Deadhorse Canyon (Lakeridge Park)
Vegetation Management Plan

Prepared for: Friends of Deadhorse Canyon

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I. INTRODUCTION

Overview

Deadhorse Canyon (DHC) is the major geographical feature in Lakeridge Park, a 41-acre public property located in southeast Seattle. DHC offers a natural environment amidst the urban landscape, providing important habitat for wildlife and a home for a wide variety of native plant species. Taylor Creek flows through the canyon and discharges into Lake Washington near the northern end of the park.

A number of factors have impacted the health of DHC since European settlement of the area**,** including logging practices initiated at the turn of the century. The legacy of selective timber harvest resulted in the removal of substantial numbers of once-dominant coniferous tree species. Their absence, and related reductions in the presence of downed wood, has reduced the ability of these species to naturally regenerate. Big leaf maple and red alder, whose extent was historically limited to stream banks, floodplains, and wet slopes, have become dominant species throughout DHC.

Urban land uses, which have increased over time as the city has expanded, have resulted in direct impacts to DHC including: introduction of native species, illegal dumping of refuse, social trail development, and altered hydrologic conditions within the watershed that flows into the canyon, and resulting alterations to stream flows within Taylor Creek.

The introduction of invasive plant species, often from residential yards bordering DHC, has decreased the ability of native plant species to establish and regenerate. Non-native invasive plant species occupy niches that have historically been occupied by native vegetation. Introduced plant species do not necessarily provide the same habitat requirements (food, water, shelter) as native plant species for native wildlife species. The encroachment of invasive plant species tends to reduce overall biodiversity in DHC. Ecosystems with lower biodiversity are more susceptible to damage resulting from disease and pests.

Illegal dumping of refuse (including household garbage and yard waste) has been a problem throughout the history of DHC and persists today. Refuse is unsightly and can pose a public health hazard. In addition, refuse piles can prevent access to areas of DHC for both visitors and managers. From an ecological standpoint, yard waste can be a vector for invasive species which then spread throughout DHC. In addition, piles of garbage suppress the native vegetation growing under them, and prevent new vegetation from establishing.

Another issue facing park managers is the formation of unauthorized social trails which can result in erosion and a reduction of water quality through sedimentation. These disturbances also act as vectors for the introduction and establishment of invasive species.

The development of the upper portions of the Taylor Creek watershed with roads and houses reduces the ability of the land to detain, cleanse, and cycle precipitation and run-off. This results in higher than normal stream flows during heavy rainfall events and reduced base flows between

storms and during summer months. High peak stream flows result in increased erosion and sedimentation. Reduced base flows result in less water for plants and wildlife during summer seasons when this resource is most needed. Reduced base flows also result in degraded fish spawning, rearing and foraging habitat.

Development and logging also resulted in significant modification of fish and wildlife habitat in the riparian corridor. Currently, Taylor Creek flows through three culverts on its way to Lake Washington, only two of which are passable to salmon. At the present time, salmon are not able to return to Taylor Creek to spawn.

Goals and Objectives

This document evaluates the issues required for effective vegetation management in DHC. It also provides a framework for the management of the natural areas in DHC. The overarching goals of this project are:

1. To provide an assessment of current vegetation resources and create a management plan based on these findings

2. To develop and implement a citizen-run restoration monitoring plan to track restoration efforts

The major objectives of the project are as follows:

1. Track past stewardship activities to document the history of restoration in DHC and to create a system where future activities can be recorded.

2. Develop baseline information on current ecological conditions in DHC.

Methods Summary

Past stewardship activities carried out over the last nine years were documented and mapped. An extensive forest assessment was conducted between November, 2004 and February, 2005. The assessment focused on measuring specific attributes of forest structure and composition in order to evaluate the current condition of the forest within DHC. A total of 37 one-tenth acre plots were sampled throughout the geographical area of DHC. In general, the following attributes were measured during the assessment of vegetation conditions:

1) current structural conditions,
2) tree regeneration,
3) native and exotic plant species diversity and abundance.

II. SITE LOCATION AND CONTEXT

History of Deadhorse Canyon

In the late 1800's the Taylor family built a sawmill at the mouth of the stream currently known as Taylor Creek. The area including DHC was logged several times before the mill closed in 1916. The mill closing coincided with the lowering of Lake Washington during the construction of the ship canal locks. Intermittent logging in DHC continued into the 1950's. Starting in 1945, development of the upper part of the watershed began and houses were constructed along the rim. In 1947, King County sold DHC to Seattle Parks and Recreation for $1. Although the property was mainly acquired to build a sewer line for the area, the Seattle Park Board recognized the value of using the forest as a park. The first sewer line was built through DHC in 1947.

Throughout its history, DHC has been used as an illegal dumping ground for trash and yard debris. Although the property was used as a park, no official trail was built through the forest and no oversight was provided by the city. In 1996, the leaking sewage line underneath the park prompted the city to hold a public meeting regarding replacement of the line. Several neighbors who attended the meeting became interested in restoring the forest, which was heavily invaded by non-native plant species and inundated with trash. This neighborhood group was the foundation for the Friends of Deadhorse Canyon (see below). In 1998, the original sewer line running through the park was replaced, and a trail was constructed over the sewer line. In 1999, a loop was added to the end of the trail, providing hikers with a 1.2 mile walk through the canyon.

Area Description

Lakeridge Park consists of approximately 42 total acres. DHC accounts for approximately 39.5 acres of forested lands within the park. The remaining park acreage (2.5 acres) consists of maintained ball fields and hard-surface courts in the North-East corner of the park along Rainier Avenue. Lakeridge Park comprises the lower portion of the Taylor Creek watershed. The upper watershed is comprised of areas within both the City of Seattle and unincorporated King County. The east and west forks of Taylor Creek join in the south end of the park and flow for approximately one-half mile through a riparian corridor down the center of the canyon. The stream eventually flows through a culvert beneath Rainer Avenue South and empties into Lake Washington.

The park is situated to the south of Rainer Avenue South, west of Rustic Road South, east of Waters Avenue South and 68th Place South, and north of 69th Place South and 71st Place South. One roadway passes through the northern portion of the park: 68th Avenue South turning into Holyoke Way. Nearly all edges of the park are bordered by residential homes including the rims on both sides of DHC.

Friends of Deadhorse Canyon

A community group known as Friends of Deadhorse Canyon (FDC) formed following the replacement of a sewer line running the length of the canyon in 1998. This group has been actively restoring multiple areas of the park since that time. The group has cleared substantial amounts of invasive plant species, removed trash and planted thousands of herbs, shrubs and conifer seedlings.

A forest restoration plan for DHC was created in 1995 by the Seattle Department of Parks and Recreation in cooperation with the University of Washington, College of Forest Resources. The plan included management recommendations for specific areas of the park. This effort was considered instrumental in directing the first restoration efforts of the Friends of Deadhorse Canyon.

Intent of this Report

This report is intended to guide restoration efforts for the ongoing stewardship and maintenance of DHC. One of the intended outcomes of this project is to update and build upon the recommendations in the 1995 plan, one of which was to conduct a comprehensive vegetation survey of the park. This project was initiated by Seattle Urban Nature Project through a grant from the King County Natural Resources Stewardship Program and with support from the Friends of Deadhorse Canyon.

Vegetation Overview

During a citywide survey of Seattle's parks and open spaces in 2000, Seattle Urban Nature Project identified 4 major habitat types in Lakeridge Park: conifer/deciduous mixed forests, deciduous forests, riparian forests and palustrine forested wetlands. The following criteria were used to delineate these forest types:

- Deciduous forests are dominated by deciduous trees, with more than 70 percent of the forest canopy containing deciduous trees, and less than 30 percent conifers in the canopy.
- Conifer/deciduous mixed forests contain 30 – 70 percent hardwood tree species, with a greater conifer component (over 30 percent) than the deciduous forest type.
- Riparian forests are associated with streams and rivers, and are often dominated by deciduous species, although a conifer component may be present.
- Palustrine forested wetlands are freshwater wetlands with a greater than 30 percent tree cover

The 2005 survey corroborated the findings of the initial survey. While big leaf maple (*Acer macrophyllum*) is the dominant overstory species found throughout the park, there are areas with substantial conifer components consisting of large and small diameter western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and Douglas-fir (*Pseudotsuga menziesii*). Red alder (*Alnus rubra*) also exists in varying proportions throughout the park, especially along the

riparian corridor and in areas of high soil moisture. Common native understory species found in the park include: sword fern (*Polystichum munitum*), beaked hazelnut (*Cornus cornuta*), salmonberry (*Rubus spectabilis*), Indian plum (*Oemlaria cerasiformis*), red elderberry (*Sambucus racemosa*), low Oregon grape (*Mahonia nervosa*), and vine maple (*Acer circinatum*). Non-native invasive plant species found in the park include: English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), English holly (*Ilex aquifolium*), cherry laurel (*Prunus laurocerasus*), hedge false bindweed (*Calystegia sepium*), Japanese knotweed (*Polygonum cuspidatum*) and herb Robert (*Geranium robertianum*).

Hydrology

Deadhorse Canyon is within the drainage basin of the lower portion of the Taylor Creek watershed (Map 1). Taylor Creek is formed by a confluence of 3 source streams; 2 of which start southwest of the park, and one which starts southeast of the park. The two southwestern source streams originate in large wetlands which occur in the vicinity of a major power line corridor. These two source streams flow through a privately owned tract of forested wetland (contiguous with source wetlands) located to the west of Renton Avenue South. The confluence of these streams occurs immediately upstream of the culvert crossing underneath Renton Avenue South. The stream downgradient of the confluence is known as the west fork of Taylor Creek (Map 1).

The wetlands in the headwaters of the southwestern source streams are partially located on private property. The property has been partially developed and additional building has been proposed. The outcome of the proposal has not been determined at the time of this report.

The southeastern source stream of Taylor Creek (known as the east fork of Taylor Creek) arises from springs in a small forested area of Skyway Park in King County. The stream flows through culverts below two parking lots and under Renton Avenue South and South 118th Place. It then flows through a series of culverts and in day-lit sections through undeveloped private property before joining with the west fork in the southern portion of the Park (Map 1). The east fork appears to contribute a smaller volume of water than the west fork.

The mainstem of Taylor Creek is the fourth largest creek in Seattle (SPU 2005) and flows year-round. The creek is vegetated on both banks by a narrow strip of riparian forest dominated by red alder, salmonberry, and vine maple. The east slope of the canyon contains a series of small hillside seeps that drain into the creek. The west slope is generally drier with several pronounced drainages, one of which originates from a small forested wetland system.

Taylor Creek flows beneath Holyoke Way South and 68th Avenue South through two fish-friendly culverts that were installed in 1999 by SPU. The culverts are lined with native streambed material. SPU plans to replace the culvert beneath Rainer Avenue South in the near future. This culvert is the final barrier to fish passage (including salmon) from Lake Washington into Taylor Creek.

Geology and Soils

The canyon and surrounding areas are part of the Vashon till geologic unit. This unit is composed of deposits of glacial till and outwash that form the terraced hill topography that typifies the landscape in Seattle and the nearby portions of the Puget Sound lowlands. Streams have carved ravines through these hills throughout the area. DHC is one such ravine. Stream action in DHC has exposed other deeper and older geologic features including small inclusions of pre-Fraser deposits. The delta area where Taylor Creek empties into Lake Washington is younger alluvium deposited by the creek.

The entire eastern slope and the majority of the western slope on either side of Taylor Creek were mapped by the City of Seattle as steep (greater than 40 percent) slope areas. The forested portions of the Park north of South Ryan Street were also mapped by the city as potential slide areas. There were no known slide areas identified during the city's mapping process in 1998, although at least one area in the southern portion of the park beneath the power line corridor has undergone substantial soil displacement. The delta area where Taylor Creek empties into Lake Washington is mapped as a potential liquefaction zone by the City of Seattle (SPU 1998).

Soils in the southwestern portion of the park are composed of 3 inches of gravelly silty sand topsoil with organics over silty sand subsoil derived from weathered glacial till. This suggests well-drained soils with low run-off potential and high permeability in the western portion of the park. No soil information is currently available for the eastern (and wetter) portion of the park.

Map 1

III. FOREST ASSESSMENT METHODOLOGY

Sampling intensity

Past vegetation management plans produced for the City of Seattle Parks Department for other parks have generally aimed to sample three to ten percent of the area of interest. Using this guideline, SUNP surveyed 37 plots sampled between November 16, 2004 and February 24, 2005. These sample plots (3.7 acres) represent approximately 9% of the forested area of the park (39.5 forested acres).

Plot Layout

One plot occurs in each acre of forest, distributed proportionately among all forest types. Sampling locations were randomly stratified across the canyon using a one-acre grid system. Of the 37 sampled plots, 16 were located in the conifer/deciduous mixed forest, 16 were located in the deciduous forest, two were located in the riparian forest, and three in the palustrine wetlands (Map 2).

The plots are rectangular and cover an area 26.2 feet (8 meters) wide and 164 feet (50 meters) long (0.1 acres). Long rectangular plots capture more 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 a cardinal axis did not allow the plot to be fully included in a particular habitat type, the orientation was modified to fall only in one habitat type.

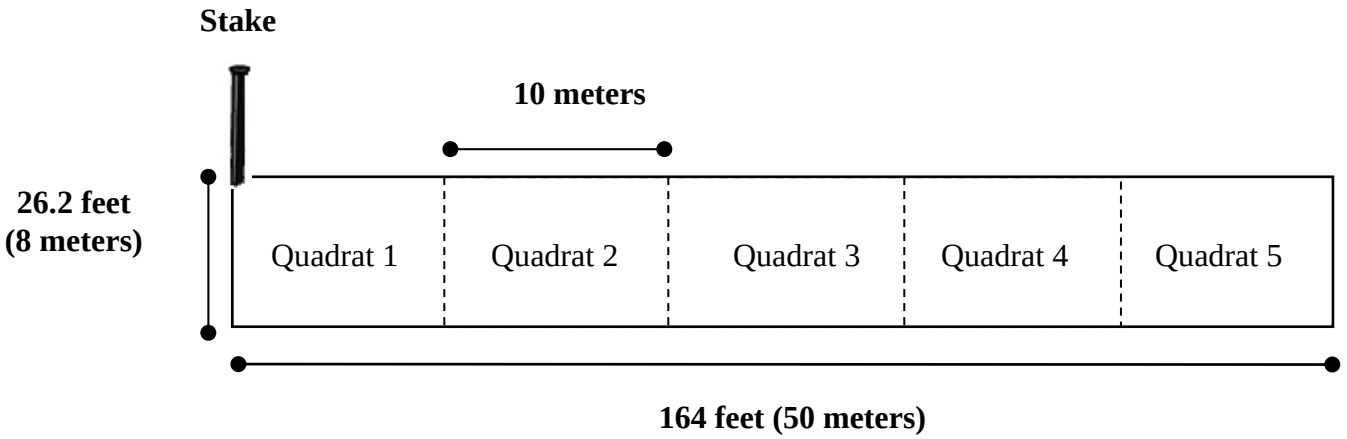
Plots are intended to be treated as permanent sampling units. The starting point of each plot was marked with a 1"x 2" wooden stake driven into the ground. GPS point locations have been recorded to within one meter accuracy at each stake (Appendix C).

Assessment Procedures

The sampling unit for this survey consisted of a 164 foot (50 meter) x 26.2 foot (8 meter) plot. These dimensions equal approximately $1/10^{th}$ acre in size, which has been a standard area for sampling units in all recent vegetation management plans (VMPs) written for other parks within Seattle.

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. A wooden stake was installed at each plot to permanently mark the beginning of each transect. The transect extends 164 feet (50m) along the transect bearing and 26.2 feet (8 m) perpendicular to the bearing on the right side of the stake (Figure 1). In addition, GPS coordinates of each stake were recorded (Appendix C).

Figure 1. Dimensions and layout of sampling plots in Deadhorse Canyon*



* not drawn to scale

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 ash (*Sorbus aucuparia*). In order for a tree to be included in the sampling plot, more than half of its 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, each tree was assessed for overall health, including colonization by English ivy. 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 were also measured and the extent of decay was estimated.

Live trees were visually inspected and assigned subjective health ratings of "good," "fair," or "poor" based on the following criteria: balanced crown structure, evidence of rot, evidence of insect or diseases affecting foliage or bark, or evidence of animal herbivory.

Snags and coarse woody debris, consisting of downed logs and stumps, were placed into one of three decay classes, I, II, or III. Decay class I indicates a branch or trunk that recently died and frequently had 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.

Map 2

Species Cover and Richness: 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. Percent cover was estimated by dividing the 50m x 8m sample area into five 10 x 8m quadrats (See Figure 1) and visually estimating canopy cover for all species present within each quadrat, then combining these subtotals to derive an estimate of cover for the entire sample area. Surveyors also visually estimated the percent cover of plant litter and bare ground. Because the survey was conducted during the winter months (from November through February), some emergent species had senesced. Species that were not apparent during this time were not included in the species tally.

Canopy cover was defined as the area of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of the plants. Small openings within the canopy are included in the canopy cover estimate. Species that were present in trace amounts were given a minimum value of 0.1%. This allowed for a complete 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.

Data Collection and Management

Data was recorded on data sheets in the field. Two data sheets were used: one for recording species cover information and one for recording tree density information. Data sheets are included in Appendix D. Data collection was conducted by two staff ecologists at Seattle Urban Nature Project. Information from the data sheets was entered into a Microsoft Access database by SUNP staff. Maps were produced using ESRI ArcMap version 8.3, which connects geographic information (e.g., maps, aerial photographs, topography) with tabular information (e.g., data plot information in Access database).

IV. RESULTS AND FINDINGS

Park-wide Vegetation Trends

The results of the 2004-5 survey indicate that approximately 38% of the forested area of the park consists of deciduous forest. Of that forest type, 63% contains trees averaging 5-15 inches in diameter and 37% contains trees averaging 15-20 inches in diameter (Table 1). Deciduous forests are generally found along the east side of the canyon and on the west side towards the north end of the park.

Approximately half of the forested park area (47%) consists of conifer/deciduous mixed forest, of which 69% averages 20-30 inches in diameter and 31% averages 15-20 inches in diameter (Table 1). These conifer/deciduous mixed forests generally have greater structural diversity than the deciduous dominated stands. Two other forest types found during the 2004-5 survey were: riparian forest bordering the creek (11% of the park area) and two palustrine forested wetlands (totaling 3% of the park area).

Table 1. Habitat types mapped in Deadhorse Canyon during the 2004- 2005 survey.[1]

Habitat Type	Diameter (inches)	Acres	Percentage of Park (%)	Number of Plots sampled
Conifer/Deciduous Mixed Forest	15-20”	5.9	15	7
Conifer/Deciduous Mixed Forest	20-30”	12.8	32	9
Conifer/Deciduous Mixed Total		18.7	48	16
Deciduous Forest	5-15”	9.4	24	11
Deciduous Forest	15-20”	5.5	14	5
Deciduous Forest Total		14.9	38	16
Palustrine Forested Wetland Total	All	1.2	3	3
Riparian Forest Total	All	4.4	11	2
Park Total		**39.2**	**100**	**37**

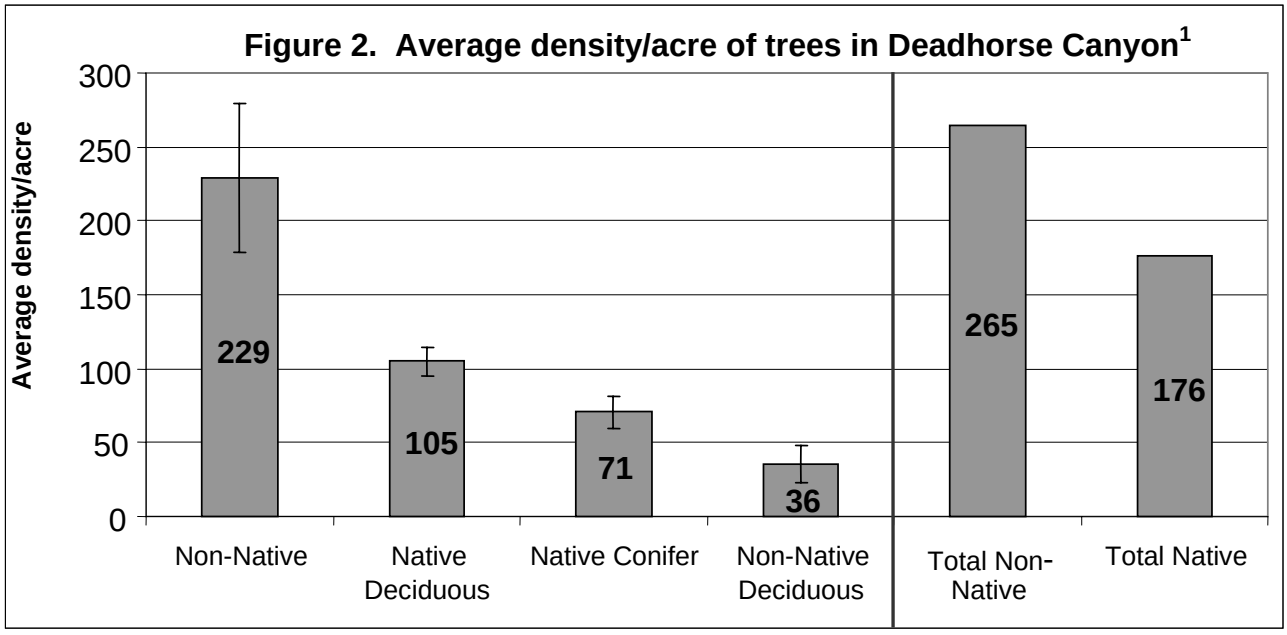
[1] For each habitat type, the acreage and percentage of park area that the type occupies is given, along with the number of plots sampled in that type during the survey. Some habitat types are further separated by diameter class, where appropriate.

The variation in tree size and composition throughout the canyon could be the result of selective logging which occurred through the late 1800's and into the early 1900's. Evidence of logging in the form of large diameter conifer stumps can be seen throughout the canyon. The east side of the canyon may have been more thoroughly or recently logged as evidenced by the small diameter stands of even-aged big-leaf maples generally dominating this area.

During the 2004-5 survey, a total of 93 plant species were found: 59 natives, 28 non-natives (of which 20 are considered potentially invasive), and 6 species that were identified only to genus, and whose origin was not determined. Appendix B lists the scientific and common names of all plants identified during the 2004-5 survey, as well as the native/non-native status of these species.

The average density of native tree species was 176 stems/acre. The composition, on average was 105 deciduous trees and 71 conifer stems/acre. A large proportion of the conifer tree density, 55 stems/acre (77% of all conifer trees), is comprised of small diameter seedlings, many of which were planted by Friends of Deadhorse Canyon.

There was an average of 36 non-native deciduous trees/acre and 229 non-native evergreen trees/acre (holly and laurels) (Figure 2).



[1] Average density/acre of non-native evergreen invasive species (English holly, cherry laurel, and Portugal laurel), three categories of trees (native deciduous, native coniferous, & non-native deciduous), and the total average stems/acre for both non-native and native tree species found in DHC. Bars represent +/- standard error.

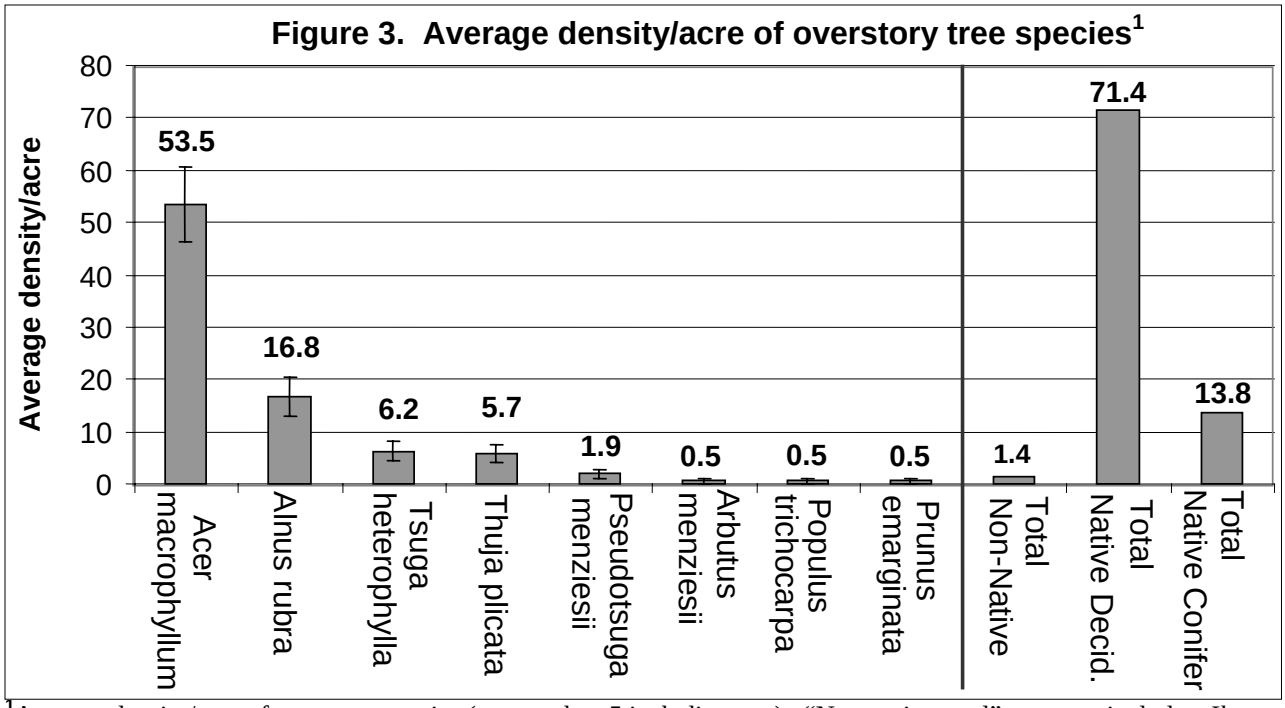
Overstory and Regenerating Tree Composition

Overstory Dynamics

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 contributing to a high structural diversity (trees of differing ages and size classes) of the canopy. Younger forests, on the other hand, generally have higher tree densities and limited structural diversity (Spies and Franklin 1991).

The forest overstory refers to the upper canopy 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. Big-leaf maple and red alder dominate the overstory, comprising 61% and 19% of overstory trees respectively. Coniferous species including western hemlock, western red cedar and Douglas-fir each comprise 7%, 6.5% and 2%, respectively (Figure 3). Native tree species present in small amounts (less than 1%) are: Pacific madrone (*Arbutus menziesii*), black cottonwood (*Populus trichocarpa*) and bitter cherry (*Prunus emarginata*).

Non-native species make up approximately 2% of the total overstory and include English holly (*Ilex aquifolium*), Portugal laurel (*Prunus lusitanica*), ornamental cedars (*Cedrus spp.),* ornamental cherry species (*Prunus spp.)* and European mountain ash (*Sorbus aucuparia*).

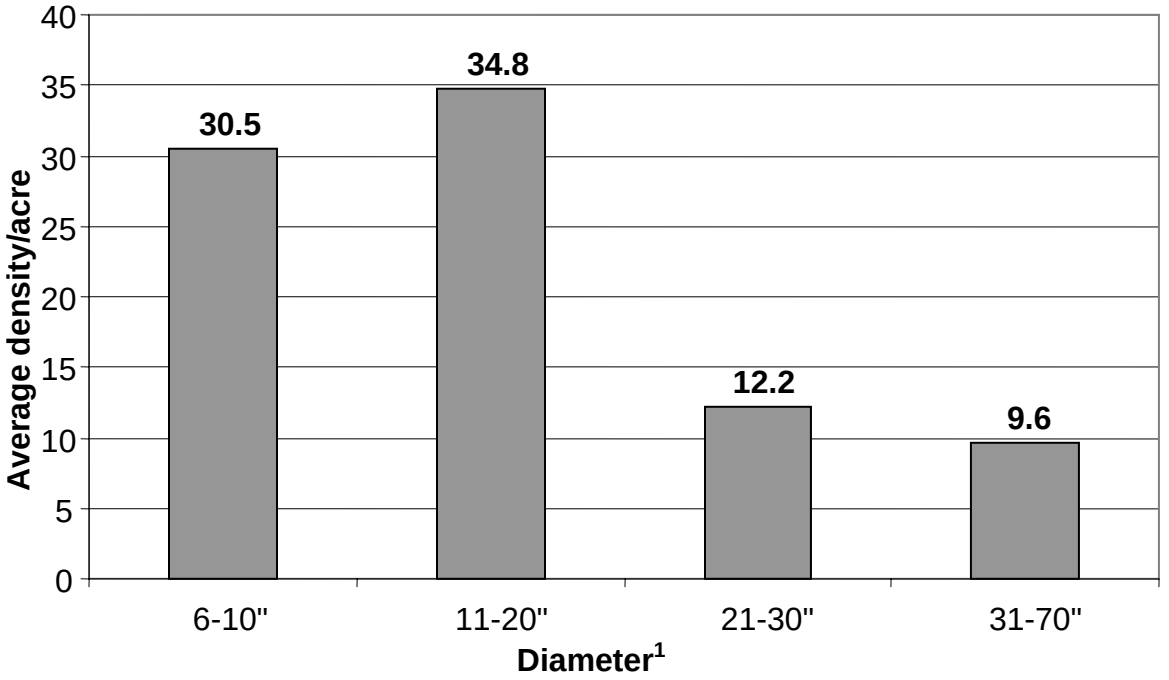


[1]Average density/acre of overstory species (greater than 5 inch diameter). "Non-native total" category includes: *Ilex aquifolium, Prunus lusitanica, Prunus sp.* and *Sorbus acuparia.* Numeral above each bar indicates species average. Bars represent +/- standard error.

Overall, the forests of DHC averaged 87 overstory trees/acre with an average diameter of 17.5 inches and height of 74 feet. The majority of the trees (65/acre) are between 6 inches and 20 inches in diameter, with fewer numbers of larger diameter trees (Figure 4). Parkwide, the overstory is clearly dominated by deciduous trees with a ratio of 84% deciduous trees to 16% coniferous trees.

A study of mature coniferous forests throughout the Pacific Northwest found the average diameter of trees (excluding trees less than 5 inch diameter) to range from 11 inches to 30 inches in diameter (Franklin et al. 1981). While the diameters of overstory trees found in DHC are comparable to old growth forest tree diameters, other measured features of the forest indicate an ealier seral stage. The average density of trees greater than 5 inches in diameter found in DHC is nearly half that of old-growth forest densities, which averaged approximately 160 stems/acre (Franklin et al. 1981). These data support the assumption that many of the original large trees were removed from DHC, resulting in low large tree densities compared to mature, undisturbed Pacific Northwest forests.

Figure 4. Overstory tree density/acre by diameter size class



[1] Diameter at breast height (dbh).

A complete list of overstory species in each habitat type can be found in Table 2. Overstory tree species richness is greatest in the deciduous tree-dominated areas of the park, with thirteen different species present. This includes four species of non-native trees.

The conifer/deciduous mixed forest has 6 overstory tree species present and the riparian forest and forested wetlands have an overstory tree species richness of three. Red alder comprises the largest proportion of the overstory in the riparian and wetland forest types. Western hemlock is more abundant in the riparian forests, while western red cedar has the highest density in the wetlands. The riparian and wetland areas have approximately half the overstory tree densities of the conifer/deciduous mixed and deciduous forests (50 stems/acre and 43 stems/acre in the riparian and wetland areas respectively compared to 88 stems/acre and 99 stems/acre in the conifer/deciduous mixed and deciduous forests respectively).

Table 2. Overstory and regenerating tree species found in each of the sampled habitat types in DHC. Values represent density (stems/acre) and proportion (in parenthesis) of each species present in each habitat type.

Scientific Name[1]	Common Name	Conifer/Deciduous Mixed forest	Deciduous forest	Riparian Forest	Wetlands
OVERSTORY TREES (Density/acre)[2]					
Acer macrophyllum	big-leaf maple	61.9 (70%)	57.5 (58%)	10 (20%)	16.7 (38%)
Alnus rubra	red alder	10.6 (12%)	21.3 (21%)	25 (50%)	20 (46%)
Arbutus menziesii	Pacific madrone		1.3 (1%)		
Cedrus sp.	cedar		.6 (1%)		
*Ilex aquifolium***	English holly		.6 (1%)		
Populus trichocarpa	black cottonwood		1.3 (1%)		
Prunus emarginata	bitter cherry	.6 (1%)	.6 (1%)		
*Prunus lusitanica**	Portugal laurel		1.3 (1%)		
*Prunus sp.**	horticultural cherry species		.6 (1%)		
Pseudotsuga menziesii	Douglas-fir	1.9 (2%)	2.5 (2.5%)		
*Sorbus aucuparia**	European mountain ash		.6 (1%)		
Thuja plicata	western red cedar	3.8 (4%)	8.1(8%)		6.7 (15%)
Tsuga heterophylla	western hemlock	9.4 (11%)	3.1 (3%)	15 (30%)	
Average density		**88.2/acre**	**99.4/acre**	**50/acre**	**43.4 /acre**
REGENERATING TREES (Density/acre) [2]					
Acer macrophyllum	big-leaf maple	38.1 (11%)	24.4 (6%)	30 (24%)	10 (3%)
*Aesculus hippocastanum**	horse chestnut	3.1 (1%)	8.1 (2%)		40 (12.5%)
Alnus rubra	red alder	.6 (T)	2.5 (1%)		10 (3%)
Cedrus sp.	cedar		.6 (T)		
*Crataegus monogyna**	one-seed hawthorn		4.4 (1%)		
*Ilex aquifolium***	English holly	146.9 (41%)	163.1 (42%)	25 (20%)	170 (53%)
Picea sitchensis	Sitka spruce	1.9 (.5%)	1.3 (T)		
*Prunus laurocerasus***	cherry laurel	95 (27%)	61.9 (16%)	10 (8%)	40 (12.5%)
*Prunus lusitanica**	Portugal laurel	1.3 (T)	16.3 (4%)		
*Prunus sp.**	horticultural cherry species	2.5 (1%)	1.3 (T)		
Pseudotsuga menziesii	Douglas-fir	6.9 (2%)	4.4 (1%)		
Rhamnus purshiana	cascara		3.1 (1%)		
Salix sp.	willow		1.3 (T)		
*Sorbus aucuparia**	European mountain ash	6.9 (2%)	45 (12%)	5 (4%)	10 (3%)
Thuja plicata	western red cedar	37.5 (10.5%)	43.8 (11%)	30 (24%)	26.7 (8%)
Tsuga heterophylla	western hemlock	14.4 (4%)	5.6 (1.5%)	25 (20%)	13.3 (4%)
Average density		**355.1/acre**	**387.1/acre**	**125/acre**	**320/acre**

[1]Species denoted by * are non-native invasive species, ** are species which have been given a legal designation by the King County Noxious Weed Program (King County 2005).
[2]T=Trace presence of species (less than 1 %).

Tree Regeneration

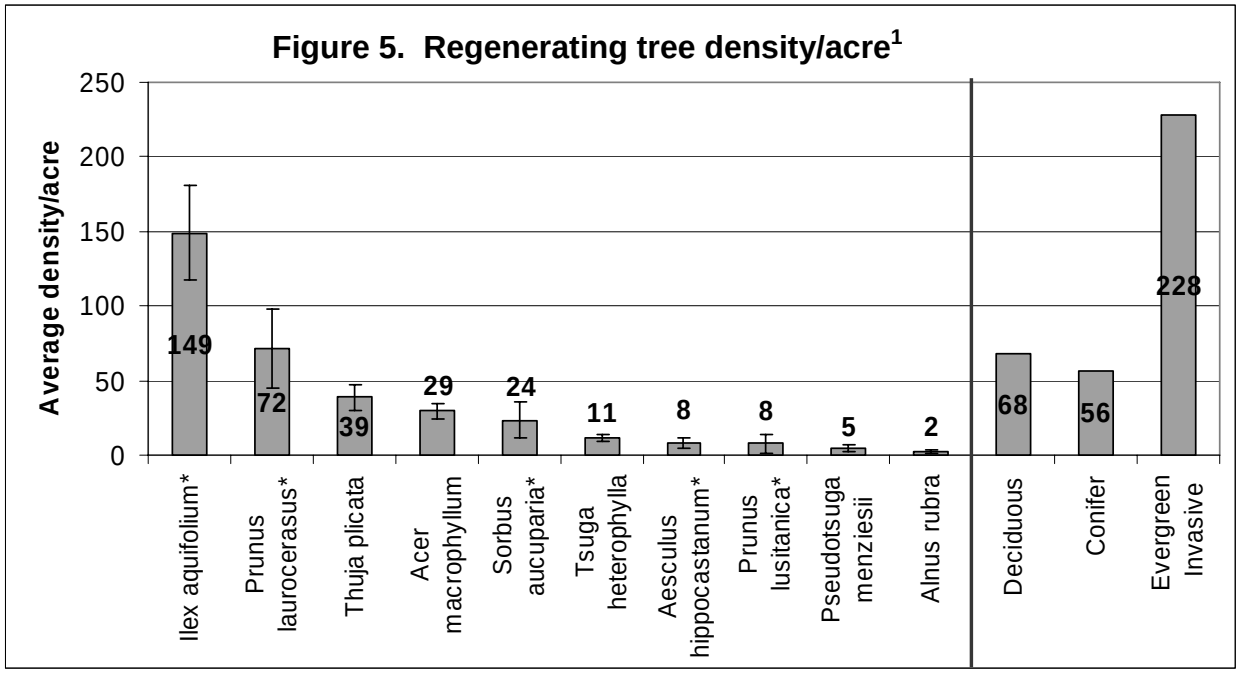
This study considered trees five inches or less in diameter at breast height to be regenerating tree species. Three general categories of trees were present in the regeneration layer in DHC: deciduous, conifer, and evergreen, tree-like shrubs. Deciduous trees included natives such as red alder and big-leaf maple, as well as non-natives such as European mountain ash. Conifer trees consisted of native species including western hemlock, western red cedar, and Douglas-fir. Evergreen tree-like shrubs are non-native invasive species which have the capacity to reach the size of a small tree and grow in the mid-story layer underneath the canopy. This category includes species such as English holly, cherry laurel and Portugal laurel. A complete list of regenerating tree species cover in each habitat type can be found in Table 2. Maps 3, 4 and 5 show regeneration densities of conifers, English holly and cherry laurel, and native deciduous trees for each plot sampled throughout the canyon respectively. The amount and composition of current tree regeneration will substantially influence the future makeup of the forest.

Map 3

Map 4

Map 5

The regenerating tree layer is dominated primarily by non-native evergreen tree-like shrubs, which comprise 75% of all small diameter stems present (266 stems/acre) (Figure 5). English holly is the most prevalent across all forest types, with an average of 41% of all stems sampled. The proportion of English holly is lowest in the riparian forest (20%) and highest in the wetland areas (53%). Cherry laurel is the second most frequent invasive tree species with an average of 20% across all plots. Proportions of regenerating cherry laurel are lowest in the riparian forest (8%) and highest in the conifer/deciduous mixed forest (27%). Additional invasive deciduous trees found in DHC include horse chestnut (*Aesculus hippocastanum)* and European mountain ash. Horse chestnut is present mainly in the wetland areas, whereas European mountain ash is present primarily in the deciduous forest. Other invasive species present in smaller amounts are Portugal laurel, ornamental cherry species, and one-seed hawthorn (*Crataegus monogyna).*

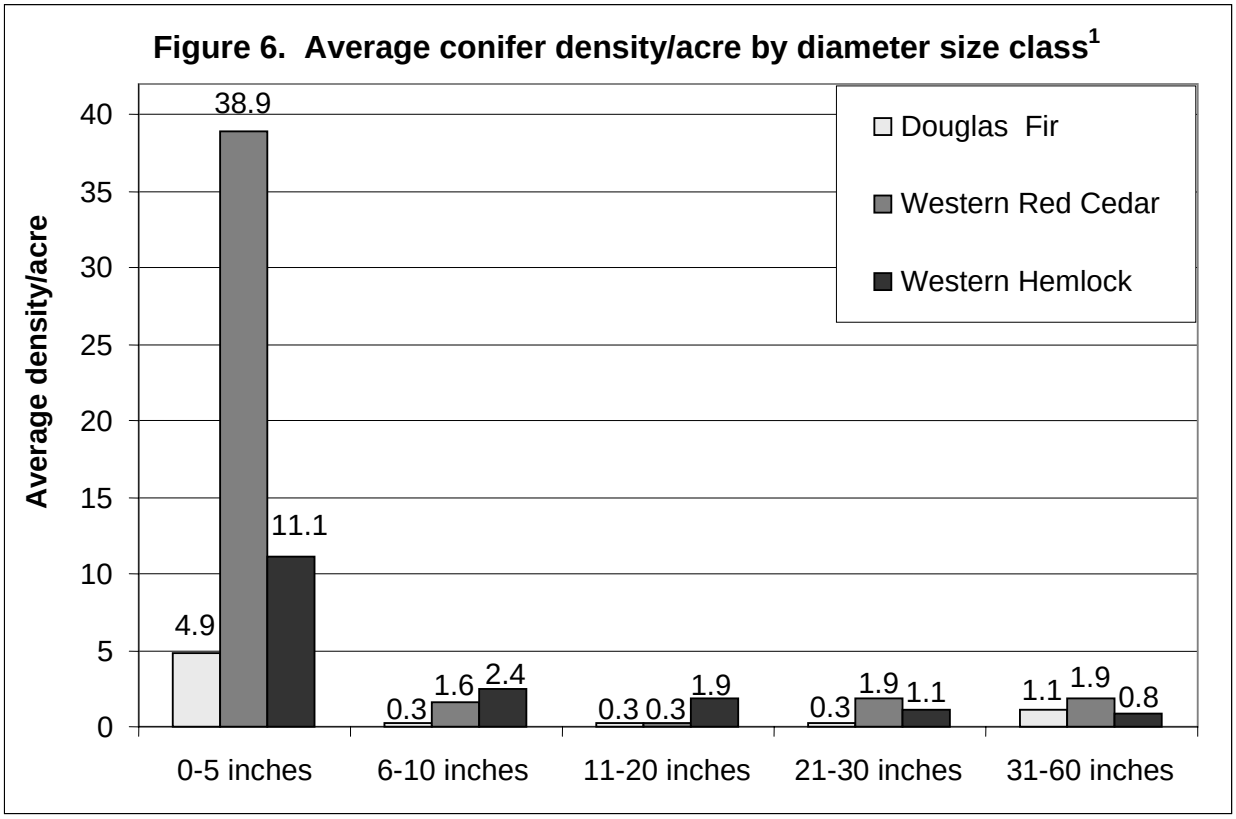


[1] Average density/acre of the ten most prevalent regenerating tree species (less than 5 inches in diameter) found in DHC. Asterisks indicate non-native invasive trees. Bars represent +/- standard error. Numeral above each bar indicates species average.

Both English holly and cherry laurel are designated by the King County Noxious Weed Control Program as Obnoxious Weeds (King County 2005). These species, along with Portugal laurel, are generally escaped plantings which are now widespread in King County. All three of these bird-dispersed evergreen species were observed growing up to 20-30 feet into the canopy in DHC. These species also have the ability to sucker from the roots of cut stems, which makes manual control difficult. Additional bird-dispersed deciduous invaders include European mountain ash, one-seed hawthorn, and ornamental cherry species. If allowed to reach reproductive maturity, these species pose the risk of becoming substantial contributors to the spread of non-native species throughout the park, as well as the surrounding area.

The 2004-5 survey shows that parts of DHC have substantial native conifer regeneration (Map 3). Of the 71 average conifer stems/acre, 56/acre (77%) are seedlings. 56% (39 stems/acre) of

all conifer trees sampled are small diameter western red cedars while 15% (11 stems/acre) are western hemlock seedlings (Figure 6). Many of the cedar seedlings appear to have been planted, whereas much of the hemlock regeneration seems to be the result of natural seed germination. Western hemlock seedlings are found predominantly in the riparian forest, with an average of 20 stems/acre,compared with an average of 3.2 stems/acre for other forest types. Hemlock seedlings establish preferentially on decomposing wood, of which the riparian forest has the highest volumes. Most of these seedlings (as well as many mid-story trees) were observed emerging from downed logs or rotting stumps.



[1] Average density/acre of native conifer trees (Douglas-fir, western red cedar, and western hemlock) within five diameter size classes. Numeral above each bar indicates species average.

All deciduous seedlings (native and exotic) taken together contribute 69 stems/acre (33 stems/acre native compared to 35 stems/acre non-native). European mountain ash and horse chestnut make up the majority of the non-native deciduous species, with a small amount of one-seed hawthorn also present. Big-leaf maple is the most abundant native tree present, (29 stems/acre), with greatest numbers in the riparian forest habitat. Two other native deciduous species are present in small quantities: red alder and cascara (*Rhamnus purshiana*). See Table 2 for a list of all regenerating tree species.

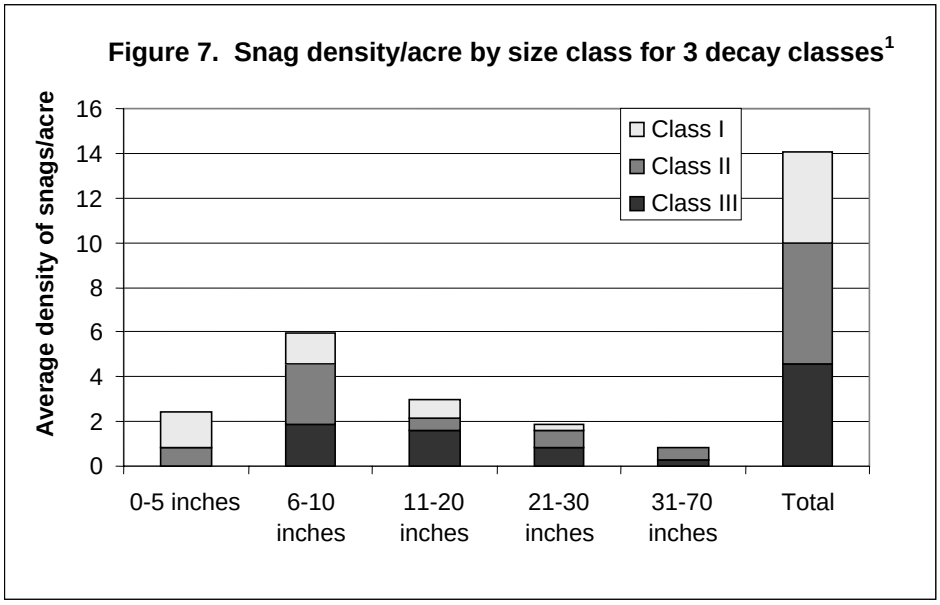
The overall number of deciduous regenerating trees is similar to the number of regenerating conifers present when all species are considered (69 stems/acre compared to 56 stems/acre). However, when only native tree species are considered, there are more conifers regenerating than deciduous trees (33 stems/acre compared to 56 stems/acre). Although these numbers represent

average stems/acre, the regeneration of both native conifer and deciduous trees is very spotty, with many plots having no regeneration at all (Figures 17 and 23). For example, there are 8 plots without any conifer regeneration, and 4 more with only 10 stems/acre. There are also 7 plots without any deciduous tree regeneration, and 8 more with 10 stems/acre.

Snags

In any discussion of forest structure, it is important to also consider the role of standing dead trees (snags). 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.

Snags were present on 68% of the plots sampled. In those plots, an average of 21 snags/acre were found. When snag density is extrapolated parkwide, the number of snags decreased to an average of 14 snags/acre. The mean diameter of snags measured was 16 inches, with an average height of 24 feet. 28% of the snags are in decay class I (minimally decayed), 39% are in decay class II (moderately decayed) and 33% are in decay class III (very decayed). For a distribution of snags by diameter classes, see Figure 7. These snag densities are fairly similar to those found in old-growth Douglas-fir forests, which have from 13 to 24 snags/acre, and increase in diameter from 16 inches at 250 years old to 25 inches at over 850 years (Franklin et al. 1981). The majority of the snags in DHC are found in the conifer/deciduous mixed and deciduous forests. Only one snag was recorded in the riparian and wetland plots surveyed. On average snags in the conifer/deciduous mixed forest are almost twice as large in diameter as those in the deciduous forest (21 inches in diameter as compared to 11 inches in diameter).



1. Density/acre of snags by decay class within five diameter classes. Decay class I is least decomposed and decay class III is most decomposed.

Coarse Woody Debris (CWD)

Coarse woody debris (CWD) can be defined as: "Sound and rotting logs and stumps (greater than 3 inches in diameter) 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, providing habitat for decomposer fungi, animals, birds, bacteria and insects, acting as nurse logs for seedlings of plants such as western hemlock and red huckleberry, retaining sediment and preventing erosion, and shaping the geomorphology of streams by creating banks, pools and slowing stream flows (Stevens 1997).

Due to the slope and topography of DHC, CWD from the upland areas is a source of material for input to the riparian areas. The average volume for CWD across all plots is 2,162 ft^3/acre, with an average diameter of 16.5 inches. The highest volume is found in the riparian area at 5,417 ft^3/acre, and the lowest in the deciduous forest at 1,473 ft^3/acre. The conifer/deciduous mixed forests and wetland areas have similar intermediate amounts of 2,390 ft^3/acre and 2,446 ft^3/acre respectively. The riparian areas in DHC approach the volumes of CWD present in old-growth forests. Douglas-fir / Western hemlock forests over 250 years old have approximately 6,400 ft^3/acre (Harmon et al.1986). The conifer/deciduous mixed forests and wetland area habitats contain approximately a third of this amount. Once early successional species such as red alder senesce and reach the end of their lifespan, they will have the potential to add considerable amounts of CWD to DHC.

Understory Composition

Shrubs

A total of 24 shrub species were identified during the 2004-5 survey, of which 21 are native. Table 3 shows percent cover of all species identified by habitat type. The highest species diversity is found in the conifer/deciduous mixed forests, with 22 species present. Deciduous forests have 17 species of shrubs, whereas the wetlands have 13 and the riparian forests have 11 different species. Overall, shrub cover averaged 66% per plot. Beaked hazelnut, salmonberry, Indian plum, low Oregon grape, vine maple and red elderberry are the most prevalent native species (Figure 8). Vine maple and salmonberry are present in highest proportions in the riparian forested areas, whereas the wetlands are dominated by red-osier dogwood (*Cornus stolonifera*) and salmonberry. Low Oregon grape and oceanspray (*Holodiscus discolor),* which prefer drier conditions, are common in the upland areas but do not extend into the riparian and wetland areas.

The only pervasive non-native invasive shrub identified was Himalayan blackberry, which is present in 92% of the plots with an average cover of 11% per plot. The highest concentration of blackberry is found in the wetland areas, which have 21% cover, and the lowest in the riparian forest with 4% cover. Himalayan blackberry is listed by the King County Noxious Weed Control Program as an Obnoxious Weed (King County 2005). Two other non-native and potentially invasive species are present in small quantities and should be monitored to ensure that they do not spread. These species are cotoneaster (*Cotoneaster sp.)* and spurge laurel *(Daphne laureola).*

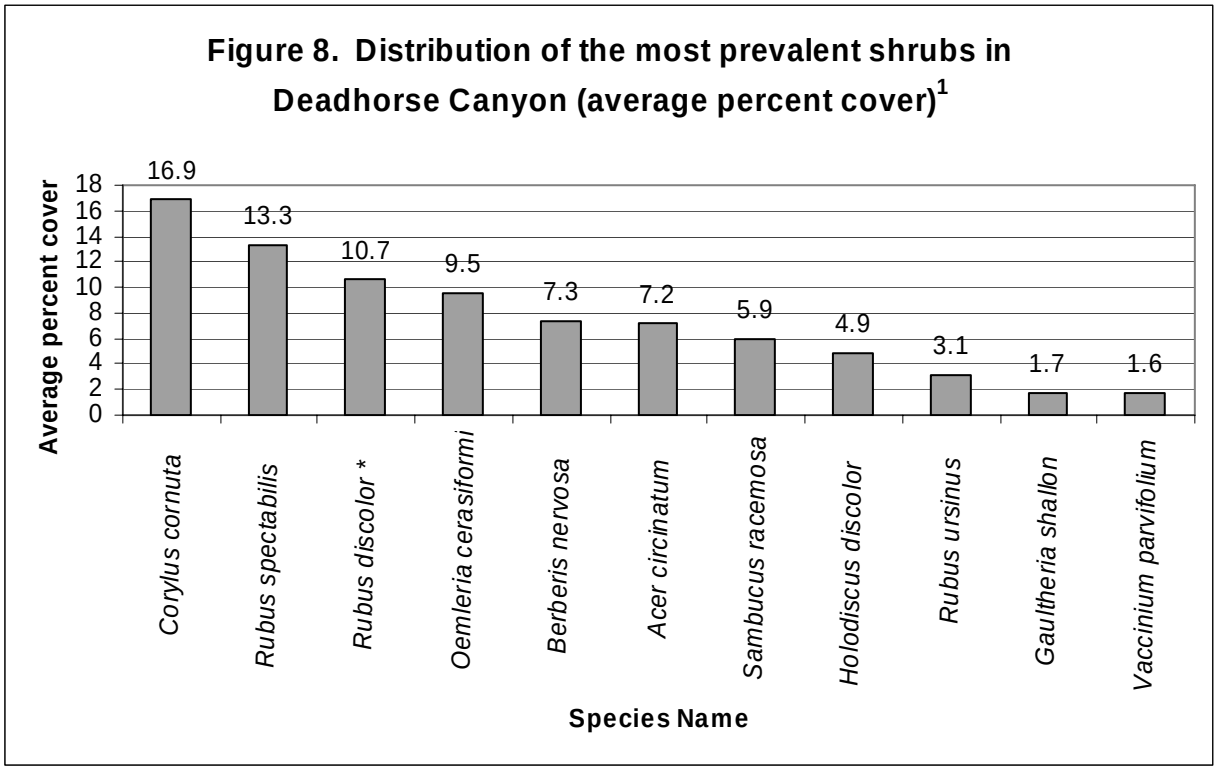
Table 3. Shrub, herb and grass species found in each of the sampled habitat types in DHC. Values represent the percent cover of each species.

Scientific Name[1]	Common Name	Conifer/deciduous mixed forest	Deciduous forest	Riparian Forest	Wetlands
SHRUBS[2]					
Acer circinatum	vine maple	8%	3%	25%	5%
Berberis aquifolium	tall Oregon grape	T			
Berberis nervosa	low Oregon grape	6%	9%		
Corylus cornuta	beaked hazelnut	19%	17%	2.5%	13%
Cornus stolonifera	red-osier dogwood	T		1%	17%
*Cotoneaster sp.**	cotoneaster	2%	T		1%
*Daphne laureola**	spurge laurel	T			
Gaultheria shallon	salal	1%	2.5%	.5%	1%
Holodiscus discolor	oceanspray	3%	6%		
Oemleria cerasiformis	indian plum	11%	9.5%	1.8%	6.5%
Physocarpus capitatus	Pacific ninebark	T			
Ribes sp.	currant	.5%			
Ribes bracteosum	stink currant	1%	2%	8%	3.5%
Rosa gymnocarpa	baldhip rose	T			
Rosa nutkana	Nootka rose		T		
Rosa sp.	rose		.5%		
*Rubus discolor***	Himalayan blackberry	7%	12.5%	4%	21%
Rubus leucodermis	blackcap	T			
Rubus parviflorus	thimbleberry	1%	1.5%		1%
Rubus spectabilis	salmonberry	8%	13.5%	24%	34%
Rubus ursinus	creeping blackberry	2%	5%	1%	2%
Sambucus racemosa	red elderberry	8%	4%	4%	3%
Symphoricarpos albus	snowberry	12%	1%		
Unknown shrub		.5%	1%		
Vaccinium parvifolium	red huckleberry	1.5%	1.5%	.5%	3%
HERBS AND GRASS[2]					
Adiantum pedatum	maidenhair fern	1%	.5%	T	
Athyrium filix-femina	ladyfern	2%	3%	9%	17%
Blechnum spicant	deerfern	.5%		T	1%
Bromus sp.	brome	T			
Bromus vulgaris	Columbia brome	.5%	.5%		.5%
Carex deweyana	Dewey sedge	T	T	1%	.5%
*Cardamine hirsute**	hairy bittercress	T	T	1%	1%
Carex obnupta	slough sedge	2%			
Carex sp.	sedge		T		
*Calystegia sepium**	hedge false bindweed	2.5%	1.5%		2.5%

Scientific Name[1]	Common Name	Conifer/deciduous mixed forest	Deciduous forest	Riparian Forest	Wetlands
*Clematis vitalba***	wild clematis		.5%		
Cyclamen sp.	cyclamen	T			
Dactylis glomerata	orchardgrass	1			
Dicentra formosa	western bleedingheart	T			
Dryopteris austriaca	wood fern	2%	.5%	6%	8%
Epilobium ciliatum	fringed willowherb	T			
Epilobium sp.	willowherb		T		
Equisetum telmateia	giant horsetail rush	.5%	1%	1%	8.5%
Galium aparine	stickywilly	T	T		
Galium sp.	bedstraw	T			
Geum macrophyllum	bigleaved avens	T	.5%	T	T
*Geranium robertianum***	herb Robert	1%	1%	T	1
Glyceria striata	tall mannagrass			T	1.5%
*Hedera helix***	English ivy	17%	50%	10%	20%
Hesperis matronalis	dames rocket	2%			
*Lapsana communis**	nipplewort	.5%	T	T	
*Lamium galeobdolon**	yellow archangel	11%			
*Lactuca muralis**	wall-lettuce	T			
Lonicera ciliosa	orange honeysuckle	.5%	1%		
*Lunaria annua**	annual honesty		T		
Lysichitum americanus	skunk cabbage			1.5%	2%
Montia sibirica	Siberian miner's lettuce	T			
Oenanthe sarmentosa	water parsley			.5%	
*Phalaris arundinacea***	reed canarygrass			1%	1%
*Polygonum cuspidatum***	Japanese knotweed		4%		14%
Polypodium glycyrrhiza	licorice fern	1.5%	1%	1.2%	.5%
Polystichum munitum	sword fern	43%	22%	23%	17.5%
Pteridium aquilinum	bracken fern	1%	1%		1
*Ranunculus repens**	creeping buttercup	10.5%	3%	T	T
Scirpus microcarpus	small-seeded bulrush				13.5%
*Solanum dulcamara***	deadly nightshade			4.5%	3%
Stachys sp.	hedgenettle			T	
*Stellaria media**	chickweed	T			
*Taraxacum officinale**	dandelion	T	T		T
Tellima grandiflora	fringecup	1%	2%	.5%	T
Tiarella trifoliata	foamflower	1%		T	
Tolmiea menziesii	piggy-back plant	3%	4.5%	12%	6%

Scientific Name[1]	Common Name	Conifer/deciduous mixed forest	Deciduous forest	Riparian Forest	Wetlands
Unknown grass		T	.5%	T	.5%
Urtica dioica	stinging nettle	3%	T	1%	

[1]Species denoted by * are non-native invasive species, ** are species which have been given a legal designation by the King County Noxious Weed Program (King County 2005).
[2]T=Trace presence of species (less than 1 %).

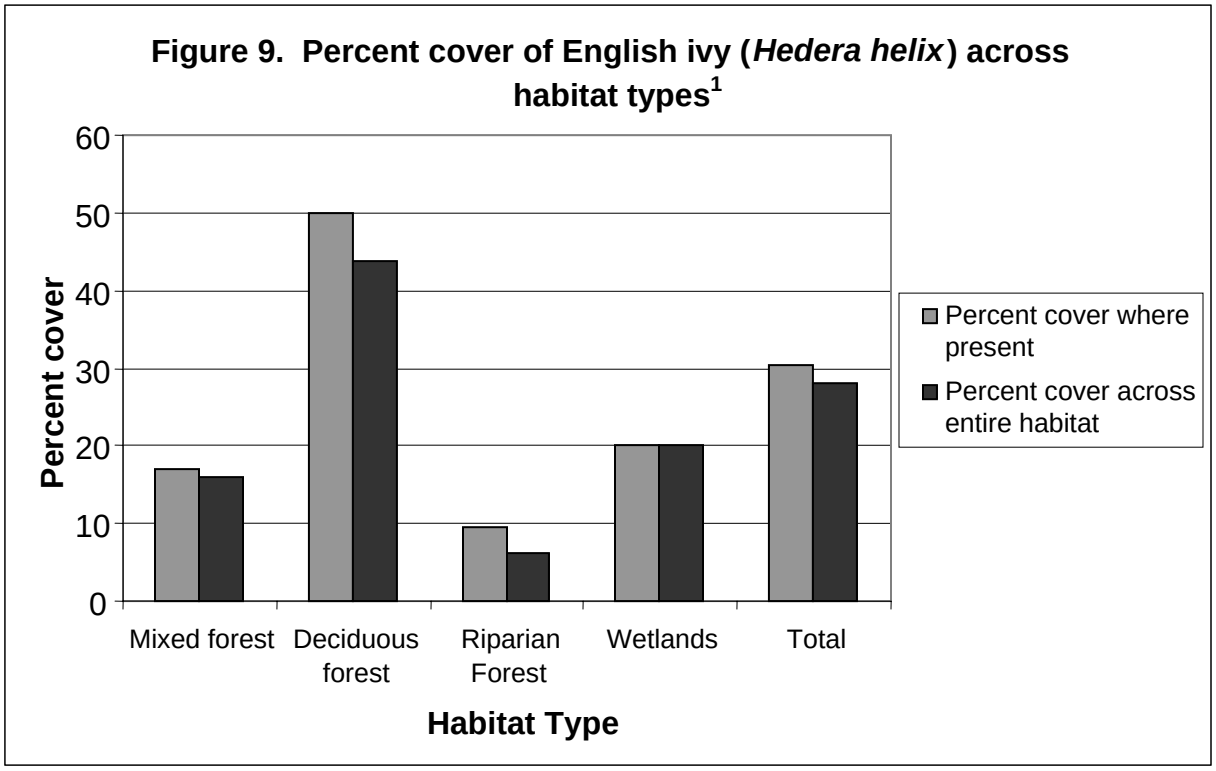


[1] 11 of the most prevalent shrubs in DHC. Invasive species are denoted by an * after the name. Numeral above each bar indicates species average.

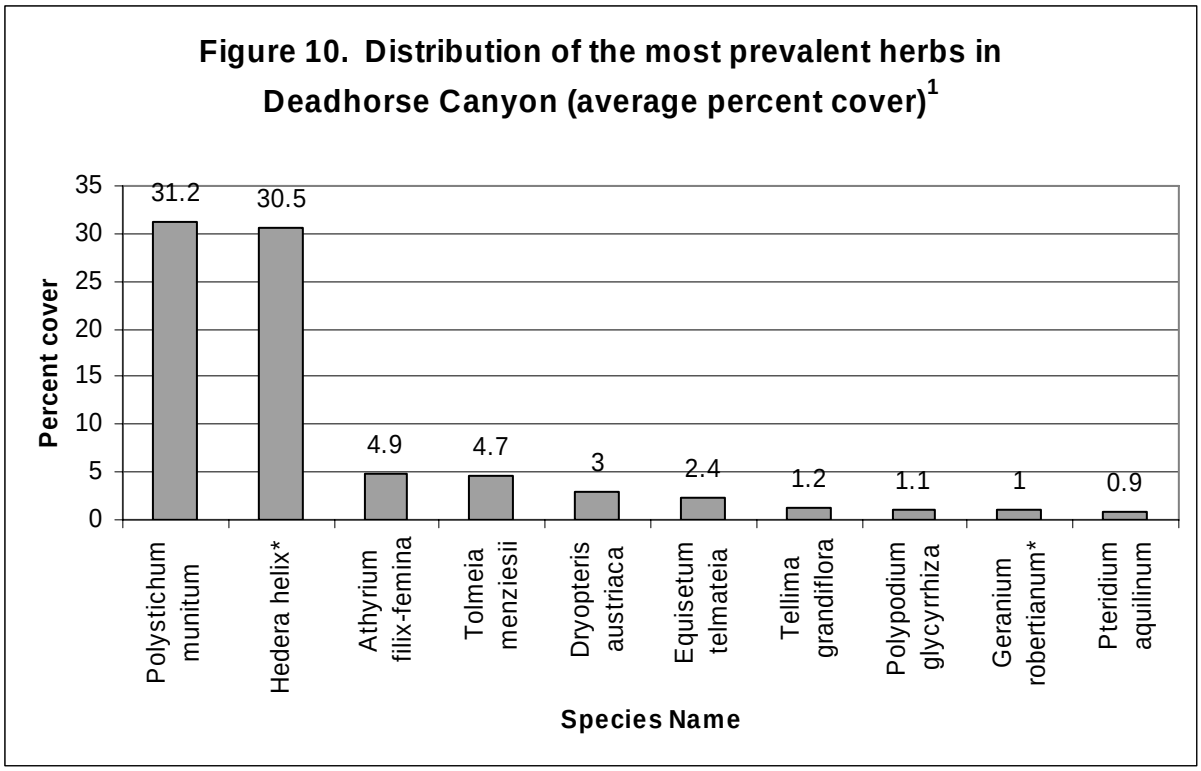
Herbs

A total of 48 herbaceous species (including vines) were recorded during the 2004-5 survey. The conifer/deciduous mixed forest contained the most diverse herb population (37 species), followed by the deciduous forest (27 species), and the riparian forest and wetlands (24 species each). Each habitat type has a unique species composition and will be discussed separately. However, it is possible to make several general statements about the park as a whole. Of the 48 total understory species, 24 are native and 24 are non-native. The non-native species contribute 43% of total understory cover in the park. The vast majority of the non-native cover is due to the presence of English ivy, a King County Noxious Weed of Concern (King County 2005), which has a cover of 30% when averaged across all sampled plots (Figure 9). The predominant native species is sword fern, with a 31% cover (Figure 10). Although most species are present across all habitats, several were found only in upland or riparian areas. Orange honeysuckle (*Lonicera*

ciliosa), western bleeding heart (*Dicentra formosa*) and Siberian miner's lettuce (*Montia sibirica*) were found in the upland areas, whereas skunk cabbage (*Lysichitum americanus*) was found only in riparian and wetland areas.



[1] Percent of English ivy across habitat types in DHC where present (on surveyed plots) and habitat-wide (results extrapolated to habitat level).



[1] Ten of the most prevalent herb species in DHC. Invasive species are denoted by an * after the name.

Herbs by Habitat Type

Conifer/Deciduous Mixed Forest

The conifer/deciduous mixed forest is dominated by swordfern (43% cover), a native forb, with twice as much cover compared to the other habitat types. Other native species present in small quantities on a majority of the plots are: ladyfern (*Athyrium filix-femina),* wood fern (*Dryopteris austriaca),* licorice fern (*Polypodium glycyrrhiza),* fringecup (*Tellima grandiflora)* and piggy-back plant (*Tolmiea menziesii).* There is also a small amount of western bleedingheart and Siberian miner's lettuce in the conifer/deciduous mixed forest habitat which is not found elsewhere in the park. See Table 3 for a list of all species by percent cover found in this habitat type.

There are several invasive non-native species that make up a large portion of the plant cover in the conifer/deciduous mixed forest habitat type. The most prevalent and dominant is English ivy, which is present in 94% of conifer/deciduous mixed forest plots at an average of 17% cover (Figure 9). Herb Robert, also a King County Noxious Weed of Concern, is present in 75% of the plots, but at much lower densities of approximately 1% per plot. Hedge false bindweed is present in 25% of the plots at an average of 2.5% per plot. Two species, creeping buttercup (*Ranunculus repens)* and yellow archangel (*Lamium galeobdolon),* are found in confined geographic areas but at high concentrations. The yellow archangel in particular is found in only one location and has completely overtaken the area (Figure 11). This presents a unique opportunity to eradicate this weed before it becomes widespread.

Figure 11. Yellow archangel (*Lamium galeobdolon)* in Deadhorse Canyon

Deciduous Forest

The deciduous forest type is heavily dominated by English ivy, which is present in 88% of the plots at an average of 50% cover. When ivy cover is extrapolated over the entire deciduous habitat sampled, it covers 44% of the ground (Figure 9). Sword fern is the second most dominant understory plant, with 22% cover. Some native plants that are consistently present in small quantities are: ladyfern , wood fern, licorice fern, fringecup and giant horsetail rush (*Equisetum telmateia).* The deciduous forest type has a similar invasive species suite to the conifer/deciduous mixed forest. Herb Robert is present in 44% of the plots at approximately 1% cover and hedge false bindweed is present in 25% of the plots at an average of 1.5% cover. Creeping buttercup is more widespread in this forest type and occupies 31% of the plots at 3% cover. Wild clematis (*Clematis vitalba),* a King County Weed of Concern is found in one plot in the deciduous forest type. In addition, there are several patches of Japanese knotweed (*Polygonum cuspidatum),* a King County Noxious Weed of Concern, which is highly invasive (see Map 7). See Table 3 for a list of all species by percent cover found in this habitat type.

Riparian Forest

The riparian forests contain the lowest amount of invasive species compared to the other forest types. English ivy, although widespread, has the lowest cover of any habitat type (9%) (Figure 9). Herb Robert and creeping buttercup are also present in trace amounts. Deadly nightshade (*Solanum dulcamara)*, a King County Obnoxious Weed, is present at approximately 5% cover. Deadly nightshade tends to grow in wet areas and is expected to be found along riparian corridors. One species of particular concern is reed canarygrass (*Phalaris arundinaceae*), a King County Noxious Weed of Concern, which was found in one of the riparian plots. This waterborne weed has the capacity to spread throughout the riparian area . Native vegetation of the riparian corridor includes a high cover of sword fern (23%), ladyfern (9%), piggy-back plant (12%) and wood fern (6%). For a complete list of other species present, see Table 3.

Forested Wetland

The wetland areas are dominated by sword fern (18%), ladyfern (17% cover), wood fern (8%), stinging nettle (*Urtica dioica)* (6%), giant horsetail rush (9%) and piggy-back plant (6%). English ivy is present in all wetlands at an average cover of (20%) (Figure 9). Hedge false bindweed, creeping buttercup and Herb Robert are present in one wetland each in low amounts (2.5%, trace and 1% respectively). Deadly nightshade is also present in one wetland at a cover of 3%. In addition, one wetland is heavily infested with Japanese knotweed (14%), and has several areas where reed canarygrass has become established (see Map 7). See Table 3 for a list of all species by percent cover found in this habitat type.

V. MANAGEMENT RECOMMENDATIONS

Structurally and functionally, DHC represents a mostly intact second-growth forest ecosystem with considerable floristic diversity (over 90 species) in all vegetation layers. The forest structure is that of a younger forest, with the majority of overstory trees between 6 inches and 20 inches in diameter. There are a relatively small number of large trees present. The species composition of the overstory is dominated by deciduous trees, with fewer than 15 conifer stems/acre. To enhance the presence of conifers in the park, a considerable amount of western red cedar and western hemlock trees have been planted in many areas. There are also a considerable number of snags located throughout the park, and as mature deciduous trees such as red alder reach the end of their lifespan, there will be an opportunity for creating and retaining more snags and coarse woody debris. In addition to the tree layer, DHC has both substantial shrub and herb layers, which add to the structural diversity and health of the forest.

Unfortunately, as with all urban parks that are surrounded by development, encroachment of invasive species, human activity and other disturbance make active stewardship vital to maintaining native species diversity. A number of management concerns identified in the 1995 management plan still pertain to conditions in the park today. A major management recommendation in the plan was a call for the control of invasive species such as Himalayan blackberry, English ivy, English holly, cherry laurel and Japanese knotweed. Populations of these species persist, despite ongoing control efforts, and the list of invasive species has grown to include reed canary grass and several tree species among others. Other issues identified in the plan that persist include the dumping of litter and creation of social trails that fragment habitat and result in the trampling of vegetation in the park. In addition, the lack of conifer regeneration in parts of the park was noted, and planting conifers was recommended. Numerous conifers have been planted in the ensuing years, which have become a prominent component of the forest. However conifer regeneration, particularly natural regeneration is still limited in many portions of the park. Due to the fact that these problems are widespread and often not limited to a specific geographic area, a comprehensive strategy will have to be undertaken to actively manage forest habitat in the park.

Past Restoration History

Friends of Deadhorse Canyon was established in 1998 following the replacement of a sewer line in the park by Seattle Public Utilities (SPU). Since its inception, the group has worked with a number of other groups and organizations from the surrounding neighborhoods to improve the state of the park. The group holds monthly work parties throughout the year (except December). Much of their work has focused on the removal of trash, the eradication of invasive plant species, and the planting of native trees, shrubs, and herbs. During the course of this forest assessment, the group's leader identified 17 general areas throughout the park where organized work had occurred (Map 6). This documentation of past efforts is intended to provide some continuity to the ongoing restoration activities. While not exhaustive or all-inclusive, it provides a general account of restoration efforts throughout the history of Friends of Deadhorse Canyon.

After the sewer line was replaced, SPU hired a contractor to install plants in the disturbed areas on either side of the new trail (which follows the sewer line). Since that time, many groups have participated in restoration activities including: Treemendous Seattle, Renton High School, Boys and Girls Club of King County, Big Brothers and Big Sisters, Seattle Central Community College, Keybank, and Microsoft. The following table gives a brief outline of the work that has been completed at each of the general restoration sites.

Table 4. Former restoration activities in Deadhorse Canyon undertaken by the Friends of Deadhorse Canyon

Site #	Date	General Description	Collaborating Partners
RS.1	1999	Ivy removal on steep slopes, used erosion control matting. Plants difficult to establish possibly due to poor soil. Ivy occasionally removed from trees. Substantial trash removal, repeated illegal dumping. Challenge to keep ivy from spreading down from adjacent private property.	Campfire Girls, Juvenile Hall Kids Service, SPU Community Project workday in 1999-2000
RS.2	1996	Originally a gravel/fill removal area. Invasive knotweed was removed and natives trees and shrubs planted followed by herbaceous species in subsequent years. Generally weeded/maintained twice a year.	Kobe Japan UW exchange students, Treemendous Seattle
RS.3	1997	Clearing of invasives and replanting with native species.	Colorado College students spring break service project
RS.4	1997	Plantings along hillside above parking area and south along the east bank of Taylor Creek.	Big Brothers, Seattle Central Community College
RS.5	1997	Removed invasive species and planted trees in riparian area. Many trees seem to have failed.	
RS.6	1997-1998	Trees planted and woody invasives removed (left cuttings on site which resprouted). Area of difficult access, not returned to often.	Treemendous Seattle
RS.7	1996-1997	Area on either side (approx. 3 ft) of footpath beneath planted following installation of sewer line. Initial plantings installed by contractor hired by SPU.	Seattle Public Utilities, Kobe Japan UW exchange students
RS.8	1998-1999	Conifers planted at toe of slope in depression above trail. Many hemlocks were lost and subsequently replaced. Boys and Girls Club planted additional conifers in 2003.	Renton High Honors Society (Key Club), Seattle Central Community College, Boys and Girls Club
RS.9	1997	Various plantings along east bank of Taylor Creek.	Big Brothers and Big Sisters
RS.10	1997	Cleared blackberry, substantial return of salmonberry and piggy-back plant with little return of blackberry.	
RS.11	1997	Nominal clearing of sparse invasives, substantial conifer plantings. Additional trail added in 1998 (SCA) with the construction of second bridge and stair installation in 2000 (SPD) creating the current loop trail.	Student Conservation Association, Renton High School, Olympia High School, Seattle Central Community College, Seattle Parks Dept.

Site #	Date	General Description	Collaborating Partners
RS.12	2000	Blackberry removal and planted with natives the following fall. Returned to often.	Keybank day of caring, Renton High School, Nordstrom's, Microsoft
RS.13	1996	Trees initially planted in 96'-97'. Ivy and blackberry have been removed and trees and understory shrubs have subsequently been planted.	
RS.14	1999-2000	Blackberry removal and tree planting. Returned to several times a year.	Renton High School, Dwight Pelz (City Councilmember)
RS.15	1998	Stream bank stabilization with the use of wood and fabric and native plantings.	Big Brothers and Big Sisters

Map 6

Current Management Recommendations

Nineteen management areas in DHC have been identified, based on habitat types (Map 7).

Recommended priority management actions focus on:
1) Removal of invasive species with limited distributions before they become widespread in the park
2) Restoring invaded wetland and riparian areas
3) Removal of invasive tree species before they mature and bear fruit
4) Planting conifer species in areas with little or no conifer regeneration

Species with limited distributions in the park that are targeted for removal include Japanese knotweed, yellow archangel, wild clematis, reed canarygrass and dame's rocket (*Hesperis matronalis).* Some of these species such as yellow archangel, reed canarygrass, wild clematis and dame's rocket can be eradicated by volunteer work parties. However, due to the large area involved and control methods required for Japanese knotweed, it is recommended that a licensed contractor be hired for this task.

Invasive tree species targeted for removal include English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings. Due to the large numbers of these species present, it is recommended that a contractor also be hired for the completion of this task. Because English holly and laurels produce stump sprouts and many seedlings, topical herbicide should be applied to cut areas. However, many of these species can be easily removed when they are younger seedlings during general restoration efforts. A park-wide view of the density of English holly and cherry laurel stems by plot can be seen in Map 5.

Two species that should be monitored over time are *Cotoneaster spp*. and spurge laurel, as their invasiveness is not currently known. They are currently present in very low concentrations in several areas.

In addition, considerable attention must be given to other invasive species that have spread throughout DHC. Due to the extent of this problem, control should be undertaken a section at a time, and native plants should be planted in reclaimed areas. Map 8 shows the percent invasive species cover on each of the 37 plots, stratified across the park. The majority of plots with low invasive plant cover (0-25%) occur in the southern half of the park, whereas the majority of the high (51-75%) and very high invasive species cover (>75%) plots occur in the northern end of the park. In particular, English ivy and Himalayan blackberry cover increases towards the northern end of the park (Maps 9 and 10).

The ongoing planting of conifer seedlings in areas with limited conifer regeneration should be continued and intensified. In addition to western red cedars and hemlocks that have been planted in the canyon, the planting stock could be expanded to include grand fir (*Abies grandis*) and Douglas-fir on drier sites. Mature individuals of these species were observed within the park. Although grand fir was not captured in the density plots, its presence in DHC indicates that it is a remnant of the original forest.

Map 7

Map 8

Map 9

Map 10

Rim management area

This management area circles the rim of DHC and is adjacent to property boundaries (Map 7). It is a major source of invasive plant infestations for the park, as many of the plants spread from residential back yards. The rim area is highly invaded by English ivy (both on the ground and climbing into trees), hedge false bindweed and Himalayan blackberry. Extensive garbage dumping over many years has also created restoration challenges. Managing this zone is a complex and long-term challenge. In addition to maintaining a buffer zone to protect the interior of the park from the rim, it is important to work with surrounding landowners to educate them about invasive plants and assist them in eradicating ivy and other invasive plants from their yards. Providing aid to individual landowners in eradicating these weeds may be an effective method of relieving some of the pressure on the park interior. In addition, many of the invasive tree problems in DHC are the result of seeds being spread from trees in the surrounding area. Encouraging landowners to refrain from planting invasive tree species and providing native alternatives should be a part of any outreach strategy. Education efforts should also focus on encouraging people not to dump garbage in the park vicinity.

DF1 and CF7 management area

These zones consist of a deciduous forest stand in the SE corner of the park, with a small stand of conifer/deciduous mixed forest in the middle of the zone (Map 7). Four plots were sampled in DF1 and one in CF7. Plots 31 and 32 have low invasive species cover, 33 and 29 have medium invasive species cover and plot 30 has very high invasive species cover (Map 8). Most of the plots in these zones have adequate conifer regeneration, with the exception of the southernmost area, which only has 10 stems/acre (Map 3).

One erosion area was identified near the southern bridge, where vegetation should be planted to stabilize the soil (Map 7). In the southern part of the zone near plot 33, extending from the riparian area, there is an area invaded by creeping buttercup and other species (see discussion of the riparian management area). There is also cherry laurel in this area. To the east of plot 33, near the top of DHC, there are very steep cliffs that are covered by Himalayan blackberry, which is descending into the forest below. Due to the slope, it would be extremely difficult to remove the Himalayan blackberry without causing erosion problems. Therefore, it is recommended that the Himalayan blackberry is kept in check by periodic containment. The northern portion of DF1 near plots 30 and 32 is invaded by a small patch of English ivy (Map 7), which will require removal and restoration plantings. The ivy in this portion of the zone is climbing up trees and needs to be periodically removed. There is also some Himalayan blackberry in the northern portion near plot 29, which needs to be removed, and a dump site in that same area, extending into the southern portion of zone CF4.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of English ivy in the zone
- Periodic containment of ivy in the northern portion of the zone, especially focusing on removal from trees

- Removal of Himalayan blackberry in northern portion of the zone
- Occasional containment of Himalayan blackberry at the eastern cliffs in the southern portion of the zone
- Plantings to stabilize erosion area shown on Map 7
- Removal of garbage from dump site in northern section of the zone
- Planting conifers in the southern part of the zone.

CF1 management area

This zone consists of a conifer/deciduous mixed forest in the southwestern section of the park (Map 7). Two plots were sampled in this zone, numbers 34 and 36, which both have medium invasive cover (from 25-50%). Both of these plots have very little or no conifer regeneration at this time. The area between the trail and the stream is the location of a major garbage dump site, and is invaded by a large amount of English holly and smaller amounts of cherry laurel, creeping buttercup, Himalayan blackberry and European mountain ash. The westernmost corner of the park between the park border and the stream has considerable Himalayan blackberry cover and a smaller amount of English ivy. Restoration potential is currently limited in this area due to difficult access. The removal of the dump site is highly recommended, as it is potentially a sanitary hazard and is currently suppressing the growth of plants in the area. Removing holly and other invasive tree species is also a priority in this zone because of their high density and potential to spread throughout the park. In addition, removal of other invasive shrub and herb species and restoration planting is recommended.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of garbage from dump site
- Removal of Himalayan blackberry and other invasives from the western portion of the zone
- Planting conifers to promote regeneration throughout the zone

Shrubland 1

This management zone runs under the power lines from the western section of the park to the stream (Map 7). The vegetation is almost exclusively dominated by Himalayan blackberry growing on steep slopes at the top of the canyon and extending to the riparian area. Due to the difficult access to this area and the fact that trees can not be planted in the upper portion of this zone due to the power line corridor, restoration of the upper slope area is not considered a high priority at this time. The removal of blackberry near the riparian area is desirable, followed by replanting with native shrubs and trees in areas that are outside the corridor. However, considerable maintenance of the plantings due to Himalayan blackberry encroachment from the slope will be necessary. For this reason, we recommend containing the shrubland by establishing a forested buffer area around the zone.

Summary recommendations:

- Removal of Himalayan blackberry from the riparian area and replanting with native plants
- Containment of the Himalayan blackberry shrubland through establishing and monitoring a forested buffer area

CF2 management area

This small zone is in fairly good condition and has been the site of past restoration work. One plot (number 35) was sampled in this area, and has a low cover of invasive plant species, and 80 trees/acre of regenerating conifers (Map 3). As with other zones in the park, invasive trees are present in this area and should be removed. A permanent monitoring plot has been established adjacent to the Himalayan blackberry shrubland to the south and can be used for monitoring the future spread of blackberry.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Containment of the Himalayan blackberry shrubland to the south through establishing and monitoring a forested buffer area

DF2 management area

This zone, similar to CF2 to the south, has been restored and is in good overall condition. One plot (number 26) was sampled in this area. The results show medium invasive species cover and 60 stems/acre of regenerating conifers. The major problem in this area is the considerable amount of European mountain ash, which is at risk of spreading to other parts of the park. There is also a smaller amount of English holly and Himalayan blackberry which should be removed from the zone.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of Himalayan blackberry throughout the zone

CF3 and Wetland 1 management areas

This is a very large conifer/deciduous mixed forest zone that makes up most of the west side of the park, and includes a wetland at the north end. The conifer/deciduous mixed forest in this zone is in good condition, with the exception of the invasive-dominated wetland area located near plots 14 and 16 (Wetland 1 on Map 7). The northern part of the zone, above plot 20, has over 50 regenerating conifer stems/acre in the plots sampled, with some areas having up to 300 stems/acre. The southern area of the zone has low regeneration, including some patches, such as plot 24, with no conifer regeneration at all (Map 3). Planting additional conifers in the southern area of the zone is recommended. Of the 11 plots sampled in this zone, 9 had low invasive species cover, whereas the 2 around the wetland area had high cover of invasive species (Map 8). The wetland area is heavily infested with horse chestnut, English ivy, English holly, Himalayan blackberry, Portugal laurel, deadly nightshade and hedge false bindweed. The ivy in this area is

coming down from the rim of the park. There is also a large dumpsite near the wetland area on the border of CF3 and DF6 and another dumpsite southwest of plot 24 (See Map 7).

Another area contains a heavy cover of yellow archangel (Map 7). Yellow archangel has a shallow root system and can be pulled by hand. Care should be taken to remove as much of the root as possible, which is fragile and breaks easily. It is recommended that this plant is removed from fall to early spring, before the seed sets and gets dispersed. Leaving the plants on the forest floor to compost is not recommended because seeds attached to the plants can be spread by ants. Removing the plants in plastic bags and disposing of them ensures that seeds do not remain on the ground (Community Mapping Network, Canada 2005 included in Appendix F).

In the middle of the zone, near plot 22, there is a well-established social trail (Map 7) that is bordered by English holly and other invasive plant species. There are also large numbers of cherry laurel seedlings near the trail around plot 22. Formalizing this trail and removing invasive plants on and around the trail is recommended. Future monitoring of this area can be accomplished by collecting data on the permanent monitoring site established near the trail (Map 11).

Restoration of the wetland area is a priority recommendation of this plan, and should lead to increased plant biodiversity and increased use by birds and wildlife. In addition, there is a small amount of reed canarygrass in the northern section of the zone, at plot 37. Reed canarygrass was found on only 3 plots in the park (17, 19 and 37), in small quantities (less than 1 percent). This plant has been known to dominate wetland areas and make establishment of native vegetation very difficult. It spreads primarily by rhizomes, but seed can travel down waterways to infest other riparian areas (Tu 2004, included in Appendix F). For these reasons, reed canarygrass has been identified for priority control before it spreads to other riparian and wetland areas in the park. Control can be achieved through several methods including digging out the roots and rhizomes, covering the infestation with black cloth or cardboard and then mulching with 4-6 inches of wood bark mulch, and alternatively by treatment with herbicides. For a thorough discussion of the biology and control methods for this plant, see Appendix F.

Summary recommendations:

- Restoration of the wetland area through removal of reed canarygrass, Himalayan blackberry, English ivy, deadly nightshade, hedge false bindweed and yellow archangel, and replanting of native species
- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of garbage from dumpsites
- Formalizing the social trail in the middle of the zone and removing invasive plant species from the trail and nearby areas
- Planting conifers in the southern part of the zone

Map 11

CF4 management area

This conifer/deciduous mixed forest zone contains a small portion of Wetland 2 in the northern part of the zone (Map 7). The wetland is discussed in detail in the DF3 management section. Whereas the southern half of this management zone is in fairly good condition, the northern half is an area of concern. Two plots were placed in this zone, numbers 27 and 28. The southern plot has a low cover of invasive species, whereas the northern plot has high cover (Map 8). Towards the southern border of the zone is a dump site which is extending south into DF1.

The northern portion of the zone is invaded primarily by English holly, cherry laurel and English ivy, along with a large patch of Japanese knotweed. The knotweed is extending from the park rim into Wetland 2 and the riparian area (Map 7). This large infestation will be very difficult to remove manually, due to its large size, the steep slopes involved and the inaccessibility of the area. The most effective form of control for Japanese knotweed is injection of herbicide directly into the stem, which is 95% - 100% effective (Crockett 2005). For this reason, it is recommended that a licensed contractor be hired to complete the work in this area. Once the knotweed is controlled, replanting the area is recommended in subsequent seasons to establish native plant populations and to control any possible erosion. For information about control of Japanese knotweed, see Appendix F.

Two large patches of English ivy are present in the zone. One is extending down from the park rim to the north of the Japanese knotweed patch, and the other is between plots 27 and 28 (Map 7). Although the English ivy infestation is particularly heavy in the northern part, there are also patches in the southern part of the zone, where it is climbing up trees and needs to be periodically removed.

In terms of conifer regeneration, both plots in the zone have more than 50 stems/acre, (Map 3) which is considered adequate to support forest succession.

Summary recommendations:

- Removal of Japanese knotweed patch
- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of large ivy patches
- Periodic containment of ivy throughout the zone, especially focusing on removal from trees

DF3 and Wetland 2 management areas

This zone consists of a deciduous stand, with a wetland covering a large portion of the zone (Map 7). Three plots, numbers 17, 18, and 19 were sampled in this zone. Both plots 17 and 18 have 10 or fewer regenerating conifer stems/acre, while plot 19 has 70 stems/acre (Map 3). Wetland plots 17 and 19 have high and very high total invasive cover respectively, while plot 18 in the deciduous forest exhibits only moderate invasive cover (Map 8).

The wetland area is dominated by Himalayan blackberry and also contains smaller amounts of English ivy, European mountain ash, English holly and reed canarygrass. Reed canarygrass was found on both wetland plots (17 and 19), an indication that is becoming established in this area. For a more complete discussion of reed canarygrass, see recommendations for zone CF3. The restoration of wetland areas in the park is a priority recommendation of this report.

This management zone contains 2 sites with Japanese knotweed, a small one at the top of the rim, and a large one in Wetland 2, which is part of a larger infestation in zone CF4 (Map 7). The site at the top of the rim is adjacent to a property fence and may be located on private property. It is recommended that Friends of Deadhorse Canyon work with the landowner to control or eradicate (if possible), the source of the infestation. Control of the wetland infestation should be coordinated with removal in CF4.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Restoration of the wetland area through removal of Japanese knotweed, reed canarygrass, Himalayan blackberry and English ivy and replanting with native species
- Planting conifer trees throughout the zone

DF6 management area

This zone represents the deciduous forests on the northwest side of DHC (Map 7). Of the four plots located in the area, numbers 4, 5, 6 and 7, one has low invasive species cover, one has high cover and two have very high invasive species cover (Map 8). All of the plots sampled have very low amounts of regenerating conifers (less than 50 stems/acre) (Map 3). While most of the forest along the trail and in the lower areas is healthy, the predominant problem in this zone is very high ivy cover, growing on very steep slopes. Control would be both difficult due to access and potentially dangerous due to erosion. However, many similarly steep slopes and cliffs in the park are covered by sword fern (Figure 12), which provides the same stabilization function as English ivy. English ivy should be removed a small section at a time, in easily accessible areas and to establish sword fern and shrubs in its place. The remaining areas that are too steep for access should be contained to prevent spread to restored areas. There is also a problem in this zone of ivy climbing into trees. It should be cut down wherever possible.

On the north side of the zone near the road is a restored area, which has a history of Japanese knotweed problems. Although this area was replanted, there is some Japanese knotweed growing back. This area can be monitored using the permanent monitoring plot established for this purpose (Map 11). There is also a patch of wild clematis, a King County Weed of Concern, in a fairly inaccessible spot along the plot 7 transect, which should be removed before it spreads further.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Monitoring and removing Japanese knotweed from restored area

- Removal of wild clematis from zone
- Replacing English ivy with sword fern and shrubs in small sections where possible
- Containment of English ivy in areas where restoration is not possible by keeping a buffer area and removing ivy from trees
- Planting conifers throughout the zone

Figure 12. Sword fern (*Polystichum munitum*) covering steep cliffs in the western portion of DHC by the trail

CF5 and Wetland 3 management areas

This conifer/deciduous mixed forest zone contains a wetland area on the western side of the management area near the stream (Map 7). Several restoration projects have taken place in this wetland area which is in fair condition with diverse native plant installations. Hedge false bindweed and deadly nightshade should be periodically cleared from this area. There is a fairly extensive stand of Oregon grape (*Berberis nervosa*) situated on the slope to the east of the wetland area. There is an eagle's nest in a large Douglas-fir tree along the northern portion of this zone and care should be taken not to disturb this area. Himalayan blackberry has invaded the area south of the wetland, and dominates the vegetation in a large patch that extends up to the rim of the canyon (Map 7). Plot number 12 in the zone has high invasive cover and is invaded by both Himalayan blackberry and English holly. There are also smaller amounts of cherry

laurel and herb Robert in this area. Keeping the wetland area buffered from the Himalayan blackberry is integral to maintaining and preserving wetland function. Monitoring the condition of the wetland can be accomplished by using the permanent monitoring plot established near the restoration area (Map 11).

In terms of regenerating conifers, only 20 stems/acre were found on the sampled plot, and more should be planted throughout the zone.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of large Himalayan blackberry patch in center of zone
- Containment and buffering of Himalayan blackberry away from the wetland
- Planting conifers throughout the zone

DF4 management area

This zone is unique due to the fact that it contains patches of Pacific madrone, which is a tree species that is known to be in decline in the Seattle area (Chappell and Giglio 1999). However, of the 3 plots sampled in this zone (numbers 9, 10 and 11), one has high invasive species cover and 2 have very high invasive species cover (Map 8). The primary invasive species in this area are English ivy, Himalayan blackberry and English holly, with smaller amounts of Portugal laurel. There is also a patch of Himalayan blackberry at the top of the draw separating this management area from zone CF5 to the south. The Himalayan blackberry should be contained or eradicated, which may require collaboration with adjacent landowners. Conifer regeneration in this zone is sporadic, with patches of high regeneration in the north and patches of low regeneration in the east and south (Map 3). There is no record of past restoration activities occurring in this zone. Removal of invasive species on accessible slopes and especially in riparian areas is recommended, followed by replanting with native species. In addition, Pacific madrone regeneration should be encouraged and monitored.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of English ivy and Himalayan blackberry from accessible areas in the zone and replanting with native plants
- Planting conifers in eastern and southern parts of the zone.

DF5 management area

This zone consists of deciduous forest on the northeast side of the park (Map 7), adjacent to the play fields. Similar to DF4, there have been no past restoration activities taking place in this zone. One plot was located in this area and had a very high invasive species cover and no conifer regeneration. This zone in particular has a stand of very large Portugal laurels (>25 feet tall) and a vast amount of regenerating English holly. Due to the size of some of the laurels,

complete removal of the trees from the zone is not recommended at this time. However, surrounding areas should be monitored to ensure that the seeds do not spread to other zones. One management option would be a phased removal of the Portugal laurels, in conjunction with planting conifers to replace the removed trees. In addition, this zone has a very high cover of English ivy, Himalayan blackberry, and smaller amounts of field bindweed, hedge false bindweed, one-seed hawthorn and cherry laurel. There is one patch of knotweed in the rim area on the east side, which is located along a private property border (Map 7). It is recommended that DHC work with the landowner to remove the infestation.

Because of the inaccessibility of this zone, and the fact that it is not adjacent to any intact area of the forest, restoration of this area is not a priority. If the adjacent zone, DF4, is restored in the future, it may be prudent to start creating a management plan for DF5. However, there is a patch of purple loosestrife (*Lythrum salicaria),* a Class B Noxious Weed in King County growing on the periphery of the zone, in front of the fence in the playfields. Control of this plant is required by law, due to its potential to spread to nearby wetlands and riparian areas.

Summary recommendations:

- Removal and monitoring of purple loosestrife near the fence in the playfields
- Removal of Japanese knotweed from the rim
- Containment and monitoring of Portugal laurel

CF6 and DF7 management areas

These zones are in the northern part of the park, located between the two forks of Holyoke Way (Map 7). Three plots were sampled in CF6, numbers 1, 2 and 3 (Map 7). Although there were no plots sampled in DF7, it is a small area that is adjacent to CF6, and contains similar vegetation. Of the sampled plots, one has high invasive species cover and two have very high cover (Map 8). In addition, plots 1 and 2 have no conifer regeneration, whereas plot 3 has 90 stems/acre. English ivy and Himalayan blackberry are the most prevalent invasive species in the zone, sometimes reaching covers of over 100 percent combined. Herb Robert, English holly, cherry laurel, creeping buttercup and hedge false bindweed are also prevalent in the zone at lower concentrations, although in some areas, their concentrations may be relatively high. It is recommended that these species be removed from the riparian areas wherever possible, and contained and/or buffered from those areas in the future.

In the northern section of CF6 there is a patch of Japanese knotweed which is located on private property (Map 7). It is recommended that DHC work with the owner to eradicate the infestation. In addition, there is a patch of yellow archangel near the road which needs to be removed (Map 7). One additional potentially invasive plant of concern is dame's rocket, which was found along the road on transect 3 and should also be removed.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of Japanese knotweed, yellow archangel and dame's rocket from the zone

- Removal of English ivy, Himalayan blackberry, creeping buttercup and hedge false bindweed from riparian areas and containment in remainder of zone
- Planting conifer trees in the northern part of the zone

Riparian management area

The riparian forest runs along the stream through the entire park (Map 7). From the data collected, it is evident that the riparian area has the lowest percent cover of invasive species of any habitat type in the park. However, there are several areas that have considerable amounts of invasive plants and need restoration. One such area is in the southern portion of the park near plot 33, which is dominated by false bindweed, Himalayan blackberry, creeping buttercup, and deadly nightshade. There is little native groundcover in this area.

In the northern section of the park, at plot 37, there is a patch of reed canarygrass which is becoming established and should be removed before it spreads. In general, it is recommended that invasive species be kept out of the riparian area to prevent them from spreading down the waterway, and to preserve function of the riparian area.

Other locations where riparian areas are impacted by invasive species are discussed throughout the different management zone sections of this report.

Summary recommendations:

- Zone-wide removal of English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings
- Removal of reed canarygrass from riparian areas
- Restoration of the southern part of the zone through removal of hedge false bindweed, Himalayan blackberry, creeping buttercup and deadly nightshade

SUMMARY OF PARK MANAGEMENT PRIORITIES

1. Use volunteer workparties to remove all infestations of yellow archangel, wild clematis, reed canarygrass and dame's rocket
2. Hire licensed contractors to control Japanese knotweed infestations
3. Hire licensed contractors to remove English holly, cherry laurel, Portugal laurel, horse chestnut, one-seed hawthorn and European mountain ash trees and seedlings and spot-treat new and existing English holly and cherry laurel stumps with herbicide
4. Conduct an outreach and education campaign to landowners who live on the rim of the park. Providing aid to individual landowners in the form of a work party may be an effective method of eradicating some infestations, if the landowner agrees to maintain the cleared area
5. Restore wetland areas 1 and 2 and replant native species in these areas
6. Restore riparian forests in areas where there are significant infestations of invasive plant species and replant native species in those areas
7. Clean-up dump sites throughout DHC

VI. MONITORING

Five separate restoration monitoring plots were established near areas where past restoration efforts have taken place. Restoration monitoring plots range in size from 30 to 60 square meters and are located throughout the park (Figure 18). Restoration monitornring plots consist of a series (ranging from three to six) of adjacent 10 x 10 meter quadrats (subplots), primarily oriented along the north/south axis. The origin and two reference positions for each plot have been marked with wooden stakes or otherwise referenced to allow location by FDC volunteers. FDC may monitor all plots, or a subset of plots in a given season, depending on time or other constraints. Plots should continue to be monitored in the same season as originally surveyed (e.g., if the plot was monitored in the summer, continue to return to that plot in the summer). Restoration monitoring plot methodology and data sheets are located in Appendix E.

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Appendix A. Average percent cover of tree, shrub, herb and grass species where present (on surveyed plots) and park-wide (results extrapolated to parkwide level).

Tree Species: Average Percent Cover

Species Code	Species Name[1]	Common Name	Average Cover in Sampled Plots	Average Cover Park-Wide	Frequency in Sampled Plots
ACMA	*Acer macrophyllum*	bigleaf maple	62.23%	62.23%	100.00%
AEHI	*Aesculus hippocastanum**	horse chestnut	2.86%	0.62%	21.62%
ALRU	*Alnus rubra*	red alder	25.77%	16.72%	64.86%
ARME	*Arbutus menziesii*	Pacific madrone	1.50%	0.04%	2.70%
CRMO	*Crataegus monogyna**	one-seed hawthorn	2.17%	0.35%	16.22%
ILAQ	*Ilex aquifolium***	English holly	5.06%	4.93%	97.30%
PISI	*Picea sitchensis*	Sitka spruce	0.25%	0.03%	10.81%
POTR	*Populus trichocarpa*	black cottonwood	19.00%	1.54%	8.11%
PREM	*Prunus emarginata*	bitter cherry	4.67%	0.38%	8.11%
PRLA	*Prunus laurocerasus***	bay laurel, cherry laurel	3.66%	2.67%	72.97%
PRLU	*Prunus lusitanica**	Portugal laurel	10.20%	0.83%	8.11%
Prunus sp.	*Prunus sp.**	hort. cherry species	3.00%	0.16%	5.41%
PSME	*Pseudotsuga menziesii*	Douglas-fir	9.83%	2.92%	29.73%
RHPU	*Rhamnus purshiana*	cascara	2.00%	0.05%	2.70%
SASC	*Salix scouleriana*	Scouler's willow	1.75%	0.09%	5.41%
SOAU	*Sorbus aucuparia**	European mountain ash	3.06%	0.91%	29.73%
THPL	*Thuja plicata*	western red cedar	7.99%	5.83%	72.97%
TSHE	*Tsuga heterophylla*	western hemlock	11.27%	7.31%	64.86%

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

Shrub Species: Average Percent Cover

Species Code	Species Name[1]	Common Name	Average Cover in Sampled Plots	Average Cover Park-Wide	Frequency in Sampled Plots
ACCI	*Acer circinatum*	vine maple	7.23%	3.91%	54.05%
BEAQ	*Berberis aquifolium*	tall Oregon grape	0.10%	0.01%	5.41%
BENE	*Berberis nervosa*	low Oregon grape	7.29%	4.14%	56.76%
COCO	*Corylus cornuta*	beaked hazelnut	16.88%	15.06%	89.19%
COST	*Cornus stolonifera*	red-osier dogwood	6.03%	0.49%	8.11%
Cotoneaster sp.	*Cotoneaster sp.**	cotoneaster	1.03%	0.08%	8.11%
DALA	*Daphne laureola**	spurge laurel	0.20%	0.01%	2.70%
GASH	*Gaultheria shallon*	salal	1.70%	0.83%	48.65%
HODI	*Holodiscus discolor*	oceanspray	4.88%	2.51%	51.35%
OECE	*Oemleria cerasiformis*	indian plum	9.54%	8.77%	91.89%
PHCA	*Physocarpus capitatus*	Pacific ninebark	0.30%	0.02%	5.41%
Ribes sp.	*Ribes sp.*	currant	0.50%	0.01%	2.70%
RIBR	*Ribes bracteosum*	stink currant	3.76%	0.81%	21.62%
ROGY	*Rosa gymnocarpa*	baldhip rose	0.10%	0.00%	2.70%
RONU	*Rosa nutkana*	Nootka rose	0.10%	0.00%	2.70%
Rosa sp.	*Rosa sp.*	rose	0.50%	0.01%	2.70%

RUDI	*Rubus discolor***	Himalayan blackberry	10.67%	9.81%	91.89%
RULE	*Rubus leucodermis*	blackcap	0.10%	0.00%	2.70%
RUPA	*Rubus parviflorus*	thimbleberry	1.10%	0.18%	16.22%
RUSP	*Rubus spectabilis*	salmonberry	13.28%	10.05%	75.68%
RUUR	*Rubus ursinus*	creeping blackberry	3.10%	2.85%	91.89%
SARA	*Sambucus racemosa*	red elderberry	5.92%	4.48%	75.68%
SYAL	*Symphoricarpos albus*	snowberry	8.50%	0.69%	8.11%
Unknown shrub sp.		Unknown shrub sp.	0.83%	0.07%	8.11%
VAPA	*Vaccinium parvifolium*	red huckleberry	1.65%	1.25%	75.68%

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

Herbaceous and Vine Species: Average Percent Cover

Species Code	Species Name[1]	Common Name	Average Cover in Sampled Plots	Average Cover Park-Wide	Frequency in Sampled Plots
ADPE	*Adiantum pedatum*	maidenhair fern	0.70%	0.08%	10.81%
ATFI	*Athyrium filix-femina*	ladyfern	4.94%	3.20%	64.86%
BLSP	*Blechnum spicant*	deerfern	0.55%	0.06%	10.81%
CAHI	*Cardamine hirsute**	hairy bittercress	0.41%	0.20%	48.65%
CASE	*Calystegia sepium**	hedge false bindweed	2.00%	0.49%	24.32%
CLVI	*Clematis vitalba***	wild clematis	0.50%	0.01%	2.70%
Cyclamen sp.	*Cyclamen sp.*	cyclamen	0.10%	0.00%	2.70%
DIFO	*Dicentra formosa*	western bleedingheart	0.15%	0.01%	5.41%
DRAU	*Dryopteris austriaca*	wood fern	2.98%	1.85%	62.16%
EPCI	*Epilobium ciliatum*	fringed willowherb	0.20%	0.01%	2.70%
Epilobium sp.	*Epilobium sp.*	willowherb	0.10%	0.00%	2.70%
EQTE	*Equisetum telmateia*	giant horsetail rush	2.38%	1.03%	43.24%
GAAP	*Galium aparine*	stickywilly	0.15%	0.02%	10.81%
Galium sp.	*Galium sp.*	bedstraw	0.30%	0.01%	2.70%
GEMA	*Geum macrophyllum*	bigleaved avens	0.23%	0.06%	24.32%
GERO	*Geranium robertianum***	herb Robert	1.00%	0.56%	56.76%
HEHE	*Hedera helix***	English ivy	30.48%	28.01%	91.89%
HEMA	*Hesperis matronalis*	dames rocket	2.00%	0.05%	2.70%
LACO	*Lapsana communis**	nipplewort	0.39%	0.16%	40.54%
LAGA	Lamium galeobdolon*	yellow archangel	11.00%	0.30%	2.70%
LAMU	*Lactuca muralis**	wall-lettuce	0.10%	0.00%	2.70%
LOCI	*Lonicera ciliosa*	orange honeysuckle	0.56%	0.14%	24.32%
LUAN	*Lunaria annua**	annual honesty	0.33%	0.04%	10.81%
LYAM	*Lysichitum americanus*	skunk cabbage	2.03%	0.16%	8.11%
MOSI	*Montia sibirica*	Siberian miner's lettuce	0.15%	0.01%	5.41%
OESA	*Oenanthe sarmentosa*	water parsley	0.50%	0.01%	2.70%
POCU	*Polygonum cuspidatum***	Japanese knotweed	9.00%	0.49%	5.41%
POGL	*Polypodium glycyrrhiza*	licorice fern	1.12%	0.91%	81.08%
POMU	*Polystichum munitum*	sword fern	31.15%	30.31%	97.30%
PTAQ	*Pteridium aquilinum*	bracken fern	0.86%	0.30%	35.14%
RARE	*Ranunculus repens**	creeping buttercup	4.20%	1.02%	24.32%
SODU	*Solanum dulcamara***	deadly nightshade	3.75%	0.20%	5.41%
Stachys sp.	*Stachys sp.*	hedgenettle	0.10%	0.00%	2.70%

STME	*Stellaria media**	chickweed	0.10%	0.00%	2.70%
TAOF	*Taraxacum officinale**	dandelion	0.14%	0.02%	13.51%
TEGR	*Tellima grandiflora*	fringecup	1.17%	0.98%	83.78%
TITR	*Tiarella trifoliata*	foamflower	1.00%	0.11%	10.81%
TOME	*Tolmiea menziesii*	piggy-back plant	4.67%	2.52%	54.05%
URDI	*Urtica dioica*	stinging nettle	1.96%	0.26%	13.51%

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

Graminoid Species: Average Percent Cover

Species Code	Species Name[1]	Common Name	Average Cover in Sampled Plots	Average Cover Park-Wide	Frequency in Sampled Plots
Bromus sp.	*Bromus sp.*	brome	0.20%	0.01%	2.70%
BRVU	*Bromus vulgaris*	Columbia brome	0.46%	0.22%	48.65%
CADE	*Carex deweyana*	Dewey sedge	0.28%	0.13%	45.95%
CAOB	*Carex obnupta*	slough sedge	2.00%	0.05%	2.70%
Carex sp.	*Carex sp.*	sedge	0.10%	0.00%	2.70%
DAGL	*Dactylis glomerata*	orchardgrass	1.10%	0.03%	2.70%
GLEL	*Glyceria striata*	tall mannagrass	0.85%	0.05%	5.41%
PHAR	*Phalaris arundinacea***	reed canarygrass	0.67%	0.05%	8.11%
SCMI	*Scirpus microcarpus*	small-seeded bulrush	13.50%	0.36%	2.70%
Unknown grass sp.		Unknown grass sp.	0.48%	0.10%	21.62%

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

Appendix B. Alphabetical list of all species found in Deadhorse Canyon listing strata, nativity, and whether it is considered to be invasive in Deadhorse Canyon.

Scientific[1]	Common	Strata[2]	Native[3]	DHC_"Invasive"
Acer circinatum	vine maple	S	Yes	
Acer macrophyllum	bigleaf maple	T	Yes	
Adiantum pedatum	maidenhair fern	H	Yes	
Aesculus hippocastanum*	horse chestnut	T	No	x
Alnus rubra	red alder	T	Yes	
Arbutus menziesii	Pacific madrone	T	Yes	
Athyrium filix-femina	Ladyfern	H	Yes	
Berberis aquifolium	tall Oregon grape	S	Yes	
Berberis nervosa	low Oregon grape	S	Yes	
Blechnum spicant	Deerfern	H	Yes	
Bromus sp.	brome	G	X	
Bromus vulgaris	Columbia brome	G	Yes	
Carex deweyana	Dewey sedge	G	Yes	
Cardamine hirsuta	hairy bittercress	H	No	
Carex obnupta	slough sedge	G	Yes	
Carex sp.	sedge	G	X	
Calystegia sepium*	hedge false bindweed	H	No	x
Clematis vitalba**	wild clematis	H	No	x
Corylus cornuta	beaked hazelnut	S	Yes	
Cornus stolonifera	red-osier dogwood	S	Yes	
Cotoneaster sp.*	cotoneaster	S	No	x
Crataegus monogyna*	one-seed hawthorn	T	No	x
Cyclamen sp.	cyclamen	H	No	
Dactylis glomerata	orchardgrass	G	No	
Daphne laureola*	spurge laurel	S	No	x
Dicentra formosa	western bleedingheart	H	Yes	
Dryopteris austriaca	wood fern	H	Yes	
Epilobium ciliatum	fringed willowherb	H	Yes	
Epilobium sp.	willowherb	H	X	
Equisetum telmateia	giant horsetail rush	H	Yes	
Galium aparine	stickywilly	H	Yes	
Galium sp.	bedstraw	H	X	
Gaultheria shallon	salal	S	Yes	

Scientific[1]	Common	Strata[2]	Native[3]	DHC_"Invasive"
Geum macrophyllum	big-leaved avens	H	Yes	
Geranium robertianum**	herb Robert	H	No	x
Glyceria striata	tall mannagrass	G	Yes	
Hedera helix**	English ivy	H	No	x
Hesperis matronalis*	dame's rocket	H	No	
Holodiscus discolor	oceanspray	S	Yes	
Ilex aquifolium**	English holly	T	No	x
Lapsana communis*	nipplewort	H	No	x
Lamium sp.	deadnettle	H	X	
Lactuca muralis*	wall-lettuce	H	No	
Lonicera ciliosa	orange honeysuckle	H	Yes	
Lunaria annua*	annual honesty	H	No	x
Lysichitum americanus	skunk cabbage	H	Yes	
Montia sibirica	Siberian miner's lettuce	H	Yes	
Oemleria cerasiformis	Indian plum	S	Yes	
Oenanthe sarmentosa	water parsley	H	Yes	
Phalaris arundinacea**	reed canarygrass	G	No	x
Physocarpus capitatus	Pacific ninebark	S	Yes	
Picea sitchensis	Sitka spruce	T	Yes	
Polygonum cuspidatum**	Japanese knotweed	H	No	x
Polypodium glycyrrhiza	licorice fern	H	Yes	
Polystichum munitum	sword fern	H	Yes	
Populus trichocarpa	black cottonwood	T	Yes	
Prunus emarginata	bitter cherry	T	Yes	
Prunus laurocerasus**	bay laurel, cherry laurel	T	No	x
Prunus lusitanica*	Portugal laurel	T	No	x
Prunus sp.*	horticultural cherry species	T	No	x
Pseudotsuga menziesii	Douglas-fir	T	Yes	
Pteridium aquilinum	bracken fern	H	Yes	
Ranunculus repens*	creeping buttercup	H	No	x
Rhamnus purshiana	cascara	T	Yes	
Ribes sp.	currant	S	X	
Ribes bracteosum	stink currant	S	Yes	
Rosa gymnocarpa	baldhip rose	S	Yes	
Rosa nutkana	Nootka rose	S	Yes	
Rosa sp.	rose	S	X	
Rubus discolor**	Himalayan blackberry	S	No	x

Scientific[1]	Common	Strata[2]	Native[3]	DHC_"Invasive"
Rubus leucodermis	blackcap	S	Yes	
Rubus parviflorus	thimbleberry	S	Yes	
Rubus spectabilis	salmonberry	S	Yes	
Rubus ursinus	creeping blackberry	S	Yes	
Sambucus racemosa	red elderberry	S	Yes	
Salix scouleriana	Scouler's willow	T	Yes	
Scirpus microcarpus	small-seeded bulrush	G	Yes	
Sorbus aucuparia*	European mountain ash	T	No	x
Solanum dulcamara**	deadly nightshade	H	No	x
Stachys sp.	hedgenettle	H	X	
Stellaria media*	chickweed	H	No	
Symphoricarpos albus	snowberry	S	Yes	
Taraxacum officinale*	dandelion	H	No	
Tellima grandiflora	fringecup	H	Yes	
Thuja plicata	western red cedar	T	Yes	
Tiarella trifoliata	foamflower	H	Yes	
Tolmiea menziesii	piggy-back plant	H	Yes	
Tsuga heterophylla	western hemlock	T	Yes	
Urtica dioica	stinging nettle	H	Yes	
Vaccinium parvifolium	red huckleberry	S	Yes	

[1]Species denoted by * are non-native invasive species, ** are species which have been given a legal designation by the King County Noxious Weed Program.
[2]Life form definitions: t=tree, s=shrub, h=herb, and g=graminoid
[3]Native: "?" denotes that species nativity is unknown

Appendix C. List of GPS locations of sampling plots in Deadhorse Canyon

Transect	Northing	Easting
1	189443.3	1290619
2	189248	1290654
3	189027	1290622
4	188797.9	1290622
5	188578.8	1290630
6	188375.1	1290660
7	188695.1	1290770
8	189286.7	1291172
9	189063.4	1290996
10	188857.2	1290995
11	189080.3	1290811
12	188669.6	1291004
13	188442.6	1290799
14	188177.7	1290796
15	188053.4	1291037
16	188069.4	1290795
17	188310.9	1291101
18	188270.8	1291212
19	188099.7	1291132
20	187823.3	1290987
21	187610	1290978
22	187836.4	1290896
23	187458.1	1290797
24	187247.4	1290801
25	187267.1	1291001
26	187078.1	1291006
27	187856.9	1291207
28	187646.4	1291168
29	187471.9	1291208
30	187250.1	1291230
31	186994.5	1291222
32	187069.3	1291332
33	186638.8	1291152
34	186634.1	1291078
35	186769	1290996
36	186505.7	1290579
37	188543.9	1290761

Appendix D. Data collection sheets used in collecting data in Deadhorse Canyon between November 16, 2004 and February 24, 2005

Date_____ Page_____

Cover Data Sheet: Seattle Urban Nature Project

Park Name Deadhorse Canyon Observers_____ Data Entered: _____

Transect Number_____ Polygon Number_____

Species Cover:			**1-20% for each Quadrant**			
Species	0-10 Meters	10-20 Meters	20-30 Meters	30-40 Meters	40-50 Meters	Totals
Litter						
Bare						
Lawn						
Impervious						

Date________ Page____________

Density Data Sheet: Seattle Urban Nature Project

Park Name______Deadhorse Canyon______ Examiners__________________________

Transect Number___________________________ Polygon No.

Site Characteristics: Slope__________ Aspect ________

Data Entered:
____

Species	Height	Diameter	Health / Decay	Ivy?

Appendix E. Restoration plot monitoring methodology for permanent monitoring plots to be monitored by Friends of Deadhorse Canyon or other volunteers and data sheets for data entry

Restoration plot monitoring methodology

1. Position plot so as to cover restoration area of interest (e.g., new planting area, recent invasive removal area, or invasive area under watch).
2. Locate the plot origin and the position of adjacent quadrats.
3. Take two photos from the origin: one showing the horizon and general plot view, one focused down towards the forest floor.
4. Mark two (or all four) sides of the first quadrat with a meter tape or flagging.
5. On the "Density Data Sheet", record diameter at breast height (DBH) and height for all trees with more than half the trunk within the quadrat. Density measurements should include non-native evergreen invasive tree-like shrubs (holly and laurel). Also note which trees have been planted in the "planted" column. Standing dead trees (snags) should also be recorded with "Snag" as the species.
6. On the "Cover Data Sheet", record percent canopy cover for dominant species or species of interest in each of the tree, shrub and herb layers (see example datasheet). Cover for all instances of each species in the quadrat should be combined. Percent cover should only be recorded within quadrat boundaries. If a plant extends beyond quadrat boundaries, record only the portion within the quadrat. (See Figure 13).
7. Repeat steps for remaining quadrats (up to 6) for each monitoring plot.
8. Transfer the field data into a Microsoft Access Database provided by SUNP for sorting and analyses. When entering plot numbers, be sure to include the year of observation (eg: MP1_2005 for Monitoring Plot #1 observed in 2005).

Helpful Hints

To accurately estimate percent cover, the following dimensions can be used:

- 3.3 feet x 3.3 feet (1m x 1m) square is 1% of a quadrat
- 10.5 feet x 10.5 feet (3.2m x 3.2 m) square is 10% of a quadrat
- 16.4 feet x 16.4 feet (5m x 5m) square is 25% of a quadrat
- 23 feet x 23 feet (7m x 7m) square is 50% of a quadrat

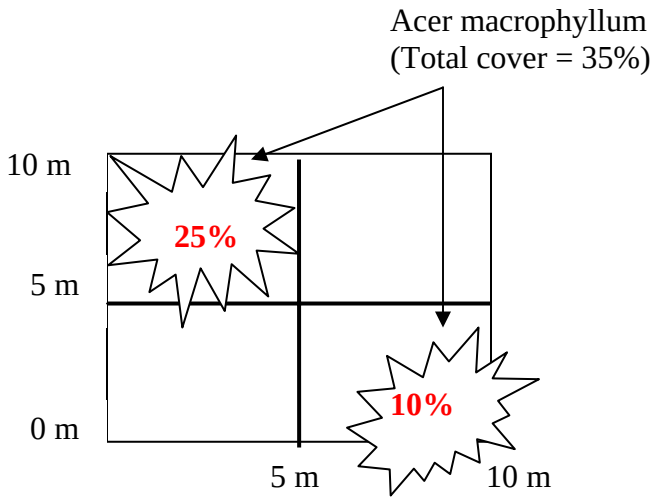

Figure 13. Example of how to record percent cover by species in a quadrat

Deadhorse Canyon
Cover Data Sheet: Seattle Urban Nature Project

Monitoring Plot Number_____ Examiners_____

Data Entered: _____

Comments:

Cover:	Quadrat						
Species	**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**	**Quad 5**	**Quad 6**	**Totals**
TREES							
SHRUBS							
HERBS							
INVASIVES							

Deadhorse Canyon
Density Data Sheet: Seattle Urban Nature Project

Monitoring Plot Number________________ Examiners______________________

Data Entered: ______

Comments:

Quadrat #	**Species**	**Height**	**Diameter**	**Planted?**

Appendix F. Best Management Practice information about selected invasive species present in Deadhorse Canyon

1. Yellow archangel (*Lamiastrum galeobdolon)*
   http://shim.bc.ca/invasivespecies/_private/yellowarchangel.htm

2. Reed canarygrass (*Phalaris arundinacea*)
   http://tncweeds.ucdavis.edu/moredocs/phaaru01.pdf

3. Knotweed (*Polygonum cuspidatum*).
   http://www.co.clark.wa.us/weed/documents/2005-crockett.pdf