North Creek Forest
UW-REN Restoration Project 2013 - 2014
Stewardship Plan

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I. Project Description

The 2013-2014 University of Washington Restoration Ecology Network (UW-REN) restoration project is located in North Creek Forest, which is defined as a priority habitat by the Washington Department of Fish & Wildlife (Friends of North Creek Forest 2013), and is adjacent to and directly north of both the 2011-2012 and 2012-2013 UW-REN sites. Occupying an area of roughly 2145 square meters, the site has a moderately steep slope on its western end that gradually levels out towards 112th Ave NE on the eastern edge. Vegetation cover ranges from a maturing seral forest on the western edge to an open area with decreasing structural and species diversity and increasing invasive species establishment to the east. Soil texture varies from silty loam in the forested area to clay and then to silty loam to the east. Taking these variabilities across the site gradient into account, we divided our project site into three polygons based on their predominant vegetation, soil characteristics, and the amount of exposure to solar radiation (Figure 1).

To prepare for restoration, the 2013-2014 UW-REN North Creek Forest Team, with the help of Friends of North Creek Forest (FNCF), removed dense thickets of Himalayan blackberry (*Rubus bifrons*) that invaded almost all of Polygon 2 along with some English holly (*Ilex aquifolium*). Another significant modification was the removal of two derelict cars and one abandoned trailer from Polygon 2 and 3 as well as the extraction of anthropogenic debris from above and below the soil in Polygon 2 as an effort to restore the soil quality. Our team has designed and implemented a restoration plan to address these issues with the help of our community partner, Friends of North Creek Forest, as well as numerous volunteers from the community. The primary goal of our project is to restore this site by enhancing its biological diversity and ecological functions in order to further plant succession, allowing the area to assimilate with the rest of the seral forest. To achieve this, our team has selected and installed a diverse array of native plants that provide habitat and resources for native fauna. These plants will also compete with and shade out invasive plant species and create structural diversity.

Due to the anthropogenic disturbances that have occurred at North Creek Forest, we acknowledge that human interference is necessary to ameliorate the forest's present conditions. In addition to teaming up with FNCF to help restore the disturbed areas of North Creek Forest, we are reaching out to the community to educate local citizens on the importance of restoring this site so that they may be encouraged to volunteer and be a part of the process. Furthermore, our site resides in an area of the forest in King County that is owned by a family and a developer, not the City of Bothell who owns the northern portion located in Snohomish County (Friends of North Creek Forest 2013). The remaining landowners are willing to sell (Friends of North Creek Forest 2013), making it crucial to bring awareness to the community of this situation in an effort to save the rest of the forest. Thus, we are aiming to foster the spirit of stewardship through promoting educational workshops, hands-on and project-based learning, and volunteering opportunities to local schools and organizations to assist in protecting, preserving, and maintaining North Creek Forest.

II. Post-Installation Site Description

Polygon 1

Polygon 1 sits on the eastern edge of the project site and is adjacent to 112th Ave NE (Figure 1). It receives direct sunlight from the east, moderately filtered light from the south, and most of the polygon receives full sun from the west as well. The area is approximately 325 square meters with a moderate incline of 15-20° from the east sloping up towards the western edge. The southern edge slopes down slightly allowing more moisture to pool in that area which is dominated by a large stand of Pacific willow (*Salix lucida* ssp. *lasiandra*). The Pacific willow stand, which spans from the southeastern section of Polygon 1 up to the southwestern section of Polygon 2, creates a natural barrier between last year's and this year's project sites. Most of the soil in Polygon 1 is a well-drained silty loam but there is also a long patch of gravelly soil from the entrance of the site continuing up through the west end. The northern edge of Polygon 1 is dominated by large, well established western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), a Garry oak (*Quercus garryana*), and a bigleaf maple (*Acer macrophyllum*), as well as a few large stumps and logs. Other than these existing trees on the northern and southern edges, there is very little canopy cover in this polygon and the understory below the mature trees was dominated by nonnative Himalayan blackberries intermingled with patches of English holly. In addition, the ditches between the road and the eastern end of the project site is inhabited with invasive reed canarygrass (*Phalaris arundinacea*). Along with the invasive species there was also a great amount of garbage and other anthropogenic debris on site including glass, tiles, plastic, barbed wire, and concrete pieces.

Working in collaboration with FNCF and student volunteers from local schools including University of Washington Bothell, almost all of the debris and invasive species were cleared away from all three polygons. The Himalayan blackberry plants were removed by cutting the stems down to a height of one to two feet. During later work parties all of the attached roots and rhizomes were dug up using shovels in order to hinder propagation and minimize the number of re-emerging Himalayan blackberry plants. Smaller English holly plants were uprooted manually as well. Soil erosion was prevented by spreading wood chip mulch to a depth of at least 2 inches after the underground parts were removed. More wood chip mulch was then applied across the polygon to a minimum depth of 6 inches which will provide the benefits of reducing erosion, retaining moisture, adding nutrients to the soil as the mulch decomposes, and reducing the re-establishment of invasive species (King County 2013c).

Our long-term goals for this site include establishing a space for education, artistic inspiration, and community involvement as well as to further develop the conifer-deciduous mixed forest across all three polygons. With these goals in mind, we created a space for reflection and teaching on the northeastern edge of Polygon 1 where a bench was placed under the canopy of the existing Douglas-fir and western redcedar stand. At the entrance of this reflective glade we placed a bridge, created from a door found on site, across the seasonal stream bed connecting the trails. Shade tolerant plants such as red huckleberry (*Vaccinium parvifolium*), western sword fern (*Polystichum munitum*), salal (*Gaultheria shallon*), evergreen huckleberry (*Vaccinium ovatum*), Pacific bleeding heart (*Dicentra formosa*), and vine maple (*Acer circinatum*) were planted around the periphery of the space in order to develop structurally

diverse understory. To enclose this small glade we planted western redcedar. On the southern side of the cedars, we installed a row of red alder (*Alnus rubra*) to create shade and vertical structure while the western redcedar mature. Along the trail and forest edges, we planted a number of shrubs approximately 0.5 to 1 meter apart. These shrubs included baldhip rose (*Rosa gymnocarpa*), common snowberry (*Symphoricarpos albus*), and red-flowering currant (*Ribes sanguineum*), which will provide food and shelter for wildlife as well as create structural diversity across the polygon. Down the length of the ditch on the eastern edge, Indian plum (*Oemleria cerasiformis*) was planted in order to partially screen our site from the road while also providing some shade to slow the growth of the reed canarygrass (King County 2011b). Around the perimeter of the Pacific willow stand we staked red-osier dogwood (*Cornus sericea*) and Pacific willow in the moist soil to create shade and structure along the southern edge of Polygons 1 and 2. Across the polygon we planted Douglas-fir, western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), and Sitka spruce (*Picea sitchensis*) spaced at least 1 m apart so that they may, over time, develop the upper canopy and facilitate the development of the conifer-deciduous mixed forest (Martin et al. 1996).

Polygon 2

Polygon 2 is roughly 936 square meters and has a slope of 25-30° with slightly more shade than Polygon 1 from the western side, but there is significantly less cover on the northern edge as there are fewer large trees along the border. The groundwater of North Creek Forest flows diagonally across this polygon from the northwestern corner to the southeastern corner (Figure 1). Seasonally there is standing water at the center. The soil here is predominantly clay and holds water well. As with Polygon 1, the understory was dominated by Himalayan blackberry, though there were a few stands of salmonberry (*Rubus spectabilis*) around the western end of the Pacific willow stand. In addition to the garbage found on all the polygons there were vehicles lying underneath the Himalayan blackberry as well as a large amount of woody debris and concrete pieces strewn across the area.

The main objectives of this polygon are to remove all the garbage and invasive plant species, utilize the existing rocks and woody debris to enhance wildlife habitat, plant species appropriate to the various microclimates, and plant trees that would further the successional progression to meet our long-term goal. With these goals in mind we removed the invasive species, applied wood chip mulch, had the vehicles cut apart and hauled away, and staked red-osier dogwood and Pacific willow around the stand of Pacific willow. The woody debris was placed in brush piles, one on the eastern edge of Polygon 1 and the other on the southwestern edge of Polygon 2 which has been utilized in creating pathway edges through the site. The concrete pieces were piled up to form a long mound around the saturated area of the polygon and it borders the north side of the main trail (Figure 1). The pile was filled with planting soil and partially covered with mulch. The mound was then treated with a moss milkshake and planted with coastal strawberry (*Fragaria chiloensis*), woodland strawberry (*Fragaria vesca*), and Kinnikinnick (*Arctostaphylos uva-ursi*). The groundwater was partially diverted to form a seasonal stream from the western to eastern edge of the polygon as well as a divergent stream that flows into the saturated area at the center of the polygon (Figure 1). In this saturated area we planted western skunk cabbage (*Lysichiton americanum*) and slough sedge (*Carex obnupta*). We also built up a bank on the southern and northern edges where devil's club (*Oplopanax horridus*)

was installed at the request of our community partner. In order to plant a greater variety of plants we created four raised beds across the polygon where seasonal moisture would otherwise cause mortality to upland plants. In these beds we installed salal, low Oregon grape (*Mahonia nervosa*), western sword fern, Douglas-fir, western redcedar, grand fir, and western hemlock. To the west of the highly saturated portion of the polygon we installed red alder in this highly disturbed soil for its nitrogen fixing properties (Uchytil 1989). We also installed bigleaf maple and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) to enhance the forest canopy well back from the main trails to eliminate the risk of falling debris harming people in the future as these trees mature (King County 2013a).

Polygon 3

In Polygon 3, all but the eastern end is under the seral forest canopy and receives mostly filtered sunlight. The slope is 15-25° with an area roughly 884 square meters where the soil is a sandy to silty loam that is well drained. Despite some encroachment of Himalayan blackberry, there is a significant understory composed of western sword fern, youth on age (*Tolmiea menziesii*), low Oregon grape, Indian plum, salmonberry, and vine maple. There was some anthropogenic debris across the polygon including an abandoned car which was cut up and removed when the vehicles from Polygon 2 were taken away. The main goal for this polygon was to enhance the existing understory with greater diversity and to extend the canopy down through to eastern edge. The Himalayan blackberry was removed and wood chip mulch was applied, though more will need to be added to achieve the minimum depth of 6 inches. We layered our planting so that we could create more diverse structure by planting shrubs about a meter from the trees and by keeping the groundcovers and ferns within 0.5 meters from the shrubs. To further develop the canopy, Douglas-fir, western redcedar, and grand fir were planted at least one meter apart. To enhance to understory diversity and structure, Pacific ninebark (*Physocarpus capitatus*), salal, goat's beard (*Aruncus dioicus*), lady fern (*Athyrium filix-femina*), and spiny wood fern (*Dryopteris expansa*) were installed.

III. Maintenance Plan

To help ensure the success of our restoration project, maintaining the native plants that our team has installed is imperative. With proper maintenance and monitoring, installed plants will have a greater chance of surviving and establishing properly to the site. Four methods of maintenance that we suggest for this site are watering, mulching, invasive plant control, and pest control. These methods of care will help secure proper plant growth, minimize invasive plant species from reemerging, and protect the plants from herbivores.

Frequency of watering will depend on the climate and time of year, the plant species and their ideal moisture requirements, the size of the plant, the location of the plant in terms of distance from flowing water, and cost-effectiveness (Dorner 2002). July and August typically have the highest average temperatures and the least precipitation, so during these drier times of the year inspection of the plants will help determine if watering is needed. Otherwise, the amount of watering should be applied to mimic average annual precipitation in Bothell to prevent overwhelming the plants with excess moisture (Dorner 2002). If the leaves of a plant that requires more moist conditions (e.g. western skunk cabbage, red-osier dogwood, devil's club,

goat's beard) are wilting or are turning dull in color, watering will be needed (Dorner 2002). The leaves of some native plant species wilt earlier than others; therefore, multiple inspections throughout the site will be required to ensure that all plants are being watered as needed (Dorner 2002).

Mulching with wood chips is an integral practice that supports the multifaceted nature of restoration practices as it helps to nurture plant growth and maintain site conditions. Wood chip mulching will retain soil moisture (King County 2013c) which will cut down the frequency of watering and help conserve water (Dorner 2002). In addition, mulching also helps inhibit weed and invasive plant species from regrowing by smothering the cut stems (King County 2013c). Protecting the soil from being directly exposed to extreme temperature and providing soil erosion control (King County 2013c) are also some beneficial traits that we aim to achieve through mulching. The natural process of decomposition and breakdown of wood chip mulch will also provide the soil with nutrients and enhance plant development.

Controlling the spread of invasive plant species is one of the most important elements of ensuring the success of a restoration project (Dorner 2002). In order for our installed native plants to develop into an upland mixed conifer forest and assimilate with the existing, more mature forest west of the site, we must inhibit the re-growth and encroachment of invasive plant species such as Himalayan blackberry and English holly to prevent them from competing with our native plants. Therefore, early detection of re-emerging invasive species and using proper methods to inhibit encroachment are vital to securing the success of our restoration site.

Lastly, protecting the plants from pests will also help ensure their survival. The two herbivores that are of main concern on the restoration site at North Creek Forest are black-tailed deer (*Odocoileus hemionus* ssp. *columbianus*) and mountain beaver (*Aplodontia rufa*). Detection of their presence and visual assessment of any damage will be required to decide the best method of control to minimize damage to the plants.

Maintenance Task List

I. Watering

Why: Watering ensures the plants' survival by keeping them hydrated and by supporting essential processes such as photosynthesis and transpiration. Our site currently has little canopy cover, with the northern and southern edges receiving filtered sunlight through neighboring vegetation, so most of the sun's radiation hits the ground directly. Watering is therefore important to help prevent desiccation and to promote optimal plant growth during dry summer months and prolonged droughts.

A. Potted plants

Where: All potted plants on site or in the nursery.

When: As needed. More watering will be required during drier months, especially during the summer when average temperatures are higher and precipitation is sparse (Table 2). Plants grown in containers will lose moisture more quickly (Department of Environment and Resource Management: Queensland). Therefore, they will need to be monitored closely and planted in the ground as soon as possible.

Resources and tools: A spigot has been set up in Polygon 2 and hoses are either already installed or stored in the tool shed. Watering can also be done using buckets of water

How: Check the moisture content of the soil by pushing your finger about 5 centimeters down the soil. If the soil feels damp at that depth, watering is not required (Department of Environment and Resource Management: Queensland). If it requires watering, use enough water to soak through the soil down to the roots to promote deep root growth (Department of Environment and Resource Management: Queensland). Also check for wilting leaves.

B. Live stakes

Where: A majority of live stakes are planted around the Pacific willow stand in the southern edges of Polygon 1 and 2 and around the northern edge of Polygon 2 (Figure 1).

When: Monitor plants for signs of desiccation, such as dropped leaves or twigs in hardwoods or odd colored needles in coniferous trees, throughout the year, especially during summer droughts, and water as needed (Table 2).

Resources and tools: A spigot has been set up in Polygon 2 and hoses are either already installed or stored in the tool shed. Watering can also be done using buckets of water.

How: Established live stakes need to be watered once a week during the first and second year following installation (DesCamp 2004) and monitored closely for signs of desiccation.

C. Bare root trees/shrubs

Where: The bare root plants can be found all over the project site but are mostly located in Polygon 2**.**

When: Water as needed after new bare root plants are established into the site and every 7 to 10 days during dry weather following the first year of establishment (Arbor Day Foundation).

Resources and tools: A spigot has been set up in Polygon 2 and hoses are either already installed or stored in the tool shed.

How: For established bare roots, soak the soil and mulch thoroughly along the drip line (the outer part of the canopy circumference where rain water drips down into the ground) gently with a hose (Arbor Day Foundation).

II. Mulching

Why: Past studies by Linda Chalker-Scott show that mulching retains soil moisture and suppresses competing weeds. Mulching was also documented to promote greater plant establishment to new sites, make their growth more vigorous, and allow overall higher survivorship (Chalker-Scott 2007).

Where: Throughout the site, especially in areas where vegetation is prominent and in areas where there is less than 6 inches of mulch.

When: Apply wood chip mulch whenever the site has been cleared of invasive species or while weeds are dormant, especially when seed germination is at its peak around spring and fall (Chalker-Scott 2007) (Table 2).

Resources and tools: Pitchforks, rakes, and wheelbarrows are available in the tool shed.

How: With time, mulch will break down and decompose due to weathering and other

natural events. In areas where mulch has deteriorated, spread fresh mulch on top of the old layer to form at least 6 inches in depth of mulch.

III. Invasive control

A. Himalayan blackberry

Why: Himalayan blackberry propagates quickly, forming dense monocultures and outcompeting native species for space and nutrients, thus decreasing ecosystem diversity (King County 2013b).
Where: Remove the remaining cut blackberry canes and rhizomes and check all throughout the site for re-emerging plants for removal (Table 2).
When: Whenever signs of regrowth are evident.
Resources and tools: Shovels, loppers, and tarps are located in the tool shed.
How: For dense thickets, start plant removal in areas that are least infested. Cut canes down to 1-2 feet above the ground to facilitate subsequent rhizome removal. Remove rhizomes and roots manually by digging around the approximate area where the rhizomes are located and pulling out as much of the underground parts as possible. Removal of the rhizome is the most critical part of preventing propagation. Pile the canes and rhizomes on top of a tarp to be collected and disposed.

Image © 2004, Ben Legler

B. English holly

Why: English holly can form dense thickets that suppress native species development (King County 2008). In addition, this species requires significant amounts of water so it may compete with native plants for moisture (King County 2008).

Where: There are several individuals on the northern edge of Polygon 2 and their presence has been acknowledged by FNCF and will be addressed in the near future. Young seedlings may appear anywhere around the site, but most specimens have been located around the northern edge of the site.

When: Whenever signs of regrowth or resprouting are evident.

Resources and tools: Axes, loppers, shovels, and tarps are available in the tool shed. Glyphosate products such as Round-Up may be purchased at hardware stores or nurseries.

How: Small plants can be pulled manually or dug out using a shovel. Remove as much of the roots as possible. For bigger trees or individuals with especially thick stems, frill or cut their trunks and directly apply Glyphosate/Round-up to the cut during drier seasons to avoid having the herbicide washed away and spread into the soil by rain (King County 2008).

Image © 2005, Ben Legler

C. Reed canarygrass

Why: Given their versatile propagation methods and aggressive habits, reed canarygrass can form monocultures in wetter areas, thus decreasing ecosystem diversity. The grass appears to be dormant during the fall and winter, but with enough moisture in the spring and summer, they will vigorously re-establish themselves around the ditch and possibly invade Polygon 1. In the past, there have been legal and administrative concerns with the city's property rights over the ditch that is invaded with reed canarygrass, so we did not administer treatments around this area. Therefore, any control approaches should be coordinated through the City of Bothell.

Where: Along the ditches, which are located on the southeastern and northeastern edge of Polygon 1.

When: Evidence of significant encroachment into Polygon 1 will be a cue for practitioners to start mitigation efforts.
Resources and tools: Shovels and loppers are available in the tool shed.
How: Mowing is arguably the most successful mechanical method that is applicable for this restoration project. It removes seed heads before maturation to prevent spreading and exposes the ground to sufficient light to encourage native species growth to prevent re-establishment of reed canarygrass (Washington State Department of Ecology). Twice yearly mowing in early to mid-June and early October in Wisconsin has demonstrated increased native species growth (Washington State Department of Ecology) and therefore promotes greater reed canarygrass control success.

Image © Richard Old

D. European mountain-ash

Why: European mountain-ash (*Sorbus aucuparia*) seeds are dispersed by birds and may replace native tree species (King County 2012). It is widespread and has been known to establish in natural lands and urban parks in King County (King County 2012). It is recommended that European mountain-ash is removed from restored sites (King County 2012) to prevent competition with native species and invasion.
Where: A few immature specimens have been located on the northern side of Polygon 2.
When: Whenever signs of new growth are evident.
Resources and tools: Shovels and tarps are located in the tool shed.
How: Due to the fact that the located specimens are new growth and immature, manual removal will suffice. If berries have been produced, remove the plants immediately to prevent seed dispersal by birds.

Image © 2005, Ben Legler

IV. Pest Control

A. Black-tailed deer

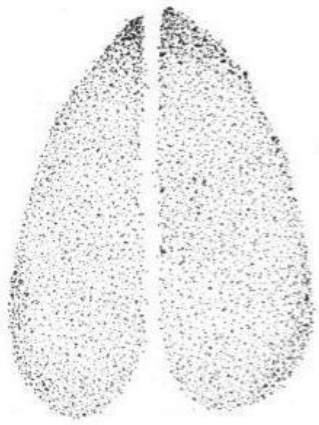
Why: Black-tailed deer may cause plant damage or plant mortality through herbivory (University of California: Statewide Integrated Pest Management Program 2004). Bucks may also strip bark off of trees and break branches by rubbing, thus decreasing plant fitness. Damage caused by these deer are severe and can potentially interfere with the restoration process, especially since the plants we installed are young. This approach is for temporary repelling until the plants are mature enough to support the deer's diet

Where: In areas where signs of herbivory are present. Check especially in areas where vine maple, salal, Douglas-fir, cascara (*Frangula purshiana*), salmonberry, willow species, or western redcedar sapling exists, since these species are plants commonly eaten by deer (Link 2014).

When: As soon as signs of herbivory or deer visitation are evident (i.e. evidence of hoof marks and droppings), deer repellent should be applied before signs of new plant growth appear to prevent deer from developing a routine feeding pattern on site (Link 2014).

Resources and tools: Homemade deer repellent, which is an effective countermeasure for dealing with short term low to moderate deer damage, can be made by mixing 2 beaten and strained eggs, 1 cup milk, yogurt, buttermilk, or sour milk, 2 teaspoon Tabasco sauce or cayenne pepper, 20 drops essential oil of clove, cinnamon, or eucalyptus, 1 teaspoon cooking oil or dormant oil, and 1 teaspoon liquid dish soap to produce 1 gallon deer repellent (Link 2014). Fences can also be used to prevent damage. Deer fences can be purchased from gardening or home improvement centers.

How: Mix the ingredients above together in a one gallon tank sprayer and top with water (Link 2014). Shake and spray the mixture onto dry foliage or areas that need protection. One application is effective 2 to 4 weeks in dry weather (Link 2014). Re-apply repellent if rain or hot temperatures occur (Link 2014).



Black-tailed deer hoof print. (Photo provided by the University of California Statewide Integrated Pest Management Program.)

Black-tailed deer droppings. (Photo provided by the University of California Statewide Integrated Pest Management Program.)

B. Mountain beaver

Why: Mountain beavers damage plants by clipping conifer seedlings or by girdling the base of mature tree roots and stems which will often weaken or even kill trees (Taylor et al. 2013). Several plant species such as sword fern, bracken fern (*Pteridium aquilinum*), Douglas-fir, western hemlock, western redcedar, and red alder are considered part of the main diet of mountain beavers (Campbell 2005). These plant species are currently present or are incorporated as a part of the restoration plan, so the presence of mountain beavers on site may detrimentally affect the course of our restoration.

Where: Wherever signs of beaver activity are apparent throughout the site. Mountain beavers dig tunnels that are six to eight inches in diameter in forested areas that have a lot of trees and leaf debris to increase their safety (Pet Control Northwest 2013).

When: Whenever evidence of beaver-caused damage is evident. Signs of beaver activity on trees with diameters of about 3-6 inches are: bark stripped from the base (girdling), no pieces of bark are left and are scattered around the girdled area, and clipping resulting in a 45 degree angle clean cut (Campbell 2005).

Resources and tools: Plastic mesh seedling protectors and cage traps.

How: Apply small diameter plastic mesh seedling protectors to protect conifer seedlings (Campbell 2005). Set cage traps in areas where there are beaver tunnels or wherever

beaver activity is apparent. According to Washington Department of Fish & Wildlife, mountain beavers are territorial; if one is removed, another may invade the area. Therefore, continued monitoring and trapping will be required for control (Washington Department of Fish & Wildlife 2014). They can be trapped anytime, but trapping them late winter before they give birth may be more effective (Washington Department of Fish & Wildlife 2014). When caught, they can be released in deeper areas in North Creek Forest away from the restoration site. Mountain beavers are unclassified so a permit to trap is not needed (Washington Department of Fish & Wildlife 2014).

Mountain beaver (Photo taken by Gary M. Fellers.)

Mountain beaver tunnel home (Photo taken by Gary M. Fellers.)

Maintenance Time Table

For our project's maintenance time table please refer to Table 2 in the Appendix section.

IV. Monitoring Plan

In order to track our project's progress, various monitoring methods have been implemented throughout the site. These methods will help track our plants' progress, monitor potential encroachment of invasive plant species, and document the overall development of our

site over time. In addition, animal activity, potential illegal human activity such as dumping trash, and topographic changes will be monitored. This information will help us determine how effective our restoration efforts have been and what needs to be adjusted over time to ensure the success of our project goals. With a baseline level of the established plants at the end of this project, we can use the methods of photo monitoring and quantitative plot sampling to observe the plants' development and transition through successional stages over time and make sure that they continue to progress in a desirable fashion. For both methods of monitoring the site has been divided into sections that are notable for monitoring structural development. Each process has been outlined below.

Monitoring Methods

There are two monitoring methods that we recommend future practitioners use to monitor several factors that are crucial for the future success of this restoration site. Several control features that we are interested in are plant survival rates, surface erosion, presence of native wildlife, and unauthorized debris disposal. Photo monitoring and quantitative plot sampling will be used to track changes of those features over time. For optimal supervision of the site's development, photo monitoring should be done at least 1-2 times a year starting from the establishment date of photo monitoring locations. For quantitative plot sampling we recommend 1-2 times per year as well, depending on labor availability. Details on locations of photo and quantitative monitoring plots have been added in the following subsections. Something to note is that the established baseline photos and plot data are included in the baseline monitoring report below.

A. Photo Monitoring

The 2013-2014 UW-REN restoration site at North Creek Forest is a large and diverse site with many different plant species and site features, some natural and some man-made. In order to monitor plant growth and success rates of newly established native species as well as the possible regrowth of previously removed invasive species, photo monitoring will be implemented on site. Photo posts have been installed in each polygon where natural features are not large and/or established enough to be used as viable focal points to monitor the progress of the site over time. Due to the large size of the site, a total of 5 man-made photo poles have been installed in each of the polygons where there are no major obstructions that might potentially introduce an external force in affecting the success or failure rates of the recently planted species (Figure 1). Several focal features to monitor using this method are native plant survival and growth, invasive species regrowth, the effect of animal activities on plant species present, illegal dumping of anthropogenic debris, water control and erosion, and mulch levels.

Each photo post has 3 photos taken from different cardinal angles resulting in 15 total pictures. Each picture is accompanied with a label detailing which photo post it was taken from and its picture number. For example, photo 2.3 would be the third photograph from the second photo post. In addition, each photo has the degree from the horizon in which the camera was tilted as well as the cardinal direction the camera was facing in terms of degrees in a circle. 0° would be north, 90° would be east, 180° would be south, 270° would be west. Each photo was

taken from roughly 67 inches above the ground, nose height for our photographer. Baseline photographs to compare to future pictures are found below in the baseline monitoring report.

B. Quantitative Plot Sampling

In order to quantitatively measure the vegetation growth and success of the 2013-2014 UW-REN site, we have selected different areas involving varied environmental conditions and plant purposes throughout the site to monitor and installed a total of 4 plots. The plots are 16 meters squared (4x4 meter plots) and include variables such as sunlight, wind, moisture, decomposing organic materials, and anthropogenic disturbances. We have chosen these plots for monitoring in order to get an accurate idea of what combinations stand the test of time. Each plot has four small blue flags positioned at each of its corners for identification.

Quantitative Plot Sampling 1 in Polygon 1

Quantitative Plot 1 is located around the center of Polygon 1, where mulch is typically dropped near the entrance of the site. This plot was chosen in order to monitor how effectively the plants will form a barrier for the site over time to eventually redirect human traffic to the desired footpath at the southern end of Polygon 1. In addition, this barrier will further enclose the grove, creating natural sound barrier from street noise, around the bench positioned in the north end of Polygon 1 (Figure 1). Initial baseline monitoring reveals that Plot 1 has approximately 60% deciduous canopy cover and a very minute 5% evergreen canopy cover.

Quantitative Plot Sampling 2 in Polygon 2

Plot 2 is located near the eastern end of the rock pile in Polygon 2 and includes a raised bed within it. This plot was chosen in order to monitor plants' establishment and success in areas that receive plenty of sunlight as well as those that are in close proximity to the ephemeral stream. This plot also allows the practitioner to monitor the success of plants establishment in the raised bed. Initial baseline monitoring reveals that Plot 2 has approximately 5% deciduous canopy cover with 0% evergreen canopy cover.

Quantitative Plot Sampling 3 in Polygon 2

Plot 3 is positioned on the northern end of Polygon 2 where there is ample shade from present and neighboring vegetation. This plot is situated so that it monitors the shade tolerant species that are located in the open expanse in front of the seral forest. Initial baseline monitoring reveals an approximate 65% deciduous and 25% evergreen cover comprise the canopy of this plot.

Quantitative Plot Sampling 4 in Polygon 3

Plot 4 is the westernmost plot and is located on the eastern edge of Polygon 3. The objective of positioning a monitoring plot here is so that we will be able to discern what kinds of plants would thrive well in partial shade, as it is immediately located on the border of the North

Creek Forest. Initial baseline monitoring shows an approximation 75% deciduous and 0% evergreen species composing the canopy coverage.

Baseline Monitoring Report

Baseline pictures for the photo monitoring plan were taken on May 26, 2014. Quantitative plot sampling analysis was performed on May 30, 2014. Data of species present, vegetation coverage, canopy cover, and plant survival rates were collected in this process as well as a visual representation of what the site looks like now at the time of this report. Below is a listing of all photo post pictures and descriptions as well as graphs showing what base levels are for plant species in the assigned quantitative plot sampling areas. Additionally, one plant in Plot 1 was unidentified after planting but we have included it in case it is identifiable over time. Recruitment in the quantitative section is in reference to whether or not any species have naturally established themselves in the plot yet. To determine this there will be a need to compare plants and see if it has been marked with flagging already. The layer category in the same section is one of three option of its future vegetation layering type. The first is G for ground cover, the second is S for shrub, and the third is C for a full canopy covering species.

A. Baseline Photo Monitoring

Photo Post 1.1 - Horizon 65° - Cardinal 5°

Photo Post 1.1 is positioned as such in order to monitor the establishment and progress of the planted Indian plum, red alder, western redcedar, large-leaved lupine (*Lupinus polyphyllus*), and baldhip rose. Additionally, from this camera position we are able to monitor the encroachment of looming reed canarygrass from the adjacent ditch in order to determine what actions need to be taken based off of their the pace of their invasion.

Photo Post 1.2 - Horizon 80° - Cardinal 290°

Photo Post 1.2's position allows us to monitor over time the growth of red alder saplings, large-leaved lupine, baldhip rose, and snowberry clusters near the satellite dish remnants. This monitoring location will allow us to witness the development of plant structure and layering of understory growth and eventually canopy cover from species like the red alder. This streamside structure development will eventually complete the glade in which we have placed our wooden bench that can be seen here in the background to the right.

Photo Post 1.3 - Horizon 80° - Cardinal 140°

Photo Post 1.3 is set up in a way that we are facing back towards the southern end of Polygon 1 and can view both plants at the entrance of the site as well as the ditch alongside the entrance. Monitoring this ditch over time will be important as although we have severely reduced the reed canarygrass (*Phalaris arundinacea*) we know that this invasive species enjoys the high moisture areas such as a ditch and so it might reinvade at a later point in time. Additionally with monitoring the potential for this reinvasion we can also monitor the wellbeing of the Indian plum (*Oemleria cerasiformis*) placed along the ditch adjacent to the trail.

Photo Post 2.1 - Horizon 80° - Cardinal 345°

Photo Post 2.1 allows us to view the health and growth of the slough sedge planted along the stream as well as other ground-covering, shade tolerant plants such as western sword fern, Pacific ninebark, low Oregon grape, and salal. This viewpoint also allows us to determine if the path gets changed at all or if there is a sudden revival of Himalayan blackberry among the currently mulched area.

Photo Post 2.2 - Horizon 70° - Cardinal 320°

Photo Post 2.2 is positioned as such so that we can monitor the raised bed seen here as well as the plants along the lower end of our featured stream waterways since we are interested in keeping track of organic structures developing along the stream. These plants' root structures will help prevent soil erosion as they establish as well as provide potential wildlife habitat and an abundance of edible material for animals such as black-tailed deer so that they don't over eat what is currently in place. Plants being developed for this purpose include Pacific rhododendron (*Rhododendron macrophyllum*), bigleaf maple, cascara, vine maple, large-leaved lupine, slough sedge, red alder, Douglas-fir, and a few western hemlock.

Photo Post 2.3 - Horizon 70° - Cardinal 105°

Photo Post 2.3 is designed to monitor the beginning of the footpath into our site. Just off camera to the left is the woody debris pile for reference and the leaning bitter cherry tree (*Prunus emarginata*) is seen in the lower right. Here we have planted species that can tolerate a bit more sunlight compared to other species and can grow quickly to redirect visitors northward to avoid trampling forward into newly planted saplings in the southern section of Polygon 2. Species seen planted in the picture here are western sword fern, Pacific rhododendron, baldhip rose, western redcedar, and two live stake species: Pacific willow and red-osier dogwood.

Photo Post 3.1 – Horizon 70 ° - Cardinal 45°

Photo Post 3.1 is set up in a position to overlook the southern end of Polygon 2 bordering Polygon 1. This is where we have set up a raised bed of soil for various upland plants that can't handle very moist conditions as well as some sunlight tolerant plants and quick growing shrubs and trees. Plants visibly seen here include western hemlock, western sword fern, baldhip rose, bigleaf maple, Douglas-fir, cascara, western redcedar, and common snowberry.

Photo Post 3.2 - Horizon 80° - Cardinal 330°

Photo Post 3.2 takes up a position viewing the majority of Polygon 2 including the central artistic piece which is the area around the rock pile and ephemeral stream water feature. The plants here were chosen for their showy artistic appeal such as coastal strawberry and devil's club. Additionally, plants that were chosen to be planted here can tolerate higher water levels, more sunlight, and develop roots quickly to help prevent soil erosion. The remaining visible plants include western redcedar, cascara, western hemlock, western sword fern, bigleaf maple, red alder, vine maple, and particularly western skunk cabbage along the moist stream-fed soil.

Photo Post 3.3 – Horizon 80° - Cardinal 230°

Photo Post 3.3 is designed to monitor the southern end of Polygon 2. This is a location where we had a woody debris pile for a long time that was only removed to be used as part of lining the footpath towards the end of the project so there is more open area to fill in later with native plants. This photo posts positioning is designed for monitoring species planted in the future as well as some of the more sun tolerant plants that have already been established. Those pictured include red alder, western hemlock, western sword fern, Pacific willow, and red-osier dogwood.

Photo Post 4.1 - Horizon 80° - Cardinal 45°

Photo Post 4.1 is positioned so that the northern side of Polygon 2 can be monitored near the base of the bigleaf maple tree. These plants are progressively more shade tolerant to the north. Over time we expect both the trees and shrubs to develop into an appropriate understory layer to the bigleaf maple and surrounding western redcedar and Douglas-fir. Plants our team has planted seen here include low Oregon grape, red alder, western sword fern, Pacific rhododendron, and slough sedge located near the stream as well as a lone western skunk cabbage in the bottom left of the photo.

Photo Post 4.2 - Horizon 70° - Cardinal 190°

Photo Post 4.2 is placed in order to monitor this sectioned off area where we planted several tree species and a couple shrub species in order to create a future filled with both upper and lower canopy structures. Plants seen here to monitor include Indian plum, western redcedar, western sword fern, Douglas-fir, and goat's beard.

Photo Post 4.3 – Horizon 75° - Cardinal 105°

Photo Post 4.3 is designed to view our water feature area the most explicitly over time. From this position we can monitor if the streams change course over time as well as which kind of species will actually thrive best in this kind of soil near watery terrain. Over time we hope our species including slough sedge and western skunk cabbage continue to grow well in the moist soil and facilitate the development of some more moisture tolerant plants as the area does get quite saturated during fall, winter, and spring. The other species we chose to put here because we believe they will help fill in the canopy gap in this area and will be able to grow in this more saturated environment. In this picture you will find western sword fern, devil's club, red alder and western redcedar. Towards the back of the frame we can also observe the two raised beds containing species such as bigleaf maple, large-leaved lupine, and cascara.

Photo Post 5.1 – Horizon 80° - Cardinal 10°

Photo Post 5.1, as well as the rest of Photo Post 5 photos, is mainly intended to monitor potential reinvasion of English holly. Not too many plants were planted in this section, so these photos are primarily designed to simply make sure this invasive species does not start encroaching on our native plants in Polygon 3.

Photo Post 5.2 – Horizon 80° - Cardinal 90°

Photo Post 5.2 faces back down the foot path and shows the eastern side of Polygon 3. Over time, we will expect to see less skyline as tree species develop on the western edge of Polygon 2. This will not happen for some time, but our goal is for this area of the site to merge with the areas in Polygons 2 and 1 that were most affected by the invasive Himalayan blackberry. In front of the camera is space for a future nursery and for a mulch pile to promote quick distribution in Polygon 3 and in areas of the seral forest west of the site. Over time we hope to witness the establishment of some natural shade tolerant plants across the trail as this spot was where an abandoned car was situated at the beginning of the project.

Photo Post 5.3 - Horizon 80° - Cardinal 160°

Photo Post 5.3's final viewpoint faces towards the trail leading back into the more mature forest. In this view we simply want to make sure no invasive species take advantage of the clear trail space to encroach and establish. In the future we must make sure to keep watch for English holly in this area as well as an overabundance of salmonberry. Even though this species is native

and a delight to have around, it can occasionally become too much for surrounding plants and take over small areas as it had done this previously on the southern end of the site where Polygon's 2 and 3 meet. There is also an unlikely chance of Himalayan blackberry reinvasion, but nevertheless it is something to monitor over time.

B. Baseline Quantitative Plot Sampling

Table 1: Initial quantitative plot sampling data.

Plot	Species	#Live	#Dead	% Cover	Recruitment	Layer
Plot 1						
	bigleaf maple	1	0	14	No	C
	Douglas-fir	3	0	3	No	C
	common snowberry	1	0	5	No	S
	Unknown Species	1	1	1.5	No	Unknown
	western redcedar	1	3	5	No	C
Totals						
	Native	7	4	23.5		
	Invasive	0	0	0		
Totals						
	Ground	0	0	0		
	Shrub	1	0	5		
	Canopy	5	0	22		
Plot 2						
	baldhip rose	1	0	2	No	S
	bigleaf maple	2	0	5	No	C
	bitter cherry	0	1	1	No	S
	black cottonwood	1	0	3	No	C

Plot	Species	#Live	#Dead	% Cover	Recruitment	Layer
	cascara	4	0	4	No	S
	Douglas iris	1	0	1	No	G
	Douglas-fir	1	0	2	No	C
	mock orange	1	0	1	No	S
	red elderberry	1	0	1	No	S
	western skunk cabbage	0	1	1	No	G
	slough sedge	2	0	4	No	G
	western redcedar	1	0	2	No	C
Totals						
	Native	15	2	27		
	Invasive	0	0	0		
Totals						
	Ground	1	1	6		
	Shrub	7	1	9		
	Canopy	5	0	12		
Plot 3						
	Indian plum	4	0	4	No	S
	low Oregon grape	3	0	4	No	G
	Pacific rhododendron	1	0	5	No	S
	red huckleberry	1	0	2	No	S
	salal	4	1	5	No	G
	white pine	1	0	10	No	C

Plot	Species	#Live	#Dead	% Cover	Recruitment	Layer
Totals						
	Native	14	1	30		
	Invasive	0	0	0		
Totals						
	Ground	3	0	4		
	Shrub	6	0	11		
	Canopy	1	0	10		
Plot 4						
	baldhip rose	1	0	5	No	S
	cascara	1	0	5	No	S
	Douglas-fir	2	0	16	No	C
	goat's beard	1	0	3	No	S
	Indian plum	1	0	2	No	S
	low Oregon grape	1	0	1	No	S
	red elderberry	2	0	3	No	S
	western redcedar	2	0	7	No	C
Totals						
	Native	11	0	42		
	Invasive	0	0	0		
Totals						
	Ground	0	0	0		
	Shrub	6	0	19		
	Canopy	2	0	23		

V. Long Term Site Management Plan

The site has been prepared by removing garbage, Himalayan blackberry, and by covering the exposed ground with wood chip mulch at a depth of at least 6 inches. With the installation of selected native species, we have completed the first stage of the restoration project. In order to meet our long term goal of developing a native upland mixed conifer/hardwood forest habitat that will support native flora and fauna, it will be necessary to continue working at the site in the capacity of assessment and maintenance in the coming years. Until the conifer trees that were planted grow large enough to create an upper canopy and shade the site, any sun loving invasive species has a higher chance of quickly re-establishing if not properly controlled. An annual walk-through in early spring will provide an opportunity to assess what plants need to be replaced and whether additional invasive species control methods need to be implemented (WSU Extension 2014). This is particularly important for the first two years while plants are establishing themselves.

Approximately two thirds of the site was down to bare earth after the removal of the Himalayan blackberry monoculture. In order to create canopy and further succession, a variety of deciduous and coniferous species were planted. In the low saturated areas surrounding the Pacific willow stand, live stakes of more Pacific willow and red-osier dogwood were planted. Western redcedar was planted in areas with greater shade and additional shade was created by planting red alder in conjunction with some of the cedar seedlings. In drier areas, and in raised beds, Douglas-fir, western hemlock, and grand fir were installed. On the drier northern end of the site, black cottonwood and bigleaf maple were planted some distance from any walking trails to prevent woody debris falling and hurting volunteers on the site in future years. Sitka spruce was planted in some of the wetter areas in the center of the site allowing for a greater diversity in the developing canopy.

Some of these trees, in particular the Pacific willow and the red-osier dogwood, were planted close together. After 5 years, we anticipate a certain amount of crowding which should be monitored to ensure that healthy successional progression is occurring. Ideally, self-thinning will naturally occur, as larger stronger plants out-compete the weaker, but manual thinning may be required in some areas. There are several reasons why thinning is important: overcrowding causes poor health as trees compete for nutrients, sunlight, and moisture, which limits their worth as wildlife habitat, and shrubs and forbs can become shaded out under their canopy (WSU Extension 2014). At this point stakes can be taken from the Pacific willow and red-osier dogwood and then be planted along the stream and other saturated areas such as the boundary where Polygons 2 and 3 meet. After 10 years, the condition of the coniferous trees will need to be assessed for overall health and potential crowding. If any trees are beginning to grow in such a way that they block access to the trails utilized for academic and community driven education events, they should be trimmed back. We also expect that there will be sufficient shade that most invasive species will not thrive, but annual walk-throughs should provide a good assessment to determine if any removal will be necessary (Bennett 2006).

Our second goal to remove all anthropogenic debris has been accomplished with the exception of objects that have been repurposed on the site in the form of found art. This brings us to the third goal of using and increasing community involvement and education within the

restoration site. By utilizing interesting objects such as horse shoes, curtains, plates, and refrigerators as found art pieces, we can create additional interest and enhance outreach to community and students. Throughout our restoration project, items have been repurposed. For instance, a red door found in the garbage has been put in place as a bridge over the stream. In addition, we added level and clearly marked trails throughout the site in order to make access easy for school tours and community volunteer events. Along with these interesting features, many of our plant species such as the devil's club, western skunk cabbage, and madrone (*Arbutus menziesii*), have been chosen for their aesthetic and educational value. It is our hope that additional plants will be added to areas like the open glade to enhance the site's value for humans as well as wildlife.

There will always be maintenance at the site as well as the adjoining land areas. Due to the hard work of our community partner, schools and community members are well informed about work parties and events. As long as the city continues to grant access to the public, this site will be a valuable tool for education and wilderness appreciation as well as an important ecological resource.

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VII. Appendices

Table 2: North Creek Forest's maintenance time table

January		**February**		**March**	
Activity	*When*	*Activity*	*When*	*Activity*	*When*
Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.
Remove litter.	As needed.	Remove litter.	As needed.	Remove litter.	As needed.
Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.
Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.
Photo monitoring.	Once a month.	Photo monitoring.	Once a month.	Photo monitoring.	Once a month.
Community involvement.	1+ a month.	Community involvement.	1+ a month.	Community involvement.	1+ a month.
April		**May**		**June**	
Activity	*When*	*Activity*	*When*	*Activity*	*When*
Water plants before 10am or after 6pm.	1-2 times a week or as needed.	Water plants before 10am or after 6pm.	1-2 times a week or as needed.	Water plants before 10am or after 6pm.	2-3 times a week or as needed.
Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.
Remove litter.	As needed.	Remove litter.	As needed.	Remove litter.	As needed.
Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.
Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.
Photo monitoring.	Once a month.	Photo monitoring.	Once a month.	Photo monitoring.	Once a month.
Community involvement.	1+ a month.	Mulch.	As needed.	Mulch	As needed.
		Community involvement.	1+ a month.	Community involvement.	1+ a month.

Table 1 (continued): North Creek Forest's maintenance time table

July		**August**		**September**	
Activity	*When*	*Activity*	*When*	*Activity*	*When*
Water plants before 10am or after 6pm.	2-3 times a week or as needed.	Water plants before 10am or after 6pm.	2-3 times a week or as needed.	Water plants before 10am or after 6pm.	1-2 times a week or as needed.
Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.
Remove litter.	As needed.	Remove litter.	As needed.	Remove litter.	As needed.
Inspect installed plants.	1-2 times a a month.	Inspect installed plants.	1-2 times a a month.	Inspect installed plants.	1-2 times a a month.
Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.
Photo monitoring.	Once a month.	Photo monitoring.	Once a month.	Photo monitoring.	Once a month.
Mulch.	As needed.	Mulch.	As needed.	Mulch.	As needed.
Community involvement.	1+ a month.	Community involvement.	1+ a month.	Community involvement.	1+ a month.
October		**November**		**December**	
Activity	*When*	*Activity*	*When*	*Activity*	*When*
Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.	Remove invasive plant species including Himalayan blackberry, English holly, and European mountain-ash.	As needed. Early detection and eradication will minimize removal efforts.
Remove litter.	As needed.	Remove litter.	As needed.	Remove litter.	As needed.
Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.	Inspect installed plants.	1-2 times a month.
Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.	Pest monitoring.	1-2 times a month.
Photo monitoring.	Once a month.	Photo monitoring.	Once a month.	Photo monitoring.	Once a month.
Community involvement.	1+ a month.	Community involvement.	1+ a month.	Community involvement.	1+ a month.

Figure 1: Project site divided into three polygons based on their soil characteristics, amount of exposure to solar radiation, and their predominant vegetation composition. Major features and landmarks are also shown. Some anthropogenic features such as abandoned trailer and derelict cars, which were previously present in Polygon 2 and 3, have been removed and thus omitted in this map.

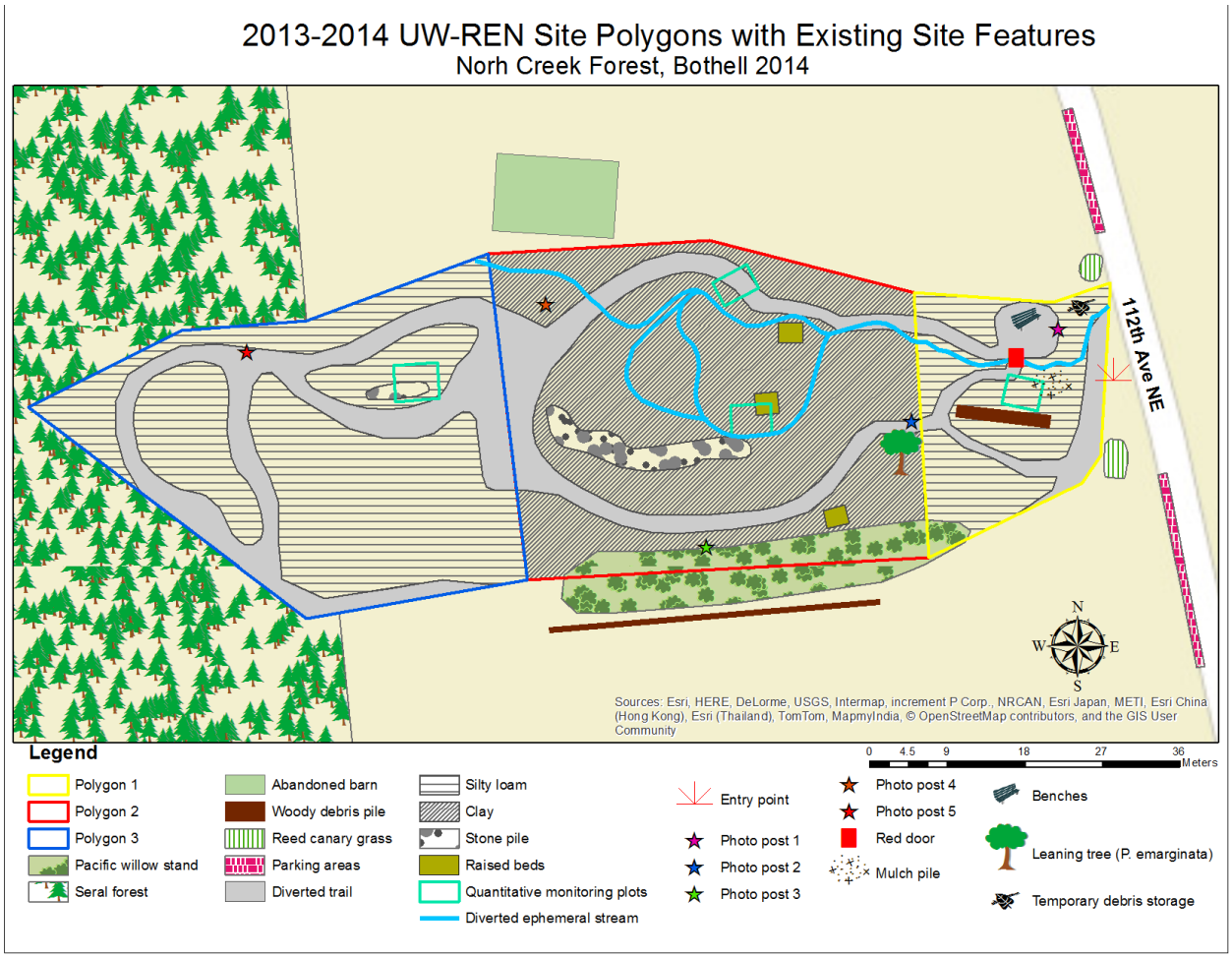

Figure 2: Final planting map. Colored areas indicate unique plant species suited to the microclimate.