 4).

(left) Low Oregon grape leaves and berries; (right) a sword fern frond.

Invasive Species Threatening Conifer Forests

In most habitats in Seattle, invasive non-native plant species occupy niches that have historically been filled by native flora. Introduced species do not necessarily provide the same habitat functions (food, water, shelter) in supporting native fish and wildlife species. Many invasive species become dominant to the exclusion of all other species on a site, thereby reducing overall biodiversity and ecosystem function in these urban forests and making them more susceptible to greater loss or damage resulting from disease, pests, and other disturbances. Ecosystems with impaired functions contribute less value to the social, biological, and economic goals of the City of Seattle. Knowing the extent and type of invasive species present can be an important step towards managing and tracking their impacts.

Seattle's conifer forests are invaded by a suite of non-native species. Invasive species of particular concern include English ivy (*Hedera helix*), herb Robert (*Geranium robertianum),* Himalayan blackberry (*Rubus armeniacus*) and invasive trees such as English holly (*Ilex aquifolium*), sweet cherry (*Prunus avium*), European mountain ash (*Sorbus aucuparia*) and cherry laurel (*Prunus laurocerasus*).

English ivy is a climbing vine, capable of creating dense mats on the forest floor, smothering native species, climbing and toppling trees and restricting natural tree and shrub regeneration. English ivy is classified as a Non-regulated Noxious Weed in King County (King County 2009). These are wide-spread species for which control is recommended but not required in the county. Herb Robert is a rapidly-spreading ground cover, capable of growing in both open and shady conditions that releases allelopathic chemicals which prevent native plants from establishing. Herb Robert is also classified as a Non-regulated Noxious Weed in King County (King County 2009). Himalayan blackberry is a shrub commonly found in open and disturbed areas. It is capable of rapidly forming dense thickets and excluding all other species over a large area. This species is also a Non-regulated Noxious Weed in King County (King County 2009).

(top) Holly leaves and berries; (middle) cherry laurel leaves; (bottom) English ivy leaves.

Invasive trees pose a significant challenge to the health of urban forests. Not only are these species capable of forming dense thickets in the forest understory and suppressing native trees, but they represent the future composition of our forests. The majority of regenerating trees are non-native invasive species which will dominate our forests in the next 50 years unless we take proactive measures to reverse these trends. All of these species are dispersed by birds that eat berries from horticultural plantings and drop seeds into natural areas.

During the CHA survey, 30 different non-native plant species were recorded in conifer forests. English holly is a serious threat in these forests with an alarming average density of 328 stems per acre and accounting for more than 60% of all tree regeneration in the conifer forest type (Appendix A). English holly is classified as a Weed of Concern in King County (King County 2009). This classification refers to species that are not classified as noxious weeds in Washington State but are recognized as posing a threat to native plant and animal habitat. Control of these plants is recommended where possible, and new plantings are discouraged. Sweet cherry is also a serious problem and has invaded conifer forests with an average of 63 stems per acre or nearly 12% of all tree regeneration (Appendix A). English ivy was found in 93% of all sampled plots at an average cover of 7% across all plots (Figure 4). Himalayan blackberry was present in nearly half of all plots at an average percent cover of 4%. Without active management, these and other invasive species have the potential to drastically alter the future makeup of the forest, substantially impacting the ecological integrity of conifer habitat on Seattle's public lands.

Conifer Forest Composition

Overstory & Regenerating Trees

Sampled conifer forests contained a total of 97 species (65 native, 30 non-native, and two that were not identified to species) recorded across 16 sample plots (Map 1). Overstory and regenerating trees are separated by diameter size – overstory trees are those larger than 5" in diameter at breast height (DBH), whereas regenerating trees include those that are 5" DBH or smaller. These forests, like their name implies, are dominated by conifer trees in their overstory, primarily Douglas-fir, western red cedar and western hemlock, with a smaller component of big-leaf maple (Figure 1 and Appendix A). Overstory trees were recorded at an average density of 125 stems per acre, of which 103 stems per acre are conifers. Conifer regeneration was recorded at a low density of 20 stems per acre, accounting for only 4% of all tree regeneration and 23% of native tree regeneration (Figure 2). In comparison, a study of similarly aged Douglas-fir forests on federal lands in Western Oregon found an average of 112 regenerating conifer trees per acre (Muir et al. 2002). As mentioned previously, very high densities of regenerating English holly were recorded in this forest type. Other invasive tree species of concern include sweet cherry (which averages 63 stems per acre), European mountain ash (*Sorbus aucuparia*) (24 stems per acre), cherry laurel (*Prunus laurocerasus*) (20 stems per acre), Portugal laurel (*Prunus lusitanica*) (four stems per acre), one-seed hawthorn (*Crataegus monogyna*) (two stems per acre) and Norway maple (*Acer platanoides*) (one stem per acre) (Appendix A).

Coarse Woody Debris

When discussing conifer forests, it is important to acknowledge the importance of coarse woody debris (CWD). This decaying wood provides important soil amendments and can act as "nurse logs" for conifer tree regeneration. Coarse woody debris is downed wood, consisting of logs and stumps, which return organic material and nutrients to the soil, retain sediment and prevent erosion (Stevens 1997). This wood has many wildlife benefits and provides shelter, cover and forage for 47 bird and animal species in the Pacific Northwest (Bunnell et al. 2002). CWD also acts as nurse logs for seedlings of plants such as western hemlock and red huckleberry (*Vaccinium parvifolium*) by providing a moist and rich substrate to grow. One of the contributing reasons for the lack of conifer regeneration in urban parks and natural areas is a lack of large sized pieces of CWD in most areas. During the course of this study, an average volume of 775 ft^3/acre was present throughout the study plots. In comparison, Douglas-fir/western hemlock forests over 250 years old typically contain approximately 6400 ft^3/acre of CWD (Harmon et al. 1986). Therefore, it is important to increase and retain CWD wherever possible in urban parks and forested areas.

Shrubs

The conifer forest type has a fairly well developed shrub layer with a combined average cover of 82%. The shrub layer of these forests are dominated by beaked hazelnut (17%), creeping blackberry (16%), salal (15%), and low Oregon grape (14%) (Figure 3). Himalayan blackberry was found in nearly half of all sampled plots (44%) at an average cover of 4%. Several other invasive shrubs were found in trace amounts and included Franchet's cotoneaster (*Cotoneaster franchetti*), scotch broom (*Cytisus scoparius*), spurge laurel (*Daphne laureola*) and evergreen blackberry (*Rubus laciniatus*).

(top) Western hemlock tree growing out of a nurse log stump; (bottom) salal flowers.

Herbs & Vines

The herb and vine layers of conifer forests are dominated most notably by sword fern, which provides approximately 18% of all cover in the forests (Figure 4). Other notable species found at low cover in this habitat type are vanilla leaf (*Achlys triphylla*) (trace), small enchanter's nightshade (*Circaea alpina*) (5% cover), hairy honeysuckle (*Lonicera hispidula*) (trace), orange honeysuckle (*Lonicera ciliosa*), false lily-of-the-valley (*Maianthemum dilatatum*) (trace), smallflower nemophila (*Nemophila parviflora*) and trillium (*Trillium ovatum*) (trace). English ivy was present in 15 out of 16 plots at an average of 7% cover, whereas herb Robert had an average cover of 4% across all plots. Other invasive species present in small amounts include: Canada thistle (*Cirsium arvense*) (trace), Spanish bluebells (Hyacinthoides hispanica) (trace), creeping buttercup (*Ranunculus repens*) (1%) deadly nightshade (*Solanum dulcamara*) (trace), and common periwinkle (*Vinca minor*) (trace).
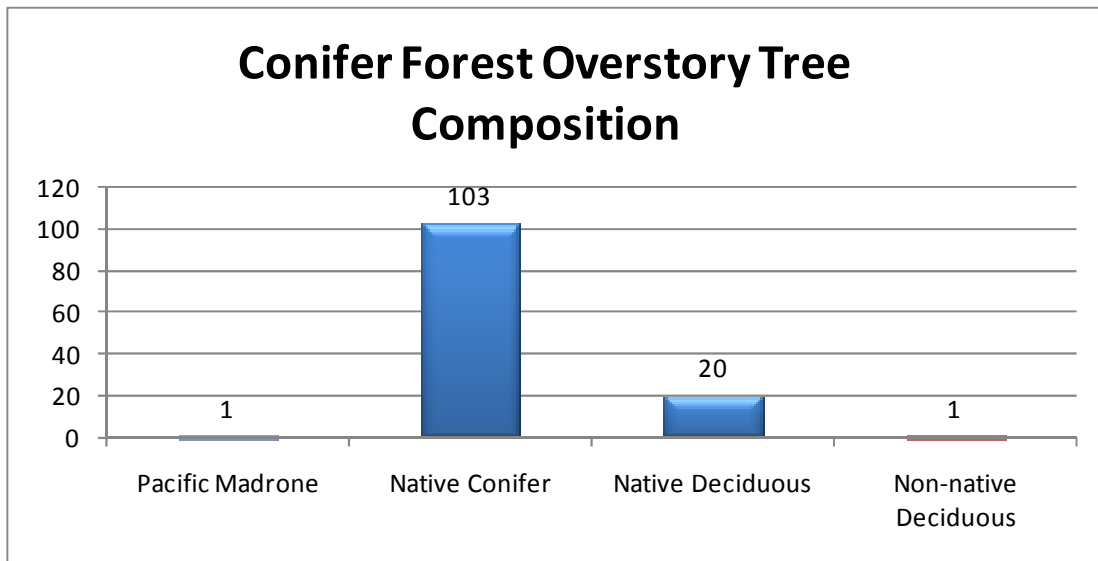
Figure 1. Overstory average tree densities for native and non-native conifer, deciduous and broadleaf evergreen (Pacific madrone) tree species found in conifer habitat plots (N=16). Categories in red indicate non-native species.

Figure 2. Regenerating average tree densities for native and non-native conifer, deciduous and broadleaf evergreen (Pacific madrone) tree species found in conifer habitat plots (N=16). Categories in red indicate non-native species.
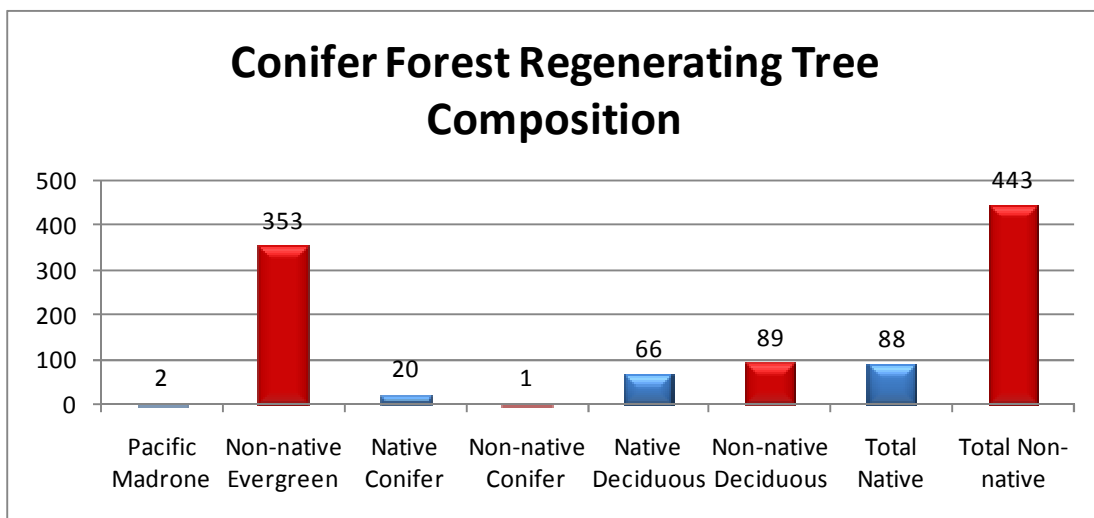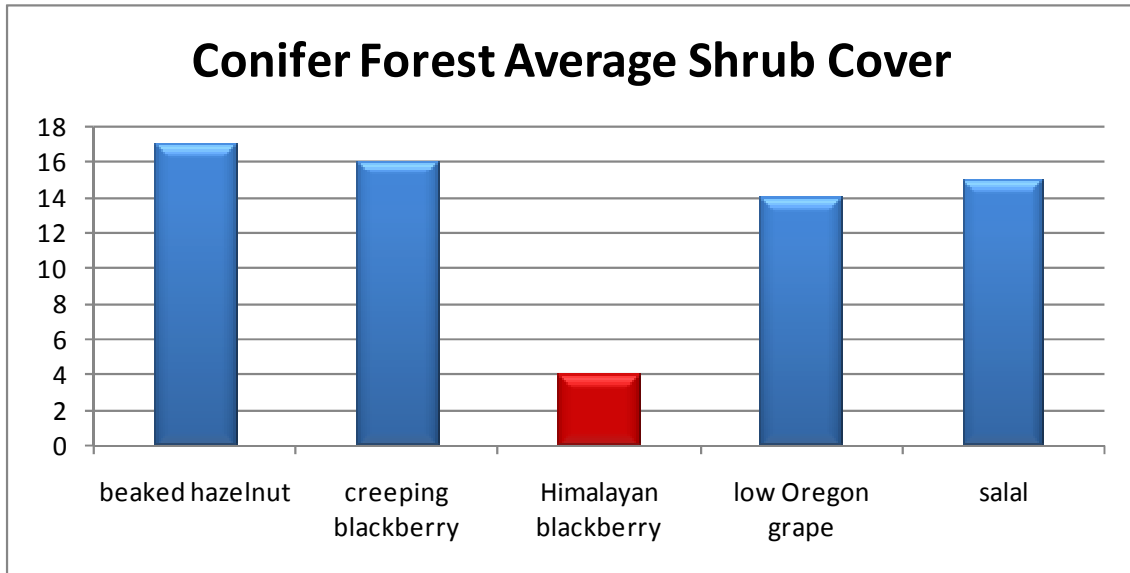
Conifer Forest Average Shrub Cover

Figure 3. Average cover for the five most prevalent shrub species found in the conifer forest type in Seattle (N=16). Categories in red indicate non-native species.
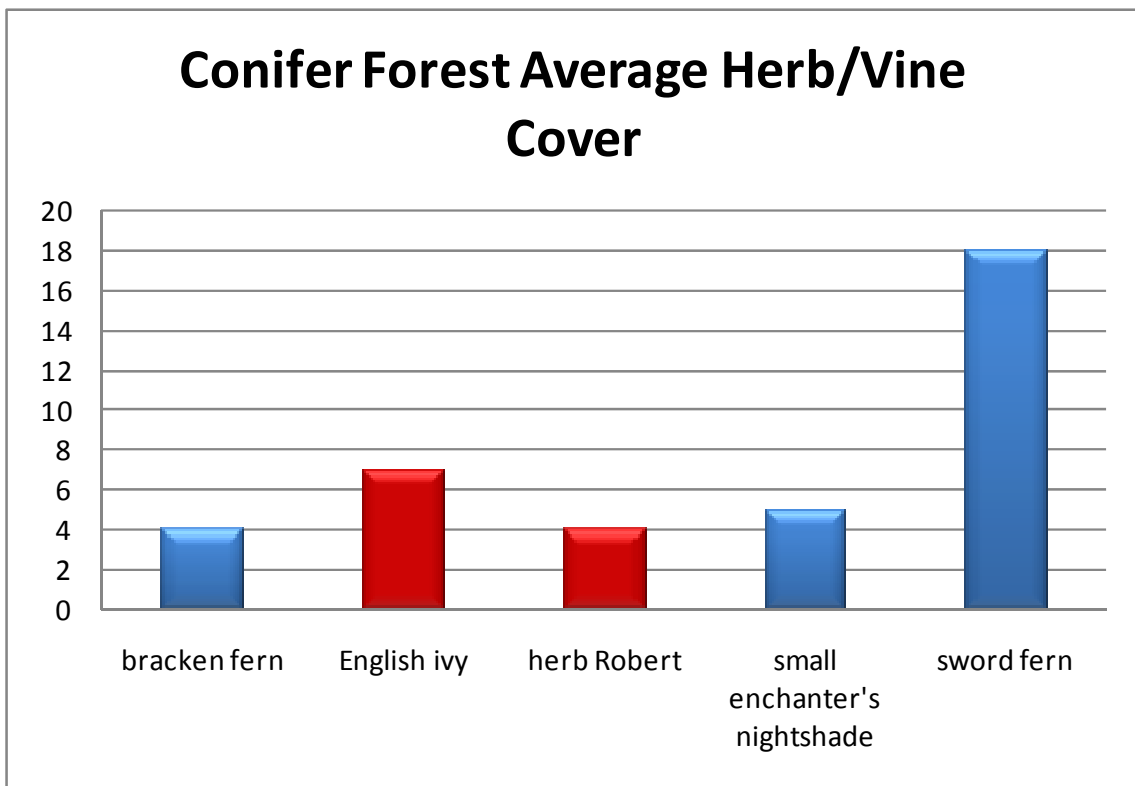
Conifer Forest Average Herb/Vine Cover

Figure 4. Average herb and vine cover for the five most prevalent species found in the conifer forest type in Seattle (N=16). Categories in red indicate non-native species.

Summary/Conclusions

Conifer forests are a vanishing resource in the Puget Sound region. These giant trees can live for more than a thousand years and are iconic symbols of the Pacific Northwest. Conifer forests provide people with important ecosystem services year-round. They improve our water and air quality, stabilize soils, slow and absorb stormwater and rain water, sequester large amounts of carbon, and provide beautiful places for urban residents to enjoy. They also provide vital habitat for native wildlife and birds. With less than 300 acres of conifer forests remaining on public lands within the City of Seattle, these forests urgently need our care and protection. Conifer trees are not regenerating in sufficient numbers to perpetuate healthy forests into the future. Instead, these forests are becoming dominated by English holly, sweet cherry, English ivy and other species that are suppressing the growth of native plants.

False lily-of-the-valley at the base of a conifer tree.

Unless we begin to actively manage these forests to reduce the impact of habitat loss, invasive species and other urban pressures, we stand to lose an incredibly valuable cultural and ecological resource. Seattle's remaining conifer forests are in decline and it's up to the community at large to reverse these trends. Some suggestions for helping to protect and restore these forests are listed below:

- Avoid planting invasive trees in residential landscapes. These species include English holly, cherry laurel, Portugal laurel, European mountain ash, one-seed hawthorn and bird cherry. If these species are present in a residential landscape, consider removing them and replacing with native conifer trees if space is available. For information and photos of these trees, along with native tree alternatives, see SUN's factsheet available at: http://www.seattleurbannature.org/Resources/Invasive_Native_Trees.pdf

- Remove English ivy, herb Robert, Himalayan blackberry and other invasive species from landscapes and greenspaces. Many of these species produce berries that are spread by birds throughout natural areas in the city. Information about invasive shrubs and groundcovers and suggestions for native plants are available from SUN's factsheets:
  http://www.seattleurbannature.org/Resources/Invasive_Native_Shrubs.pdf
  http://www.seattleurbannature.org/Resources/Invasive_Native_Plants.pdf

- Consider joining work parties at a local park to help restore habitat in neighborhood forests. Many community organizations have monthly work parties focusing on removing invasive species and planting native plants. Seattle's forests need everyone's help and stewardship to reverse a century of neglect and decline. Information about restoration events in Seattle is available at: http://www.greenseattle.org/events

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Appendix A. Overstory (greater than 5 inches DBH) and regenerating (5 inches DBH or smaller) tree species found in the conifer habitat type in Seattle. Values represent density (stems/acre) and proportion (in parentheses) of each species averaged all cross all plots (N=16).
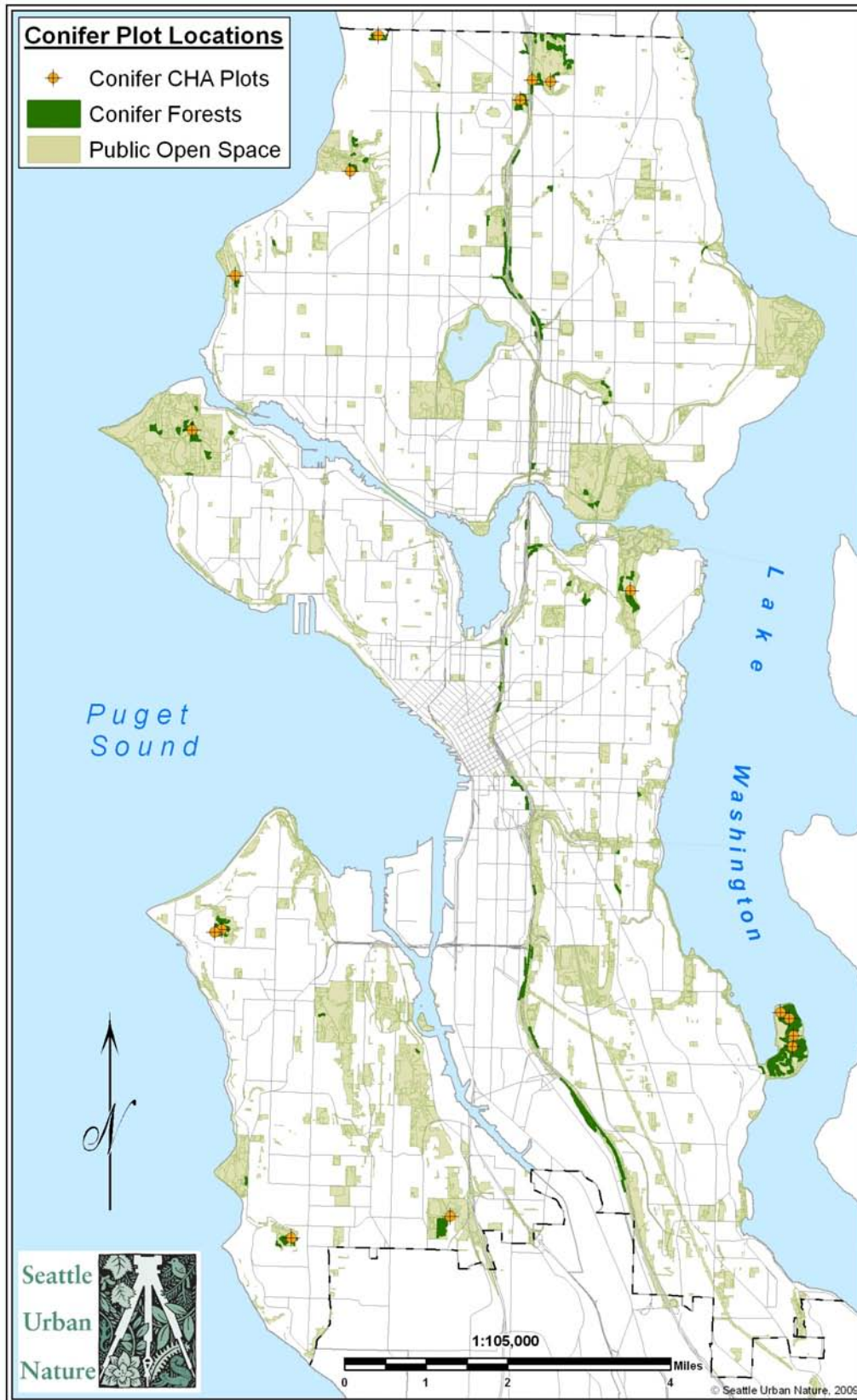
Scientific Name[1]	Common Name	Overstory density (stems/acre)	Regeneration density (stems/acre)[2]
Acer macrophyllum	big-leaf maple	14 (11%)	52 (10%)
Acer platanoides*	**Norway maple**		1 (T%)
Alnus rubra	red alder	4 (3%)	1 (T%)
Arbutus menziesii	Pacific madrone	1 (1%)	2 (T%)
Cornus nuttallii	Pacific dogwood	3 (2%)	1 (T%)
Crataegus monogyna*	**one-seed hawthorn**		2 (T%)
Frangula purshiana	cascara		13 (2%)
Ilex aquifolium*	**English holly**		328 (62%)
Juniperus sp.	juniper		1 (T%)
Prunus avium*	**sweet cherry**	1 (1%)	63 (12%)
Prunus laurocerasus*	**cherry laurel**		20 (4%)
Prunus lusitanica*	**Portugal laurel**		4 (1%)
Pseudotsuga menziesii	Douglas fir	63 (51%)	3 (T%)
Sorbus aucuparia*	**European mountain ash**		24 (4%)
Taxus brevifolia	western yew	2 (2%)	
Thuja plicata	western red cedar	24 (19%)	8 (2%)
Tsuga heterophylla	western hemlock	14 (12%)	9 (2%)

[1] Species in bold are non-native species. Species denoted by * are species which have been given a legal designation by the King County Noxious Weed Program (King County 2008).
[2] T=Trace presence of species (less than 1%).

Spiny wood fern frond.

Map 1.
Locations of
plots sampled
in the conifer
forest type
throughout
Seattle.

Conifer Plot Locations

+ Conifer CHA Plots

Conifer Forests

Public Open Space

Puget Sound

Lake Washington

Seattle
Urban
Nature

1:105,000

Miles
0   1   2   4

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