2008

Shadow Lake Vegetation Management Plan

SHADOW
SAVE HABITAT AND DIVERSITY OF WETLANDS

Seattle Urban Nature

Shadow Lake

Vegetation Management Plan

Prepared for: Save Habitat and Diversity of Wetlands

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Executive Summary

The Shadow Lake Bog property is recognized by the King County Council as a significant wetland and wildlife habitat for Southeast King County. The bog and surrounding natural areas serve important stormwater detention functions and provide vital wildlife habitat in an increasingly urbanized environment. In 2006, SHADOW (Save Habitats and Diversity of Wetlands) received grant funding to contract with Seattle Urban Nature to survey and map the nearly 93 acres of contiguous properties adjacent to Shadow Lake.

During the 2007 field season, SUN ecologists identified seven natural habitat types totaling 83 acres on the property, including sphagnum bog-associated wetlands, riparian forested wetlands, upland forests, and a diverse scrub/shrub wetland complex that borders Shadow Lake. These natural areas are made up of generally undisturbed forested and wetland systems with high ecological diversity. Notable features found on the property include a unique intact sphagnum bog, approximately 1,345 feet of lake shoreline and the headwaters of a tributary to Jenkins Creek. The majority of the area is forested and includes conifer forests (9.7 acres), conifer/deciduous mixed forests (24.7 acres), deciduous forests (10.6 acres), riparian forested wetlands (14.1 acres) and a forested bog (called the hemlock/sphagnum bog) (3.6 acres). Open-canopy habitats consist of a sparsely forested Labrador tea/sphagnum bog (11.7 acres) and several scrub/shrub wetland complexes (8.5 acres).

The varied habitats present at Shadow Lake create a unique environment that supports a diverse array of plant communities. A total of 134 vascular plant species were found within the 41 plot survey areas consisting of 19 tree species (10 native and 9 non-native), 33 shrub species (31 native and 2 non-native), and 82 herbaceous and vine species (55 native, 24 non-native, and 3 that were undetermined). A total of 97 of these species are native, 34 are non-native, and three are not determined. The upland forests have abundant natural conifer regeneration and the wetlands and riparian forests are unique habitats with a variety of native shrub and herbaceous species. The most species-rich habitat type is the conifer/deciduous mixed forest with 58 native species recorded (8 trees, 16 shrubs, and 34 herbaceous plants).

Overarching management goals to help guide the ongoing restoration and management of the property are to:

1. Reduce invasive species concentrations - The most common invasive species encountered during the survey include evergreen blackberry (*Rubus laciniatus*), English holly (*Ilex aquifolium*), herb Robert (*Geranium robertianum*), Himalayan blackberry (*Rubus armeniacus*), European mountain ash (*Sorbus aucuparia*), bittersweet nightshade (*Solanum dulcamara*), and English ivy (*Hedera helix*);
2. Maintain an official trail network and buffer and revegetate cleared areas adjacent to areas of development and the access road;
3. Preserve large snags and increase coarse woody debris whenever possible.

Management priorities are detailed by vegetation zone, as well as timing for short, medium and long-term priorities.

1. INTRODUCTION

In 2007, Save Habitat and Diversity of Wetlands (SHADOW) contracted with Seattle Urban Nature (SUN) to survey and map approximately 92 acres of forested property owned and managed by SHADOW and the King Conservation District. The entire 92 acre SHADOW property is referred to as Shadow Lake in this report. SUN is a non-profit organization whose mission is to create tools to empower stewards for healthy urban ecosystems. SUN assists community groups, governments, non-profit organizations and private citizens in their efforts to survey, map, restore and maintain urban forests in the Puget Sound region.

The purpose of this report is to assist SHADOW in the planning efforts for the ongoing stewardship and maintenance of their properties. Because of the increasing use and pressure from human impacts and invasive species, this natural area will require active management to maintain and improve its aesthetic and ecological value. This report presents the findings of a scientific inventory of forest resources and evaluates the actions required for effective vegetation management of the property. This effort also establishes baseline information with which future surveys and monitoring may be compared. Specific goals of the project are to:

1) Identify and map habitats in Shadow Lake,
2) Provide an inventory of current vegetation conditions on the property, and
3) Create a management plan based on data collected during the inventory.

1.1 Overview

SHADOW is a 501 (c) (3) organization that was formed in 2000. Their purpose is to preserve wetland regions through the promotion of environmental research, public education and developing ecologically sensitive environmental education facilities with the goal of maintaining and preserving the land for biological and wildlife preservation. To date, SHADOW has protected more than 90 contiguous acres adjacent to Shadow Lake, including approximately 1,345 feet of the lake's western shoreline (Map 1). The property is comprised of a variety of habitats that include an extensive sphagnum peat bog surrounded by upland and riparian forested wetlands and other unique wetland complexes.

The bog is recognized by the King County Council as a significant wetland and wildlife habitat for Southeast King County (SHADOW website 2007). The King County Council stated that the bog is "an important wetland which functions as a natural deterrent to flooding by absorbing many times its weight in water," and that if "left wet and undisturbed plays a vital role in protecting the environment and serving as a wildlife habitat."

Most of the property is forested and consists primarily of conifer and conifer/deciduous mixed forests, with large wetland and riparian complexes. The upland areas are structurally diverse forested systems with well developed shrub and herbaceous layers. The wetlands and riparian forested areas are unique systems that include hemlock- and shrub-dominated sphagnum bogs and an intricate scrub/shrub wetland adjacent to Shadow Lake. Overall, the property consists of generally undisturbed natural areas that exemplify a high level of ecological diversity. The bog

and surrounding habitats serve important stormwater detention functions and provide vital wildlife habitat in an increasingly urbanized environment. These types of wetlands are also very rare in the Puget lowlands, due to their sensitivity to disturbance and the very long time (centuries) required for these systems to become established.

2. SITE LOCATION AND CONTEXT

2.1 Area Description

Shadow Lake is a small freshwater lake located in unincorporated King County two miles north of Covington, WA and six miles southeast of Renton, WA. Shadow Lake is located approximately one mile southeast of Lake Youngs, a major drinking water reservoir for the greater Seattle area. The 92.3 acre property is situated to the west of Shadow Lake and extends north to SE 216th Street, west to 184th Avenue SE, and south to Peter Grubb Road SE (Map 1).

2.2 Hydrology

Shadow Lake is located in the Jenkins Creek drainage basin in the Duwamish-Green River watershed (Water Resource Inventory Area (WRIA) 9). Shadow Lake is fed by rainfall and runoff from the surrounding area with localized ground water input in the form of Artesian springs (King Conservation District 2007). Because there is only a single, indirect outlet, the low-lying areas near the lake become saturated with water, creating an ideal environment for the growth of the moss species, *Sphagnum*. In these types of depressional bogs, the rate of sphagnum peat accumulation exceeds the rate of decomposition. The surface of the sphagnum remains immediately above the water table, while peat accumulates under this surface mat. The peat at Shadow Lake has been measured to a depth of 65 feet deep (SHADOW website 2007).

The water in the lake and wetland complex seeps into a low-lying area directly south of the bog where it eventually surfaces and drains through a glacial striation (groove in the bedrock caused by glacial activity) to the south east. This outflow forms the headwaters of a branch of Jenkins Creek, which is a major tributary to Soos Creek. Soos Creek is an important salmon-bearing stream supporting fall Chinook, coho, and winter steelhead (King Conservation District 2007). Soos Creek eventually flows into the Green River.

2.3 Topography, Geology, and Soils

The northern portion of the project area is a low-gradient landform that gently grades downhill to the east towards Shadow Lake. The southern portion of the property has a steeper gradient that slopes down towards the Jenkins Creek channel and Shadow Lake.

The geology of the Puget Sound lowland, including Shadow Lake, is heavily influenced by glacial processes which ended 15,000 to 20,000 years ago in this area. Layers of sands, gravels, and silts were distributed by the movement or compaction from glacial ice and glacial outwash (streams generated from the melting of glacial ice). As the glaciers receded, fragments were left behind that carved out and compressed the landscape beneath them. Shadow Lake was formed as one of these glacial depressions. The striated landform can be seen in the digital orthoimagry

of the surrounding area. The headwaters for the Jenkins Creek tributary, the only outlet for the lake, collects and flows through one of these glacial striations.

The underlying geology of the SHADOW property consists of two general geological units (Pacific Northwest Center for Geologic Mapping Studies 2007). The predominantly upland areas in the northeast and southern portions of the property are composed of Vashon glacier till, a compact mixture of silt, sand and gravel that was glacially transported and deposited under ice. The wetland, bog and riparian areas in the low-lying areas adjacent to Shadow Lake, on the other hand, are composed of non-glacial wetland deposits which formed after the glaciers receded. This material is composed primarily of peat and alluvium or organic-rich sediment that is generally poorly drained and intermittently wet (Pacific Northwest Center for Geologic Mapping Studies 2007).

2.4 History of the SHADOW property

Perhaps because of the saturated hydrology, the area which now includes the SHADOW property was left virtually untouched by early European settlers who began logging and farming the adjacent countryside in the late 19th century (SHADOW website 2007). Sometime after 1910, areas of the upland forests were logged, as evidenced by the large diameter stumps that can be found scattered throughout the property. Many of the remaining stumps show evidence of springboard notches, a logging practice that persisted into the late 1940's. However, many large conifer trees are still present today, especially in the more upland areas located in the southern portion of the property.

In 1995, Max and Erin Prinsen purchased an 18-acre parcel in an attempt to prevent further development and to preserve the area. The Prinsen's also recognized the opportunity for this property to serve as an educational resource and as an example to other landowners to help promote the conservation of natural open spaces. From this vision, SHADOW was formed as a 501(c)(3) organization in December, 2000 (SHADOW website 2007).

The initial 18-acre parcel the Prinsens purchased included a filled wetland area that contained 110 cubic yards of various materials. The Prinsens partnered with the Audubon Society, King County, King Conservation District, and other groups to create an amphibian pond on this filled site. A grant from King County WaterWorks was received for fill removal, pond construction, an education room, and a 600-foot long boardwalk into the peat bog for educational tours (SHADOW website 2007).

Since the initial purchase of land in 1995, SHADOW has partnered with various organizations including Cascade Land Conservancy and Conservation Futures to acquire additional properties. Most recently, SHADOW received an ALEA grant that was matched by the King Conservation District to purchase a 42 acre property that extended the protected habitat to include approximately 1,345 feet of the lake's western shoreline, the headwaters of a tributary to Jenkins Creek, and extensive upland forested habitat. To date, SHADOW has protected nearly 93 acres of contiguous properties adjacent to Shadow Lake (SHADOW website 2007).

3. FOREST ASSESSMENT METHODOLOGY

The purpose of the forest inventory is to:

1) Identify and map habitats in Shadow Lake
2) Provide an inventory of current vegetation conditions on the property

The following section describes methodology used in this forest assessment.

3.1 Habitat Mapping

The property was initially divided into areas of similar habitat types based on dominant plant species. Prevailing habitat types were identified in the field using recent aerial orthoimagery maps and utilizing Geographic Positioning Systems (GPS) to digitally mark boundaries and principal reference points. This information was used to create a Geographic Information System (GIS) base layer of the property in order to geographically represent the arrangement of each habitat type and to quantify the spatial area of each individual habitat. The initial habitat boundaries were revised and updated during the course of the plot-level survey. The final map displays the locations and distribution of each habitat type accompanied by the corresponding combined acreage for each habitat (Map 1).

3.2 Sampling Intensity

Vegetation management plans generally aim to sample three to ten percent of the forested area of interest. Using this guideline, SUN surveyed 41 plots in 2007. These sample plots (0.1 acre each, with a combined coverage of 4.1 acres) represent approximately 5% of the total forested and wetland areas of the property (82.7 acres). Residential/developed portions of the property were not included in the survey. Approximately 9.5 acres were not sampled using plot-level assessment procedures, including 7.0 acres of residential and pasture lands. Other areas not sampled include the access road and surrounding clearings, the area directly surrounding the amphibian pond, and the 0.4 acre newly acquired parcel bordering the lake at the end of the gated road (Map 1).

3.3 Plot Layout

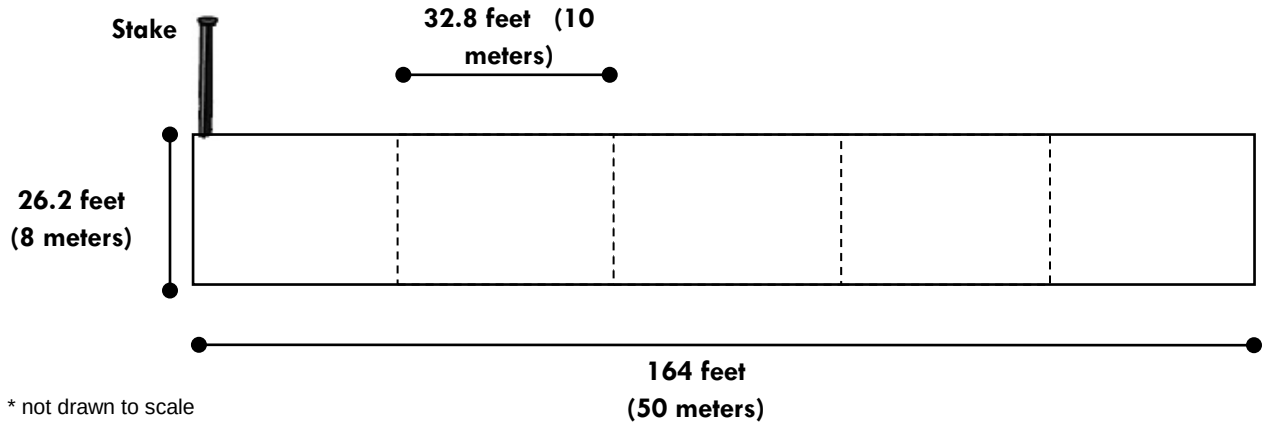
Plots were distributed proportionately among all forested and wetland habitat types and randomly located within a particular type. Of the 41 sample plots, 14 were located in the conifer/deciduous mixed forest, six in the deciduous forest, six in the riparian forested wetland, six in the Labrador tea/Sphagnum bog, four in the scrub/shrub wetland, three in the conifer forest, and two were located in the Hemlock/Sphagnum bog (Map 1).

The plots are rectangular and cover an area 26.2 feet (8 meters) wide and 164 feet (50 meters) long (Figure 1). These dimensions equal approximately 0.1 acre in size, which has been a standard area for sampling units in all recent vegetation management plans (VMPs) written for other parks within the City of Seattle (Jones and Stokes 2002, Sheldon and Associates, Inc. 2003, Seattle Urban Nature 2006, Seattle Urban Nature 2005). Long rectangular plots provide a more accurate sampling of the naturally occurring variation that occurs within clumped distributions of

plant species, thereby producing more accurate estimates than round or equal sided plot shapes, particularly for density-related measures (Elzinga et al. 1998).

The majority of plots are either oriented along the north/south or east/west geographical axis. If orientation along these axes did not allow the plot to be fully included in a particular habitat type, the orientation was modified to sample in one specific habitat type. Plot bearings are listed in Appendix C. The starting point of each plot was marked with a 1"x 2" x 12" wooden stake driven into the ground. The transect extends 164 feet along the transect bearing and 26.2 feet perpendicular to the bearing on the right side of the stake (Figure 1). GPS point locations have been recorded to within one meter accuracy at each stake (Appendix C).

Figure 1. Dimensions and layout of sampling plots in Shadow Lake*



3.3 Assessment Procedures

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

3.3.1 Tree density

All trees with trunks occurring within the 1/10th acre plot were identified and enumerated including non-native tree-like species such as cherry laurel, English holly and European mountain ash (*Sorbus aucuparia*). In order for a tree to be included in the sampling plot, more than half of its rooted trunk had to occur inside the plot. Height and diameter at breast height (dbh – breast height is defined as 4.5 feet from the ground surface) were recorded for each tree. In addition, trees were assessed for colonization by English ivy (*Hedera helix*). For trees smaller than 4.5 feet in height, average stem diameter was recorded to the nearest ½ inch.

Snags and coarse woody debris (CWD) greater than 5 inches in diameter, consisting of downed logs and stumps, were measured and placed into one of three decay classes, I, II, or III. Decay class I indicates a branch or trunk that recently died and frequently has intact bark and branches and hard wood. Decay class III characterized wood in an advanced state of decay with little to no bark or branches left intact, softened crumbling wood and extensive epiphytes. Decay class II provided an intermediate designation between these two extremes. CWD measurements from sampling plots were used to extrapolate an estimate of cubic feet of wood per acre (ft^3/acre) for further analysis.

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

3.3.2 Vegetation cover

All plant species occurring in, or with foliage overhanging the $1/10^{th}$ acre plot, were identified and percent cover was visually estimated for each species. Vegetation cover was estimated by dividing the 50m x 8m sample area into five 10m x 8m quadrats and estimating cover within each quadrat (See Figure 1). Within each quadrat, percent cover was visually estimated for all species present, and then these subtotals were combined to derive an estimate of cover for the entire sample area. Species that were present in trace amounts were given a minimum value of 0.1%. This allowed for a comprehensive floristic survey (i.e. species richness) for each plot location.

Cover and richness were chosen as measurable attributes in order to provide an estimate of species and structural diversity. These attributes can be extrapolated to provide an estimate of the extent that an area has been invaded by non-native species.

3.4 Data Collection and Management

Data was recorded using a TDS Recon PDA. Data collection was led by two staff ecologists at Seattle Urban Nature, with the aid of two supervised field assistants. Information from the PDA was transferred to a Microsoft Access Database, which was used for data analysis. A Trimble GeoXT GPS unit with a ProXR external antenna was used for habitat delineations and for recording plot locations. Maps were produced using ESRI ArcMap version 9.1, which connects geographic information (e.g. maps, aerial photographs, topography) with tabular information (e.g. data plot information in an Access database).

4. RESULTS AND FINDINGS

The results and findings section provides a summary and analysis of collected field data for seven individual habitat types: conifer forest; conifer/deciduous mixed forest; deciduous forest; hemlock/sphagnum bog; Labrador tea/sphagnum bog; riparian forested wetland; and scrub/shrub wetland. For each habitat type, the following information is presented: overstory tree composition and structure (section 4.2); regenerating tree composition and structure (section 4.3); snags (section 4.4), coarse woody debris (section 4.5), shrubs (section 4.6); and herbaceous and vine percent cover (section 4.7). Map 1 shows the locations and extents of mapped habitat types. Locations of established assessment plots can be found in Appendix D.

4.1 Property-wide Vegetation Trends

A variety of habitat types are found throughout the property at Shadow Lake. Most of these habitats are generally undisturbed natural areas that exemplify a high level of ecological diversity. The habitats are intricately arranged according to the unique hydrology and geography of the area, creating a complex mosaic of diverse plant associations and vegetation patterns across the landscape. Small changes in topography, differences in soil characteristics, and the history of disturbance (logging, fire, storm blowdown events, insect and pathogen outbreaks, etc) contribute to the complexity of the existing system.

Because of the complexity at the local scale, it can be difficult to make broad generalizations regarding the overall ecological condition of the property, particularly in relation to structure and function. The following analyses explore these relationships predominantly at a habitat-level scale, with implications as to how these individual components contribute to the function of the entire system.

4.1.1 Habitat type overview

Seven forested or wetland habitat types were identified during the 2007 forest inventory and survey, and are discussed in the sections below. These forested and wetland areas consist of 82.7 acres, or 90% of the 92.3 acre property (Map 1). Four additional habitat types totaling 9.5 acres are non-forested and were not sampled using plot-level surveys. These include seven acres of residential and pasture lands, a 0.6 acre amphibian pond near the Richter Interpretive Center, and the 1.8 acre access road and surrounding clearings. The locations and extents of these habitat types are shown on Map 1, but were not surveyed.

The results of the 2007 survey indicate that 62.6 of the sampled 82.7 acres (76%) are forested and include: 44.9 acres of upland forests made up of the conifer forest, conifer/deciduous mixed forest, and the deciduous forest types; 14.1 acres of the riparian forested wetland type; and 3.6 acres of the hemlock/sphagnum bog habitat type. The remaining 20.1 acres (24%) are composed of 11.7 acres of sparsely forested Labrador tea/sphagnum bog and 8.5 acres of scrub/shrub wetlands (Table 1).

Table 1. Habitat types mapped in Shadow Lake during the 2007 survey.

Habitat Type	Acres	Percentage of Total Area	Number of Plots Sampled
Forested/Wetland Habitats			
Conifer Forest	9.7	10%	5
Conifer/Deciduous Mixed Forest	24.7	27%	12
Deciduous Forest	10.6	11%	6
Hemlock/Sphagnum Bog	3.6	4%	2
Labrador Tea/Sphagnum Bog	11.7	13%	6
Riparian Forested Wetland	14.1	15%	6
Scrub/Shrub Wetland	8.5	9%	4
Subtotal	**82.7**	**89%**	**41**
Developed Habitats			
Access Road	1.8	2%	
Grassland	0.2	0%	
Amphibian Pond	0.6	1%	
Residential/Pasture	7.0	8%	
Subtotal	**9.5**	**11%**	
Total	**92.3**		**41**

4.1.2 Conifer forests

The pure conifer forest habitats are found in five separate areas across the property, of which four were sampled (Map 1). The fifth conifer area was not sampled due to its small size (0.6 acres). The conifer forests of Shadow Lake show considerable diversity between the northern and southern sections of the property. The 3.6 acre conifer forest in the northern part of the property (adjacent to the sphagnum bog) is a unique area with a dynamic forest structure. The forest is in a transitional area between the saturated soils of the bog and the more upland forests to the west. As a result of the high water table and generally saturated soils, trees in this area have shallow root systems and are often growing on slightly elevated mounds and raised areas. This results in a high occurrence of tree-fall events from storm blowdowns and a forest with a patchy open canopy and high volumes of coarse woody debris. The conifer forests in the southern part of the property, on the other hand, are generally more stable upland systems. The sampled conifer areas are dominated by a mix of western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and Douglas fir (*Pseudotsuga menziesii*) in the overstory with substantial regenerating western hemlock and western red cedar trees in the understory. Dominant shrubs in this habitat type include creeping blackberry (*Rubus ursinus*), salal (*Gaultheria shallon*), and salmonberry (*Rubus spectabilis*). The herbaceous layer is dominated by sword fern (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), and false lily of the valley (*Maianthemum dilitatum*).

Map 1

184th Ave SE

Peter Grubb Rd SE

SE 224th St

Shadow Lake

Riparian Forested Wetland 4.6
Interpretive Pond 0.6
Hemlock/Sphagnum Bog 1.9
Conifer Forest 3.6
Residential 1.3
Ledum/Sphagnum Bog 11.7
Deciduous Forest 3.4
Residential 5.8
Deciduous Forest 0.3
Hemlock/Sphagnum Bog 1.7
Conifer Forest 0.4
Scrub/Shrub Wetland 0.2
Grassland 0.2
Scrub/Shrub Wetland 6
Riparian Forested Wetland 9.5
Con/Dec Mixed 4.6
Access Road 1.8
Deciduous Forest 5.3
Conifer Forest 1.1
Conifer Forest 2.2
Con/Dec Mixed 10.2
Con/Dec Mixed 4.2
Scrub/Shrub Wetland 2.3
Conifer Forest 1.7
Con/Dec Mixed 5.7
Deciduous Forest 1.5
Conifer Forest 0.6

32 40 30 33 38 39 34 29 28 41 37 36 27 35 31 24 23 26 22 12 25 11 16 21 10 9 13 18 8 7 17 19 14 15 6 20 4 5 3 2 1

N W E S

Feet

0 250 500 1,000

1:3,500

Habitat Types (Acres) 92.3 Total

- Hemlock/Sphagnum Bog (3.6)
- Ledum/Sphagnum Bog (11.7)
- Palustrine Scrub/Shrub Wetland (8.5)
- Conifer Forest (9.7)
- Conifer/Deciduous Mixed Forest (24.7)
- Riparian Forested Wetland (14.1)
- Deciduous Forest (10.6)
- Amphibian Pond (0.6)
- Grassland (0.2)
- Residential (7.0)
- Access Road (1.8)

Shadow Lake Bog

Habitat Types

King County, WA

Legend

- Access Road
- Boardwalk
- Trails
- Jenkins Creek
- S.H.A.D.O.W. Property
- 2007 Assessment Plots
- Richter Interpretive Center

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4.1.3 Conifer/Deciduous mixed forests

Conifer/deciduous mixed forests are found primarily in the southern portion of the property and were mapped as four separate areas (Map 1). This habitat is the most dominant type found on the property, making up 27% of the total area and covering 24.7 acres (Table 1). The dominant overstory tree in this forest type is western hemlock, with substantial components of both Douglas fir and western red cedar. Approximately 30% of the overstory is made up of deciduous trees, dominated by red alder (*Alnus rubra*) and big-leaf maple (*Acer macrophyllum*), with a small black cottonwood (*Populus balsamifera ssp. trichocarpa*) component. The regenerating layer is composed mainly of big-leaf maple and western red cedar with lesser amounts of western hemlock. Dominant shrubs include salmonberry, creeping blackberry, and vine maple (*Acer circinatum*), with sword fern and western bleedingheart (*Dicentra formosa*) in the herbaceous layer. This forest type has the highest herbaceous species richness with 40 native species recorded during the survey.

4.1.4 Deciduous forests

The deciduous forest habitat type occurs in three areas and is distributed across the western portions of the property covering approximately 11% of the area (Map 1). These moist forests have a low overstory density and are dominated by red alder with a substantial big-leaf maple component. A very young forest with substantial red alder regeneration is present in the southwest corner of the property adjacent to the access road (Map 1). The shrub layer is predominately composed of salmonberry, creeping blackberry, and vine maple. Sword fern is the most dominant herbaceous species, but is not as prevalent as in the conifer and conifer/deciduous forest types. Other sub-dominant herbs include western bleeding heart and fringecup (*Tellima grandiflora*).

4.1.5 Hemlock/Sphagnum bog

Approximately 4% of the property is composed of pure stands of closed-canopy western hemlock trees over a moss-dominated forest floor. This habitat type was described and mapped as hemlock/sphagnum bog and was found in two narrow corridors in the north-eastern portion of the property (Map 1). This habitat type has a very sparse shrub layer along its edges and in small canopy gaps, composed mainly of Labrador tea (*Ledum groenlandicum*) and bog laurel (*Kalmia microphylla*). The most prevalent forbs found in low amounts in these forests are lady fern (*Athyrium filix-femina*), skunk cabbage (*Lysichiton americanus*), and sword fern. This forest type corresponds to the "*Tsuga heterophylla - (Thuja plicata)* / *Sphagnum* spp.forest" component association described by NatureServe, but could also fall under the "*Tsuga heterophylla - (Thuja plicata)* / *Ledum groenlandicum* / *Sphagnum* spp. forest" type (NatureServe website 2008).

4.1.6 Labrador tea/Sphagnum bog

A fairly large portion of the north-eastern property (11.7 acres) was mapped as Labrador tea/sphagnum bog (Map 1). This area is distinguished by dense expanses of Labrador tea with clumps of western hemlock trees interspersed throughout. High densities of small diameter western hemlock trees were recorded in this forest type. Also of note is the substantial component of bog laurel and the presence of small cranberry (*Vaccinium oxycoccos*), a species

associated with sphagnum bogs. Very low amounts of herbaceous plants were recorded in this habitat type and were made up primarily of bracken fern. Soft rush (*Juncus effuses*), skunk cabbage, and woolgrass (*Scirpus cyperinus*) are also present at low covers. This forest type corresponds to the "*Ledum groenlandicum - Kalmia microphylla / Sphagnum* spp. shrubland" described by NatureServe (NatureServe website 2008).

4.1.7 Riparian forested wetlands

The depressional area below the Labrador tea/sphagnum bog habitat type acts as a transitional area between the bog and the upland forests to the south. Water from the bog seeps into this area and drains through a shallow channel towards the south-east. This area, along with the perennial wet forest along the northern border of the property, was mapped as riparian forested wetland and occupies 14.1 acres, or 15% of the property (Map1). The moderately open-canopied overstory found in these areas is dominated by red alder with a lesser Pacific willow (*Salix lucida ssp. lasiandra*), hemlock, and cedar component. Dominant shrubs include salmonberry, red-osier dogwood (*Cornus sericea*), creeping blackberry, and twinberry (*Lonicera involucrata*). The herbaceous layer is dominated by water parsley (*Oenanthe sarmentosa*) and lady fern, indicating that high levels of moisture persist in these areas.

4.1.8 Scrub/Shrub wetlands

Approximately 8.5 acres of the property were mapped as palustrine scrub/shrub wetlands. These include a small 2.3 acre wetland in a shallow ravine near the southern border of the property and a larger complex (approximately 6 acres) adjacent to Shadow Lake (Map 1). The southern-most wetland empties into a roadside ditch along Peter Grubb Road. These wetlands have sparse overstory trees dominated by cascara (*Frangula purshiana*) and western red cedar, with a minor black cottonwood component. A high density of cascara was measured in the understory. These areas are shrub dominated, with relatively high covers of western crabapple (*Malus fusca*), hardhack (*Spiraea douglasi*), and salmonberry. The herbaceous layer of this habitat type is relatively sparse and dominated by sword fern, with lesser amounts of bracken fern and false lily-of-the-valley.

4.1.9 Species compositions

The varied habitats present at Shadow Lake create a unique environment that supports a diverse array of plant communities. During the 2007 survey, a total of 134 vascular plant species were found within the 41 established vegetation plots: 19 tree species (10 native and 9 non-native), 33 shrub species (31 native and 2 non-native), and 82 herbaceous and vine species (55 native, 24 non-native, and 3 undetermined). A total of 97 of these species are native, 34 are non-native, and 3 are undetermined. Appendix A lists the scientific and common names of all plants identified during the survey, as well as the native/non-native status of each species.

4.1.10 Invasive species overview

A number of non-native plant species have invaded the forested and wetland areas of the property. Seventeen of the 34 non-native species recorded are considered potentially invasive, and nine of these have been given a legal designation by the King County Noxious Weed Control Board. Because of its relatively intact natural areas with minimal human disturbances, the property has generally low occurrences of invasive species when compared to more urban natural areas. However, without active management these species will continue to spread and affect other areas of the property.

Dominant non-native invasive tree species found in Shadow Lake include English holly (*Ilex aquifolium*) and European mountain ash (*Sorbus aucuparia*). Additional species found at low densities include cherry laurel (*Prunus laurocerasus*), one-seed hawthorn (*Crataegus monogyna*), and sweet cherry (*Prunus avium*).

Only two invasive shrub species, Himalayan blackberry (*Rubus armeniacus*) and evergreen blackberry (*Rubus laciniatus*), are present on the property in relatively low amounts. Invasive herbs and vines present in the forested and wetland habitat types include herb Robert (*Geranium robertianum*), bittersweet nightshade (*Solanum dulcamara*), creeping buttercup (*Ranunculus repens*), and English ivy. Small amounts of Canada thistle (*Cirsium arvense*), bull thistle (*Cirsiuim vulgare*), and tansy ragwort (*Senecio jacobaea*) were also recorded.

English ivy, herb Robert, Canada thistle, and bull thistle are listed as Non-designated Noxious Weeds in King County. These weeds are listed as noxious weeds on the Washington State Weed List but are so widespread in King County that control is highly recommended but not required by law (King County 2008). Tansy ragwort is a Class B weed whose control is required in King County (King County 2008).

English holly, cherry laurel, Himalayan blackberry, evergreen blackberry, bittersweet nightshade, and creeping buttercup are designated as Weeds of Concern by King County. Weeds of Concern are widespread, unregulated species which impact and degrade native plant and animal habitat. Control and containment of existing populations is highly recommended but not required by law (King County 2008).

European mountain ash, one-seed hawthorn, and sweet cherry are non-native invasive tree species that have not been given a legal designation by the county or state governments. These species have the ability to colonize and reproduce in forested natural areas, competing with native plants for available resources.

4.2 Overstory Tree Composition and Structure

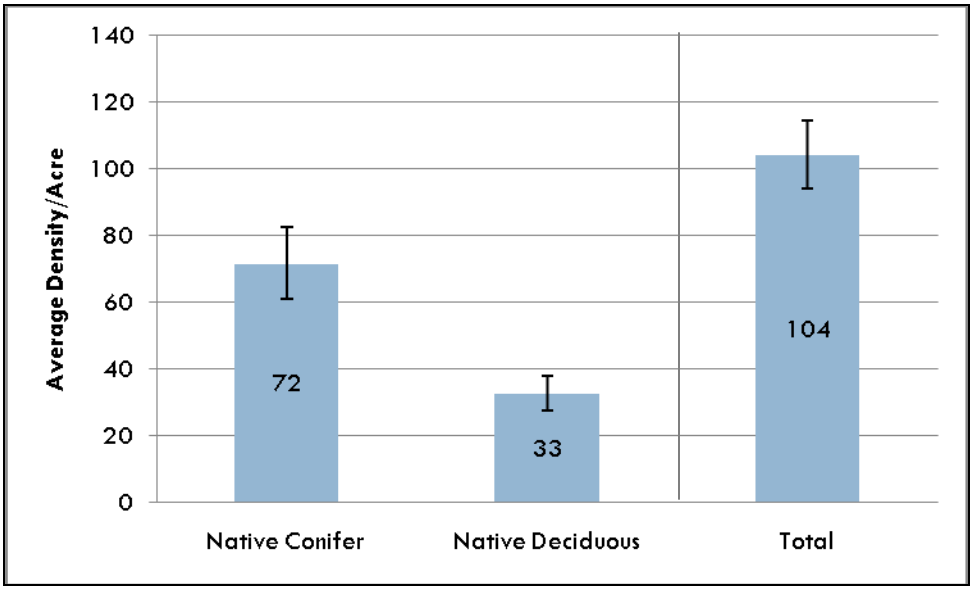
The forest overstory refers to the upper and mid canopies of a forest. Only trees with a diameter measuring greater than 5 inches (a standard measure for overstory) were considered for the purposes of this overstory analysis.

Tree density can be used to draw inferences about overall forest development and succession. In general, older stands tend to have lower densities due to self-thinning through the process of competitive exclusion. These forests generally exhibit a variety of tree heights and diameters which creates a canopy with high structural diversity (trees of differing ages and size classes).

Younger forests, on the other hand, generally have higher tree densities and limited structural diversity (Spies and Franklin 1991).

Overall, the overstory trees in Shadow Lake are predominantly coniferous and account for approximately 70% of all trees with diameters greater than five inches (Figure 2). Overstory tree densities across all seven sampled habitat types average 104 stems per acre with an average dbh of 13.9 inches. Western hemlock is by far the most dominant overstory tree found on the property, accounting for approximately 41% of all trees measured and averaging 43 stems per acre across all sampled habitat types. The non-forested scrub/shrub wetland habitat type has the lowest overstory density on the property, with an average of 34 stems per acre. Of the forested habitat types, deciduous forests exhibit the lowest overstory tree density with 63 stems per acre, while the hemlock/sphagnum bog has the highest density with 200 stems per acre (Table 2). The conifer and conifer/deciduous forest types have overstory densities between these extremes averaging 154 and 125 stems per acre respectively. The riparian forested wetland has slightly higher densities than the deciduous forest and averages 87 stems per acre (Table 2).

Figure 2. Average density per acre of overstory trees in Shadow Lake. Values represent averages from 41 plots across seven habitat types. Bars represent +/- standard error.



4.2.2 Conifer forest overstory

The density of overstory trees in the conifer forest averages 154 total stems per acre across all five plots sampled in this forest type. The trees in the overstory average 74.5 feet tall and 15.6 inches in diameter. The overstory is predominantly coniferous, composing 91% of the canopy. The conifer trees are dominated by western hemlock which represents more than a third of all trees at 34% (Table 2). Western red cedar (25%) and Douglas fir (25%) make up an additional 50 % of the canopy. Approximately 7% of the canopy is composed of Sitka spruce (*Picea sitchensis*) at 10 stems per acre. This is the only forest type where spruce trees were measured in the canopy. The remaining 9% of the overstory is made up of red alder (8%) and big-leaf maple (1%). The majority of overstory trees (approximately 41%) in this forest type are between 11

and 20 inches diameter. Approximately 21% are greater than 20 inches in diameter, totaling 32 stems per acre (Figure 4). The trees in this forest type exhibit considerable structural diversity, as evident from the distribution of native trees at different height classes (Figure 3). Aside from the relatively high densities of small statured trees in the 0-15 foot height class, the densities of taller trees are well distributed throughout the remaining height classes (Figure 3). The conifer forest also has the largest number of trees greater than 120 feet tall (a density of 24 stems per acre).

Table 2. Overstory and regenerating tree species found in each of the sampled habitat types in Shadow Lake. Values represent density (stems/acre) and proportion (in parenthesis) of each species averaged across all plots (N) in each habitat type.

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
OVERSTORY TREES (Density/acre)[2]								
Acer macrophyllum	big-leaf maple	2 (1%)	14 (11%)	13 (21%)			2 (2%)	
Alnus rubra	red alder	12 (8%)	22 (18%)	33 (52%)			52 (60%)	
Frangula purshiana	cascara			2 (3%)			2 (2%)	15 (46%)
Picea sitchensis	Sitka spruce	10 (7%)						
Populus balsamifera ssp. trichocarpa	black cottonwood		2 (2%)					5 (15%)
Prunus emarginata	bitter cherry			7 (11%)				
Pseudotsuga menziesii	Douglas fir	38 (25%)	29 (23%)	2 (3%)		8 (8%)		3 (8%)
Salix lucida ssp. lasiandra	Pacific willow						13 (15%)	
Thuja plicata	western red cedar	38 (25%)	20 (16%)	3 (5%)			8 (9%)	8 (23%)
Tsuga heterophylla	western hemlock	54 (34%)	38 (30%)	3 (5%)	200 (100%)	90 (92%)	10 (12%)	3 (8%)
Average density		**154/acre**	**125/acre**	**63/acre**	**200/acre**	**98/acre**	**87/acre**	**34/acre**
REGENERATING TREES (Density/acre)[2]								
Acer macrophyllum	big-leaf maple	56 (5%)	98 (19%)	23 (3%)				
Alnus rubra	red alder		3 (1%)	653 (71%)			17 (4%)	8 (T)
Castanea sp.	chestnut	2 (T)	1 (T)					
Crataegus monogyna**	one-seed hawthorn						5 (1%)	
Frangula purshiana	cascara	312 (29%)	178 (35%)	68 (7%)	30 (9.5%)	25 (2%)	230 (51%)	2268 (93%)
Ilex aquifolium*	English holly	212 (20%)	75 (15%)	108 (12%)			53 (12%)	128 (5%)
Picea sitchensis	Sitka spruce			3 (T)				
Pinus monticola	western white pine					2 (T)		

Table 2 (Continued)

Scientific Name[1]	Common Name	Conifer Forest (N=5) [2]	Conifer/ Deciduous Mixed Forest (N=12) [2]	Deciduous Forest (N=6) [2]	Hemlock/ Sphagnum Bog (N=2) [2]	Labrador Tea/ Sphagnum Bog (N=6) [2]	Riparian Forested Wetland (N=6) [2]	Scrub/Shrub Wetland (N=4) [2]
Populus balsamifera ssp. trichocarpa	black cottonwood							5 (T)
Prunus avium **	sweet cherry		1 (T)					3 (T)
Prunus emarginata	bitter cherry		3 (1%)	27 (3%)				
Prunus laurocerasus*	cherry laurel		1 (T)	3 (T)			7 (1%)	
Prunus sp.	horticultural cherry species			3 (T)				
Prunus X pugetensis	Prunus × pugetensis							3 (T)
Pseudotsuga menziesii	Douglas fir					12 (1%)		
Quercus sp.	oak	2 (T)						
Sorbus aucuparia*	European mountain ash	36 (3%)	16 (3%)	2 (T)	5 (1.5%)		43 (9%)	18 (1%)
Thuja plicata	western red cedar	172 (16%)	83 (16%)	23 (3%)		7 (1%)	42 (9%)	3 (T)
Tsuga heterophylla	western hemlock	290 (27%)	46 (9%)	8 (1%)	280 (89%)	1282 (96%)	58 (13%)	18 (1%)
Average density		**1082/acre**	**505/acre**	**921/acre**	**315/acre**	**1328/acre**	**455/acre**	**2454/acre**

[1] Species in bold are non-native species. Species denoted by * are species which have been given a legal designation by the King County Noxious Weed Program (King County 2007). Species denoted by ** are non-native invasive species which do not have a legal designation at this time.
[2]T=Trace presence of species (less than 1%).

4.2.3 Conifer/Deciduous mixed forest overstory

The overstory of the conifer/deciduous mixed forest habitat type exhibits only a slightly lower stem density than the conifer forest type with 125 stems per acre across 12 plots. In general, trees in these forests are larger in height and diameter than other habitat types with stems averaging 83.1 feet tall and 17.3 inches in diameter. This forest type is dominated by conifer trees which account for 69% of the canopy and are comprised of western hemlock (30%), Douglas fir (23%), and western red cedar (16%). The remaining 31% of the canopy is deciduous, made up of red alder (18%), big-leaf maple (11%), and black cottonwood (2%) (Table 2). Like the conifer forest, overstory trees in this forest type are structurally well distributed. Native tree densities show a relatively even distribution throughout all height classes greater than 15 feet tall, with 22 stems per acre measured at 120 feet or taller (Figure 3). Tree diameters are also well distributed, with 28% of overstory trees greater than 20 inches in diameter (Figure 4).

4.2.4 Deciduous forest overstory

The overstory of the deciduous forest has the lowest density of any forested habitat type with only 63 stems per acre averaged across six plots (Table 2). Overstory trees average 59.6 feet in height and 12.1 inches in diameter. Only the scrub/shrub wetland has fewer numbers of overstory trees. Red alder dominates the canopy in this forest type, accounting for more than 50% of measured trees at 33 stems per acre (Table 2). Big-leaf maple (21%) and bitter cherry (*Prunus emarginata*) (11%) are also present in the overstory, along with smaller amounts of western red cedar (5%), western hemlock (5%), and cascara (3%). The majority of native trees measured in this forest type (66%) are between 15 and 45 feet in height, with very few trees (7%) taller than 45 feet (Figure 3). This forest type is found in three separate areas of the property (Map 1). One of the six plots sampled in this forest type, plot 12, had no trees measured in the overstory. This area was recently cleared and is currently in an early-successional stage of extremely high density regenerating red alder trees. The forest to the south of plot 12 adjacent to the access road has also undergone varying degrees of human disturbance, as has the northern deciduous forest adjacent to the residential areas. These areas act as buffers along edges of development and other disturbances, and are consequently in a less natural state compared to other areas of the property. The 1.5 acre deciduous forest in the southern part of the property is less disturbed. The plot sampled in this forest (plot 2) had the highest deciduous overstory density at 120 stems per acre.

4.2.4 Hemlock/Sphagnum bog overstory

The hemlock/sphagnum bog habitat type has the highest measured overstory tree density of all sampled habitat types at 200 stems per acre averaged across two plots (Table 2). These trees are made up entirely of western hemlock and average 48.5 feet tall and 10.9 inches in diameter. The majority of overstory trees in these forests (55%) have diameters less than 10 inches in diameter, with few trees (5%) measured with diameters greater than 20 inches (Figure 4). As noted earlier, trees in this habitat type are generally shorter than in other conifer-dominated habitat types, with few trees over 80 feet in height. Tree heights are limited in these areas due to the restricted rooting depth available in high-water table areas and the poor nutrient conditions that exist in peat systems. Mature western hemlock trees generally reach heights between 100 and 150 feet tall (The Natural History of North America website 1999). While most native trees (52%)

measured in this forest type are less than 15 feet tall, 30% are between 16 and 45 feet in height (Figure 3). Only 18% of trees (90 stems per acre) are taller than 45 feet (Figure 3).

4.2.5 Labrador tea/Sphagnum bog overstory

Although the Labrador tea/Sphagnum bog habitat type is characteristically shrub dominated, overstory tree densities across six sampled plots averaged 98 stems per acre (Table 2). Overstory trees average 45.0 feet tall and 8.7 inches in diameter. The majority of trees (92%) are composed of western hemlock (90 stems/acre), with a minor Douglas-fir component (Table 2). This habitat type has high densities of short and medium statured native trees, especially in the 0-15 foot height category (Figure 3). Taller trees measured in this habitat were generally clumped together in tree islands throughout the bog. Because of this uneven distribution, overstory density measurements were highly variable between plots. No overstory trees were recorded in plot 35, while plot 39 contained only 10 stems per acre. Plot 38 had the highest density with 220 stems per acre. The tallest trees measured were 65 feet tall, with relatively few trees taller than 45 feet. The relatively sparse overstory canopy is made up primarily (76%) of small diameter trees 6 to 10 inches in diameter, with 24% in the 11-20 inch diameter size class (Figure 4).

4.2.6 Riparian forested wetland overstory

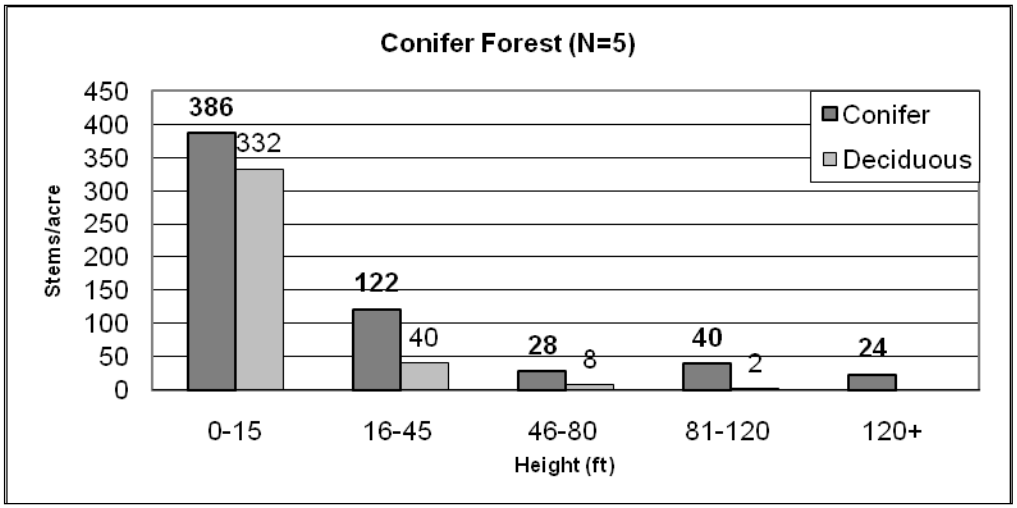
The riparian forested wetland exhibits relatively low overstory tree densities compared to other forested habitat types with only 83 stems per acre averaged from two plots (Table 2). Overstory trees in this forest type average 47.3 feet tall and 10.8 inches in diameter, and are dominated by red alder with 52 stems per acre and accounting for 57% of all trees. Sub-dominant tree species include Pacific willow (15%), western hemlock (11%), and western red cedar (9%) (Table 2). Also present at lower densities are cascara (6%) and big-leaf maple (2%). Densities of trees decline as tree heights increase, with less than 10% of all native trees measured at greater than 45 feet in height (Figure 3). Average diameters of overstory trees in this forest type are split evenly between the 6 to 10 inch diameter and the 11 to 20 inch diameter size classes (Figure 4). Less than two percent of trees measured were greater than 20 inches in diameter.

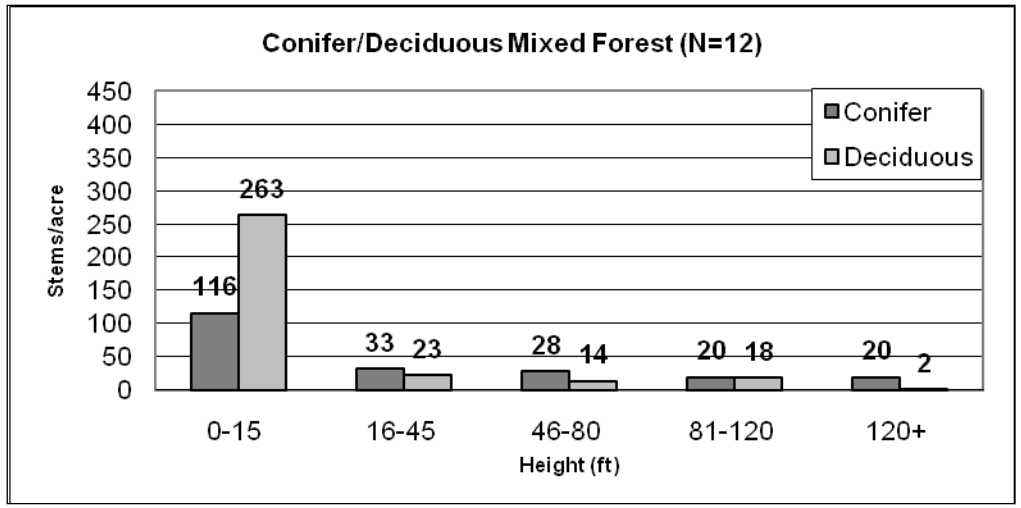
4.2.7 Scrub/Shrub wetland overstory

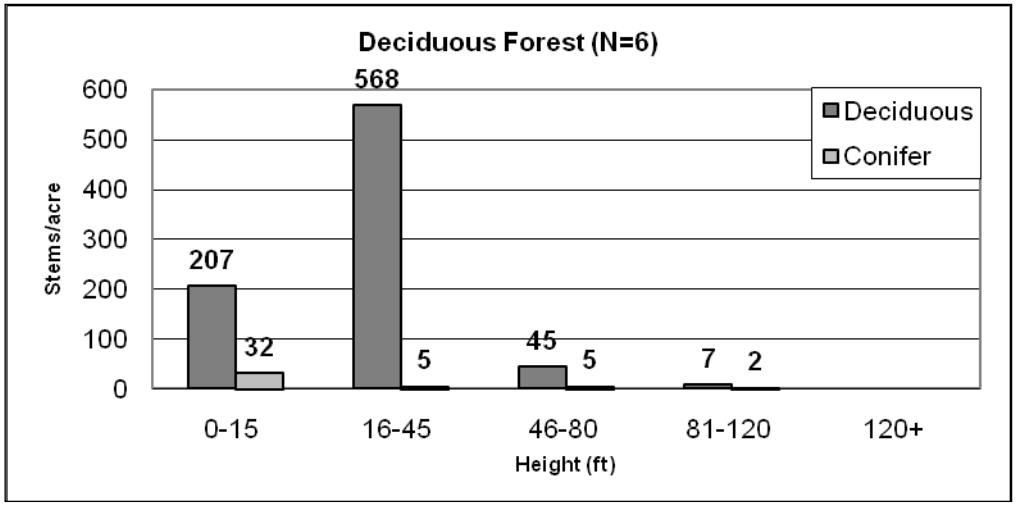
The scrub/shrub wetland habitat type has the lowest recorded overstory tree density of any sampled habitat type at Shadow Lake, with only 34 stems per acre of trees greater than five inches in diameter (Table 2). Trees measured from four plots averaged 62.2 feet in height and 15.8 inches in diameter. The most northern of the four plots (plot 23) had no overstory trees, with densities ranging from 20 to 60 stems per acre across the other three plots. The most dominant tree is cascara, accounting for nearly half of all overstory trees measured (Table 2). Other prevalent trees include western hemlock (23%), black cottonwood (15%), western red cedar (8%) and Douglas fir (8%) (Table 2). The largest of the scrub/shrub wetlands is a six acre complex that borders Shadow Lake (Map 1). This complex is heavily dominated by shrub species with a sparse overstory tree component of cascara and western red cedar. Trees greater than five inches in diameter in this wetland were made up predominantly of the short-statured cascara tree, and no trees taller than 45 feet were sampled. The only Douglas-fir measured in this habitat type was found in plot 22 in this area. Although not sampled during the 2007 plot-level inventory, a small grove of quaking aspen (*Populus tremuloides*) was noted in the region between plots 26 and 23. The smaller 2.3 acre wetland complex in the southwestern part of the

property has a different overstory tree structure and composition than the other wetlands. Plot 20 in this wetland has several trees taller than 100 feet, including the largest western hemlock measured on the property (154 feet tall and 51 inches in diameter). Other tall trees found here include black cottonwood and western red cedar. No cascara trees were measured in the overstory of this plot. The general lack of overstory and weak vertical structural diversity of these wetlands is exemplified by the absence of mid-story trees in the 46 to 80 foot height class and only the occasional tree over 80 feet in height (Figure 3). Most overstory trees (greater than 60 percent) have smaller diameter stems, while only 8% are between 11 and 20 inches in diameter (Figure 4). Approximately 31% of stems are greater than 21 inches in diameter (Figure 4).

Figure 3. Native overstory and regenerating tree density/acre by height size class in seven habitat types found on the Shadow Lake property.







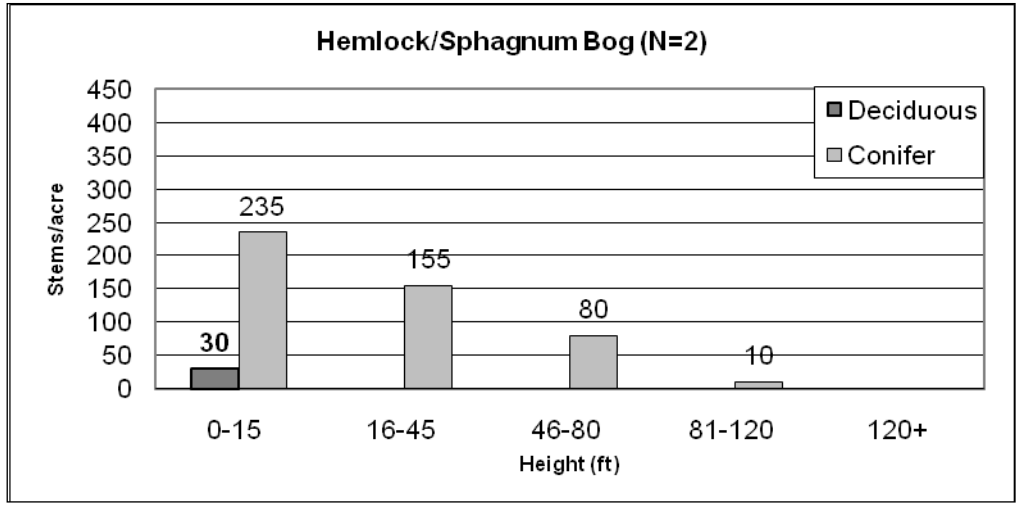
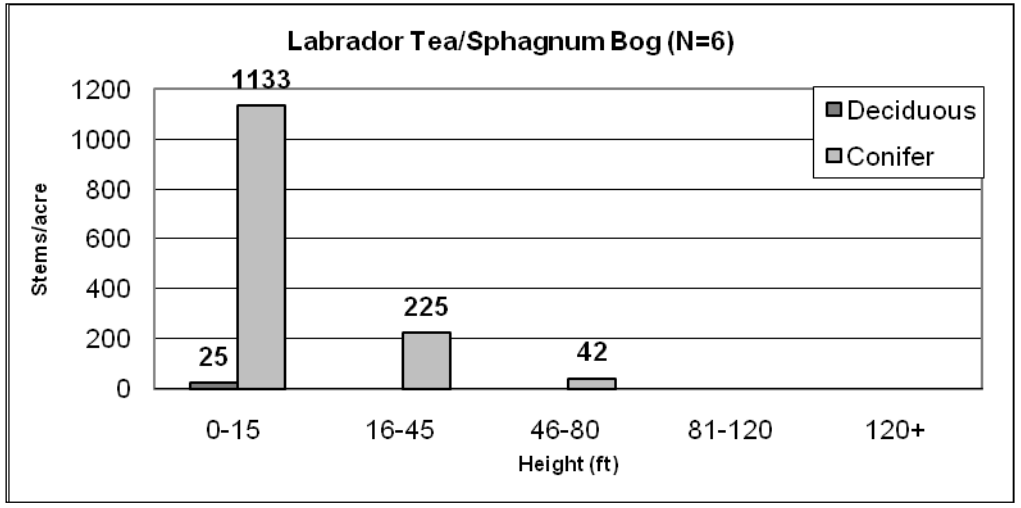
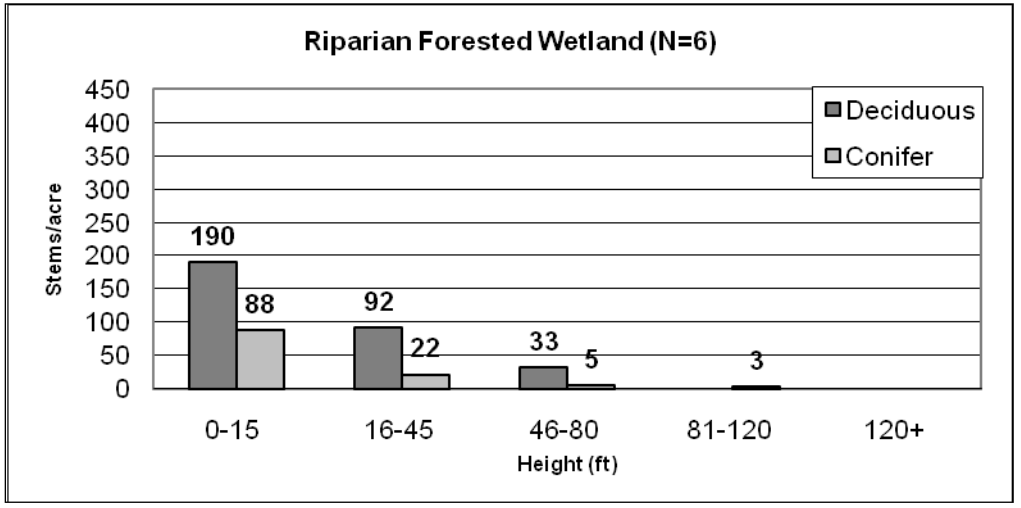
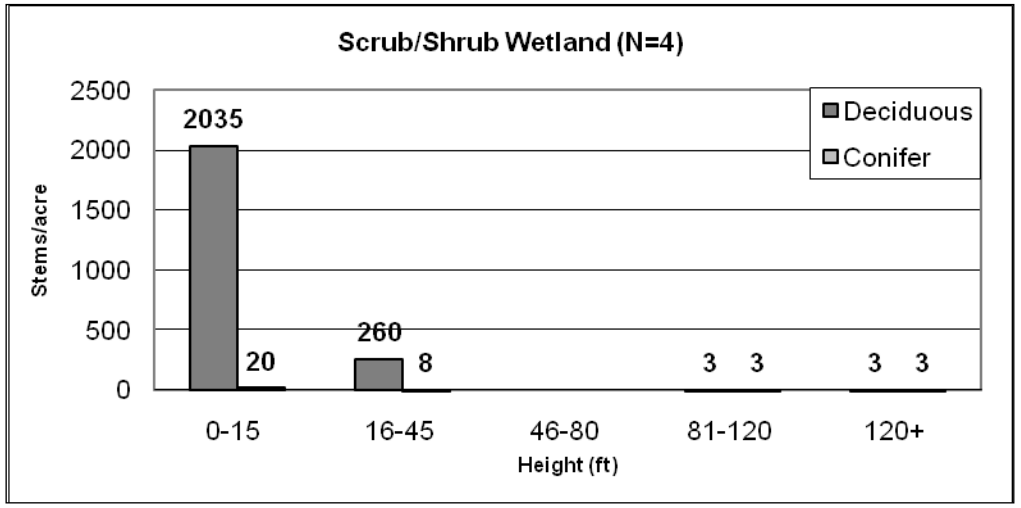


Figure 3. (Continued)







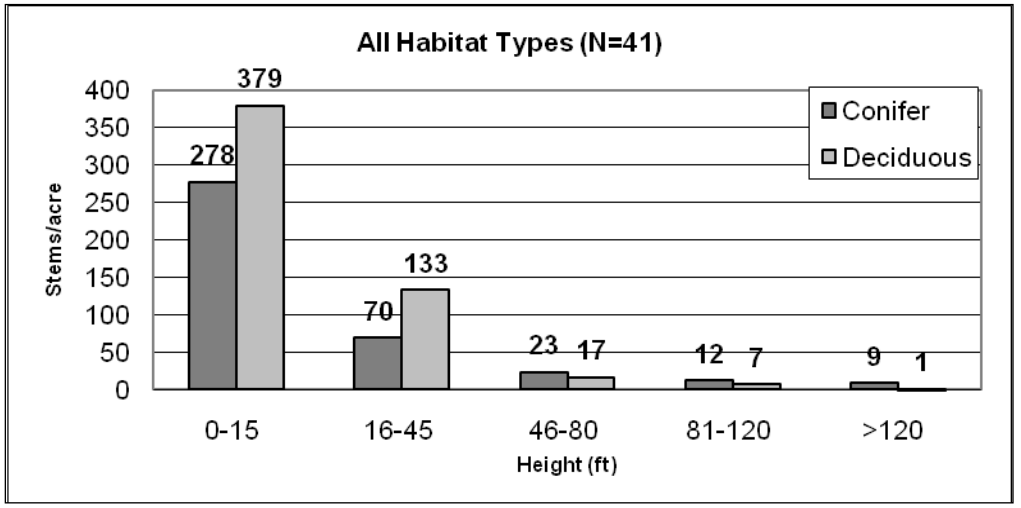
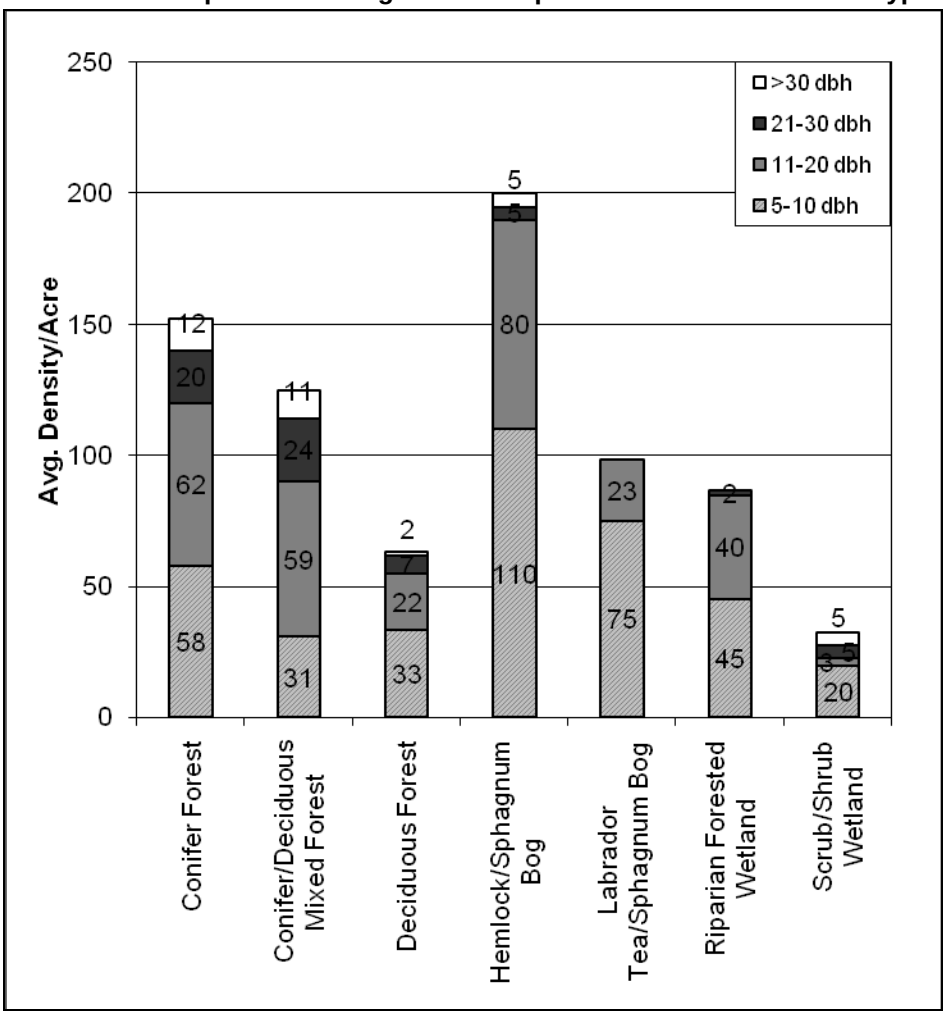


Figure 4. Overstory tree density/acre by diameter size class for sampled habitat types in Shadow Lake. Values represent averages from 41 plots across seven habitat types.



4.3 Regenerating Tree Composition and Structure

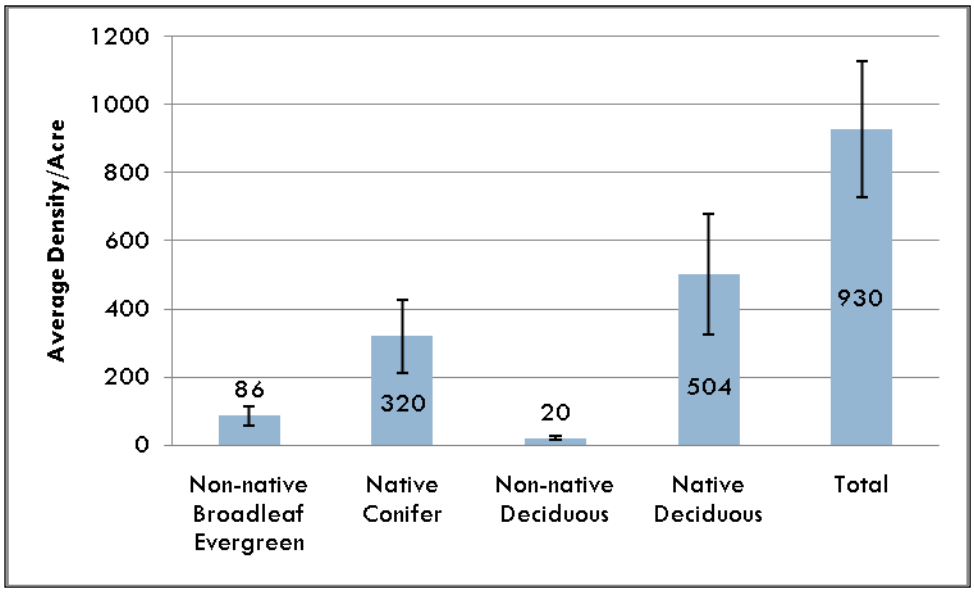
This survey considered trees five inches or less in diameter at breast height to be regenerating tree species. The amount and composition of current tree regeneration will substantially influence the future makeup of the forest.

The habitats found in Shadow Lake average 930 regenerating stems per acre across all seven habitat types with a total of 19 species: 10 native and nine non-native, of which six are considered to be invasive (Table 2). Deciduous tree species dominate the regenerating layer accounting for 54% of all trees five inches or less in diameter (Figure 5). The most common tree by far found in the regenerating layer is cascara, present at 360 stems per acre (39%) averaged across all seven sampled habitat types, followed by red alder with 100 stems per acre (11%). Native conifer tree species account for 34% of tree regeneration (Figure 5). Western hemlock is the most prevalent, found at an average density of 261 stems per acre (28%), with western red cedar contributing an additional 56 stems per acre (6%).

As is common in an increasing number of urban and suburban forested areas in the lowland Puget Sound region, the regenerating tree layer in Shadow Lake has become invaded by English holly. Currently, this species accounts for approximately nine percent of all regenerating trees and is found at an average of 84 stems per acre across all sampled plots. English holly is found in five of the seven habitat types and has an average density of 202 stems/acre in the 17 plots where it is present (Appendix A). It is most prevalent in the conifer forest habitat at a density of 212 stems per acre across all five plots (Table 2). Cherry laurel, another non-native invasive broadleaf evergreen tree species, is also present in low amounts throughout the property at an average density of two stems per acre. These introduced Eurasian species have become naturalized and are now widespread throughout our region. They are capable of rapidly establishing and colonizing forested habitats, their increasing presence and abundance pose a serious threat to the future structure, composition and function of rural and urban forested and natural habitats.

A small amount of non-native deciduous trees is also present in the regenerating tree layer. A total of six species of non-native deciduous trees were recorded during the survey accounting for approximately 2% of property-wide tree regeneration. Three of these are considered to be potentially invasive (Table 2). European mountain ash is the most dominant accounting for 18 stems per acre property-wide and found in six of the seven sampled habitat types. Other invasive species invading the regenerating layer include one-seed hawthorn (one stem per acre property-wide) and sweet cherry (less than one stem per acre).

Figure 5. Average density /acre of regenerating trees in Shadow Lake. Values represent averages from 41 plots across seven habitat types. Bars represent +/- standard error.[1]



[1] Non-native broadleaf evergreen species include English holly and cherry laurel.

4.3.1 Conifer forest tree regeneration

The conifer forest has 1082 stems per acre of regenerating trees five inches or smaller in diameter. Of these, native trees account for approximately 77% and are made up predominantly of cascara (312 stems per acre), western hemlock (290 stems per acre), and western red cedar

(172 stems per acre). Native conifer regeneration is particularly high in this habitat type accounting for a combined 42% (462 stems per acre) of all regeneration. Big-leaf maple is also present at 56 stems per acre, or 5% of all regeneration (Table 2). A large proportion of all native trees measured in this forest type are less than 15 feet in height (74%), with comparable numbers of both conifer and deciduous small statured trees (Figure 3).

The conifer forest habitat type has the highest densities of non-native trees in the regenerating layer compared to other habitat types. A total of 252 stems per acre (23% of all regeneration) of non-native trees were measured, with English holly accounting for 212 stems per acre (20%) (Table 2). English holly is most prevalent in the northern 3.6 acre forest, present at 790 stems per acre in plot 30 (Map1). Non-native deciduous trees are less frequent in the understory at a combined stem density of 40 stems per acre, or 4% of overall regeneration. European mountain ash is the most prevalent at 36 stems per acre (3% of overall regeneration). Small densities of horticultural chestnut (*Castanea sp.)* and oak (*Quercus sp.)* were also measured at low densities (Table 2).

4.3.2 Conifer/Deciduous mixed forest tree regeneration

The conifer/deciduous mixed forest habitat has approximately half the regenerating tree density as the conifer forest habitat type at 505 stems per acre averaged across 12 plots (Table 2). With proportions similar to the conifer forest, the majority (71%) of all native trees (regenerating and overstory) measured in this habitat type are less than 15 feet in height (Figure 3). Native deciduous trees dominate and account for 56% of all regeneration, made up primarily of cascara (35%) and big-leaf maple (19%). Small amounts of bitter cherry were also measured in the regenerating layer. Conifer regeneration makes up approximately 25% of total tree regeneration at a combined 129 stems per acre. Western red cedar regeneration is more prevalent than western hemlock in this forest type, accounting for 17% and 9% respectively (Table 2).

Invasive tree species make up approximately 19% of all regeneration in the conifer/deciduous mixed forest, with English holly accounting for 75 stems per acre (15%). Additional invasive tree species include European mountain ash (3%), sweet cherry (trace), and cherry laurel (trace).

4.3.3 Deciduous forest tree regeneration

Regenerating tree densities in the deciduous forest average 921 stems per acre across the six plots sampled in this habitat type. This number is somewhat elevated as a result of the high densities of regenerating trees in one plot (plot 12) located to the north of the access road (Map 1). This plot measured 3,670 stems per acre of regenerating red alder trees. Regenerating tree densities in the remaining five plots average approximately 450 stems per acre. The single plot sampled in the southern-most 1.5 acre deciduous forest has the lowest density at only 240 stems per acre. On average, most of the native trees (overstory and regenerating) measured in this forest type are between 16-45 feet in height (66%), with an additional 27% of all trees less than 16 feet tall (Figure 3). The majority of all regenerating trees measured in this habitat type are red alder, accounting for 71% at 653 average stems per acre. Additional regenerating trees include cascara (7%), big-leaf maple (3%), bitter cherry (3%), and western red cedar (3%) (Table 2).

Small amounts of Sitka spruce were found in plot 28, the only measured regeneration of this species in Shadow Lake.

Approximately 13% of all regeneration found in the deciduous forest habitat is from non-native species. Although not as dense as in the conifer forest, English holly is present in the regenerating layer at 108 stems per acre and accounts for 12% of all tree regeneration. All English holly in the deciduous habitat type was measured in the 3.4 acre forest adjacent to the residential areas, with the vast majority (620 stems per acre) sampled in plot 28 (Map 1). Small amounts of cherry laurel, horticultural cherry species (*Prunus sp.)* and European mountain ash are also present in this forest type (Table 2)

4.3.4 Hemlock/Sphagnum bog tree regeneration

The hemlock/sphagnum bog has the lowest recorded regenerating tree density of all sampled habitat types with 315 stems per acre across two plots (Table 2). More than half (52%) of all native overstory and regenerating trees are less than 16 feet tall (Figure 3). Like the overstory, the regenerating tree layer is composed predominantly of western hemlock, accounting for 89% of all regeneration. Ten percent of trees five inches or less in diameter are cascara, while the non-native invasive European mountain ash provides an additional two percent with 5 stems per acre (Table 2).

4.3.5 Labrador tea/Sphagnum bog tree regeneration

Tree regeneration in the Labrador tea/sphagnum bog is comparably high with 1328 stems per acre averaged across six plots (Table 2). This high density is due primarily to the large numbers of western hemlock trees found throughout this habitat type at an average of 1282 stems per acre and accounting for 97% of all regeneration. Eighty-one percent of all overstory and regenerating native trees in this habitat are less than 16 feet tall (Figure 3). Like the overstory, regenerating tree densities varied substantially among sample plots, ranging from 4080 stems per acre in plot 39 to 150 stems per acre in plot 35. Other native trees found at low densities include cascara (2%), Douglas fir (1%), western red cedar (trace) and western white pine (*Pinus monticola*) (trace). The small amount of Douglas fir found in two of the six sampled plots (plots 27 and 41) is the only recorded regeneration of this species on the property. The only recorded western white pine is also found here in plot 38, although a few mature trees were noted in the overstory of this habitat type between sample plots.

4.3.6 Riparian forested wetland tree regeneration

The riparian forested wetland has the second lowest regenerating tree density at 455 stems per acre across six plots (Table 2). Native deciduous trees account for approximately 55% of all regeneration at 247 stems per acre, made up predominantly of cascara (51%) with a lesser red alder component (4%). Native conifer trees make up approximately 22% of measured regenerating trees made up of western hemlock (13%) and western red cedar (9%) and averaging 58 and 42 stems per acre respectively (Table 2).

Approximately 23% of all regenerating trees are non-native and average 108 stems per acre (Table 2). English holly and European mountain ash are the most prevalent at 53 and 43 stems per acre respectively. Nearly all of the English holly was sampled in a single plot (plot 24) in the lower riparian forested wetland at a density of 240 stems per acre. Plot 24 also has the highest

density of European mountain ash at 130 stems per acre. Cherry laurel and one-seed hawthorn are also present at low densities totalling an additional 12 stems per acre averaged across all six plots (Table 2).

4.3.7 Scrub/Shrub wetland tree regeneration

The scrub/shrub wetland has the highest recorded density of all sampled habitat types with 2,454 stems per acre (Table 2). Nearly all of this density is due to the extremely high numbers of cascara sampled from two plots (plots 22 and 26) in the six acre wetland adjacent to Shadow Lake (Map 1). These two plots alone average 4,355 stems/acre of this small-statured tree species. Additional native trees found at low densities include western hemlock (18 stems per acre), red alder (8 stems per acre), black cottonwood (5 stems per acre), and western red cedar (3 stems per acre).

Four species of non-native trees were found in this habitat, with English holly being the most prevalent at 128 stems per acre (Table 2). European mountain ash is also present at 18 stems/ per acre and sweet cherry at 3 stems per acre. *Prunus* x *pugitensis*, a hybrid known to occur between the native bitter cherry and the non-native sweet cherry, was found at low density in the lower 1.9 acre wetland complex in the southwestern part of the property (Jacobsen & Zika, 2007).

4.4 Possible Successional Trajectories

The habitat types found throughout the property exhibit a variety of structural compositions and age classes. While some show relatively stable characteristics, others show evidence of dynamic systems with high rates of change. The conifer and conifer/deciduous mixed forested areas display many of the characteristics of a mid- to late successional forested system. These forests have tree densities that exhibit a high degree of structural diversity, with tree heights well distributed across all height classes and substantial native tree regeneration (Figure 3). This structural diversity is also evident by the even diameter distribution of overstory trees within these two habitat types and the relatively high proportions of large diameter trees greater than 20 inches in diameter (Figure 4). While these forests may be in a constant state of flux as a result of small scale disturbances (such as canopy gaps from windfall events), they appear relatively stable in relation to species composition and overall structure. The deciduous forests located on the property, on the other hand, appear to be recovering from more recent and comprehensive disturbances. On average, these forests seem to represent an earlier successional system, as evidenced by the majority of trees present in a single, relatively small height class (Figure 3). These forests have low overstory tree densities that are made up of predominately small diameter trees (Figure 4). The riparian forested wetlands also have relatively low densities of overstory and regenerating trees, which are well distributed across the small to mid-range height classes (Figure 3). This is possibly due to the unstable conditions created by the high water table and frequent flooding in these areas. These saturated soil conditions limit tree establishment in general and tend to favor wetland-adapted tree species such as alders and willows.

The wetland and bog areas also exhibit differing levels of stability and change. The scrub/shrub wetlands have very low overstory tree densities, likely due to the saturated soil conditions. These areas appear relatively stable and are dominated by tall statured shrubs such as western crabapple, twinberry, and willow species (*Salix ssp.*) (Table 2). The hemlock/sphagnum bog

also exhibits characteristics of a stable system with a structurally diverse tree canopy (Figure 3). Tree densities do however show a steady decline as tree heights increase (Figure 3). Factors limiting growth could be nutrient poor and acidic conditions created by the bog environment, or to lack of soil stability. The Labrador tea/sphagnum bog, on the other hand, exhibits characteristics of a dynamically changing system. Although this habitat type is characterized by large expanses of shrub-dominated growth, the recorded overstory tree densities are higher than three other habitat types, including the deciduous and riparian forested wetland types (Table 2). The majority of trees in this habitat are relatively small, with high densities of regenerating conifers (Figure 3). There are also numerous "tree islands" or pockets of trees interspersed throughout this habitat. In the absence of future disturbances, it is possible that the Labrador tea/sphagnum habitat type will transition towards a more forested system. As the numerous regenerating trees mature and the "tree islands" expand and merge, the shrub-dominated system could decline in favor of a more dominant hemlock/sphagnum forested habitat type. However, the current shrub-dominated state of the Labrador tea/sphagnum bog is likely to persist for the next several hundred years and will be reinforced by disturbances such as wind storms and beaver activity.

4.5 Snags

Standing dead trees (snags) play a crucial role in the structure and function of a forest system. Snags provide important habitat for wildlife, birds, insects, non-vascular plants such as mosses and fungi, and are a store of nutrients for the forest. In the Pacific Northwest, 69 vertebrate animal and bird species commonly use cavities excavated in snags (Bunnell et al. 2002).

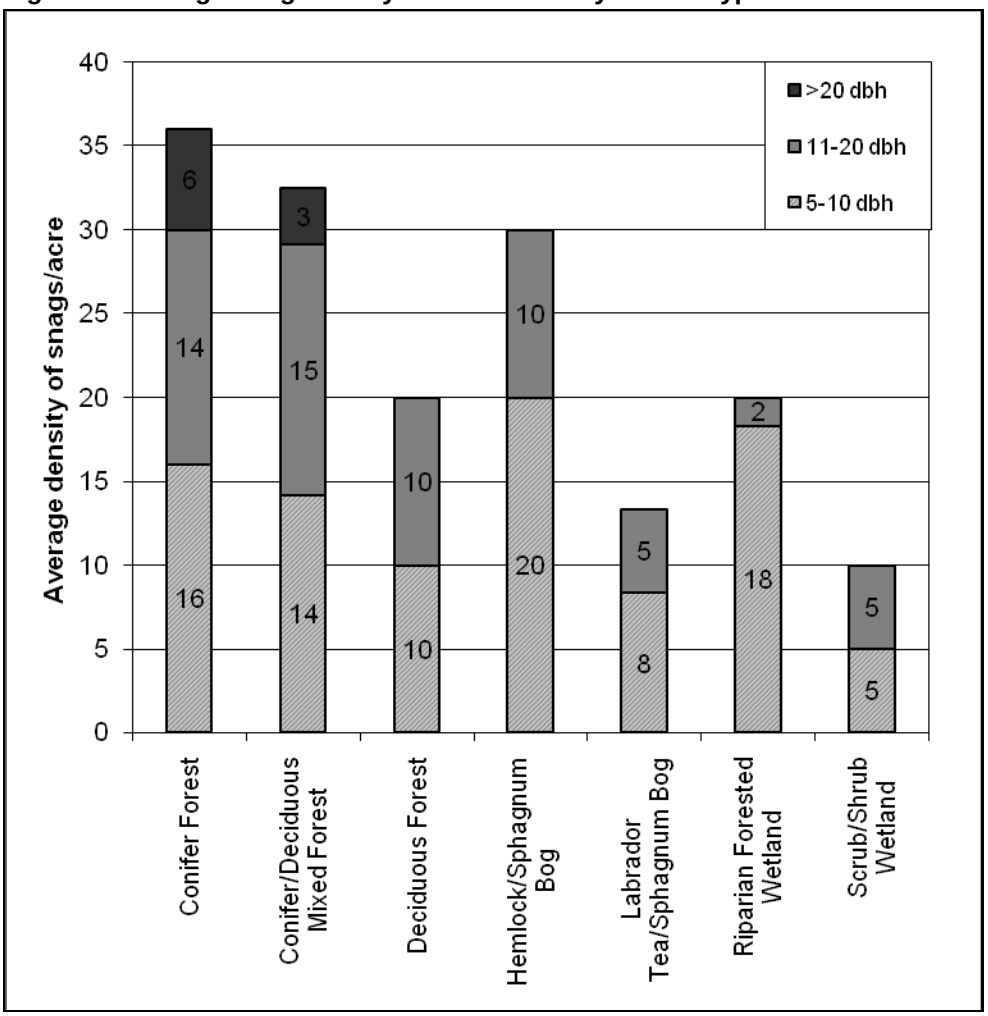
Snags are found on 32 of the 41 sampled plots at an average density of 24 stems/acre across all plots. The average snag height is 27.0 feet tall with an average diameter of 11.8 inches. Plots without snags are found in the Labrador tea/sphagnum bog (4 plots), the scrub/shrub wetland (2 plots), the deciduous forest (2 plots) and the riparian forested wetland (1 plot) habitat types. Snags average 31 stems per acre in plots where snags are present. Snag densities range from an average of 36 stems per acre in the conifer forest to 10 stems per acre in the scrub/shrub wetland (Figure 6). The hemlock/sphagnum bog averages 30 stems per acre, while the deciduous and riparian forested wetlands average 20 stems per acre each (Figure 6). Average snag diameters range from 14.3 inches in the conifer forest to 8.6 inches in the riparian forested wetland. The average snag diameter in the conifer/deciduous mixed forest is 13.1 inches. In comparison, a study of old-growth Douglas fir forests in Washington and Oregon found densities from 13 to 24 snags per acre, with diameters ranging from 16 inches at 250 years old to 25 inches at over 850 years (Franklin et al. 1981). This suggests that snags in the conifer and conifer/deciduous mixed forests in Shadow Lake have diameters approaching those of 250 year old Pacific Northwest conifer forests. These average diameters, however, may be elevated due to past logging events in these areas. Many of the large diameter snags measured are less than 20 feet tall, including an 8 foot tall "stump" with a diameter of 61 inches.

The majority of all measured snags (57%) are less than 10 inches in diameter (Figure 6). These small snags are generally short-lived and quickly become downed woody debris which rapidly decays on the forest floor. Both the hemlock/sphagnum bog and the riparian forested wetland habitat types have high proportions of these smaller diameter snags (Figure 6). Thirty-seven percent of snags are between 11 and 20 inches in diameter, while six percent (nine stems per

acre) are greater than 20 inches in diameter and are found only in the conifer and conifer/deciduous mixed forests Figure 6).

Large diameter snags are an important factor in providing wildlife habitat. A study by Mannan et al. (1980) found that hole-nesting birds usually use snags over 24 inches in diameter and over 50 feet tall. None of the snags measured in Shadow Lake meet this criteria. Of the 16 snags 50 feet or taller, the average diameter is only 12.6 inches. However, the fact that there are more than 18 stems per acre of living trees greater than 20 inches in diameter across all plots suggests that future large diameter snag recruitment will be possible. Preserving large snags when practical will improve the structural diversity of the forest and provide wildlife habitat on the property that could help to attract species which are not currently present.

Figure 6. Average snag density and diameter by habitat type in Shadow Lake



4.6 Coarse Woody Debris (CWD)

Coarse woody debris (CWD) can be defined as "sound and rotting logs and stumps that provide habitat for plants, animals and insects and a source of nutrients for soil structure and development" (Stevens 1997). CWD plays a vital role in forests by adding organic material and nutrients to the soil and providing habitat for decomposer fungi, animals, birds, bacteria and insects. In the Pacific Northwest, 47 vertebrate bird and animal species utilize downed wood for foraging, shelter and cover (Bunnell et al. 2002). CWD also acts as nurse logs for seedlings of plants such as western hemlock and red huckleberry (*Vaccinium parvifolium*), retains sediment and prevents erosion (Stevens 1997).

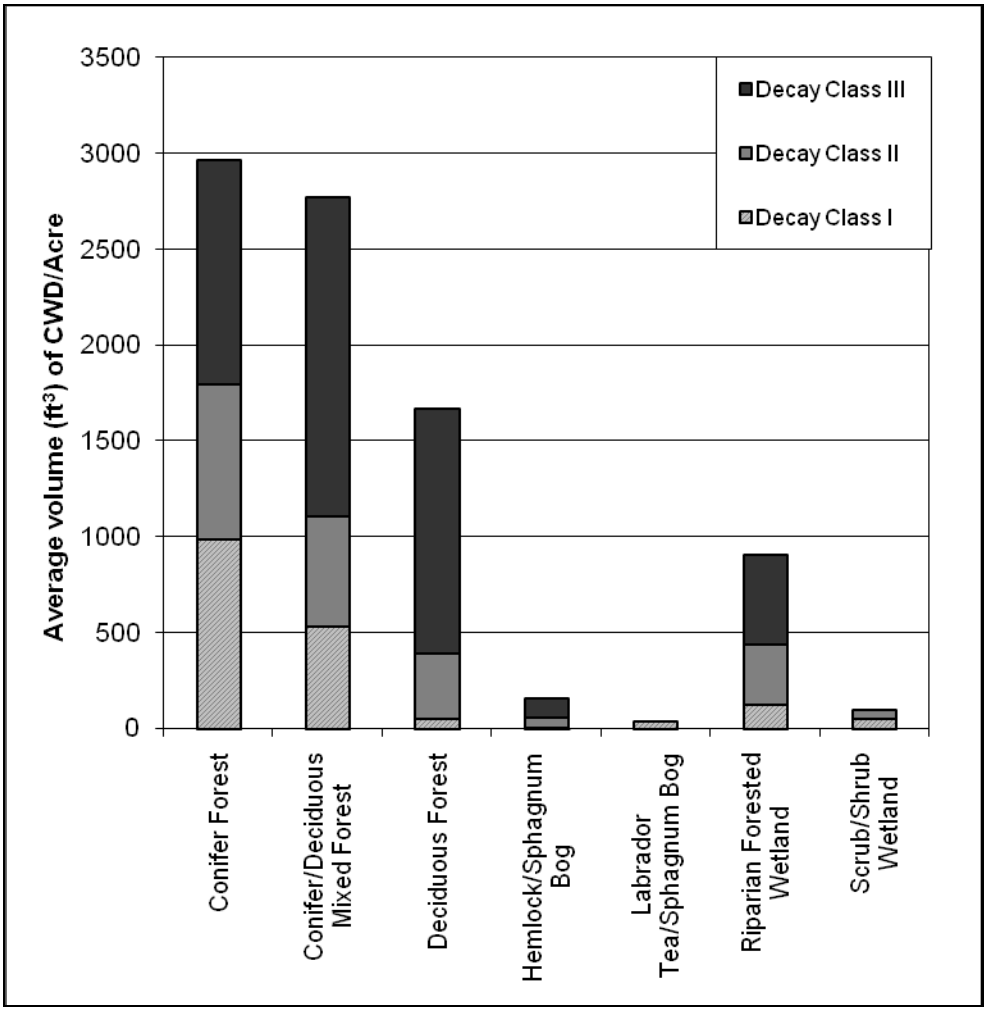
4.6.1 CWD distribution

CWD was measured on 34 of the 41 total plots sampled. Overall, CWD averages 130 pieces per acre across all sampled plots (157 pieces/acre where present) and averages 11.4 feet in length

and 11.8 inches in diameter. The average volume of wood per plot across all plots is 1,572 ft^3 per acre and 1,896 ft^3 per acre across the 34 plots where CWD is present. Volumes of CWD vary across plots from a high of 8,251 ft^3 per acre to 47 ft^3 per acre. The conifer forest and the conifer/deciduous mixed forest habitat types have the highest average volume at 2,963 ft^3per acre and 2,774 ft^3 per acre respectively (Figure 7). In comparison, Douglas fir /western hemlock forests over 250 years old typically contain approximately 6,400 ft^3 per acre of CWD (Harmon et al.1986). The non-forested wetland habitats have low volumes of CWD, resulting from the low densities of overstory trees present in these forests types. The Labrador tea/sphagnum bog has the lowest volume with 34 ft^3 per acre, while the scrub/shrub wetland has comparably low volumes at 95 ft^3 per acre (Figure 7).

As it decays, CWD provides a progression of ecological functions that contribute to the diversity of species and processes in the forest. Large pieces in particular are important as significant stores of carbon and energy. This large material generally decays more slowly and provides a steady input of nutrients and long-lasting structural components to the forest system (Stevens 1997). Relatively large amounts and proportions of CWD in the later stages of decay (class III) are present in the upland forested systems that include the conifer forest, conifer/deciduous mixed forest, and deciduous forest habitat types (Figure 8). The average diameter of downed wood in these forest types is comparably high, averaging 9.8 inches in the conifer forest, 13.5 inches in the conifer/deciduous mixed forest, and 13.2 inches in the deciduous forest. Newly recruited CWD (class I) is generally lacking in the deciduous forest (Figure 8). This could be of future concern, especially considering the low densities of large diameter trees currently present in the overstory (Table 2). Compared to other forest types, the riparian forested wetland and the hemlock/sphagnum bog habitat types have relatively low measured volumes of CWD. This could have been amplified by the fact that downed wood may become obscured by mud, water, and moss in these areas.

Figure 7. Average volume of coarse woody debris (CWD) and decay class by habitat type in Shadow Lake



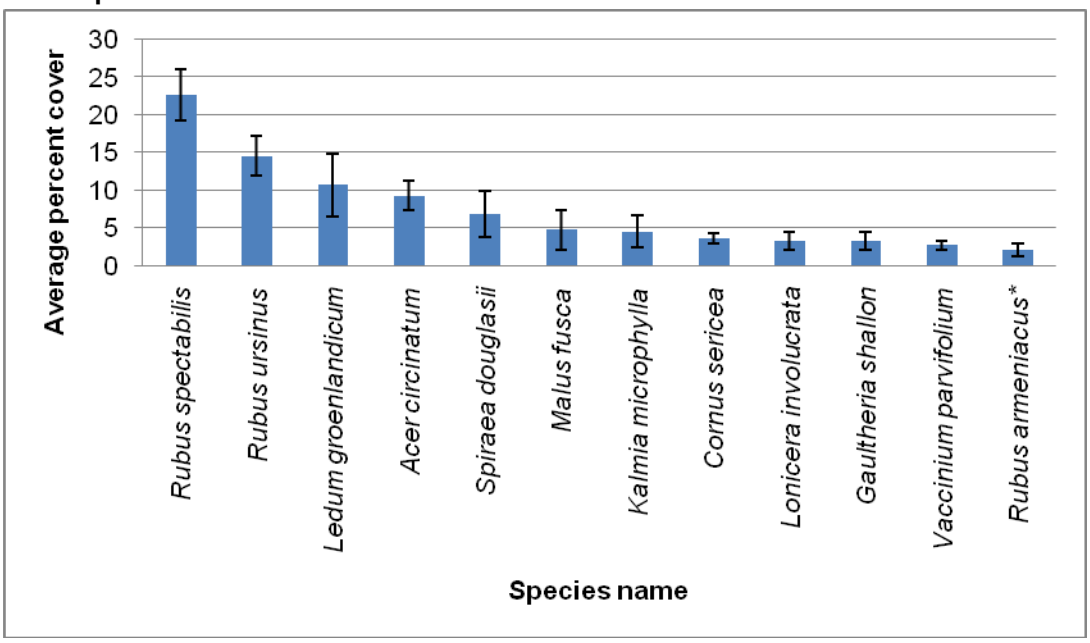
4.7 Shrub Composition and Diversity

A total of 33 shrub species were recorded in Shadow Lake during the 2007 survey, of which 31 are native to the Puget Sound lowlands and two are considered to be non-native invasive species (Table 3). The most dominant shrub property-wide is salmonberry, found in 34 of the 41 sampled plots (83%) with an average cover of 23% across all plots and 27% where present (Figure 8 & Appendix A). Creeping blackberry is common with a combined cover across all plots of 15% and found in 85% of all plots. Other dominant shrubs property-wide include bog laurel, vine maple, and hardhack (*Spirea douglasii*) (Figure 8). Red huckleberry and red elderberry (*Sambucus racemosa*) are found at relatively low covers but at the high frequencies of 85% and 73% of all plots respectively (Appendix A). Creeping blackberry and red huckleberry are the only two shrubs found in all seven habitat types (Table 3). Labrador tea has the highest recorded average cover in the 11 plots where it was present at 40%.

Himalayan blackberry, a non-native invasive shrub, has the twelfth highest average percent cover property-wide with 2% (6% where present) and is found in approximately one-third of all plots (34%) (Appendix A). Evergreen blackberry is found at a higher frequency (46%), but at the relatively low average cover of less than 1% property-wide and 2% where present (Appendix A).

Total combined cover of native shrubs averages 95% across all 41 sample plots. Combined cover for individual plots can be greater than 100% if several species have high covers present in overlapping strata. Native shrub cover averages range from 7% in the hemlock/sphagnum bog to 145% in the scrub/shrub wetland habitat type. Other habitats with high native shrub covers include the Labrador tea/sphagnum bog (121%), the riparian forested wetland (118%), and the deciduous forest (114%). The upland habitat types have lower native shrub covers, averaging 74% in the conifer/deciduous mixed forest and 61% in the conifer forest. These habitats do, however, have considerable amounts of sword fern in the herbaceous layers (56% and 26% respectively) compared to other habitat types found in Shadow Lake (Table 4).

Figure 8. Distribution of the 12 most prevalent shrubs in Shadow Lake across all plots (N=41). Bars represent +/- standard error.[1]



[1] Species denoted by * are non-native species which have been given a legal designation by the King County Noxious Weed Program (King County 2007).

4.7.1 Conifer forest shrub composition

The conifer forest habitat type has 21 species of shrubs present across all five plots, of which 19 are native (Table 3). Only the scrub/shrub wetland habitat has more native shrub species with 20 different species recorded there. Total native shrub cover averages 61% across all plots, dominated by creeping blackberry and salal, with 20% and 13% cover respectively (Table 3). Salmonberry is present at 10%, with red huckleberry accounting for five percent of the total cover, the highest for any sampled habitat type in Shadow Lake (Table 3). Vine maple (4%), red elderberry (2%) and devils club (*Oplopanax horridus*) (1%) are present in smaller amounts.

Trace amounts of rusty menziesia (*Menziesia ferruginea*) were found in a single plot (plot 30) and only in this forest type. Invasive blackberry species account for two percent of the total shrub cover and are found in four of the five plots (plots 8, 9, 30, and 34). One plot in particular (plot 30) had a relatively high cover of evergreen blackberry at 7% of the plot area.

4.7.2 Conifer/Deciduous mixed forest shrub composition

Sixteen native shrub species and two non-native invasive shrub species are found in the conifer/deciduous mixed forest habitat type (Table 3). The shrub species composition is similar to that found in the conifer forest habitat type, although the proportions of dominant species differ considerably. Combined native shrub cover for all plots averages 74% and is dominated by salmonberry (27%), creeping blackberry (18%), and vine maple (15%). Red huckleberry (4%), red elderberry (3%), salal (2%), devils club (1%), and beaked hazelnut (*Corylus cornuta*) (1%) are present in lower amounts (Table 3). Trace amounts of Lewis' mock-orange (*Philadelphus lewisii)* were recorded in one plot (plot 3) in this forest type, the only occurrence noted on the property. Himalayan blackberry and evergreen blackberry are found in trace amounts in six of the twelve plots sampled in this habitat type (plots 6, 7, 11, 15, 17, and 19), all found in the forests located in the southern part of the property (Map 1)

4.7.3 Deciduous forest shrub composition

The deciduous forest habitat type has a similar shrub species composition compared to the other upland forested habitat types, again with differing proportions of the dominant species. Most significant are the comparably high covers of salmonberry (51%), creeping blackberry (27%), vine maple (19%), and beaked hazelnut (7%) which are found in highest amounts property-wide in this habitat type. Fifteen native species were recorded at an average combined cover of 114% across all six sampled plots (Table 3). One species unique only to this habitat type, wild gooseberry (*Ribes divarcatum*), was found in trace amounts in plot 28. As discussed earlier, parts of this habitat type have undergone substantial disturbance. As a result, these forests have the highest average cover of invasive blackberry species, with Himalayan blackberry averaging 11% across all plots (Table 3). This species was recorded in four of the six plots (plots 12, 13, 14, and 29) at an average of 17% across these plots. The highest cover was recorded in plot 29 at 25% of the plot area.

4.7.4 Hemlock/Sphagnum bog shrub composition

The corridors that make up the hemlock/sphagnum bog habitat types have the lowest recorded shrub cover and species richness in Shadow Lake, with eight native species averaging a combined cover of only 7% across both sample plots (Table 3). The low cover is likely due to the dense, closed canopy of western hemlock trees throughout this habitat type. As a result, shrubs are only present towards the edges and beneath the small openings in the canopy. The most prevalent shrub in these forests is Labrador tea with an average cover of 2% (Table 3). Additional species include red elderberry, salal, red huckleberry, creeping blackberry, and bog laurel, all present at one percent cover. Salmonberry and hardhack are also present in trace amounts (Table 3). Only one non-native invasive species, evergreen blackberry, was recorded in trace amounts in the lower forest complex in plot 36 (Map 1).

4.7.5 Labrador tea/Sphagnum bog shrub composition

The nearly 12 acres of Labrador tea/sphagnum bog habitat type has the second highest shrub cover with a combined average of 121% across all six sample plots. Like the hemlock/sphagnum bog habitat type, this habitat has relatively low shrub species richness with a total of nine native shrub species present. Labrador tea is the most dominant shrub species with an average cover of 71%, and a range of 39% to 95% across all six plots (Table 3). The sub-dominant shrub bog laurel grows interspersed with the Labrador tea and averages 30% across all plots. Hardhack averages 14% across all plots, but is found on only two of the six plots sampled in this habitat type. The shrub composition in the south-eastern most plot (plot 35) suggests that this area is influenced by the nearby scrub/shrub wetland adjacent to the lake (Map 1). This plot is dominated by hardhack with a cover totaling 84% of the plot area and has the only recorded occurrence of western crabapple in this habitat type at 12%. Small cranberry is found in five of the six plots at an average cover of 2% (Table 3). Additional species include salal (1%), red huckleberry (1%), twinberry (trace), and creeping blackberry (trace) (Table 3).

4.7.6 Riparian forested wetland shrub composition

The riparian forested wetland habitat type has a high combined native shrub cover with a percent cover comparable to the Labrador tea/sphagnum bog habitat with an average of 118% across six plots. The riparian forests have a unique shrub composition compared to the other habitat types, more closely resembling the scrub/shrub wetland than the upland or bog habitat types (Table 3). Salmonberry is the most dominant shrub with an average of 27%. Sub-dominant shrub species include red-osier dogwood (20%), creeping blackberry (16%), twinberry (14%), pacific willow (12%), and hardhack (10%) (Table 3). Pacific ninebark (*Physocarpus capitatus*) was found in one plot of the northern riparian forest complex (plot 32) at a cover of 7% of the plot area, the only incidence of this species recorded on the property.

Invasive blackberry species are present in all six plots at a combined average cover of 1%. Highest covers exist in plots 21 (4%) and 24 (2%) in the southern riparian forest complex (Map 1).

4.7.7 Scrub/Shrub wetland shrub composition

The four plots sampled in the scrub/shrub wetland habitat type have the greatest average combined native shrub cover compared to other habitats on the property at 145%. The most substantial difference in shrub composition in this habitat type is the dominant cover of western crabapple (39%) and hardhack (31%). Western crabapple is only found in the southern portion of the six acre wetland bordering Shadow Lake (plots 22 and 26), where it dominates the habitat at high covers of 71% and 85% respectively. The northern portion of this wetland system transitions to a willow dominated habitat. The northern-most plot (plot 23) is dominated by willow species with a combined cover of 50%, mostly comprised of Scouler's willow (*Salix scouleriana*) (24%) and Hooker's willow (*Sallix hookeriana*) (20%). Also of significance is the relatively high diversity of willow species found here, with five species combining to average 13% cover across all plots (Table 3). Salmonberry (22%), twinberry (11%), and vine maple are also prevalent in this habitat type.

Invasive blackberry species (Himalayan and evergreen blackberry) average six percent across all plots in the scrub/shrub habitat, the second highest cover of these species compared to other

habitat types found on the property (Table 3). These species are found in three of the four plots at the relatively high covers of 11% (plot 20), 8% (plot 26), and 6% (plot 22).

Table 3. Shrub species found in each of the sampled habitat types in Shadow Lake. Values represent the percent cover of each species averaged across all plots (N) in each habitat type.

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
Acer circinatum	vine maple	4	15	19			4	9
Cornus sericea	red-osier dogwood	1					20	6
Corylus cornuta	beaked hazelnut	1	1	7			T	T
Gaultheria shallon	salal	13	2	T	1	1	4	3
Kalmia microphylla	bog laurel				1	30		
Ledum groenlandicum	Labrador tea	T			2	71		1
Lonicera involucrata	twinberry	1				T	14	11
Mahonia nervosa	low Oregon grape	T	1	T				
Malus fusca	western crabapple	T	T	1		2	3	39
Menziesia ferruginea	rusty menziesia	T						
Oemleria cerasiformis	Indian plum	T	1	2				
Oplopanax horridus	devil's club	1	1	T			T	T
Philadelphus lewisii	Lewis' mock-orange		T					
Physocarpus capitatus	Pacific ninebark						1	
Ribes divaricatum	wild gooseberry			T				
Ribes lacustre	swamp gooseberry		T	T			T	
Rosa gymnocarpa	baldhip rose	T	T					
Rosa nutkana	Nootka rose							1
Rubus armeniacus*	Himalayan blackberry	T	T	11			1	3
Rubus laciniatus*	evergreen blackberry	2	T	1	T		T	3
Rubus leucodermis	blackcap	T	T					T
Rubus parviflorus	thimbleberry	T	T	1				
Rubus spectabilis	salmonberry	10	27	51	T		27	22
Rubus ursinus	creeping blackberry	20	18	27	1	T	16	6

Table 3 (Continued)

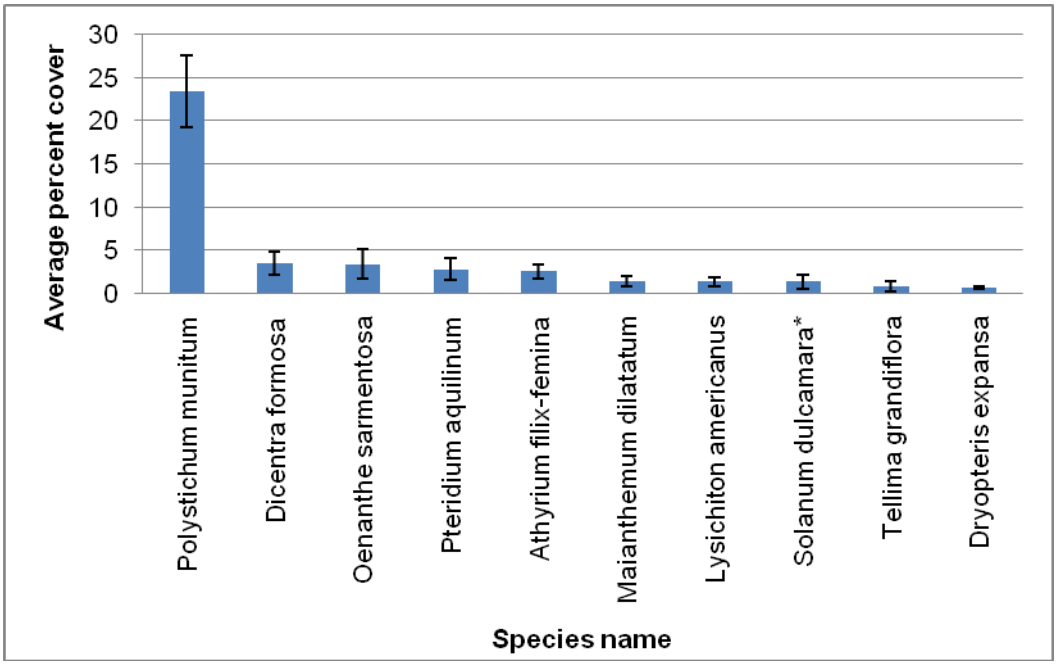
Scientific Name[1]	Common Name	Conifer Forest (N=5) [2]	Conifer/ Deciduous Mixed Forest (N=12) [2]	Deciduous Forest (N=6) [2]	Hemlock/ Sphagnum Bog (N=2) [2]	Labrador Tea/ Sphagnum Bog (N=6) [2]	Riparian Forested Wetland (N=6) [2]	Scrub/Shrub Wetland (N=4) [2]
Salix geyeriana	Geyer willow							T
Salix hookeriana	Hooker's willow						1	5
Salix lucida ssp. lasiandra	Pacific willow						12	1
Salix scouleriana	Scouler's willow						1	7
Salix sitchensis	Sitka willow							T
Sambucus racemosa	red elderberry	2	3	3	1		1	1
Spiraea douglasii	hardhack	1		T	T	14	10	31
Vaccinium oxycoccos	small cranberry					2		
Vaccinium parvifolium	red huckleberry	5	4	2	1	1	2	1

[1] Species in bold are non-native species. Species denoted by * are species which have been given a legal designation by the King County Noxious Weed Program (King County 2007).
[2]T=Trace presence of species (less than 1%).

4.8 Herbaceous and Vine Composition and Diversity

Herbaceous and vine species include forbs, grasses, and fern species. A total of 82 herbaceous and vine species were recorded in Shadow Lake during the 2007 survey, of which 55 are native, 24 are considered to be non-native, and three are undetermined (Table 4). The most dominant herbaceous species property-wide is sword fern, found in 32 of the 41 sampled plots (78%) with an average cover of 23% across all plots and 30% where present (Figure 9 & Appendix A). Other dominant herbaceous and vine species property-wide include western bleeding heart, water parsley, bracken fern, and lady fern (Figure 8). Species found at relatively low covers but at high frequencies include licorice fern (*Polypodium glycyrrhiza*) (80% frequency), wood fern (*Dryopteris expansa*) (73%), Dewey sedge (*Carex deweyana*) (71%), cleavers (*Galium aparine*) (68%), and small-flowered wood rush (*Luzula parviflora*) (59%) (Appendix A). Herb Robert and wall lettuce (*Mycelis muralis*) are the most commonly encountered non-native species at 37% and 34% frequencies respectively. Bittersweet nightshade (29% frequency), English ivy (20% frequency), and creeping buttercup (*Ranunculus repens*) (20% frequency) are also prevalent. Bittersweet nightshade has the highest average percent cover of non-native species at 1% across all 41 plots and 5% where present. Creeping buttercup averages <1% property-wide and 3% where present (Appendix A).

Figure 9. Distribution of the 10 most prevalent herbaceous and vine species in Shadow Lake across all plots (N=41). Bars represent +/- standard error.[1]



[1] Species denoted by * are non-native species which have been given a legal designation by the King County Noxious Weed Program (King County 2007).

Total combined cover of native herbaceous species averages 45% across all 41 sample plots. Combined native cover averages range from 2% in the Labrador tea/sphagnum bog to 71% in the conifer/deciduous mixed forest habitat type. The conifer (60%), riparian (53%), and deciduous forests (53%) all have similar average total native herbaceous covers. The wetland and bog

habitats have relatively low covers of native herbaceous species, ranging from 2% in the Labrador tea/sphagnum bog, 8% in the hemlock/sphagnum bog, and 11% in the scrub/shrub wetland. Total cover of non-native species averages 2% across all plots property-wide.

4.8.1 Upland forested habitats herbaceous and vine composition

The conifer, conifer/deciduous mixed, and the deciduous forests have similar herbaceous species compositions. All have a dominant sword fern component which is highest in the conifer/deciduous mixed forest where it averages 56% (Table 4). The conifer forest has relatively high covers of bracken fern (10%), lady fern (3%), and deer fern (2%), as well as high average covers of false lily-of-the-valley (7%) and twinflower (*Linnaea borealis*) (4%) (Table 4). Trace amounts of goatsbeard (*Aruncus dioicus*) were also found in the conifer forest. The conifer/deciduous mixed forest and the deciduous forest both have relatively high average covers of western bleedingheart at eight and seven percent respectively. The conifer/deciduous mixed forest habitat type has the highest native species richness with 35 species recorded. This forest has the highest average cover of foamflower at one percent compared to all other sampled habitat types (Table 4). Species unique to the conifer/deciduous mixed forest include vanilla leaf (*Achyles triphylla*), baneberry (*Actea rubra*), and Alaska oniongrass (*Melica subulata*). The deciduous forest has the lowest sword fern cover at 19%. This forest type has relatively high average covers of fringecup (5%), stinging nettle (*Urtica dioica*) (3%), and .piggy-back plant (1%) (Table 4).

The most pervasive non-native invasive species present in the upland forested habitat types include bittersweet nightshade, herb Robert, and English ivy (Table 4). English ivy is found in trace amounts in both the conifer and deciduous forests. One large patch of English ivy was also noted in the 1.7 acre forest in the southern part of the property below plot 5 (Map 1). Trace amounts of the invasive weed tansy ragwort were found in plot 30 in the north end of the 3.6 acre conifer forest adjacent to the bog (Map 1). Tansy ragwort is listed as a Class B Noxious weed in King County (King County 2007). Trace amounts of ground ivy (*Glechoma hederacea*) were found in the conifer/deciduous forest in plot four. This is a potentially invasive species that spreads by rhizomes and can be difficult to eradicate.

4.8.2 Riparian forested wetland herbaceous and vine composition

Many of the moisture-dependent herbaceous species that are found in the upland forested habitats are also present in the riparian forested wetland habitat type. These forests have high average covers of water parsley (23%), a wetland obligate species usually found growing in areas with standing water. Lady fern (11%) and bracken fern (6%) are also prevalent (Table 4). Sword fern is present at the relatively low cover of four percent. Skunk cabbage averages three percent in this forest type, with average covers similar to the conifer and deciduous forested habitat types. Species unique to the riparian forest habitat type include slough sedge (*Carex obnupta*), western rattlesnake plantain (*Goodyera oblongifolia*), blue skullcap (*Scutellaria laterifolia*) and an unidentified violet species (likely *Viola palustris*). A *polygonum* species was also noted in the channel of Jenkins creek near plot 21, and is likely the native water pepper (*Polygonum hydropiperoides*).

This habitat type has the highest average cover of invasive herbaceous and vine species of any other sampled habitat type at 10%. Bittersweet nightshade is found in four of the five riparian

forested wetland plots at an average cover of eight percent (Table 4). This invasive species was especially prevalent in the northern 4.7 acre riparian forest (plots 32 and 33) at covers of 7% and 32% respectively. Plot 21 along the Jenkins Creek waterway in the south also had relatively high cover of bittersweet nightshade at 7% of the plot area. One non-native species of particular concern found predominantly in this habitat type is marsh forget-me-not (*Myosotis scorpioides***)**, a potentially invasive species that colonizes wet areas. This species is common in the low-lying areas where Jenkins Creek begins to become channelized and was found in plots 21 and 25 at covers of 6% and 2% respectively. Other non-native invasive species of concern are found at generally low average covers (less than one percent) in this habitat and include creeping buttercup and herb Robert found in three plots and English ivy found in two plots. Plot 31 has the highest cover of creeping buttercup at four percent of the plot area.

4.8.3 Sphagnum bog habitats herbaceous and vine composition

The hemlock/sphagnum bog and the Labrador tea/sphagnum bog habitat types both have relatively low covers of herbaceous species. These habitat types are characterized by having high covers of sphagnum and other types of mosses growing in the herbaceous layer. The hemlock/sphagnum bog has 8% cover of native species while the Labrador tea/sphagnum bog has only 2%. The hemlock/sphagnum bog also has a higher richness with 11 native species present, with lady fern (2%), skunk cabbage (2%), sword fern (1%), and bracken fern (1%) being the most dominant (Table 4). One native species, single delight (*Monesus uniflora*), was found only in this habitat type in trace amounts. The Labrador tea/sphagnum bog has only four native herbaceous species present, dominated by bracken fern at two percent (Table 4). Woolgrass (*Scirpus cyperinus*), a native bulrush, is present in low covers and is found only in this habitat type.

Small amounts of non-native species are found in the hemlock/sphagnum bog habitat type. These species include wall-lettuce, bull thistle (*Cirsium vulgare*), and bittersweet nightshade, all found at less than one percent average cover (Table 4). Soft rush (*Juncus effusus*) is also found in trace amounts in both sphagnum bog habitat types and was not identified as either the native or non-native variant.

4.8.4 Scrub/Shrub wetland herbaceous and vine composition

The scrub/shrub wetland also has relatively low cover of herbaceous species (11%), but has a much higher richness than the sphagnum bog habitats with 24 native species and 10 non-native species present. Sword fern is by far the most dominant species at an average of 6% cover across all four plots sampled in this habitat, with the majority occurring in the 2.3 acre wetland in the southern part of the property in plot 20.(Map 1). Bracken fern, false lily-of-the-valley, and licorice fern (*Polypodium glycyrrhiza*) each average one percent cover. The remaining 31 species were recorded in trace amounts averaged across all four plots (Table 4). The plot sampled in the northern portion of the six acre wetland (plot 23) has the fewest number of herbaceous species with a richness of six. The most dominant species here is northern bugleweed (*Lycopus uniflora*) with a cover of one percent. Trace amounts of marsh forget-me-not were also recorded in plot 23. Piggy-back plant (*Tolmiea menzesii*) (2%), ladyfern (1%), and Dewey's sedge (1%) are locally present at relatively high covers in the southern wetland in plot 20.

Non-native species cover averages less than one percent across all sample plots in the scrub/shrub wetland habitat. Only four non-native species are present in the six acre wetland bordering Shadow Lake of which two are considered potentially invasive: marsh forget-me-not and English ivy. Seven non-native species are present in the lower wetland complex, two of which are potentially invasive: herb Robert and creeping buttercup. All non-native species were sampled at trace amounts in plots where they were present.

Table 4. Herbaceous and vine species found in each of the sampled habitat types in Shadow Lake. Values represent the percent cover of each species averaged across all plots (N) in each habitat type.

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
Achlys triphylla	vanilla leaf		T					
Actaea rubra	baneberry		T					
Agrostis sp.	bentgrass		T	1				
Agrostis stolonifera	creeping bentgrass							T
Ajuga reptans	common bugle			T				
Angelica genuflexa	kneeling angelica			T				
Aruncus dioicus	goatsbeard	T						
Asarum caudatum	wild ginger		T					
Athyrium filix-femina	ladyfern	3	T	1	2		11	T
Blechnum spicant	deer fern	2	T	T			T	T
Bromus vulgaris	Columbia brome	T	T	T	1			T
Cardamine hirsuta	hairy bittercress	T	T	T				
Carex deweyana	Dewey sedge	T	T	2			T	T
Carex hendersonii	Henderson's sedge	T	T					
Carex obnupta	slough sedge						T	
Circaea alpina	small enchanter's nightshade		1	T				
Cirsium arvense*	Canada thistle		T					
Cirsium vulgare*	bull thistle				T			
Claytonia sibirica	Siberian miner's lettuce	T	1	1			T	T
Deschampsia caespitosa	tufted hairgrass		T					
Dicentra formosa	western bleedingheart	1	8	7				T
Digitalis purpurea	foxglove		T					T
Dryopteris expansa	wood fern	1	1	T	T		1	T

Table 4 (Continued)

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
Elymus glaucus	blue wildrye			T				
Epilobium ciliatum	fringed willowherb	T	T	T			T	T
Equisetum telmateia	giant horsetail	T		4				
Galium aparine	cleavers	T	1	2			T	T
Geranium robertianum	herb Robert	T	T	T			T	T
Geum macrophyllum	bigleaved avens	T		T			T	
Glechoma hederacea	ground ivy		T					
Glyceria striata	tall mannagrass	T		1			T	T
Goodyera oblongifolia	western rattlesnake plantain						T	
Hedera helix	English ivy	T		T			T	T
Holcus lanatus	velvetgrass	T	T	T			T	
Hydrophyllum tenuipes	Pacific waterleaf			T				
Juncus effusus	soft rush				T	T		T
Lapsana communis	nipplewort		T	T				
Linnaea borealis	twinflower	4					T	
Lonicera ciliosa	orange honeysuckle		T	T				
Lunaria annua	annual honesty			T				
Luzula multiflora	common woodrush	T	T	T				
Luzula parviflora	small-flowered woodrush	T	T	T			T	T
Lycopus uniflorus	northern bugleweed						T	T
Lysichiton americanus	skunk cabbage	3		3	2	T	3	T
Maianthemum dilatatum	false lily-of-the-valley	7	1	1			1	1
Melica subulata	Alaska oniongrass		T					
Mentha arvensis	wild mint						T	
Monesus uniflora	single delight				T			
Mycelis muralis	wall-lettuce	T	T		T		T	T

Table 4 (Continued)

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
Myosotis scorpioides	marsh forget-me-not						1	T
Nemophila parviflora	smallflower nemophila		T	T				
Oenanthe sarmentosa	water parsley						23	
Osmorhiza berteroi	sweet cicely		T					
Polypodium glycyrrhiza	licorice fern	T	T	1	T	T	1	1
Polystichum munitum	sword fern	26	56	19	1		4	6
Pteridium aquilinum	bracken fern	10	T	1	1	2	6	1
Ranunculus repens	creeping buttercup		T	2			1	T
Rorippa nasturtium-aquaticum	water cress						T	
Rumex crispus	curly dock			T				
Rumex obtusifolius	bitter dock						T	T
Scirpus cyperinus	woolgrass					T		
Scirpus microcarpus	small-seeded bulrush				T			
Scutellaria lateriflora	blue skullcap						1	
Senecio jacobaea	tansy ragwort	T						
Solanum dulcamara*	bittersweet nightshade	1	T	1	T		8	
Stachys chamissonis var. cooleyae	hedgenettle			T				T
Stellaria calycantha	northern starwort			T				
Stellaria crispa	crisp sandwort	T	1	1			T	T
Stellaria media	chickweed		T	T				
Streptopus amplexifolius	clasping twistedstalk		T					T
Taraxacum officinale	dandelion			T				T
Tellima grandiflora	fringecup		T	5	T		T	
Tiarella trifoliata	foamflower	T	1	T			T	T

Table 4 (Continued)

Scientific Name[1]	Common Name	Conifer Forest (N=5)[2]	Conifer/ Deciduous Mixed Forest (N=12)[2]	Deciduous Forest (N=6)[2]	Hemlock/ Sphagnum Bog (N=2)[2]	Labrador Tea/ Sphagnum Bog (N=6)[2]	Riparian Forested Wetland (N=6)[2]	Scrub/Shrub Wetland (N=4)[2]
Tolmiea menziesii	piggy-back plant	T	T	1			T	T
Trientalis borealis ssp. latifolia	starflower	T	T					T
Trillium ovatum	trillium	T	T	T				
Urtica dioica	stinging nettle		T	3			T	
Veronica americana	American Speedwell	T			T		T	T
Veronica officinalis	common gypsyweed	T						T
Vicia sativa	garden vetch		T					
Viola sempervirens	evergreen violet	T	T	T				
Viola sp.	violet						T	

[1] Species in bold are non-native species. Species denoted by * are species which have been given a legal designation by the King County Noxious Weed Program (King County 2007). Species denoted by ** are non-native invasive species which do not have a legal designation at this time.
[2]T=Trace presence of species (less than 1%).

5. MANAGEMENT RECOMMENDATIONS

Each of the seven forested and wetland habitat types identified during the 2007 survey shown on Map 1 are treated as individual management zones for this report. Two additional management zones discussed in this section include the 0.6 acre amphibian pond and the 1.8 acre access road (Map 1). Overarching management goals within the property are to:

1) Reduce invasive species concentrations
2) Maintain an official trail network and forest buffer and revegetate cleared areas adjacent to areas of development and the access road
3) Preserve large snags and increase coarse woody debris whenever possible

The natural areas of Shadow Lake provide important ecosystem services and functions including improved water quality and filtration of pollutants from the air. Forests and wetlands clean and store stormwater runoff, retain sediment, provide groundwater recharge and discharge services, and provide important habitat for a variety of plant and animal species (Guntenspergen and Dunn 1998). In addition, the extensive wetland and forested areas offer a valuable cultural resource to the Puget Sound community and provide important educational opportunities.

These natural areas represent a significant and contiguous undeveloped habitat in an increasingly built-up environment. As urban pressures continue to intensify, areas of natural habitat are becoming increasingly important. Population growth and expansion in the Puget Sound region has led to increased pressure from development on the remaining open spaces, resulting in fewer intact forests and greater habitat fragmentation.

The forests and wetlands of Shadow Lake represent many of the characteristics of a mature, intact natural system. Most of these systems are structurally diverse and species rich areas with little human caused disturbances. Natural tree regeneration is abundant throughout the majority of the property, and relatively high volumes of coarse woody debris are present in the forested habitats. Sphagnum bogs are truly unique wetland systems that have become increasingly rare in the Puget Sound region, and those at Shadow Lake have been exceptionally preserved.

Unfortunately, encroachment of invasive species, human activity and other disturbances make active stewardship vital to maintaining and increasing the natural function of the forests and wetlands at Shadow Lake. Invasive species in particular pose a serious threat to the future composition of the forest and wetland systems. These issues will need to be addressed with proactive management.

Recommendations for each of the nine identified management zones will be discussed in detail in section 5.6. Two property-wide management issues have been identified and include: trails and human impacts (section 5.2) and invasive species eradication and control (section 5.3). These issues are discussed below. Specific management recommendations for the property are summarized in section 5.1, Management Priorities.

5.1 Management Priorities

Management recommendations for Shadow Lake have been separated into three categories:

- Short-term priorities. These are actions that are of high importance and could be completed within the next two years
- Medium-term priorities. These are actions that will take planning to complete and could be completed within the next three to five years
- Long-term priorities. These are on-going activities that will take many years to accomplish.

Short term priorities

1) Removal of English holly and European mountain ash from the northern 3.6 acre conifer forest
2) Removal of discrete patch of ivy in the 1.7 acre conifer forest habitat type and replanting with native species
3) Removal of discrete areas of invasive blackberries and bittersweet nightshade in the 3.6 acre conifer forest and replanting with native species
4) Assessment and removal of large herb Robert infestations from the central 10.2 acre conifer/deciduous mixed forest
5) Locate extents of ground ivy in the lower 5.7 acre conifer/deciduous forest and assess eradication requirements
6) Removal of limited invasive species present in the lower 1.7 acre hemlock/sphagnum bog habitat to prevent further spread
7) Assessment of extents of heavy infestations and removal of isolated patches of bittersweet nightshade in the northern 4.6 acre riparian forested wetland
8) Restrict access to sensitive areas of the property and close off unnecessary informal trails.

Medium-term priorities

9) Removal of invasive blackberry and creeping buttercup from the forest interior in the deciduous forest in the vicinity of plot 29 to buffer against heavy encroachment and replanting with native species
10) Removal of English holly from the northern 3.4 acre deciduous forest in the vicinity of plot 28 and replanting with native species
11) Removal of isolated patches of invasive blackberries from the central 5.3 acre deciduous forest and replanting with native species
12) Removal of English holly and European mountain ash from the lower 9.5 acre riparian forested wetland, the 6.0 acre scrub/shrub wetland bordering Shadow Lake, and the conifer/deciduous mixed forest in the vicinity of Jenkins creek
13) Removal of relatively low covers of invasive blackberries from the lower 9.5 acre riparian forested wetland and replanting with native species
14) Assessment and removal of marsh forget-me-not from the riparian areas in the vicinity of Jenkins Creek
15) Removal of invasive blackberries from the lower 2.3 acre scrub/shrub wetland from the area north of the main access trail and replanting with native species
16) Removal of invasive blackberries from the southern portion of the 6.0 acre scrub/shrub wetland complex that borders Shadow Lake and replanting with native species

17) Provide on-going maintenance and monitoring of restored areas
18) Preserve the hydrologic conditions on the site, including limiting any potential impacts from adjacent development or other alterations to the natural flow of ground water, surface runoff, and storm water.

Long-term priorities

19) Removal of invasive blackberry infestation between the pasture and the northern 3.4 acre deciduous forest and replanting with native species
20) Removal of invasive blackberry and restoration of the lower 2.3 acre scrub/shrub wetland south of the main access trail and along the roadside ditch adjacent to Peter Grubb Road SE
21) Removal of major invasive blackberry infestations from the central 5.3 acre deciduous forest and replanting with native species
22) Removal of major infestations of bittersweet nightshade from the northern 4.6 acre riparian forested wetland
23) Provide on-going maintenance and monitoring of restored areas

5.2 Trails and Human Impacts

Currently, the main trail in the northern section of the property receives the greatest concentration of visitors. The elevated boardwalk performs the crucial function of reducing disturbance to the fragile bog habitat, and care should be taken to limit foot traffic onto existing or new trails off of this network. In addition to being conduits for invasive species such as herb Robert, wall lettuce, and other non-native species, social trails can be a major cause of habitat fragmentation, soil compaction and erosion. These actions have the potential to trample native vegetation and can cause and exacerbate the detrimental effects of soil erosion and compaction and should be limited or excluded.

The main trail that winds through the southern portion of the property generally passes through a more upland environment than the northern bog trail. This trail requires regular clearing to keep it free of brush and extensive growth. There are currently several species of non-native plants that have established here that do not appear to pose an immediate threat. However, care should be taken to limit disturbances whenever possible and to monitor the trail and surrounding areas for the introduction and spread of potentially invasive species.

The access road and associated clearings in the south-west are additional areas where non-native growth has established. Although previous actions have been undertaken to eradicate invasive species from this area, ongoing maintenance and monitoring will be required to avoid future reintroduction. Particular species of concern noted in this area include: butterfly bush (*Buddleja davidii*), Himalayan and evergreen blackberry, and Canada thistle (*Cirsium avense*).

In addition to trails and roads located on the property, residential development on and off the property can jeopardize the integrity of the natural systems. Areas of particular concern include the 3.4 acre deciduous forest in the northern part of the property that buffers the residential areas and amphibian pond from the interior forest and the 5.3 acre deciduous forest between the access road and the residential development along the south-western property line (Map 1). As

previously described, these forests are heavily invaded with invasive blackberry species. It is recommended that invasive species be removed and cleared areas be replanted with native species. Conifer trees should be planted where appropriate as buffers and invasive species should be monitored to mitigate any spread into the interior forests.

5.3 Invasive Species Eradication and Control

The locations and extents of invasive species were recorded during the plot level survey and the results are described in section 4 above. In addition, a few large infestations of invasive species were also noted in areas between sample plot locations. The most common invasive species encountered during the survey (based on frequency) are evergreen blackberry (46%), English holly (41%), herb Robert (37%), European mountain ash (34%), Himalayan blackberry (34%), bittersweet nightshade (34%), English ivy (20%), and creeping buttercup (17%) (Appendix A). Invasive trees with the greatest density where present are English holly (202 stems/acre), European mountain ash (51 stems/acre), cherry laurel (23 stems/acre), one-seed hawthorn (15 stems/acre), and sweet cherry (10 stems/acre). Invasive shrubs, herbs and vines with the greatest cover where present are Himalayan blackberry (6% cover), bittersweet nightshade (5% cover), creeping buttercup (3%), marsh forget-me-not (3%), and evergreen blackberry (2%).

The following information describes the most common methods for removing the most prevalent invasive species in the property.

<u>Bittersweet nightshade</u>

Bittersweet nightshade is a deciduous vine that is classified as a Noxious Weeds of Concern in King County (King County 2008). This species is commonly found in wetland areas and can cover large areas, smothering native vegetation. Control of bittersweet nightshade requires management over multiple growing seasons. For plant infestations of less than 200 square feet, manual removal is typically effective. Wearing gloves, hand pull stems that are close to the ground and pull or dig up roots. This method is often more efficacious after rain or in loose soils. Take care to remove all stems and roots to avoid re-sprouting. For larger infestations, dig out roots using tools such as a hand tiller, shovel, spade, or claw mattock. In unincorporated King County, hand removal or removal with hand tools of up to 7000 square feet of bittersweet nightshade is allowed without the use of a permit. In incorporated King County, check with local land use agencies for permit information regarding removal of large infestations.

Mechanical methods such as mowing are typically not effective due to the habitat and growth patterns of bittersweet nightshade. However, brush cutting of dense thickets of the plant may facilitate access to roots for manual removal. Application of sheet mulching or a “heavy duty geotextile fabric” over an infestation for at least two years may also stunt the growth of bittersweet nightshade. Take care to cut any emerging plants to avoid re-growth. If removing dense patches, the area should be replanted with natives and mulched to help deter future invasive growth. Currently, there are no known biological methods of controlling bittersweet nightshade. Chemical methods of controlling Bittersweet nightshade infestations are known to be effective, especially if combined with other methods such as manual control and monitoring. Use of herbicides containing products such as glyphosate can be useful when applied after

berries have formed or in the early summer after plants have produced leaves. It is important to select an herbicide that is appropriate for the particular site, either aquatic or terrestrial. Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

Creeping buttercup

Creeping buttercup is a low-growing perennial herbaceous flowering plant in the buttercup family. Although creeping buttercup is not currently listed on the King County Noxious Weed List, it poses considerable problems in many wetland and riparian areas within the Puget Sound region. Creeping buttercup reproduces through seeds and stolons (creeping stems) and can exclude other herbaceous species. It is also toxic when consumed by livestock. Young plants in small patches can be manually removed using a small tool such as a hand tiller. It is important to remove all roots and stem fragments to prevent re-growth. Mechanical methods for control are confined to tilling as mowing is not effective to control this species. Tilling large areas repeatedly during a single season can be effective. However, many areas where this plant grows are too wet to be able to till several times a year. In addition this type of treatment is not appropriate in natural wetland or riparian areas. Chemical methods may also be effective in controlling creeping buttercup, as studies have indicated that application of selective herbicides such as 2,4-D can deter growth of the plant. It is important to select an herbicide that is appropriate for the particular site, either aquatic or terrestrial (Burrill 1992). Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

English Ivy

English ivy is one of the most invasive species in the Pacific Northwest. This evergreen climbing vine is capable of forming dense mats in the forest understory and excluding all other understory species. It can also climb up trees, preventing light from reaching the leaves and adding weight to the tree canopy, causing trees to weaken and fall during wind storms.

The most effective method for controlling English ivy is manual removal. Because English ivy can impact tree health by growing vertically, the first priority is to remove any vines growing on tree trunks and in the canopy. Install "survival rings" around trees by cutting or prying vines at shoulder height with the aid of a hand tool, killing any upper vines on the tree. Lower vines then need to be cleared, along with roots and vines found within at least a five foot radius of the base of the tree. For ivy growing along the ground, use hands or a small tool such as a hand tiller to pull or dig out the leaves and vines growing above the soil, as well as the woody roots growing just below the surface of the soil.

For disposal of hand-removed English ivy, several options are available. Disposal at a municipal vegetation waste facility is preferred. If the site will be monitored regularly, ivy can be piled on site on top of a paved area or tarp to prevent stems from re-rooting. Allow the pile to dry out, flipping periodically to ensure complete decomposition. Chemical methods of controlling English ivy are typically ineffective. The waxy leaves of the plant do not easily absorb herbicides, and herbicide run-off from the leaves results in risk to non-target plants (King County

2004). Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

English holly and cherry laurel

Cherry laurel and English holly are evergreen trees that can reach up to 50 feet in height, but are usually shorter when present in the forest understory. Both species can form thickets in the forest understory, reproducing in low-light conditions and excluding native plant species. These trees can be difficult to control as they form extensive root sprouts after being cut down. The most effective method of control is to remove the entire root while the plant is small and can be pulled. If the plant is larger, it is possible to remove it using a weed wrench. If the tree is too large to be either hand pulled or removed with a weed wrench, cutting the stem as close as possible to the ground and applying an herbicide such as Roundup directly to the cut portion of the stem as soon as possible is usually effective. Due to the fact that these trees tend to root spout and have many seedlings, monitoring around the infested areas on a regular basis will be necessary for several years after removal. It is very important not to cut the trees down without herbicide application, as this can lead to numerous root sprouts and re-growth from the stem (King County 2007a). Fact sheets including plant descriptions, distribution information and best management practices for control can be found in Appendix B.

European mountain ash, Sweet cherry and one-seed hawthorn

Sweet cherry, European mountain ash and on-seed hawthorn are all deciduous trees that can form dense thickets in the forest understory and exclude native trees and shrubs. Manual means of controlling these tree species include hand pulling small seedlings and removing young trees with a weed wrench where possible. It is easier to implement manual control when the soil is moist. If the tree is too large for manual removal, girdling can be an effective means of control. Girdling can be accomplished by cutting through the bark and growing layer (cambium) in a complete ring around the trunk. This method is most effective in the spring. Larger trees can also be cut down although re-growth should be monitored and removed for several years after the tree is cut down to prevent resprouting (USDA Forest Service 2006 and 2007). Fact sheets including plant descriptions, distribution information and best management practices for control can be found in Appendix B.

Herb Robert

Herb Robert is a fall and spring annual flowering plant in the geranium family. This low growing ground cover can spread vigorously in the forest understory and displace native plants. It is most often found along trail corridors and other disturbed areas. Herb Robert is most successfully controlled throughout several growing seasons. In order to prevent spreading, it is necessary to remove the plant before it produces any flowers or seeds. Due to the weak root system of Herb Robert, manual removal methods are often effective. Wearing gloves to prevent skin irritation from the sticky oils of the plant, pull gently at the base to pull up the roots. A mechanical method such as a string trimmer can also be effective if used before the plant sets seed. Do not dispose of Herb Robert in on site compost piles, as seeds can survive and spread from composting. Utilize municipal yard waste facilities, as commercial high heat composting

prevents germination of seeds. Chemical methods such as a systemic herbicide can be effective, especially if combined with monitoring for surviving plants. Such herbicides are absorbed by the foliage of the plant and travel through the plant to kill the roots. It is important to select an herbicide that is appropriate for the particular site, either aquatic or terrestrial. Take care to properly identify the plant prior to removal, because bleeding heart (*Dicentra formosa*), a Pacific Northwest native, is a strong look-alike (King County 2007b). Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

Himalayan and evergreen blackberry

Himalayan and evergreen blackberry are vigorous evergreen shrubs armed with prickles on the stems. These plants thrive in open, disturbed areas but can also invade forested areas on both wet and dry sites. Invasive blackberries often form large thickets that exclude all other species and can also climb and smother small trees.

Control of invasive blackberries requires management over a number of years. Based on the size of the site, various strategies can be effective. For small infestations of invasive blackberries, manual removal is appropriate. For larger infestations, mechanical methods such as mowing or brush cutting can be effective. Manual control consists of cutting blackberry canes with loppers or pruners one foot above the ground. Depending on the size of the plants, dig up the root balls using tools such as a hand tiller, shovel, pulaski, or pick mattock. Canes can be piled on site on top of a tarp or an impervious surface and left to decompose. Place any root balls on top of the pile to avoid re-rooting. Due to possible vigorous re-sprouting from the root crown, monitoring the infested area on a regular basis will be necessary for several years after removal. Removal procedures are repeated as necessary for complete control. After removing invasive blackberries, the area should be replanted with natives and mulched to help deter future invasive growth (King County 2005).

Biological methods of controlling blackberry are also an option. The introduction of animals such as goats or pigs can be useful in controlling infestations from one to four years old. Chemical methods of controlling large blackberry infestations are also known to be effective, especially if combined with other methods such as mechanical control and monitoring (King County 2005). Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

Tansy ragwort

Tansy ragwort is a biennial flowering plant that is commonly spread through contaminated hay. Consumption of tansy ragwort is one of the most common causes of poisoning in cattle and horses. After germination in fall or winter, tansy ragwort spends the first year as a rosette and then dies the following year after producing flowers and seeds. Each plant can produce up to 150,000 wind dispersed seeds which have a high germination rate and can remain dormant in the soil for up to 15 years. Tansy ragwort is often confused with common tansy (*Tanacetum vulgare*), which has button-like flowers with no petals and flattened, fern-like leaves.

Control of tansy ragwort requires management over a number of years. Based on the size of the site, various strategies can be effective. For small infestations, manual removal is appropriate. Look for rosettes in spring, while the plant is still young. Remove as much of the root as possible. If the plant has already flowered, flower stalks should be bagged as they will go to seed after they are pulled.

For large infestations, mechanical means such as tilling may be effective, but may cause germination of seeds that are already in the soil. **Mowing is not an effective means of controlling tansy ragwort as it stimulates root growth and will cause the plants to flower repeatedly.** Chemical control can also be effective for large infestations. Selective herbicides such as 2,4 D, dicamba and triclopyr can be applied to rosettes in spring and fall if this options is selected. It is important to select an herbicide that is appropriate for the particular site, either aquatic or terrestrial and to ensure that the applicator has appropriate licenses if applying in a wetland area (King County 2007c). Fact sheets including in-depth plant descriptions, distribution information and best management practices for control can be found in Appendix B.

5.4 Planting and maintenance

Planting with native species is recommended following removal of invasive plants. Establishing shade and canopy cover can be important for the control of certain invasive species such as Himalayan blackberry which can quickly colonize disturbed areas. Due to the climate in the Pacific Northwest, the planting season extends from late fall to early spring during the rainy season when sufficient moisture exists to allow plants to establish. Newly installed plants should be monitored and watered during the hot summer months for the first several years to ensure proper establishment.

Maintenance is vital to the success of any restoration project. The removal and control of invasive species is a long-term commitment that requires regular weeding and maintenance for several years. Many of the invasive species present in Shadow Lake have a tendency to re-grow from deep roots and must have regular maintenance at least two or three times a year in order to achieve effective invasive control and protect any installed native plantings. Maintenance can involve removing any re-growing invasive plants (with the roots whenever possible), regular mulching of native plantings, replacing native plants that have died, and watering newly installed plants through at least the first two growing seasons.

5.5 Monitoring

Monitoring is equally important to the success of a restoration project. Regular monitoring is particularly important in urban areas where forested stands are surrounded by development and invasive species are able to quickly establish. Monitoring can take many forms including visual inspections, photo documentation and scientific monitoring. A detailed monitoring plan using permanent sampling plots located throughout the property can be found in Appendix D.

A basic type of monitoring is the visual inspection of restored areas during regular intervals and making note of any maintenance that is required. This type of monitoring can be done by

volunteers, staff or contractors in charge of the restoration project. It should be conducted at least twice a year and more often if possible. This type of monitoring can generate information quickly, but generally does not provide a documented record of changing conditions or trends. Quantifiable data is usually not collected in this type of monitoring.

Another type of monitoring that can easily be implemented is establishing photo points throughout specific restoration areas and photographing the same geographic areas each year. Photo monitoring allows for long-term documentation and comparison of site conditions from year to year. This type of monitoring can also be conducted by volunteers, but the photographs must be taken at the same time each year for accurate comparison. Photo monitoring can be effective in documenting site conditions and is not time intensive. However, the photographs must be analyzed and compared to those from previous years to track changes over time. In addition, it is difficult to generate quantifiable data from this monitoring method.

A third type of monitoring, which is more labor intensive and rigorous than the first two types, involves setting up permanent plots and collecting scientific data similar to that gathered during the 2007 forest inventory discussed in this report. The data can include any number of parameters deemed to be useful to the forest stewards but at a minimum should include survival data, tree density data and cover data for native and invasive shrubs and herbaceous species present. This type of monitoring can be conducted by properly trained volunteers, staff or contractors. This type of monitoring can occur on an annual basis for the first three to five years, and then can be conducted on a bi-annual basis or more frequently depending on site conditions. Using permanent plots to monitor restoration sites allows for evaluation of site conditions and regular opportunities to evaluate the effectiveness of management techniques. In addition, it allows for a quantitative comparison of site conditions and an evaluation of planting and maintenance techniques over time.

5.6 Specific Recommendations for Management Areas

This section discusses specific recommendations for each of nine management zones identified in Shadow Lake. The management zones are based on habitat delineations conducted in 2007 throughout the property (Map 1). These zones are further divided based on the spatial distribution of distinct areas of these habitats across the property. The small 0.2 acre grassland and the seven acres of residential properties were not considered management zones for this analysis (Map 1). Specific recommendations for each zone have been separated into short-term, medium-term and long-term priorities and are presented in section 5.1, Management Priorities.

5.6.1 Conifer forest habitat type management recommendations

The conifer forests in Shadow Lake are structurally diverse forested systems with considerable native conifer tree regeneration. The general management objective for these areas is to maintain and protect this structural integrity. The greatest threat to the conifer forest habitat type is the invasion of non-native invasive species, particularly invasive evergreen trees in the understory.

The management goals in the conifer forest are to:

1. Remove English holly, bittersweet nightshade, invasive blackberries, and English ivy
2. Monitor and remove tansy ragwort and herb Robert

This habitat type has the highest average density of English holly on the property at over 200 stems/acre and making up 20% of all tree regeneration (Table 2). English holly was measured at high densities in plot 30 of the northern 3.6 acre forest adjacent to the bog (790 stems/acre). European mountain ash is also present at lower densities in plots 30 and 34 in the same northern conifer forested area. A management priority should be to eradicate these species before they continue to spread and proliferate. It is recommended that the northern 3.6 acre forested area in particular receive consideration for the eradication of English holly and European mountain ash. Small stems should be pulled by hand or dug out with the roots, while larger trees may require the use of a weed wrench. Control and management recommendations for these species can be found in the invasive species section of the report.

Invasive blackberries (Himalayan and evergreen blackberry) are present at relatively low levels in plots throughout this zone. One exception is plot 30 in the northern section of the property where there is a relatively high cover of evergreen blackberry (7%). Because most of these infestations are relatively isolated, they should be targeted for immediate removal. Specific best management practices on how to control and manage Himalayan and evergreen blackberry can be found in the invasive species section of the report. In areas where native trees or other vegetation are present, manual control is recommended. Applying cardboard and 4-6 inches of mulch and replanting immediately after clearing and grubbing the blackberry roots is an effective strategy to control this species. Follow-up maintenance will be necessary for several years following blackberry removal (see the maintenance section of the report).

Bittersweet nightshade has the highest average cover of any non-native herbaceous and vine species found in this management zone at one percent. All occurrences were located in plots 30 and 34 of the northern 3.6 acre conifer forest, with the highest cover occurring in plot 30 at four percent (Map 1). Tansy ragwort was also found only in this area. Eradication and control efforts of these species should be focused in this vicinity. Tansy ragwort is a Class B Noxious Weed in King County, and control of this species is required by law. Plants should be removed with as much of the roots as possible. The best time of year to remove tansy ragwort is in early spring, while the ground is still damp and the plants are relatively small. Monitoring for resprouts will need to be conducted regularly for several years to completely eradicate both species. Control recommendations for these can be found in the invasive species section of the report.

Invasive species are less common in the southern conifer forested areas. The 2.2 acre conifer forest in the eastern part of the property has trace amounts of both bittersweet nightshade and herb Robert. These species should be eradicated from this area while they are at relatively low covers before they are able to proliferate. See the invasive species section for control and management recommendations for these species.

English ivy was found throughout the conifer forests in plots 5, 9, and 30 in trace amounts. This species should be removed whenever possible to reduce its capacity to spread to other areas of the property. A relatively large infestation is located in the 1.7 acre conifer forest below plot 5 in

the southern portion of the property (Map1). This area is particularly vulnerable due to its close vicinity to Peter Grubb Road SE and should be considered a high management priority. Ivy should be immediately cut from any trees and cleared away from all trunks before thorough eradication efforts can take place. Due to the relatively small and isolated nature of the infestation, it should be possible to manually remove the plant making sure to grub out as much of the roots as possible, followed by replanting with native species. Repeated efforts and careful monitoring will be required to completely eradicate this species. More information regarding the control of this species can be found in the invasive species section of this report.

5.6.2 Conifer/Deciduous mixed forest habitat type management recommendations

Like the conifer forests, the conifer/deciduous mixed forest habitat type has a structurally diverse tree composition and relatively high levels of natural tree regeneration. Shrub and herbaceous cover is also diverse and abundant. Invasive species are the greatest threat to the integrity of these areas.

The management goals in the conifer/deciduous forest are to:

1. Remove English holly and invasive blackberries
2. Monitor and remove herb Robert and ground ivy

English holly is present in relatively low densities throughout this habitat type (Table 2). The highest densities were recorded in plots adjacent to the Jenkins creek channel (plots 10, 11, 17, and 18) (Map 1). Eradication efforts should focus on these areas while they are still in a relatively manageable state. Most stems should be removable by hand due to their small size. When dealing with larger plants, make sure to grub out as much of the roots as possible. A weed wrench might be useful to remove medium-sized stems. Additional invasive tree species that are found at low densities throughout this habitat should be removed during these efforts. These species include European mountain ash, sweet cherry, and cherry laurel. Control and management recommendations for these species can be found in the invasive species section of the report.

Invasive blackberries were found at trace amounts in half of the plots throughout the conifer/deciduous forest habitat type. Plants should be eradicated whenever encountered before they are able to spread and proliferate. This could be performed in conjunction with holly removal efforts.

Herb Robert was found in seven of the 12 plots in this habitat type. It was found at the highest cover of 4% of the plot area in plot 18 (Map 1). Larger infestations such as these should be addressed whenever possible. Without control efforts, this species can spread and form carpets that are difficult to eradicate. Plants can easily be pulled by hand, taking care to remove all of the shallow roots. Large cleared areas should be covered with cardboard and 4-6 inches of mulch and replanted to inhibit re-colonization. Control and management recommendations for this species can be found in the invasive species section of the report.

A small infestation of ground ivy was recorded along an abandoned road in plot four of this habitat type (Map 1). This plant is generally found in moist woods in disturbed areas. Ground

ivy is a potentially invasive species that can spread in low-light forested conditions. The full extent of this infestation should be ascertained before eradication and control efforts are taken. Ground ivy can be difficult to remove and ongoing maintenance will be necessary.

5.6.3 Deciduous forest habitat type management recommendations

As previously discussed in the results section of this report, some areas of the deciduous forest habitat type have been subject to disturbance. As a result, structural diversity is low and infestations of invasive species are frequent and widespread.

The management goals in the deciduous forest are to:

1. Remove English holly and control invasive blackberries
2. Increase structural diversity and conifer regeneration

The deciduous forest habitat type is located in three separate regions of the property (Map 1). The northern 3.4 acre forest and the southern 1.5 acre forest appear to be naturally occurring deciduous forests due to geography and hydrology of these areas. The middle 5.3 acre forest adjacent to the access road, on the other hand, is likely a result of recent clearing and aggressive reestablishment by pioneering deciduous tree species. The southern 1.5 acre forest is relatively healthy and had no presence of invasive species recorded in the sample plot (plot 2). However, invasive blackberries were noted along the edges of this habitat type towards the wetland ditch along Peter Grubb Road SE.

The northern 3.4 acre deciduous forest is currently threatened by invasive species, especially Himalayan blackberry, and bittersweet nightshade. The eastern portion of this forest (plot 29) has the highest recorded cover of invasive blackberries of all plots sampled throughout the property with 26%. A large thicket of Himalayan blackberry is present along the border of this habitat type and the residential area to the southwest. Control efforts will require a considerable undertaking and should be planned in incremental clearings. One approach would be to clear blackberry form the interior of the forest where it still manageable and work towards the larger, more dense thickets. This could help buffer the forest from further infestation until more significant efforts can be achieved. Specific best management practices on how to control and manage Himalayan blackberry can be found in the invasive species section of the report. Another invasive species prevalent in this area is creeping buttercup, present at a cover of 12%. Bittersweet nightshade is also present in this area (plot 29) at relatively high cover (4%). Plants should be removed with as much of the roots as possible and monitored for reestablishment. Control recommendations for these species can be found in the invasive species section of the report.

The western portion of the 3.4 acre northern deciduous forest (plot 28) is situated between the two residential areas and is relatively open and dominated by large diameter big-leaf maples. This area has a well established shrub layer and minimal invasive species impacts. The greatest threat here is the high density (620 stems/acre) of English holly. Eradication and control of this species should be a high priority to reduce the possibility of spreading to other parts of the property. Many of the holly trees in this management zone may be too large and dense for hand pulling and may need to be cut down and treated with herbicide. Specific best management

practices on how to control and manage English holly can be found in the invasive species section of the report.

The central 5.3 acre deciduous forest is also heavily invaded by both Himalayan and evergreen blackberry. Eradication efforts should focus on isolated patches and work towards containing and preventing further spread of these species. Cleared areas should be covered with cardboard and 4-6 inches of mulch and replanted with native species, including native conifer trees such as western red cedar and western hemlock. Douglas fir can be planted in cleared areas with open canopies. Reestablishing a conifer canopy will increase structural diversity and eventually provide shade and cover to help reduce the prevalence of invasive blackberry species in this area. Finally, several stems of a horticultural cherry species (*Prunus sp.*) were recorded in this area. It is possible that this could be *Prunus X pugetensis*. Recent evidence suggests that the native bitter cherry and the invasive bird cherry can hybridize; making identification particularly difficult (Jacobson and Zika 2007). Monitoring of this species to properly distinguish between the native bitter cherry also present in this zone should be considered.

5.6.4 Hemlock/Sphagnum bog habitat type management recommendations

The hemlock/sphagnum bog habitat type has very low occurrences of non-native invasive species. The greatest threat to this habitat type is potentially from the effects of trampling of the delicate bryophyte mats found throughout this habitat type. Care should be taken to limit access to these areas whenever possible.

The management goals in the hemlock/sphagnum bog are to:

1. Limit and reduce human access
2. Remove European mountain ash, bittersweet nightshade, and thistle
3. Remove rubbish and trash

Small amounts of invasive species were recorded in this habitat type during the 2007 survey, all of which were found in the lower 1.7 acre forest complex (plot 36) (Map 1). Relatively low densities of European mountain ash, along with low covers of bittersweet nightshade, evergreen blackberry, and bull thistle are present here. These species should be removed and monitored for reestablishment.

Limited amounts of trash and human debris were noted in both portions of this habitat type. Items including sleeping bags, clothes, blankets, and other debris should be removed when possible, taking care to avoid disturbing these fragile areas.

5.6.5 Labrador tea/Sphagnum bog habitat type management recommendations

The plots sampled in the Labrador tea/sphagnum bog habitat type had no occurrences of non-native species. The dense shrub growth in this area appears to be prohibiting the establishment of most invasive species. However, several stems of invasive tree species including European mountain ash and English holly were observed in between established plots during the survey. Like the hemlock/sphagnum bog habitat, the greatest potential threat to this habitat is from trampling.

The management goals in the Labrador tea/sphagnum bog are to:

1. Limit and reduce human access
2. Monitor for the possible introduction of invasive species

Several informal trails bisect this habitat and provide access into the interior parts of the property. Access on these trails should be limited and discouraged where possible. It is recommended that invasive species monitoring occur whenever these trails are traveled in order to avoid potential invasion.

5.6.6 Riparian forested wetland habitat type management recommendations

The riparian forested wetland habitat type occupies a relatively large portion of the property. Management of these areas can be limited due to the difficult access created by the perennially wet conditions. Care needs to be taken in these areas to avoid disturbance. Invasive species pose the greatest threat to the integrity of the riparian forested wetland habitat.

The management goals in the riparian forested wetland are to:

1. Remove or control bittersweet nightshade
2. Remove invasive tree species (English holly, European mountain ash, cherry laurel, and one-seed hawthorn) and invasive blackberries
3. Remove or control marsh forget-me-not

Bittersweet nightshade is the most prevalent invasive species in this habitat type and is present in both the northern 4.6 acre forest and the larger 9.5 acre forest at the headwaters of Jenkins creek (Map 1). The areas with the highest recorded covers were plots 33 with 32% and plots 32 and 21 each with 7%. These major infestations are situated in areas with relatively high amounts of standing water. Difficult access into these areas will also make eradication and control efforts difficult. It is recommended that control begin in areas where access is possible, and that areas currently not heavily infested be regularly cleared to reduce the spread of this species. Control with the use of herbicides should be considered if eradication is deemed a high priority. Additional information about the control and management of this species can be found in the invasive species section of the report.

Non-native invasive trees are also present in the understory of this habitat type. The highest densities of English holly (260 stems/acre) and European mountain ash (130 stems/acre) were recorded in plot 24 in the lower riparian forested wetland complex. This is a transitional area between the forest and the scrub-shrub wetland to the east and has a moderately open canopy cover. Eradication efforts should be prioritized in this area before they continue to proliferate. Creeping buttercup is also present at relatively high covers in this plot, which should be addressed. Control recommendations for these species can be found in the invasive species section of the report.

Invasive blackberry species are present in all six plots sampled in this forest type. The highest covers were measured for Himalayan blackberry in plots 21 (4%) and 24 (2%). Because of the relatively low covers throughout this zone, it is recommended that these species be removed

before they continue to proliferate. Control recommendations for these species can be found in the invasive species section of the report.

Another species of concern in the riparian forested wetland habitat type is marsh forget-me-not. This species is currently confined to the lower forest where the Jenkins Creek headwaters begin to become channelized (plots 21 and 25). This species is potentially invasive and should be considered for control. Little control information is available for this species, but it is recommended that eradication efforts be undertaken during the dry summer months when less surface water is present. Care should be taken during control activities to not disturb the low-lying areas of the creek where it has become established.

5.6.7 Scrub/Shrub wetland habitat type management recommendations

The scrub/shrub wetland habitat type is a diverse area with high covers of native shrub species. The larger six acre complex that borders Shadow Lake is generally less disturbed than the smaller 2.3 acre complex in the southern part of the property that partially borders Peter Grubb Road SE (Map 1). The spread of invasive species poses the greatest threat to this habitat type.

The management goals in the scrub/shrub wetland are to:

1. Remove invasive blackberries
2. Remove invasive tree species (English holly and European mountain ash)

The lower 2.3 acre wetland has a high cover of Himalayan blackberry throughout much of its area. This species was present in 11% of the plots sampled in the interior of this wetland complex (plot 20). The area drains into a shallow channel that becomes a roadside ditch along Peter Grubb Road SE that is also heavily infested with Himalayan blackberry (Map 1). It is recommended that initial eradication efforts be focused in the interior part of this complex. Efforts should also be taken to monitor and remove this species in areas adjacent to the wetland and ditch to prevent it from spreading into the forest interior. Long term goals should include the restoration and removal of blackberry from the roadside ditch to prevent the continued encroachment of this species into other areas of the property.

Evergreen blackberry was measured at relatively high covers in the southern portion of the six acre wetland complex that borders Shadow Lake (plots 22 and 26). Covers totaled 8% in plot 26 and 6% in plot 22. It is recommended that discrete patches or individuals of this species be removed, with larger infestations marked and incrementally eradicated. Covering the area with cardboard and 4-6 inches of mulch and replanting immediately after clearing and grubbing the blackberry roots is an effective strategy to control this species. Follow-up maintenance will be necessary for several years following blackberry removal (see the maintenance section of the report). Additional mapping of invasive species in this habitat type could help to identify specific areas of concern and provide more detailed prioritization for restoration and removal efforts.

English holly and European mountain ash have relatively high densities also in the southern part of the six acre wetland complex. English holly is the greatest concern with 300 stems/acre measured in plot 22 and 210 stems/acre in plot 26. Eradication of these species should be

considered a high priority for management in this area to limit further invasion. Hand removal should be an effective strategy due to the relatively small stature of most of these plants. The area should be monitored regularly for new recruitment and reestablishment of these species. Car should be taken, however, to avoid unnecessary disturbance of the fragile wetland ecology. Control recommendations for these species can be found in the invasive species section of the report.

5.6.8 Amphibian pond management recommendations

Primary management recommendations for the amphibian pond area are to reduce the impacts of non-native invasive species. Of particular concern is the relatively high cover of reed canary grass (*Phalaris arundinaceae*) found in this vicinity. This species was also noted along the trail and boardwalk leading into the forest and bog habitat types. It is recommended that this species be controlled and any errant infestations be immediately eradicated before spreading to additional areas of the property.

5.6.9 Access road management recommendations

Primary management recommendations for the access road are to reduce the impacts of non-native invasive species. Cleared areas should be replanted with native species to reduce reestablishment of invasives. Particular species of concern noted in this area include: butterfly bush, Himalayan and evergreen blackberry, Canada thistle and tansy ragwort.

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Appendix A. Average percent density of trees (stems/acre) and cover of shrub, herb and grass species where present in Shadow Lake (on 2007 surveyed plots) and frequency (N=41) property-wide.

Scientific Name[1]	Common Name	Native	Average cover or density in sampled plots[2]	Frequency property-wide (Percent)
Trees				
Acer macrophyllum	big-leaf maple	Yes	103 stems/acre	44
Alnus rubra	red alder	Yes	197 stems/acre	61
Castanea sp.	chestnut	No	10 stems/acre	5
Crataegus monogyna**	one-seed hawthorn	No	15 stems/acre	5
Frangula purshiana	cascara	Yes	437 stems/acre	83
Ilex aquifolium*	English holly	No	202 stems/acre	41
Picea sitchensis	Sitka spruce	Yes	23 stems/acre	7
Pinus monticola	western white pine	Yes	10 stems/acre	2
Populus balsamifera ssp. trichocarpa	black cottonwood	Yes	30 stems/acre	5
Prunus avium**	sweet cherry	No	10 stems/acre	5
Prunus emarginata	bitter cherry	Yes	48 stems/acre	12
Prunus laurocerasus*	cherry laurel	No	23 stems/acre	7
Prunus sp.	horticultural cherry species	No	10 stems/acre	5
Prunus X pugetensis	Prunus × pugetensis	No	10 stems/acre	2
Pseudotsuga menziesii	Douglas fir	Yes	40 stems/acre	41
Quercus sp*.*	oak	No	10 stems/acre	2
Sorbus aucuparia	European mountain ash	No	51 stems/acre	34
Thuja plicata	western red cedar	Yes	105 stems/acre	66
Tsuga heterophylla	western hemlock	Yes	402 stems/acre	76
Shrubs				
Acer circinatum	vine maple	Yes	14	68
Cornus sericea	red-osier dogwood	Yes	13	27
Corylus cornuta	beaked hazelnut	Yes	4	34
Gaultheria shallon	salal	Yes	9	37
Kalmia microphylla	bog laurel	Yes	26	17
Ledum groenlandicum	Labrador tea	Yes	40	27
Lonicera involucrata	twinberry	Yes	11	29
Mahonia nervosa	low Oregon grape	Yes	1	32
Malus fusca	western crabapple	Yes	12	39
Menziesia ferruginea	rusty menziesia	Yes	1	2
Oemleria cerasiformis	Indian plum	Yes	2	34

Scientific Name[1]	Common Name	Native	Average cover or density in sampled plots[2]	Frequency property-wide (Percent)
Oplopanax horridus	devil's club	Yes	2	34
Philadelphus lewisii	Lewis' mock-orange	Yes	3	2
Physocarpus capitatus	Pacific ninebark	Yes	7	2
Ribes divaricatum	wild gooseberry	Yes	1	2
Ribes lacustre	swamp gooseberry	Yes	T	12
Rosa gymnocarpa	baldhip rose	Yes	1	5
Rosa nutkana	Nootka rose	Yes	1	5
Rubus armeniacus*	Himalayan blackberry	No	6	34
Rubus laciniatus*	evergreen blackberry	No	2	46
Rubus leucodermis	blackcap	Yes	1	17
Rubus parviflorus	thimbleberry	Yes	T	34
Rubus spectabilis	salmonberry	Yes	27	83
Rubus ursinus	creeping blackberry	Yes	17	85
Salix geyeriana	Geyer willow	Yes	2	2
Salix hookeriana	Hooker's willow	Yes	14	5
Salix lucida ssp. lasiandra	Pacific willow	Yes	19	10
Salix lucida ssp. lasiandra	Pacific willow	Yes	40	5
Salix scouleriana	Scouler's willow	Yes	9	10
Salix sitchensis	Sitka willow	Yes	T	2
Sambucus racemosa	red elderberry	Yes	3	73
Spiraea douglasii	hardhack	Yes	17	39
Vaccinium oxycoccos	small cranberry	Yes	2	12
Vaccinium parvifolium	red huckleberry	Yes	3	85
Ferns, forbs and vines				
Agrostis sp.	bentgrass	X	2	7
Agrostis stolonifera	creeping bentgrass	No	T	2
Bromus vulgaris	Columbia brome	Yes	T	39
Carex deweyana	Dewey sedge	Yes	1	71
Carex hendersonii	Henderson's sedge	Yes	T	7
Carex obnupta	slough sedge	Yes	T	5
Deschampsia caespitosa	tufted hairgrass	Yes	T	2
Elymus glaucus	blue wildrye	Yes	T	2
Glyceria striata	tall mannagrass	Yes	1	15
Holcus lanatus	velvetgrass	No	T	10
Juncus effusus	soft rush	X	1	7
Luzula multiflora	common woodrush	Yes	T	10
Luzula parviflora	small-flowered woodrush	Yes	T	59

Scientific Name[1]	Common Name	Native	Average cover or density in sampled plots[2]	Frequency property-wide (Percent)
Melica subulata	Alaska oniongrass	Yes	T	2
Scirpus cyperinus	woolgrass	Yes	T	5
Scirpus microcarpus	small-seeded bulrush	Yes	T	2
Achlys triphylla	vanilla leaf	Yes	T	2
Actaea rubra	baneberry	Yes	T	2
Ajuga reptans	common bugle	No	T	2
Angelica genuflexa	kneeling angelica	Yes	T	2
Aruncus dioicus	goatsbeard	Yes	T	2
Asarum caudatum	wild ginger	Yes	T	5
Athyrium filix-femina	ladyfern	Yes	3	76
Blechnum spicant	deer fern	Yes	1	39
Cardamine hirsuta	hairy bittercress	No	T	10
Circaea alpina	small enchanter's nightshade	Yes	1	24
Cirsium arvense*	Canada thistle	No	T	2
Cirsium vulgare*	bull thistle	No	T	2
Claytonia sibirica	Siberian miner's lettuce	Yes	1	49
Dicentra formosa	western bleedingheart	Yes	7	46
Digitalis purpurea	foxglove	No	T	5
Dryopteris expansa	wood fern	Yes	1	73
Epilobium ciliatum	fringed willowherb	Yes	T	27
Equisetum telmateia	giant horsetail	Yes	11	5
Galium aparine	cleavers	Yes	1	68
Geranium robertianum*	herb Robert	No	T	37
Geum macrophyllum	bigleaved avens	Yes	T	10
Glechoma hederacea	ground ivy	No	T	2
Goodyera oblongifolia	western rattlesnake plantain	Yes	T	2
Hedera helix*	English ivy	No	T	20
Hydrophyllum tenuipes	Pacific waterleaf	Yes	T	5
Lapsana communis	nipplewort	No	T	10
Linnaea borealis	twinflower	Yes	7	7
Lonicera ciliosa	orange honeysuckle	Yes	T	7
Lunaria annua	annual honesty	No	T	2
Lycopus uniflorus	northern bugleweed	Yes	T	7
Lysichiton americanus	skunk cabbage	Yes	3	41
Maianthemum dilatatum	false lily-of-the-valley	Yes	3	51
Mentha arvensis	wild mint	Yes	T	2

Scientific Name[1]	Common Name	Native	Average cover or density in sampled plots[2]	Frequency property-wide (Percent)
Monesus uniflora	single delight	Yes	T	2
Mycelis muralis	wall-lettuce	No	T	34
Myosotis scorpioides **	marsh forget-me-not	No	3	7
Nemophila parviflora	smallflower nemophila	Yes	T	5
Oenanthe sarmentosa	water parsley	Yes	28	12
Osmorhiza berteroi	sweet cicely	Yes	T	5
Polypodium glycyrrhiza	licorice fern	Yes	1	80
Polystichum munitum	sword fern	Yes	30	78
Pteridium aquilinum	bracken fern	Yes	5	56
Ranunculus repens **	creeping buttercup	No	3	17
Rorippa nasturtium-aquaticum	water cress	No	T	2
Rumex crispus	curly dock	No	T	2
Rumex obtusifolius	bitter dock	No	T	5
Scutellaria lateriflora	blue skullcap	Yes	1	7
Senecio jacobaea*	tansy ragwort	No	T	2
Solanum dulcamara*	deadly nightshade	No	5	29
Stachys chamissonis var. cooleyae	hedgenettle	Yes	T	5
Stellaria calycantha	northern starwort	Yes	T	5
Stellaria crispa	crisp sandwort	Yes	1	51
Stellaria media	chickweed	No	T	5
Streptopus amplexifolius	clasping twistedstalk	Yes	T	5
Taraxacum officinale	dandelion	No	T	5
Tellima grandiflora	fringecup	Yes	4	22
Tiarella trifoliata	foamflower	Yes	1	39
Tolmiea menziesii	piggy-back plant	Yes	1	34
Trientalis borealis ssp. latifolia	starflower	Yes	T	24
Trillium ovatum	trillium	Yes	T	37
Urtica dioica	stinging nettle	Yes	3	15
Veronica americana	American Speedwell	Yes	T	10
Veronica officinalis	common gypsyweed	No	T	5
Vicia sativa	garden vetch	No	T	2
Viola sempervirens	evergreen violet	Yes	T	17
Viola sp.	violet	X	T	5

[1] Species in bold are non-native species. Species denoted by * are species which have been given a legal designation by the King County Noxious Weed Program (King County 2007). Species denoted by ** are non-native invasive species which do not have a legal designation at this time.
[2] T=Trace presence of species (less than 1%).

Appendix B. Invasive Species BMPs.

Trees

English holly (*Ilex aquifolium*). http://dnr.metrokc.gov/wlr/lands/weeds/holly.htm

European mountain ash (*Sorbus aucuparia*)
http://www.na.fs.fed.us/fhp/invasive_plants/weeds/european-mountain-ash.pdf

Sweet cherry (*Prunus avium*). http://www.na.fs.fed.us/fhp/invasive_plants/weeds/sweet-cherry.pdf

Shrubs

Himalayan and evergreen blackberry (*Rubus armeniacus* and *Rubus laciniatus*)
http://dnr.metrokc.gov/wlr/lands/weeds/pdf/blackberry-control.pdf

Herbaceous Species and Vines

Bittersweet nightshade (*Solanum dulcamara*)
http://dnr.metrokc.gov/wlr/lands/weeds/pdf/bittersweet-nightshade-control.pdf

Creeping buttercup (*Ranunculus repens*)
http://extension.oregonstate.edu/catalog/html/pnw/pnw399

English ivy (*Hedera helix*)
http://dnr.metrokc.gov/wlr/lands/weeds/pdf/english-ivy-control.pdf

Herb Robert (*Geranium robertianum*)
http://dnr.metrokc.gov/wlr/lands/weeds/pdf/Herb_Robert_Factsheet.pdf

Tansy Ragwort (*Senecio jacobaea*)
http://dnr.metrokc.gov/wlr/lands/weeds/pdf/tansy_ragwort.pdf

Appendix C. Stake location coordinates and transect bearings for 41 plots established in Shadow Lake during the 2007 survey.

GCS WGS 1984 - Decimal Degrees			
Plot	**Latitude**	**Longitude**	**Bearing**
1	47.39829279	-122.0858636	0
2	47.39839166	-122.0868651	0
3	47.39906731	-122.0866179	0
4	47.39987427	-122.0865387	270
5	47.39979401	-122.0881681	135
6	47.40056915	-122.0857075	180
7	47.40134123	-122.0864426	180
8	47.40151764	-122.0893951	0
9	47.40186033	-122.086559	45
10	47.40226013	-122.0871623	0
11	47.40276505	-122.0879453	0
12	47.4029787	-122.0903549	0
13	47.40159397	-122.0904158	0
14	47.40045668	-122.0906365	0
15	47.40035693	-122.089788	0
16	47.40226586	-122.0892881	0
17	47.40073104	-122.0880547	0
18	47.40147224	-122.0884333	0
19	47.4008615	-122.0889956	0
20	47.40007964	-122.0888091	0
21	47.40219101	-122.0879471	315
22	47.4032282	-122.0864687	135
23	47.4039669	-122.0877148	90
24	47.40394206	-122.0890959	90
25	47.4031715	-122.0890649	0
26	47.403539	-122.087448	90
27	47.40475907	-122.0905543	90
28	47.40621195	-122.0950363	270
29	47.40659461	-122.0940987	130
30	47.40726513	-122.0950066	90
31	47.40390864	-122.0902371	90
32	47.4079118	-122.0952164	90
33	47.40761473	-122.0927783	0
34	47.40688094	-122.0935071	180

Appendix C (Continued)

GCS WGS 1984 - Decimal Degrees			
Plot	**Latitude**	**Longitude**	**Bearing**
35	47.40465649	-122.0894695	90
36	47.40516181	-122.09035	270
37	47.40555726	-122.0904377	0
38	47.40711742	-122.0928202	90
39	47.40716084	-122.0915826	180
40	47.40770901	-122.0921215	90
41	47.40635596	-122.0915749	90