University of Washington
BOTANIC GARDENS

Centennial Woods Restoration and Management Plan

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A project in partial fulfillment of the requirements for the degree of
Master of Environmental Horticulture

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Table of Contents

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Introduction

Ecological restoration presents many opportunities and challenges. The project I have completed for my Master of Environmental Horticulture degree was to take advantage of an existing situation and address the challenges that it presented. In 2007, trees were planted at a volunteer event and the site was mostly abandoned, resulting in a very high tree mortality rate and dominance of invasive species. I saw the opportunity to restore this site to what was originally intended: a wooded area that would commemorate the 100-year anniversary of the University of Washington (UW) College of Forest Resources, and to develop a long-term management plan.

As I started the planning process, it occurred to me that another opportunity existed. With global warming well underway and the future climate of the Pacific Northwest uncertain, I thought it would be interesting to include some tree species from warmer climate zones to monitor and assess the differences between these and the native species over time.

Finally, and especially because the site is very close to the western entrance to a public natural area, I decided to include an interpretive trail with numerous signs explaining what ecological restoration is, and describing the project and the species that were planted. There wasn't enough time to complete this during the available time, so it will be one of the first things done, as will be described in the management plan.

Site Description

Centennial Woods is a 0.67-acre site located on the west side of the 74-acre Union Bay Natural Area (UBNA, see map, Figure 1), which is part of the University of Washington Botanic Gardens' (UWBG) Center for Urban Horticulture. The site was initially named "Centennial Grove," but after reviewing various definitions of "grove" and "woods," I concluded that the latter better describes what this site will become. The definition of a "wood" (Merriam Webster's Collegiate Dictionary 2005) is "a dense growth of trees usually greater in extent than a grove and smaller than a forest - often used in plural."

The site slopes at approximately 5 degrees from its highest point on the eastern side to its lowest point on the west (D. Zabowski, personal communication 2012). There is a moisture gradient along the slope - dry along the high eastern side to moist along the gully on the western edge (Calimpong, et al. 2012). Along the gully is a mix of young *Salix scouleriana* (Scouler's willow) and mature *Populus balsamifera* ssp. *trichocarpa* (black cottonwood). The Scouler's willows have grown rapidly over the past 5 years, and together with the black cottonwoods provide shade from late afternoon sun to the western side of the site. The eastern part of the site is dry and until 2007 was covered almost completely with non-native grasses and *Rubus armeniacus* (Himalayan blackberry). The southern boundary of the site is the main gravel trail through UBNA, Wahkiakum Lane. The northern boundary is a stand of mature black cottonwood. Figure 2 is a map of the Centennial Woods site.

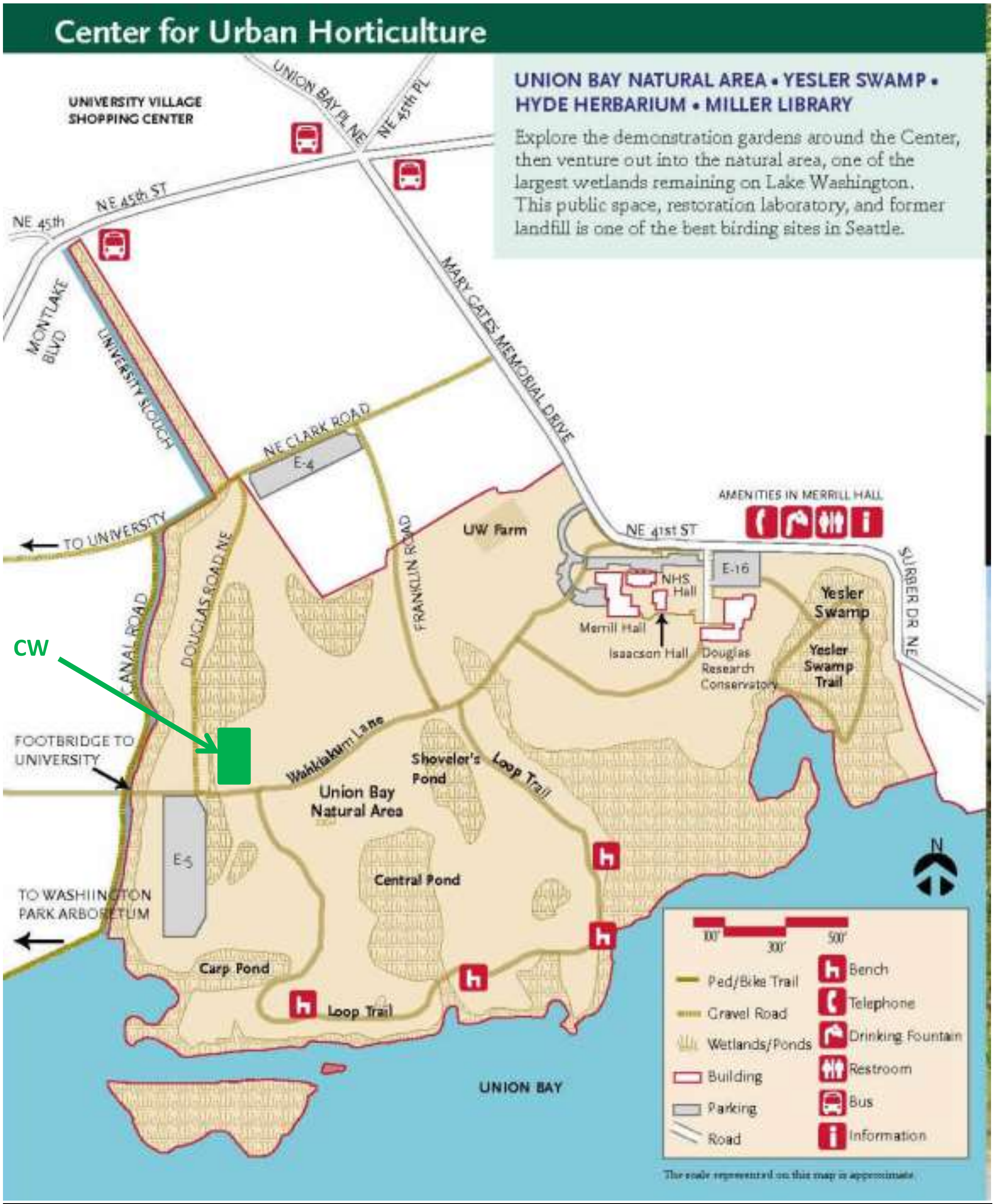

Figure 1. Center for Urban Horticulture map, showing Union Bay Natural Area and Centennial Woods (CW) (UW Botanic Gardens website).

Figure 2. Centennial Woods, May 2013. Approximate area inside yellow trapezoid. (Google Earth)

Site History

Centennial Woods, as well as most of UBNA, is on top of a former landfill on the western shore of Lake Washington. With the construction of the Chittenden Locks at Ballard in 1916, the lake's water level was lowered by 12 feet, and a large cattail marsh developed where the water had receded (Jones and Jones 1976). In 1926 the City of Seattle opened a garbage dump at the site to "reclaim" the marshland (Union Bay Planning Committee 1995).

No detailed records were kept of what was dumped; it was a mixture of residential and industrial waste - building refuse, shrubbery, scrap metal, etc. In 1964, parking lots and athletic fields were constructed on top of previously-filled areas. Over the years, subsidence has required the periodic addition of soil to maintain level surfaces in those areas. In 1966, waste disposal at the site was halted, and in 1971 the landfill was capped with soil excavated from the UW Health Sciences expansion (Osborn and Ray Planners, Inc. 1980). The site was then graded and seeded with a mixture of 26 European pasture grasses (Table 1).

Table 1. European pasture grasses planted at UBNA after landfill capping.

Agropyron repens	*Agrostis alba*
Agrostis tenuis	*Aira caryophyllea*
Aira praecox	*Anthoxanthum odoratum*
Arrhenatherum elatius	*Bromus commutatus*
Bromus mollis	*Bromus pacificus*
Bromus rigidus	*Dactylis glomerata*
Echinochloa crusgalli	*Festuca arundinacea*
Festuca bromoides	*Festuca idahoensis*
Festuca myuros	*Festuca rubra*
Holcus lanatus	*Lolium perenne*
Panicum capillare	*Phalaris arundinacea*
Phleum pratense	*Poa annua*
Poa compressa	*Poa pratensis*

In 1966, standards for capping a landfill called for a minimum of 2 feet of soil to be placed on top of the entire site. Several studies of this site have shown the thickness of the soil cap to be highly variable, ranging from 0 to 12 feet. Over the years, due to differential compacting of the refuse in the landfill and dewatering of the underlying peat and clay, the surface has subsided by varying degrees, resulting in the appearance of a natural, hilly prairie.

The City of Seattle turned the land over to the UW after it was filled and capped. In 1986, the Center for Urban Horticulture opened, which the UW designated for teaching, research, and public service. By this time much of it had been colonized by "very difficult invasive plant species such as purple loosestrife (*Lythrum salicaria*), Himalayan blackberry (*Rubus armeniacus*), and others" (Ewing and Reichard 2013). Restoration projects got underway in 1990 and have been continuing ever since (Ewing and Reichard 2013). As of 2010, approximately 14 acres had been restored, "primarily through student projects and volunteer labor" (Ewing 2010).

Initial Restoration, 2007

On April 28, 2007, I participated in a tree planting event in UBNA to commemorate the centennial of the University of Washington (UW) College of Forest Resources (CFR; now School of Environmental and Forest Sciences, SEFS). Sponsored by the CFR Alumni Association, the event also coincided with Earth Day and the "Washington Weekend" of special events throughout the University community. Approximately 35 volunteers planted about 400 bare-root conifer saplings of the following species:

- *Alnus rubra* (red alder)
- *Picea sitchensis* (Sitka spruce)
- *Pinus contorta* var. *contorta* (shore pine)
- *Pseudotsuga menziesii* (Douglas-fir)
- *Thuja plicata* (western redcedar)
- *Tsuga heterophylla* (western hemlock)

Prior to the planting event, the site had been well-prepared by mowing the grasses and blackberry and applying about six inches of wood-chip mulch. Within several hours after planting, the trees were watered in (Anonymous 2007). However, several factors contributed to the very low (10%) survival rate of the trees planted that day:

- The stock, donated by several nurseries and alumni, had wintered over from the previous year in large paper bags (K. Ewing, personal communication March 2014).

- Many of the volunteers had no experience planting trees, which resulted in the following:

    - Many of the trees were planted in unsuitable sites. For example, Sitka spruces, western redcedars, and western hemlocks were planted in full sun on the upper, dry part of the site.

    - Even though instructed to keep the roots moist and out of the sun and wind, many volunteers allowed them to dry out before they were planted.

    - Improper planting techniques were used. The forester alumni who were leading the event had instructed volunteers to create a wedge with their shovels, insert the tree roots, and then compress the soil onto the roots. This is a common method which, when done correctly, can be successful. However, many dead saplings were later found to be loose in their wedges, indicating that the soil had not been compressed enough to make sufficient contact with the roots. Another common error was that many of the trees were planted in the mulch and not in the soil.

- The summer in 2007 was hotter than average, and the following two years had colder than average winters (2007-2008, 2008-2009) (Seattle Monthly Averages and Records, Weather Warehouse).

- Inadequate maintenance (see next section below).

Maintenance Efforts, 2007-2011

Over the next two years, some sporadic attempts were made by myself and other volunteers to control the blackberry and non-native grasses that had quickly grown up through the mulch as it compacted and decomposed. Since the trees were unevenly spaced, it was difficult to find them, as they were completely covered by the blackberry and grasses. Despite our efforts, by the end of 2011 only 38 trees had survived the 2007 planting event:

- *Alnus rubra* (1)
- *Picea sitchensis* (9)
- *Pinus contorta* var. *contorta* (17)
- *Pseudotsuga menziesii* (10)
- *Thuja plicata* (1)
- *Tsuga heterophylla* (0)

No work was done at the site for the rest of 2007. In 2008, some attention was paid to clearing blackberry from around the trees. This probably contributed to the survival of the 38 trees as stated above, but it was too much to do by too few volunteers (at the time, only myself and my wife). Also, this site was not a priority at the time. We did a lot of work in other areas of UBNA, which included removing Scotch broom and blackberry, planting live willow stakes, and planting western redcedars in Yesler Swamp (see Figure 1). In the fall of 2008 I noticed that a few more trees had been planted at the south end of the site by a UW restoration ecology class, but this event wasn't documented. Most of those trees died, and by 2009 the blackberry had once again come to dominate the site.

In February 2009, ten 5-foot tall *Acer macrophyllum* (bigleaf maple) trees were planted, but by the end of that summer only one had survived, presumably due to the unusual cold weather that month and the following March, as well as the record high temperatures in August and September (National Weather Service Forecast Office 2009).

On April 4, 2009, the College of Forest Resources and Alumni Association hosted a “Day of Service” blackberry removal work party (Anonymous 2009) at the site. In addition to the faculty, staff, graduate students, and alumni who participated, the volunteers also included a class of undergraduate Environmental Science and Resource Management students. This event was very productive, but again not sufficient by itself to keep the invasive plants at bay.

Very little maintenance was done between April and June of 2009, and then nothing at all until January, 2010. Between January and August there were sporadic visits to remove blackberry, and then no activity again until April 2011. Consequently, during these two years the blackberry dominated the site yet again.

In July 2011 the site was mowed as part of the annual effort to control blackberry in all of UBNA. At the time there were no signs or fences identifying or protecting the site, and most of the smaller surviving trees were covered with blackberry and grasses, so most in the central area were inadvertently cut down. There were a few more maintenance visits during that summer, but the site was ignored until early 2012 when I decided to undertake rigorous restoration of the site for my MEH project. By that time, the non-native grasses had grown back up through what was left of the 2007 mulch, and several other invasive species had colonized (Table 2).

Table 2. Invasive species that colonized Centennial Woods, 2007-2012.

Scientific Name	Common Name(s)
Cichorium intybus	chicory
Circium vulgare	bull thistle
Calystegia sepium	hedge bindweed
Daucus carota	Queen Anne's lace, wild carrot
Galium aparine	cleavers
Hedera helix	English ivy
Rubus armeniacus	Himalayan blackberry
Vicia americana	American vetch

Project Goals

The purpose of this project was to create a wooded area similar to a natural ecosystem in an urban setting that will serve as an educational resource for the University of Washington and surrounding communities. After the initial planting of trees and understory plants over the first several years, with proper stewardship a canopy will develop and minimal maintenance will be required to control invasive species that will inevitably be brought in on visitors' shoes, clothing, and pets. Specific goals are summarized below.

1. Restore the site utilizing better methods and more consistent maintenance. This will be accomplished by planting native trees and understory species and removing invasive species that threaten to out-compete the natives during their initial establishment period. Special attention will be given to Himalayan blackberry, as it has the greatest potential for resuming domination of the site. As the canopy develops over the next 10 years or so, the invasive plants will be shaded out, and the site will provide suitable conditions for volunteer understory plant species as well as habitat for birds and mammals.

2. Plant non-native trees from warmer climate zones to assess how well these species respond to any potential climate changes.
3. Build a trail through the site to facilitate access for maintenance, and to accommodate future public access for educational purposes.
4. Develop a long-term Management Plan which will provide specifications and suggestions for continued monitoring and maintenance of the site for the enjoyment and education of future generations.

Methods

Species Selection

Because this site had originally been submerged under Lake Washington, the previous condition of the site cannot be used as a reference ecosystem for its restoration. Therefore, it was decided that a wooded area would be created that includes tree and understory species common to the Puget Sound lowlands (Franklin & Dyrness 1973, Kruckeberg 1991). In addition, several tree species from warmer climate zones were included (Bever 1981, Lanner 2002), as described in the Introduction above, for comparison purposes in assessing the effects of climate change over time.

Several understory species, which are not usually included in the early phases of a forest restoration project, were planted to increase diversity. Because there would be little or no shade on the site for several years, the selected understory species were chosen for their tolerance of full-sun conditions. These are expected to do even better as the developing canopy gradually increases the amount of shade. The kinnikinnik were planted along the south edge of the site along Wahkiakum Lane, and they should continue to provide good native ground cover at least until the canopy begins to shade them from the north.

After the above specifications for species selection were established, procurement of stock was based on availability and cost. Plants were obtained from the following sources:

- Nurseries
- Donations from individuals
- Washington Native Plant Society fall plant sale, September 2012

- Extra trees from a graduate student project that had been donated by the Washington Department of Natural Resources
- Seedlings that had grown from seeds that had fallen into containers from native trees in adjacent forest

Table 3 lists the species that were planted for this project, as well as the number of each and the region they came from. Table 4 lists the nurseries from which plants were purchased.

Table 3. Species Planted at Centennial Woods, 2012 - 2013. *CA = California; PSL = Puget Sound Lowlands; SOR = Southern Oregon

Species	Common Name	Number Planted	Source Region*
Trees:			
Abies grandis	grand fir	42	PSL
Acer circinatum	vine maple	2	PSL
Acer macrophyllum	bigleaf maple	18	PSL
Alnus rubra	red alder	1	PSL
Calocedrus decurrens	incense-cedar	21	SOR
Picea sitchensis	Sitka spruce	19	PSL
Pseudotsuga menziesii	Douglas-fir	86	PSL
Pseudotsuga menziesii	Douglas fir	25	SOR
Salix scouleriana	Scouler’s willow	17	PSL
Sequoia sempervirens	coast redwood	11	CA
Sequoiadendron giganteum	Sequoia	1	CA
Thuja plicata	western redcedar	20	PSL
Tsuga heterophylla	western hemlock	1	PSL
Shrubs:			
Gaultheria shallon	salal	10	PSL
Ribes sanguineum	red-flowering currant	10	PSL
Vaccinium ovatum	evergreen huckleberry	12	PSL
Groundcovers:			
Arctostaphylos uva-ursi	kinnikinnik	10	PSL
Lonicera hispidula	pink honeysuckle	2	PSL
Lycopodium clavatum	running club moss	2	PSL
Polystichum munitum	sword fern	10	PSL

Table 4. Nurseries from which plants were purchased.

Nursery	Location	Species
Fernwood Nursery	Medford, OR	Douglas-fir, incense-cedar
King Conservation District	Renton, WA	evergreen huckleberry, kinnikinnik, red-flowering currant, salal
Olympic Nursery	Woodinville, WA	Douglas-fir
Plants Northwest	Redmond, WA	Douglas-fir
The Jonsteen Company	McKinleyville, CA	coast redwood

Planting Techniques and Timeline

Because one of the initial plans for the site was to continue annual mowing to control Himalayan blackberry, the trees were planted on 8-10 foot centers to allow a large (7-foot wide) mower to easily pass between them. Another reason for the relatively low density was that there would not be enough time, manpower, or funding (to purchase plants) available to complete this project at a more typical density of 4-foot centers.

In order to achieve a more natural appearance, while still allowing ample space for the mower, the "rows" of trees were somewhat staggered.

Later it was recognized that the lower planting density was appropriate for another reason. Some of the pits dug to collect soil samples (see below) revealed small pieces of refuse, indicating that the topsoil in the landfill cap was very shallow. In these areas, therefore, the tree roots would have had increased competition for water and nutrients at higher planting densities, thereby decreasing the long-term survival rate (D. Zabowski, personal communication 2013).

After delivery to the Center for Urban Horticulture and until they were planted, trees in containers were kept outside, and bare-root and plug stock was kept in a refrigerated room. All trees were planted within two weeks of delivery, with one exception as noted below, for Douglas-fir plugs from Fernwood Nursery.

For all planting, standard procedures were used: holes were dug a little deeper than the root ball and about twice as wide. Also, all blackberry roots as well as grass roots (and rhizomes of perennial species such as *Elymus repens* - quackgrass, and *Agrostis gigantea* - redtop) were removed from the holes and immediate vicinity (within about a foot).

My wife helped with most of the planting and tagging, except the one-day planting session for the 30 grand firs and 20 Sitka spruces, described in the next section.

February - March 2012

Fifty Douglas-firs, purchased from Olympic Nursery in 5-gallon containers, were planted. The nursery owner was converting his business from retail nursery to tree consulting, and was liquidating his stock. So, while we obtained these trees inexpensively, we discovered that many were not very healthy (slightly chlorotic and root-bound). Because they were root-bound, it was impossible to remove much of the potting soil to free and prune the roots without damaging them. Also, at this early stage I wasn't experienced enough to check for girdling roots. Consequently, not enough native soil was mixed in the planting hole. Another oversight due to my inexperience was not watering in the trees even though the soil was moist and it was lightly raining on several of the planting days.

Thirty grand firs and 20 Sitka spruce were also planted. They were all bare-root, purchased from the King Conservation District (KCD) native plant sale. These were planted mostly in one day, with help from the graduate student who was the manager of UBNA at the time, and two interns from the Edmonds Community College Horticulture program.

I planted 2 pink honeysuckles that had been grown from seeds planted the previous year in small pots kept on my condo deck. The seeds had been purchased from a Washington Native Plant Society sale.

Also during this time, 16 bigleaf maples, 6 grand firs, 3 Douglas-firs, and 2 western redcedars, donated by the graduate UBNA manager mentioned above, were planted. They had been harvested from his yard or the Washington Park Arboretum (volunteers that had grown from seeds in areas where they were not wanted) and bare-rooted.

August 2012

We started tagging and numbering the trees using yellow flagging tape and writing the numbers on the tape using a permanent black marker. Flags were tied to a high branch of taller trees (greater than about 3 feet), or to the top of a bamboo stake pushed into the soil a few inches from the tree.

The annual mowing for blackberry control took place. I was on site to supervise and guide the mower driver through the rows. Despite our efforts, a few trees were destroyed.

October - November 2012

Two each of the following species, all in 1-gallon containers from the Washington Native Plant Society fall sale, were planted: grand fir, vine maple, and western redcedar. These had been purchased in September and left in the shade on site. They had to be watered twice because of unseasonably dry weather, but they remained healthy.

Ten bare-root coast redwoods from Jonsteen were also planted. Blue tubes were added a week later, along with additional mulch, to help protect them from freezing weather. They were removed the following spring because the new growth was too confined.

Seventeen Scouler's willow live stakes, harvested from trees at another UBNA site, were planted along the gully at the western edge of the site. They were not assigned numbers and are not included in any survival analyses.

February - March 2013

Twenty-one bare-root incense-cedars and 11 Douglas-fir plugs from Fernwood Nursery were planted. Due to time constraints, 17 Douglas-firs that had been in the same shipment were not planted. They were stored on site, in complete shade, with their roots under thick mulch and kept moist.

I obtained 10 red-flowering currants on March 2 from the KCD annual sale, and planted them that day because they were much bigger than I had expected (about 3-4 feet), and their roots had started to dry out in the paper bag they came in.

Ten sword ferns were planted in moist, low areas. They were extra plants acquired from an undergraduate capstone class project.

May - June, 2013

Even though this is much too late to plant trees, I had no choice but to plant the 17 Douglas-fir plugs mentioned above. They would not have survived until fall, even if put back into the cold room.

Nine bare-root western redcedars that were donated by a graduate student (not needed for his project) were planted. This species is especially vulnerable to excessive heat, so they were planted in a shady, moist area. I accepted the donation because the trees had a better chance of survival by being planted than they would have if returned to the cold room.

On June 22, the site was mowed without my knowledge or consent. Sixteen small trees were destroyed in the central area. This was not good for the trees that survived, because cutting down the tall grasses along with blackberry removed protection against sun and wind, just as the summer drought was beginning.

July 2013

In order to avoid further mowing or other disturbance, I put up a fence around most of the site, using metal fence posts with string tied between them and orange flagging tape hanging from the string to make it visible. Signs were located on several of the fence posts to identify the site, ask people to stay out, and provide my contact information.

November 2013

Twenty-five Douglas-firs in 5-gallon containers, from Plants Northwest, were planted. All of them looked very healthy and most were not root-bound. Any roots that looked like they might girdle were pruned. As much potting soil as possible was removed, so the roots were planted mostly in native soil. The potting soil was set aside and used as top-dressing after planting. Cardboard mulch was placed between the top-dressing and wood-chip mulch for 13 of these trees, and only wood-chip mulch was used for the other 12. After a year of growth, the two groups will be compared to see if the cardboard provided a tangible benefit.

On November 30, I planted 10 kinnikinniks along the southern edge of the site, about 6 feet north of Wahkiakum Lane. They had been purchased at the KCD sale in March, but the plugs were too small to be planted at the site, so I planted them in pots and kept them on my condo deck all summer and fall. They were still quite small, but their roots had had time to further develop.

December 2013

I planted 10 salal and 9 evergreen huckleberries. These were also purchased at the March KCD sale as plugs and planted in pots (same as the kinnikinnik described previously).

January 2014

My wife and I planted 3 large evergreen huckleberries (in 10-gallon pots) that had been donated from a Society of Ecological Restoration native plant salvage.

March2014

I planted 2 running club mosses that had been donated from a Society of Ecological Restoration native plant salvage.

Miscellaneous Plantings

Throughout the above time span (February 2012 - December 2013), 18 additional trees from miscellaneous sources were planted. These include several that had grown from seeds that had germinated in pots on the deck of my condo, which has Douglas-fir, western redcedar, and bigleaf maple branches growing virtually right over it. A coast redwood was transplanted from a half barrel in my stepfather's backyard, where it had been growing for about 7 years (originally purchased at Muir Woods in California as a "souvenir." Finally, a western hemlock, which had been growing as a bonsai for about 15 years, was planted at the site in complete shade, hoping that it would develop a leader and resume a more natural growth habit. As of this writing, it is still alive (with new growth), but so far it still retains its bonsai shape.

Maintenance: Watering, Weeding, Additional Mulching, Tree Replacement

Trees that showed signs of stress (e.g., wilting, browning, drying) during summer were given approximately 1/3 to 1 gallon of water each, depending on size and/or perceived need. It was not feasible to water every tree, as water had to be hauled in in 1-gallon jugs, and there were only two people available. Often we would run out and had to refill one or more of the jugs in nearby University Slough.

Weeds were removed by scything and pulling so that sufficient space was maintained around each tree to allow maximum light to reach the leaves, and to minimize root competition with invasive species. The major invasive species were blackberry, grasses, bindweed, and cleavers. Even though the latter is native, it has proven to be quite troublesome on this site, growing very fast in spring. It grows over and through tree branches, clinging to them with their hooked bristles and almost completely shading them out. Then in late summer, the dry fruit (burs) cling to clothing and must be removed to avoid disseminating them to other sites.

Additional mulch was added only for a relatively few highly stressed trees, in conjunction with watering and weeding.

During this initial planting period (February 2012 - December 2013), 68 trees died and were replaced.

Soil Sampling and Testing

As mentioned above, many trees did not survive their first season. Because it was known that the soil used to cap the landfill was inconsistent (see Site History above), soil conditions were suspected as one possible cause. Samples were taken from 6 trees: 3 that had died and 3 that remained healthy. Trees were not selected by any random or pseudo-random method. I simply selected different species from different areas of the site (i.e., dry, moist). Samples for the dead trees were taken from the pit left after the tree was removed. Samples for the healthy trees were taken from a pit dug approximately 1 foot from the trunk, so the roots wouldn't be disturbed. One sample was taken from each distinct horizon down to a depth of 30cm. Table 5 lists the samples.

Table 5. Soil samples.

Sample#	Species	Status	Horizon	Depth (cm)
170A	Pseudotsuga menziesii	healthy	A	0-11
170B			Bw	12-30
185A	Picea sitchensis	healthy	A	0-13
185B			Bw	14-24
185C			Bg	25+
302A	Abies grandis	healthy	A	0-16
302B			Bw	17-24
442A	Pseudotsuga menziesii	dead	A	0-10
442B			Bw	11-27
777A	Abies grandis	dead	A	0-18
777B			Bw	18+
897A	Picea sitchensis	dead	A	0-14
897B			Bw	15-23

Lumps and clods were broken up and stones and plant roots and other debris were removed from each sample. Then they were dried and one cup of each was sent to the University of Massachusetts Soil and Plant Tissue Testing Laboratory for analysis. The following tests were completed (their "Standard Fertility Test" package):

- pH
- Modified Morgan extractable nutrients (Phosphorus, Potassium, Calcium, Magnesium, Iron, Manganese, Zinc, Copper, Boron)
- Lead
- Aluminum
- Cation Exchange Capacity
- Exchange Acidity
- Base Saturation
- Scoop Density

The roots of the dead trees were examined to determine the extent of root development. Photos were taken to document their appearance.

Trail Construction

Trail construction started in November 2013. At first, only wood chip mulch was used. But after grass started growing up through it (even in the shortening, cold days of late November), it was decided to place cardboard down under the wood chips for the next section. For the last section, completed in January 2014, landscape fabric was used under the wood chips rather than cardboard. About ¾ of the trail has cardboard under wood chips, and about half of the remaining ¼ has either nothing or landscape fabric under the wood chips.

The trail was routed around the outer portion of the site, varying approximately 15-30 feet from the perimeter, with the ends terminating at Wahkiakum Lane in a U shape. There is also a section that connects the eastern and western legs of the trail, which makes the trail resemble a figure-8 when Wahkiakum Lane is considered as its southern leg.

Tree Diameter Measurements

In the spring of 2014, tree diameters were measured using digital calipers (General Tools & Instruments, Model No. 147). This data will serve as a baseline for subsequent assessment of tree growth. Measurements were taken at 10 cm above ground level, or just below the first branch if lower than 10 cm.

Data Collection, Storage, and Analysis

Data collected in the field was written in a notebook and later entered into Microsoft Excel 2010 spreadsheets or a Microsoft Access 2010 database. The spreadsheets were loaded into the Access database. Queries were created in Access, and selected output entered into Excel, where column charts were produced that show variations in tree survival by species, month planted, and stock type.

Results

Overall, tree survival rates were very good, especially when compared with the dismal outcome of the 2007 plantings. However, there were some unexpected results, which will be described in the Discussion section below. Note that there were 33 trees planted in November and December of 2013 that were not included in the analyses below, since they have been at the site for less than a year and haven't experienced summer drought.

First-Year Tree Survival by Species

Figure 3 shows the percent survival of 7 of the tree species planted for this project. Three species (red alder, vine maple, and western hemlock) were omitted due to very small numbers (1, 2, and 1 respectively).

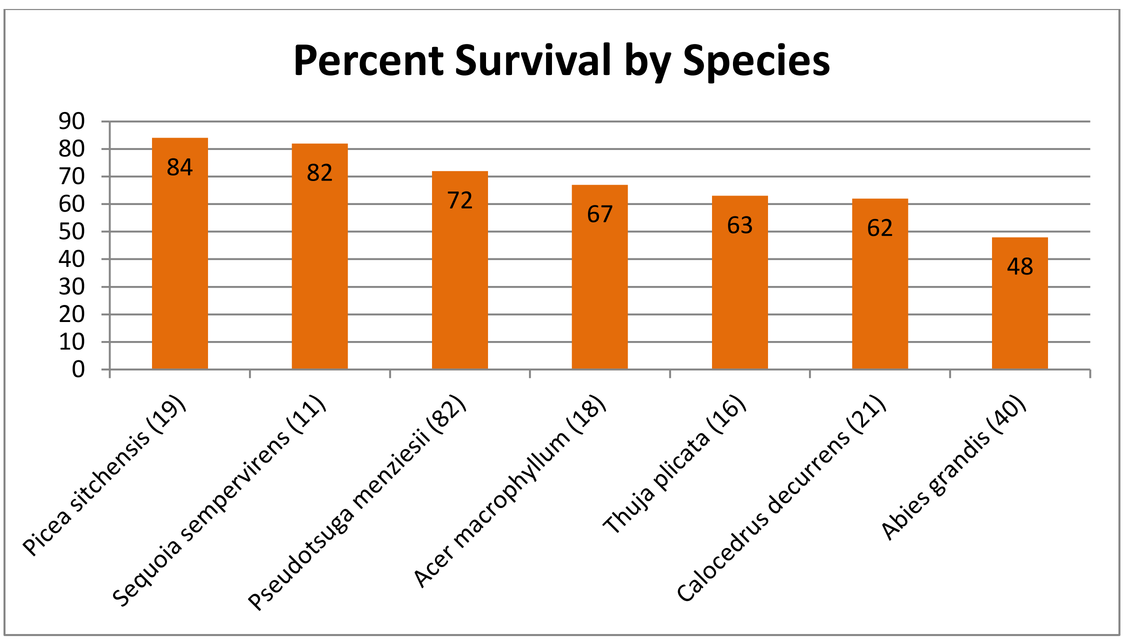

Figure 3. First-Year Tree Survival by Species. Numbers of trees of each species planted are in parentheses.

First-Year Tree Survival by Month Planted

Figure 4 shows the percent survival of trees by the month they were planted. It includes trees of all species appearing in Figure 3. Only one tree was planted in April, so it was excluded. No trees were planted in January, July, August, or September.

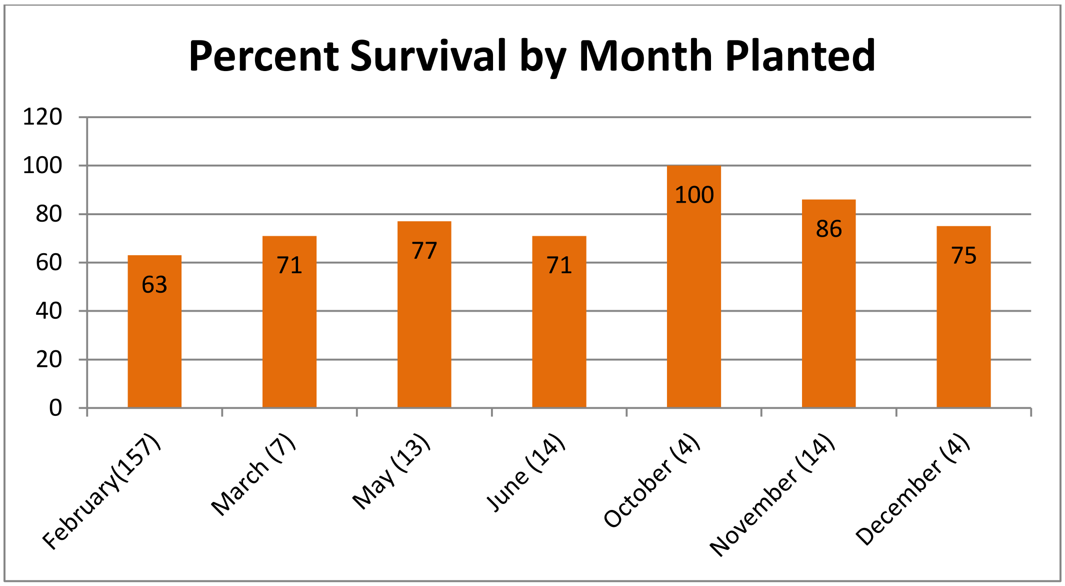

Figure 4. First-Year Tree Survival by Month Planted. Numbers of trees planted each month are in parentheses.

First-Year Tree Survival by Stock Type

Figure 5 shows the percent survival of trees by stock type. It includes trees of all species appearing in Figure 3. A small number of trees that were obtained by donation (most in small pots) were not included.

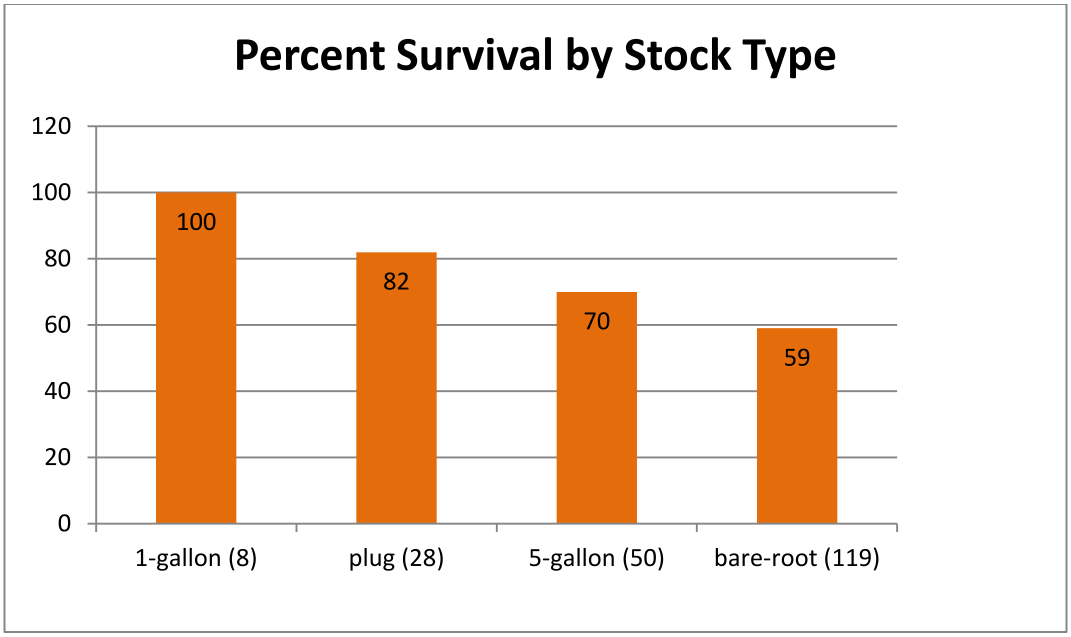

Figure 5. First-Year Tree Survival by Stock Type. Numbers of trees of each stock type planted are in parentheses.

Understory Plant Survival

Understory plants were not numbered or tracked individually as was done for trees. However, few enough have been planted so far that it was feasible to determine their survival rates (Table 6). Note that the rates for evergreen huckleberry, kinnikinnik, and salal are preliminary, as they were planted less than a year ago and have not yet had to withstand summer drought. The survival rate for the running club mosses would have also been preliminary, but that's moot since they both died.

Table 6. Survival of understory plants. Data for species marked with * are preliminary.

Species	Number Planted	Number Survived	Percent Survival
evergreen huckleberry*	12	12	100
kinnikinnik*	10	10	100
pink honeysuckle	2	2	100
red-flowering currant	10	8	80
running club moss*	2	0	0
salal*	10	10	100
sword fern	10	4	44

Soil Analyses

All of the samples had pH values from 5.5 to 7.1, well within the normal range for optimum plant growth (Brady and Weil 2010). No optimum values were provided in the UMass test interpretation documentation for Cation Exchange Capacity, Exchange Acidity, and Scoop Density, but all appeared to be normal (D. Zabowski, personal communication February 2014).

Selected test results are shown in Table 7. Table 8 lists the optimum ranges provided by UMass. It is worth noting that abnormally high and low values of nutrients as well as high values of lead were found in the soil from healthy as well as dead trees. For example, tree 185 was healthy even though it had low levels of phosphorus, potassium, and calcium in all 3 horizons sampled, low levels of zinc in 2 horizons, a low level of manganese in 1 horizon, and a high level of magnesium in one horizon. Similarly, the soil from some dead trees had mostly normal values. For example, tree 442 had no low values and only 4 high values, two of which were calcium and magnesium. High values of lead were present in only one of the three dead trees, but also in one of the healthy trees. The many low levels and one high level of base saturation were all very close to the optimum range. Aluminum values were within the optimal range for all samples.

Table 7. Selected UMass soil test results. Yellow = low, white = optimum, red = high. Green-shaded sample numbers are samples from healthy trees. Brown-shaded sample numbers are samples from dead trees.

Sample #	Modified Morgan extractable, ppm									Base Saturation, %	
	P	K	Ca	Mg	Mn	Zn	Cu	Fe	Pb	Ca	K
170A	3.9	271	1644	225	2.8	5.8	0.2	4.5	26.9	50	4
170B	0.8	111	728	124	1.6	2.5	0.5	6.7	48.6	45	4
185A	0.4	47	904	152	1.9	1.2	0.4	6.4	4.0	43	1
185B	0.5	22	715	118	0.7	0.6	0.4	4.5	2.3	56	1
185C	1.2	21	873	104	2.3	0.7	0.6	8.2	3.1	83	1
302A	4.6	129	2052	290	3.8	8.5	0.3	8.2	16.8	48	2
302B	1.4	77	1130	168	1.7	5.4	0.4	11	16.6	41	1
442A	13	131	3812	379	4.5	13.1	0.3	9.7	18.3	60	1
442B	3.2	124	1063	159	3.2	15.0	0.3	39	49.6	28	2
777A	5.6	334	1519	233	4.5	6.4	0.2	5.2	25.0	45	5
777B	1.1	155	919	132	1.8	3.4	0.3	4.3	33.8	47	4
897A	4.8	174	1379	234	3.6	3.5	0.1	4	5.2	46	3
897B	1.9	96	803	151	2.1	1.9	0.2	4.3	5.6	41	2

Table 8. Optimum ranges for UMass soil tests shown in Table 7.

Test	Optimum Range
P	4-14 ppm
K	100-160 ppm
Ca	1000-1500 ppm
Mg	50-120 ppm
Mn	1.1-6.3 ppm
Zn	1.0-7.6 ppm
Cu	0.3-0.6 ppm
Fe	2.7-9.4 ppm
Pb	< 22 ppm
Base Saturation, Ca	50-80%
Base Saturation, K	2.0-7.0%

As stated in the Site History section above, the expected soil depth should have been at least 2 feet, with the possibility that it could be anywhere from 0 to 12 feet deep, depending on location. Another study determined that the soil was 8 feet deep in some areas, as measured with augers (Ewing, K., personal communication 2014). However, debris and/or garbage was found in some of the deeper holes (approximately 30-40 cm) dug for planting the trees and evergreen huckleberries that came in larger containers. This consisted of small shards of glass, large slabs of asphalt and concrete, and various intact items of garbage (including empty bleach bottles, a shoe, and plastic bags). This clearly indicates how variable the soil depth is.

The dead trees in Table 5 didn't show any signs of nutrient deficiency or disease prior to dying. They just gradually turned brown and died. Figure 6 shows one of the dead trees. It is apparent that there was insufficient root pruning when it was planted, resulting in girdling. This is strong evidence that it was not any property of the soil that caused its death.

Figure 6. Root ball of dead Douglas-fir, showing girdled root (arrow). Note replacement tree in center foreground.

Discussion

Because this site is located on top of a landfill cap that is too thin in some places, it was assumed that a major cause of tree death was poor soil conditions. However, from the inconclusive soil results presented above, it is clear from the other results that many other factors have been involved in determining the health and survival of each individual tree. It is possible that the roots of the healthy trees with low nutrients in the soil samples have found what they need by sending their roots in other directions. Another possibility is that not enough time has passed for the trees that are healthy now to develop any nutrient deficiencies. This is why continuous monitoring, as will be outlined in the Management Plan below, is so important.

Survival Analysis

As mentioned above, no single factor or group of factors can be identified as the cause(s) for the differential survival of the trees that were planted. Also, there is no area of the site where trees are dying more than in other areas. Many possibilities exist, and may have contributed alone or in combination with others to cause the death of individual trees. The contributions of these factors are summarized below.

Water Availability

As noted in the Methods section above, it was necessary to water many of the trees throughout the summer drought. This was undoubtedly the major factor in the loss of some of the trees on the higher, drier east side of the site. Furthermore, because water is essential for the growth and health of all plants, it is likely that inadequate water exacerbated most of the other factors discussed below. For example, small sapling size could have been accommodated by more frequent watering and weeding, but as previously mentioned, limited resources made this unfeasible.

Sapling Size

Many of the trees, particularly the bare-root stock, were very small when planted, some as short as 12-18 inches. In an ideal situation, they all would have been planted early in the fall, as soon as the rains started (usually mid-October in Seattle), the seasonal precipitation would have been at or above average, there would have been very few days with freezing temperatures, and the following summer would have had no extended heat waves. Of course, these ideal conditions rarely occur in the course of any given year, which is why trees used for this type of project have to be large enough (and the roots undamaged; bare-rooting always causes some damage) to withstand substandard conditions. But they shouldn't be so big that their health would be compromised by transplant shock.

Planting Technique

For this project, standard planting techniques were used for most trees. However, some of the Douglas-firs planted in the early phase of the project were root-bound in their containers, and not enough effort was made to separate and prune the roots, especially those with girdling or potentially girdling. As seen in the photo in Figure 6, it is safe to say that this probably contributed to more than one tree death.

Another issue that came up after some late fall plantings was the tipping of several trees by the wind. While the root balls didn't become exposed, the roots were disturbed. These trees were subsequently staked to hold them in place, but staking should have been done for all trees in the areas of the site most exposed to the wind when they were planted. None of these trees have died, but they were the most recently planted, so it may be too early to tell whether being tipped will have any negative effects.

Species

Sitka spruces and coast redwoods had the highest survival rates, with Douglas-fir close behind. Survival of the latter would have been higher than 72% if not for the batch of 50 (mentioned above) that were not healthy when received from the nursery.

Bigleaf maples, at 67%, were slightly lower because most of them were at least 4-5 feet tall when transplanted. A higher mortality rate was expected, and in fact there was significant die-back the first year for many of the survivors, after which they came back stronger the next year.

As noted below (Oxygen Availability), many of the western redcedars were planted in locations that were too wet even for them, which probably explains the 63% survival rate.

The incense-cedars and all but 2 of the grand firs were bare root, which when considering the size issue discussed above, explains their lower survival rates of 62% and 48%, respectively.

Month Planted

The data shown in Figure 4 above are not conclusive, since the numbers of trees planted in all the months other than February are so small. And the low survival for February-planted trees is not necessarily an indication that that is a bad month in which to plant. Rather, it reflects the fact that the substandard batch of 50 Douglas-firs were planted that month, and most of the others planted that month were bare-root (which had the lowest survival rate of all the stock types).

Stock Type and Condition

As discussed above, bare-root stock has presented the most challenges for ensuring survival, while containerized trees seem to have provided the best opportunity for survival. If containerized trees are intermediate in size, healthy, and aren't root-bound (and if they are, close attention is paid to loosening and pruning the roots before planting), good results can be expected. However, bare-root stock is much cheaper and can thus be replaced on a relatively large scale at nominal cost. The downside of bare-root stock is that it takes much longer to become established and for trees to grow into a significant canopy.

Oxygen Availability

This was a strong possibility for some of the western redcedars planted close to the gully along the west edge of the site. While this species prefers moist soils, there may have been too much water in winter and spring to allow sufficient oxygen uptake by their roots.

Nitrogen Availability

Since nitrogen analysis wasn't included in the UMass standard fertility test, it is possible that a borderline deficiency could have existed that might have contributed along with other factors. As noted in the Methods section above, only a relatively few of the trees (Douglas-firs) showed overt signs of nitrogen deficiency (chlorosis) when received from the nursery. Most of those suffered substantial leaf loss during the first year, but presumably because of increased nutrient availability from the native soil they were planted in, the survivors of this group had abundant new growth in years 2 and 3.

Trace Metal Toxicity

In addition to lead and aluminum, which were included in the soil tests conducted for this project, there could be other heavy metals present (e.g., cadmium, mercury, arsenic) that could have contributed to some tree deaths. Since some refuse was encountered when digging holes for planting trees and sampling soil, this is an important area for future concern.

Other Toxic Substances

Also not tested for in this project was the presence of other toxic substances such as petrochemicals (e.g., motor oil, paint, solvents) and pharmaceutical waste.

Insect Damage, Pathogen Infection

While no overt signs were noted, it is possible that upon closer inspection there might have been insect or microorganism infections present. It is also possible (though highly unlikely) that partially decomposed animals may have become trapped in the garbage piles before the landfill was capped. They may be harboring bacteria that could be upsetting the balance of microbial flora in the rhizosphere, or out-competing beneficial endophytic bacteria.

Climate Change Predictions

It is well known that global warming is occurring due to the increasing additions of greenhouse gases to the atmosphere, mostly from the burning of fossil fuels. As a result, global climate patterns are changing. There are many models that attempt to predict what these changes will be in any given region. For the Pacific

Northwest, the decrease of snowpack in the mountains with rising temperatures could increase warming by losing the cooling effects of the snow (Climate Change in the Pacific Region 2011, Mass 2008). On the other hand, because global warming will increase low marine clouds over the Pacific, the region could actually become cooler (Mass 2008). In either case, annual precipitation totals may not change significantly. However, "considerable uncertainty exists" (Mass 2008), so it is prudent to plan for either contingency. This is the basis for planting incense-cedars and Douglas-firs from southern Oregon, and redwoods and sequoias from California, at this site for future monitoring.

Conclusions

For a restoration project of this type and scope, there are several lessons learned from experience working on this project for the past two and a half years.

While it is tempting to go out and start planting trees right away (especially when you find a good deal from a nursery that is liquidating its substandard stock, and they have exactly what you need), thorough planning at an earlier stage could have avoided some tree losses.

For a site of this size, use containerized trees that are at least 3-4 feet tall (depending on species). If the budget can support it, only get high-quality stock that is healthy and not root-bound.

Be more systematic in mapping the site and numbering the trees. Assigning numbers in the order planted would be helpful. In this project, when entering tree numbers into the Access database, we found that we had three duplicates that had to be corrected.

Take the time to plant each tree carefully, by digging a large enough hole, loosening and pruning roots as necessary, shaking out as much potting soil as possible, and planting the roots in native soil (from borrow pits if necessary). Water in thoroughly, and add up to 8 inches of mulch (Chalker-Scott 2002). (For this project, only 2-4 inches of mulch were used, which is why frequent weeding was necessary.)

Finally, enlisting more help from volunteers would have lessened the workload for all individuals, instilled a sense of long-term commitment (for ongoing stewardship of the site), and most importantly it would have resulted in higher rates of tree survival.

Management Plan

This plan will specify maintenance goals, monitoring tree and understory growth, comparing the relative survival of natives vs. trees from warmer climates, and observing any limitations of root growth due to soil depth over the landfill or exposure to toxic substances in the shallower soil depths.

This report and all data files associated with this project will be left with the faculty manager of UBNA (currently Professor Kern Ewing), with instructions to pass them on to their successors. This will ensure continuity of maintenance and enhancement of the site, as it develops from its current state to an established (and eventually old growth) ecosystem.

Inventory of Existing Vegetation

In addition to the survivors of the initial 2007 plantings (listed in the Introduction), a few species of European pasture grasses (Table 1), the invasive species that subsequently colonized (Table 2), and the native species planted (Table 3), there are several other species present.

There are several large black cottonwoods (*Populus balsamifera* ssp. *trichocarpa*) along the northern edge of the site. There are also a few snowberry (*Symphoricarpos albus*), some Pacific willow (*Salix lucida*), one Oregon ash (*Fraxinus latifolia*), and 5 species of moss.

Goals and Objectives; Performance Standards

The overall goal of this plan is to assist the site in achieving a self-sustaining ecosystem composed of native plant species that provide habitat for birds and mammals, and that provides educational opportunities to the general public.

The specific objectives are to monitor the growth and survival of the trees that were planted in 2007 and 2012-2013, and to compare the success of the native species with the non-natives as climate change occurs. These provide good opportunities for future graduate student projects.

For the first 10 years, all trees that die will be replaced. By then a reasonable canopy will have become established. For those that have died after their third growing season, soil will be tested for toxic chemicals that may have seeped up from the underlying landfill. If any hazardous situation is discovered, the UW Department of Environmental Health and Safety will be notified so they can assess the situation and take corrective action if necessary. After 10 years, if a tree dies it will be left in place as a snag, to provide bird habitat and simulate natural conditions.

The desired result is a wooded area that resembles a Puget Sound lowland forest as much as possible, given its location on a capped landfill, somewhat eclectic species composition, and small size. The western edge will border the wetland that will be created as part of the WashDOT Highway 520 Mitigation Plan (see below), but the site's hydrology will not be changed as a result. This lowest edge of the site (currently bordered by a gully) will serve as a transition zone, having already been planted with Scouler's willow, sword fern, western redcedar, Sitka spruce, and western hemlock, species that prefer moist soil.

The maximum overstory canopy cover will probably be approximately 80-90%, due to the plan to leave snags after the first 10 years, and subsequent expected losses due to senescence, wind damage, or pests. It is difficult to estimate the growth rate for any given tree species, since it depends on many site-specific factors, such as planting density, water and nutrient availability, and the presence of invasive species. But since Douglas-fir has the greatest number of trees on this site, and several have survived for 7 years since the 2007 initial restoration attempt, growth and canopy development of the site can be roughly approximated from the growth of those trees. The largest of those is currently about 15 feet tall and has a spread of about 10 feet. Assuming a constant rate of growth, it is reasonable to expect that after 10 years the largest of the trees planted for this project will be approximately 21 feet tall with 14-foot spreads. (I have observed almost exactly that rate of growth in a Douglas-fir I planted as a bare-root sapling in a residential yard in Seattle in 1990, that is now about 50 feet tall.) That 7-foot radius around each tree would almost completely close the canopy in a pure Douglas-fir stand planted on 8-foot centers. But since Douglas-firs only account for 44% of the trees planted on this site (N=111), the growth rates of the other species would have to be considered in estimating canopy development. The next most abundant tree species is grand fir (N=42), then at approximately equal numbers are incense-cedar (N=21), western redcedar (N=20), Sitka spruce (N=19), and bigleaf maple (N=18). Incense cedar, Sitka spruce, and bigleaf maple are fast-growing (as is Douglas-fir), while grand fir and western redcedar grow somewhat more slowly (Kruckeberg 1996). Therefore, the 10-year canopy would fall short of the 80% minimum that is expected when the site is mature. There are too many variables to be able to make an exact prediction, but a reasonable estimate is that this level will be reached somewhere between 15 and 20 years from now.

There will be an uneven understory sub-canopy, which will depend on what additional species are later planted, and where they are planted.

Because of the inconsistent depth and quality of the landfill cap soil at the site, the trees that are in shallower areas may not reach their full growth potential due to increased competition for nutrients and water. If it is determined that a given tree has died for this reason, it should be replaced with a smaller tree or one or more large understory shrubs.

In order to accomplish the project goals, it is important that maintenance is done consistently. Therefore, it is imperative that someone be responsible for coordinating these activities. Ideally, that would be a permanent Restoration Ecologist whose job it would be to oversee all restoration activities at UBNA. But until and unless this type of position is created, the responsibility for carrying out this plan should be divided between the UWBG restoration ecology faculty, the graduate student UBNA manager (during the quarters when that position is funded), and the SEFS Alumni Association.

In order to encourage volunteers and help them realize their time investment as well-spent, they should be reminded that as the native trees and understory plants become more established and able to better compete with invasive species, the maintenance efforts will gradually decrease.

Compatibility with UBNA Management Guidelines 2010

This project is in compliance with all 9 "broad categories of action" specified in the "Guidelines" document (Ewing 2010). They are listed below, with explanatory information added for those categories not fully addressed in this report.

- *Remove invasive non-native plants and animals.* No invasive non-native animals have been observed at this site.

- *Add native plants.*
- *Maximize habitat diversity and native biodiversity.*
- *Control human impacts.* The interpretive signage specified for this project will foster appreciation for the natural state of this site, and remind visitors to stay on posted trails.
- *Monitor physical and biological conditions.*
- *Increase and coordinate teaching and research.* The educational aspects of this project should attract the interest of instructors and students from the UW and other local educational institutions.
- *Enhance personal safety.* The trail will be kept clear of weeds and debris that might impede visibility or cause tripping accidents.
- *Ensure public accessibility.*
- *Provide educational interpretation.*

Compatibility with Washington Department of Transportation (WashDOT) Highway 520 Mitigation Plan

This project site is not included in the WashDOT Plan, and should not be impacted by any of the mitigation projects. Neither the enhancement of the forested wetland to the north of the site, nor the construction of a hydrology berm near the northwest corner of the site, will be impacted. The berm, only about 8 feet wide (WashDOT draft specification map, 4/16/2014), will direct water southward into the seasonally inundated pond that will be constructed at the current location of the E-5 parking lot (adjacent to the southwest corner of the project site).

Timeline

Summer 2014

- Replenish wood-chip trail.
- Install interpretive signage.
- Open trail to the public.
- Continue invasive species control, ensuring a weed-free buffer around each tree and understory plant.

Fall 2014

- Organize SEFS Alumni Association work party to plant trees to replace those that have died, as well as filling in the few available spaces not previously planted (at 8-9 foot center density).

Winter 2015

- Conduct invasive species removal work party; concentrate on Himalayan blackberry, which is not actively growing and is easier to get to.

Spring 2015

- Conduct invasive species removal work party.
- Start regular testing soil for trees that have died after their 3rd growing season.

Fall 2015

- Remove and replace trees that have died.
- Start planting more understory plants in the shade of the biggest trees.

2016 and Beyond

- Continue winter and spring invasive species removal work parties.
- Replace interpretive signage as conditions change.
- Continue regular soil testing for dead trees.
- Continue planting understory plants to increase diversity.
- Continue replacing dead trees every fall.
- Start measuring tree trunk diameters in 2017 and every three years after that (baseline done in 2014), to be used in assessing overall survival and comparison between natives and non-natives, as described above.

2023

- This will be the last year to replace dead trees.
- Discontinue soil testing.

2044

- Start selective thinning to create openings for sunlight, to encourage native trees to grow and become established.

Recurring Tasks

As indicated in the Timeline above, there should be invasive species removal work parties conducted every winter and spring.

Until year 10, trees that have died will be replaced. Soil should be tested for toxic substances for trees that have died after their 3rd growing season.

Understory species should be added as appropriate every fall until an adequate level of diversity is reached.

Interpretive signage will have to be updated as site conditions change, trees are replaced, and understory plants added.

Tree diameter measurements should be taken every few years to provide data for long-term growth monitoring, which has the potential for use in graduate student projects.

Staffing Requirements

Maintaining and monitoring this site will be carried out primarily by community volunteers as well as UW students (work parties for course requirements of extra credit). As recommended above, oversight and coordination will be the responsibility of UWBG faculty, the graduate student UBNA manager, and the SEFS Alumni Association.

Plant Materials

Trees will need to be purchased or donated to replace trees that die within the first 10 years. Also, additional understory plants should be added as the canopy develops and provides increasing shade. This won't be expensive for a site of this size, so even $500-$1000 per year of UWBG funding (adjusted for future inflation) should be adequate to cover all costs. Plant donations will decrease the amount of UWBG funding actually used (but see the next section for potential costs of hired contractors and soil testing). If funding and/or donations permit, intermediate-sized trees in containers should be used rather than bare-root stock. This will minimize the time it takes them to become established, and assuming adequate care and maintenance, will result in very high survival rates.

Resources and Equipment Needs

In order to perform maintenance of the site (i.e., invasive species control and planting replacement trees), tools such as shovels, pruning shears, loppers, and weed wrenches, will be needed. It is hoped that arrangements can be made to borrow these from the UBNA tool cage, in a relationship similar to the one that the "Friends of Yesler Swamp" currently has.

Because it is expected that canopy development will increasingly shade out invasive species, manual and mechanical removal methods will probably be sufficient. However, if any particularly troublesome, unexpected invasions occur (for example, English ivy in the increasing shade), it may be necessary to use herbicides. In this case, appropriate equipment would be needed. This should be available from CUH grounds staff. If none of the volunteers have a herbicide license, then CUH could provide someone to do the work. As a last resort, a contractor could be hired if funds are available.

As stated above, soil testing will be done for all trees that die after their third growing season. These could be done as a student project, but if that option isn't available, samples would have to be processed by a professional lab. CUH funds could be made available, or donations solicited from volunteers.

Collaboration with SEFS Alumni Association

Efforts will be made to encourage the SEFS Alumni Association to participate in the stewardship of this site. They were responsible in part for the establishment of the site for the initial planting in 2007, and are aware of the current restoration project. Through regular maintenance events, volunteer recruitment can be increased by encouraging members to bring along family and friends.

Outreach and Education Opportunities

Because this site is located on Wahkiakum Lane, a very popular and heavily-used gravel path through UBNA (birders, hikers, joggers, and people passing through to attend events at the Center for Urban Horticulture or Husky Stadium), it presents an opportunity to educate the public about ecological restoration. This can be accomplished by installing interpretive signs to explain the purpose and goals of restoration ecology, the techniques used and problems encountered for this project, and information about the species planted (i.e., for diversity and climate change). The signs should be erected at the entrances to the site (overview of the project, goals of restoration, reminder to stay on the wood chip trail - people and dogs) as well as along the wood chip trail (information on species planted, especially non-natives from Oregon and California, as well as invasive species).

Two or three benches should be installed for visitors to sit and rest, to observe birds and other wildlife, or to simply reflect on the natural processes that are taking place around them.

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Appendix - Seattle Weather Data

Monthly High Temperatures, 2007 (degrees Fahrenheit). All data from Weather Warehouse, except *, from Seattle Monthly Averages and Records.

Year	Month	High	Average High for this Month/Year	Seattle Monthly Average High*
2007	June	84	69.3	70
2007	July	98	77.3	75
2007	August	86	74.8	76

Monthly Low Temperatures, 2007 - 2009 (degrees Fahrenheit). All data from Weather Warehouse, except *, from Seattle Monthly Averages and Records.

Year	Month	Low	Average Low for this Month/Year	Seattle Monthly Average Low*
2007	December	28	36.0	36
2008	January	25	33.8	36
2008	February	31	38.2	37
2008	March	31	37.0	39
2008	December	14	33.0	36
2009	January	25	34.4	36
2009	February	26	34.8	37
2009	March	26	35.4	39

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