University of Victoria Natural Features Study
Bowker Creek, Cunningham Woods, Upper Hobbs Creek/Mystic Vale

Hilary Harrop-Archibald

Supervisor: Dr. Val Schaefer
Restoration of Natural Systems Program
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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 to supply important information to guide future planning on the campus as part of the Campus Plan Implementation program.

The Natural Features Study has been broken down into two phases. Phase one, the subject of this report, includes a literature review and 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. A thorough literature review was conducted, and data was collected on wildlife trees, woodpecker holes, bird nests, Coarse Woody Debris, rootballs, erratics, Arbutus trees, culverts, watercourses, successional status, tree, shrub and herb layer species composition, tree health, species cover, slope, 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, and zones with a strongly fluctuating water table in the study areas.

According to the indicator plant analysis, Bowker Creek East and upper Hobbs Creek contain FdBg-Oregon grape site series, Bowker Creek west contains Cw-Snowberry site series, Cunningham Woods east contains CwBg-Foamflower site series, and Cunningham Woods west contains Cw-Slough 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. Recommendations include invasive species removal, trail relocation, stream restoration, and stormwater management.

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. Phase One of the project included research and mapping three of the ecologically significant natural areas remaining on the University of Victoria campus lands, specifically, Bowker Creek, Upper Hobbs Creek, and Cunningham Woods (Figure 1) These areas include wetland and riparian ecosystems, woodlands, and second growth forests. For this project, an ecosystem is defined as a portion of natural campus landscape with relatively uniform dominant vegetation.

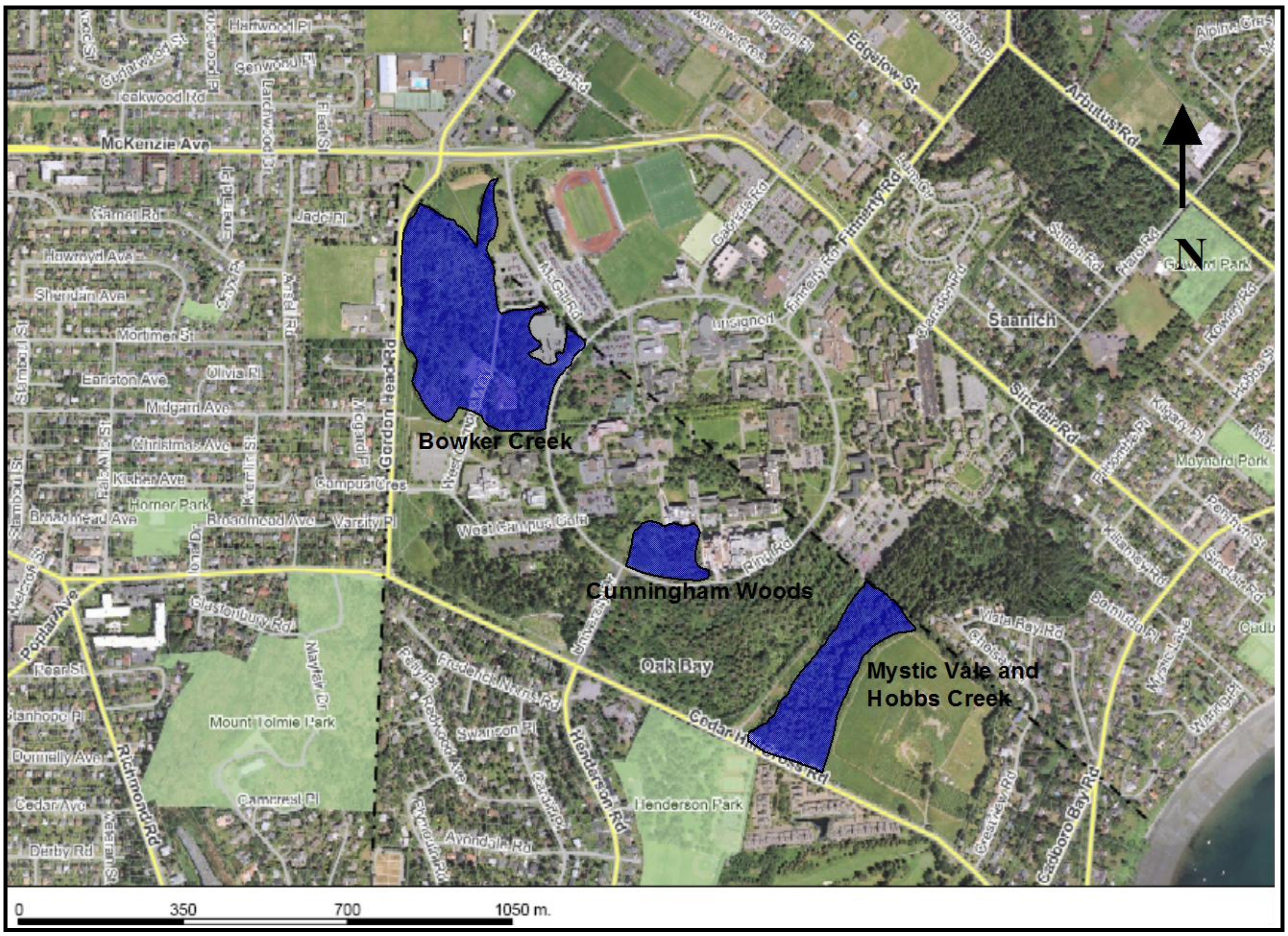


Figure 1. Ecologically significant areas on University of Victoria campus (image source: CRD Natural Areas Atlas)

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 summarized from reports from 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 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). Historically, this area was a 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) (Appendix C).

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 rainshadow 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 H (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). 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

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 shrew or 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 cottontail (*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).

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 I (Chatterson 1995).

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).

2.2 Site-specific Information

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

2.2.1 CJVI Property

The CJVI property 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 and broadcasting tower once used by the local radio station CJVI. The CJVI 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

The Garry Oak Meadow 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). 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 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 Reclamation Trials is 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). 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).

2.2.3 Finnerty Ravine and Haro Woods

The university portion of Haro Woods is a natural area encompassing 1.1 ha (2.8 acre). It 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). 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 campus portion of Finnerty Creek is surrounded by Lam Circle Ravine which is a steep sided gulley (20-30°) with exposed bedrock (Lloyd 2004). A preliminary map of this area can be found in Appendix L. The Finnerty Creek channel contains some Large Woody Debris and is slightly down-cut in some areas. 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).

2.2.4 South Woods

South Woods 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 X 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). 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.

The South Woods drains to the east into Mystic Vale through a culvert underneath the Haro Woods right-of-way (Lloyd 2004). 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).

2.2.5 Cunningham Woods and Native Plant Garden

A Native Plant Garden 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 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).

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).

2.2.6 Mystic Vale and Hobbs Creek

Hobbs Creek 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) area. 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 95% 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). 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. 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).

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 X 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 X 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 2). 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). 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).

Figure 2. Dead Trees Adjacent to Old Compost Site (2007)

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).

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.

2.2.7 Bowker Creek Headwaters

The Bowker Creek 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 S) 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 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).

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

2.3.1 General

Storm water 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.*

2.3.3 Finnerty Creek and 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.*

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 Geographic Information System (GIS). 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 using a Thales mobile mapper, and ArcPad software during the months of March and April. Differential GPS (DGPS) was used when mapping all polygons. Differential positioning is a technique that allows 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. The GIS data has been compiled and submitted to Facilities Management, and is summarized here.

There were occasions during point and line data collection when poor conditions did not allow for a differential fix; due to time constraints a 3D position was recorded in such a case. 3D positional readings require a minimum of four satellites to compute the position and elevation of each location. 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 Bowker Creek East, transects were approximately 20 m apart, whereas in the densely wooded areas 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. After all three areas had been traversed and were thus familiar to the observer, boundaries between relatively homogenous tree stands were mapped. The same process was used for both the shrub and herbaceous layers. Most vegetation was identified with field guide books. Vegetation that the observer was unsure of was photographed, put in a plant press, and brought to the herbarium for further study and accurate identification by herbarium staff.

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 2. 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).

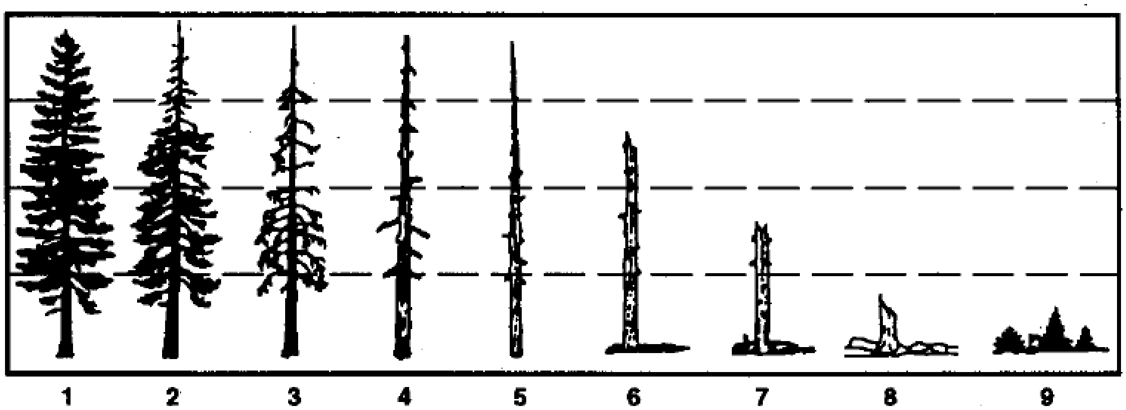


Figure 3 Visual Appearance Codes For Wildlife Trees (Green and Klinka 1994)

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 can not be sure that the counts are complete and these point data counts should be considered a minimum estimate for these areas.

<u>Coarse Woody Debris (CWD) & Rootballs</u>
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.

<u>Erratic</u>
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.

<u>Arbutus</u>
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.

<u>Culverts</u>
All culverts in the context of streams were mapped.

3.2.2 Attribute information collected as line data

<u>Watercourses</u>
Upper Hobbs Creek was mapped with 3 dimensions because a differential fix was not forthcoming on that particular day. 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.

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

Invasive Species Layer
This includes most large Himalayan blackberry and Scotch broom patches found within the study area. 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 question with ivy was not where it is, but where is it not? 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.

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 2. Natural Features Study Species Abbreviations and Indicator Species Group Designations

Species	Abbreviation	Moist. ISG #	Nut. ISG #
Pacific Crab Apple *Malus fusca*	MF	6	3
Bigleaf Maple *Acer macrophyllum*	ACM	4	3
Pacific Ninebark *Physocarpus capitatus*	PC	5	3
English Hawthorn *Crataegus monogyna*	CM	N/A	N/A
Black Cottonwood *Populus balsamifera ssp. Trichocarpa*	PB	4	3
Red Alder *Alnus rubra*	AR	N/A	3
Douglas-Fir *Pseudotsuga menziesii ssp. Menziesii*	PM	N/A	N/A
Grand Fir *Abies grandis*	AG	N/A	N/A
Western Redcedar *Thuja plicata*	TP	N/A	N/A
Arbutus *Arbutus menziesii*	AM	2	N/A
Garry Oak *Quercus garryana*	QG	2	N/A
Trembling Aspen *Populus tremuloides*	PT	N/A	3
Black Hawthorn *Crataegus douglasii*	CD	5	3
Bitter Cherry *Prunus emarginata*	PE	N/A	N/A
English Holly *Ilex aquifolium*	IA	N/A	N/A
Baldhip Rose *Rosa gymnocarpa*	RG	2	2
Himalayan Blackberry *Rubus discolor*	RD	N/A	N/A

Red-osier dogwood *Cornus stolonifera*	CS	5	3
Dull Oregon grape *Mahonia nervosa*	MN	3	2
Indian plum *Oemleria cerasiformis*	OC	4	3
Salmonberry *Rubus spectabilis*	RS	5	3
Salal *Gaultheria shallon*	GS	N/A	1
Daphne *Daphne laureola*	DL	N/A	N/A
English Ivy *Hedera helix*	HH	N/A	N/A
Thimbleberry *Rubus parviflorus*	RP	N/A	3
Trailing blackberry *Rubus ursinus*	RU	3	2
Scotch broom *Cytisus scoparius*	CSS	2	2
Nootka Rose *Rosa nutkana*	RN	4	3
Common Snowberry *Symphoricarpos albus*	SA	N/A	3
Oceanspray *Holodiscus discolor*	HD	2	2
Red Huckleberry *Vaccinium parvifolium*	VP	N/A	1
Cascara *Rhamnus purshiana*	RPU	5	3
Wild Gooseberry *Ribes divaricatum*	RDI	3	2
Red Elderberry *Sambucus racemosa ssp. Pubens*	SRP	4	3
Tall Oregon grape *Mahonia aquifolium*	MA	2	2
Red Flowering Current *Ribes sanguineum*	RSA	2	2
Rhododendron	Rspp	N/A	N/A
Scouler's Willow *Salix scouleriana*	SS	N/A	2
Sticky Current *Ribes viscosissimum*	RV	N/A	N/A
Rowan Tree *Sorbus aucuparia*	SAU	N/A	N/A
Black Twinberry *Lonicera involucrata*	LI	5	3
Saskatoon *Amelanchier alnifolia*	AA	3	2
Pacific Willow *Salix lucida ssp. lasiandra*	SL	N/A	N/A
White fawn lily *Erythronium oregonum*	EO	3	2
Cleaver *Galium aparine*	GA	N/A	3
Broad-leaved star flower *Trientalis latifolia*	TL	3	2
Creeping buttercup *Ranunculus repens*	RR	5	3
Pathfinder *Adenocaulon bicolor*	AB	3	3
Lady Fern *Athyrium filix-femina*	AFF	5	3
Skunk Cabbage *Lysichitum americanum*	LA	6	3
Bracken Fern *Pteridium aquilinum*	PA	N/A	N/A
False lily-of-the-valley *Maianthemum dilatatum*	MD	5	3

Pacific Water-Parsley *Oenanthe sarmentosa*	OS	6	3
Siberian Miner's-Lettuce *Claytonia sibirica*	CSI	4	3
Miner's Lettuce *Claytonia perfoliata*	CP	N/A	N/A
English Daisy *Bellis perennis*	BP	N/A	N/A
Fringecup *Tellima grandiflora*	TG	4	3
Pacific Sanicle *Sanicula crassicaulis*	SC	2	3
Foamflower *Tiarella trifoliata*	TT	4	3
Stinging Nettle *Urtica dioica*	UD	4	3
Sword Fern *Polystichum munitum*	PMU	N/A	3
Licorice Fern *Polypodium glycyrrhiza*	PG	N/A	N/A
Vanilla-Leaf *Achlys triphylla*	AT	N/A	3
Western Trillium *Trillium ovatum*	TO	4	3
Cooley's Hedge Nettle *Stachys cooleyae*	SCO	5	3
Deer Fern *Blechnum spicant*	BS	4	1
Few-Seeded Bitter-Cress *Cardamine oligosperma*	CO	N/A	N/A
Western Trumpet Honeysuckle *Lonicera ciliosa*	LO	2	2
Wall Lettuce *Lactuca muralis*	LM	4	3
Common Dandelion *Taraxacum officinale*	TOF	N/A	N/A
Mountain Sweet-Cicely *Osmorhiza chilensis*	OCH	4	3
Sitka Sedge *Carex sitchensis*	CSII	6	3
Poison-Hemlock *Conium maculatum*	CMA	N/A	N/A
Large-Leaved Avens *Geum macrophyllum*	GM	4	3
Herb-Robert *Geranium robertianum*	GR	N/A	N/A
Cutleaf Geranium *Geranium dissectum L.*	GD	N/A	N/A
Lyre-Leaved Rockcress *Arabis lyrata*	AL	N/A	N/A
Common Horsetail *Equisetum arvense*	EA	N/A	2
Scouring-Rush *Equisetum hyemale*	EH	4	3
Fig Buttercup *Ranunculus ficaria*	RF	N/A	N/A
Common Vetch *Vicia sativa*	VS	N/A	N/A

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 3 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

Slope
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.

Aspect
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
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.
- 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.

<u>Date</u>
The date that the polygon data was recorded has been noted

<u>Area</u>
The total area of each polygon in m^2 has been calculated.

<u>Ecosystem Classification (Tree Layer Only)</u>
Each polygon was classified as a wetland, riparian area, woodland, or older second growth forest.

3.2.4 Attribute information observed but not spatially referenced

Water Quality
An oily sheen was observed on the water in both Bowker Creek and Upper 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
Two resident black tailed deer were observed in Cunningham Woods, and there were several student observations of five resident black tailed deer in Bowker Creek. There was also a morningcloak butterfly (*Nymphalis antiopa)* observed in Bowker Creek and 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, there was one occasion where an unusually large congregation of approximately 40 Stellar Jays was observed in Bowker Creek; Stellar Jays are moderately territorial and tend to travel in pairs and family groups so an assembly this size seemed odd. Additional observations in Bowker Creek include numerous animal tracks (Figure 3), an ungulate skull (Figure 4), and several bird and rabbit carcasses.

Figure 4. Animal Tracks in Bowker Creek

Figure 5. Ungulate Skull in Bowker Creek

There have also been several invasive American bullfrog (*Lithobates catesbeianus)* observations made on campus. Several years ago there were bullfrogs observed in both the pond adjacent to the University Club and the pond next to the Biology building. However, it appears that bullfrogs no longer inhabit these areas. This spring, a bullfrog was captured in Finnerty Gardens. As there are no source populations within the immediate vicinity of the campus, the bullfrogs must be moving to the campus via human translocation (Govindarajulu pers. com. 2007).

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 not all of the foliage was out, 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 underestimated. 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 6 to 8.

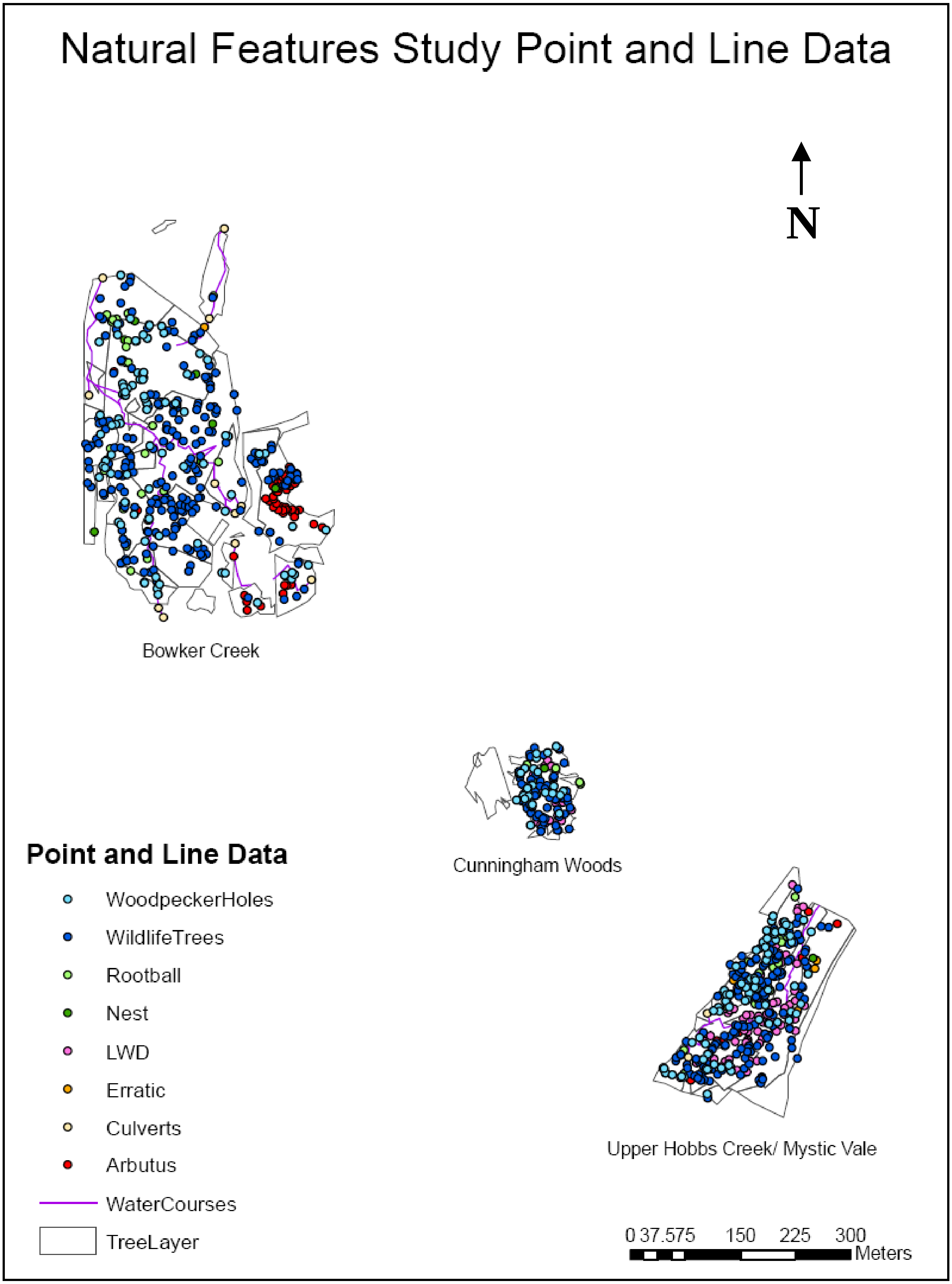


Figure 6. Point and Line Data

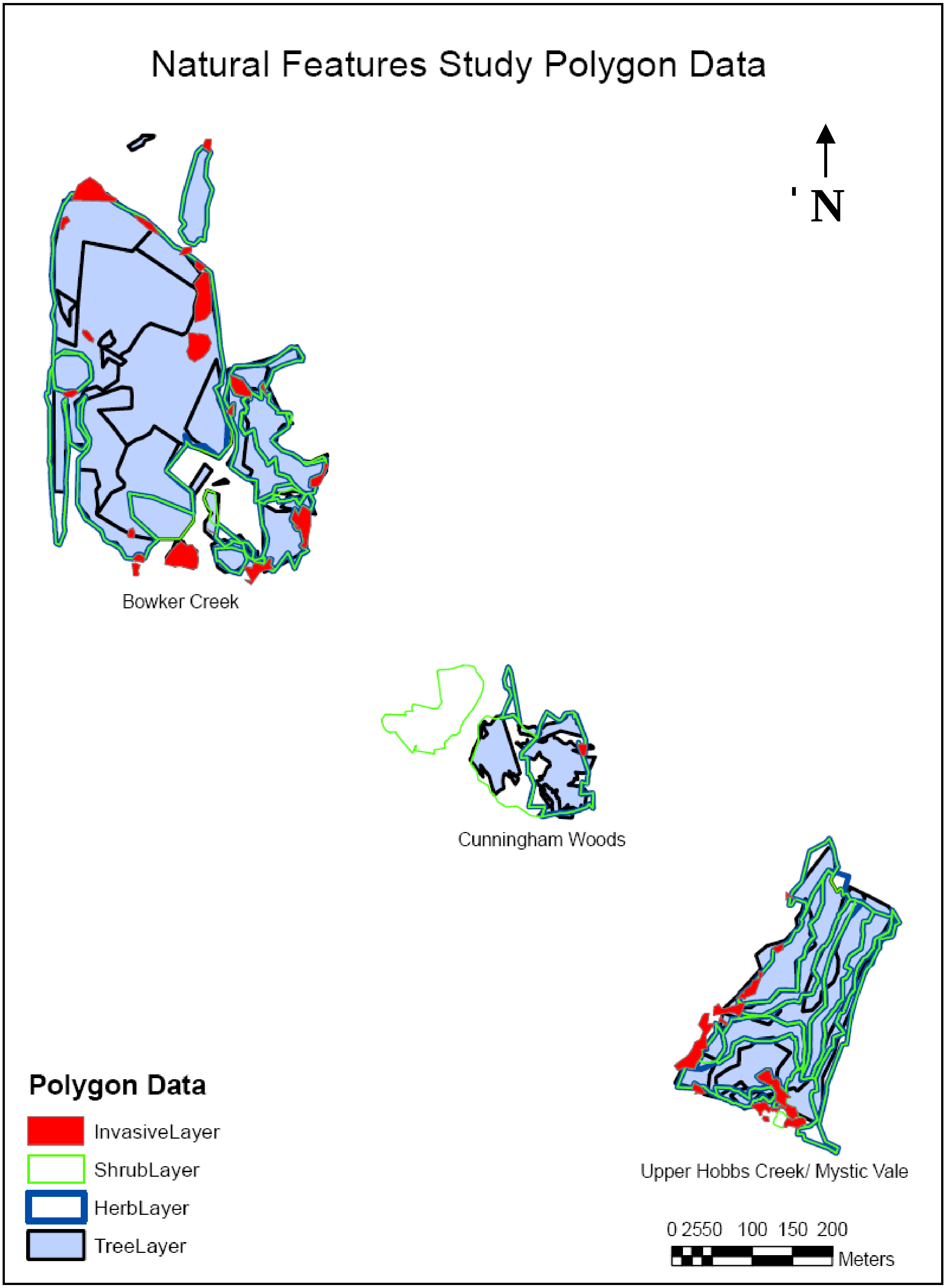


Figure 7. Polygon Data

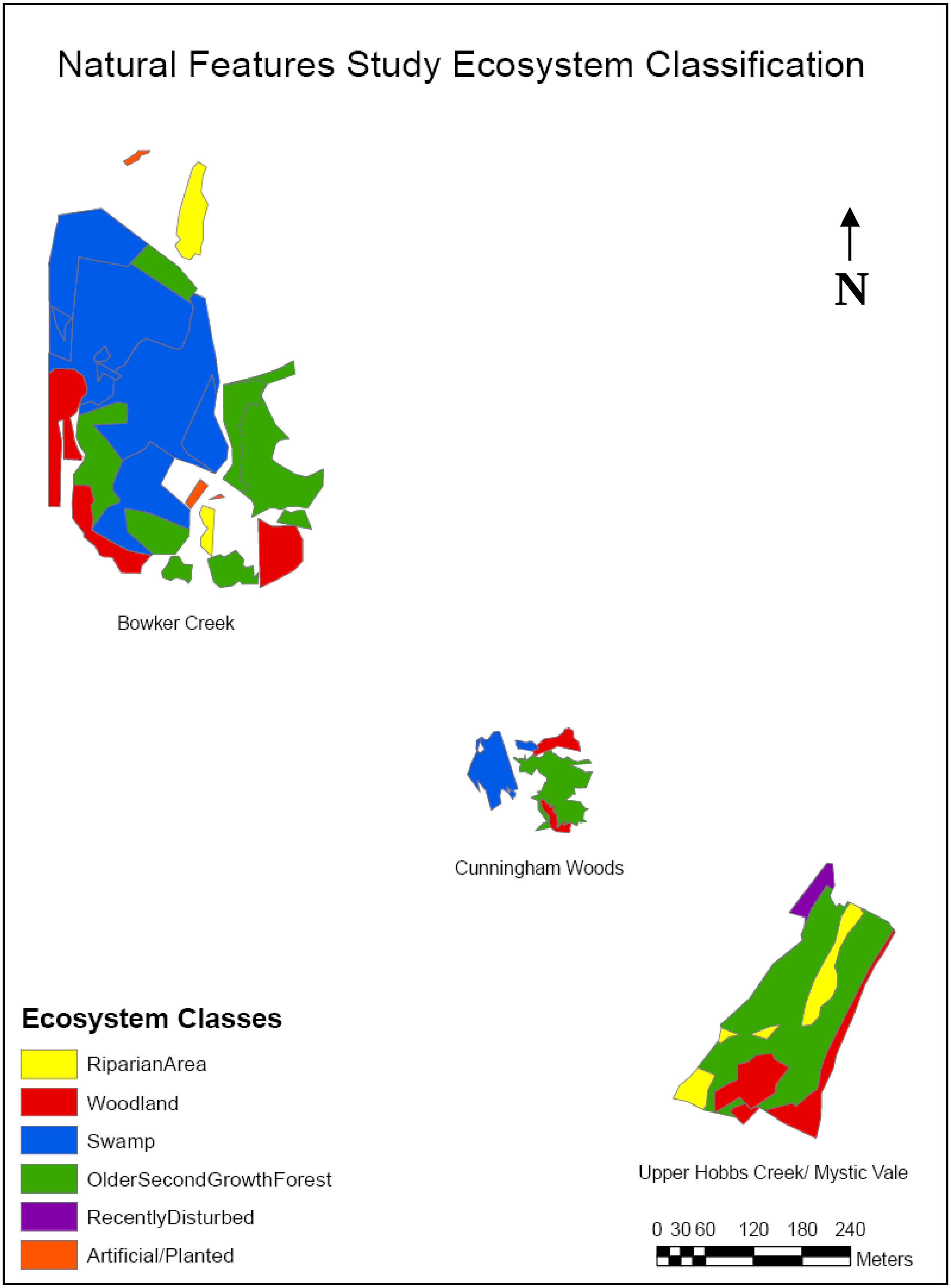


Figure 8. Ecosystem Classification

4.1 Site Series Classification Scheme

Terrestrial Ecosystem Mapping (TEM) 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 4 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 5 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 of each ISG for each site (Table 6) and then using this information to determine site series. 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: Bowker Creek East, Bowker Creek West, Upper Hobbs Creek, Cunningham Woods East, and Cunningham Woods West. 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 6. Study Area ISG Frequency Profiles

Frequency Profiles (Bowker Creek West)

Moisture Regime	ISG1	ISG2	ISG3	ISG4	ISG5	ISG6	Total
Summed Cover		7	3.5	102	65.5	33.5	211.5
Frequency (%)		3	2	48	31	16	100
Nutrient Regime	ISG1	ISG2	ISG3	Total			
Summed Cover		10	272.5	283			
Frequency (%)		4	96	100			

Frequency Profiles (Bowker Creek East)

Moisture Regime	ISG1	ISG2	ISG3	ISG4	ISG5	ISG6	Total
Summed Cover		40	22	93.5	33		188.5
Frequency (%)		21	12	51	18		100
Nutrient Regime	ISG1	ISG2	ISG3	Total			
Summed Cover	3	41	178	222			
Frequency (%)	1	19	80	100			

Frequency Profiles (Mystic Vale)

Moisture Regime	ISG1	ISG2	ISG3	ISG4	ISG5	ISG6	Total
Summed Cover		37.5	37	59	12.5	3	149
Frequency (%)		25	25	40	8	2	100
Nutrient Regime	ISG1	ISG2	ISG3	Total			
Summed Cover	1.5	51	151	204			
Frequency (%)	1	25	74	100			

Frequency Profiles (Cunningham Woods East)

Moisture Regime	ISG1	ISG2	ISG3	ISG4	ISG5	ISG6	Total
Summed Cover		36	36	44	59		175
Frequency (%)		21	21	24	34		100
Nutrient Regime	ISG1	ISG2	ISG3	Total			
Summed Cover		51	159	210			
Frequency (%)		24	76	100			

Frequency Profiles (Cunningham Woods West)

Moisture Regime	ISG1	ISG2	ISG3	ISG4	ISG5	ISG6	Total
Summed Cover				78.5	3		81.5
Frequency (%)				96	4		100
Nutrient Regime	ISG1	ISG2	ISG3	Total			
Summed Cover			178	178			
Frequency (%)			100	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**
Bowker Creek East	Slightly Dry and Fresh to Moist	Rich and Very Rich	N/A	FdBg-Oregon grape
Bowker Creek West	Very Moist to Wet	Rich and Very Rich	Floodplain/ High Bench Site	Cw-Snowberry
Cunningham Woods East	Slightly Dry and Fresh to Moist	Rich and Very Rich	N/A	CwBg-Foamflower
Cunningham Woods West	Wet	Rich and Very Rich	Strongly Fluctuating Water Table	Cw-Slough sedge
Upper Hobbs Creek	Moderately Dry to Slightly Dry and Fresh	Rich and Very Rich	N/A	FdBg-Oregon grape

In two instances the areas under consideration were classified as special sites due to the unique environmental features of the sites. Bowker Creek West was classified as a high bench floodplain site because it is under the influence of periodic flooding, a forest floor is present, there are mature stands dominated by conifers which are restricted to elevated micro sites, and there are successional stands dominated by red alder, cottonwood, and bigleaf maple. Cunningham Woods West was classified as a site with a strongly fluctuating water table because the soil moisture regime of this site varies significantly through out the year. In the winter months water was observed spilling out beyond the periphery of the naturally vegetated area onto the surrounding lawn; in the summer months this is not the case. Thus the soils 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. Notably, Upper 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. The results from the site series assessment are shown in figure 9.

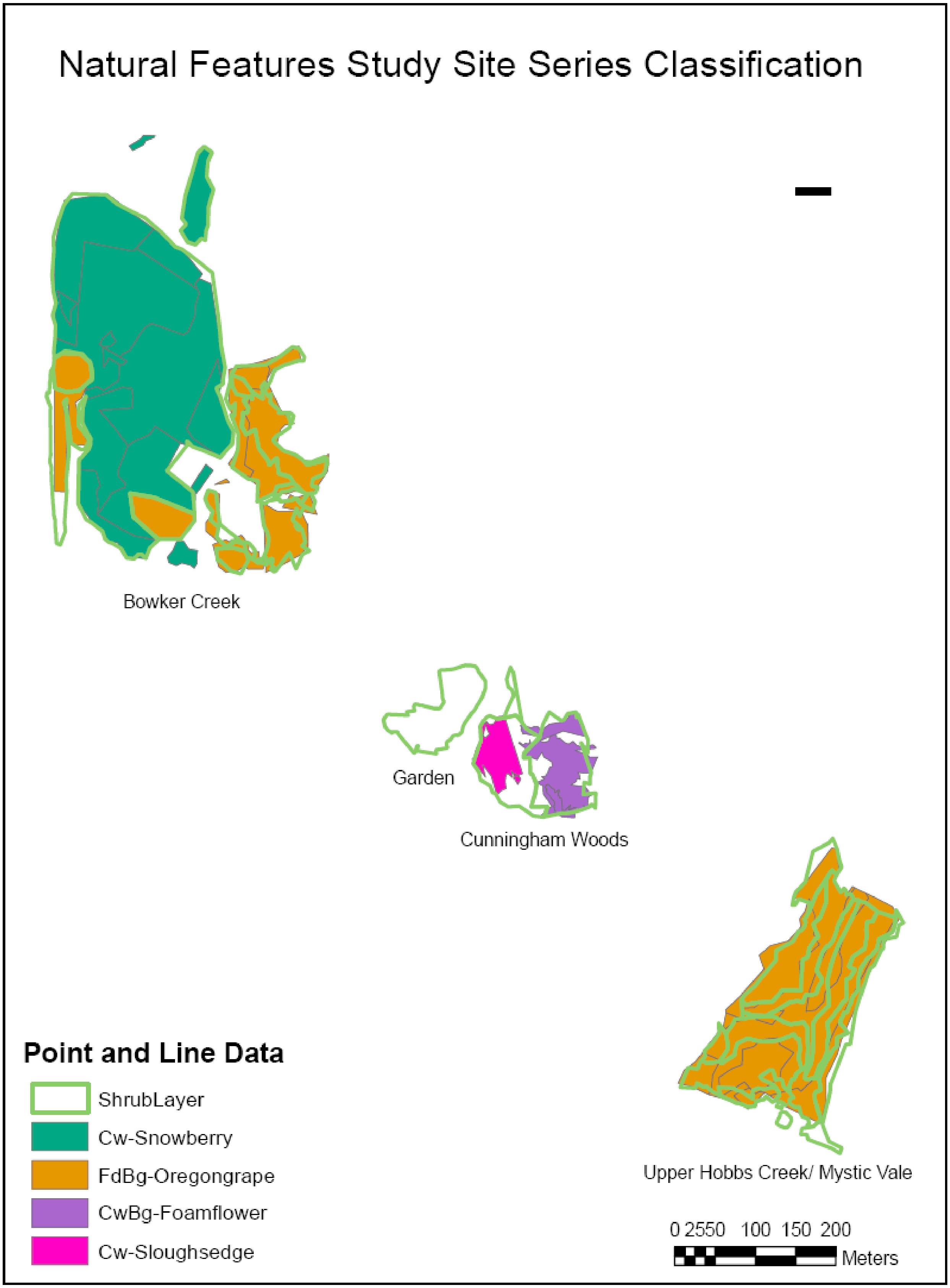


Figure 9. Site Series Classification

4.2 Sensitive Ecosystem Inventory Classification Scheme

The sensitive ecosystem inventory 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 used for this project were wetlands, riparian areas, woodlands, and older second growth forests. 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 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. The tree layer of the study sites is shown in Figure 7.

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.

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 big leaf 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).

5.0 Discussion and Recommendations

The eastern coastal lowland of Vancouver Island has exceptionally high biodiversity values and comprises a unique ecological region in Canada. Intense development pressure has resulted in the loss of many rare ecosystems in the Greater Victoria area. This report was initiated in response to the urgent need for inventory information on the natural areas of the University of Victoria campus, to support sound land use planning and promote good land stewardship. This report provides scientific data on ecosystem distribution, vegetation, quality and condition as an aid to land management decisions. Following is a brief general assessment of each area considered during phase one of the Natural Features Study, as well as recommendations for management and restoration. More detailed information can be found in the attribute tables associated with the maps.

5.1 Bowker Creek

The Bowker Creek natural area on the campus is in a constant state of flux; this is evident by the mosaic of shrub and herb species with different water tolerances throughout the swamp. These changes in hydrology are due to storm water diversion, development, increased impervious surfaces, and natural seasonal fluctuation. The swamp plays an important role in moderating the hydrology of Bowker Creek by slowing rainfall runoff into the stream and acting as a storage site for surface water; the result is reduced peak storm flows and increased summer base flows. Considering the importance of this wetland as wildlife habitat, and the implications the wetland has for downstream water quantity and quality, it is recommended that development within or adjacent to the wetland not occur.

Wetlands such as Bowker Creek act as natural biofiltration devices because they reduce the levels of sediment, nutrients, and toxic chemicals in outflow water (McPhee *et al.* 2000). In the past, wetlands were commonly undervalued (and consequently destroyed and converted to more "productive" uses) or used for disposal of refuse and waste water. Although these wetlands currently receive stormwater, and likely function to improve the downstream water quality, the ability of natural wetlands to take up pollutants without damage is limited (EPA 1996). Stormwater can have a number of deleterious effects on natural wetlands, due to factors such as excess sedimentation, alteration of hydrological patterns, and pollutants that may be toxic to, or otherwise alter, microorganism and plant/animal communities (EPA 1996). Wetlands are vulnerable to changes in hydrology and water quality; lowering of the water table, urban storm drainage, sediment from construction sites, and even limited changes nitrogen or phosphorus levels (Ward *et al.* 1997). Factors such as the source, velocity, renewal rate and timing of water entering the wetland affect the type and location of the wetland and sediment nutrients which then affect the ecosystem characteristics such as species composition, primary productivity, and nutrient cycling (McPhee *et al.* 2000). For example, short-term flooding can lead to increased soil moisture and nutrient deposition whereas long-term flooding can reduce dissolved oxygen, increase levels of toxic materials in the soil, and reduce water and nutrient uptake (Keeland and Sharitz 1997). Therefore, direct discharge of additional stormwater to natural wetlands such as Bowker Creek is not recommended; it is preferred to infiltrate and treat stormwater on site, using a combination possible best management practices, including watershed planning and management, and structures such as raingardens, swales and constructed wetlands (EPA 1996). It should also be noted that the Ministry of Environment Riparian Area Regulation prohibits treatment of stormwater within the Streamside Protection and Enhancement Area next to streams/wetlands (Province of British Columbia 2004).

5.2 Cunningham Woods

Cunningham Woods is a small patch of forest and wetland relative to the other natural areas assessed in phase one of this study. However, Cunningham Woods's proximity to South Woods makes Cunningham Woods accessible to wildlife which increases the wildlife habitat value of this area, for example the two resident black tailed deer which are frequently observed browsing in Cunningham Woods. Furthermore, Cunningham Woods seems to contain a disproportionately high number of native plant species relative to the other natural areas assessed. This plant diversity may be attributed to fewer invasive plants, the occurrence of two distinct ecosystem types, and a high level of structural complexity which translates into a greater number of plant habitat niches.

As previously mentioned, the wetland portion of Cunningham Woods West appears to have a strongly fluctuating water table because the soil moisture regime of this site varies significantly throughout the year. In the winter months water spills out beyond the periphery of the naturally vegetated area onto the surrounding lawn; in the summer months there is no water visible in the wetland. For this reason it is recommended that no stormwater be diverted to this area.

5.3 Mystic Vale

Mystic Vale is not a healthy functional riparian area. A significant portion of Mystic Vale is overrun with English ivy. This translates into reduced native herbaceous species cover and diversity, and reduced wildlife habitat. Trail placement in conjunction with dog activity has resulted in the removal of stream bank vegetation. The consequences of riparian area vegetation removal include decreased drag which increases water velocity and scouring, decreased bank stability leading to erosion, undercutting and slumping, and increased water turbidity (Figure 10). Another issue associated with the trail network in Mystic Vale is that soil compaction of the root zone along trails may be leading to deteriorating tree health.

Figure 10 Erosion of Stream Bank Adjacent to Trail

The findings of this study concur with the recommendations put forth by the previous studies presented in the literature review (Section 2.3) with one exception. Considering the amount of blowdown that occurred in Mystic Vale during the wind storms this past winter, and the gaps this has created in the canopy, it is no longer considered necessary to remove selected trees to increase the sunlight penetrating to promote understory vegetation growth.

Another issue is the impact of the high volume of dog traffic throughout Mystic Vale; throughout this study not a single dog was observed on a leash even though there are signs posted asking owners to do so at both ends of Mystic Vale. This is a concern because dogs frequently go off trails and trample the already stressed native vegetation, contribute to stream bank instability and erosion, and reduce water quality by increasing the particulate matter suspended in the water.

The cumulative effects of poorly placed trails, stream downcutting, bank erosion, invasive species, and trampling by dogs are having a significant negative impact on the health and function of Mystic Vale. Managing access through active control methods such as fences, railings, trail relocation, rogue trail decommissioning, elevated boardwalks, and passive methods such as more signs stating restrictions regarding dogs on leashes and careful site selection for trail relocation would go a long way towards improving the health of Mystic Vale. Significant work is necessary to restore Mystic Vale, but given its historical cultural significance, and current local use of the area, it is recommended that the university make this a priority.

5.4 Additional Inventory Data

Ideally, this inventory should take place through all of the seasons over a period of a year. Otherwise trails could unknowingly be built over a rare species that was not previously observed due to seasonality. In such as case, the very values that land managers on campus are attempting to maintain would either be highly disturbed or destroyed.

5.5 Invasive Species Removal

The most significant threat to the natural areas observed in this study is the invasion of exotic species. Exotic species are dispersed throughout all of the natural areas studied. The five most common invasive species are: English holly, English hawthorn, daphne, Himalayan blackberry, and English ivy. Of these species the ivy and blackberry are the most pervasive.

5.5.1 English Ivy

English ivy exhibits dense growth with abundant leaves which blocks sunlight from low growing native plants, crowds them out, and prevents the germination of their seeds. All of the natural areas examined in this study contain patches of 'ivy desert' where ivy growth is so dominating that it has excluded most other plants on the forest floor. English ivy was also observed on the trunks of many trees. This is an issue because it deprives bark of normal contact with air and micro-organisms. Heavy ivy cover may reduce the tree's foliage and thus its capacity for photosynthesis, and the weight of the vines and leaves together with moisture from rain, makes these trees top-heavy and prone to damage or blowdown during windstorms (GOERT 2003). Significantly, almost all of the blowdown trees in the area surveyed, which are marked as rootballs on the map, are covered with ivy.

The highest priority for ivy removal should be the ivy on tree trunks to remove the seed source; ivy only produces fruits and seeds after a vertical climb (GOERT 2003). Vines should be cut approximately one meter above ground level to kill the upper portions, after which, the vines can be left to decay on the trees or be removed when brittle (GOERT 2003). Vines on the ground can be hand-pulled, and shovels should be used to remove as much of the root system as possible. It is important to pull seedlings before they become firmly established. In order to minimize soil erosion, large areas on steep slopes should not be cleared all at once, clearing should not be conducted too soon before heavy winter rains, and the ground should be re-planted, and preferably mulched, immediately after clearing.

5.5.2 Himalayan blackberry

Himalayan blackberry can turn open areas into shrub dominated ecosystems. Himalayan blackberry has a dense canopy which blocks out light, eliminates the ground cover of most native herbaceous species, and prevents the sprouting and establishment of small trees (GOERT 2003). Himalayan blackberry can be cut and removed with hand tools including shears/loppers, shovels and weed wrenches. This should be done before the blackberry seeds set and is easiest when the ground is still moist. The root should be removed as much as possible to minimize resprouting. If the blackberry is pulled before seeds are produced, the debris may be piled and left as brush cover for birds and small mammals. However, care must be taken to prevent the rooting of cut material, and areas where blackberry has been removed should be checked in subsequent years for any sprouting roots which may have been missed. Large established patches can be controlled by cutting new growth from late July to early October. This will prevent the tips from rooting and expanding the patch. The time of year control measures are initiated is important. If the blackberry is cut too early in the year new tips will grow (GOERT 2003).

7. Conclusions

The Natural Features Inventory is intended to be used as a management tool and alert land use decision makers to the current state of the natural areas on campus and the existence of important ecological features. Although these ecosystems are mapped individually, most are interdependent and should not be considered in isolation; they must be evaluated within the context of the overall landscape. Small, fragmented stands do not support a large diversity of wildlife. However, the University of Victoria natural areas function as reservoirs for biodiversity in an otherwise highly urbanized landscape, act as buffers between residential areas and more fragile ecosystems such as riparian areas, and provide wildlife corridors and important habitat niches throughout the campus. In other words, the value of individual ecosystem types lies at least in part on their spatial pattern upon a landscape and how they abut and interact with nearby ecosystems and land use. Where there is a mosaic of ecosystems such as wetlands mixed with woodlands or second growth conifer forests, the value of individual ecosystem components is greatly enhanced as wildlife habitat. For example, many of the bird species that mainly feed in wetlands will perch or nest in adjacent forests. Another example are some amphibians, which spend most of their year in forest habitats but reproduce in wetlands.

All of the natural areas on campus have been modified by human activity to some extent. Nevertheless, if any land use changes such as storm water diversion or development are being contemplated, it is imperative that a site assessment is carried out by a qualified professional to determine if the proposed change will have a detrimental effect on the ecosystem. Time can not be turned back, however, it is possible to conserve, restore, and enhance ecosystem remnants so that they function well for future generations of humans and wildlife species. Ecosystems and plant species will change over time through the process of succession regardless of human involvement. Yet the remaining ecosystems on campus can be managed to maintain resource values while simultaneously minimizing the loss of ecosystem function.

8. References

BC Ministry of Forests and BC Ministry of Environment. 1998. Field Manual For Describing Terrestrial Ecosystems. BC Min. For. And BC Min. Environ., Lands and Parks, Victoria, BC.

Cannings, R. and S. Cannings. 1996. British Columbia: A Natural History. Graystone Books, Vancouver.

Capital Regional District and Provincial Capital Commission. 1996. Green/Blue Spaces Strategy: Proposed Green/Blue Spaces Systems for the Saanich Peninsula, Core Communities, and Western Communities. Victoria, British Columbia.

Capital Regional District. 2003. Bowker Creek Watershed Management Plan. http://crd.bc.ca/es/environmental_programs/stormwater/bowker_creek.htm

Chandler, L. 1995. Trillium Research Project Phase Two: Survey of the Introduced Invading Vegetation in the Natural Areas of the UVic Campus. Submitted to ES 490. Unpublished Document. Victoria, British Columbia.

Chatterson, B. (no date) A Study of Coarse Woody Debris and Wildlife Trees in the Natural Areas of the University of Victoria. Submitted to ES 490. Unpublished Material. Victoria, British Columbia

Costanzo, G., Allen, G.A., and J.A. Antos. 1995. Checklist of Vascular Plants of the UVic Campus. University of Victoria Herbarium Contribution No. 3. Victoria, British Columbia.

Fowells, H.A. 1965. Silvics of Forest Trees in the United States. Agric. Handb. 271. Washington, DC: U.S. Department of Agriculture, Forest Service.

Friends of Bowker Creek website. http://bowkercreek.org

Franklin, J.F. and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR. U.S. Department of Agriculture, Forest Services, Pacific Northwest Forest and Range Experiment Station.

Garry Oak Ecosystem Recovery Team. 2003. Field Manual: Invasive Species in Garry Oak and Associated Ecosystems in BC. http://www.goert.ca/resources/invspecies.htm

Garry Oak Ecosystem Recovery Team. 2002. Recovery Strategy for Garry Oak and Associated Ecosystems and their Associated Species at Risk in Canada, 2001-2006 (Draft 20 February 2002). Victoria, British Columbia.

Godfrey, A. and P. Comeau. 1975. A Preliminary Survey of the Epiphytic Bryophytes on the University of Victoria Campus. Submitted to Biology 418. Unpublished Document. Victoria, British Columbia.

Green, R. and K. Klinka. 1994. A Field Guide for Site Identification and Interpretation for the Vancouver Island Forest Region. Land Management Handbook Number 28, Ministry of Forests. Victoria, British Columbia.

Hebda, R. 1993. Garry Oak-Meadow Colloquium Proceedings, 1993, Victoria, BC. Garry Oak Meadow Preservation Society, Victoria, BC.

Hocking, M. 2000. UVic Sustainability Project: 2.1 Campus Ecology. Unpublished Document. Victoria, British Columbia.

Hosie, R.C. 1969. Native Trees of Canada. 7th ed. Ottawa, ON: Canadian Forestry Service, Department of Fisheries and Forestry. 380 p.

Isaac, L. 1943. Reproductive habits of Douglas-fir. Washington, DC: Charles Lathrop Pack Forestry Foundation. 107 p.

Ketcheson, M.V., Kromm, K.L. and W.D. Wainwright. 1975. Mapping the Vegetational History of the UVic Campus. Submitted to Biology 418. Unpublished Material. Victoria, British Columbia

Keeland, B.D. and R.R. Sharitz. 1997. The Effects of Water Level Fluctuations on Weekly Tree Growth in a Southeastern USA Swamp. American Journal of Botany 84(1): 131-139.

Klinka, K., Feller, M.C., Green, R.N. 1990. Ecological Principles: Applications. *In* Lavender, D.P., Parish, R., and C.M. Johnson (eds). Regenerating British Columbia's Forests. Vancouver, BC. University of British Columbia Press:55-72

Krajina, V.J., Klinka, K. and J. Worrall. 1982. Distribution and Ecological Characteristics of Trees and Shrubs of British Columbia. Vancouver, BC: University of British Columbia, Department of Botany and Faculty of Forestry.

Lloyd, R.H. 2004. Integrated Stormwater Management Plan. University of Victoria Project No. 02-4367. Victoria, British Columbia.

Lucey, W.P., Barraclough, C.L., Malmkvist, L., LaCas, B. and V. Wilson. 2002. Audit of the Proper Functioning Condition (PFC) of Hobbs Creek: Watershed Management Plan. Unpublished Document. Victoria, British Columbia.

McKenzie, W, and A. Banner. 1998. A Wetland and Riparian Ecosystem Classification Framework (WREC) for British Columbia. Unpublished draft.

McPhee, M., Ward, P., Kirkby, J., Wolfe, L., Page, N., Dunster, K., Dawe, N.K., and I Nykwist. 1997. Sensitive Ecosystem Inventory: East Vancouver Island and Gulf Islands, 1993-1997. Volume 2: Conservation Manual. Technical Report Series No. 345, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Province of British Columbia. 2004. Riparian Areas Regulation. Order in Council No. 837.
http://www.env.gov.bc.ca/habitat/fish_protection_act/riparian/documents/regulation.pdf

Rood, S.B., Braatne, J.H. and F.M.R. Hughes. 2003. Ecophysiology of Riparian Cottonwoods: Stream Flow Dependency, Water Relation and Restoration. Tree Physiology 23, 1113-1124.

Schmitt, C. 2005. A Field Guide to Aquatic Phenomena.
www.umaine.edu/WaterResearch/FieldGuide/Field%20guide.pdf

Tappeiner, J.C., McDonald, P.M. and T.F. Hughes. 1986. Survival of Tanoak and Pacific Madrone Seedlings in Forests of Southwest Oregon. New Forests. 1: 43-55.

Tatum, J.B., Barclay, H., Harvey, T., Harcombe, A., Ring, R. and A. Saunders. 1971. Report of the Ad Hoc Committee to Investigate Campus Bird Populations. Unpublished Report. Victoria, British Columbia

Thurber Engineering Ltd. 2003. UVic Storm Water Disposal Study Geotechnical/ Geological Conditions. Unpublished Document. Victoria, British Columbia.

Turner, N. 1993. UVic Graduating Class Funding for Establishment of a Native Plant Garden. Unpublished Letter. Victoria, British Columbia.

Turner, N. 2000. Wild Habitats of UVic's Campus. Unpublished Document. Victoria, British Columbia.

University of Victoria. 2006. Sustainability Report.
http://web.uvic.ca/fmgt/pdf/SustainRpt_web.pdf

University of Victoria. 2003. Campus Plan. http://web.uvic.ca/vpfin/campusplan/

Ward, P. Radcliffe, G., Kirkby, J., Illingworth, J., and C. Cadrin. 1997. Sensitive Ecosystem Inventory: East Vancouver Island and Gulf Islands, 1993-1997. Volume 1: Methodology, Ecological Descriptions and Results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

United Stated Environmental Protection Agency. 1996. Protecting Natural Wetlands: a Guide to Stormwater Best Management Practices. EPA-843-B-96-001

Westland Resource Group. 1993. An Environmental Overview of the University of Victoria's Eastern Lands. Unpublished Document. Victoria, British Columbia.

Appendix A –UVic Vascular Plant Species (Herbarium 2000)

Checklist of Vascular Plants of the UVic Campus
University of Victoria Herbarium Contribution No. 3
Compiled by B. Costanzo, G. A. Allen and J. A. Antos
April 1995; updated February 2000.

II. Overall Species List (* recorded by David Newell in 1983 list and "?" indicates doubtful occurrence or not inventoried since 1993)

Abies grandis
Acer circinatum -planted
Acer glabrum*?
Acer macrophyllum
Achlys triphylla
Adenocaulon bicolor
Agropyron repens
Agrostis alba*
Agrostis exarata*
Agrostis oregonesis*
Agrostis tenuis*
Aira praecox (outcrops)
Allium acuminatum
Alnus rubra
Alopecurus geniculatus
Amaranthus albus*
Amaranthus retroflexus*
Amelanchier alnifolia
Anagalis arvensis
Anemone lyalli*?
Anthemis arvensis*
Anthemis cotula
Anthoxanthum odoratum
Arabidopsis thaliana
Arbutus menziesii
Arenaria macrophyllum
Arrhenatherum elatius
Aruncus slyvester*?
Aster eatonii*
Aster hesperis*?
Aster sp.
Aster subspicatus
Athyrium filix-femina

Avena fatua
Barbarea verna*
Bellis perennis
Betula sp.
Bidens amplissima*
Brassica campestris
Brassica nigra*
Brassica sp.
Brodiaea coronaria
Brodiaea hyacinthina (=Triteleia hyacinthina)
Bromus carinatus*
Bromus pacificus
Bromus sitchensis*
Bromus tectorum*
Calandrinia ciliata
Capsella bursa-pastoris
Camassia quamash
Cardamine angulata
Cardamine oligosperma
Cardamine pulcherrima
Carex hendersonii
Cerastium arvense (outcrops)
Cerastium vulgatum*
Chenopodium album
Chrysanthemum leucanthemum
Cirsium arvense
Cirsium edule
Cirsium sp.
Conium maculatum*
Convolvulus arvensis
Convolvulus sepium
Corallorhiza maculata
Cornus stolonifera
Crataegus douglasii
Crataegus monogyna
Cynosurus cristatus
Cytisus scoparius
Dactylis glomerata
Daphne laureola
Daucus carota
Disporum hookeri*?
Dodecatheon hendersonii
Dodecatheon pulchellum*?
Dryopteris expansa
Echinochloa crusgalli*
Epilobium angustifolium

Epilobium munitum
Epilobium sp.
Epipactis helleborine
Equisetum arvense
Erodium cicutarium
Erythronium oreganum
Erythronium revolutum
Eschscholtzia californica*
Galium triflorum
Gaultheria shallon
Geranium carolinianum
Geranium dissectum*
Geranium molle (outcrops)
Geranium pusillum*?
Geum macrophyllum
Glyceria striata (in stream near bridge) Gnaphalium palustre*
Goodyera oblongifolia
Habenaria dilatatum
Hedera helix
Heracleum lanatum*
Hieracium sp.
Holcus lanatus
Holodiscus discolor
Hordeum leporinum*?
Hypericum formosum*
Hypericum perforatum*?
Hypochaeris radicata
Ilex aquifolium
Juncus balticus*
Juncus bolanderi*?
Juncus bufonius*
Juncus effusus (in drainage ditch) Juncus tenius
Lactuca communis
Lactuca muralis
Lamium purpureum
Lapsana communis
Lathyrus nevadensis
Leotodon taraxocoides*
Lepidium campestre
Lepidium heterphyllum*
Linaria canadensis*
Lolium perenne
Lomatium nudicaule
Lonicera ciliosa
Lonicera hispidula
Lupinus bicolor

Lupinus arboreus
Luzula campestris
Luzula sp.
Lysichitum americanum (aquatic)
Madia glomerata*?
Mahonia nervosa
Maianthemum dilatatum
Malus sp.
Matricaria maritima
Matricaria matricaria
Matricaria matricarioides
Medicago luplina*
Medicago sativa*
Melica subulata*
Melilotus alba
Melissa officinalis*
Monotropa uniflora
Montia linearis
Montia perfoliata
Montia sibirica
Myosotis discolor
Myosotis laxa*
Navarretia squarrosa
Nemophila parviflora
Oemleria cerasiformis
Oenanthe sarmentosa
Orobanche uniflora*
Osmorhiza chilensis
Oxalis stricta*
Pachistima myrsinites
Papaver argemone*
Phalaris arundinacea
Phalaris canariensis*
Philadelphus lewisii
Phleum pratense
Physocarpus capitatus
Plagiobothrys scouleri*
Plantago lanceolata
Plantago major
Poa annua*
Poa bulbosa*
Poa compressa*
Poa pratensis
Polygonum aviculare
Polygonum douglasii*
Polygonum lapathifolium

Polygonum persicaria*
Polypodium glycyrrhiza
Polystichum munitum
Populus tremuloides
Populus balsaminifera ssp. trichocarpa
Portulaca oleraceae*
Potentilla pacifica/anserina
Prunella vulgaris
Prunus emarginata
Pseudotsuga menziesii
Pteridium aquilinum
Pyrus fusca (=Malus fusca)
Quercus garryana
Ranunculus acris*
Ranunculus ficaria*
Ranunculus occidentalis
Ranunculus unicinatus
Ranunculus repens
Raphanus raphanistrum
Rhamnus purshiana
Rhinanthes minor
Ribes bracetosum*
Ribes lobbii
Ribes sanguineum
Rorippa curvisiliqua
Rosa gymnocarpa
Rosa nutkana
Rosa pisocarpa
Rubus discolor
Rubus parviflorus
Rubus spectabilis
Rubus ursinus
Rumex acetosa
Rumex crispus
Rumex occientalis*
Rumex obtusifolius (along lawn)
Salix hookeriana
Salix lasiandra
Salix scouleriana
Salix sitchensis
Sambucus racemosa
Sanicula crassicaulis
Satureja douglasii
Senecio vulgaris
Silene gallica*
Sisyimbrium officinale

Sisyrinchium angustifolium
Smilacina racemosa
Solanum nigra*
Solanum dulcamara
Spergula arvensis
Spergularia rubra*
Spiraea douglasii
Spiranthes romanzoffiana
Stachys cooleyae
Stellaria calycantha*
Stellaria media
Symphoricarpos albus
Taraxacum officinale
Taxus brevifolia
Tellima grandiflora
Thalspi arvense*
Thuja plicata
Tiarella trifoliata
Tragopogon porrifolius
Trientalis latifolia
Trifolium arvense*
Trifolium dubium
Trifolium pratense
Trifolium repens
Trillium ovatum
Tsuga heterophylla*?
Typha latifolia
Ulex europaeus*
Urtica dioica
Vaccinium parvifolium
Veronica arvensis*
Veronica americana
Veronia peregrina*
Veronica persica*
Veronica serpyllifolia*
Vicia cracca
Vicia hirsuta
Vicia sativa
Vicia villosa
Vulpia myuros*

Appendix B –Bryophyte and Tree Species Data (Godfrey 1975)

Table 1. A list of the species of bryophytes found on each tree species

I. On Abies grandis

Isothecium stoloniferum (Hook.)Brid.
Homalothecium lutescens (Hedw.)Robins.
Dicranum Hedw.species
Homalothecium nuttallii (Wils.)Jaeg.
Plagiothecium elegans (Brid.)Sull.

II. On Quercus garryana

Neckera menziesii Hook.
Isothecium stoloniferum (Hook.)Brid.
Orthotrichum pulchellum Brunt.
Orthotrichum Hedw.species
Homalothecium lutescens (Hedw.)Robins.
Homalothecium nuttallii (Wils.)Jaeg.
Eurhynchium stokesii (Turn.)B.S.G.

III. On Acer macrophyllum

Homalothecium lutescens (Hedw.)Robins.
Isothecium stoloniferum (Hook.)Brid.
Neckera menziesii Hook.
Eurhynchium stokesii (Turn.)B.S.G.
Dicranum Hedw. species
Orthotrichum pulchellum Brunt.
Orthotrichum Hedw. species
Porella platyphylloidea (Schwein.)Lindb.
Porella species
Bazzania species
Scapania species

IV. On *Populus trichocarpa*

Homalothecium lutescens (Hedw.)Robins.
Eurhynchium stokesii (Turn.)B.S.G.
Eurhynchium oreganum (Sull.)Jaeg.&Sauerb.
Orthotrichum pulchellum Brunt.
Isothecium stoloniferum (Hook.)Brid.
Neckera douglasii Hook.
Brachythecium asperillum (C.Muell.)Sull.
Porella platyphylloidea (Schwein.)Lindb.
Porella species
Scapania species

V. On *Pseudotsuga menziesii*

Hypnum circinale Hook.
Dicranum Hedw. species

Table 2. Constancy* of Bryophyte species on each tree species

Tree Species	Stand no.	Number of plots	Isoth stol	Neck menz	Porella p	Homal lut	Eurh stok	Ortho sp.	Porella sp.	Ortho pul	Neck dougl	Homal nutt	Eurh oreg	Brachythec	Dicranum	Plagiothec	Bazzania	Scapania
			Bryophyte species															
Abies grandis	1	6	5												1			
	2	6	5			1									1	1		
	4	7	5									1						
Quercus garryana	1	10	3	4		1	1			2		1						
Acer macrophyllum	2	2	3	3				3	3								3	
	3	6			4	4	1	3	3	2					1			1
Populus trichocarpa	3	14	1		2	4	4		1	2	1		1	1				

*Constancy classes: 1=0-20%, 2=21-40%, 3=41-60%, 4=61-80%, 5=81-100%.

Species abbreviations: Isoth stol=Isothecium stoloniferum, Neck menz=Neckera menziesii, Porella p=Porella platyphylloidea, Homal lut=Homalothecium lutescens, Eurh stok=Eurhynchium stokesii, Ortho pul=Orthotrichum pulchellum, Neck dougl=Neckera douglasii, Homal nutt=Homalothecium nuttalii, Eurh oreg= Eurhynchium oreganum.

Appendix Ca –Coarse Woody Debris Data (Chatterson 1995)

Table 1. Volume of coarse woody debris in each of the two natural areas (m^3/ha).

Mystic Vale	Cunningham Woods
85.5	53.1

Table 2. Number of pieces of coarse woody debris in each size class for both areas.

Diameter (cm)	Mystic Vale	Cunningham Woods
5.0-9.9	1	9
10.0-14.9	5	4
15.0-19.9	2	4
20.0-24.9	3	2
25.0-29.9	3	4
>30.0	8	3
Totals	21	27

Table 3. Number of pieces of coarse woody debris by decay class in both natural areas.

Decay class	Mystic Vale	Cunningham Woods
1	2	2
2	7	11
3	7	8
4	6	5
5	4	7
Totals	26	33

Appendix Cb –Snag Data (Chatterson 1995)

Table 4. Snags in the natural areas

Decay Class	Mystic Vale	Cunningham Woods
2	3	2
3	10	16
4	11	15
5	3	7
6	2	3
7	0	1
Totals	29	44

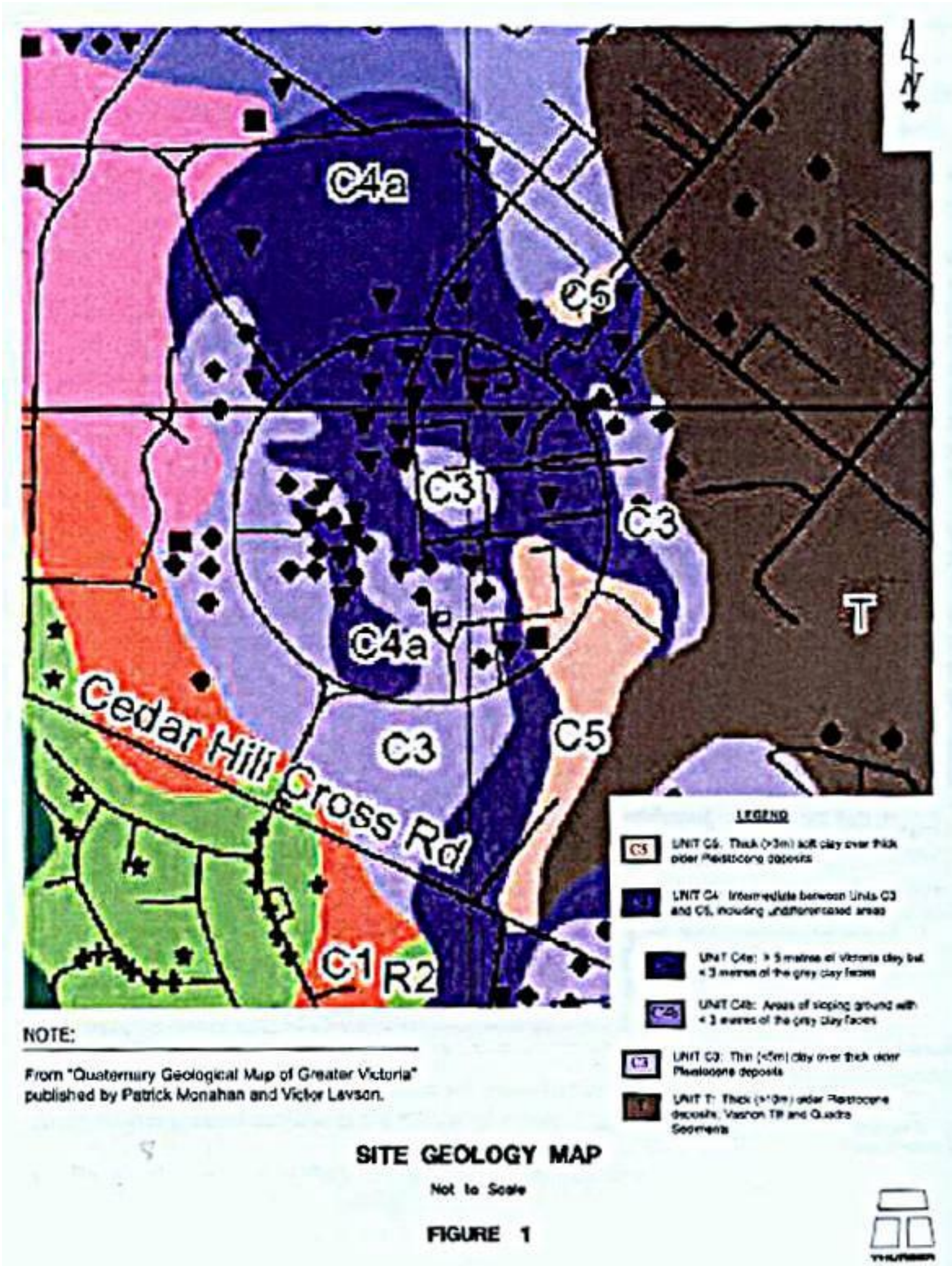
Table 5. Number of snags by diameter class in the natural areas.

Diameter (cm)	Mystic Vale	Cunningham Woods
20.0-29.9	3	4
30.0-39.9	0	11
40-49.9	1	10
50.0-59.9	1	11
60.0-69.9	9	3
>70	14	4
Totals	29	44

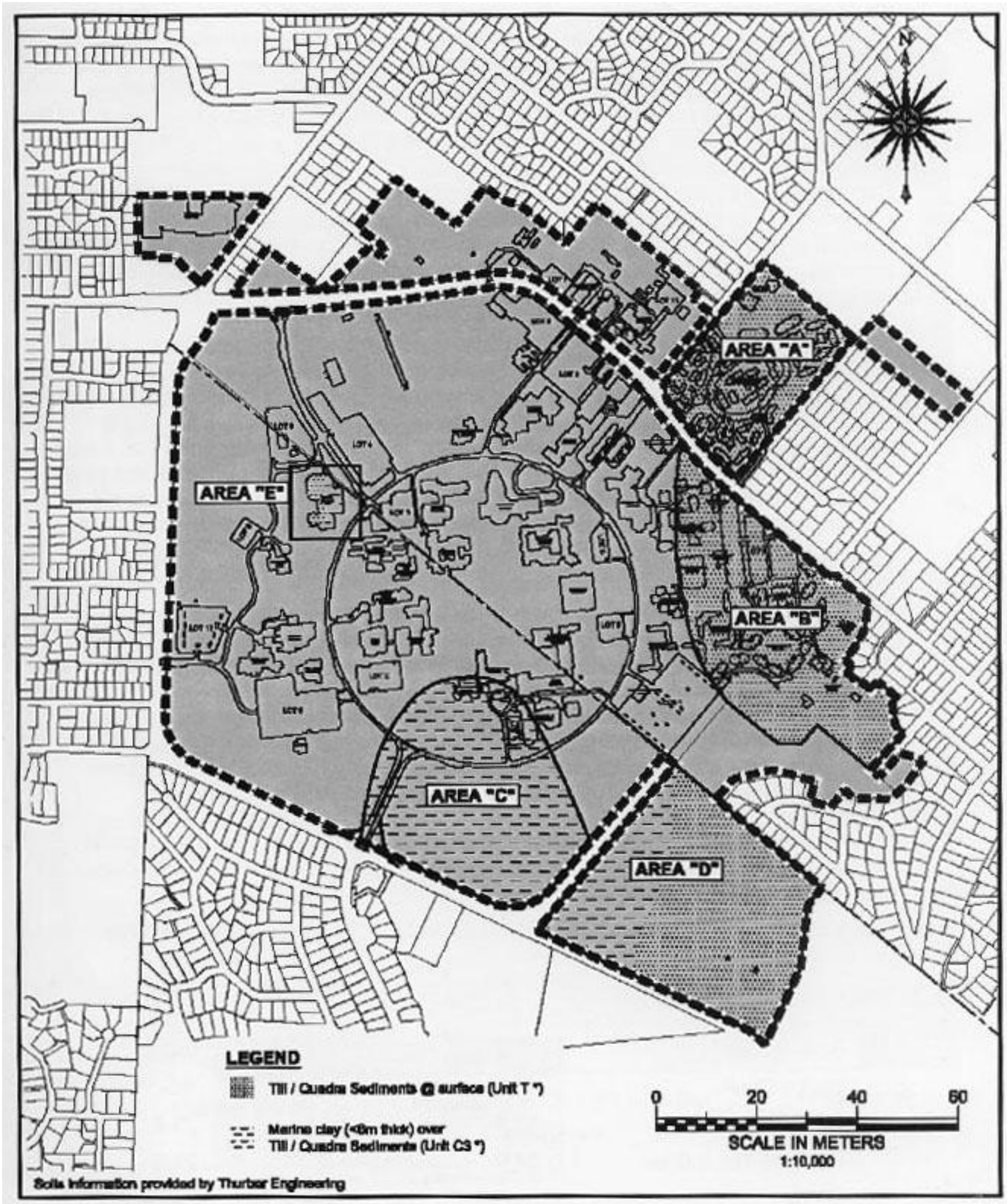
Table 6. Height of snags in natural areas.

Height (m)	Mystic Vale	Cunningham Woods
1.0-4.9	0	10
5.0-9.9	8	13
10.0-14.9	5	4
15.0-19.9	2	7
20.0-24.9	3	7
>25	10	2
Totals	29	44

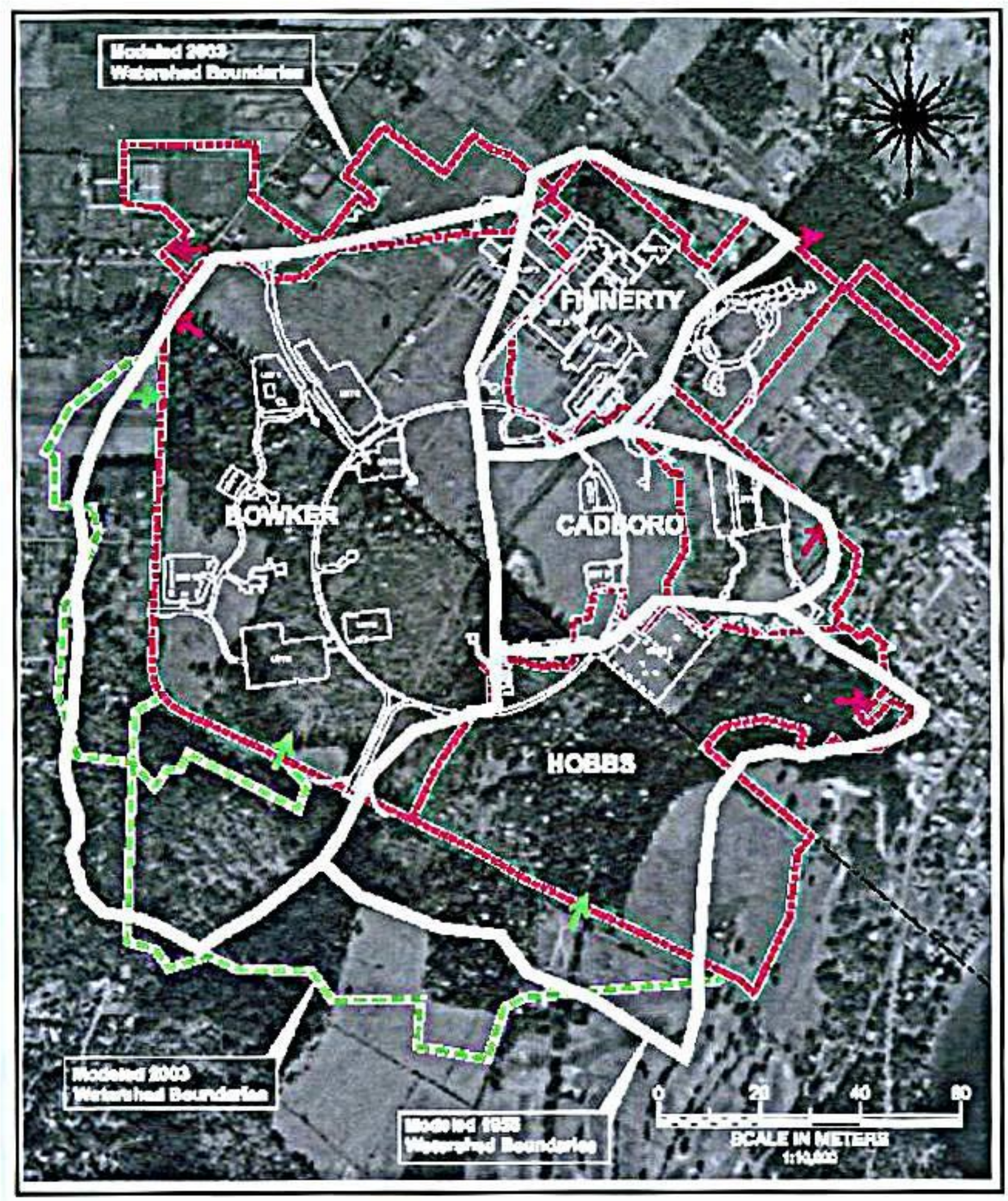
Appendix D - Site Geology Map (Thurber 2003)



Appendix E - Soil Assessment Summary (Lloyd 2004)



Appendix F –Watershed Boundaries (Lloyd 2004)



Appendix G –Watershed Characteristics (Lloyd 2004)

	Bowker Creek				Finnerty				Cadboro Bay				Hobbs Creek			
	Total Runoff		Peak Flow		Total Runoff		Peak Flow		Total Runoff		Peak Flow		Total Runoff		Peak Flow	
	Volume (m3)	Relative to 1956	Rate (m3/s)	Relative to 1956	Volume (m3)	Relative to 1956	Rate (m3/s)	Relative to 1956	Volume (m3)	Relative to 1956	Rate (m3/s)	Relative to 1956	Volume (m3)	Relative to 1956	Rate (m3/s)	Relative to 1956
Predevelopment	15,520		0.40		3,906		0.11		4,022		0.11		8,417		0.22	
1956 Campus Lands	20,950		0.55		11,560		0.67		5,487		0.17		9,806		0.26	
2003 UVic Campus - "As-Is"	46,180	2.2	1.92	3.5	11,530	1.0	0.81	1.2	5,084	0.9	0.41	2.4	26,760	2.7	0.98	3.8
2003 UVic Campus - with "BMP's"	38730	1.8	1.60	2.9	8855	0.8	0.64	1.0	4562	0.8	0.33	2.0	25580	2.6	0.84	3.3
2003 Campus Plan Buildout- "As-Is Technology"	53,910	2.6	2.03	3.7	11,530	1.0	0.81	1.2	5,339	1.0	0.43	2.6	26,870	2.7	0.99	3.9
2003 Campus Plan Buildout with BMP's	37,060	1.8	1.58	2.9	8,855	0.8	0.64	1.0	3,967	0.7	0.34	2.0	25,220	2.6	0.84	3.3

Appendix H – Changes in Hydrological Characteristics (Lloyd 2004)

Table 2.5. Predevelopment To 2003 Changes In Hydrologic Characteristics

Watershed	Drainage Area (ha)		% Impervious Area		Remarks
	1956	2003	1956	2003	
Bowker	92.9	100.4	1.6	51	Some areas within the campus now drain to Bowker Creek
Hobbs	50.7	66.8	0	31	Areas south of Cedar Hill Cross Road now drain to Hobbs
Finnerty	21.8	20.6	48	61	Little change
Cadboro	21.9	9.1	0	55	Loss of drainage area to Bowker Creek

The hydrologic effects of the change in drainage areas and the increase in impervious areas on runoff rates and volumes are illustrated in the bar graphs (Figure 2.6) for each watershed. The Hydrologic Summary Table 2.2 presents the numeric values of runoff volumes and flow rates. Comparisons of the runoff hydrographs are provided in Appendix B.

Appendix I –Bird Use of Wildlife Trees (Chatterson 1995)

Birds which have been sited on the University of Victoria campus that are known to use wildlife trees. (Adapted from Backhouse and Lousier, 1991).

Great Blue Heron: open nest on large tree limbs.
Hooded Merganser: secondary cavity nester.
Turkey Vulture: roosting.
Bald Eagle: open nest on large tree limbs, hunting perch, roost.
Red Tailed Hawk: hunting perch.
Merlin: Secondary cavity nester.
Great horned owl: secondary cavity nester, nest in broken tree top, hunting perch.
Barred Owl: secondary cavity nester, nest in broken tree top, winter roost.
Western Screech Owl: secondary cavity nester, winter roost.
Vaux's Swift: secondary cavity nester, roost.
Belted Kingfisher: hunting perch.
Red Breasted Sapsucker: primary cavity nester, roost, foraging.
Northern Flicker: primary cavity nester, roost, foraging.
Pileated Woodpecker: primary cavity nester, roost, foraging.
Downy Woodpecker: primary cavity nester, roost, foraging.
Hairy Woodpecker: primary cavity nester, roost, foraging.
Pacific Slope Flycatcher: secondary cavity nester, hawking perch.
Violet Green Swallow: secondary cavity nester.
Tree Swallow: secondary cavity nester.
Chestnut Backed Chickadee: primary cavity nester (opportunistic secondary cavity nester), foraging, winter roost.
Red Breasted Nuthatch: primary cavity nester, occasional secondary cavity nester, foraging, winter roost.
Brown Creeper: secondary cavity nester, foraging.
Bewick's Wren: secondary cavity nester.

Appendix J – UVic Bird Species (Chatterson 1995)

Bird Species of the University of Victoria Campus:
by Paul Levesque

Codes:
F = Seen by Biology 329 Friday morning birding trips
O = Seen by author and others in past four years
S = Seen on morning surveys, Spring 2000
H = Historical records predating 1990

COMMON NAME	CODE	COMMENTS
Double-crested Cormorant	O	few records, seen flying over campus
Great Blue Heron	F, O, S	commonly seen roosting and feeding in ponds, fall - spring
Turkey Vulture	F, O	large flocks soaring overhead in fall
Canada Goose	F, O, S	seen flying over campus
Trumpeter Swan	O	2 seen flying over campus on migration
Wood Duck	F	few records
Gadwall	F, H	few records
Eurasian Wigeon	F, O	two records
American Wigeon	F, O, S, H	common
Mallard	F, O, S, H	common, suspected nesting
Northern Shoveler	F, H	few recent records, historically common winter resident
Northern Pintail	F, O, H	few recent records, historically common winter resident
Green-winged Teal	F, O, H	overwinter on ponds
Hooded Merganser	F, O	few records
Bald Eagle	F, O, S	known to nest in Mystic Vale
Sharp-shinned Hawk	F, O, H	winter resident, low numbers
Copper's Hawk	F, O, S, H	known breeder, four nests in 1999
Red-tailed Hawk	F, O, S	uncommon, but seen regularly throughout the year
American Kestrel	H	no recent records
Merlin	F, O, S, H	an immature suckeyi was seen, Feb.12 and 17, 2000
Peregrine Falcon	F, H	few records
Ring-necked Pheasant	H	introduced, no recent records
California Quail	F, H	introduced ?, no recent records
Sandhill Crane	O	3 were seen flying over in migration, Oct. 99
Black-bellied Plover	H	no recent records, once common winter resident
American Golden-Plover	H	one sight record
Killdeer	F, O, H	year round resident, playing fields, nests
Willet	H	one sight record
Spotted Sandpiper	F	one sight record
Whimbrel	H	few records
Long-billed Curlew	H	one sight record

Western Sandpiper	H	no recent records, once common winter resident
Least Sandpiper	H	no recent records, once common winter resident
Pectoral Sandpiper	H	no recent records
Dunlin	H	no recent records, once common winter resident
Short-billed Dowitcher	H	no recent records, once common winter resident
Common Snipe	F, H	few recent records
Mew Gull	F, O	common winter resident
Herring Gull	F	few records
COMMON NAME	CODE	COMMENTS
Thayer's Gull	F, O	small flocks frequent lawns and fields in winter months
Western Gull	F	few records
Glaucous-winged Gull	F, O, S, H	common resident
Rock Dove	F, O, S, H	introduced, common resident, likely breeding
Band-tailed Pigeon	F, O, H	few recent records, once nested in wooded areas
Mourning Dove	H	no recent records
Barn Owl	H	one sight record
Western Screech-Owl	H	historically nesting, now thought to be extirpated
Great Horned Owl	F, O, H	known to nest in Mystic Vale
Barred Owl	F, O, S, H	suspected nesting
Northern Saw-whet Owl	H	one found dead, hit by an automobile
Common Nighthawk	H	no recent records, historical nesting
Black Swift	O	few recent sight records
Vaux's Swift	F, O	few recent sight records
Anna's Hummingbird	F, O, S	year round resident, spring 2000 at least 8 pairs
Rufous Hummingbird	F, O, S, H	common summer, likely breeding
Red-breasted Sapsucker	F	few records
Downy Woodpecker	F, O, S, H	year round resident, spring 2000 at least 3 pairs
Hairy Woodpecker	F, O, S, H	one pair, nests
Northern Flicker	F, O, S, H	year round resident, at least 1 pair spring 2000, likely more
Pileated Woodpecker	F, O, S, H	year round resident, at least 1 pair spring 2000
Olive-sided Flycatcher	O, H	current status unclear, few recent records
Willow Flycatcher	H	current status unclear, few recent records
Pacific-slope Flycatcher	F, O, H	current status unclear, few recent records
Northern Shrike	O, H	few records, seen in winter, in apple orchards
Cassin's Vireo	F, H	few records, suspected nesting
Hutton's Vireo	O, S	few records, suspected nesting
Red-eyed Vireo	H	one record
Steller's Jay	F, O	common most winters, but unpredictable
Northwestern Crow	F, O, S, H	common, nests
Common Raven	F, O, S, H	nests, 1 pair in Mystic Vale spring 2000
Sky Lark	H, F	introduced, once nested, few recent records

Tree Swallow	F, O, H	common summer, suspected nesting
Violet-green Swallow	F, O, S, H	common summer, suspected nesting
Northern Rough-winged Swallow	O	few records
Cliff Swallow	O, H	historically nested on McPherson Library
Barn Swallow	F, O, H	common, nests in University Center parkade
Chestnut-backed Chickadee	F, O, S, H	nests, common in wooded areas
Bushtit	F, O, S, H	nests, common in wooded areas
Red-breasted Nuthatch	F, O, S, H	nests, common in wooded areas
Brown Creeper	F, O, S, H	nests, common in wooded areas
Bewick's Wren	F, O, S, H	nests, common in wooded areas
Winter Wren	F, O, S, H	nests, common in wooded areas
Golden-crowned Kinglet	F, O, S, H	year round resident, common, nests
Ruby-crowned Kinglet	F, O, S, H	winter resident, common
Swainson's Thrush	F, O, H	summer resident, nests
Hermit Thrush	F, H	uncommon winter resident
American Robin	F, O, S, H	common, nests
Varied Thrush	F, O, S, H	winter resident, low numbers
European Starling	F, O, S, H	introduced, common, likely breeding
COMMON NAME	CODE	COMMENTS
American Pipit	F, O, H	few recent records
Cedar Waxwing	F, O, H	small flocks< 30 frequent campus
Orange-crowned Warbler	F, O, S, H	suspected nesting, few overwinter
Yellow warbler	F, O, H	suspected nesting
Yellow-rumped Warbler	F, O, H	suspected nesting
Black-throated Gray Warbler	H,O	few records
Townsend's Warbler	F, O, H	suspected nesting
Northern Waterthrush	F	one record, struck window at Cunningham
MacGillivray's Warbler	F, O, H	suspected nesting
Wilson's Warbler	F, O, H	suspected nesting
Western Tanager	F	few records
Spotted Towhee	F, O, S, H	common year round resident, nests
Chipping Sparrow	F, H	few recent records
Savannah Sparrow	F, H	few recent records, historically nested
Fox Sparrow	F, O, S, H	wintering, low numbers
Song Sparrow	F, O, S, H	common, year round resident, low numbers, nests
White-crowned Sparrow	F, O, H	year round resident, low numbers, nests
Golden-crowned Sparrow	F, O	winter resident, low numbers
Harris's Sparrow	O	one sight record, Jan 98
Dark-eyed Junco	F, O, S, H	common, year round resident, nests
Black-headed Grosbeak	H	no recent records
Red-winged Blackbird	F, O, S, H	year round resident, low numbers

Western Meadowlark	H	no recent records, historically nested
Yellow-headed Blackbird	H	few records
Brewer's Blackbird	F, H	few recent records
Brown-headed Cowbird	F, H	probable nest parasite of nesting birds
Purple Finch	F, H	few recent records
House Finch	F, O, S, H	common, year round resident, suspected nesting
Red Crossbill	F, O, S, H	common, year round resident
Pine Siskin	F, O, S, H	common, year round resident, suspected nesting
American Goldfinch	F, O, S, H	spring, summer, fall, low numbers
Evening Grosbeak	O, H	few recent records of small flocks
House Sparrow	F, O, S, H	introduced, common, nests

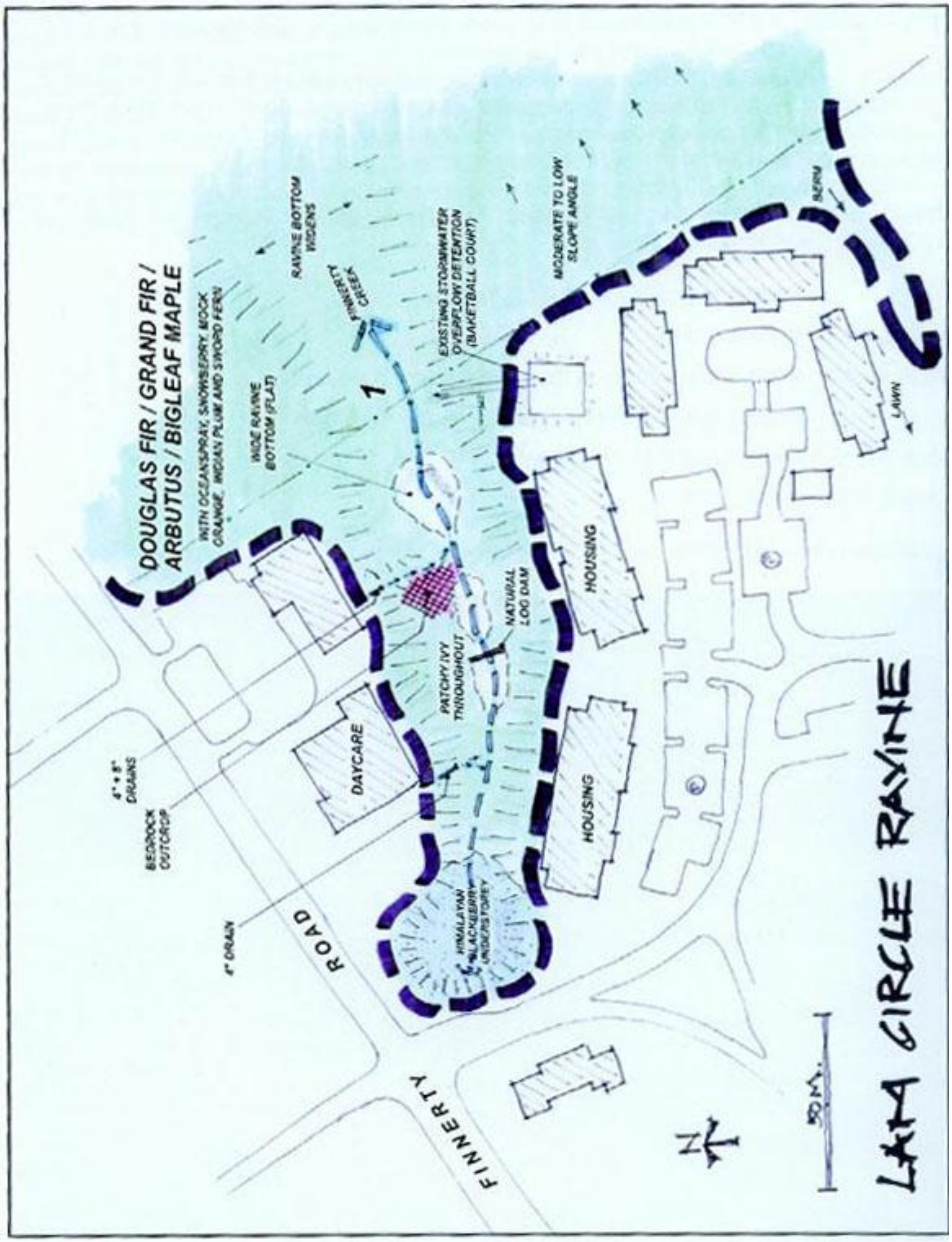
Species known to occur on campus, total: 123
Names and sequence of species are based on the American Ornithologist's Union Checklist of North American birds.
It should be noted that this list does not represent an exhaustive review of all literature and thus it is likely to be incomplete.

Appendix K – Garry Oak Meadow Species List (Bein & Eastman 2006)

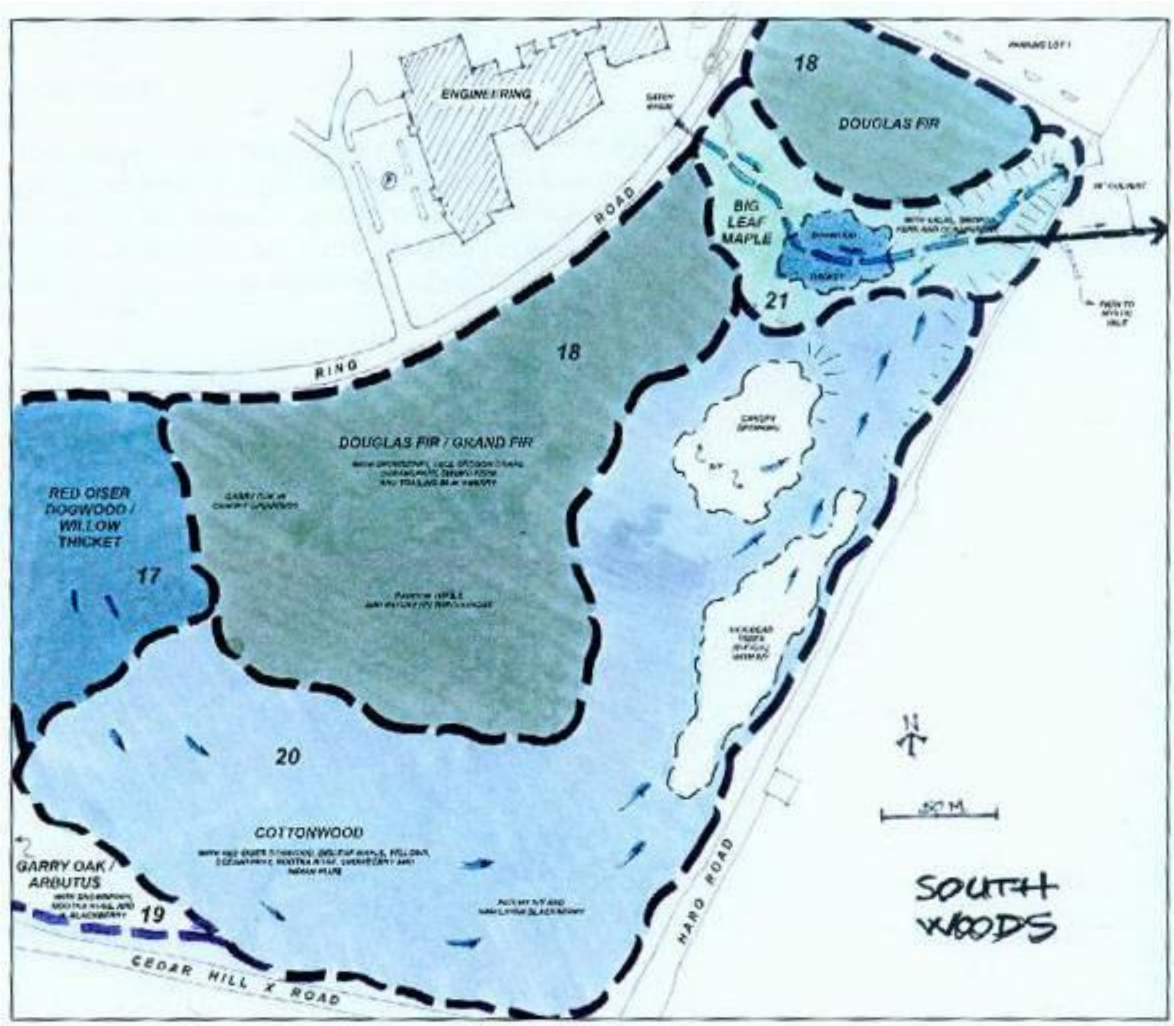
Family Scientific Name
Asteraceae *Achillea millefolium*
Asteraceae *Bellis perennis*
Asteraceae *Cirsium vuloare*
Asteraceae *Hypochaeris radicata*
Asteraceae *Leucanthemum vulgare*
Asteraceae *Matricaria perforate*
Asteraceae - *Senecio sylvatica*
Asteraceae *Sonchussp.* ________
Asteraceae *Taraxacum officinale*
Asteraceae *Tragopogon porrifolius*
Boraginaceae *Myosotis discolor*
Brassicaceae *Brassica* sp. *(?)*
Brassicaceae *Capsella bursa-pastoris*
Brassicaceae *Lepidiumpj*
Brassicaceae *Raphanus* sp.
Brassicaceae *Sisyimbrium officinale*
Caryophyllaceae *Spergula arvensis*
Caryophyllaceae *Søeraularia* SD.
Caryophyllaceae *Stellaria media*
Chenopodiaceae *Chenopodium album*
Compositeae *Daucus carota*
Compositeae *Sanicula crassicaulis*
Fabaceae *Cytisus scoparius*
Fabaceae *Lupinus bicolor*
Fabaceae *Medicago arabica*
Fabaceae *Trifolium dubium*
Fabaceae *Trifolium pretense*
Fabaceae *Trifolium repens*
Fabaceae *Vicia hirsuta*
Fabaceae *Vicia sativa*
Geraniaceae *Erigodium* sp.
Geraniaceae *Geranium* sp.
Juncaceae *Juncus bufonius*
Lilaceae *Camassia leichtlinii*
Lilaceae *Camassia guamash*
Lilaceae *Erythronium spp.*
Orchictaceae *Spiranthes romanzofinna*
Plantaginaceae *Plantago lanceolata*
Poaceae *Agrostis sp.*
Poaceae *Anthoxanthum odoratum*
Poaceae *Arrhenatherum elatius*
Poaceae *BrOmus sitchensis*

Poaceae *Bromus* **sp.** 1
Poaceae *Bromus* sp. 2
Poaceae *Cynosurus cristatus*
Poaceae *Dactylis glomerata*
Poaceae *Danthonia californica*
Poaceae *Elymus glaucus*
Poaceae *Elymus repens*
Poaceae *Festuca* **sp.**
Poaceae *Holcus lanatus*
Poaceae *Lolium perenne*
Poaceae *Phleum pratense*
Poaceae *Poe annua*
Poaceae *Poa pratensisssspgtensis*
Poaceae unknown grass
Poaceae *Vulpia myuros*
Polemoniaceae *Navarretia squarrosa*
Polygonaceae *Amaranthus*
Polygonaceae *Polygonum aviculare*
Polygonaceae *Rumex acetosella*
Polygonaceae *Rumex crispus*
Portulacaceae *Montia linearis*
Portulacaceae *Portulacca*
Prim ulaceae *Dodecatheon hendersonu*
Ranunculaceae *Ranunculus occidenta!is*
Rosaceae *Crataegus monogyna*
Rosaceae *Fragaria vesca*
Rosaceae *Rosa nutkana*
Rosaceae *Rubus armeniacus*
Rosaceae *Rubus ursinus*
Scrophulariaceae *Veronica* spp.
Solanaceae *Solanum or Physolus*

Appendix L – Lam Circle Ravine (Lloyd 2004)



Appendix M – South Woods (Lloyd 2004)



Appendix N – UVic Native Plant Garden (Herbarium 2001)

Native plants in the UVIC native plant garden as at July 2001:

Achlys triphylla – Vanilla-leaf
Adiantum pedatum – Northern Maiden-hair Fern
Allium cernuum - Nodding Onion
Amelanchier alnifolia - Saskatoon
Aquilegia formosa - Columbine
Arctostaphylos uva-ursi - Kinnikinnik
Aruncus dioicus - Goat's Beard
Artemisia tridentata – Sagebrush
Aster subspicatus – Douglas' aster
Athyrium filix-femina - Lady Fern
Blechnum spicant - Deer Fern
Camassia leichtlinii - Great Camas
Camassia quamash - Common camas
Ceanothus velutinus - Snowbrush
Cornus stolonifera – Red-Osier Dogwood
Delphinium menziesii – Menzies' Larkspur
Dicentra formosa - Bleeding heart
Disporum smithii - Fairy Bells
Dodecatheon cusickii - Cusick's Shootingstar
Dodecatheon hendersonii - Henderson's Shootingstar
Dodecatheon meadia - Shootingstar
Dodecatheon pulchellum - Few-flowered Shootingstar
Dryopteris expansa – Sping wood fern
Eriophyllum lanatum - Woolly Sunflower
Erythronium oregonum - Easter lily
Erythronium revolutum - Pink Easter lily
Fauri crista-galli – Deer-cabbage
Fragaria chiloensis - Coastal strawberry
Fragaria vesca - Wild strawberry
Gaultheria shallon – Salal
Geranium viscosissimum – Sticky geranium
Gymnocarpium dryopteris - Oak fern
Gymnocarpium robertinanum – Oak fern
Heuchera micrantha – Small-flowered Alum Root
Iliamna rivularis - Stream globe-mallow
Iris setosa - Northern Flag
Ledum groenlandicum - Labrador Tea
Linnaea borealis - Twinflower
Lonicera ciliosa - Orange Honeysuckle
Mahonia aquifolium - Tall Oregon Grape

Mahonia nervosa - Dull Oregon Grape
Maianthemum dilatatum - False lily-of-the-Valley
Malus fusca – Pacific crabapple
Matteucia struthiopteris - Ostrich Fern
Mimulus guttatus - Yellow Monkey-Flower
Mitella ovalis – Oval-leaved Mitrewort
Oemleria cerasiformis – Indian-Plum
Oplopanax horridus – Devil's club
Oxalis oregana -Oregon Sorrel
Pachistima myrsinites - False box
Penstemon fruticosus - Shrubby Penstemon
Philadelphus lewisii - Mock Orange
Physocarpus capitata - Ninebark
Potentilla fruticosa - Shrubby Cinquefoil
Polypodium glycyrrhiza -Licorice Fern
Polystichum braunii - Braun's Holly Fern
Polystichum munitum – Sword fern
Quercus garryana – Garry oak
Rhododendron albiflorum – White-flowered rhododendron
Rhododendron macrophyllum – Pacific rhododendron
Ribes divaricatum - Wild Gooseberry
Ribes lacustre - Black Gooseberry
Ribes laxiflorum – Trailing Black Currant
Ribes lobbii - Gummy Gooseberry
Ribes sanguineum - Red-flowering Currant
Ribes viscossisimum – Sticky currant
Rosa gymnocarpa -Bald Hip Rose
Rosa nutkana - Nootka Rose
Sambucus racemosa - Red Elderberry
Saxifraga integrifolia – Grassland saxifrage
Sedum spathulifolium – Broad-leaved Stonecrop
Shepherdia canadensis - Soapberry
Sisyrinchium californicum -Yellow-eyed Grass
Sisyrinchium douglasii - Satin Flower
Smilacina racemosa - False Solomon's Seal
Solidago canadensis – Goldenrod
Sorbus stichensis – Mountain ash
Spiraea betulifolia – Birch-leaved spirea
Symphoricarpos albus –Snowberry
Symphoricarpos mollis – Trailing snowberry
Tellima grandiflora - Fringecup
Tiarella trifoliata - Foamflower
Tolmiea menziesii - Piggy-back Plant
Trautvettaria caroliniensis - False Bugbane
Trillium ovatum - Trillium
Triteleia hyacinthina - Fool's Onion
Vaccinium parvifolium - Red Huckleberry

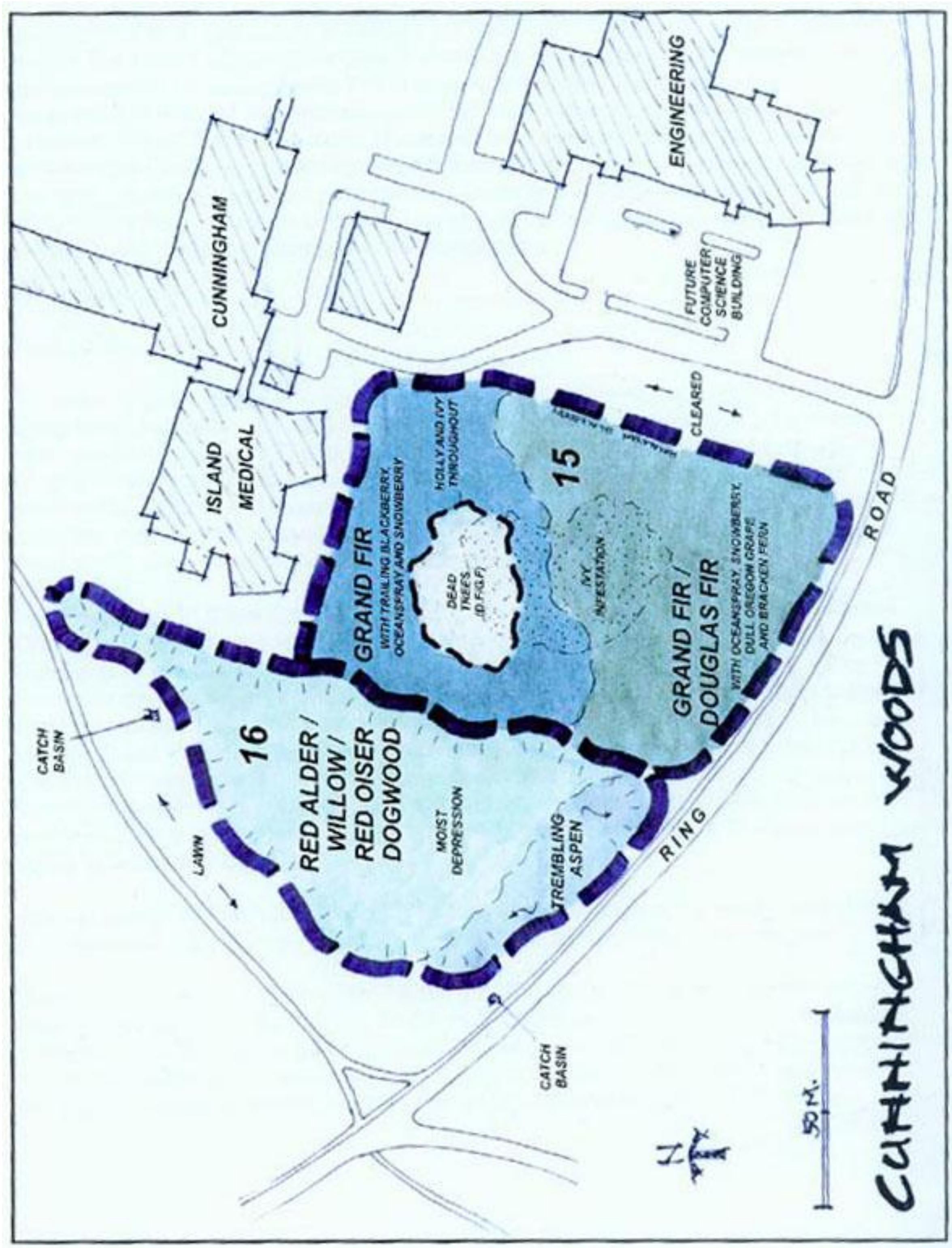
Vaccinium ovatum - Evergreen Huckleberry
Vaccinium vitis-idaea - Lingonberry
Viburnum edule - Highbush Cranberry
Viola glabella - Stream Violet
Woodwardia fimbriata - Giant Chain Fern
Xerophyllum tenax – Bear grass
Zygadenus venenosus - Death Camas

For more information see the following references:

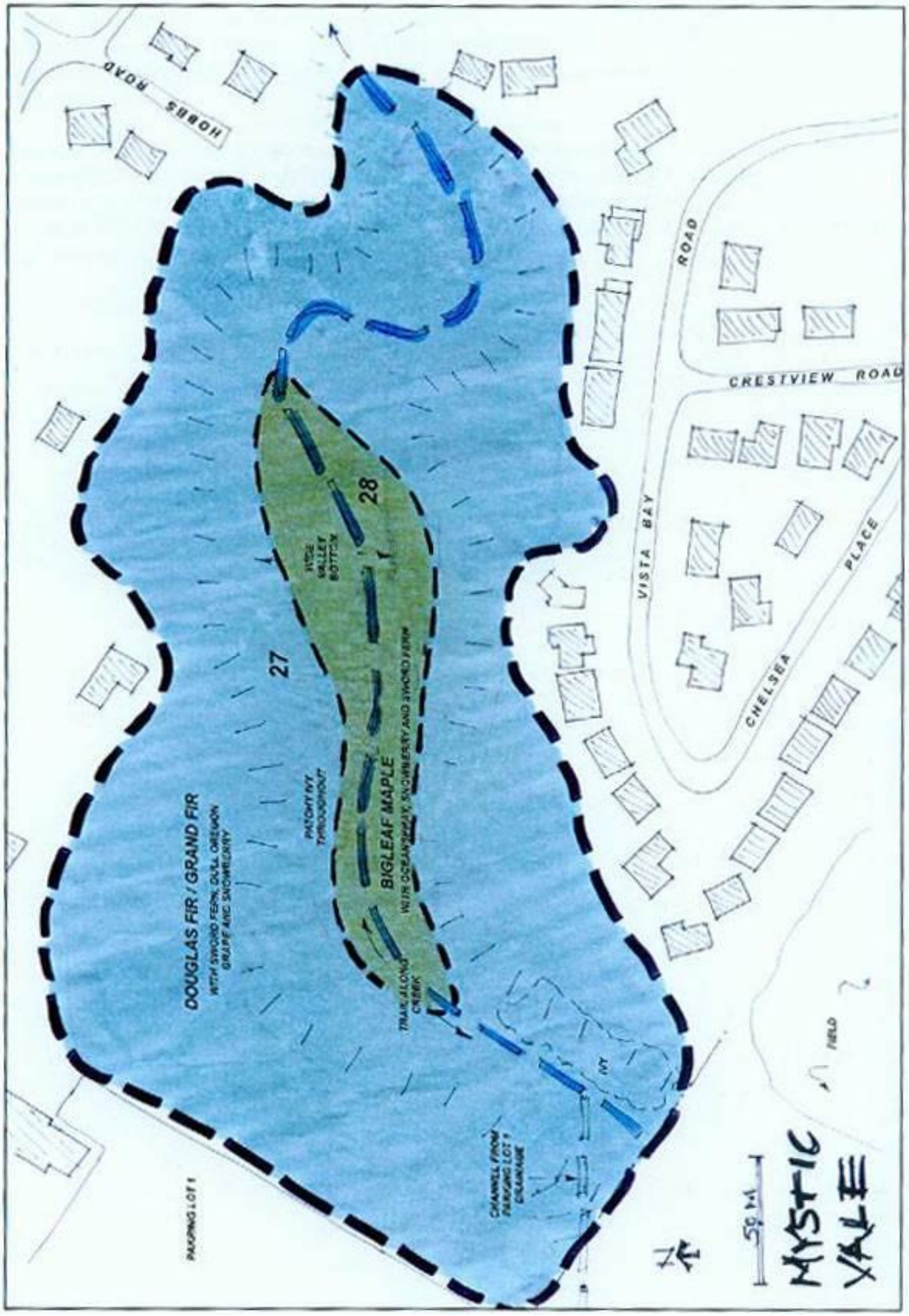
Native Plants in the Coastal Garden. 1996. April Pettinger. Whitecap Books, Vancouver, BC.

Plants of Coastal British Columbia. 1994. Jim Pojar and Andy Mackinnon. Lone Pine Press, Vancouver, BC.

Appendix O – Cunningham Woods (Lloyd 2004)



Appendix P – Mystic Vale (Lloyd 2004)



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Appendix Q– Native Plants of Mystic Vale (Turner 1993)

NATIVE PLANTS OF MYSTIC VALE, SAANICH, BRITISH COLUMBIA

Nancy J. Turner and Brett Heneke
Environmental Studies Program
University of Victoria

January 20, 1993 (updated March, 1993)

List of Plant Species from Brief Survey of rim, slopes and creekside areas of Mystic Vale. - Please note that many herbaceous perennials and annual plant species are not visible at this time of year. (Species listed alphabetically by scientific name within major categories of TREES, SHRUBS, HERBACEOUS FLOWERING PLANTS, FERNS AND FERN-ALLIES, MOSSES AND LIVERWORTS. A note on LICHENS and FUNGI is also made.

TREES

Grand fir (*Abies grandis*)
Broadleaf maple (*Acer macrophyllum*)
Red alder (*Alnus rubra*)
Arbutus (*Arbutus menziesii*)
Black cottonwood (*Populus balsamifera*
ssp. *trichocarpa*)
Bitter cherry (*Prunus emarginata*)
Douglas-fir (*Pseudotsuga menziesii*)
Cascara (*Rhamnus purshiana*)
Hooker's willow (*Salix hookeriana*)
Scouler's willow (*Salix scouleriana*)
Sitka willow (*Salix sitchensis*)
Western red-cedar (*Thuja plicata*)
Pacific yew (*Taxus brevifolia*)

SHRUBS

Saskatoon berry (*Amelanchier alnifolia*)
Red-osier dogwood (*Cornus stolonifera ;*
syn. *Cornus sericea*)
Salal (*Gaultheria shallon*)
Oceanspray (*Holodiscus discolor*)
Orange-flowered honeysuckle (*Lonicera ciliosa*)
Hairy honeysuckle (*Lonicera hispidula*)
Tall Oregon-grape (*Mahonia aquifolium;*
syn. *Berberis aquifolium*)
Common Oregon-grape (*Mahonia nervosa ;* syn. *Berberis nervosa*)
Indian-plum (*Oemleria cerasiformis*)
False box (*Pachistima myrsinites*)
Mock-orange (*Philadelphus lewisii*)
stink currant (*Ribes bracteosum*)
black gooseberry (*Ribes divaricatum*)
Red-flowering currant (*Ribes sanguineum*)
Dwarf wild rose (*Rosa gymnocarpa*)
Nootka rose (*Rosa nutkana*)
Thimbleberry (*Rubus parviflorus*)
Salmonberry (*Rubus spectabilis*)
Trailing wild blackberry (*Rubus ursinus*)
Red elderberry (*Sambucus racemosa*)
Snowberry, or waxberry (*Symphoricarpos albus*)

Red huckleberry (*Vaccinium parvifolium*)

HERBACEOUS FLOWERING PLANTS
Vanilla-leaf (*Achyls triphylla*)
Sedge (*Carex* spp.)
Coralroot (*Corallorhiza maculata*)
Sweet-scented bedstraw (*Galium triflorum*)
Large-leaved avens (*Geum macrophyllum*)
Rattlesnake plantain orchid (*Goodyera oblongifolia*)
Purple pea (*Lathyrus nevadensis*)
Twinflower (*Linnaea borealis*)
Wood-rush (*Luzula* sp.)
Skunk-cabbage (*Lysichitum americanum*)
Indian pipe (*Monotropa uniflora*)
#Siberian miner's-lettuce (*Montia sibirca*)
Nemophila (*Nemophila parviflora*)
Water-parsley (*Oenanthe sarmentosa*)
#Sweet cicely (*Osmorhiza ? purpurea*)
Sanicle (*Sanicula crassicaulis*)
Yerba buena (*Satureja douglasii*)
False Solomon's-seal (*Smilacina racemosa*)
Hedge-nettle (*Stachys cooleyae*)
#Common twisted-stalk (*Streptopus amplexifolius*)
Tall fringecup (*Tellima grandiflora*)
Fringecup (*Tiarella trifoliata*)
Starflower (*Trientalis latifolia*)
Western trillium (*Trillium ovatum*)
Stinging nettle (*Urtica dioica*)

(NOTE: a number of grass species were also observed,
but not identified)
additional species from May, 1993

FERNS AND FERN-ALLIES
Lady fern (*Athyrium filix-femina*)
Spiny wood fern (*Dryopteris expansa*)
Common horsetail (*Equisetum arvense*)
Branchless horsetail (*Equisetum hiemale*)
Giant horsetail (*Equisetum telmateia*)
Licorice fern (*Polypodium glycyrrhiza*)
Sword fern (*Polystichum munitum*) (NOTE: Mystic Vale contains one of the most spectacular populations of sword fern anywhere on southern Vancouver Island)
Bracken fern (*Pteridium aquilinum*)

SOME MOSSES AND LIVERWORTS
(NOTE: This list is very incomplete, representing only a fraction of the species occurring in the Vale)

Antitrichia moss (*Antitrichia curtipendula*)
Fork moss (*Dicranum scoparium*)
Hypnum moss(*Hypnum circinale*)
Stolon moss (*Isothecium myosuroides* ; syn. *I. stoloniferum* , *I. spiculiferum*)
Oregon feather moss (*Kindbergia oregana* ; syn. *Eurhynchium oreganum*)
Feather moss (*Kindbergia praelonga*; syn. *Eurhynchium praelongum*)
Palm-tree moss (*Leucopelis menziesii*)
Douglas neckera moss (*Neckera douglasii*)
Neckera moss (*Metaneckera menziesii*)
Mnium moss(*Plagiomnium insigne*)

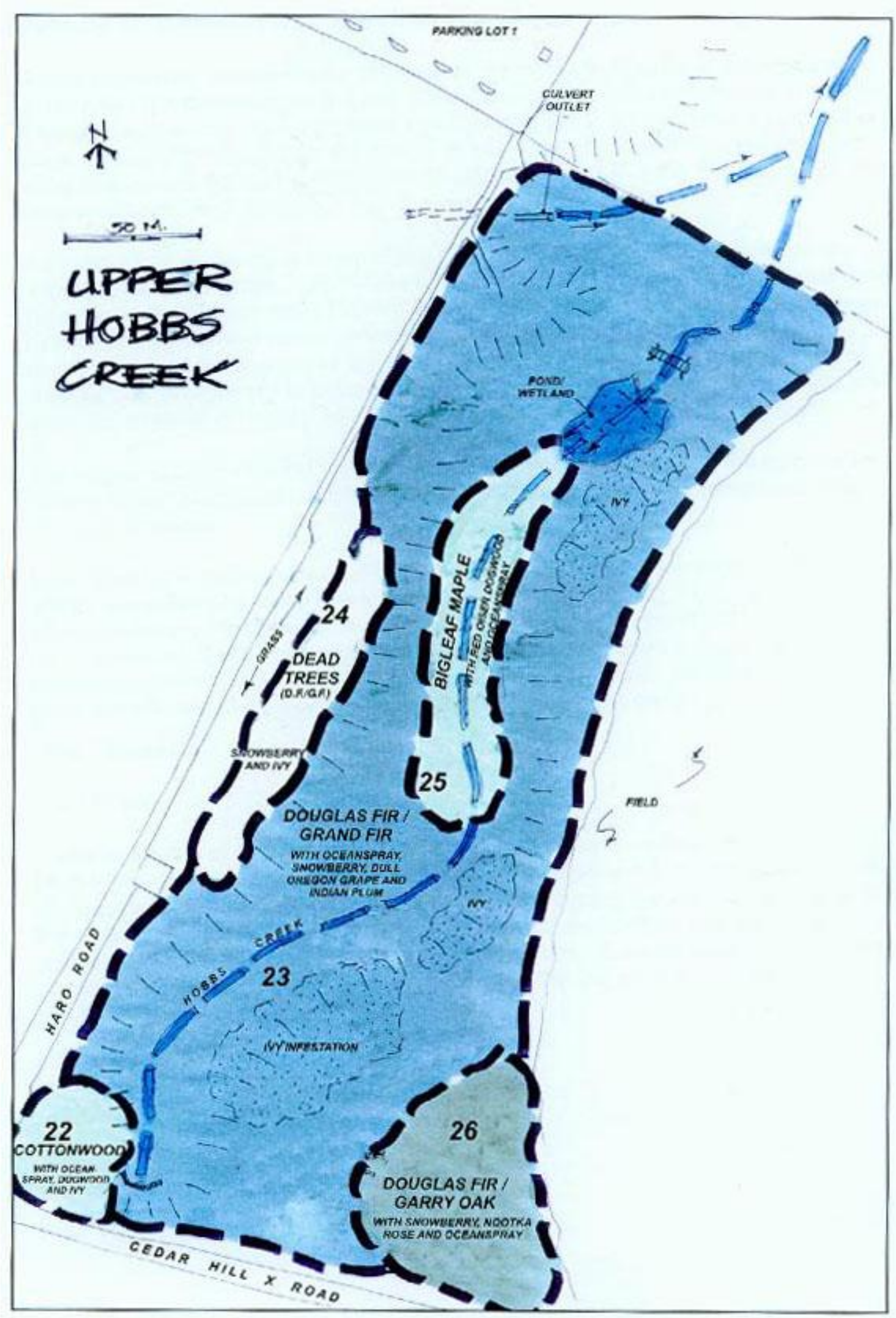
Plagiothecium moss (*Plagiothecium undulatum*)
Leafy liverwort (*Porella navicularis*)
Mnium moss(*Rhizomnium glabrescens*)
Feather moss (*Rhytidiadelphus loreus*)
Triangle-leaved feather moss (*Rhytidiadelphus triquetrus*)
Leafy liverwort (*Scapania bolanderi*)

NOTE ON LICHENS and FUNGI

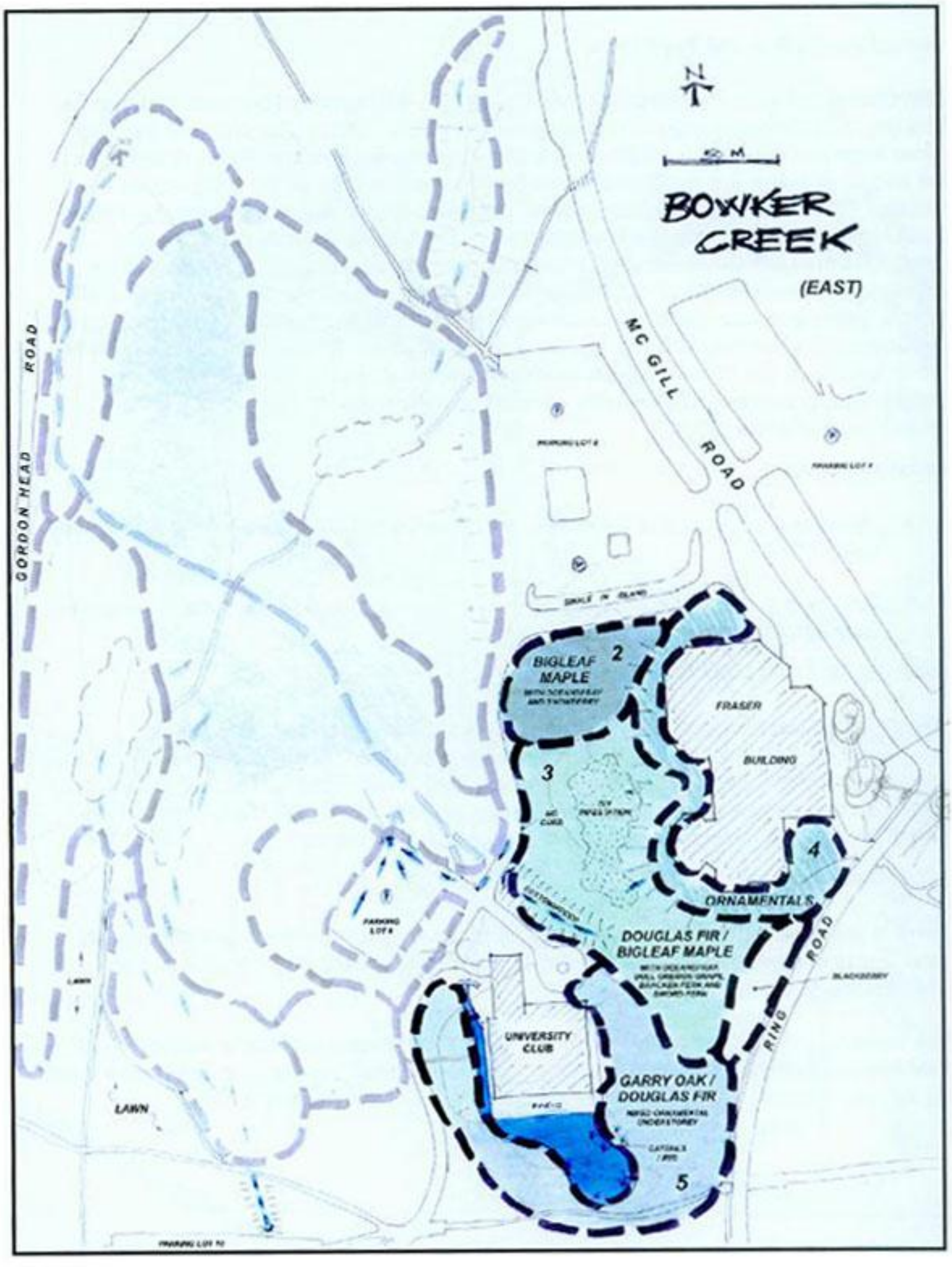
A complete inventory of Mosses, Liverworts, Lichens and Fungi in the Mystic Vale area should be made. A few identifiable lichens seen include: *Ochrolechia* sp.; *Cladonia* spp.; *Cetraria* spp.; *Platismatia glauca* ; *Parmelia sulcata* ; *Hypogymnia physodes* ; *Peltigera* sp.; *Usnea hirta* . A wide variety of fungi, including mushrooms and tree fungi, also occur in the area, contributing to the overall biodiversity.

BIRDS
NOTE: It is particularly important to survey this area on a year-round basis, not just over a short period, because the woods of Mystic Vale and surrounding areas may provide critical habitat not just for resident bird species, like winter wren and rufous-sided towhee, but also for migratory species, which need these areas for resting and feeding on their northward and southward journeys. Woodpeckers abound in the vale, as do a wide variety of small songbirds--kinglets, bush tits, juncos, creepers, wrens. Owls, eagles and other raptors need the tall trees and snags for nesting and perching.

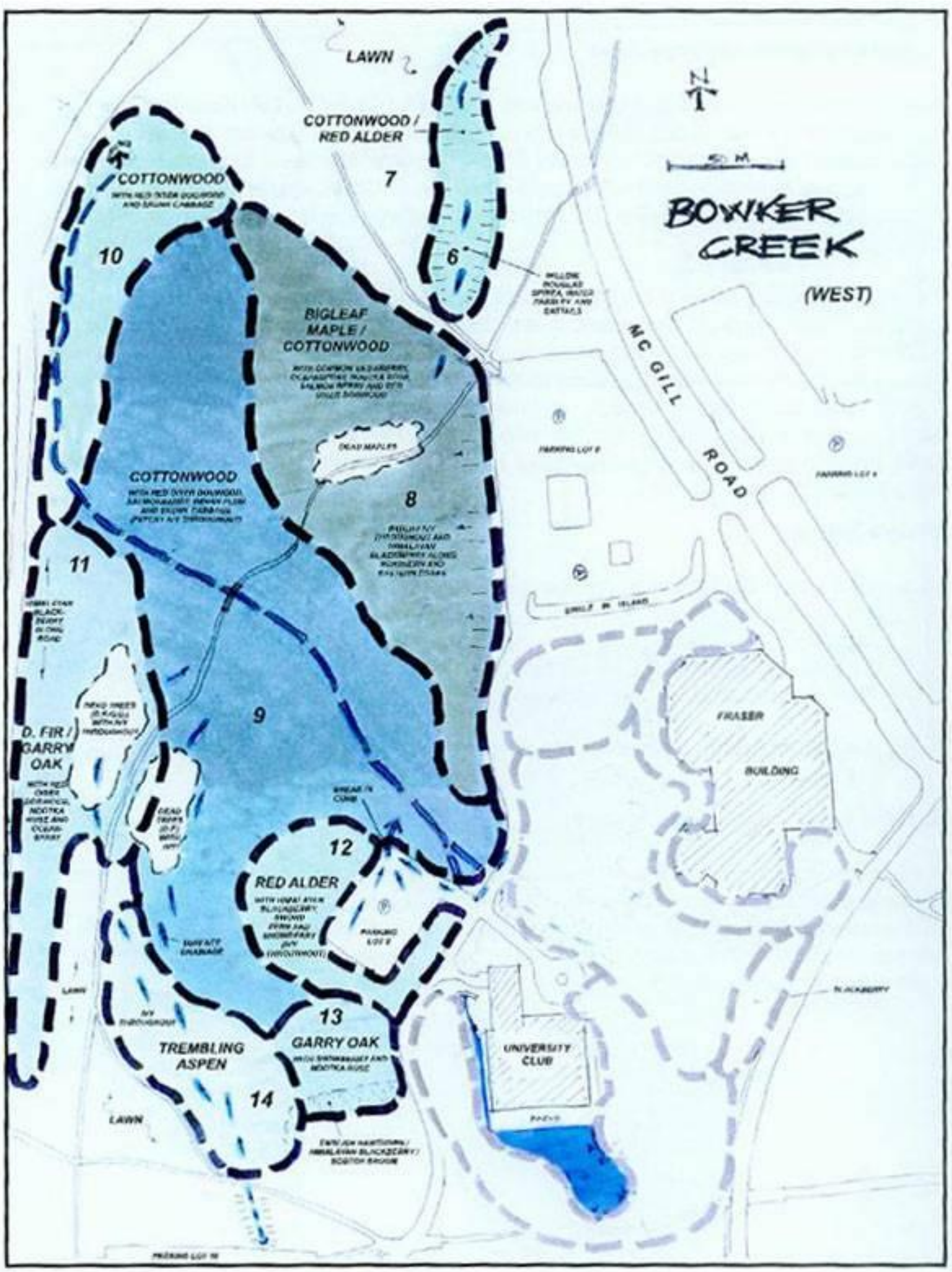
Appendix R – Upper Hobbs Creek (Lloyd 2004)



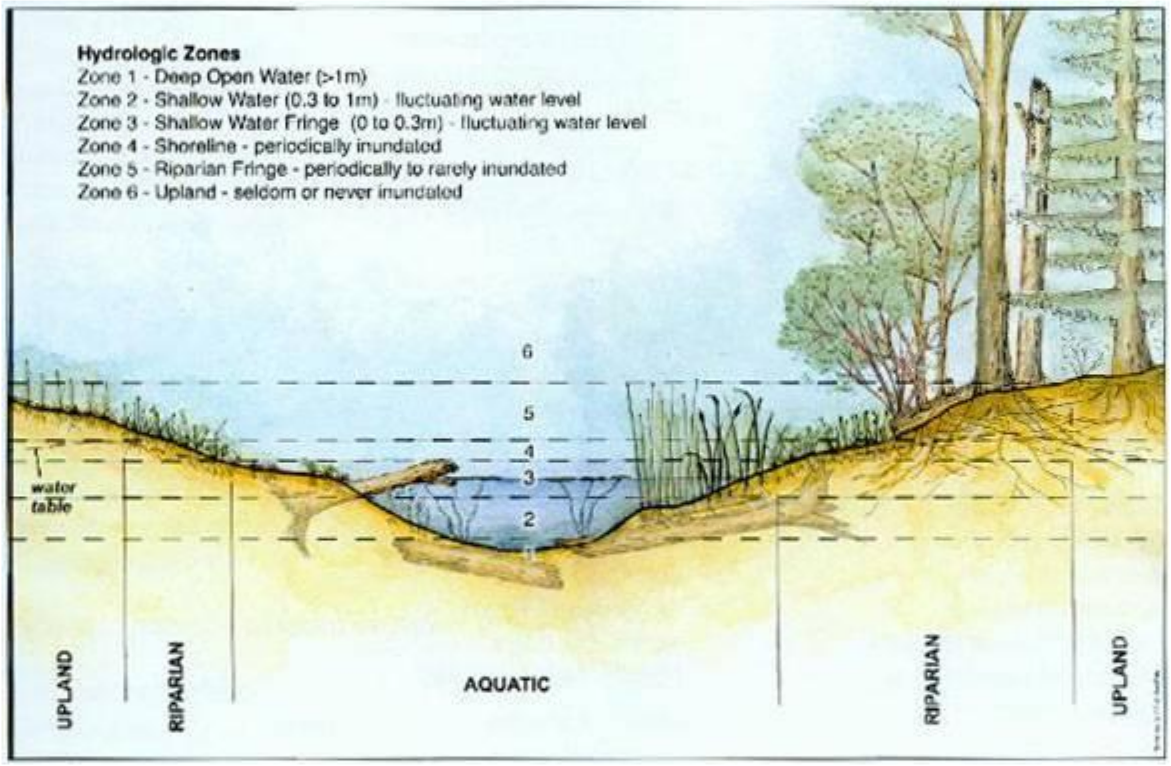
Appendix S – Bowker Creek East (Lloyd 2004)



Appendix T – Bowker Creek West (Lloyd 2004)



Appendix Ua – Hydrological Zones (Source: Lloyd 2004)



Appendix Ub –Proposed Planting List (Lloyd 2004)

Zone 1 - Deep Open Water (>1 m)

No rooted vegetation

Zone 2 - Shallow water (0.30m to 1 m) - fluctuating water level

Sagittaria latifolia	wapato, arrowhead
Scirpus acutus	hard-stemmed bulrush
Scirpus microcarpus	small-flowered bulrush
Typha latifolia	cattail

Zone 3 - Shallow water fringe (0-0.30 m) - fluctuating water, regularly inundated

Cornus stolonifera	red-osier dogwood
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Spirea douglasii	hardhack
Carex mertensii	Merten's sedge
Carex obnupta	slough sedge
Carex rostrata	beaked Sedge
Carex sitchensis	Sitka Sedge
Carex stipata	sawbeak Sedge
Juncus effusus	common Rush
Juncus ensifolius	dagger-leaf Rush
Lysichiton americanum	skunk cabbage
Oenanthe sarmentosa	Pacific water-parsley
Typha latifolia	cattail

Zone 4 - Shoreline - periodically inundated

Populus trichocarpa	black cottonwood
Cornus stolonifera	red-osier dogwood
Crataegus douglasii	black hawthorn
Lonicera involucrata	black twinberry
Rhamnus purshiana	cascara
Rubus spectablis	salmonberry
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Sambucus racemosa	red elderberry
Spirea douglasii	hardhack
Carex mertensii	Merten's sedge
Carex obnupta	slough sedge
Carex rostrata	beaked Sedge
Carex sitchensis	Sitka Sedge
Carex stipata	sawbeak Sedge
Juncus effusus	common Rush
Juncus ensifolius	dagger-leaf Rush
Lysichiton americanum	skunk cabbage

Zone 5 - Riparian Fringe - rarely inundated

Alnus rubra	red alder
Populus trichocarpa	black cottonwood
Thuja plicata	western red cedar
Cornus stolonifera	red-osier dogwood
Crataegus douglasii	black hawthorn
Lonicera involucrata	black twinberry
Physocarpus capitus	Pacific ninebark
Populus tremuloides	trembling aspen
Rhamnus purshiana	cascara
Rubus parviflorus	thimbleberry
Rubus spectablis	salmonberry
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Sambucus racemosa	red elderberry
Spirea douglasii	hardhack
Athyrium felix-femina	lady fern
Aruncus sylvester	goat's beard
Blechnum spicant	deer fern
Polystichum munitum	sword fern
Pteridium aquilinum	bracken fern

Zone 6 - Upland - seldom or never inundated

Acer macrophyllum	bigleaf maple
Malus fusca (Pyrus fusca)	Pacific crab apple
Prunus emerginata	bitter cherry
Quercus garryana	Garry oak
Thuja plicata	western red cedar
Amelanchier alnifolia	saskatoon
Arctostphylos uva-ursi	kinnickinick
Holodiscus discolor	oceanspray
Mahonia nervosa	dull Oregon grape
Oemleria cerasiformis	Indian plum
Philadelphus lewisii 'Gordianus'	mock orange (Coastal)
Ribes sanguineum	red flowering currant
Rosa gymnocarpa	baldhip rose
Rosa nutkana	Nootka rose
Rosa pisocarpa	clustered wild rose
Rubus parviflourus	thimbleberry
Rubus spectablis	salmonberry
Sorbus sitchensis	Sitka mountain ash
Symphoricarpos albus	common snowberry
Vaccinium membranaceum	black huckleberry
Polystichum munitum	sword fern
Pteridium aquilinum	bracken fern