**University of Victoria Natural Features Study Phase Two**
**University Cedar Hill Corner Property, Garry Oak Meadow and Camus Meadow Area, Finnerty Ravine, Haro Woods, South Woods, Lower Hobbs Creek/Mystic Vale**

Hilary Harrop-Archibald

Supervisor: Dr. Val Schaefer
Restoration of Natural Systems Program
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January 3, 2008

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# Table of Contents

## List of Figures

## List of Tables

## Acknowledgements

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# Executive Summary

The University of Victoria Natural Features Study entailed inventory data collection and mapping of the natural areas of the Gordon Head campus, Victoria, British Columbia. A detailed inventory and assessment of the natural features of the University of Victoria campus was required by the office of Campus Planning and Sustainability to provide critical information to guide future planning on campus as part of the Campus Plan Implementation program.

The Natural Features Study has been broken down into two phases. Phase one, conducted from January 1-May 31, 2007, included biophysical spatially referenced inventories of: a) Bowker Creek headwaters bounded by Mackenzie Avenue, McGill Road and the fine arts building; b) the Oak Bay portion of Mystic Vale, and; c) the southwest quadrant land between the Engineering Computer Science building and the MacLaurin building. Phase two, the subject of this report, conducted from August 1-December 31, 2007, includes the remainder of the natural areas on campus. Namely: a) the University Cedar Hill Corner property; b) the Garry Oak Meadow and camus meadow area; c) Finnerty Ravine; d) Haro Woods; e) South Woods; f) the portion of Mystic Vale and Hobbs Creek not covered in Phase 1.

A thorough literature review was conducted, and data was collected on wildlife trees, woodpecker holes, bird nests, Coarse Woody Debris, rootballs, erratics, Arbutus and Garry oak trees, culverts, watercourses, successional status, tree, shrub and herb layer species composition, tree health, species cover, slope range, aspect, and slope position.

The provincial Sensitive Ecosystem Inventory classification scheme was adapted to provide a framework for describing the natural ecosystems on campus, and indicator plant analysis was carried out to determine site series classification. According to the classification scheme used in this project there are woodlands, swamps, older second growth forests, riparian areas, recently disturbed areas, and zones with a strongly fluctuating water table in the study areas.

According to the indicator plant analysis, Lower Hobbs Creek/ Mystic Vale and the dry portion of South Woods contain FdBg-Oregon grape site series, the wet portion of South Woods contains Cw-twinberry site series, Haro Woods and Finnerty ravine contain FdPl-Arbutus site series, and the Garry oak Woodland contains Fd- Oniongrass sedge site series.

Potential sources of error for the site series classification include incomplete plant inventories due to seasonality, the highly disturbed nature of the study areas, and the scale of the analysis. The most environmentally significant areas on campus are Bowker Creek, Mystic Vale, South Woods, Haro Woods, and the Garry oak Meadow.

**General Recommendations**

*General recommendations include invasive species removal, trail relocation, stream restoration, erosion control, and stormwater diversion.*

**Previous Studies**

*This current study agrees with the recommendations concerning the management of natural areas on campus as outlined in the literature review on pages 45-47.*

**Campus Natural Resource Management Plan**

*The university develop a natural resource management plan for the campus that includes goals, objectives, guiding principles, and detailed restoration strategies. The plan should be in place before the moratorium is lifted on building development within South Woods, the Garry oak Meadow, and the Bowker Creek Wetlands and needs to coordinate with the University of Victory Campus Plan (2003).*

Additional and more site-specific recommendations are as follows:

**Mystic Vale**

1. *The findings of this study concur with the recommendations put forth by the previous studies presented in the literature review with one exception. The amount of blowdown in Mystic Vale during wind storms in 2007 created gaps in the canopy so it is not necessary to remove selected trees to increase sunlight penetration to the forest floor.*
2. *The University needs to take additional measures to reduce the impacts of dogs and mountain bikes impacts in the natural areas on campus.*
3. *The University needs to take measures to reduce yard waste impacts.*
4. *The University needs to alert residents whose properties are adjacent to the campus to the negative impacts of non-native invasive species from their properties.*
5. *The University needs to re-design trails that are currently in riparian areas.*
6. *Given its historical cultural significance, current use of the area, and the universities commitment to protect and restore Mystic Vale, it is recommended that the university make restoring this area a priority.*

**South Woods**

*A professional risk assessment of forest fires associated with the blowdown in South Woods needs to be undertaken.*

**Haro Woods and Finnerty Ravine**

*The university follow the example of the Cordova/ Cadboro Bay Residents' Association in invasive species removal and ecological restoration. The illegal dumping of yard waste needs to be discouraged by signage and notices to nearby homes to remove this source of invasive plants*

**University Cedar Hill Corner**

*It is recommended that the university's soil storage pile be covered by tarps to prevent further seed germination and seed bank expansion.*

**Garry Oak Meadow and Camas Meadow Area**

*The area adjacent to Gordon Head Road and Cedar Hill Cross Road should be mowed regularly to maintain the structure and function of the Garry oak meadow.*

**Additional Inventory Data**

*There is a need for additional inventory data to avoid building over species at risk on campus. Ideally, this inventory should take place through all seasons of a year to identify rare species not previously observed due to seasonality.*

**Invasive Species Removal**

*It is strongly recommended that several actions are undertaken to mitigate the spread of invasive species. First, the populations at the advancing edges of populations of periwinkle and St. John's Wort in Mystic Vale should be removed as soon as possible before they become better established. Second, ivy should be cut at the base of all of the trees it is currently climbing in all of the natural areas on campus. The ivy may be left on the trees until it has died at which point pulling it down can be done much more easily. Finally, a monitoring program should*

# 1.0 Introduction

The purpose of the Natural Features Study on the University of Victoria's Gordon Head campus was to collect spatially referenced data on ecosystem distribution and health, vegetation composition, and other points of interest. The study was initiated as a result of both the University's commitment to "maintain and continue to evolve an open space system which protects and enhances environmentally significant areas" (University of Victoria, 2003), and the University's pledge to "protect and restore identified natural areas on campus" (University of Victoria, 2003). Section 5 of the campus plan also states that the University will "undertake further environmental studies on natural areas….with an emphasis on identifying all components of a maintenance and restoration strategy….complete an ecological inventory and map of the entire campus"(University of Victoria 2003). This study meets the inventory and mapping requirement as outlined above for the natural areas on campus..

A detailed inventory and assessment of the natural features of the University of Victoria campus was required by the office of Campus Planning and Sustainability to provide critical information to guide future planning on campus as part of the Campus Plan Implementation program. This study is intended to be used a management tool to alert land use decision makers to the current state of the natural areas on campus and the existence of important ecological features as mandated in both the Campus Plan (2003) and Strategic Plan (2006).

Phase one of this project researched and mapped three ecologically significant natural areas on the University of Victoria campus lands, specifically, Bowker Creek, Upper Hobbs Creek, and Cunningham Woods (Figure 1).

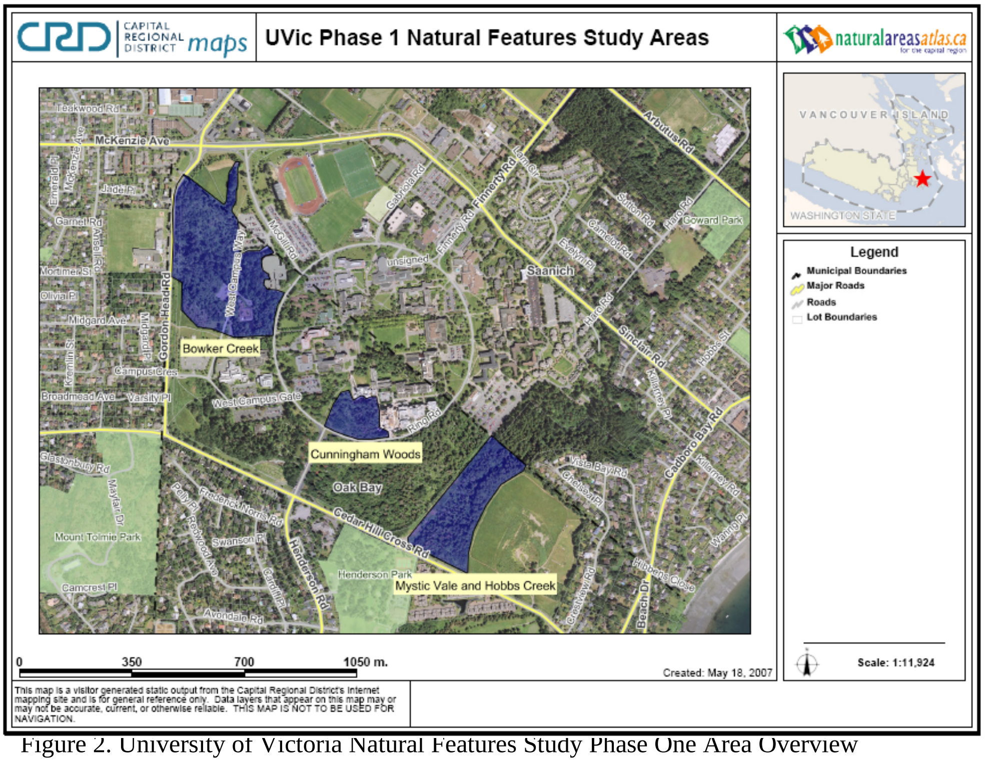

Figure 2. University of Victoria Natural Features Study Phase One Area Overview

Phase two of the project researched and then mapped the remaining ecologically significant natural areas on campus, specifically, the University Cedar Hill Corner property, the Garry Oak Meadow and camus meadow area, Finnerty Ravine and Haro Woods, South Woods, and the portion of Mystic Vale and Hobbs Creek not covered in Phase 1 (Figure 2).

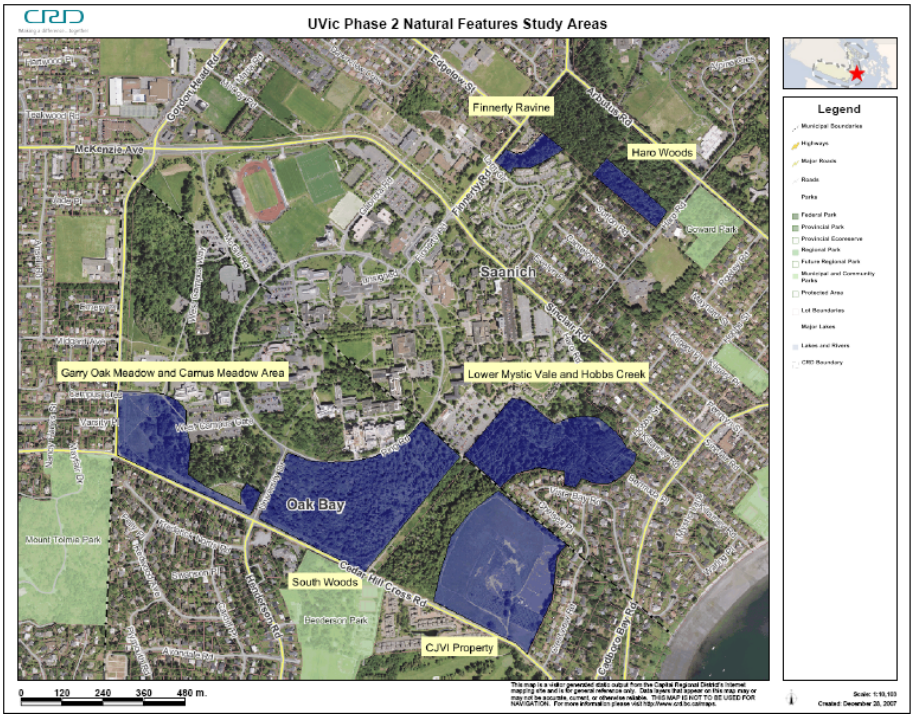


Figure 2. University of Victoria Natural Features Study Phase Two Area Overview

These areas include wetland and riparian ecosystems, woodlands, older and younger second growth forests, meadows, and a remnant orchard. For this project, an ecosystem is defined as a portion of natural campus landscape with relatively uniform dominant vegetation.

# 2.0 Literature Review

## *2.1 General Information*

### 2.1.1 Introduction

The following account is a synthesis of information pertaining to the natural areas of the University of Victoria campus. This information was garnered from reports by consultants previously hired by the university such as the Westland Resource Group, as well as Facilities Management, Faculty, and past student projects. The Geography department, Biology department, and the School of Environmental Studies/Restoration of Natural Systems Program were all consulted. Unfortunately, many student reports that addressed the natural areas of the campus are no longer available as they are not stored in any central location. For example, only one section of the Trillium Research Project that was conducted on campus in 1995 could be found. However, it should be noted that the Biology Department Herbarium has kept many student reports on campus vegetation dating back to 1970. It may be useful to revisit projects such as Ketcheson *et al.* (1975) after the vegetation associations on campus have been mapped to compare how the vegetation has changed over time.

### 2.1.2 Historical Land Use

The University of Victoria is situated on the traditional territories of the Straits Coast Salish peoples, including several different communities, both Senchalhen, or Saanich, and Lekwungen, or Songish (Turner 2000). These people played an important role in managing the landscape for thousands of years through traditional practices such as burning and the selective harvesting of root vegetables, especially camas (*Camassia* spp.) (Bein & Eastman 2006). Evidence of prescribed burning and/or natural fire can be seen as dark soils with charcoal layers. First Nations management using fire is also suggested by oak physiognomy that is characteristic of prairie fires, and traditional ecological knowledge (Bein & Eastman 2006). Under such management, both the Garry oak (*Quercus garryana*) and Douglas-fir (*Pseudtosuga menziesii*) ecosystems would have been more open and less bushy (Turner 2000).

Further evidence of First Nations occupation of the campus lands prior to European settlement includes the recent discovery of a beautifully crafted bifaced slate point approximately 10 cm long in Hobbs Creek in Mystic Vale (Turner 2000). The family group Chekonein of the Lekwungen peoples had a principle village in Cadboro Bay which was within 2 kilometers of all of the natural areas on campus (ES 482/ER 411, 2007). Historically, Mystic Vale was a sacred site used for rituals concerning pubescent girls passing into womanhood, for young couples as a fertility site, and as a place for collecting medicinal herbs (ES 482/ER 411, 2007).

Prior to European collonization, the landscape was predominantly Douglas-fir forest and contained a mosaic of Douglas-fir and grand fir (*Abies grandis*) forests, Garry oak meadows, forested creek ravines, and wetland habitats (Lloyd 2004). In the late 1800's the landscape began to change as a result of European settlement (Lucey *et al.* 2002). By the mid 1900's, the land had been logged, farmed, built upon, and used for military activities. Prior to the development of the university, approximately 46% of the original 105.6 ha (261 acres) of land had been cleared and used as army training grounds, and 54% of the original land had been logged by the Hudson's Bay Company and contained second growth forest (University of Victoria 2003). There were also several fires between 1886 and 1905. Collectively, these human activities severely altered the original landscape (Ketcheson *et al.* 1975). In 1959, 120 acres of land was purchased for the construction of Victoria College. By 1963, Victoria College had been transformed into the University of Victoria and occupied 380 acres of land in Gordon Head (Lucey *et al.* 2002). The university currently straddles two municipalities, the south portion of the campus rests within Oak Bay and the north portion rests within Saanich.

### 2.1.3 Natural Areas

The University campus is comprised of 162.7 ha (402 acres). Natural areas, planted areas and lawns comprise 116.6 ha (288 acres), or 71% of the land base (University of Victoria 2003). The land area of much of the campus is gently sloping from west to east but for most purposes can be considered relatively flat (University of Victoria 2003). Most of the natural areas are on flat or low lying areas and contribute to water storage; in some areas storm water detention has resulted in a transition from dry soil plants to more wetland tolerant vegetation (Lloyd 2004). A vascular plant species inventory was conducted by Costanzo *et al.* (1995) for the campus and can be found in Appendix A. There is also data available from a bryophyte study by Godfrey and Comeau (1975) (Appendix B), and a coarse woody debris and snag study by Chatterson (1995) (Appendices Ca and Cb).

### 2.1.4 Climate

The University of Victoria is located at 48° 28' N and 123° 19'W on southern Vancouver Island, British Columbia, Canada. The area is in the Coastal Douglas-fir Biogeoclimatic Zone, which lies in the rain shadow of the Olympic Mountains and the mountains of Vancouver Island. As a result it receives approximately 70 cm of rain annually, and is characterized by a moderate climate with mild, wet winters and warm, dry summers (Cannings and Cannings 1996). This climatic regime, which is unusual for coastal B.C., results in a diversity of ecosystem types and relatively high productivity, thus contributing significantly to biodiversity values in the province (Ward *et al.* 1997).

### 2.1.5 Soil

The soils along the eastern side of the campus are a drumlinoid ridge of thick Pleistocene deposits. The upper layer is Vashon till which consists of silt clay till intermixed with sand (Thurber 2003). The Vashon tills have low permeability and thus surface water infiltration on the campus is generally low (Lloyd 2004). Underlying the till layer there is the Quadra layer (Thurber 2003). The Quadra layer is interglacial and consists primarily of dense silty sand and poorly graded sand that is moderately permeable (Lloyd 2004). The area to the north, south, and within Ring Road lies on the flank of the drumlinoid ridge, and in general it consists of more recent Victoria Marine Clay (Thurber 2003). Victoria Marine Clay is very stiff to hard near the surface but at depths of approximately six metres it becomes firm to soft (Thurber 2003). The clay deposits vary in thickness from less than five metres to greater than eight metres and have low permeability (Thurber 2003). In some areas there is a thin layer of surficial beach lag silty sand above the impermeable Vashon Till; these deposits tend to be less than two metres thick and often become saturated during wet winter months (Thurber 2003). In the southwest corner of campus near the main entrance there is bedrock at the surface, however, elsewhere the bedrock is fairly deep (Thurber 2003). Additional information can be found in Appendix D (Thurber 2003), the site geology map, and Appendix E (Lloyd 2004), the site soil assessment summary.

### 2.1.6 Hydrology

The campus is located at a topographic high point between Gordon Head and Cadboro Bay and is part of four watersheds: Finnerty Creek to the north, Sinclair or Cadboro drainage system to the north-east, Hobbs Creek to the east, and Bowker Creek to the west (Lloyd 2004). Appendix F from Lloyd (2004) shows the watershed boundaries. Historically, the hydrologic behavior of this terrain was typical of low relief upland areas with heavy forest cover. As stated by Lloyd (2004), at that time less than one third of the precipitation received on campus lands would have been released as surface runoff to nearby streams because: a) the forest canopy and organic rich topsoil intercepted and absorbed large amounts of rainfall; b) the gentle slope of the land lacked sufficient gradient to induce strong lateral drainage; c) the headwater status of the land eliminated the possibility of accumulating enough water mass to drive available water down slope; d) the surface of the ground was relatively rough and thus the formation of overland flow was unlikely; and e) the absence of defined channels means that runoff had to find its way to streams either through the soil as interflow or through the subsoil as groundflow.

In 2003, a hydrological analysis of the campus was conducted using a hydrologic simulation model (Lloyd 2004). The computer model chosen was the Personal Computer Stormwater Management Model (PCSWMM), which evolved from Storm Water Management Model (SWMM) developed by the United States Environmental Protection Agency. The stormwater model was used to simulate five scenarios: the campus predevelopment; the campus as it was in 1956; the campus in its 2003 condition; the campus in its 2003 condition with Best Management Practices (BMP); the campus as planned at buildout of the 2003 Campus Plan using conventional stormwater management methods; and the campus as planned at buildout of the 2003 Campus Plan with BMPs. For each scenario the model simulated the hydrology of the UVic campus in response to a 24 hour rainstorm that will, on average, reoccur every 25 years (Lloyd 2004). The results of the hydrological analysis can be found in Appendix G (Lloyd 2004).

In 2004, approximately 23.5% of the campus was impervious surfaces such as roofs, sidewalks, and parking lots. This is significantly higher than the 6.5% impermeable surface area observed in 1956 (Lloyd 2004). Since 1956, the runoff volume from the campus lands has doubled (Lloyd 2004). Data relating to this change can be found in Appendix H (Lloyd 2004).

Changes in campus hydrology are also evident in wetland areas; in recent years, the wetland areas are larger for longer periods of time (Westland Resource Group 1999).This is in part the result of increased impervious surfaces which do not allow water to be dissipated through soil infiltration and thus water is focused in depressed, wetland areas. Other potential factors contributing to the recent wetland hydrological changes include changes in Faculty Club drainage, increased irrigation in the sports fields, and increased rainfall in recent years (Westland Resource Group 1999). That said, the grounds department does run a state of the art computer controlled irrigation system that only waters the lawns and sports fields when required and during a time of day with the least amount of evaporation to conserve water resources (University of Victoria 2006). Furthermore, “in order to protect natural ecosystems and prevent flooding, the university has undertaken an aggressive plan to reduce the quantity and flow, as well as improve the quality, of stormwater runoff leaving the campus” (University of Victoria 2006). Details concerning how the University will accomplish this can be found in the Integrated Stormwater Management Plan (2004).

The most common contaminants in the University of Victoria stormwater are sediments and oily drippings that wash off parking lots and roads (Lloyd 2004). Less visible non-point source pollutants typically include pathogens, nutrients, heavy metals, pesticides, and other toxins (Hocking 2000), although these have not been quantified for the university campus.

### 2.1.7 Wildlife

The University of Victoria woodlands contain relatively large areas of forested wildlife habitat within the Greater Victoria region. The closest tracts of large-sized forested wildlife habitat are Mount Tolmie, Mount Douglas Regional Park, and Elk Lake Regional Park. Within this context, the study area contains relatively significant woodland habitat on a local scale (Westland Resource Group 1999).

Salish elders have recounted their parents and grandparents coming to Gordon Head to hunt and pick berries (Turner 2000). Furthermore, in the mid-1800s, there are accounts of Fort Victoria residents hunting elk, wolves, bear, cougar, and after that, herds of deer at Gordon Head (Turner 2000). However, most of the large mammals once observed in the area are no longer present. Current information about most vertebrate and invertebrate species found on campus is lacking. There are likely many rodents on campus, namely, the house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), Norway rat (*Rattus norvegicus*), and some vole species (Hocking 2000). This conclusion was drawn from observations of small mammal skulls in owl pellets on campus. Other mammals present include raccoons (*Procyon lotor)*, black-tailed deer (*Odocoileus* sp.), grey squirrels (*Sciurus carolinensis*), and the European rabbit (*Orychtolagus cuniculus*) (Hocking 2000). Notably, the native Douglas squirrel (*Tamiasciurus douglasii)* seems to have been eliminated from the area, possibly as a result of the invasion of the grey squirrel (Hocking 2000). There are also potentially two species of garter snakes (*Thamnophis* spp.*)*, common and western terrestrial. Red-eared slider turtles (*Trachemys scripta* ssp. *elegans)* have been introduced to a pond adjacent to the Cunningham building, where western red-backed salamanders (*Plethodon cinereus)*, and rough-skinned newt (*Taricha granulosa* ssp. *granulosa*) have also been seen (Hocking 2000).

In 1970, an unspecified area of the campus was sprayed with diazinon, a short lived but fairly toxic insecticide (Tatum et al. 1971). Although this chemical is known to negatively impact birds, there were no documented effects on the bird population in the area. Tatum *et al.* (1971) investigated bird populations on the campus and concluded the following:

- The population of Skylark (*Alauda arvensis*) on the University of Victoria campus on March 4, 1971, was exactly 18 birds.

- The only area on campus occupied regularly by Skylarks was the Cornett Fields.
- The playing fields on campus were important feeding grounds for American Robin (*Turdus migratorius*), Mew Gull (*Larus canus*), Glaucous-winged Gull (*Larus glaucescens*), Dunlin (*Calidris alpina* ssp. *pacifica*), and Black-bellied Plover (*Pluvialis squatarola*) in the winter when the fields were wet and turned up.
- The lawns were also used by American Robins and Mew Gulls during this time.
- Although the coniferous woods were not documented as rich bird habitat, Golden-crowned Kinglets (*Regulus satrapa*) and Chestnut-backed Chickadees (*Poecile rufescens*) were observed to breed there.
- Other birds observed in the conifer dominated forests include Brown Creeper (*Certhia americana*), Winter Wren (*Troglodytes troglodytes*), a pair of Pileated Woodpeckers (*Dryocopus pileatus*), and a pair of Common Ravens (*Corvus corax*).
- The deciduous forests were considered the richest bird habitats. The arbutus (*Arbutus menziesii*) trees are important for American Robin, Varied Thrush (*Ixoreus naevius*), and Cedar Waxwing (*Bombycilla cedrorum*).
- The low shrubs are important foraging areas for warblers, vireos, flycatchers, Spotted Towhees (*Pipilo maculatus)*, White-crowned Sparrow (*Zonotrichia leucophrys*) and Song Sparrows (*Melospiza melodia)*, and in the winter, Golden-crowned Sparrow (*Zonotrichia atricapilla*) and Fox Sparrows (*Passerella iliaca*). Garry oaks are important for Downy Woodpecker (*Picoides pubescens*) and Band-tailed Pigeon (*Patagioenas fasciata*).
- Appendix I (Chatterson 1995) lists some of the birds uses of trees in more detail.

There are two categories of bird species that historically have been observed on campus, but whose populations were recorded by Tatum as either declining or lost in 1971. The first category consists of ground-nesting birds whose habitats have been extensively destroyed. The Western Meadowlark (*Sturnella neglecta*) and the Common Nighthawk (*Chordeiles minor*) no longer reside on campus and there were only a few pairs of Skylark and Savannah Sparrow (*Passerculus sandwichensis)* when the report was published (Tatum 1971). The second category includes wintering ducks and migrant shorebirds. There was originally a swampy area behind the Vikes Stadium where these birds used to feed, but as the size of the swamp has decreased they are no longer found there (Tatum 1971). However, since there were no breeding birds involved, and most of the birds were elsewhere abundant, this loss was not considered serious (Tatum 1971). The possible exception is the rare Cinnamon Teal (*Anas cyanoptera*), which was once thought to breed on campus (Tatum 1971). Within the wooded areas, especially deciduous treed areas, the small songbird population was determined to be stable and rich in numbers and variety. Notably rich areas were clearings in the wooded area east of University Drive. Bird populations that were observed to be increasing in numbers include the Cliff Swallow (*Petrochelidon pyrrhonota)*, the Barn Swallow (*Hirundo rustica*), and European Starling (*Sturnus vulgaris)* (Tatum 1971).

Tatum's study of bird populations on the University of Victoria campus provides an excellent baseline from which we can measure the changes in bird populations that have taken place in the last thirty years. In 2000, it was noted that the Skylark, Western Meadowlark, Common

Nighthawk, Savannah Sparrow, Black-bellied Plover, and Dunlin had not been seen on the campus for quite some time (Hocking 2000). Furthermore, there are at least 20 more species of birds Tatum lists as either common, breeding, or uncommon that are no longer seen on campus. In other words, it appears that the campus has lost approximately 24 bird species in the past 30 years (Hocking 2000). A list of campus bird species can be found in Appendix J (Chatterson 1995).

The most important wildlife value for the natural areas on campus is that they contain a dense concentration of nesting Cooper's Hawks relative to the rest of CRD (Westland Resource Group 1999). The Cooper's Hawk is a medium sized forest raptor that is found through out southern BC. However, the Cooper's Hawk is restricted to the southeastern parts of Vancouver island, and it is estimated that the breeding sites on campus represent approximately 12% of the Greater Victoria area population (Westland Resource Group 1999).

### 2.1.8 Wildlife Trees

One of the benefits of the large number of dead or dying trees on campus is that it has resulted in an increase in wildlife habitat for organisms that require woody debris for reproduction, foraging, and/ or shelter (Hocking 2000). According to Macher and Steeger (1995), 16% of all vertebrates in BC require wildlife trees to some extent in their life history. Fauna at UVic dependant on wildlife trees include Pileated Woodpecker, Downey Woodpecker, Hairy Woodpecker (*Picoides villosus*), Northern Flicker (*Colaptes auratus*), Great Horned Owl (*Bubo virginianus*), Barred Owl (*Strix varia)*, Brown Creeper, Red-breasted Nuthatch (*Sitta canadensis)*, Chestnut-backed Chickadee, several small mammal species, and many invertebrates (Hocking 2000). A summary of bird use of wildlife trees is listed in Appendix I (Chatterson 1995).

### 2.1.9 Levels of Protection

The Garry Oak Meadow, Mystic Vale, and Bowker Creek are classified as 'sensitive ecosystems' as part of a municipal sensitive ecosystem inventory due to their unique ecological characteristics (CRD/PCC 1996). Mystic Vale and Haro Woods are protected from development in perpetuity (University of Victoria 2003). There is a ten year moratorium established in 2003 on building development within the South Woods, Garry Oak Meadow, and Bowker Creek wetlands; the addition of paths and underground services are exempt from the moratorium (University of Victoria 2003). These areas are considered natural and relatively undisturbed by development. There is also a ten year freeze on development within Cunningham Woods (University of Victoria 2003).

### 2.1.10 Major Concerns

Major concerns identified in existing reports regarding the natural areas on campus include invasive species, the impact of construction and other activities on soil conditions and drainage patterns, stormwater management, stream channel erosion, and public access in riparian zones (University of Victoria 2003; Lucey *et al.* 2002).

Invasive species can stress and kill trees, compete with native shrub and herb species, and reduce seedling recruitment (Hocking 2000). Over time, invasive species have the potential to completely alter the forest community, resulting in a major shift in vegetation dynamics and species composition (Hocking 2000). The natural areas on campus are particularly vulnerable to invasions due to their high degree of disturbance and the widespread availability of seeds as a result of cultivation that has taken place in the surrounding areas (Chandler 1995).

Soil conditions are a concern because of the combined effects of compacted, poorly drained soils and highly impervious surface coverage, which limits tree root depth to the superficial soil layers. These shallow roots, in conjunction with the tree exposed to wind at the periphery of developed lands, result in increased potential for blowdown. Furthermore, stressed trees, due to soil compaction and poor soil water conditions, are thought to be vulnerable to attack by both bark beetles and root diseases (Hocking 2000).

Stormwater management (i.e. detaining, treating and infiltrating runoff from road and other impervious surfaces) is important in order to prevent degradation of stream channels due to high-energy flows (Lucey *et al.* 2002; Lloyd 2004). In 2002, severe erosion of the stream channel and banks was ongoing in Hobbs Creek and Mystic Vale in particular (Lucey *et al.*, 2002), and continues to be a problem today. A major contributing factor to this problem is trampling from unrestricted public access in the riparian zone, from ill-placed trails (Lucey *et al.* 2002).

To date, there have not been any formal beetle surveys conducted on campus. However, no obvious signs of primary bark beetle damage such as resinosis, fresh frass, or unexplained clumps of dead trees have been observed (Westland Resource Group 1999). It is not uncommon for true firs on Vancouver Island to be attacked by the Balsam wolly adelgid (*Adelges piceae*) which can weaken the trees and make them vulnerable to secondary pests (Westland Resource Group 1999). It has been suggested that if beetles are observed on campus, they will most likely not be bark beetles (such as *Dendroctinus* sp.), but rather engraver beetles (such as *Scolytus venbtralis*).Bark beetles attack vigorous trees and are often primary agents of tree mortality. Engraver beetles are secondary pests of trees that are stressed from root pathogens, prolonged drought, partial cutting etc. However, it is thought that if the primary stresses on trees are removed, the engraver beetles will not pose a significant threat on a stand basis (Westland Resource Group 1999).

## 2.2 Site-specific Information

The following information is a summary of previous studies pertaining to specific areas on the campus.

### 2.2.1 University Cedar Hill Corner Property

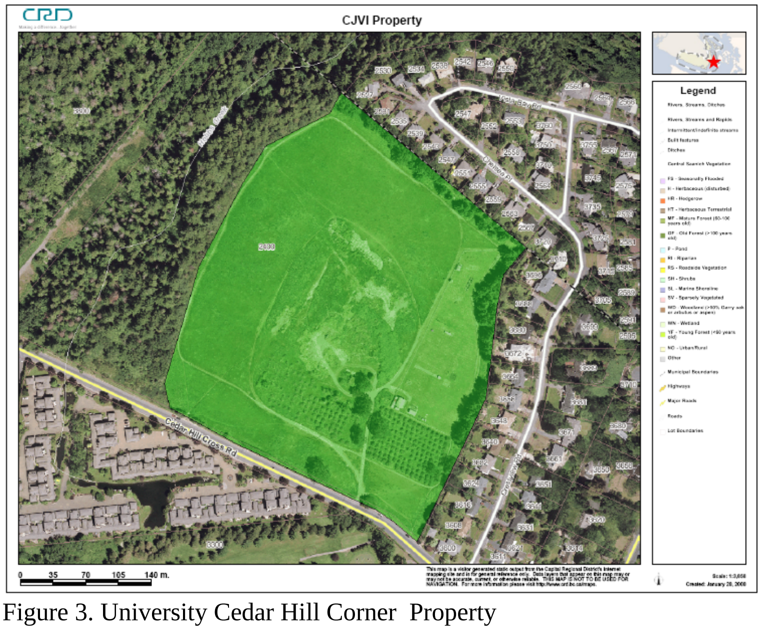


Figure 3. University Cedar Hill Corner  Property

The University Cedar Hill Corner property (Figure 3) is open land that encompasses 12.4 ha (30.7 acres). It is located on the southeast corner of the campus north of Cedar Hill Cross Road and adjacent to the South Woods and Mystic Vale (University of Victoria 2003). The property was purchased in 1964 and has remained undeveloped since that time. On the property there is an orchard, soil pile, Frisbee Golf course, and small enclosure used by the Centre of Forest Biology for experimentation. Although the orchard had been neglected for several decades, in 2006 a class from Camosun College pruned half the orchard and it is anticipated they will return to do the second half in the coming year (Jim Hansson pers. com.). The University Cedar Hill Corner site is being considered for temporary uses and permanent development. Sections of this property may be used for academic expansion, facility and student housing, sports and recreation facilities, parking, and any special use opportunities that may arise (University of Victoria 2003).

## 2.2.2 Garry Oak and Camas Meadow

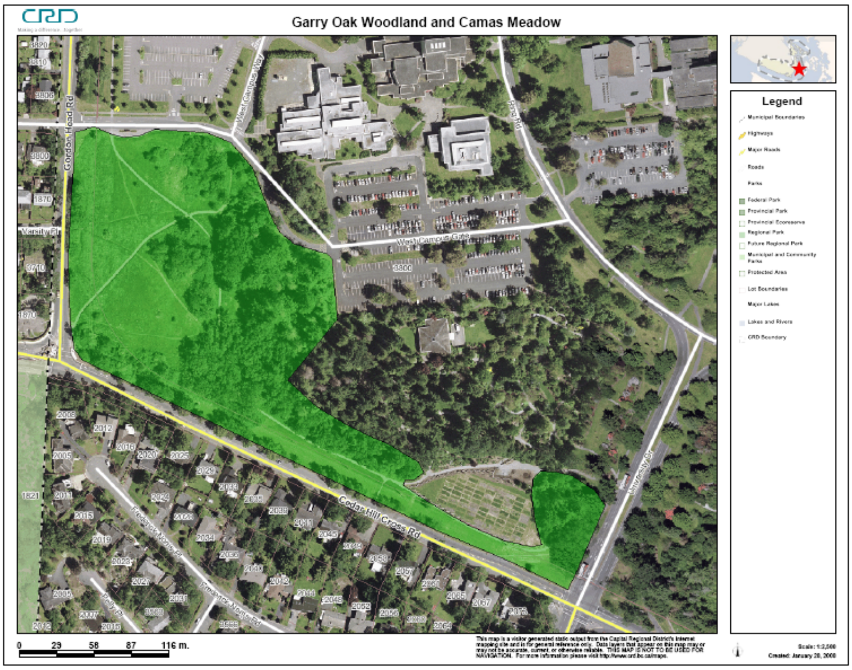


Figure 4. Garry Oak Woodland and Camas Meadow

The Garry Oak Meadow (Figure 4) is a natural area located on the southwest corner of campus. Garry oak meadows are a rare ecosystem type in British Columbia that are critically threatened due to loss from human development, damage from invasive species, and the suppression of traditional land management practices that once helped to maintain them (Garry Oak Ecosystem Recovery Team 2002).

Although this area does include a stand of rare Garry oaks, the trees are of a small to medium size and do not have the cavities often found in larger oaks. Thus they do not contain suitable habitat for cavity-using species such as owls, bats, squirrels, and raccoons. Furthermore, the grassland habitat within this area most likely has low nesting bird habitat due to its high level of disturbance by people, dogs, and cats (Westland Resource Group 1999). That said, the meadow area is likely used by small cavity nesters such as the Red-breasted Nuthatch, the oak acorns are likely consumed by wildlife such as Steller’s Jay, and the large conifers within this area are likely used as nesting habitat by birds such as kinglets (Westland Resource Group 1999).

The remnant Garry Oak Meadow on campus is a reasonably well drained site with exposed bedrock in some areas (Hocking 2000). The main plant species on site include camas, western buttercup (*Ranunculus occidentalis*), shooting star (*Dodecatheon spp*.), Indian plum (*Oemleria cerasiformis*), Garry oak and several native and non-native grass species (Hocking 2000). A plant species list and inventory maps for this area can be found in Appendix K (Bein and Eastman 2006). The open meadow area consists of a drought tolerant community that flourishes with regular disturbance by fire (Hocking 2000). The oak overstory transitions into an adjacent conifer dominated forest that is very dense; this transition is most likely due to changes in moisture and soil regime as well as historical factors (Hocking 2000). The Garry Oak Meadow is the only natural area on campus with a substantial Scotch broom (*Cytisus scoparius*) population (Chandler 1995). In 1994/1995, a volunteer work party organized by VIPIRG's Native Vegetation Committee removed several truck loads of Scotch broom from the area (Chandler 1995). Another species of concern is orchard grass (*Dactylis glomerata*). Although control efforts have been initiated, the Garry oak meadow is still threatened by invasive plant, animal, and insect species (University of Victoria 2003).

The Garry oak Meadow Ecosystem Mapping and Flora/ Fauna Inventory, a joint project between Facilities Management and Human Resources Development Canada, was conducted in 2004 (Kranenburg, 2004). The deliverables from the Garry oak Meadow project include a.) a map of the overall density and location of the invasive and/or exotic species present in the meadow b.) a map identifying the location of early flowering native plants to indicate intact, sensitive areas, and to provide information pertinent to grounds management such as mowing; and c.) a map and complimentary database containing information on the status and health of all Garry oak trees with a diameter at breast height greater then ten cm within the meadow. According to the Garry oak Meadow Ecosystem Mapping and Flora/ Fauna Inventory, there is currently one known location of the British Columbia Conservation Data Center Red listed species, *Carex tumulicola*, within the Garry oak Meadow. This is significant because red listed species are considered critically imperiled and thus are likely candidates for becoming listed as either extripated, endangered or threatened within British Columbia (CDC, ACCESSED SEPT 2007).

The Garry Oak Reclamation Trials was a joint restoration research project between Facilities Management and the Restoration of Natural Systems program that was initiated in 2003 (University of Victoria 2006). The study area, approximately 3500 $m^2$, is located on the north side of Cedar Hill Cross Road between Gordon Head and Lansdowne Roads (Bein and Eastman 2006). Prior to the initiation of this project, the vegetation in this area was dominated by agronomic grasses and introduced herbs with very few native species (Bein and Eastman 2006). Based on three soil pits, the site has been described as having an upper horizon (Ah) of 25-30 cm of sandy-loam with a root mat to 15cm (Maxwell 2002). This surface material is likely a beach sand with Aeolian sands on compact silt subsoil (Maxwell 2002). The subsoil horizon is 35-55 cm deep and consists of very compact clay-loam (Maxwell 2002). This horizon is both mottled and slightly cemented; this horizon restricts both water and root penetration (Maxwell 2002). In 2004, a drain in the north-west side of the site was blocked to enable the return of the historical flooding patterns in the winters (Bein and Eastman 2006).

The project entails a field experiment to compare different methods of soil preparation and planting regimes to assess optimal ways of controlling exotic species and re-establishing native plant communities, as well as a native plant demonstration garden (University of Victoria 2006). Additionally, some areas within the site have been left for future restoration and a small area has been left aside for a vernal pool. Significant browsing and grazing by black-tailed deer and European rabbits has been observed at the study site (Bein and Eastman 2006). In response to this, a wire-mesh fence has been erected around the site to prevent deer and rabbits from entering the area.

### 2.2.3 Haro Woods

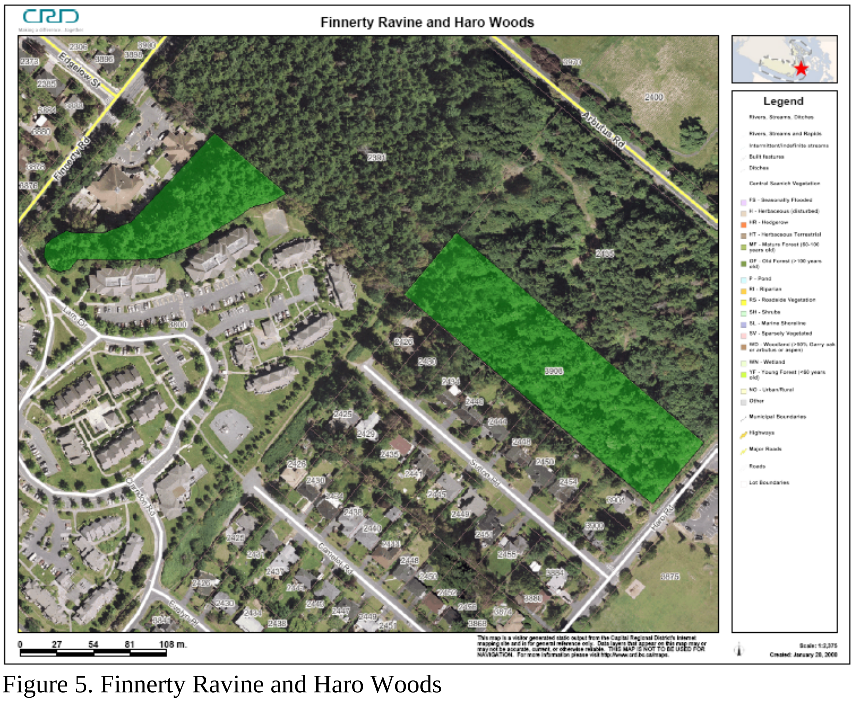

Figure 5. Finnerty Ravine and Haro Woods

The university portion of Haro Woods (Figure 5) is a natural area encompassing 1.1 ha (2.8 acre). Saanich owns 7.4 acres of Haro Woods, and the Queen Alexander Foundation owns 10 acres of Haro Woods (Cadboro Bay Residents association, 2007). The University portion of the woods is located in the northeast corner of campus, and contains second growth forest (University of Victoria 2003), including western redcedar (*Thuja plicata*), shore pine (*Pinus contorta*, var. *contorta*), Pacific yew (*Taxus brevifolia*), oceanspray (*Holodiscus discolor*), common snowberry (*Symphoricarpos albus*), and Oregon grape (*Mahonia spp.)* (Hocking 2000), and many arbutus (*Arbutus menziesii*). Two significant concerns in Haro Woods are invasive species, and the small size of the protected area (Hocking 2000). In the past, ornamental species have been observed invading Haro Woods from adjacent gardens (Hocking 2000).

The majority of Haro woods is owned by the municipality of Saanich and is currently protected from development by a Local Area Plan. An additional 10 acres are owned by the Queen Alexander Foundation, community consultation is underway to determine the fate of this parcel of land. Both the Cadboro Bay Residents Association and the Gordon Head Residents Association want the entire Haro Woods property preserved as a public park and natural green space (Cadboro Bay Residents Association, 2007). The Cadboro Bay Residents Association and other community members actively removed invasive exotic species from the Saanich property from mid 2004 to 2007; volunteer work parties were held twice a week, resulted in rapid progress, and concluded with the eradication of most non-indigenous plant species from the area.

### 2.2.4 Finnerty Ravine

The campus portion of Finnerty Creek (Figure 5) is surrounded by a steep sided gulley (20-30°) with exposed bedrock (Lloyd 2004). A preliminary map of this area referred to here as Lam Circle Ravine can be found in Appendix L. The Finnerty Creek channel contains some Large Woody Debris. A wet area in the middle of the ravine is the remnant of a wetland created by a log across the channel which has rotted to the point is no longer detaining water. Two storm drains and culvert drain into the channel near the east property boundary (Lloyd 2004).

The vegetation consists primarily of Douglas-fir with some grand fir in the overstory, and bigleaf maple (*Acer macrophyllum*) and arbutus in the understory. The shrub and herbaceous layer are dominated by oceanspray, snowberry, Himalayan blackberry (*Rubus discolor*), and English ivy (*Hedera helix*). Other species in the ravine include mock orange (*Philadelphus lewisii*), Indian plum, red elderberry (*Sambucus racemosa*), dull Oregon grape (*Mahonia nervosa*), laurel-leafed daphne (*Daphne laureola*), English holly (*Ilex aquifolium*), English hawthorn (*Crataegus monogyna*), sword fern (*Polystichum munitum*), Pacific water parsley (*Oenanthe sarmentosa*), and stinging nettle (*Urtica dioica*) (Lloyd 2004).

In terms of invasive species distribution, there is a large Himalayan blackberry infestation at the upstream end of the ravine, and other invasive species such as English ivy, English holly, laurel-leafed daphne, and Himalayan blackberry occur in patches throughout the ravine. There are also some potential trail problems similar to those in Mystic Vale; soil compaction, loss of riparian vegetation, and the beginning of channel down-cutting has been observed in the ravine (Lloyd 2004).

In the fall of 2007, an advanced ecological restoration class in the School of Environmental Studies undertook a project to design a naturescape around the University of Victoria’s Child Care Center Four. The purpose of the project was to both create a vision for a safe and nurtutring environment where children can play in and be engaged with the natural environment, and also to design a plan to restore the upper headwaters of Finnerty Creek which is adjacent to the Child Care Center (ES 482/ER 411, 2007). During there investigation of Finnerty ravines ecosystem history, tree core samples were taken on November 12, 2007. The investigators found that the Douglas-fir were between 118-108 years old with no other cohorts of Douglas-fir in the stand. Observations were also made on a cut arbutus stump which showed very dense growth rings; it was determined that the sub-canopy arbutus likely predate the Douglas-fir. Thus it is surmised that Finnerty Creek had a different stand structure and was characterized by drier conditions prior to 1880 then what is observed today (ES 482/ER 411, 2007). This is supported by the Capital Regional Districts Natural Areas Atlas which shows a portion of Finnerty Creek as part of a Garry oak ecosystem circa 1800 (Figure 6).

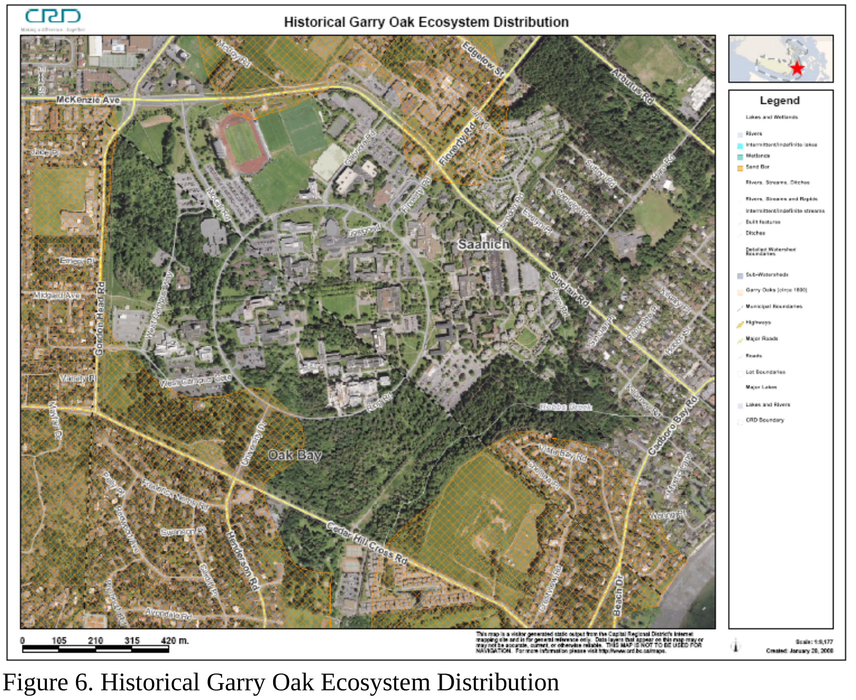


Figure 6. Historical Garry Oak Ecosystem Distribution

## 2.2.5 South Woods

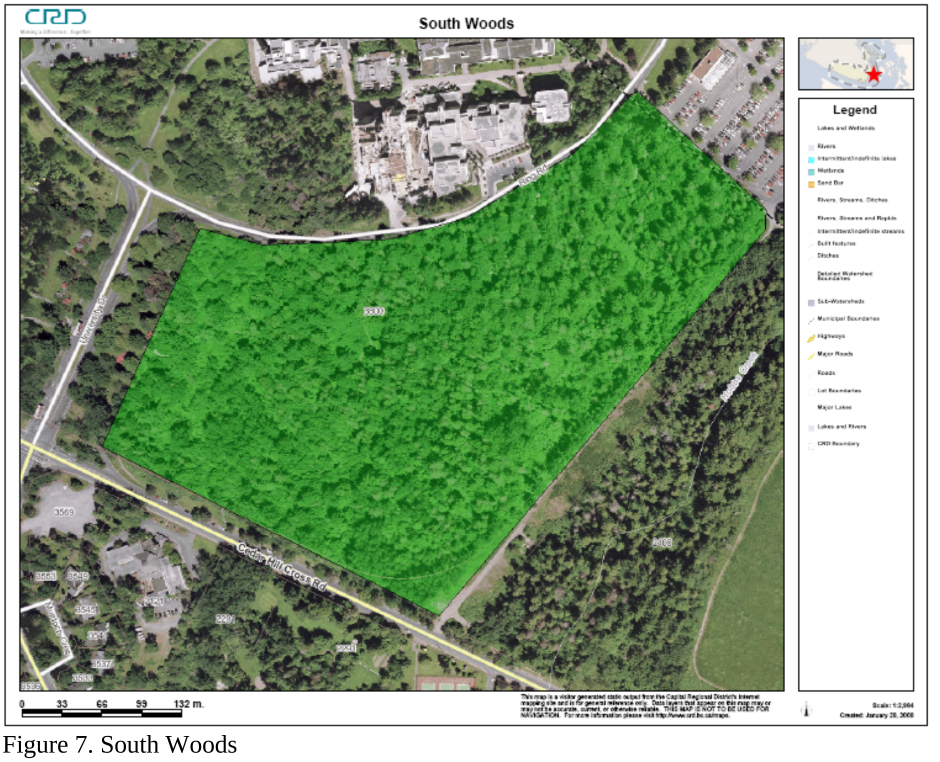


Figure 7. South Woods

South Woods (Figure 7) is a natural area encompassing a 11.5 ha (28.5 acre) area and contains second growth trees generally younger than 100 years old (University of Victoria 2003). A previous study map of this area can be found in Appendix M. The South Woods borders the Henderson Road entrance, Cedar Hill Cross Road, Ring Road, and the Haro Road right of way. These woods contain a flat upland conifer forest and a large moist area (Lloyd 2004). Conditions within this wooded area are highly variable - some areas are quite wet and some areas have high levels of anthropogenic disturbance (University of Victoria 2003).

The conifer forest overstory is dominated by Douglas-fir, grand fir, bigleaf maple, and Garry oak. The shrub and herbaceous layers consist primarily of snowberry, oceanspray, Indian plum, English ivy and sword fern. Other species found in this area include Nootka rose (*Rosa nutkana*), dull Oregon grape, baldhip rose (*Rosa gymnocarpa*), trailing blackberry (*Rubus ursinus*), English holly, Himalayan blackberry, Saskatoon berry (*Amelanchier alnifolia*), thimbleberry (*Rubus parviflorus*), bracken fern (*Pteridium aquilinum*), pink fawn lily (*Erythronium revolutum*), white fawn lily (*Erythronium oregonum*), and western trumpet honeysuckle (*Lonicera ciliosa*) (Lloyd 2004; Hocking 2000). The conifer dominated area has several invasive species, including English ivy, English holly and Himalayan blackberry (Lloyd 2004).

The moist region contains thickets of red-osier dogwood (*Cornus stolonifera*) and willow (*Salix* spp.), and an overstory of black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), bigleaf maple, and red alder (*Alnus rubra*) (Lloyd 2004). There are also a few western yew near the north east side of the woods (Westland Resource Group 1999). The dominant understory species are red-osier dogwood, Indian plum, snowberry, salal (*Gaultheria shallon*), English ivy, and sword fern. Other species at the site include Nootka rose, baldhip rose, trailing blackberry, English holly, cascara (*Rhamnus purshiana*), Pacific crabapple (*Malus fusca*), Scouler's willow (*Salix scouleriana*), Hooker's willow (*Salix hookeriana*), Himalayan blackberry, Saskatoon berry, thimbleberry, red huckleberry (*Vaccinium parvifolium*), bracken fern, deer fern (*Blechnum spicant*), creeping buttercup (*Ranunculus repens*), and stinging nettle (Lloyd 2004). Invasive English holly is prevalent within the thicket and cottonwood areas.

There is an ephemeral stream running northeast through the woods which enters Hobbs Creek via two culverts through the Haro Road right-of-way (Westland Resource Group 1999). This drainage pattern is the result of fill that was dumped along the Haro Road right of way in the 1960's (Westland Resource Group 1993); in some areas the fill is as great as 15 m deep and it seems to have changed the original drainage pattern within the woods (Hocking 2000). This is hypothesized to be the cause of the dead and dying trees on the west side of this site (Lloyd 2004). There is currently a plunge pool at the culvert outlet that is contributing to the down cutting of the channel in the ravine; there is also a heavy infestation of English holly at the bottom of the ravine (Lloyd 2004). Stormwater inputs arrive via storm drains from parking lot one, and a dug channel from Ring Road across from the Engineering Building (Lloyd 2004). This forest provides a transition zone between Mystic Vale and the Gary oak meadow, and is used by both the Biology Department and the Environmental Studies Program (University of Victoria 2003).

South Woods previously contained Western Screech-Owls, but no longer does so (Westland Resource Group 1999). The subspecies of Western Screech-Owl (*Otus kennicottii saturatus)* that has historically been found on the campus is Blue listed in BC; this subspecies is restricted to southeastern Vancouver Island, the Gulf Islands, and Puget Sound. Furthermore, the global population is estimated to be less then 3000 individuals, and BC is estimated to contain approximately 100 breeding pairs (Westland Resource Group 1999). At least one nest box has been erected, in an unspecified location within South Woods in an open stand of conifers, for this species (Westland Resource Group 1999). In nearby Mystic Vale, a pair of Great Horned Owls raised three young in 1999; it is possible that the presence of these large owls precluded the presence of the smaller Western Screech-Owl. Other documented inhabitants of South Woods includes a pair of nesting Cooper's Hawks, and a pair of Barred Owls (Westland Resource Group 1999).

## 2.2.6 Cunningham Woods and Native Plant Garden

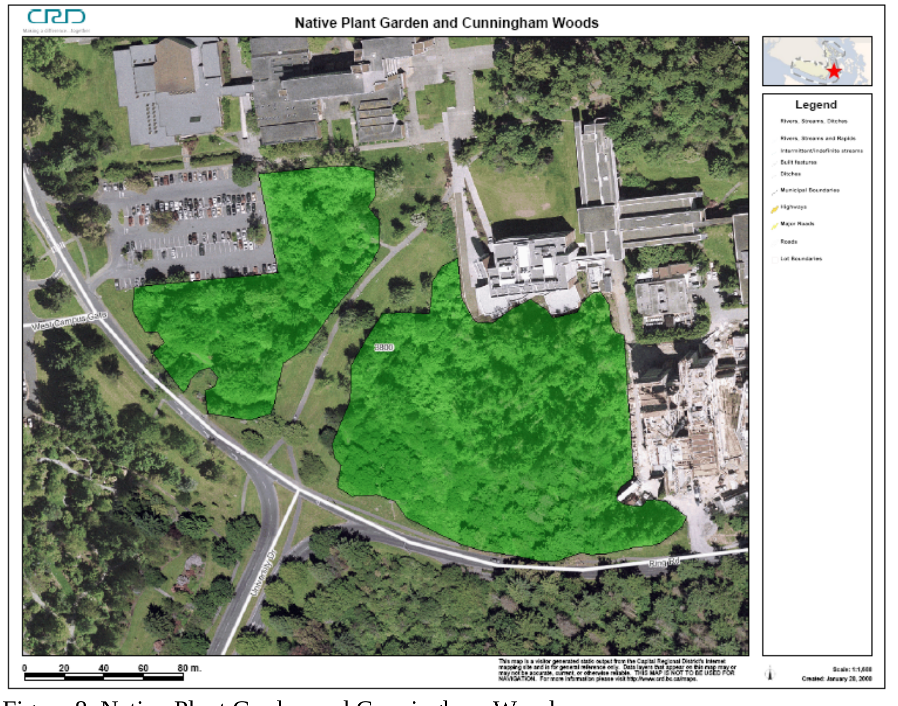


Figure 8. Native Plant Garden and Cunningham Woods

A Native Plant Garden (Figure 8) has been constructed in the southwest quadrant of the campus. This garden provides a living collection of representative, rare and endangered plants of the Saanich flora (Turner 1993). A complete species list can be found in Appendix N (University of Victoria Herbarium 2001). The garden provides educational opportunities for many departments, and serves to encourage students, faculty, and staff to value local native plants for their botanical, cultural, and aesthetic qualities. Furthermore, the garden also enhances the biodiversity of the campus, and provides shelter and habitat for native birds, insects and other wildlife (Turner 1993).

Cunningham Woods (Figure 8) is an extension of the South Woods inside Ring Road (Appendix O, Lloyd 2004). The wooded area is relatively flat and consists of two distinct areas, coniferous woodland and a wet depression. The coniferous woodland does not show evidence of overland flow and has many small depressions. The wet depression experiences ponding and is regularly inundated (Lloyd 2004). The vegetation in the coniferous woodland is predominantly grand fir and Douglas-fir in the overstory, and oceanspray, snowberry, English ivy, and trailing blackberry in the shrub and herbaceous layers (Lloyd 2004). Other understory species include red-osier dogwood, dull Oregon grape, thimbleberry, English holly, Indian plum, English hawthorn, Saskatoon berry, Himalayan blackberry, baldhip rose, tall Oregon grape, sword fern, bracken fern, broad leaved star flower, and honeysuckle (Lloyd 2004). In the centre of this area are a large number of dead or dying trees. It has been suggested that this is due to the raised water table. However, there is some evidence of fungal pathogens in these trees and it is unclear whether this is the cause or a result of the decline in tree health (Lloyd 2004). The wet depression consists of a red-osier dogwood, willow, and red alder thicket, and the south end of the depression is dominated by a stand of trembling aspen (Lloyd 2004). Trembling aspen is a relatively rare species in the CDFmm – Coastal Douglas-fir maritime museum Biophysical Ecosystem Classification (BEC) zone (Westland Resource Group 1999).

Stand age and diameter data indicate the oldest trees in Cunningham Woods are approximately 75 to 100 years old; the average diameter of these trees is 65 centimetres (Chatterson 1995). Cunningham Woods is recorded as containing 44 snags or 8.8 snags per hectare; 5 of these snags appear to be human-created and 54% of the snags in Cunningham Woods showed evidence of feeding by birds and insects (Chatterson 1995). Approximately 95% of the snags were observed along the eastern edge of Cunningham Woods near a parking lot A; it is hypothesized that the concentration of snags in this area may be due to the changes in forest structure that occurred when the parking lot was constructed. In comparison to literature on similar forest types, the level of course woody debris found in this area is lower than other natural stands (Chatterson 1995). These low values are probably due to firewood collection, logging, and land clearing that has taken place on the UVic campus (Chatterson 1995).

## 2.2.7 Mystic Vale and Hobbs Creek

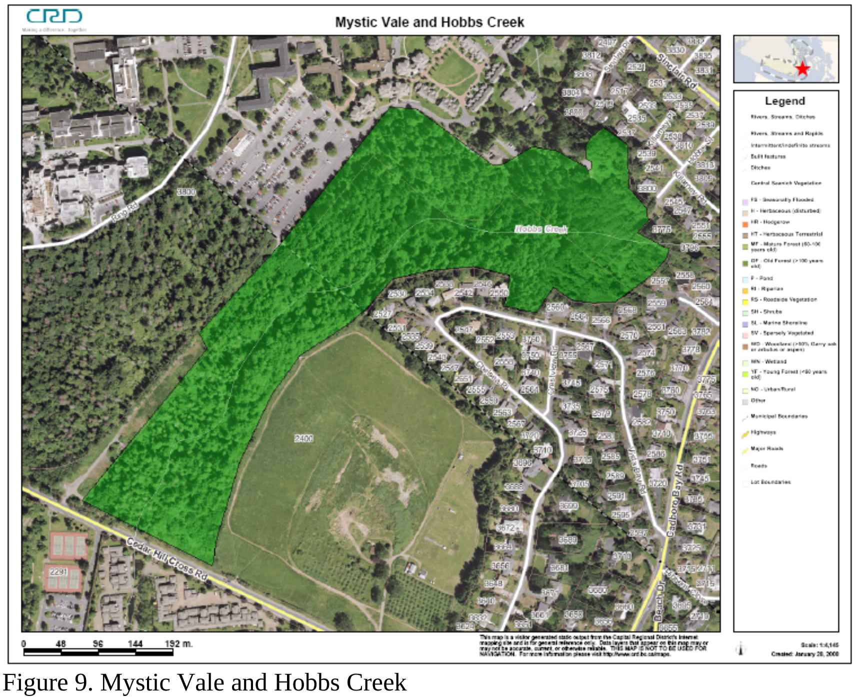


Figure 9. Mystic Vale and Hobbs Creek

Hobbs Creek (Figure 9) flows northeast from a municipal stormwater culvert on Cedar Hill Cross Road (on the southeast side of the University campus), down through a steep-sided gulley called Mystic Vale, then curves to the east/southeast through residential neighbourhoods near Cadboro Bay Rd., and discharges into the marine environment in Cadboro Bay. Mystic Vale is a natural area encompassing a 4.7 ha (11.6 acre). A preliminary map of Mystic Vale can be found in Appendix P. Mystic Vale is a coniferous woodland, has moderately steep side slopes (20-30º), and the valley and upper watershed have been extensively modified since the mid-1800's (Lucey *et al.* 2002). Upper edges of the ravine support species such as arbutus, salal and Oregon grape, while skunk cabbage (*Lysichiton americanum*), Pacific water parsley (*Oenanthe sarmentosa*), and false lily-of-the-valley (*Maianthemum dilatatum)* populate the valley bottom due to its continually moist condition (Hocking 2000). Hocking (2000) suggests that the flood plains and moist condition of this site would normally support Western redcedar, however few are present. The overstory vegetation consists primarily of Douglas-fir, grand fir, and bigleaf maple (Lloyd 2004). There are few young conifers or alders in the understory (Lucey *et al.* 2002). The understory is predominantly oceanspray, snowberry, Indian plum, English ivy, and sword fern. Additional species in Mystic Vale include dull Oregon grape, English holly, red huckleberry, red elderberry, red-osier dogwood, mock orange, false Solomon's seal (*Maianthemum racemosum*), vanilla leaf (*Achlys triphylla*), bracken fern, trailing blackberry, broad leaved star flower (*Trientalis borealis* ssp. *latifolia*), rattlesnake plantain (*Goodyera pubescens*), stink currant (*Ribes bracteosum*), western trillium (*Trillium ovatum*), and orchids (Lloyd 2004; Turner 2000). A species list for Mystic Vale can be found in Appendix Q. English ivy is widespread and has infested many trees (Lucey *et al.* 2002; Chandler 1995).

Stand age and diameter data from Mystic Vale indicate that the oldest trees are between 100 and 150 years old; the average diameter of trees in this age class in 1995 was 75 centimetres (Chatterson 1995). There are many trees in this age class, and over 75 native plant and wildlife species (University of Victoria 2003). Several trees appear to be older, with an estimated age of between 350 to 500 years, but no tree cores to confirm age have been performed (Hocking 2000). Mystic Vale also contains 31 snags or 6.9 snags per hectare (Chatterson 1995). Approximately 45% of the snags were observed to occur along the northern edge of Mystic Vale near a parking lot. In comparison to literature on similar forest types, the level of coarse woody debris found in this area is lower than in other natural stands. These low values are probably due to the history of firewood collection, logging, and land clearing that has taken places on the UVic campus (Chatterson 1995).

Mystic Vale's resident mammals include black-tailed dear (*Odocoileus hemionus*), raccoon, gray squirrel, eastern cottontail rabbit (*Sylvilagus floridanus*), and bats (Lucey *et al.* 2002). River otter (*Lontra canadensis*) tracks have also been observed along the creek bed (Lucey *et al.* 2002). Avifauna such as the Bald Eagle (*Haliaeetus leucocephalus)*, Cooper's Hawk (*Accipiter cooperii)*, and Great Horned Owl use the tall trees for nesting and resting (Lucey *et al.* 2002). Additional residents are Mallard (*Anas platyrhynchos)*, Ring-necked Pheasant (*Phasianus colchicus)*, Bushtit (*Psaltriparus minimus)*, Hutton's Vireo (*Vireo huttoni)*, kinglets (*Regulidae)*, Dark-eyed Junco (*Junco hyemalis)*, creepers, wrens (*Troglodytidae)*, five species of woodpeckers including Pileated, Downy, and Hairy woodpeckers (Fraser 1980), as well as Barred Owl and Raven (Westland Resource Group 1993).

The watershed's hydrology is dominated by impermeable surfaces, some pollution, and a highly confined floodplain, riparian zone, and creek channel (Lucey *et al.* 2002). In the winter months the slopes of the Vale can become saturated due to a combination of high rainfall and stormwater from the adjacent parking lot. Towards the end of 2007, slope saturation resulted in the slumping of a small section of lower Mystic Vale; Patrick Lucey has been engaged to create a restoration plan for this area (Jim Hansson pers. com.). Pollution in the watershed consists of the standard urban mix of organics, fertilizers, road runoff and salts applied during snow falls. There is extensive stream bank instability and failure within the Mystic Vale segment of the watershed. This instability is primarily the result of improperly located trails, bridges which are inappropriately sited or too short, insufficient Large Woody Debris (LWD) within the stream channel, head-cuts, and a significant reduction in riparian plant biomass (Lucey *et al.* 2002). There has been extensive channel down-cutting which has resulted in severe undercutting of stream banks. Additional stress on the riparian vegetation includes the activities of joggers, mountain bikers, and a large number of dogs in the riparian zone (Figures 10 and 11). The loss of riparian vegetation has caused stream bank instability and bank failure with subsequent increases in sediment loading (Lucey *et al.* 2002). Also, the heavy use of trails within the riparian zone has resulted in significant soil compaction along those trails (Lucey *et al.* 2002).

Figure 10. Evidence of dogs in the riparian zone

Figure 11. Lack of vegetation in riparian area adjacent to trail

**Hobbs Creek**

Historically, the Hobbs Creek area was dominated by a mixed Douglas-fir and bigleaf maple overstory along the channel. A map of Upper Hobbs Creek created by a previous study can be seen in Appendix R. The upper portion of Hobbs Creek, adjacent to Haro Road and Cedar Hill Cross Road, is primarily coniferous woodland with 20-30º side slopes. Hobbs Creek receives stormwater drainage from Oak Bay through a large culvert under Cedar Hill Cross Road (Lloyd 2004). According to Lloyd (2004), the overstory vegetation in this area consists of Douglas-fir, grand fir, bigleaf maple, black cottonwood, and some red alder and western redcedar. The understory is predominantly oceanspray, snowberry, Indian plum, English ivy, and sword fern. Other species present include thimbleberry, red-osier dogwood, red elderberry, Saskatoon berry, baldhip rose, dull Oregon grape, bracken fern, lady fern (*Athyrium filix-femina*), creeping buttercup, and piggyback plant (*Tolmiea menziesii*) (Lloyd 2004). According to Lucey *et al.* (2002), the overstory species in this area are approximately 80% coastal Douglas-fir, 10% grand fir, and 10% bigleaf maple, cottonwood, and Pacific yew. The shrub understory species are primarily snowberry, Indian plum, trailing blackberry, Himalayan blackberry, holly, English ivy, and oceanspray. The herb understory species are primarily cleavers (*Galium* sp.), stinging nettle, morning glory (*Ipomoea indica*), and sword fern (Lucey *et al.* 2002).

There are several issues associated with this area. Soils from the leveled compost zone above the tree line appear to have a high organic content, may be phenolic/ tannic, and are likely contributing to low pH run-off (Lucey *et al.* 2002). The understory juvenile grand fir and yew trees present at the site are either dead or dying. Between 60-70% of the mature overstory species within 10-20m of the leveled compost area are dead or dying (Lucey *et al.* 2002; Figure 12). Furthermore, the dying wood has become a host for several pathogenic organisms. Bark beetle infestations have been observed in dead Douglas-fir, and systemic fungal infections have been observed on dying maple trees (Lucey *et al.* 2002).


Figure 12. Dead Trees Adjacent to Old Compost Site (2007)

Invasive species pose an additional threat to this area. Patches of English holly and laurel-leafed daphne are found throughout the area, and Himalayan blackberry is present in the valley bottom and around the edges of the area (Lloyd 2004). Furthermore, a lush understory of invasive ivy and morning glory will make recruitment of seedling overstory species unlikely in the short term (Lucey *et al.* 2002).

The existing creek and riparian zones provide minimal floodplain storage within the lotic portion of the watershed. There is a small amount of storage and habitat in both Galimberti Pond and Mystic Pond, for fish, amphibians, and small mammals. However, there is minimal littoral complexity and thus little shelter from predators or substrate for invertebrates (Lucey *et al.* 2002). Hobbs Creek has minimal functionality in the riparian areas, widespread bank erosion and sediment loading, extensive stream bottom instability, and few pool-riffle sequences (Lucey *et al.* 2002). Bridge abutments have been placed in the creek channel and/ or the riparian area causing bank instability and erosion. There are heavily eroded rivulet trails heading off the main trail down to Hobbs Creek, there are also multiple steep trails up to the parking lots that have mini-streams associated with them which are eroding banks (Lucey *et al.* 2002). Furthermore, due to the system's high percentage of impermeable surface areas in the upper watershed, high flow events are a frequent occurrence. Lucey *et al.* (2002) concluded that Hobbs Creek in Mystic Vale was "nonfunctional" according to the Proper Functioning Condition (PFC) criteria, due to active erosion, insufficient vegetation and channel complexity to stabilize stream banks, and high-energy flows from a relatively impervious watershed. Restoration recommendations included adopting an integrated watershed planning program, controlling invasive species, replanting native species, installing weirs to slow flows, and re-routing public trails away from the stream channel (Lucey *et al.*, 2002).

Hobbs Creek exhibits a Rosgen creek type: A6/B6 alternating based on > 4% slope < 4% slope, and a Type II valley type (Lucey 2002). The Hobbs Creek watershed has been identified by the District of Saanich as a Type 1 watershed (Lloyd 2004). This designation is associated with several Saanich bylaws that restrict storm water discharge from development sites. The bylaws state that special detention of storm water is required to reduce runoff rates equivalent to 5 L/s per ha of development, and storage must be 200 m3 /ha of impervious surface. Potential mitigation measures include treatment drains, and/or infiltration or constructed wetlands to detain runoff (Lloyd 2004).

**Past Remediation Measures**

Since its purchase in 1993, work conducted in Mystic Vale includes creek stabilization measures, removal of invasive plant species, and trail enhancements (University of Victoria 2003). In the past, English ivy removal was carried out in a manner that increased soil erosion; care must be taken to ensure this does not happen in the future (Lucey *et al*. 2002). Three hundred cubic metres of sediment were removed from the Galimberti pond, as well as a large quantity from the delta of Hobbs Creek at its juncture with Mystic Pond (Lucey *et al.* 2002). Emergency remediation measures in the form of temporary weirs based on PFC prescriptions were implemented in response to the rapid loss of stream channel and bank structure in 2001 (Lucey *et al.* 2002). As of 2002, the prescriptions appeared to be effective in minimizing bank erosion, stabilizing downstream sediment movement, and initiating the process of elevating the stream channel bottom (Lucey *et al.* 2002). The latter process is essential for the stream to regain its functional use of the floodplain during high flow events (Lucey et *al.* 2002). Large wood was also used to stabilize bank erosion, and public access to some stream bank areas has been restricted to allow riparian vegetation to become re-established (Lloyd 2004).

Facilities Management has spent significant funds since 2005 to remove invasive species and remediate the stream course. Removal of invasive species was temporarily stopped over concerns that removing more vegetation would destabilize the slope and will resume after the necessary engineering assessments and prescriptions.

### 2.2.8 Bowker Creek Headwaters

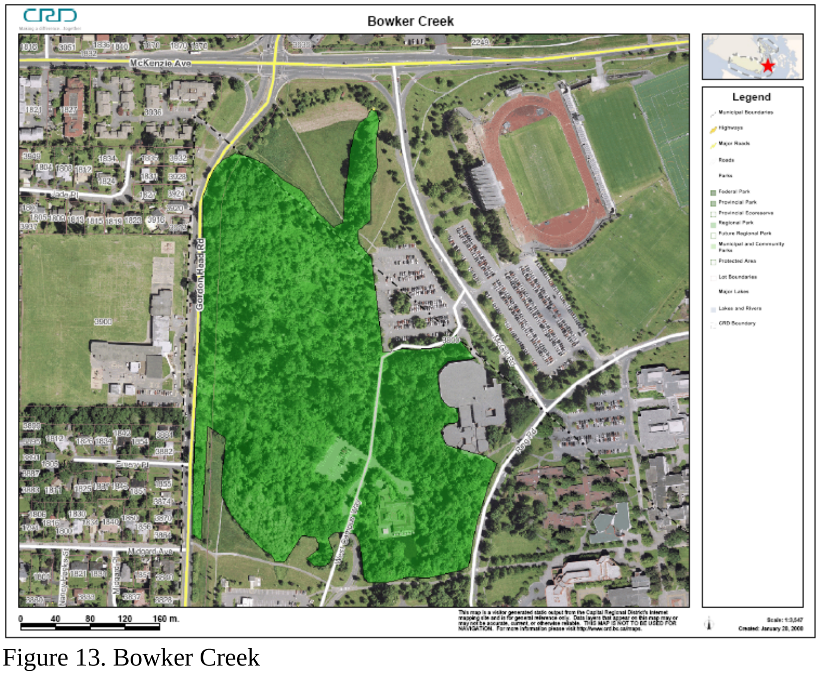


Figure 13. Bowker Creek

The Bowker Creek (Figure 13) natural area includes areas around the Fraser building, University Club, and vegetated areas around parking lot #8. It encompasses 5.7 ha (14 acre) and is located along the west side of the campus. Today, Bowker Creek flows from the University, west via storm drains along McKenzie Ave., then south along Shelbourne St., and southeast behind the Jubilee Hospital, Richmond Elementary School, the Oak Bay Fire Hall, and it discharges into the marine environment near Glenlyon-Norfolk School (Friends of Bowker Creek website). 70 percent of the channel is confined in storm drains, and about 45% of the watershed is considered impervious (CRD, 2003). In an 1858 map of the region, there is no connection marked between the University of Victoria campus and Bowker Creek, which is shown as a slightly meandering watercourse running along the Shelbourne Valley. Thus, the existing connection is likely a result of storm water diversions. Oral histories of First Nations and European settlers in the area attest that the stream was once a considerable size, and supported salmon populations (Friends of Bowker Creek website). Historically, the Bowker Creek area on the campus may have been a wet depression that had no surface flow connection to other areas. Lloyd (2004) suggests that the vegetation in the Bowker Creek natural area (on the campus) had a predominantly black cottonwood overstory in the riparian area, and Douglas-fir and Garry oak in surrounding areas.

Currently, the vegetation around Bowker Creek East (Appendix S, Lloyd 2004), adjacent to the Fraser Building and University Club, consists primarily of bigleaf maple, Douglas-fir, arbutus and black cottonwood in the overstory, and some planted areas containing red alder, Garry oak, and western redcedar (Lloyd 2004). The shrub and herbaceous layer consist primarily of oceanspray, snowberry, dull Oregon grape, Himalayan blackberry, and English ivy (Lloyd 2004). Other understory species present in both planted and natural areas include English holly, Indian plum, cascara, daphne, Saskatoon berry, English hawthorn, red-osier dogwood, bracken fern, and sword fern. There are several invasive species within this area. Himalayan blackberry occurs along most edges and in patches throughout the woods. There is a large ivy infestation in the woods, and English hawthorn, daphne, and English holly are scattered throughout the area (Lloyd 2004; Chandler 1995).

Bowker Creek West (Appendix T) is the upper Bowker Creek drainage and receives stormwater directly from parking lots 8-10, Bowker creek East, and from a wet area to the north; the wet area to the north is the receiving body for stormwater and irrigation water from the stadium, parking lot 4, playing fields and huts (Lloyd 2004). Within Bowker Creek West, moist areas are dominated by black cottonwood and bigleaf maple with some red alder, trembling aspen (*Populus tremuloides*), and Pacific willow (*Salix lasiandra*) in the overstory. The large black cottonwood trees found throughout this site seem to be the largest and oldest of this species on campus (Hocking 2000). It has been suggested that the wet, cottonwood dominated areas may be home to several native amphibian species, however, no inventory has been carried out (Hocking 2000). Drier areas are dominated by Douglas-fir with some grand fir and Garry oak in the overstory (Lloyd 2004).

The shrub and herbaceous layers consist primarily of red-osier dogwood, snowberry, Nootka rose, Himalayan blackberry, oceanspray, Indian plum, bracken fern, and English ivy (Lloyd 2004). Other understory species include Scouler's willow (*Salix scouleriana*), salmonberry (*Rubus spectabilis*), English hawthorn, Pacific crabapple, black hawthorn (*Crataegus douglasii*), Saskatoon berry, Pacific ninebark (*Physocarpus capitatus*), cascara, hardhack (*Spirea douglasii*), Hooker's willow (*Salix hookeriana*), English holly, Scotch broom, trailing blackberry, skunk cabbage, watercress (*Nasturtium nasturtium-aquaticum)*, cattail (*Typha* *latifolia*), creeping buttercup, European bittersweet (*Solanum dulcamara*), and sword fern (Lloyd 2004). Invasive species locations can be seen in Appendix T.

Due to observations of encroachment of cottonwood and trembling aspen, and the death of some Douglas-fir, it is evident that there have been some changes in the water table in parts of this area (Lloyd 2004). The wetland plays an important role in reducing peak flows from entering Bowker Creek by acting as sponge to absorb run-off then releasing it slowly over time. This is important because increased peak run-off presents downstream flooding risks and may require retrofitting downstream storm drain systems. In fact, flooding is already an issue of concern for properties near the mouth of the creek in the Monteith area (Westland Resource Group 1999). University practices are being altered to prevent additional storm water flow to this area, and it is expected that the ecosystem will adapt, over time, to changes that have occurred in the water regime (Lloyd 2004).

The Bowker Creek Watershed is one of the largest watersheds in the region (University of Victoria 2006). The District of Saanich has classified this watershed as a Type II watershed and there are several Saanich bylaws that restrict storm water discharge from development sites within the watershed. They are as follows, discharge flows must be detained to reduce runoff rates equivalent to 10 L/s of the total contributory catchment, storage must be 100 m3 /ha of impervious surface, and detention ponds, wetlands, or underground storage can be used for storage (Lloyd 2004). Presently, there is some storm water detention in the wetlands near the head of Bowker Creek (Lloyd 2004). This wooded wetland area contains a relatively high diversity of trees and wildlife, in particular, this area supports the largest number and diversity of bird species anywhere on campus (University of Victoria 2003). There is an abundance of songbird species, a pair of breeding Cooper's Hawks, several owl and woodpecker species, and until 2000, a pair of rare Western Screech Owl (*Megascops kennicottii*) nested in the area (Hocking 2000). This area also likely contains the amphibians Pacific tree frog and red-backed salamander (Westland Resource Group 1999). The university staff have had an active role in revitalizing this urban watershed through creek clean up and riparian area restoration projects (University of Victoria 2006).

## 2.3 Previous Study Recommendations

There have been several professional studies (as opposed to student projects), done in the past that address natural features at the University of Victoria, usually addressing concerns about stormwater management and erosion. Notable reports relevant to the current natural features study include: *Integrated Stormwater Management Plan* by Lloyd (2004), *Audit of the Proper Functioning Condition of Hobbs Creek* by Lucey et al. (2002), *Storm Water Disposal Study Geotechnical/Geological Conditions* by Thurber Engineering Ltd. (2003) and *An Environmental Overview of the University of Victoria's Eastern Lands* by Westland Resource Group (1993). These studies include some recommendations for vegetation and land management.

### 2.3.1 General

Stormwater pollutants such as oil and sediment can be dealt with by diverting storm water into vegetated swales and wetlands; in these areas micro-organisms can break down the petrochemicals and vegetation can filter the sediment before the stormwater reaches a stream (Lloyd 2004). Disturbed areas should be re-planted with drought tolerant native vegetation to reduce water demand (Lloyd 2004).

### 2.3.2 Hobbs Creek and Mystic Vale

The following recommendations are stated by Lloyd (2004):

- Work on the detention function of the ravine area and culverts going into Hobbs Creek needs to happen.
- Signs educating users of this area about the watershed and stormwater management program in this area should be posted.

The following recommendations are among those stated by Lucey *et al.* (2002) for Hobbs Creek in the Mystic Vale area:

- *A geologist and/or a geomorphologist should be retained to ensure that there are no landslide and slope instability issues prior to conducting major creek channel and upslope restoration works.*
- *The stability of the steep slopes adjacent to residences near the break-in-slope terrace edge, on the south-eastern side of Mystic Vale, should be reviewed.*
- *All future UVic development plans should be done in collaboration with the District of Saanich and the municipality of Oak Bay to ensure that storm water management options are based on protecting the proper functioning condition of all downstream aquatic systems (e.g. Hobbs Creek, Gyro Park wetlands, Bowker Creek).*
- *All trails throughout Mystic Vale should be reviewed to determine their effect on the Proper Functioning Condition of Hobbs Creek and whether they are a primary cause of the creek channel instability and erosion process.*
- *Signage should be placed at all entrances to Mystic Vale explaining the restoration works and the loss of functional condition in existing creek channel and riparian zones. Signage should also reflect the damage which occurs when people walk off the trails.*
- *A complete program of* ***Accelerated, Cooperative Riparian Restoration and Management*** *works should be developed (with budgets and scheduling) and coordinated with trail relocation.*
- *The existing head cuts should be temporally stabilized to minimize downstream sediment loading.*
- *If the soil structure permits, the former pond in the upper portion of the creek should be restored as a wetland, within a new defined creek channel; otherwise, the restoration of the lake should be considered*
- *New trail locations should be selected to protect riparian structures, should be located outside the floodplain, and should not cause damage to root structures.*

- *Trail runoff should be collected over short intervals and redirected through energy dissipating structures before being diverted into the creek.*
- *Small sediment trapping ponds should be incorporated to prevent sediment from upslope areas reaching the creek.*
- *Foot bridges should be relocated to minimize their effect on channel / riparian processes*
- *Consideration should be given to reviewing the need to remove selected trees to increase the sunlight on the valley floor, as an aid to promoting vegetation growth.*
- *Large wood on-site should be used in any creek channel restoration works.*
- *The removal of ivy, especially ground cover, must be done in a manner that does not increase soil erosion, as has occurred in the past.*
- *Large trees which fall should not be cut up, but should be left in place (unless they represent a hazard and liability to park users).*
- *A replanting program should be initiated to provide a future source of large wood and a multiple age class structure should be developed.*
- *The planting should be done over a significant time period to provide the age class diversity required.*
- *Consideration should be given to relocating portions of the creek from its existing entrenched channel into a new channel to provide access to potential floodplain lands.*

***Vegetation adjacent to the compost storage area***

- *Confirmation of the soil / pH leachate relationship should be undertaken before any remediation measures are implemented.*
- *Possible remediation treatments for the site would involve removal of dead wood from the area, to prevent the further spread of pathogenic organisms.*
- *Given confirmation of the soil / pH leachate relationship (as noted above) compost material which has been leveled over the storage area, and heaped close to the creek bank, should be removed to prevent further contamination of the bank soil.*
- *Replanting of this section of the watershed should not be considered until the soil pH conditions have been restored to levels that would not be deleterious.*
- *Strategies to remove ivy and morning glory, while allowing regeneration of appropriate understory vegetation and conifer recruitment, should be considered in this area.*

***Vegetation along trails in Mystic Vale adjacent to Hobbs Creek***

- *Moving the trail to the top of the bank, and therefore away from large overstory species will immediately prevent this problem from becoming worse.*
- *Roots damaged by the trail should be covered over and left to recover.*

See also Appendix U for additional information on hydrological zones and a proposed planting list for Mystic Vale.

### 2.3.3 Finnerty Creek and Haro Woods

**Comment [n1]:** No reference below to Haro Woods.

Lloyd (2004) had the following comments and recommendations for Finnerty Creek and Haro Woods:

- *There was a composting facility on campus which produced organic leachate which may possibly have an affect on the water quality in Finnerty Creek. Runoff from the site goes into a biofiltration process just prior to going into a sanitary sewer.*
- *The composting facility was removed from the site in 2005. However, there is probably still acid loading in the soil from the compost which in turn is probably still affecting this area. This must be taken into account when considering remediation in and adjacent to Finnerty Creek.*
- *There is also the potential to accommodate a storm water detention facility such as a bioswale or wetland in the upstream portion of Finnerty Creek. Furthermore, the former wetland in the middle of the ravine could be recreated.*

The Advanced Principles and Concepts of Ecological Restoration Class ER 411/ES 482, 2007, outlined the following goals for Finnerty Creek. The same goals were put forward for Haro Woods by the Principles and Concepts in Ecological Restoration Class ER311/ES341 in 2008.

- *Remove garbage, structural hazards, and invasive plants.*
- *Increase native plant diversity.*
- *Reduce erosion influences through work parties, planting projects for kids, and trail system implementation.*

### 2.3.4 South Woods

Lloyd (2004) had the following comments and recommendations for South Woods:

- *Recommendations include the stabilization of down cut areas and the creation of some step pools in the ravine between the engineering building and parking lot 1 to accommodate additional stormwater detention in this area.*
- *It is also suggested that the dogwood/ willow thicket be examined to determine its potential to receive further stormwater (Lloyd 2004).*
- *Another issue raised is the impact of established and unauthorized trails through out the South Woods; soil compaction is a problem along these trails and in some cases they are directing water flow to areas where damage is occurring. Thought should be given to decommissioning some of these trails.*

# 3.0 Natural Features Study Methods

## *3.1 Field Mapping*

The University of Victoria Natural Features Study was developed using ArcMap which is a type of Geographic Information System (GIS) software. GIS ensures the accurate measurement and location of spatial data, offers an efficient method of spatial analysis, and allows for the timely updating of information.

Data was collected by the author and an assistant using Thales mobile mappers, and ArcPad software from March to April for phase one, and from September to December for phase two. Differential GPS (DGPS) was used when mapping most polygons. Exceptions are listed below. Differential positioning is a technique that facilitates overcoming the effects of environmental errors on GPS signals to produce a highly accurate position fix; DGPS entails comparing a known position to a computed position and then transmitting this differential to the GPS receiver.

There were occasions during point, line, and polygon data collection when poor conditions did not allow for a differential fix; due to time constraints a 3D position was recorded in such cases. 3D positional readings require a minimum of four satellites to compute the position and elevation of each location. Line data collected using 3D includes Upper and Lower Hobbs Creek, and the trails in Mystic Vale. Polygons created without DGPS include some invasive species polygons which were digitized, and the historic floodplain of Lower Hobbs Creek due to poor satellite signals in the ravine.

When looking for point features such as nests, rootballs, Coarse Woody Debris (CWD), erratics, and wildlife trees, each area was traversed along visual transects of various widths depending on visibility. For example, in relatively open areas such as most of Mystic Vale, transects were approximately 20 m apart, whereas in the densely wooded areas, such as the Red-oiser Dogwood dominated thickets in South Woods, transects were approximately 10 m apart. Within the densely wooded areas, transects were marked with flagging tape to keep the observer on course and prevent double counting.

Due to the seasonal disappearance of most herbaceous species and the seasonal loss of foliage by many shrub species, phase two employed the creation of ten meter plots in the beginning of this phases field season in all areas under study to determine the plant species composition and cover of said areas (Appendix V). Boundaries between relatively homogenous tree stands and shrub/ herbaceous groups were then mapped, and the plot data was used to populate the field attribute tables for the shrub/ herb layer. The herb layer was not mapped separately in phase two due to the fact that many herbaceous species could no longer be seen at the time polygons were being created.

Another field sampling technique used exclusively in phase two of this report is the study forest structure parameters such as population density, basal area, and biomass in lower Mystic Vale using the Point Center Quarter Method. The data, which is presented in

Appendix W, was collected by aboriginal youths enrolled in the Information Technology program at the Oregon Museum of Science and Industry in conjunction with the author in the month of November. The data has been used to calculate the importance value of each tree species in lower Mystic Vale; the importance value is defined as the sum of relative density, relative cover, and relative frequency.

Most vegetation was identified with field guide books. Vegetation that the observers were unsure of was photographed, put in a plant press, and brought to the University's herbarium for further study and accurate identification by herbarium staff. Additionally, some fresh samples were brought to botanists in the School of Environmental Studies and identified by them.

## *3.2 Attribute Information Collection*

### 3.2.1 Attribute information collected as point data

<u>Wildlife Trees</u>
Wildlife trees are living or dead, naturally occurring trees that provide present or future important habitat for the maintenance or enhancement of wildlife (Green and Klinka 1994). The value of wildlife trees is variable depending on factors such as age, size, structure, rot, species, elevation, and proximity to critical habitats (Green and Klinka 1994). For example, taller and larger diameter snags are used by more species than smaller snags. Wildlife trees provide habitat for nest cavities, nest platforms, dens, roosts, hunting perches, foraging sites, and display stations during breeding (Green and Klinka 1994).

Wildlife trees were classified according to appearance, using a code (1-9) as illustrated in Figure 14. When a wildlife tree appeared to be in transition between two of the appearance codes, crown condition code descriptions were used as supplementary guidelines (Table 1).

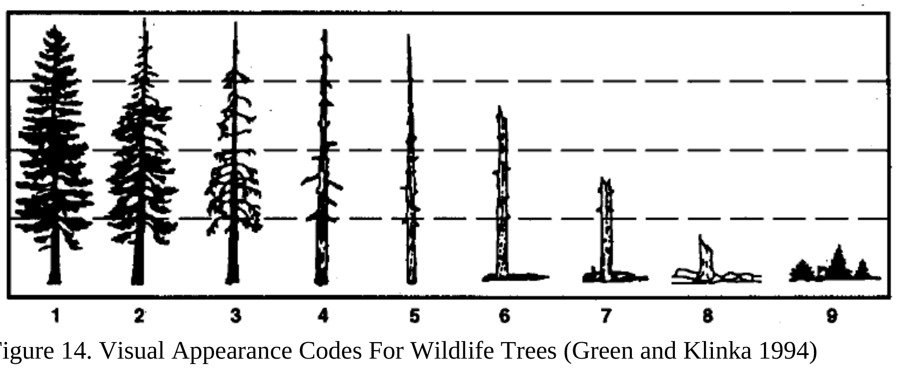


Figure 14. Visual Appearance Codes For Wildlife Trees (Green and Klinka 1994)

Table 1. Crown Condition Codes (Green and Klinka 1994).

| Code | Description |
|---|---|
| 1 | All foliage, twigs, and branches present |
| 2 | Some or all foliage lost; possibly some twigs lost; all branches usually present; possible broken top |
| 3 | No foliage present; up to 50% of twigs lost; most branches present; possible broken top |
| 4 | No foliage or twigs present; up to 50% of branches lost; top usually broken |
| 5 | Most branches gone; some sound branch stubs remain; top broken |
| 6 | No branches present; some sound and rotting branch stubs, top broken |

Woodpecker Holes & Nests
Any standing trees that were observed to have woodpecker holes or standing trees that were observed to have nests were documented. However, it is suspected that many nests may have been missed because they were obscured by vegetation. We cannot be sure that the counts are complete and these point data counts should be considered a minimum estimate for these areas.

Coarse Woody Debris (CWD) & Rootballs
Coarse Woody Debris consists of large woody material such as logs, root wads, bark, limbs, and stumps at various stages of decay on the forest floor (Green & Klinka 1994). Coarse Woody Debris is important wildlife habitat; many invertebrates, amphibians, reptiles, birds, and mammals use CWD as food, den sites and breeding habitat (Green & Klinka 1994). During this study rootballs were differentiated from CWD because they are an indication of blowdown. Measuring CWD in disturbed areas is very time consuming; given the time constraints of this study it was decided that CWD would not be measured in Bowker Creek. In both Mystic Vale and Cunningham Woods the diameter of the CWD was measured with a dbh tape and its length was estimated. The dbh is the diameter of a tree at breast height or approximately four feet (1.3 m) which is the standard used for measuring tree width.

Erratic
Any pieces of rock that seemed to deviate from the size and type of rock native to the different areas in this study were documented. As the name implies, it is assumed that these rocks were carried to there current locations by glacial ice.

Arbutus
Arbutus is Canada’s only native broadleaved evergreen tree, and it rarely extends inland more than five miles in southern British Columbia (Hosie, 1969). Arbutus is also a tree of cultural significance to the Straits Salish. For these reasons Arbutus is considered a tree of special

interest and all arbutus were documented. The arbutus were mapped as points when there were individual occurrences and as polygons when there were clumps of arbutus trees.

Culverts
All culverts in the context of streams were mapped.

Bird and Bat Boxes
Bird and Bat boxes have been placed in some of the natural areas on campus to increase wildlife habitat. For this reason all bird and bat boxes were recorded.

Ivy Cover
English ivy is the most prevalent invasive exotic species in the natural areas on campus. While collecting point data, the extent of the ivy coverage over point features was also recorded. A value of one indicates a tendril of ivy, two indicates a quarter of the feature is covered in ivy, three indicates half the feature is covered in ivy, four indicates three quarters of the feature is covered in ivy, and five indicates that the feature is completely covered in ivy.

### 3.2.2 Attribute information collected as line data

Watercourses
Upper and Lower Hobbs Creek was mapped with 3 dimensions because a differential fix was not forthcoming in the ravine environment. This means that a minimum of four satellites were used to compute the position and elevation of each vertex along the line representing the creek, but environmental errors such as ionosphere and tropospheric delay were not taken into consideration in location calculations along Upper Hobbs Creek. Furthermore, the observer walked adjacent to the stream rather then in it. Bowker Creek was mapped with a differential fix, and the side channels were distinguished from the main channel.

Trails
There are many designated and rogue trails throughout the natural areas on campus. These trails were mapped with a few exceptions. Finnerty ravine is very small and did not contain any substantial trail networks. And unfortunately the data associated with the trail extending through the Garry oak and camus meadow area became corrupted and thus needs to be recollected.

### 3.2.3 Attribute information collected with tree, shrub, and herbaceous polygon data

Dominant Species
This includes the most abundant species of the layer (tree, shrub, herb) under consideration. For the tree layer, the dominant species tends to be veterans of past disturbance regimes. Due to attribute table space constraints, all species names were abbreviated and coded (Table 2).

Table 6. Natural Features Study Species Abbreviations and Indicator Species Group Designations

| Species | Abbreviation | Moist. ISG # | Nut. ISG # |
|---|---|---|---|
| **1. Tree** | | | |
| Arbutus *Arbutus menziesii* | AM | 2 | N/A |
| Bigleaf Maple *Acer macrophyllum* | ACM | 4 | 3 |
| Bitter Cherry *Prunus emarginata* | PE | N/A | N/A |
| Black Cottonwood *Populus balsamifera ssp. Trichocarpa* | PB | 4 | 3 |
| Black Hawthorn *Crataegus douglasii* | CD | 5 | 3 |
| Cascara *Rhamnus purshiana* | RPU | 5 | 3 |
| Chestnut *Castanea sp.* | Cspp | N/A | N/A |
| Douglas-Fir *Pseudotsuga menziesii ssp. Menziesii* | PM | N/A | N/A |
| English Hawthorn *Crataegus monogyna* | CM | N/A | N/A |
| Garry Oak *Quercus garryana* | QG | 2 | N/A |
| Grand Fir *Abies grandis* | AG | N/A | N/A |
| Pacific Crab Apple *Malus fusca* | MF | 6 | 3 |
| Pacific Ninebark *Physocarpus capitatus* | PC | 5 | 3 |
| Pacific Willow *Salix lucida ssp. Lasiandra* | SL | N/A | N/A |
| Pacific Yew *Taxus brevifolia* | TB | N/A | N/A |
| Red Alder *Alnus rubra* | AR | N/A | 3 |
| Rowan Tree *Sorbus aucuparia* | SAU | N/A | N/A |
| Scouler's Willow *Salix scouleriana* | SS | N/A | 2 |
| Sitka Willow *Salix sitchensis* | SSI | N/A | 2 |
| Trembling Aspen *Populus tremuloides* | PT | N/A | 3 |
| Western Hemlock *tsuga heterophylla* | TH | N/A | N/A |
| Western Redcedar *Thuja plicata* | TP | N/A | N/A |
| **2. Shrub** | | | |
| Baldhip Rose *Rosa gymnocarpa* | RG | 2 | 2 |
| Black Twinberry *Lonicera involucrata* | LI | 5 | 3 |
| Common Periwinkle *Vinca minor* | VM | N/A | N/A |
| Common Snowberry *Symphoricarpos albus* | SA | N/A | 3 |
| Cotoneaster sp | COspp | N/A | N/A |

| | | | |
|---|---|---|---|
| Daphne *Daphne laureola* | DL | N/A | N/A |
| Deer Fern *Blechnum spicant* | BS | 4 | 1 |
| Dull Oregon Grape *Mahonia nervosa* | MN | 3 | 2 |
| English Holly *Ilex aquifolium* | IA | N/A | N/A |
| English Ivy *Hedera helix* | HH | N/A | N/A |
| Falsebox *Paxistima myrsinites* | PMY | 3 | 1 |
| Hardhack *Spiraea douglasii* | SDO | 5 | 2 |
| Himalayan Blackberry *Rubus discolor* | RD | N/A | N/A |
| Indian plum *Oemleria cerasiformis* | OC | 4 | 3 |
| Lady Fern *Athyrium filix-femina* | AFF | 5 | 3 |
| Licorice Fern *Polypodium glycyrrhiza* | PG | N/A | N/A |
| Mock-Orange *Philadelphus lewisii* | PL | 3 | 2 |
| Morning Glory *Convolvulus arvensis* | CA | N/A | N/A |
| Nootka Rose *Rosa nutkana* | RN | 4 | 3 |
| Oceanspray *Holodiscus discolor* | HD | 2 | 2 |
| Red Elderberry *Sambucus racemosa ssp. Pubens* | SRP | 4 | 3 |
| Red Flowering Current *Ribes sanguineum* | RSA | 2 | 2 |
| Red Huckleberry *Vaccinium parvifolium* | VP | N/A | 1 |
| Red-osier Dogwood *Cornus stolonifera* | CS | 5 | 3 |
| Rhododendron | Rspp | N/A | N/A |
| Salal *Gaultheria shallon* | GS | N/A | 1 |
| Salmonberry *Rubus spectabilis* | RS | 5 | 3 |
| Saskatoon *Amelanchier alnifolia* | AA | 3 | 2 |
| Scotch broom *Cytisus scoparius* | CSS | 2 | 2 |
| Sticky Current *Ribes viscosissimum* | RV | N/A | N/A |
| St. John's-wort *Hypericum formosum* | HF | 4 | 2 |
| Sword Fern *Polystichum munitum* | PMU | N/A | 3 |
| Tall Oregon grape *Mahonia aquifolium* | MA | 2 | 2 |
| Thimbleberry *Rubus parviflorus* | RP | N/A | 3 |
| Trailing Blackberry *Rubus ursinus* | RU | 3 | 2 |
| Western Trumpet Honeysuckle *Lonicera ciliosa* | LO | 2 | 2 |
| Wild Gooseberry *Ribes divaricatum* | RDI | 3 | 2 |
| 3. **Herb** | | | |

| | | | |
|---|---|---|---|
| Baneberry *Actaea rubra* | ARU | 4 | 3 |
| Big-Leaved Sandwort *Moehringia macrophylla* | MM | 3 | 3 |
| Black Nightshade *Solanum dulcamara* | SD | N/A | N/A |
| Bracken Fern *Pteridium aquilinum* | PA | N/A | N/A |
| Broad Leaved Helleborine *Epipactis helleborine* | EHE | N/A | N/A |
| Broad Leaved Star Flower *Trientalis latifolia* | TL | 3 | 2 |
| Canada Thistle *Cirsium arvense* | CAR | N/A | N/A |
| Canada Violet *Viola canadensis* | VC | N/A | N/A |
| Cleaver *Galium aparine* | GA | N/A | 3 |
| Common Dandelion *Taraxacum officinale* | TOF | N/A | N/A |
| Common Horsetail *Equisetum arvense* | EA | N/A | 2 |
| Common Plantain *Plantago major* | PMA | N/A | N/A |
| Common Vetch *Vicia sativa* | VS | N/A | N/A |
| Cooley's Hedge Nettle *Stachys cooleyae* | SCO | 5 | 3 |
| Cutleaf Geranium *Geranium dissectum L.* | GD | N/A | N/A |
| Creeping buttercup *Ranunculus repens* | RR | 5 | 3 |
| Cyclamen spp | CYspp | N/A | N/A |
| English Daisy *Bellis perennis* | BP | N/A | N/A |
| False Lily-Of-The-Valley *Maianthemum dilatatum* | MD | 5 | 3 |
| Few-Seeded Bitter-Cress *Cardamine oligosperma* | CO | N/A | N/A |
| Fig Buttercup *Ranunculus ficaria* | RF | N/A | N/A |
| Foamflower *Tiarella trifoliata* | TT | 4 | 3 |
| Fringecup *Tellima grandiflora* | TG | 4 | 3 |
| Hedge Mustard *Sisymbrium officinale* | SO | N/A | N/A |
| Herb-Robert *Geranium robertianum* | GR | N/A | N/A |
| Kneeling Angelica *Angelica genuflexa* | AGE | 6 | 3 |
| Lamium *Lamiaceae* | LAspp. | N/A | N/A |
| Large-Leaved Avens *Geum macrophyllum* | GM | 4 | 3 |
| Lyre-Leaved Rockcress *Arabis lyrata* | AL | N/A | N/A |
| Mexican Hedge Nettle *Stachys mexicana* | SM | 5 | 3 |
| Miner's Lettuce *Claytonia perfoliata* | CP | N/A | N/A |
| Money Plant *Lunaria annua* | LAN | N/A | N/A |

| | | | |
|---|---|---|---|
| Mountain Sweet-Cicely *Osmorhiza chilensis* | OCH | 4 | 3 |
| Nipplewort *Lapsana communis* | LC | N/A | N/A |
| Pacific Sanicle *Sanicula crassicaulis* | SC | 2 | 3 |
| Pacific Water-Parsley *Oenanthe sarmentosa* | OS | 6 | 3 |
| Pathfinder *Adenocaulon bicolor* | AB | 3 | 3 |
| Poison-Hemlock *Conium maculatum* | CMA | N/A | N/A |
| Purple-Leaved Willowherb *Epilobium watsonii* | EW | N/A | N/A |
| Purple Peavine *Lathyrus nevadensis* | LN | 3 | 3 |
| Scouler's Harebell *Campanula scouleri* | CSC | 2 | 1 |
| Scouring-Rush *Equisetum hyemale* | EH | 4 | 3 |
| Siberian Miner's-Lettuce *Claytonia sibirica* | CSI | 4 | 3 |
| Sitka Sedge *Carex sitchensis* | CSII | 6 | 3 |
| Skunk Cabbage *Lysichitum americanum* | LA | 6 | 3 |
| Stinging Nettle *Urtica dioica* | UD | 4 | 3 |
| Sweet-Scented Bedstraw *Galium trilorum* | GT | 4 | 3 |
| Vanilla-Leaf *Achlys triphylla* | AT | N/A | 3 |
| Wall Lettuce *Lactuca muralis* | LM | 4 | 3 |
| Western Buttercup *Ranunculus occidentalis* | RO | N/A | 2 |
| Western Dock *Rumex occidentalis* | ROC | N/A | N/A |
| Western Trillium *Trillium ovatum* | TO | 4 | 3 |
| White Clematis *Clematis ligusticifolia* | CL | N/A | N/A |
| Wood Groundsel *Senecio sylvaticus* | SSY | 3 | 3 |
| Yarrow *Achillea millefolium* | AM | 2 | 2 |

Co-Dominant Species
This includes the second most abundant species of the layer under consideration.

Sub-Dominant Species
This includes the third most abundant species of the layer under consideration.

Other Species
Other species within each polygon were recorded

Cover

The class midpoint percent cover of each species within each polygon was recorded. The classes were broken down according to the Ministry of Forests (1998) standard as follows.

Table 7 Breakdown of Class Midpoint Percent Cover

| Code | Class Interval (%) | Class Midpoint (%) |
|---|---|---|
| + | <1 | 0.5 |
| 1 | 1-5 | 3 |
| 2 | 5-25 | 15 |
| 3 | 25-50 | 38 |
| 4 | 50-75 | 63 |
| 5 | >75 | 88 |

In the attribute table records with a value of one were noted and divided in half during calculations. This is because the field type associated with the database does not allow decimal places. Thus all values recorded as one are actually 0.5.

Slope (Tree Layer Only)
Slope affects the amount of incoming solar radiation that reaches a site per unit area, hence temperature and moisture, when combined with aspect (defined below). Slope also influences soil drainage. This attribute was measured with a clinometer. However, the degree of slope within a polygon is somewhat variable, and can change significantly over relatively short distances in gully environments such as Mystic Vale. For this reason the numbers recorded should be viewed as approximations in relation to the actual range recorded rather then fact.

Aspect (Tree Layer Only)
Aspect refers to the cardinal (compass) direction a slope faces. Aspect affects the amount of incoming solar radiation that reaches a site, hence temperature and moisture, when combined with slope. The direction a slope faced was measured with a compass.

Slope position (Tree Layer Only)
Slope position affects the soil water movement on the slope. Crests shed water and are drier where as toes receive additional water which includes dissolved nutrients and thus are wetter and richer.

Diseased (Tree Layer Only)
This includes all polygons containing trees that showed evidence of disease. The primary observation was that of galls; certain insects lay eggs in certain plants and the plant cells around the laid eggs multiply until something develops that looks like a plant tumor.

Compromised (Tree Layer Only)
This includes all polygons containing many trees that were dead or dying, and that did not have an obvious reason for this mortality, such as known changes in hydrology.

Successional Status (Tree Layer Only)
The tree layer was characterized according to successional status. The following classes were applied (MOF 1998).

- Young Seral: Young stands of early seral species or communities where self thinning has not occurred. They are generally young even-aged stands (usually < 60 years old) with an even aged canopy height.
- Maturing Seral: Mid-seral stands of mature age (generally 60-140 years old) that have gone through an initial natural thinning due to species interactions. There is generally one age class in the overstory and the regeneration of a much younger age class, composed of the same species and/ or climax species, and or species with greater shade tolerance.
- Late Seral: Stands dominated by the original species at an old age (usually >140 years old). The trees in the main canopy are dying. The secondary tree canopy may consist of the same species or a more shade tolerant species. Some of the individuals belonging to the second generation may have entered the main canopy.
- Young Climax: Stands composed of species in proportions typical of the climax expected at the site, but the community structure expected at the climax has not yet developed. This stage differs from other climax stages in being even-aged and young (<80 years old), and having a uniform canopy height.
- Maturing Climax: Stands composed of species expected to be present in the climax stand, where the stand has undergone natural thinning, gaps have been created, and a structure similar to that expected at climax has developed. This stage differs from the young climax in having a better developed understory and more or less continuous age and height class distribution, although gaps may exist between the older or upper class and the next class.
- Maturing Edaphic Climax: Stands differ from Maturing Climax stands in species composition and site conditions; these are azonal sites where soil properties differ primarily in terms of soil moisture and nutrient regime. An example of this class of successional status is the wet, nutrient rich red-oisier dogwood dominated thicket adjacent to the Haro road right-of-way in South Woods; the natural hydrological regime of this area appears to have been altered, most of the conifers are either dead or dying and the stand has been replaced with more water tolerant species such as black cottonwood and cascara.
- Disclimax: A self-perpetuating community that strongly differs in species composition from the climax expected for the site. Normal succession has been arrested by external physical or anthropogenic factors. An example of this class of successional status is

the floodplains of Bowker Creek; the natural hydrological regime has been altered due to increased impermeable surfaces and inputs of stormwater, and floodplains themselves are highly variable.

In some cases it was difficult to identify the successional stage of a polygon due to high levels of disturbance and the fact that some polygons are in transition between seral stages. In such cases the closest ‘fit’ was used, however, certain characteristics may be lacking.

Date
The date that the polygon data was recorded has been noted

Area
The total area of each polygon in $m^2$ has been calculated.

Ecosystem Classification (Tree Layer Only)
Each polygon was classified as a wetland, riparian area, area with a strongly fluctuating water table, woodland, older or younger second growth forest.

### 3.2.4 Miscellaneous Polygons

Invasive Species Layer
This includes most large Himalayan blackberry and Scotch broom patches found within the study area. It also includes outlier population of St. John’s-wort, common periwinkle, and a Lamium species. It does not, however, include English ivy, English holly, or daphne because these plants were dispersed throughout all of the areas and with the exception of the ivy were generally not found in clumps. The English ivy was not mapped because it was so pervasive that it was found almost everywhere. The north end of Bowker Creek West contained relatively little ivy relative to the rest of the swamp, and the wet area of Cunningham Woods contained relatively little ivy relative to its drier counterpart. South Woods, Mystic Vale, and Haro woods contains ivy through the majority of there areas, and the Garry oak Meadow contains ivy underneath the tree layer, but it is absent from the meadow itself. The University Cedar Hill Corner property has very little ivy, and although there is some ivy in Finnerty Ravine, the dominant invasive on site is Himalayan blackberry.

Additional Features
There were several instances where it was deemed important to record features that did not fall into any of the other polygon groups. This includes the camas meadow area which was inventoried in the Garry Oak Meadow Project; the perimeter of the University Cedar Hill Corner  lands; the soil pile and Center for Forest Biology within the University Cedar Hill Corner property; the likely perimeter of the historic floodplain of Lower Hobbs Creek as delineated by the residual floodplain terraces or bench; an area of extensive blowdown in South Woods; and the location of the plots used to interpolates values for the shrub and herbaceous layer.

### 3.2.5 Attribute information observed but not spatially referenced

Water Quality
An oily sheen was observed on the water in Lower Hobbs Creek. The ‘oil’ was determined to have come from natural sources; the sheen was poked with a stick and because the sheen broke apart and did not flow back together the way petroleum would, it was from bacteria, plant, or animal decomposition (Schmitt 2005).

Animal Observations
A minimum of two black tailed deer were regularly seen in South Woods. There was also a purplish copper butterfly (*Lycaena helloides*) in Mystic Vale. Many birds were observed in all of the study areas. However, the observer did not have sufficient bird knowledge to accurately identify most species. That said, a Barred Owl was also regularly seen on its preferred perch in Mystic Vale.

Notably, just because many wildlife and plant species were not observed on campus does not mean they are not there.

## *3.3 Accuracy and Sources of Error*

The ideal time to conduct mapping of point data such as Coarse Woody Debris is in the winter when it is easy to differentiate from surrounding vegetation. In the summer, point data such as nests are difficult to see through the dense foliage. However, the same cannot be said for the tree, shrub, and herbaceous layers; foliage is necessary for a complete inventory, identification purposes and accurate estimations of coverage. Thus, due to the time of year the study was conducted, and the fact that some foliage had already experienced die-back, it is probable that some herbaceous species were not seen and thus not recorded in the inventory, and it is possible that some coverage estimates were off. For example, based on observations during phase one of this study, it is probable that there is white fawn lily located in lower Mystic Vale along the crest between the Vale and the University Cedar Hill Corner property. Yet due to seasonal constraints, it was not observed during the second phase of this study. Furthermore, in areas containing substantial amounts of Big-leaf maple, remnant herbaceous species were obscured by a carpet of leaves in the fall.

The line data and polygon boundaries in the bottom of the ravine in Mystic Vale may be somewhat skewed due to poor satellite reception; line data was generalized in this area and thus is not necessarily accurate. It is also important to note that polygon boundaries represent transition zones, therefore, the location of polygon edges are somewhat subjective decisions. Furthermore, the landscape is constantly changing; some of the polygons mapped during this project may become altered over time.

In ideal conditions, it is possible to achieve sub-meter accuracy when receiving real time differential GPS readings with a Thales unit. This is because single point code positioning with pseudorange corrections are applied from simultaneous observations at a known position. However, some of this study was conducted in poor conditions for GPS data collection; the spring foliage obstructs the sky and makes it difficult to get accurate GPS readings. To offset this potential error, the Thales was set to average 50 readings for each location.

The maximum positional dilution of precision (PDOP) was set at 6, the minimum signal to noise ratio (SNR) was set at 24, and the elevation mask was set at 15. The PDOP is a measure of satellite geometry and consists of a mathematical calculation that accounts for each satellite's location relative to the other satellites within range to predict the accuracy of positions obtained from the satellite constellation. PDOP is considered the best overall indicator of accuracy, and generally speaking, the lower the PDOP value, the more accurate the reading. A PDOP mask of 6 meets industry standards and ensures the accuracy standards published with the GPS unit have been met. The SNR value refers to the strength of the signal of each satellite that is being tracked. If a signal is too weak and thus does not meet the SNR mask, it will not be used to calculate positions. A SNR of 6 or more is considered good by industry standards, however, the author choose to retain the Thales unit default mask which was set at 24 to make certain that the accuracy values published with the GPS unit were met. The elevation mask is the lowest elevation, in degrees, at which a GPS receiver will track a satellite. The Thales unit default mask of 15 increases the accuracy of readings by blocking the satellite signals that are likely being interfered with by buildings and trees.

# 4.0 Results and Analysis

The point, line, and polygon data and ecosystem classification information collected during the Natural Features Study is presented in Figures 15 to 17. The map colours are based on www.ColorBrewer.org (Brewer 2008), Geography, Pennsylvania State University.

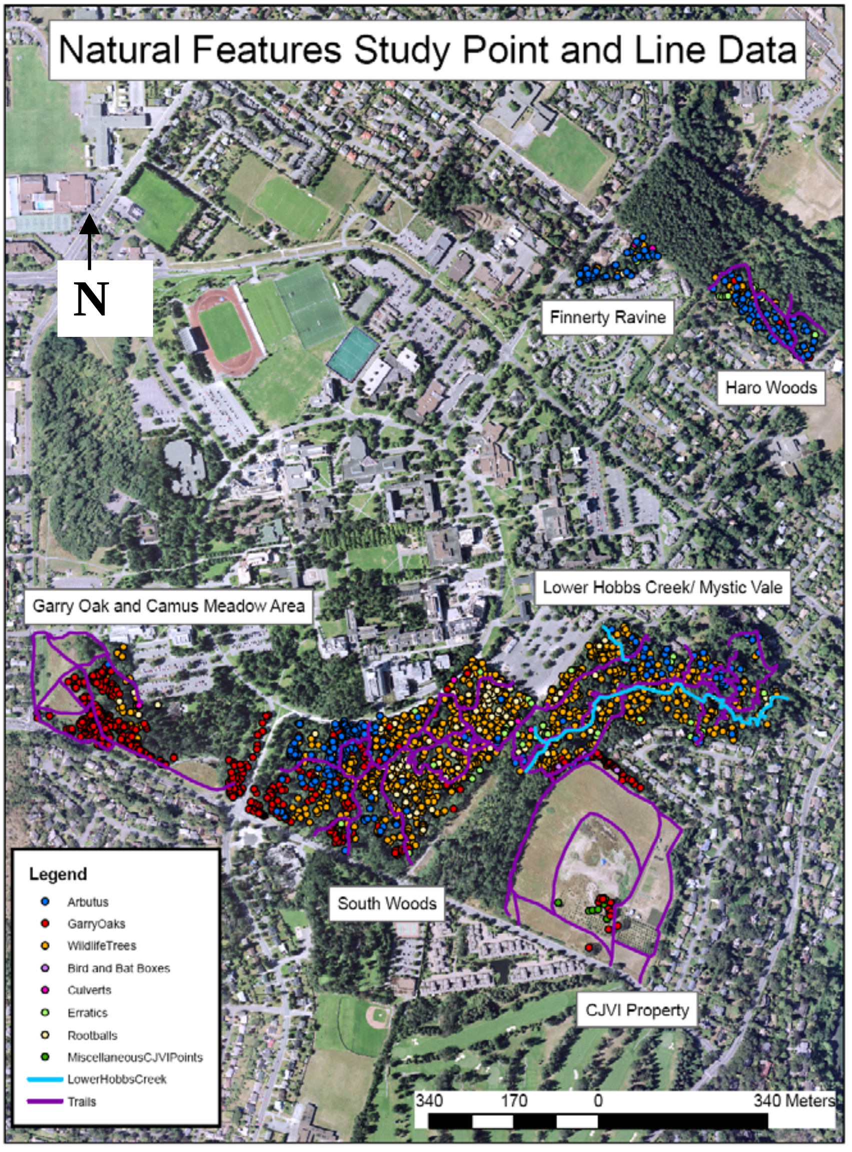


Figure 15. Point and Line Data

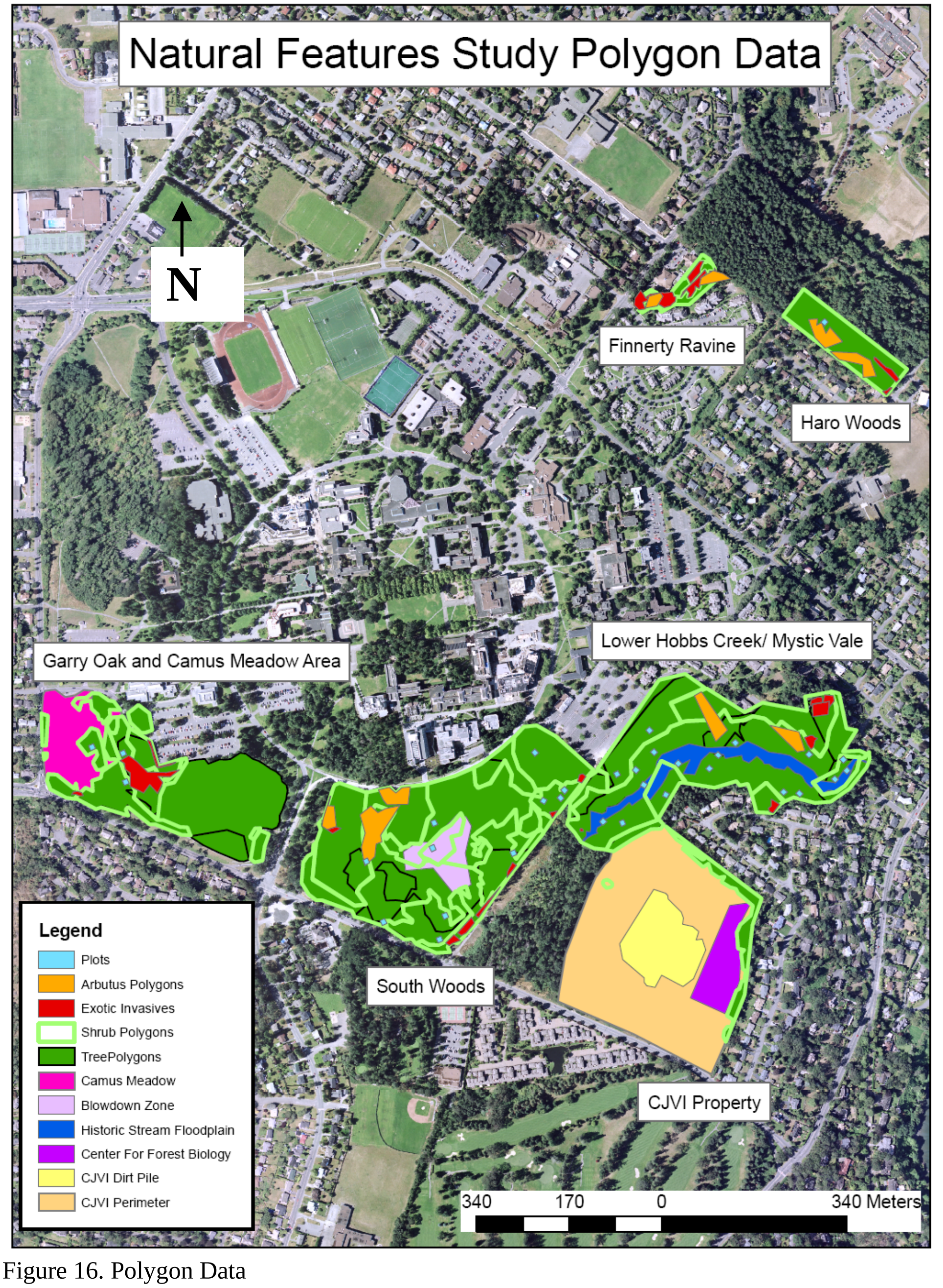


Figure 16. Polygon Data

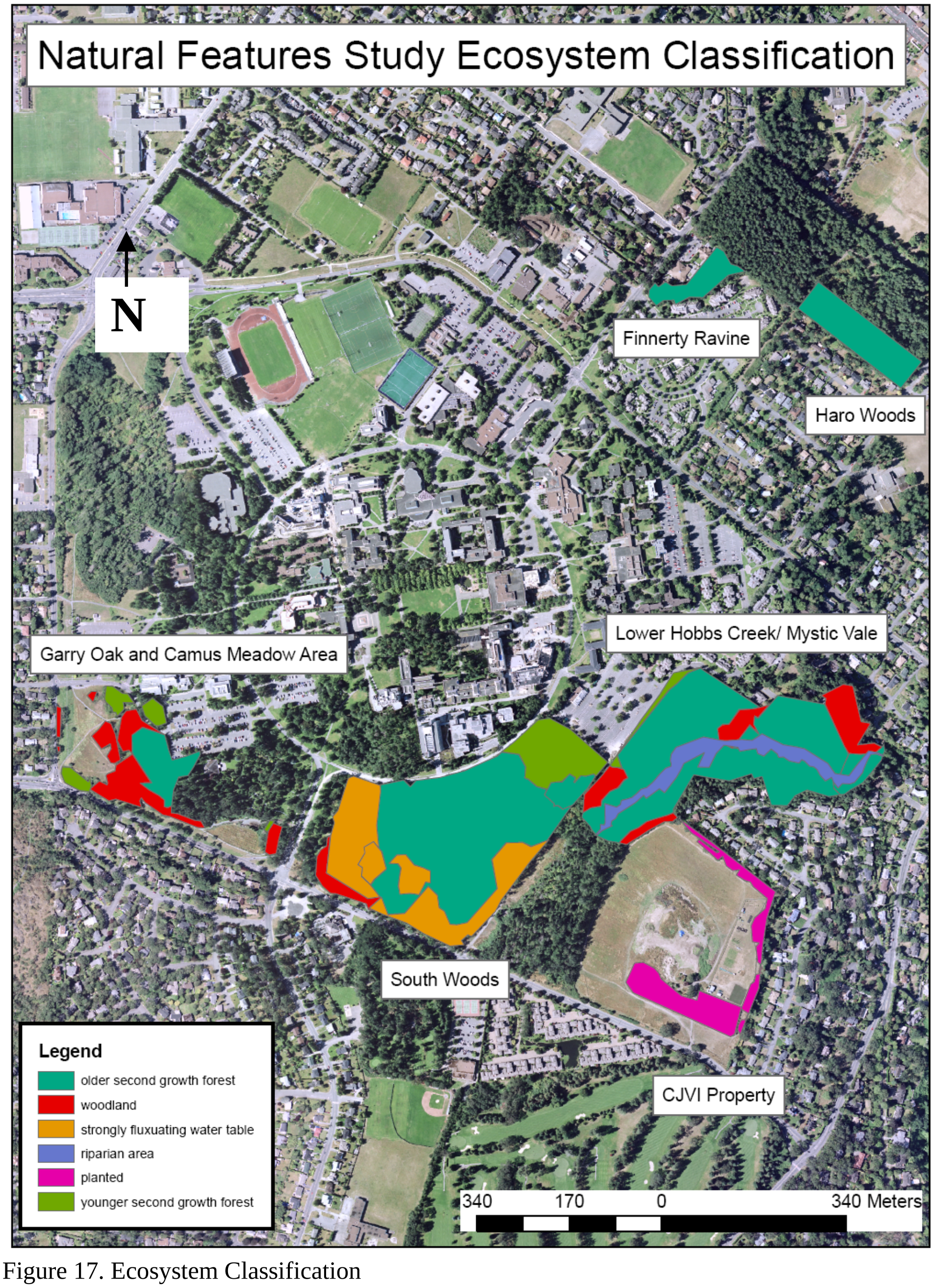

Figure 17. Ecosystem Classification

### 4.1 Site Series Classification Scheme

Terrestrial Ecosystem Mapping (TEM), an industry standard for conducting biophysical inventories, applies best to late seral or climax stands with relatively stable understories because these are the type of sites from which they were derived. However, indicator plant analysis can be used with successional stages providing there are at least 12 species. The exception is early successional stages dominated by pioneer species with wide ecological amplitude (Green and Klinka 1994). The actual occurrence of plant communities on site depends on several factors including successional stage and the type of disturbance that initiated the succession (Green and Klinka 1994). Some plants, such as Garry oak and cottonwood, are unique to environmental extremes such as the driest and wettest sites respectively. However, most plants are not exclusive to a particular site series, it is the relative abundance as well as presence and absence that distinguishes one vegetation community from another. That said, forest vegetation is one of the best integrators of site conditions; the composition and health of forest vegetation reflects the biotic and abiotic influences that contribute to the site growth potential (Green and Klinka 1994). Vegetation analysis is an integral part of site assessments.

Indicator plant analysis is based on the premise that plant species can have ecological amplitudes in relation to soil moisture and soil nutrient regime properties. Soil moisture regime (SMR) refers to the average annual amount of soil water available to plants. Soil nutrient regime (SNR) refers to the amount of essential soil nutrients, particularly nitrogen, that are available to plants (Klinka *et al.* 1990). Both the actual SMR and SNR of a site can be indirectly inferred using indicator plants. This requires the collection of a comprehensive list of species and an estimate of their cover. Species with similar ecological amplitudes are combined into indicator species groups (ISGs, Table 2); there are six soil moisture ISGs (Table 1) and three soil nutrient ISGs (Table 2.).

Table 8 Indicator Species Groups of Soil Moisture (Green and Klinka 1994)

| **ISG No.** | **Range of actual SMR** |
|---|---|
| 1 | Excessively dry to very dry |
| 2 | Very dry to moderately dry |
| 3 | Moderately dry to fresh |
| 4 | Fresh to very moist |
| 5 | Very moist to wet |
| 6 | Wet to very wet |

Table 9. Indicator Species Group of Soil Nutrients (Green and Klinka 1994)

| **ISG No.** | **Range of actual SNR** |
|---|---|
| 1 | Very poor to poor |
| 2 | Medium |
| 3 | Rich to very rich |

Indicator plant analysis involved preparing a frequency profile (Table 6) of each ISG for each site and then using this information to determine site series. Table seven shows the results of the site series analysis. Site series classification covers a range of soils from dry/nutrient poor to wet/nutrient-rich in each biogeoclimatic unit. The study area was broken into the following groups: Lower Mystic Vale, Haro Woods, Finnerty Ravine, South Woods, and the Garry Oak Woodland area. The camus meadow associated with the Garry oak woodland was not assessed using indicator plant analysis because few of the native plant species were identifiable at the time of the study; many of the wildflowers associated with Garry oak ecosystems appear early in spring, and then disappear in the summer which are generally characterized by droughts. The University Cedar Hill Corner property was not assessed using indicator plant analysis because there were not enough native plants that have designated soil moisture and soil nutrient ranges associates with them to accurately perform this type of analysis on the site. Each group was analyzed individually. The decision to divide the study area in this fashion was based on Tobler's First Law of Geography which states that near things are more likely to be similar than far things, vegetation characteristics such as wetlands verses forests, and time constraints.

Table 10 Study Area ISG Frequency Profiles

**Frequency Profiles (Lower Mystic Vale)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 14 | 17.5 | 30.5 | 1 | 1 | 64 |
| Frequency (%) | | 22 | 27 | 48 | 1.5 | 1.5 | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | 3.5 | 32 | 74.5 | 110 | | | |
| Frequency (%) | 3 | 29 | 68 | 100 | | | |

**Frequency Profiles (Haro Woods)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 80 | 34 | 17 | | | 131 |
| Frequency (%) | | 61 | 26 | 13 | | | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | 1 | 113 | 24 | 138 | | | |
| Frequency (%) | 1 | 82 | 17 | 100 | | | |

**Frequency Profiles (Finnerty Ravine)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 16 | 6.5 | 4 | | | 26.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Frequency (%) | | 60.5 | 24.5 | 15 | | | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | | 7 | 34 | 41 | | | |
| Frequency (%) | | 17 | 83 | 100 | | | |

**Frequency Profiles (South Woods-Wet)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 5 | 1 | 66 | 60 | | 132 |
| Frequency (%) | | 4 | .5 | 50 | 45.5 | | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | | 8.5 | 145 | 153 | | | |
| Frequency (%) | | 5 | 95 | 100 | | | |

**Frequency Profiles (South Woods- Dry)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 23.5 | 22.5 | 22.5 | 1 | | 69.5 |
| Frequency (%) | | 33.5 | 32.5 | 32.5 | 1.5 | | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | 3.5 | 43.92 | 65.65 | 113.07 | | | |
| Frequency (%) | 3 | 39 | 58 | 100 | | | |

**Frequency Profiles (Garry Oak Woodland)**

| Moisture Regime | ISG1 | ISG2 | ISG3 | ISG4 | ISG5 | ISG6 | Total |
|---|---|---|---|---|---|---|---|
| Summed Cover | | 17 | 1.5 | 35.5 | 16 | 0.5 | 70.5 |
| Frequency (%) | | 24 | 2 | 50.5 | 23 | 0.5 | 100 |
| Nutrient Regime | ISG1 | ISG2 | ISG3 | Total | | | |
| Summed Cover | | 3 | 87 | 90 | | | |
| Frequency (%) | | 3 | 97 | 100 | | | |

The study area ISG frequency profiles were calculated through the following procedure.

1. The polygons from each layer that represent each area were extracted from the general map and merged.
2. The weighted average of midpoint percent cover according to the area each species covered in each polygon was calculated.
3. The moisture and nutrient ISG number for each indicator species was recorded in an excel spreadsheet.
4. The following process was repeated for soil moisture then soil nutrients.
    a. Sum the midpoint values for all species in each ISG
    b. Sum the cover values for all ISGs

c. Calculate the frequency of each ISG represented at the site. An ISG frequency equals its cover divided by the total cover of all ISGs, multiplied by 100.

The frequency profiles were then compared to the standard profiles for soil moisture and nutrient regime classes to determine the closest fit and subsequently site series (Table 7).

Table 7 Site Series Classification

| Location | SMR | SNR | Special Sites | Site Series | Notes |
|---|---|---|---|---|---|
| Lower Hobbs Creek/ Mystic Vale | Slightly Dry and Fresh | Rich and Very Rich | N/A | FdBg- Oregon grape | |
| Haro Woods | Very Dry to Moderately Dry | Poor | N/A | FdPl- Arbutus | |
| Finnerty Ravine | Very Dry to Moderately Dry | Rich and Very Rich | N/A | FdPl- Arbutus | |
| South Woods-Wet | Very Moist | Rich and Very Rich | Strongly Fluctuating Water Table | Cw- Black twinberry? | Not Conclusive- need to dig soil pit and check for gleying, no slough sedge observed |
| South Woods- Dry | Very Dry to Slightly Dry and Fresh | Rich and Very Rich | N/A | FdBg- Oregon grape | |
| Garry oak Woodland | Moderately Dry to Slightly Dry and Fresh | Rich and Very Rich | N/A | Fd- Oniongrass | |

The results of the indicator plant analysis were cross-referenced with Site Classification Grids and Vegetation Summary Tables which are used as an alternative approach to vegetation analysis. These tables compare the vegetation composition of site series within biogeoclimatic subzones. This method entailed comparing the percent cover of key species in the natural areas on campus with prominence values shown in the table, to determine the site series of the natural areas on campus. It was decided to use this second method in conjunction with the indicator plant analysis because some of the frequency profiles were not a good fit with known frequency profiles. This situation is not uncommon as indicator plant analysis does not always give precise results. When indicator plant analysis gives wide-ranging results due to unsuitable floristic conditions, the results should be weighed against other forms of analysis with emphasis on environmental conditions.

In one instance the area under consideration may have been classified as special site due to the unique environmental features of that site. The south east portion of South Woods that is dominated by a thicket could potentially be classified as a site with a strongly fluctuating water table because the soil moisture regime of this site varies significantly through out the year, and the vegetation present includes many water tolerant species. The soils within this section of South Woods appear to be saturated during the winter months due to a combination of flat topography, dense, poorly drained soil layers, and fine textures. In the summer months the water table appears to drop, leaving an aerated zone. However, no soil pts were dug to check for gleying, which is what you would expect if the wet areas are in fact characterized by a strongly fluctuating water table. Furthermore, no slough sedge was observed during field work, although red-osier dogwood is abundant in these areas. Further study is needed to determine if the wet, red-osier dogwood dominated areas warrant special site status. Notably, Lower Hobbs Creek does not fall into the floodplain special site category because it is no longer periodically flooded due to downcutting of the stream channel. Finnerty Ravine also does not warrant this special site classification even though it contains a creek because the creek bed is dry for most of the year and thus the ecological process associated with riparian zones do not hold true for this area. The results from the site series assessment are shown in Figure 18.

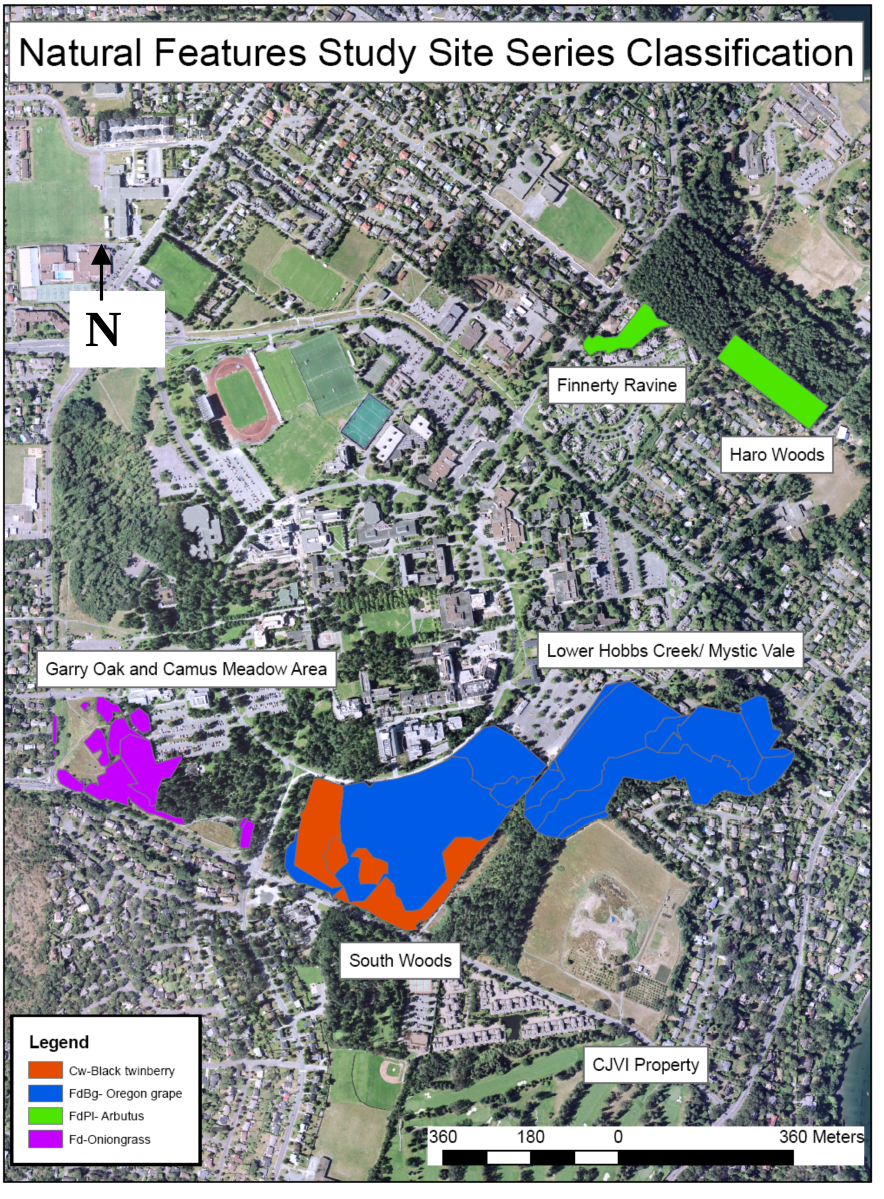


Figure 18. Site Series Classification

## 4.2 Sensitive Ecosystem Inventory Classification Scheme

The sensitive ecosystem inventory (SEI) classification scheme was loosely adapted for the Natural Features Study to provide a framework for describing the natural ecosystems on campus. The ecosystem categories used are generalized groupings of ecosystems that share many characteristics, particularly ecological sensitivities, ecosystem processes, and wildlife habitat values. Within these broad categories there is a range of specific vegetation communities that occur.

The ecosystem categories adapted from SEI and used for this project were wetlands, riparian areas, woodlands, and older second growth forests. An additional category, younger second growth forests, was added to this classification scheme by the author. Although the Sensitive Ecosystem Inventory only recognized riparian ecosystems that were relatively undisturbed by human activities, this report did not make this distinction. It is also important to note that the study areas assessed during the University of Victoria Natural Features Study are much smaller then those examined during the Sensitive Ecosystem Inventory; scale is important because many of the wildlife habitat attributes of these ecosystem types are diminished in small isolated remnant forest patches.

During the process of differentiating polygons into these categories, particular attention was paid to the composition of the tree layer because trees are the longest lived species within each of the sites; tree species presence, absence, abundance, and health can be used to indicate successional status, as well as the past and present ecological process at each of the sites.

### 4.2.1 Tree Characteristics

<u>Douglas-Fir</u>
Coastal Douglas-fir is a large coniferous tree which is adapted to moist mild climates and is a dominant tree species in the Pacific Northwest; it is a major, long lived seral dominant of low and middle elevations (Franklin and Dyrness 1973). Coastal Douglas-fir competes well on most parent materials, slopes and aspects and commonly live more than 500 years. The roots of young coastal Douglas-fir are not particularly deep. Germination and seedling establishment are best on mineral soil; first year seedlings survive and grow best in partial shade, however, once they are established seedlings require full sunlight (Isaac 1943).

<u>Grand Fir</u>
In southern British Columbia, grand-fir is most common on moist soils and is infrequent on wet or dry soils. Grand fir does not require disturbance to establish and persist on most sites, however, it may colonize a site soon after a fire or other stand-replacing disturbances. Grand fir is tolerant of fluctuating water tables and floods (Klinka *et al.* 1990). Grand fir is not generally restricted by soil type but does best on streamside alluvium and deep nutrient rich valley bottoms (Klinka *et al.* 1990). Grand fir occurs in the overstory of both seral and late successional forests. Grand fir exhibits moderate growth in open areas, yet is shade tolerant enough to establish and grow beneath a moderate forest canopy.

Bigleaf Maple

Bigleaf maple is most common on moist sites, however, stands can also occur on dry sites. The persistence of bigleaf maple at both moisture extremes may be due to the fact that both ends of the moisture spectrum tend to promote open overstory conditions; bigleaf maple has low to moderate shade tolerance (Krajina *et al.* 1982). Bigleaf maple is flood tolerant and often persists in floodplain habitats. The successional role of bigleaf maple in Pacific Northwest coniferous forests is not clear; it appears to be a seral species due to its prevalence in the early seral stages of Douglas-fir forests and its absence from older stands which are characterized by dense shading.

Red Alder

Red alder and Douglas-fir are the principle pioneer tree species of lower and middle elevation forests in southwestern British Columbia. Red alder is shade intolerant, very fast growing and quickly overtops Douglas-fir. Early seral red alder can suppress competing conifer growth for approximately 25 years. However, after this length of time the conifers begin to equal red alder height and begin to overtop them. After about 40 years Douglas-fir becomes dominant, and after 60 years, few red alder remain in the stand. Historically, red alder was restricted to streams and other wet areas, and in naturally disturbed areas. However, anthropogenic disturbance has exposed large tracts of bare mineral soil, which red alder has colonized, thus increasing its distribution. Individuals or clumps of red alder may occur to varying degrees within coniferous forests, but stand development occurs along streams, moist depressions, and moist lower slopes. Soils under red alder stands develop higher nitrogen levels than adjacent coniferous forests due to the ability of red alder to fix nitrogen.

Cottonwood

Cottonwood is a moisture-loving species. Both cottonwoods and willows are ecological pioneers that colonize barren riparian areas. Within mixed stands of deciduous riparian forests, black cottonwood occurs as a codominant with red alder and bigleaf maple. In wetter regions, cottonwoods are followed in succession by other hardwoods, in the Pacific region, they are followed by conifers (Rood *et al.* 2003).

Arbutus

Arbutus is a long lived, moderately shade tolerant, seral species (Fowells 1965). Despite high rates of germination, seedling survival is poor on most sites. Poor seedling establishment on forested sites is attributed to mortality from litterfall, drought, seed predation, and insufficient light (Tappeiner *et al.* 1986). Successful establishment occurs most frequently on moist, partially shaded, mineral soil. However, as the conifer canopy closes Arbutus coverage gradually declines (Fowells 1965). Their massive, wide spreading root system is associated with ericoid mycorrhizae. Once established, arbutus are wind firm, drought tolerant, and somewhat tolerant of wet freezing conditions (Fowells 1965). Although Arbutus is ubiquitous throughout its range, it rarely occurs in pure stands (Fowells 1965). Thus the clump of Arbutus observed in Bowker Creek East is an unusual occurrence and there is a possibility it could have been planted.

Garry oak

Garry oak is the only native oak in western Canada. It is a tree that is uniquely adapted to the Mediterranean climate found in the rainshadow of Vancouver Island (GOERT 2007). It is exclusively found at low elevations, most often on dry, rocky slopes or bluffs, and sometimes on deep, rich, well-drained soil (Pojar and Mackinnon 1994). Less then 5% of the Garry oak ecosystems in Canada remain in an intact state (GOERT 2007). Garry oak ecosystems range from shady woodlands to open meadows, and in mixed stands they are most often associated with Arbutus and Douglas-fir (GOERT 2007).

A summary map of the arbutus and Garry oak points collected in phase two of the natural features study is presented in Figure 19.

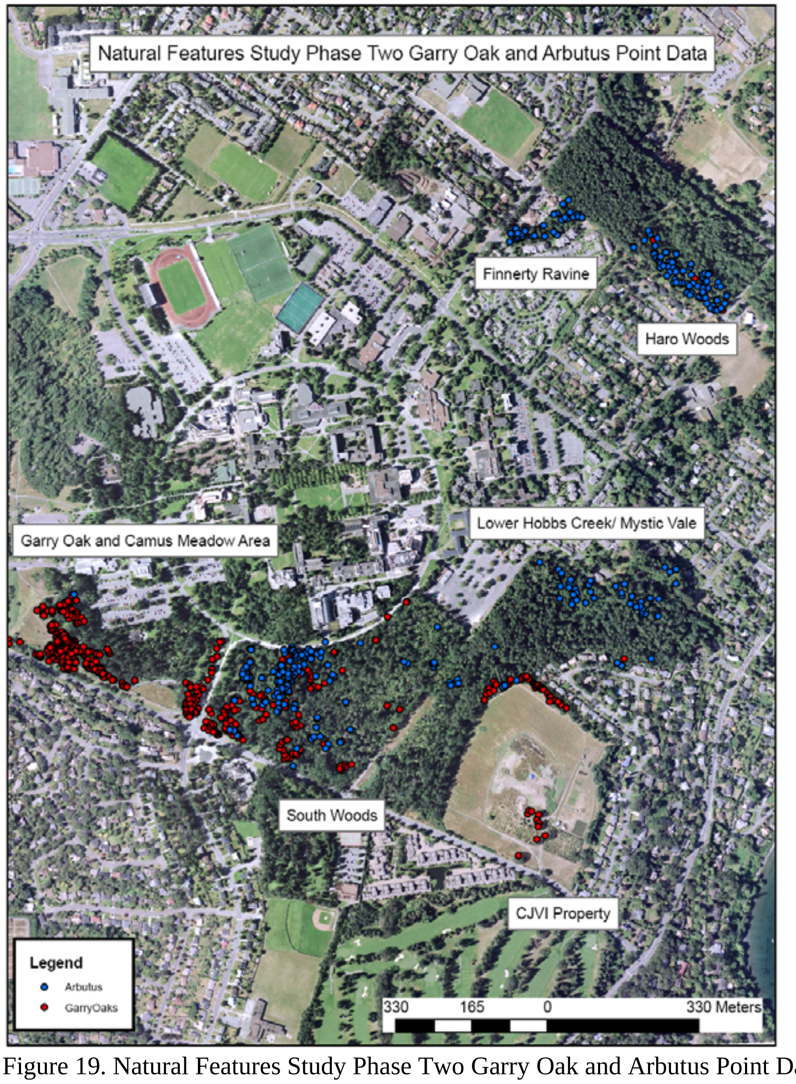


Figure 19. Natural Features Study Phase Two Garry Oak and Arbutus Point Data

### 4.2.4 Wetlands

Wetland ecosystems make up some of the most productive environments of the world. This type of ecosystem is uncommon on Southern Vancouver Island because of the rain-shadow climate (Ward *et al.* 1997), and because many historical wetlands have been drained for agriculture and urban development. Yet on Vancouver Island, wetlands support many habitat niches which provide critical territory for numerous mammal, bird, reptile, amphibian, and vertebrate species. Wetland classification is based on a combination of vegetation community and site factors such as hydrology and nutrient availability. However, it should be noted that there is considerable variation within these areas; wetland ecosystems are usually in a state of perpetual change and complexes of several different types of vegetation within one polygon are common. Wetlands occur where the water table is at, near, or above the soil surface, and where the soils are saturated for a sufficient length of time that water and the related low oxygen concentrations are the principle determinants of vegetation and soil development (McKenzie and Banner 1998).

The wetlands on campus are treed swamps. They are characterized by periodic flooding and nearly permanent subsurface water flow through mixtures of mineral and organic materials. And there is standing or gently flowing water through pools and channels which results in some aeration so there is sufficient dissolved oxygen to support shrubs or trees. The wooded wetlands on campus are dominated by 25% or more cover of flood tolerant trees and shrubs (Ward *et al.* 1997). Bowker Creek West exemplifies the swamp profile; the overstory is a combination of black cottonwood, bigleaf maple, and red alder, the understory is a mosaic of skunk cabbage, false lily of the valley, salmonberry, red-osier dogwood, snowberry, and Indian plum.

### 4.2.5 Riparian Areas

Riparian areas support a disproportionately high number of species for the area they cover. This is because they contain the three critical habitat components for wild life: water, food, and cover, and because they have a high level of plant diversity and structural complexity. Furthermore, riparian ecosystems have different microclimates from the surrounding coniferous forests due to increased humidity, higher rates of transpiration, and greater air movement (Ward *et al.* 1997). The ecological health of streams is heavily influenced through the shading, bank stability, and the addition of large woody debris contributed by the adjacent riparian ecosystem. Furthermore, riparian ecosystems experience chronic and episodic disturbances such as periodic flooding, wind throw, stream channel changes, and slope failures. This translates into a high level of structural forest features such as snags, downed logs, a multi layered uneven aged canopy, and a range of successional stages.

Riparian ecosystems vary in width and are delineated by site-specific vegetation, soil, and elevation features. The vegetation that develops within a riparian area varies with flooding frequency; this is because vegetation community growth depends on soil moisture and nutrient availability. A typical tree layer is a mix of flood tolerant conifers combined with red alder, black cottonwood, willows, and bigleaf maple. Typical shrubs include salmonberry, red elderberry, and devil’s club (*Oplopanax horridus*). The dominant plant species, vegetation age, and vegetation structure tends to exhibit a pattern of zonation radiating out from the aquatic feature (Ward *et al.* 1997). Riparian gullies are a type of elevational feature exhibited in Mystic Vale that in normal conditions would help define the width of the riparian area. Typical riparian gullies are steeply sloped and receive moisture and nutrients from above and thus they tend to be particularly rich and productive sites. However, Mystic Vale is not a typical, healthy riparian area due to high levels of anthropogenic disturbance, invasive species, and channel downcutting.

### 4.2.6 Woodlands

Woodlands are defined as open broad-leaved forests with a canopy covering less than 50%, pure stands of Garry oak or trembling aspen, and mixed stands of Douglas-fir-Garry oak and Douglas-fir-arbutus. Woodlands often occur on rocky knolls, south facing slopes, and ridges where summer soil moisture is low and shallow soils are common. Woodlands are characterized by an open stand structure and a rich mosaic of wildflowers, grasses, and shrubs. Common shrub species include snowberry, oceanspray and baldhip rose. The exception is trembling aspen woodlands which are typically associated with moist rich sites.

Woodlands in general support a rich assemblage of plants, insects, reptiles, and birds. This high level of biological diversity is linked to the stand structure complexity, particularly, the open canopy, mixed age class, snags, seasonal leaf fall, organically enriched upper soil layers, and there proximity to other ecosystem types (Ward *et al*. 1997). It is estimated that only 1-5% of the original Garry oak habitat on Southern Vancouver Island remains (Hebda 1993). Oak woodlands support the highest plant species diversity of any terrestrial ecosystem in coastal BC (Ward *et al.* 1997).

### 4.2.7 Older Second Growth Forests

Older second growth forests are coniferous forests 60-100 years old with a deciduous component (McPhee *et al.* 1997). Older second growth forests are the most common ecosystem type in the natural areas examined during this study. As the name implies, all second growth forests have been disturbed by either logging or some other anthropogenic disturbance. The second growth forests with the highest wildlife values are the mixed stands with red alder or bigleaf maple, and the older stands with some of the characteristics of older forests. Forest features associated with high biodiversity begin to develop after 80 years and include large, tall Douglas-fir, snags, Coarse Woody Debris, and dense saplings where gaps in the forest canopy have formed (McPhee *et al.* 1997)**.** Older second growth forests are ecologically important for several reasons. As these forests age their biodiversity values will increase thus they will be able to sustain more and larger species of plants and animals (McPhee *et al.* 1997). Older second growth forests provide connectivity between other natural areas and therefore promote the movement and dispersal of forest species across the landscape (McPhee *et al.* 1997). Finally, older second growth forests can act as buffers and minimize disturbance to sensitive ecosystems that occur within or adjacent to the forest stand (McPhee *et al.* 1997).

### 4.2.8 Younger Second Growth Forests

Younger second growth forests are mixed deciduous and conifer forests that have recently experienced a disturbance. The younger second growth forest fragments on campus are highly variable, contain a mixture of age classes in the overstory, and a mosaic of shrub and herbaceous vegetation patches in different stages of succession. The extent of the variability of any given site is dependant, in part, on the ecological memory of said site. Ecological