Vegetation Management: A Guide for Puget Sound Bluff Property Owners

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Preface

This publication has been prepared to provide property owners and others with information about the role, benefits, and management of existing vegetation common to steep, often unstable shore sites in the Puget Sound area. It will also identify and discuss the limitations of plant cover under some conditions. The focus of this guide is on vegetation management during site development with an emphasis on reducing the hazard of surface and mass soil erosion (landslides).

It is beyond the scope of this publication to deal with the effects, advisability, or design of shoreline armoring structures such as bulkheads. Refer to *Marine Shoreline Erosion: Structural Property Protection Methods* in "Recommended Reading." The subject of vegetative restoration of slopes will be discussed in a companion publication, *Slope Stabilization and Erosion Control Using Vegetation*, that will be published concurrently with this guide. Issues regarding sealevel rise, beach nourishment, regulatory management of shorelands and other important topics are likewise not addressed here.

Vegetation management is a crucial element of an overall shoreline management strategy. The Shorelands and Costal Zone Management Program (Shorelands) of the Washington State Department of Ecology (D.O.E.), in an effort to deal with coastal and Puget Sound erosion concerns, has been exploring a multiplicity of issues for several years. The Coastal Erosion Management Strategy (CEMS) project, initiated in 1992, is a comprehensive effort to coordinate research, assessment, and monitoring of beach processes and erosion control measures. For more information on the CEMS project, or to order the Department of Ecology publication listed in "Recommended Reading," contact:

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The patient assistance of Abbey Carpenter and Janie Pulsifer was invaluable in editing, proofing and preparation of this manuscript. Thanks to the illustrator, John M. Dispenza for rendering my rough sketches presentable, and to the Island County Beach Watchers for the phrase "Living on the Edge."

Although many people and publications have helped in preparing this guide, I take responsibility for the content and accuracy of the information presented.

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A Word of Caution

There is a lack of detailed research on vegetation management for Puget Sound bluff sites. The information and recommendations provided here have been gathered from a variety of published and unpublished sources in forestry, fisheries, geology, horticulture, soil science, and arboriculture. Many of the observations and suggestions are based on the experience of the author and from conversations with researchers and land managers from the United States and Canada.

This guide is not intended as a substitute for professional assistance. Readers are advised to become familiar with any federal, state, county and/or municipal ordinances that may apply to development of shoreline sites. Neither the author nor the Washington State Department of Ecology assumes responsibility for any results or consequences that arise from the treatments or techniques mentioned in this guide.

Readers who have additional information, pertinent bibliographic citations, or management suggestions are invited to submit their comments to the Washington State Department of Ecology's Shorelands and Coastal Zone Management Program or to the author at:

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Introduction

Imagine you have just bought the property in Illustration 1. You are going to build your dream house here. Note the stand of trees on the uplands, the brush and trees growing on the crest, and the scattered growth on the face of the bluff. The information in the guide will help the following unfortunate scenario from happening to you.

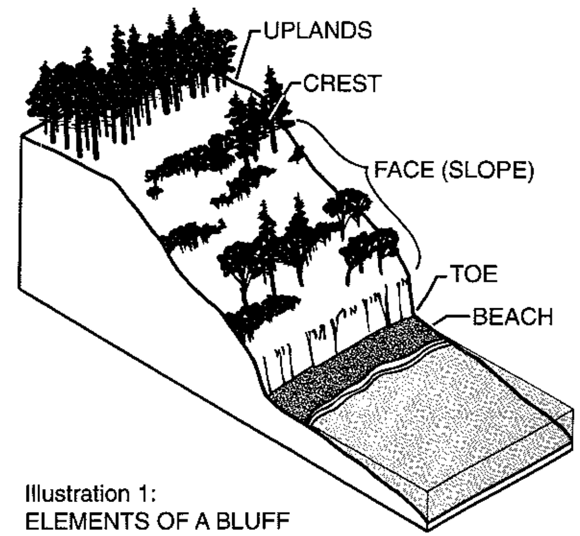


Illustration 1:
ELEMENTS OF A BLUFF

Heavy equipment clears the brush and small trees from the uplands. Trees on the bluff top are cut; their stumps and roots are pulled and pushed over the crest. Clearing debris are piled and burned or join the stumps over the bluff edge. Trees on the slope and crest are removed or topped to open up the view. The top of the bluff is graded to remove topographic irregularities and allow free access to the edge.

The home is sited as close to the crest as possible to obtain the most dramatic panorama. The septic system is installed. Excavations for foundation footings are dug. Trenches for water, power, and waste lines are dug. Roof and footing drains are installed. Construction of the residence is begun. The house takes shape quickly. As construction proceeds, a stairway is built to the beach and more trees and brush are removed from the slope.

The area surrounding the house has been repeatedly scraped, graded, and subjected to traffic. Soil has become compacted and fairly impervious to water. It is doubtful that it will support a lawn. A landscaper is called in. Topsoil is brought in and the lawn is installed. Flower beds are built and ornamental trees are planted. In neglected corners of the clearing thickets of alder, thistle, and Scot's broom grow in the disturbed soil.

After several years some irritating problems begin to worry you. The lawn dries out in the summer and requires frequent watering. In the winter the yard is soggy and puddled. The few trees left on the bluff top have blown down, died, or the tops of some have broken in the wind. The brush below the crest has grown too tall to see over *and young alders have begun to obscure the view. The trees that were topped are also in the way again and make you nervous when the wind blows. The trees you planted don't seem to be doing well; they are brown and dead-looking on the seaward side.*

A tree trimmer tops the trees again and cuts the brush and alder so your view is back. He mentions that some of the old stumps from the initial view-clearing are becoming undermined by erosion and the rootwads that were pushed over the edge made it difficult to work. They have been sliding downslope and have caused some small landslides. He also remarks that in places the edge of the bluff is undermined and seems unsafe. He notices that there are several patches of bare ground and signs of mudslides. You are surprised and concerned. You don't remember seeing bare spots the last time you used the stairway to the beach, though you have not been down there since a washout made it unsafe.

After the tree trimmer's visit you decide to call a geologist. Her investigations indicate that the slope shows signs of serious surface erosion, soil slumpage and the potential of a landslide. She also notes the undermined crest and suggests it be fenced off from use. She says that bluff retreat has accelerated and advises that perhaps the house be moved further back from the edge in the near future. You are understandably unhappy and wonder how your dream house could become such a nightmare.

The scenario above is rather dismal. While often the situation is not this bleak, these problems nevertheless occur all too often in the Puget Sound area. Many of the problems property owners experience in regard to surface erosion and slope failure can be attributed to ill-advised clearing of vegetation. It can sometimes take years for the consequences to become evident. Thus it is crucial that property owners understand the role of vegetation in the shoreline environment and how proper management and planning during development of shore and bluff sites can benefit the land and protect your investment.

Vegetation management should be incorporated into your site development plans before you begin construction. This requires that you understand the role of vegetative cover and its ability to protect a site in relation to topography, drainage patterns, soil type, and natural shore processes such as wave attack. Also, before you alter the shoreline environment, it is wise to first learn how it was formed and the processes that are continually shaping it.

Keep in mind that vegetation alone cannot protect against erosion in all cases. Vegetation cannot withstand wave attack at the toe of a slope, nor will it prove effective in stabilizing a slope already subject to deep-seated mass soil movements. If you suspect problems of this nature, seek the services of a geologist who is familiar with conducting geotechnical site investigations before you build.

Could the difficulties our hypothetical homeowner suffer have been avoided? What could have been done differently? Would careful clearing and tree trimming rather that removal have made a difference? There are no "cookbook" recipes for maintaining the stability of dynamic shorelands, but a knowledgeable property owner is less likely to make mistakes that could have been avoided. The purpose of this guide is to give you the resources to make informed choices.

Chapter 1: The Shoreline Environment

Living on the Edge

Beaches and shorelands are dynamic zones between land and water, an intricate landscape continually shaped by water and wind. Where water meets land, land changes, and though the glaciers receded long ago, water continues to shape the shores of Puget Sound. Sometimes the changes are gradual, almost imperceptible. At other times one winter storm brings drastic changes in a matter of hours. Consider the following a primer on how our shores were formed and the processes at work today.

Glacial Origins

Much of Puget Sound's uplands are comprised of and underlain by glacial and interglacial deposits of sand, gravel, silt, and clay. Repeated glaciations have sculpted, compacted, transported, and deposited these materials. The most recent of these, together with stream and shoreline processes, formed the landscape we see today. This landscape is generally characterized by steep, eroding bluffs of glacial and interglacial sediments, and narrow beaches. In places such as the northern end of Whidbey Island, and the islands of Skagit, Whatcom, and San Juan Counties, bedrock is exposed and the beaches are commonly discontinuous.

Factors Affecting Bluff Stability

Several geologic, topographic, and watershed-related characteristics can determine general slope stability and the type, rate, and severity of erosion common to shorelands comprised of glacial and interglacial materials. (Rocky shores and sites of exposed bedrock are not discussed specifically but much of the information on the role and management of vegetation will apply.) The Coastal Zone Atlas (see "Recommended Reading") for your county is a valuable source of information. County planning and engineering offices usually have a copy available for the public. Property owners should become familiar with the characteristics of their land before beginning clearing or grading.

Soil Type, Bluff Materials and Stratigraphy

Soil types vary greatly depending on the kind of materials they are formed of, the plants that have grow and died within them, their composition, and many other factors. A detailed discussion of soil types can be found in the Soil Survey for your county. (See "Recommended Reading" or contact your Soil Conservation Service Office.) For the purposes of this guide, we will be discussing the basic properties of soils that dictate how much water they can hold, how well they grow plants, whether they can support and anchor trees and how susceptible they are to erosion. Simply put, soil is the upper layer of "dirt" we are all familiar with. It has characteristics of texture, color, depth, moisture, and fertility. Soil is what our hypothetical landowner scraped away with the brush during land clearing.

Bluff materials refer to the sand, gravel, clay, silt, and glacial till that comprise many Puget Sound bluffs. Their characteristics and properties can influence the extent to which a site may be prone to erosion and slope instability.

Stratigraphy, the sequence of bluff materials in a particular shore profile, can influence whether your property is well-drained or boggy, if your trees are prone to blowing down, or whether you should move your house site back another fifty feet.

The **properties** of bluff

materials vary depending on whether they are generally coarse or fine textured. Soil types derived from bluff materials will have many properties in common, but will differ in factors such as depth, organic material (humus), and mixing of coarse and fine textured materials. For example, soils with high percentages of clay materials will be more prone to compaction than sandy soils, and soils with high humus content hold water better than purely mineral soils. The properties and characteristics that property owners need to know are outlined below.

Coarse-textured materials (sand, gravel)

- Readily permeable to water infiltration
- Highly susceptible to wave action
- Soils prone to surface erosion
- Soils readily penetrated by plant roots
- Soil less subject to compaction

Fine-textured materials (clays, silts)

- Resist water infiltration
- Become slick when wetted
- Somewhat resistant to surface erosion
- Resistant to penetration of plant roots
- Susceptible to wave action
- Clay soils highly susceptible to compaction

Glacial till (wide range of textures)

- Resistant to water infiltration
- Resistant to surface erosion
- Moderately resistant to wave action
- Soil resistant to further compaction

Glacial till (or hardpan) is usually comprised of combinations of the above and is characterized by being very hard and compact.

The materials that make up Puget Sound bluffs can be extremely diverse in composition. There will often be mixtures of the coarse and fine-textured soils within one layer and the thickness of individual layers can vary considerably. The stratigraphy of these soils can also be complex. Each combination and configuration responds differently to wind, water, and the force of gravity. For instance, glacially compacted materials are harder and denser than those sediments deposited later.

Topography

The presence of swales, gullies, or drainage channels on or adjacent to a shore site can affect surface water movement. These features can direct surface water flow towards or away from the bluff face and slope. They also affect the accumulation of sub-surface water and groundwater. The sometimes steep sides of such features can concentrate and accelerate runoff, increasing surface erosion. These features often indicate the site of past erosion or landslides. Modifications of existing topography should not be undertaken lightly.

Steepness of Slope

The tendency of bluff materials to fall, slide, or flow downslope depends on the force of gravity, other factors being constant. For example, sand and gravel banks are stable at around 30 to 40 degrees. If the slope is modified by wave attack or other means, that material will seek a new equilibrium causing a mass soil movement. Many vegetated slopes in Puget Sound are at or beyond this equilibrium point. The removal of vegetation can tip the balance of forces.

Steep, almost vertical bluffs composed of glacial till are common in the area and can sometimes stand for years if undisturbed. When subjected to wave attack and erosion, however, they may collapse.

The importance of slope gradient in determining stability must be assessed in conjunction with factors such as soil characteristics, stratigraphy, topography, and watershed characteristics. These factors are greatly influenced by the shore processes discussed below.

Causes of Erosion

Natural Processes

The erosive agents of water and weather act on bluffs in several ways (Illustration 2). As mentioned, these processes occur constantly, altering and modifying shorelands over time.

Beach processes, in particular the transport of beach materials along the shore by the combined action of waves, currents, and wind, can create a protective area between the waters of the Sound and the toe of a bluff. This area is called a backshore and is generally stable and dry from year to year. These are the beaches we walk on at high tide in the middle of winter when most others are inaccessible. Often they support the growth of vegetation and are above the drift line where logs accumulate. The result of net accumulations of sand and gravel, they are termed "accretional beaches" and they are relatively rare in an area where most beaches are erosional (that is, the result of net removals of sand and gravel). They are significant in terms of bluff stability because they offer a natural buffer from the erosive forces of wave activity. The shore shown in Illustration 2 has no protective backshore and thus is subject to wave attack.

Water is widely regarded as the most important force at work on shore sites. It can be misleading to discuss water-related processes separately; they often act in combination. Property owners should be cautious when attempting to control one problem because they may create other hazardous situations.

Wave action on shorelines with narrow beaches can attack the base of bluffs, eroding the toe, steepening the slope, and decreasing bluff support. This process is most active during winter months when storm-generated waves increase in size, and storms in frequency.

While wave attack is often an important cause of mass soil failures, it is not always a precipitating factor. Other factors, such as surface erosion or groundwater may actually be the cause of a bluff failure. The construction of traditional erosion control structures such as bulkheads, seawalls, and other devices

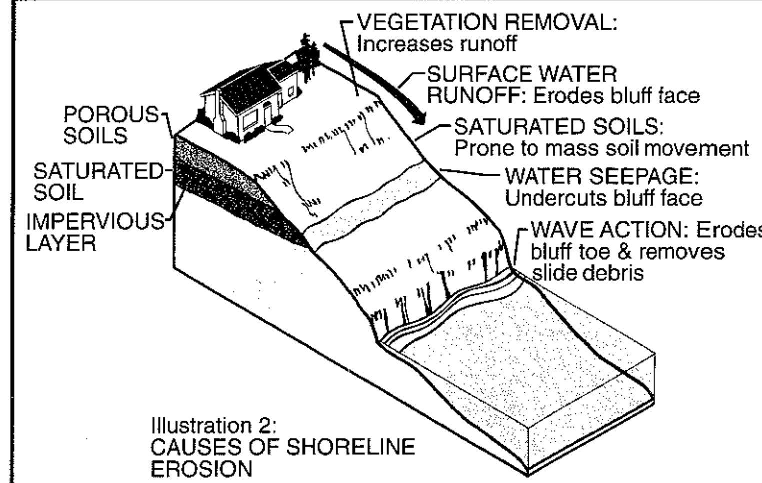


Illustration 2: CAUSES OF SHORELINE EROSION

designed to protect the toe of shore slopes from erosion can be expensive and ineffective. Current research has indicated that, in some cases, they will actually aggravate unstable situations by directing or deflecting wave energy that can result in outflanking or undermining the structure. For a thorough discussion of this subject refer to the "Recommended Reading."

Remember that bluffs undergoing active erosion from wave attack cannot be protected by the presence of vegetation. If you determine that your bluff is actively eroding, it is wise to site upland structures far enough back from the slope so they are not in jeopardy. In many Puget Sound counties there are bluff setback requirements in the zoning ordinance to guide homeowners. Prudent setbacks allow natural beach processes to occur without the need for disruptive and expensive engineering solutions.

Groundwater influences bluff properties in a variety of ways. The extent to which a particular site is subject to groundwater problems is a function of bank materials, stratigraphy, and our wet winter weather (though rainfall varies greatly within Puget Sound). During the winter, rainstorms are frequent and of long duration while evaporation from the ground is reduced due to increased humidity. Like wave action, groundwater impacts increase during the winter.

Much of the rain falling on the land soaks into the ground. If the upper layers are coarse-textured and permeable, the water percolates down until it reaches a layer of lower permeability such as the denser clays. This interruption of groundwater movement is often referred to as perched water; its subsequent lateral movement and discharge on exposed bluffs is commonly observed as seeps or springs.

The two influences of increased groundwater on slopes are shown in Illustration 2. When the soils above the impermeable layer become saturated, they are subject to landslides in the form of slumps, earthflows, and debris avalanches. This movement on a previously stable site is the result of a drastic reduction of the soil's ability, when wet, to resist the force of gravity (Illustration 6). This is the most common way groundwater affects slope stability.

Where seeps appear on bluff faces, the discharged water erodes the soil below, causing the upper unsupported layers to fall or slide. This can be a problem where bank materials below the seep discharge are erodible sand or gravel.

Vegetation can play an important role in maintaining stability in these situations. The removal of groundcovers and trees from uplands and bluff faces is a major contributing factor in triggering these events. (This will be discussed at length in Chapter 2.) However, vegetation alone cannot prevent occurrences of this nature if they are precipitated by other factors. Unusually heavy rains can often increase local groundwater influences (such as saturated soils) and initiate serious mass soil movements. Clearing of adjacent property can exacerbate these problems on your land.

Surface water runoff and the sediments it carries as it flows have been perceived as relatively unimportant as an erosional hazard in the Puget Sound area. However, while its effects are not as dramatic as landslides or bluff collapse caused by wave action, surface erosion can become a serious problem that is difficult to repair. Aside from the impacts to water quality, marine life, and soil productivity, soil erosion by surface water can have serious

implications for bluff property owners.

The two most serious initiators of surface erosion on shore properties are clearing of ground and tree cover and the compaction or disturbance of shallow soils by construction-related activities such as grading. The role vegetation plays in reducing and guarding against surface erosion is discussed in detail in Chapter 2. The subject of construction-related surface erosion is touched upon in Chapter 4, "Vegetation Management: Other Commonly Asked Questions."

Illustration 3 shows the process of surface erosion and the damage it can cause. The process is initiated by the force of **raindrops** striking bare ground and dislodging soil particles. Once dislodged they are transported and become agents of further erosion. **Sheet erosion** occurs when the ground can no longer absorb water or the rate of flow exceeds the percolation rate (like filling a coffee filter too fast). More soil is dislodged and joins the flow. Topographic features concentrate the flow and are deepened, developing into **rills and gullies**.

Governing the severity and rate of surface erosion are slope, topography, and the properties of the affected soils. Obviously the steeper the slope, the faster the water flows and the greater its erosive capacity. Topographic features such as ditches and swales direct the flow. Soils such as sand and gravel are more prone to surface erosion than denser fine-textured soils.

Weathering of shore landforms by wind, rain, and freeze/thaw cycles is constantly occurring. Wind can be a cause of substantial erosion on sandy bluffs exposed to heavy gales if there is no vegetative cover. Rainwater falling on undisturbed sites causes some weathering but is not an important consideration when vegetative cover is present. The freeze/thaw cycle levers and breaks up the surface of exposed bluff faces and contributes to weathering, even on rocky slopes, but is rarely of concern in the Puget Sound area.

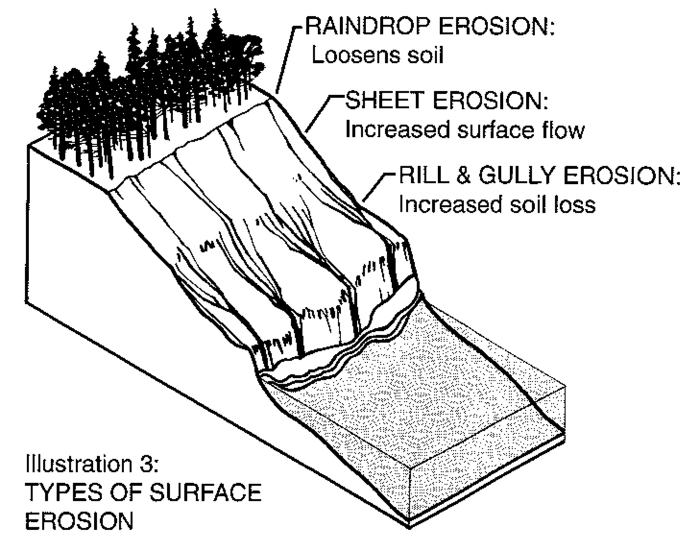


Illustration 3:
TYPES OF SURFACE EROSION

Human impacts

Human impacts that modify the factors and causes discussed above can potentially initiate or accelerate erosion and mass soil movements. Many of the problems encountered by our hypothetical owner in the Introduction could have been avoided or minimized. Below is a list of alterations and modifications common during site development. Their impacts should be considered carefully.

• Hydrologic changes, both

surface water and groundwater flow

- Topographic changes due to excavation or filling
- Vegetation removal
- Construction or road building in marginally stable areas
- Soil compaction by heavy equipment

Questions to Answer Before You Begin

The key to maintaining a stable bluff lies in recognizing the natural forces at work on your site. We have discussed the major processes that contribute to unstable situations and the factors that need to be considered. Obviously, some properties and bluff sites are difficult or impossible to develop while maintaining stability. It is important to recognize these sites and to avoid the expense and frustration of attempting to develop them. If you are considering the purchase of bluff property, these questions will be valuable guidelines for what to avoid. If you already own a problem site the questions below will serve as a checklist to help you make decisions.

- Is the bluff presently stable?
- Are there signs of past instability (landslides)?
- Can you determine when the last one occurred?
- Is the bluff toe subject to wave attack?
- If subject to wave attack, what is the nature and frequency of such action?
- Is the shoreline accreting or eroding?
- If eroding, what is the rate of bluff retreat?
- Would a greater setback of structures from the edge be practical?
- What materials comprise the bluff?
- What is the stratigraphic sequence of the sediments making up the bluff?
- What are the soil moisture and groundwater conditions?
- Is there surface water drainage over the bluff on or adjacent to the property?
- What is the angle of the bluff?
- What vegetation is present?
- Is the property large enough for your purposes (i.e., required setback, driveway, septic, yard, and home)?
- Can the property be developed successfully without initiating or aggravating erosion?

Some of these questions cannot be answered adequately by the homeowner and require the help of a geotechnical expert.

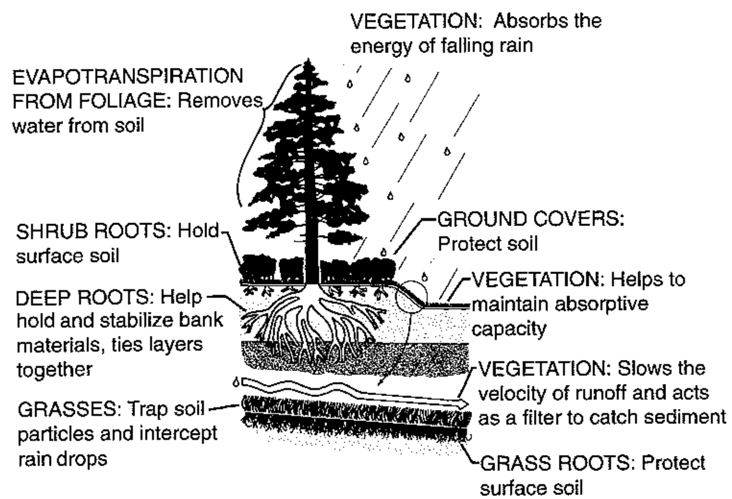


Illustration 4:
EFFECTS OF VEGETATION IN MINIMIZING EROSION

Chapter 2: Vegetation on Shore Bluffs

When property owners become aware of the dynamic and fragile nature of shore areas through an understanding of the landscape's origins and the processes continually shaping it, they are better able to answer some of the questions listed at the end of Chapter 1. A knowledge of the nature and functions of the vegetation growing on these sites is no less important if they are to avoid the sometimes disastrous consequences of ill-advised development practices.

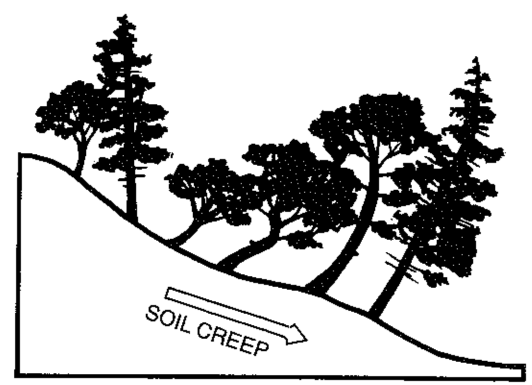
The Role of Vegetation in Minimizing Erosion

Illustration 4 shows ways vegetation protects soil from surface erosion. Live plant foliage and forest litter (partly decomposed leaves, twigs, etc.) break the force of falling rain and reduce the impact of raindrops, which can loosen soil and transport it downslope. Absorptive capacity of the soil is increased substantially by the presence of forest litter, which acts as a sponge by holding water and releasing it slowly over an extended period. Low-growing plants catch and slow rainfall and allow some moisture to evaporate from leaf surfaces. Groundcovers and forest litter also help reduce surface water runoff velocity and act as a filtering system for soil particles in suspension. Plants draw water up through their stems or trunks and branches to their leaves and into the air by the mechanism of transpiration, thereby removing water from the soil.

Plant roots, especially the smaller feeder roots, provide a fibrous web that stabilizes and anchors soil. They function much like reinforcing steel in concrete structures, increasing the cohesive strength within a soil horizon. The roots of many brush and tree species penetrate deeply across the contact zone between two soil layers, thus increasing the soil's shear strength and reducing risk of shallow landslides.

Several layers of plant foliage multiply the benefits discussed above. Ideally, a site will support low groundcovers, small shrubs, taller shrubs, and small and large trees.

Vegetation, though more effective in protecting against surface erosion than in controlling mass soil movements triggered by groundwater, can still be valuable in sustaining slope stability. As mentioned, many bluff sites are barely stable and the removal of vegetation on some slopes can precipitate a landslide or re-activate an old one. Due to the complex root network formed by trees and shrubs, potentially unstable slopes are held together and the resistance of the soil to slipping, sliding, and washing away is increased. Slopes susceptible to soil creep



Soil creep causes districtive curved form of tree trunks over time.

Illustration 5:
INDICATIONS OF SOIL CREEP

(Illustration 5) are also held in check to some degree by the presence of vegetation. The ability of plants to absorb water and slow its velocity also allows time for soils to "meter" the absorption and discharge of water more effectively.

Vegetation Indicators of Slope History and Stability

The type, age, health, and abundance of vegetation growing on a shoreline bluff site can offer valuable clues to determine slope stability. Even the presence of stumps and fallen trees can tell a story to a knowledgeable observer. This section discusses these clues and what they may indicate. Vegetative indicators are best interpreted in combination with soil and geological data.

Curved Trunks

Trees on a slope curved as shown in Illustration 5 are usually the result of a slow, gradual soil creep. Care should be exercised in clearing sites like this because you may de-stabilize an already marginally stable area.

"Jackstrawed" Trees

Illustration 6 shows the jumbled appearance of trees after a slump or earthflow. In situations like this, groundwater problems can cause a mass of soil and the vegetation on it to move downslope. If the trees are dead, this may indicate that the roots were sheared or broken loose.

Trees Tipped Downslope

On sites with shallow soils and steep slopes, this may indicate mechanical shifting of materials and signal the potential for a slope failure.

Groups of Trees Growing Across the Slope in a Line

Lines of trees growing across a slope may indicate two conditions. If the trees are species such as Red alder or willow, a slide may have caused bare ground in the recent past, subsequently offering a site for germination and growth of these fast-growing trees. Chances are good that the slide is active and periodic. The age of trees growing in this manner can be a clue to when the slide occurred.

A line of trees may also indicate an area of perched water or groundwater seepage that in turn may indicate a layer of impervious material underlying a deposit of sandy soil (Illustration 7). These sites usually are unstable and should be investigated geologically.

Bluff Faces Without Vegetation

Shorelands with slopes or sections of bluffs devoid of vegetation can indicate many different situations. Generally, a bare bluff face suggests a site is either too steep to

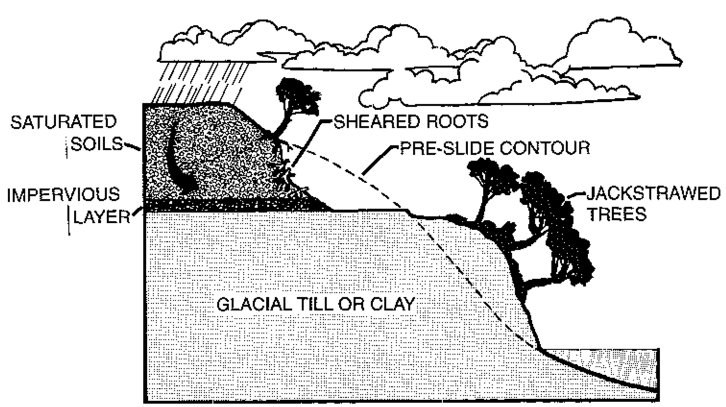


Illustration 6:
INDICATION OF EARTH SLUMP, DEBRIS AVALANCHE CAUSED BY GROUNDWATER INFLUENCES

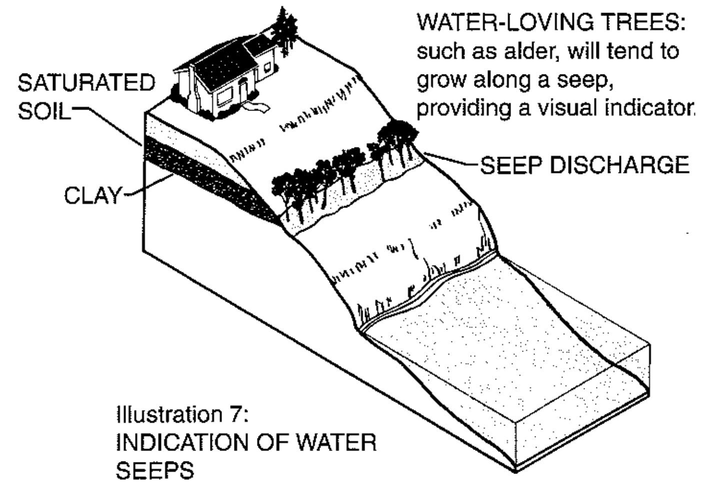


Illustration 7:
INDICATION OF WATER SEEPS

support vegetation or that recurrent erosion precludes the establishment of plants (Illustration 2). The first case is common on exposed bluff faces comprised of glacial till. These sites are often vertical. They are difficult places for vegetation to become established. Of more concern to property owners are steep, erodible sandy bluffs that are actively eroding or retreating. These sites are usually not able to be stabilized by vegetation.

Bare areas may also be indicative of recent or active slope failure. These sites are usually obvious. If the toe of the slope is protected from wave action, signs of debris will be seen. However, wave action will often remove the evidence of erosion.

Old Stumps

Stumps from past logging and clearing are often found on shoreline sites. These remnants can offer much information about the stability of a site and the history of an area. Most shorelines were logged off by the turn of the century. Old-growth trees were often eight feet or more in diameter and they were usually two hundred or more years old when they were cut. Thus, an old-growth stump found today indicates that a site has probably experienced no appreciable mass movement for at least three hundred years. This, of course, is not an inflexible rule and does not always mean the site is currently or permanently stable. All indicators should be used in context with other available information.

Partially buried old-growth stumps can indicate soil movement from up slope in the form of debris avalanches.

Downed Trees

The presence of downed trees may indicate several things. In sites where rooting is shallow, wind may cause trees to blow down. Shallow rooting can be the result of wet soils like those found in wetlands, or can be caused by shallow soils underlain by impervious layers that resist penetration of roots.

Fallen trees may also result from adjacent clearing or excessive tree removal within the stand, which often exposes previously stable trees to unusual wind stresses. In some cases, diseases such as root rot may cause substantial windthrow on a site. Another potential and common cause of downed trees is a slope disturbance such as excavation of the toe, or previous thinning, which leads to local erosion undermining downslope portions of the rootmass. This condition becomes obvious when bare roots and "caves" are observed under trees.

Whatever the cause of fallen trees, the results are similar: accelerated erosion, de-stabilization of the slope, and substantial disturbance to the area These sites should be examined carefully to determine the cause, impact and severity of a disturbance. Any remedial actions deemed necessary should be accomplished quickly.

Single Dominant Species and Even-aged Stand

Occurrence of a predominantly single-species, even-aged stand of Red alder or willow accompanied by understory vegetation such as stinging nettle or bracken fern, can indicate a fairly recent, large-scale, mass soil movement. A plant community similar to that described above, though apparently indicating a stable site, hints at the presence of recurrent large scale disturbances. Linear down-slope "stripes" of such vegetation commonly mark the paths of debris avalanches.

These vegetation types are sometimes associated with high water tables, shallow soils, and marginally stable slopes. They are often adjacent to wetlands and underlain by impervious soils. They are extremely difficult to manage successfully for most residential development. It is often impossible to attain shoreline amenities such as a view on these sites because they are predominantly deciduous and even when fully vegetated are barely stable. In many cases attempts at forest thinning can cause blowdown and subsequent erosion.

Single-age stands can also indicate past clearing or tree removal. Look for old stumps and note size and condition to estimate how long ago the trees were removed. Tree rings can tell you how old the trees were when cut.

Recently Cleared Areas

Partial clearing of uplands and slopes to allow access for prospective buyers and reveal views can cause modifications that could precipitate erosion. Seldom has the clearing been planned and executed with long-range slope stability in mind. Since the impacts of clearing may take several years to become evident, an unwitting buyer may purchase a potentially unstable site. Though this is not always the case, previous clearing will reduce your options for site development.

Dead/Dying Trees

Properties with large numbers of dead or dying trees indicate that there is cause for concern. Look for insect or disease incidence, signs of past wildfire, changes in local hydrology, or other probable causes. Healthy vegetation is important to your property's long-term stability.

Multi-species, Multi-age Vegetation

A site that has a wide variety of vegetation of various ages, is usually stable. A variety of vegetation (groundcovers, shrubs, and trees of deciduous and evergreen species) often indicates the site has not been recently disturbed and that local soil movements are likely to be stabilized naturally by the surrounding vegetation.

Each plant, from the smallest herb to the largest tree, contributes a stabilizing influence to the soil through its rootmass. Some plants have shallow, fibrous roots; others have deep roots. Together they form a strong mat that resists erosional stresses.

As a result of the inherently stable nature of a diverse vegetative community, your management options are increased.

Low-growing Brush May Hide Problems

Because many brush species grow fast and luxuriantly, a slope face that appears fully vegetated may be actively or potentially unstable. Many brush species found on logged slopes in the Puget Sound area can hide signs of old slides or the clues that would indicate an inherently unstable site. It is sometimes necessary to investigate beneath this vegetation to inspect for signs of seepage, soil movement, or surface erosion. Sites with extensive cover of Himalayan blackberry or salmonberry should be carefully inspected.

Factors Influencing the Vegetation Found on Shore Sites

If you explore Puget Sound by boat or walk the beaches you will notice a wide variety of trees, shrubs, and other plants growing along the shores and bluffs. In some places the slopes are densely wooded with evergreens and broad-leaved trees while other places support mostly brush or herbaceous plants such as ferns and foxglove. There are places where madrone and salal line the shores and others where barely anything grows. What causes this variety and variability? What are the implications for site development and slope stability? Property owners need to be familiar with the interactions between what grows on their land and the environmental conditions that influence that growth.

In previous sections of the guide we have discussed the geologic origins and natural processes shaping much of Puget Sound. We have described some of the clues that help explain the recent geologic history of shore properties and how to recognize unstable situations. Now we will explore some of the general factors that influence the shoreline vegetation. Keep in mind that invariably more than one factor will influence the growth and variety of vegetation on any given site. Refer to the tables in the Appendix, "Plants Commonly Found on Puget Sound Shorelands."

Steepness

The steepness of a slope is often a controlling factor influencing its stability. On steep slopes prone to mass soil movements plants may never become established and large mature trees are scarce. The effect of slope gradient on vegetation establishment is strongly related to soil type, stratigraphy, and hydrology. Many steep slopes remain stable and well-vegetated until some critical factor is altered

Examples:

Stable sites offering good rooting conditions will support densely wooded slopes with great vegetative diversity.

Unstable sites will show obvious slide paths and have a high proportion of species such as alder, willow and wild cherry which are relatively short-lived but readily colonize disturbed areas.

Soil types

Soil type and development influence plant growth and vigor, rooting depth, and available moisture.

Examples:

Deep, porous soils that have a high humus content are more productive and hold water better than soils that are mostly mineral.

Poor or recently disturbed soils will often be colonized by species such as Scot's broom and Himalaya blackberry, which thrive in poor soils.

Deep, productive soils will support mature, diverse plant communities comprised of conifers, broad-leaved trees, various shrubs, and herbaceous growth.

Shallow or saturated soils may support a wide range of brush species such as salmonberry, gooseberry, thimbleberry, and elderberry, but trees requiring solid rooting such as Douglas-fir may be absent.

Hydrology

Hydrology is always a factor to consider. Plants are sensitive to both saturated and droughty soil conditions. Some plants can tolerate wide extremes of soil moisture while others cannot.

Examples:

Shore pine can be found on both wet and dry sites, butterfly bush is common on dry sites, and Black cottonwood is an indicator of wet sites.

Aspect

Aspect, the orientation of a slope face in relation to the sun, influences the vegetation growing on shore sites in several important ways. It determines the amount and duration of sun exposure, temperature, and the severity and type of environmental stresses, especially wind, that plants are subjected to.

A south-facing slope is generally hotter and dryer than a north-facing one. A steep east-facing slope will receive full sun in the morning during summer but be in shade by afternoon. A slope oriented towards the west will be exposed to the sun throughout the afternoon and evening during long summer days. The influence of aspect is complicated by topographic features such as canyons and stream courses, causing complex local microclimates that can support radically different plant communities within a small geographical area.

Examples:

East-facing slope: Bigleaf maple with sword fern

West-facing slope: Grand fir and Shore pine

South-facing slope: Oceanspray and snowberry

North-facing slope: Red cedar, hemlock, and salal

Microclimate

Microclimate is a word that refers to the existence of localized conditions of shade, wind, air temperature, and humidity that can combine to influence plant occurrence and growth and which can vary from the general conditions existing on a slope. The effects of factors such as steepness, soil type, hydrology, and aspect can be locally modified by microclimate influences such as fog and frost pockets and the movement of cold air down canyons and stream channels.

Microhabitat

Microhabitats are created by these microclimate conditions and the presence of localized differences in soil, topography, and hydrology. Microhabitats are places within a larger area that support plants or communities of plants different from those more generally found on a site.

An awareness of these factors will help you to understand and explain the sometimes complex nature of the plant communities seen on Puget Sound shorelands.

Environmental stresses

Environmental stresses influence the type of vegetation and its position on a slope. Drought, periods of cold, intense rain, heat, and exposure to wind can reduce plant vigor. Some plants have a broad natural adaptability and can thrive under a wide range of conditions, while others are more limited in the stresses they can withstand. If conditions change slowly over a long period of time, most species can adapt. When natural and human-caused environmental stresses combine to rapidly alter microclimate and habitat characteristics, plant communities change as less-adaptive species weaken and are replaced by plants more able to adjust to new conditions.

Listed below are common conditions to which species found around Puget Sound have adapted.

Drought: Oregon white oak, Western white pine

Saturated soil: alder, willow, salmonberry, Devil's club, Black cottonwood

Hot, exposed sites: wild rose, Oregon white oak, Western white pine

Cool, wet sites: Western red cedar, Grand fir, Sword fern

Full sun: Douglas-fir, alder, Pacific madrone

Shade: Western hemlock, maple, Pacific yew, Evergreen huckleberry

Wind: Pacific madrone, Sitka spruce, Grand fir

Salt spray: Pacific madrone, Sitka spruce

Many of our common plants are adapted so well to various conditions that they can be found almost anywhere. Pacific madrone, Red alder, willows, oceanspray, and Himalayan blackberry (an invasive, non-native) are a few of these.

Site Disturbance

Site disturbance, whether caused by natural processes or human impacts, affects the nature of plant communities and how long they have had to develop and mature. Below, we discuss the causes of site disturbance.

Natural processes contributing to site disturbance include erosion (both surface and mass soil movements), fire, extreme episodes of wind, rain or cold, seismic activity, and unusual tidal/storm events that de-stabilize the toe of slopes.

Human impacts that can cause severe site disturbance include logging, clearing, road building, and grading of shore areas.

The impact of removing mature trees from a site, while not as disruptive as clearing and grading, can severely alter microclimate conditions. Many smaller native trees and shrub species have adapted to the low-light conditions under forest cover. When large trees such as Douglas-fir, Western hemlock, Western red cedar, Sitka spruce, and Grand fir are removed these understory plants suffer from light increases and may die and be replaced by less desirable brush species.

Salal, Evergreen huckleberry, Oregon grape and Pacific yew are all valuable native species that supply wildlife habitat, erosion control benefits and are easily maintained. They are all, to some extent, adapted to flourish under the shade provided by tree canopies.

Species such as Sword fern, Vine maple, snowberry, and Red huckleberry are also valuable native species. They are more adaptive and able to survive environmental modifications.

Many of the shrub and herbaceous plants that thrive in full sun or increased light conditions are less beneficial than those above because they have inferior erosion control abilities, are extremely invasive, and/or create maintenance problems. They respond to increased light by height increases and by rapid spread. The worst of these for view and access management on bluff crests include Himalaya blackberry, English ivy, salmonberry, Devil's club, nettle, oceanspray, and Scot's broom.

Succession is a term used by ecologists to describe the natural development of plant communities over time. Starting with bare soil, certain highly-adaptive plants such as alder, willow, and fireweed will colonize the disturbed soil if nearby seed sources are present. These **pioneer species** are often short-lived and contribute organic material to the bare soil, and allow various other species, such as Evergreen huckleberry, Oregon grape, Salal, and Western hemlock to become established under their shade.

Factors such as soil type, hydrology, aspect, and local climate all influence the composition of various plant communities and how well they develop. Natural plant succession can require many years to produce a heavily wooded site. Generally, a plant community that is composed of a wide variety of evergreen and deciduous trees and shrubs is more resistant to environmental stresses and erosional processes than a "younger" plant community.

Often, though, plant species from other parts of the world, such as English ivy, Scot's broom, Himalaya blackberry, and Butterfly bush have been introduced and become well-established here. They are termed "non-native" and "exotic" plants and can compete successfully with the native pioneer species that form the first link in the succession towards a stable plant community.

They are called "invasive" when they colonize sites and spread to surrounding areas, often at the expense of native plants. In the case of Himalaya blackberry and English ivy the erosion control capabilities of these plants are inferior to the natives they dispossess. Himalaya blackberry has a deep root system but does not hold or bind soil well. English ivy creates a dense mat that discourages other species' growth and establishment. Both of these invasive exotics grow extremely fast and rob the soil of nutrients. Scot's broom offers good erosion control but reduces the establishment of evergreen and hardwood species. Butterfly bush and foxglove, while exotics, do not displace natives and offer wildlife benefits.

Many exotics spread readily by seed or plant parts. They can be inadvertently introduced to a site in loads of structural fill and topsoil. Once established they can be very difficult to control and they compete with landscape plantings.

Off-site influences

Off-site influences can impact the plants growing on your property and indirectly increase the potential for erosion in various ways. Adjacent clearing can modify the hydrologic and drainage characteristics on your property. Sudden increases or decreases in surface and subsurface water can subject the vegetation (especially evergreen trees) to environmental stresses that can weaken them. Madrone, our only broadleaved evergreen tree, can be rapidly killed by even minimal increases in summer soil moisture.

Off-site clearing can also remove wind protection or change wind patterns. It is difficult to generalize, but frequently windthrow or blowdown of nearby trees results.

In some areas salt-laden wind has affected barrier trees (trees between the wind and an inland stand of trees) over many years and they have adapted to the prevailing conditions. They protect the trees and shrubs to leeward (behind them). These barrier trees are often misshapen, broken, and gnarled, but they have developed root systems that have allowed them to withstand many winter storms. If they are removed, the trees to leeward are exposed to stresses they are not adapted to. Windthrow and damage from salt often result.

Summary

We have discussed the value of vegetation in minimizing and reducing erosion and described the vegetative clues for diagnosing slope stability. Some of the factors that influence why certain plants grow where they do have been examined and the concept of a constantly changing plant community has been introduced. See if you can use this information to answer the questions posed in the next two chapters.

Chapter 3: Vegetation Management: Tree Removal

Owners of bluff properties have many questions about site development, erosion control, view clearing and beach access. Often, these questions are asked too late: after the damage is done and possible options are eliminated. Even when a property owner is aware that his or her decisions are critical to the long-term stability of a site, it can be difficult to judge the best course of action.

In preceding chapters the complexity of the shoreline environment and the role of vegetation has been discussed. By now you realize that it is important to consider all the factors involved before acting. This chapter and the next address some of the most common questions asked by shore property owners and offers generalized answers.

Should trees be removed?

This simple question generates a range of sometimes contradictory answers. There are many factors to consider before reaching a decision. These factors include: stability of the slope, species, age, health, current stability of the tree, position on the slope, surrounding vegetation, rooting habit/soil type, density of the stand, and the ability of the tree to sprout. Before we discuss these factors, it is necessary to mention some general considerations that apply to tree removals on steep slopes.

General Considerations Pertaining to Any Tree Removal

Tree Roots. The root systems of trees form an interlocking network, especially on many shoreline sites where rooting can be shallow. Often rooting is only two to three feet deep. The depth of root penetration is largely a function of soil depth and type, soil moisture, and the presence or absence of a dense layer of clay or till. These factors have a greater influence on rooting than any tendency of a tree to develop a characteristically deep or shallow root system.

Trees compensate for shallow rooting by increased spread of root systems. Recent research has indicated that a tree's root system will extend considerably beyond the dripline, often as much as two to three times as far. Extensive lateral root systems are common where soil moisture is excessive, soil is shallow, and impervious soil layers impede vertical growth. Where soils are porous, well-drained, deep, and no impervious layer exists, deeper rooting will occur.

Generally, the influence of a tree's roots on a given site will be related to the tree's age and size. Larger trees will have more extensive, often deeper and better developed root systems. Dominant trees, those larger and taller than the surrounding ones, have been more subject to wind and usually have developed stronger root systems as a result. Before clearing trees, consider the effects of removal on tree rootmass over time. Roots of dead trees decay, their stabilizing influence diminishing over a three to nine year period. *As a result of the gradual loss of root strength after tree removal, barely stable slopes may fail several years after clearing or thinning.*

Trimming debris can contribute to stability problems by smothering vegetation and by causing damage to the slope in sliding or rolling downhill. It is difficult to offer general recommendations for dealing with this material due to the wide range of site characteristics and debris volumes that might be generated.

Since regulations regarding the disposition of trimming debris vary it is advisable to check with local planning or engineering departments for advice.

Disposing of bluff top clearing debris over the edge of a slope will be discussed later in the guide.

Do Not Remove Trees Without Cause. People tend to remove many more trees than are necessary during site preparation. The value of a healthy, strong tree on a slope or bluff far outweighs its value as lumber or firewood. A tree should be retained unless it is a hazard to life or property, is growing on the proposed house site or drainfield area or has some other major problem. Do not clear a reserve drainfield area before it is needed. Explore alternatives to removal thoroughly before deciding to cut. The location of trees and other factors involved should be considered carefully. Do not remove trees on slopes until home construction is complete. You may find that the trees do not need to be removed.

On Choosing a Tree Service

The tree care industry is currently undergoing something of a revolution. Many common practices, such as tree topping, are no longer recommended. There has been a great deal of recent research regarding how trees grow and react to environmental changes. New equipment and techniques are continually being developed.

Groups like the Seattle-based *Plant Amnesty* actively lobby to abolish topping and poor pruning practices. Professional associations such as the *International Society of Arboriculture* support research and provide certification programs for tree care practitioners. They are good sources of assistance in finding a tree service. See "For More Information."

Choosing a tree service can be a bewildering experience for a property owner. For an owner of shore property, making the wrong choice can have serious consequences. Beware of bids that seem "too good to be true." The money saved initially may pay dividends of disaster within a few years.

When hiring a tree service to work on a potentially unstable site, require proof of the following:

1. Experience (ask for references)
2. Proper equipment
3. Valid license and insurance
4. Understanding of your concerns

Most of the pruning practices described later in this guide are hazardous operations. They should only be performed by qualified and well-equipped personnel. Most property owners should not attempt to perform the work themselves.

Specific Factors to Consider in Tree Removal

Species. Different species have different characteristics. The growth habit, rooting habit, height, shape, longevity, strength, durability, resistance to salt and climatic stresses, and tolerance to pruning all differ among species. Refer to the plant lists in the Appendix for a relative comparison of characteristics for trees commonly encountered on Puget Sound shorelands.

Age. Tree age in relation to expected longevity of a particular species, can be an important consideration when deciding whether or not a tree should be removed. For example, should you cut down a 65 year-old, large Red alder that is obscuring your view? Because alder is a fairly short-lived species that seldom survives beyond 70 years of age, it is probably not going to survive much longer. In this case, expensive view pruning would not be warranted. The advisability of the tree's removal would be dependent on its role in stabilizing the site. If the tree in question were a Pacific madrone, which can live for well beyond 200 years, then removal would not be advised. Alternatives such as pruning would be an excellent investment for the Pacific madrone. This simple example does not take into consideration other factors that may bear upon a decision to remove a tree in a particular location.

Health of the Tree. Tree health and vigor are important considerations when deciding on removal. Root rots and stem or trunk diseases are the most serious defects. In dense, single species stands infested by root rot, removal may be your only choice. It is advisable to confer with a knowledgeable professional, such as a forest pathologist or arborist if widespread forest health problems are observed.

Current Stability. An assessment of the stability of a tree in relationship to surrounding trees is important. Before landscape alterations begin, determine if the tree is part of an inter-dependent group or can be managed as an individual. Generally, if mature trees grow within 10 feet of each other and share crown canopy space, they are functionally a group. If rooting in the area is shallow due to high water table, impervious or impermeable layers, or shallow soils, then inter-dependence will be greater. If tree trunks lean away from each other (Illustration 8) it is probable they are "balanced" and the removal of one will predispose the other to windthrow.

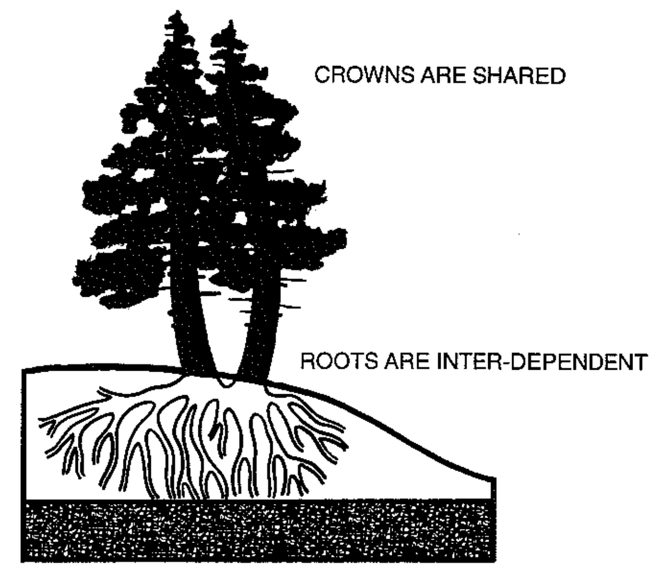


Illustration 8:
INTER-DEPENDENT GROUPING

It is often difficult to evaluate how inter-dependent a grouping is when considering a dense stand. Normally, the denser the stand and the younger the trees, the more can be removed safely. Again, consider all pertinent factors.

When a tree on a slope has become undermined or is otherwise in danger of falling over it should be cut. Determine if an individual tree is losing anchorage or if the lean is the result of soil movement as shown in Illustration 6. Exercise extreme caution when cutting trees on slopes.

Position on Slope. Consider a tree's location on the slope before removal. Illustration 9 depicts a situation where various conifers and deciduous broad-leaved trees

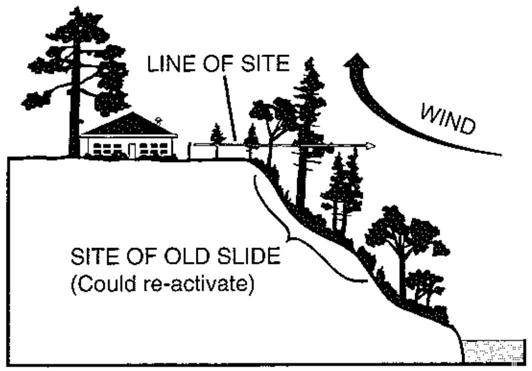


Illustration 9:
POSITION OF TREES ON A SLOPE

are obscuring the view. They are also protecting the residence from the full force of prevailing winds, as well as stabilizing the site of an old slide. Tree cover can often reduce the height of brush. If trees are removed, the brush grows higher thereby requiring constant trimming.

One solution would be to remove some or all of the trees to access a view. However, upon considering the benefits these trees provide and some of the possible adverse impacts that could result, a landowner might seek ways to enhance the view without removing the trees. This might include interlimbing, cutting windows, and skirting-up as discussed later in the question, "What are alternatives to tree removal and topping?" (See illustrations 12 and 13.)

Surrounding Vegetation. All factors should be considered together. This is especially important in regard to the vegetation surrounding trees being considered for removal.

As mentioned, some brush species thrive and flourish when a tree overstory is removed, creating a view management problem. This is particularly true for species such as elderberry, oceanspray, and salmonberry. Alder, wild cherry and some willow species may become maintenance problems when tree canopies are removed and additional light is able to reach the ground. Another species encouraged by increased light levels is Himalayan blackberry which is difficult to control. Invasive species such as Scot's broom prefer disturbed sites with abundant light, and can require constant control to maintain a view.

Native shrub species such as Oregon grape, salal, and Evergreen huckleberry are excellent groundcovers that are often common under conifers. They are sometimes over-stressed when trees are removed and can be replaced by less desirable or weedy species.

Most brush problems occur in the area of the bluff between the uplands, the crest, and the upper margin of the slope face. Lower down on the slope, brush is not a consideration in view obstruction. When contemplating the removal of trees high on the bluff, consider the response of surrounding vegetation so as not to create subsequent problems.

Stability of the Slope. An analysis of slope condition by a geologist or geotechnical engineer is strongly advised and in many counties is required. Vegetative clues should be used in conjunction with the geotechnical data and an assessment of the role of the vegetation on the site should be made.

In situations where soil and hydrological conditions promote well-rooted, healthy, mature trees, the trees should be left insofar as is possible. As mentioned, the practice of removing a majority of trees on a slope can greatly increase the probability of a slope failure in the future as the trees roots decompose and their soil-binding capacity declines.

Some geologists or geotechnical engineers routinely recommend the removal of trees because of concerns that: 1) large trees exposed to wind can transmit that force to the slope, thereby causing slope failure; 2) soil moisture is reduced by evapotranspiration of trees, thereby creating cracks in impermeable layers and promoting water infiltration to lower soil layers; and 3) the weight of trees on the slope may cause landslides.

These concerns have been addressed in recent research and the overwhelming conclusion is, that in the vast majority of cases, vegetation (especially well-rooted, mature trees) helps to stabilize a slope.

Density of the Stand. The implications of dense stands of short-lived species such as alder and willow have been discussed. In the case of dense stands of conifers such as Douglas-fir, Western hemlock, Red cedar, Grand fir, Sitka spruce or mixed stands of these species, the situation can be quite different. On stable sites with no serious ground water or surface runoff problems, the landowner has several options.

When trees are fairly young (between 5 and 30 years old) they are still capable of vigorous growth in response to thinning. It is possible to remove enough trees to attain a view and even improve the strength and growth of existing trees without creating a potentially hazardous situation. If the crowns of the trees are "crowding" each other and receiving light only from the top, then a thinning could be done. Caution should be exercised not to predispose the remaining trees to windthrow by altering the wind-deflecting properties of the windward trees or allowing wind to be channeled into the interior of a stand that was previously protected.

Removal of trees from a dense stand without damaging those remaining can be difficult and expensive, but the extra care required is a good investment in maintaining the health of the trees that protect your property. Broken tops and branches, as well as trunk scars left by falling trees can serve as entry ports for disease and insects. Consult with a qualified tree service when low-impact falling and removal of trees on a slope is necessary.

There are many other possible situations where stand density could be a consideration. Most of them require good judgement and compromise.

Ability of the Tree to Stump-sprout

The ability of a tree to sprout from a cut stump can be an important characteristic when a property owner is concerned about securing a view without jeopardizing the stability of a slope. The maintenance of a vigorous, live root system insures soil-binding benefits.

Though most tall brush species common to our area will readily sprout when cut, there are relatively few tree species that do so. All of these are broad-leaved deciduous trees. Careful cutting of the species listed offers a means of view clearing without jeopardizing slope stability. The following common trees are capable of sprouting when cut. (See the question "When is the best time to cut back vegetation?" in the next chapter.)

Willow: sprouts readily.

Red alder: often sprouts; leave four to five inches of trunk uncut for more vigorous growth. Older trees sprout less consistently. Repeated cutting increases mortality.

Bigleaf maple: sprouts profusely when cut. Older, larger stems, when cut, can be avenues of infection. Sprouts can grow as much as six feet per year.

Vine maple: sprouts similarly to Bigleaf maple. Vine maple can be trained and pruned into tree form.

Most conifers will not successfully stump-sprout when cut.

Remember that cutting back of brush and trees near the crest will be required periodically to maintain your view. If you find that brush must be cut more often than once every two to three years you may want to consider planting a lower-growing species to replace the existing brush. Kinnikinnick, an evergreen, forms a dense, low mat and has good erosion control properties. Allow at least three years for its establishment and provide protection from animal damage for the new plantings as required. The offending brush will eventually die if cut back repeatedly after two or three years. Under no circumstances should herbicides be applied to kill unwanted brush. The value of the root system far outweighs the inconvenience of maintenance when slope stability is a concern.

Chapter 4: Vegetation Management: Other Commonly Asked Questions

Should trees be topped?

As mentioned earlier, "topping" can be an emotion-charged term. In the context of view management it usually means the removal of a substantial portion of the upper tree trunk in conifers and the cutting of all branches at a particular height for deciduous trees. Illustrations 10 and 11 show typical topped trees.

Topping is not advised

Opinions vary on the usefulness and dangers of tree-topping. For years trees have been topped for a variety of reasons: to reduce height; to minimize wind resistance; to afford views; and to install television antennas. However, it has been clearly demonstrated that topping trees is a poor and damaging practice.

A topped tree requires periodic maintenance to maintain its reduced size. That can become expensive in the long-term. Also, conifers will often form a weakened top as the side branches all try to grow up as shown in Illustration 10. In addition, the cut top often becomes an entry site for decay organisms, that weaken the tree and increase the danger of a top breaking in high winds.

For broad-leaved trees such as maple, madrone or oaks severe topping is even more damaging. It can seriously harm the tree's health and cause various safety hazards. Illustration 11 shows a radically topped deciduous tree. There may be rare circumstances where the owner of bluff property may decide that the situation warrants topping a tree, but all alternative options should first be explored. Readers who seek more information can contact the International Society of Arboriculture or Plant Amnesty (see "For More Information").

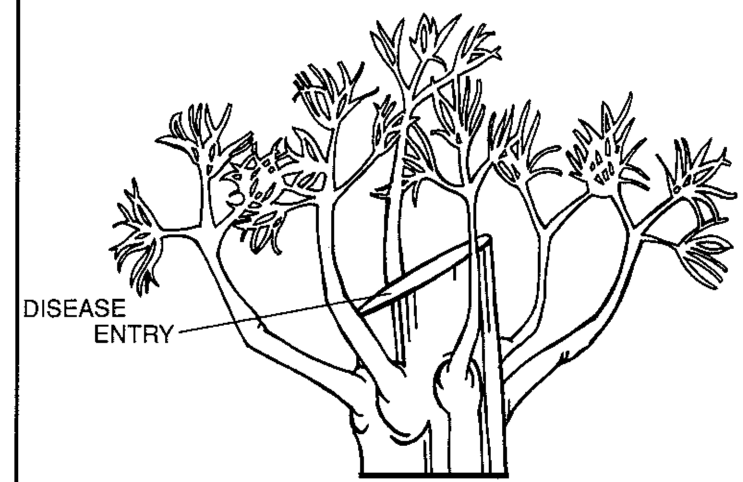


Illustration 10:
TOPPED CONIFERS: One year later

What are alternatives to tree removal and topping?

Given the importance of tree cover on potentially unstable slopes and the advisability of retaining them for erosion control purposes, a landowner should explore alternative options to tree removal or topping.

Several trimming practices can be used successfully on conifers. They are listed below and can be used in combination to create views without compromising tree health or slope stability.

View-enhancing Pruning Alternatives for Conifers

1. Windowing
2. Interlimbing
3. Skirting-up

Note: In any pruning practice or combination, a minimum of 60% of the original crown should be retained to maintain tree health and vigor. The removal of too much live foliage can reduce the tree's ability to supply food to the roots, thereby weakening them.

Windowing. This pruning practice allows a view "window" through the existing foliage of the tree's canopy (Illustration 12-A). In pruning major limbs and branch whorls, sections that obscure a view are removed. Many people find that this technique creates an aesthetically pleasing effect.

Interlimbing. The removal of entire branch whorls or individual branches throughout the canopy allows more light to pass through, as well as reducing wind resistance of the tree. As seen in Illustration 12-B, this practice can be used in conjunction with windowing to improve views.

Skirting-up. Limbing the tree up from the bottom allows a clear line of sight (Illustration 12-C). Instead of an obscuring mass of foliage, the tree trunk is the only object between you and the view. This technique is useful when the tree in question is located high on the bluff face or upon the tableland. Relatively more branches can be removed with this technique because the lower branches contribute less nutrients to the tree than higher branches.

Pruning Broad-leaved Trees

Pruning and trimming of broad-leaved trees is usually more complicated, especially for trees grown in the wild. The occurrence of these trees where they obscure views requires the landowner to weigh and consider the many factors discussed previously to decide if pruning or removal is a smart option. Generally, short-lived species such as alder, willow and Bitter cherry are not worth pruning, while trees like madrone, White oak, Bigleaf maple, and Vine maple will warrant the expense. Basically, proper pruning of broad-leaved trees entails removal of some limbs as shown in Illustration 13. Note the difference between "B" and "C". Refer to "Recommended Reading" and "For More Information" for information on proper pruning.

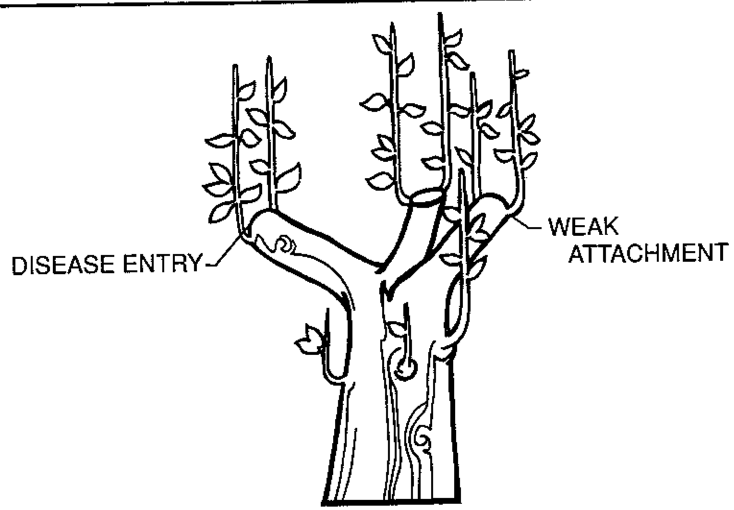


Illustration 11:
TOPPED DECIDUOUS TREE: One year later

If a tree must be cut, should the stump and roots also be removed?

Stumps and root systems should be left undisturbed when a tree is cut on a slope. The beneficial nature of roots for erosion control has been discussed. Trees removed for foundation excavations, septic system construction, road building, or gardens should be removed during site development. Stumps remaining when trees are cut for view or hazard considerations should generally be left. They can be cut flush with the ground or be incorporated into a landscape design. In some cases stump grinders can be employed to remove the stump without causing the disturbance associated with pulling or digging the stump out.

Should groundcovers and brush be removed?

Extensive clearing of bluff properties is very common, especially on uplands. Since heavy equipment is on the property, people decide they may as well make the most of the machinery's presence. Rather than planning what requires site preparation (septic system, well site, house site, access road) they have the entire area scraped at one time. While it may appear simpler and less expensive to conduct site development this way, in the long run you may be setting the stage for chronic slope stability problems and greater expense. Keep in mind the processes at work on bluff properties and the benefits of vegetation, as well as the results of altering local hydrology, topography and vegetational cover. It makes sense to proceed carefully and thoughtfully in clearing your property.

Leave and maintain a buffer of groundcover and brush between the construction site and the crest of the bluff. If the vegetation is suitable it can be incorporated into a landscape scheme. Many native brush and groundcover species are effective as noise and site barriers between you and your neighbors. They are already established and require little care. If your property supports species such as Oregon grape, salal, snowberry, Wild rose, Sword fern, Evergreen huckleberry and Butterfly bush, then you have a wide

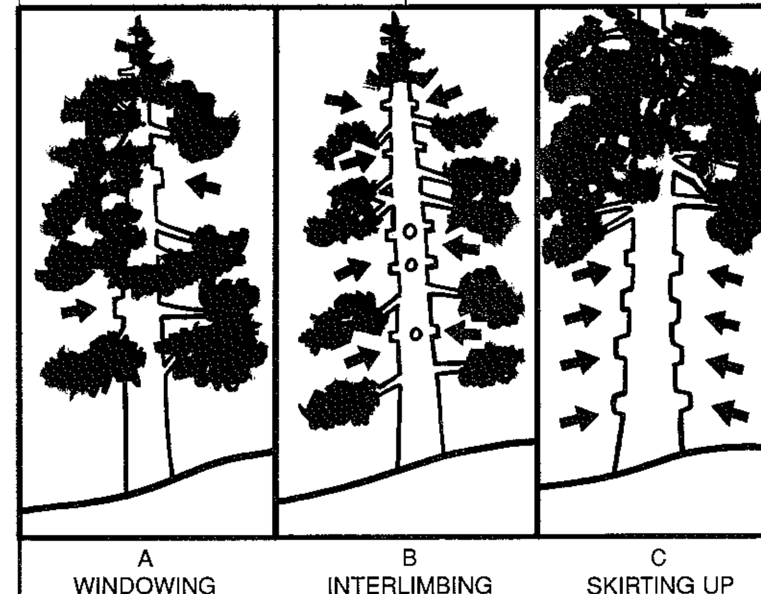
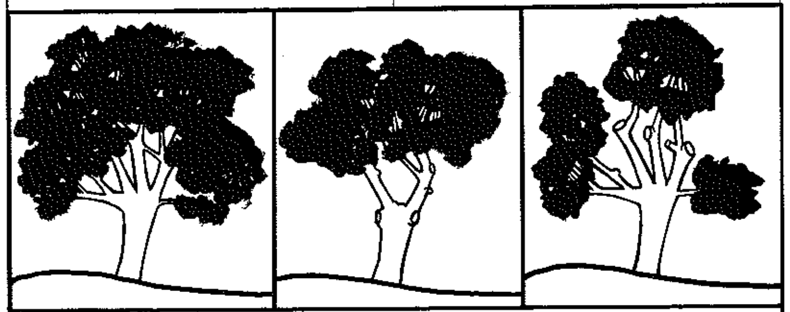


Illustration 12:
ALTERNATIVE PRUNING PRACTICES: Conifers

range of valuable plant materials with which to work. On disturbed sites where plants such as blackberry, Scot's broom, thistle, dock, tansy and Bracken fern predominate, you may want to judiciously clear them out and establish native or ornamental plantings. This can require a lot of work and dedication on the part of the landowner. It should be done by hand to reduce damage to potentially unstable areas. In the case of horsetail, be fore-warned that trying to dig them out only makes them thrive, but sometimes establishing a dense growth of evergreen shrubs will discourage their growth. Refer to *Slope Stabilization and Erosion Control Using Vegetation* for some helpful suggestions.

Note: English ivy is common on many sites. It has a tendency to climb trees and can constrict tree growth and contribute to mortality. It should therefore be removed from the trunks of trees. Ivy also tends to cascade over sheer bluff faces. While it offers little rooting protection it does protect exposed bluff faces from wind and rain erosion. Ivy is emphatically not recommended for new plantings, but if it exists on a site it can be of some protective value. It is almost impossible to eradicate once it has become established.



A BEFORE — B AFTER (Correct) — C AFTER (Wrong)

Illustration 13:
PRUNING PRACTICES: Broad leaved trees

When is the best time to cut back vegetation?

Generally, the best time to trim woody vegetation is the period between late fall and early spring, when the plant is dormant. The frequency of trimming should not be so often that the food reserves needed for growth are depleted. Generally, a five-year maintenance schedule for most brush species will be adequate. Severity of pruning or trimming should be commensurate with the ability of the plant to tolerate the pruning damage.

Should I install a lawn?

Bluff-top property owners often install large expanses of lawn subsequent to land clearing. Lawns are relatively inexpensive to establish and maintain, and allow free access and open space around residences. They are especially good groundcovers for septic drainfields because of their shallow rooting. However, the shallow rooting of most grasses that makes them attractive cover for drainfields means their erosion control values are limited.

On sites where soil erosion and surface water runoff could be of concern it would be wise to limit the area of lawn. While low-growing or closely cropped vegetation (like lawns) helps filter and trap sediments to some extent, its capacity to do so is limited when compared to other groundcovers. During heavy rain periods, areas covered by lawns soon become saturated since rooting is shallow, water retention capacity is minimal, and canopy interception is not available. Surface water can pool in depressions and runoff occurs.

Lawns on upland sites should be bordered on the downslope side by a buffer of deeper rooted, more effective groundcover like salal, Oregon grape, Wild rose, trailing blackberry, kinnikinnick or other low-growing plants. Lawns should not extend to the crest of a slope, nor should they be established on erosion-prone sloping areas that would tend to drain over the bluff.

Are some trees better than others?

Previous sections of the guide have discussed factors that contribute to a particular species' usefulness as an erosion control element. Generally, short-lived deciduous trees are of less value and require more management than longer-lived species. Conifers, maples, and the evergreen broad-leaf tree, Madrone, are the most valuable and every effort should be made to retain and safeguard them. The relative value of a tree is a function of the physical characteristics of the site, the natural processes influencing the property, and the property owner's needs and goals.

What about construction damage during site development?

Trees retained on a development site often die as a result of various construction-related influences. Understanding these damaging construction practices can help the property owner and contractor be more effective in preserving trees as well as increasing property values.

Construction Damage to Trees (see "Recommended Reading") is required reading. This informative publication discusses major construction-related impacts that should be avoided. These are:

1. Grade changes around trees

2. Soil compaction by heavy machinery

3. Mechanical injury caused by heavy machinery

4. Tree thinning

Give the trees you retain plenty of room. Keep machinery back at least to the edge of the dripline of the canopy. Do not bury roots when grading. Even a foot of fill over the existing grade can cause the death of a mature evergreen. Wounding of the tree by equipment can stress the tree directly as well as offer entry paths for decay organisms. Installations of temporary exclusion fencing during construction can be helpful.

Soil compaction is a common occurrence on construction sites. Hand clear brush surrounding trees rather than using heavy machinery. Compacted earth restricts root development and reduces water-holding capacity. Exclusion fencing will reduce soil compaction.

As mentioned, thinning of trees on the bluff top should be done only after consideration of factors such as species, rooting, hydrology, wind patterns, tree health, and age have been assessed. The economic value of the timber should be of secondary importance. The extra initial expense of careful site development will be a worthwhile investment.

Note: There are several general site development and construction-related practices that property owners should be aware of. Since they are beyond the scope of this guide, they are not discussed here. Refer to the Shorelands Technical Advisory Papers in "Recommended Reading."

What to do with clearing debris

The process of site development invariably creates a large volume of plant debris. The disposal of this material can become a major concern The location of debris on your property will dictate the best disposal method to employ.

Upland areas, where development and home construction occurs, generate the largest volume of debris. The best way to deal with this material is by chipping. The resultant chips can be used on rustic walkways and as free mulching materials to discourage weeds. Other options include piling and burning or disposal off-site In densely populated areas burning may be restricted and burning in rural areas may require a permit. Contact the Washington State Department of Natural Resources or your local Fire Department. Disposal off-site may be expensive but some counties have large-scale composting programs that accept clearing debris.

Never dump material over the bluff edge or allow your equipment operator to do so. Stumps and clearing debris can cause slope damage, add unwanted weight, disturb and smother vegetation, and make access difficult in the future. Yard waste and construction debris can also cause problems and a steep bluff is no place to dump toxic chemicals such as paint or solvents. It is up to you to make sure your contractor understands your concerns.

Are there any problems to consider in using the existing trees in my landscaping?

Often when trees are retained and integrated in a landscape design, they are damaged inadvertently by typical yard maintenance practices. Remember that native trees evolved over time to become suited to regional conditions such as rainfall, shade, and wind. Radical changes should be avoided or done gradually to allow the tree to adjust to new conditions over time

One notable example is Pacific madrone. This tree is intolerant of root disturbance. Established madrones should never be watered in the summer. Because madrone is such a striking tree, it is often used as a major landscape element with flower beds surrounding it. As a result, the area is tilled and watered. Both of these practices can kill madrone within a few years. Madrone, while valued by many, can be a problem as a landscape element because it tends to shed leaves all year. Its value as wildlife habitat and its excellent erosion control qualities make it worthwhile nonetheless.

Bigleaf maple can often prove to be a maintenance concern because of heavy leaf-fall and a tendency to drop large limbs. Again, wildlife and erosion control benefits often outweigh these drawbacks. Maple branches should be removed where they present a hazard to residences but in general the tree should be retained. At present, there is little information available that deals with maintaining native vegetation in residential settings. The best practice is to alter local conditions as little as possible.

Why did my trees blow over?

After site development and construction is completed, and sometimes even after several years have passed, the retained trees on a property will blow over. This can cause property owners considerable expense. To safeguard against this occurrence it is necessary to understand the nature of the inter-dependence of trees in the original stand. This has

been discussed in the question "Should Trees Be Removed?" and in the question concerning construction damage. Briefly, trees blow over due to increased exposure to wind, root damage and decline, and changes in hydrology caused by vegetation removal and soil compaction. Careful consideration of factors discussed in this guide during site planning and careful construction practices during development will reduce subsequent tree loss. Blowdown often occurs as a result of tree removal or clearing on adjacent properties. Talk with your neighbors.

Why do the trees on my bluff look so scraggly?

As discussed in the section on "Factors Influencing Vegetation" in Chapter 2, trees exposed to severe environmental stresses such as exposure to wind and salt-laden air will develop differently than trees that have grown in protected environments. Trees growing on exposed bluff sites often are twisted, stunted, and smaller than their inland cousins. They often have many broken branches and tops. Their foliage can be sparse and of a different color than less-exposed trees of the same species.

Trees adjust in various ways to local conditions and show the wear and tear of time. These trees often protect the ones behind them from the full force of the elements. They are a valuable asset on a bluff site. Any pruning done on them should be carefully considered and properly executed. They should not be removed unless conditions absolutely warrant it.

Is this tree a hazard?

The question of hazard trees often comes up during site development. The conditions existing on a particular site and the specific tree characteristics dictate the hazard potential present. The erosion control values of a tree on bluff properties are an additional consideration in determining whether a tree should be removed or pruned.

Two major considerations contribute to the hazard present. First, a determination of the nature, probability, and severity of a failure must be made. Second, the worst-case damage resulting from a potential failure should be determined. For example, even if a tree is in poor shape with a broken top, an old unhealed trunk wound and perhaps other defects, if it will not cause property damage or personal injury when it falls, it is not a hazard. Conversely, if a tree is healthy and sound but has a large heavy branch overhanging a bedroom or nursery it could be a hazard and the limb should be removed. Remember Bigleaf maple's tendency to drop branches.

If a potentially hazardous situation exists and you cannot decide what to do, contact a qualified arborist or other competent person. Be sure to explain your concern regarding the stability of the site.

Note regarding snags: Snags are dead, standing trees They have died for a variety of reasons: old age, insect attack, disease, past disturbances. In the case of conifers, they are seldom a blowdown hazard and may persist for many years (Large conifer snags can remain standing for as long as 100 years.) They offer nesting and perching sites for many wildlife and bird species, including Bald eagles. If they are located so as not to constitute a hazard to structures, they should be retained. Smaller conifers and most hardwood trees will not last nearly as long (madrone and oak are exceptions). Generally snags will not be a threat to bank stability.

If I have existing slope erosion problems on my land how do I solve them? Can vegetation help?

Often, properties already have problems resulting from past practices like those described in the Introduction. There are many ways that low-cost solutions using vegetation can be implemented. A companion volume to this guide dealing specifically with the use of vegetation to control erosion is available from the Washington State Department of Ecology. Ask for *Slope Stabilization and Erosion Control Using Vegetation*.

Conclusion

This publication has stressed that shoreland areas in the Puget Sound region are complex and often fragile places. Influenced by many factors, they are in a constant state of change from the effects of wind, rain, and the waters of Puget Sound.

While not all landslides and erosion can be prevented, it is clear that the actions of shoreline property owners can have a great impact on the stability of bluff areas. Landowners need to understand how their actions can affect their surroundings and learn to minimize or avoid development-related practices that can set the stage for future problems and require costly, difficult solutions.

The clearing of trees and brush, installation of utilities, construction of access roads, and siting of homes should all be well-planned with landscape and stability concerns in mind. Compromise is often necessary between the needs of the property owner and the unforgiving realities imposed by land and water.

Wise planning and development will improve property values, reduce maintenance costs, and contribute to slope stability. Before you decide that doing things right is too expensive, talk to neighbors who have lived on the edge for awhile. Their stories might sound similar to that of the hapless landowner in the Introduction. Make the effort to learn to live in harmony with your land.

Appendix A

Plants Commonly Found on Puget Sound Shoreland Sites

The following tables illustrate the great diversity of plants found growing on Puget Sound bluff sites. There are many others that you may be familiar with that are not listed here. The influences of the Sound's intricate waterways and the surrounding mountains foster a multitude of species in the area. Some are found only in long-protected spots while others are seen almost everywhere.

Representative trees, shrubs, and herbaceous growth have been included to furnish readers with information on the plants that may be encountered on their property. The sprouting, rooting, and erosion control information is the result of observations by the author, verified through research and technical material where possible. The age and height listed for shrub and tree species are from varies sources. They are furnished to indicate general longevity and approximate size at maturity. Remember that many climatic and site factors can influence plant characteristics. Heights may vary considerably.

The plants listed here are not necessarily the most valuable species possible for erosion control, wildlife, or aesthetics. They are simply common throughout the area. Some of the most common shrubs are invasive, non-native plants that are becoming widespread problems. These are indicated by an asterisk (*). They should never be planted and should be discouraged where possible.

Readers who are interested in more detailed information on Northwest and Puget Sound flora can refer to "Recommended Reading" and "For More Information" in this appendix. There are several excellent field guides available as well.

Plants Commonly Found on Puget Sound Shoreland Sites (Herbaceous)

Common Name	Botanical Name	Native/Non-native	Dediduous/ Evergreen	Rooting habitat **	Erosion control	Ground cover quality quality
Sword fern	Polystichum munitum	Native	Evergreen	Shallow	Fair	Good
*English ivy	Hedra helix	Non-native	Evergreen	Shallow-moderate	Poor	Good
Honeysuckle	Lonicera spp.	Native	Deciduous	Shallow-moderate	Fair	Fair
Nettle	Urtica spp.	Native	Deciduous	Wide, very shallow	Poor	Poor
Foxglove	Digitalis purpurea	Non-native	Deciduous	Very shallow	Poor	Poor
Perennial pea	Lathyrus spp.	Non-native	Deciduous	Shallow-moderate	Fair	Fair
Bracken fern	Pteridium aquilimum	Native	Deciduous	Shallow	Fair	Poor
*Horsetail	Equisetum spp.	Mostly non-native	Deciduous	Wide, shallow	Poor	Fair
*Grasses	Various	Mostly non-native	Evergreen	Shallow-moderate	Fair	Excellent (low)

* Invasive, do not plant
** Please note that the depth and character of the roots are determined more by soil conditions than species characteristics.
Greenbelt Consulting, Vegetation Management: A Guide for Puget Sound Bluff Property Owners

Plants Commonly Found on Puget Sound Shoreland Sites (Shrubs, small trees)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat **	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height(ft)
Trailing Blackberry	Rubus ursinus	Native	Semi-deciduous	Shallow	Fair	Good	Yes	Vine
*Himalaya blackberry	Rubus discolor	Non-native	Semi-Evergreen	Moderate	Poor	Good	Yes	Vine-cane
Vine maple	Acer circinatum	Native	Deciduous	Deep, wide	Excellent	Fair	Yes	10+
Oceanspray	Holodiscus discolor	Native	Deciduous	Deep, wide	Excellent	Good	Yes	10+
*Scot's broom	Cytisus scoparius	Non-native	Deciduous	Deep, wide	Excellent	Good	Yes	To 8
Willow	Salix spp.	Native	Deciduous	Deep, wide	Excellent	Fair/Good	Yes	10+
Snowberry	Symphoricarpos albus	Native	Deciduous	Deep, wide	Excellent	Excellent	Yes	3+
Rose	Rosa spp.	Native	Deciduous	Shallow-moderate	Good	Good	Yes	2-10
Elderberry	Sambucus spp.	Native	Deciduous	Moderate	Fair	Poor	Yes	To 15
Salmonberry	Rubus spectabilis	Native	Deciduous	Moderate	Good	Fair	Yes	To 12
Salal	Gaultheria shallon	Native	Evergreen	Shallow-moderate, dense	Good	Excellent	Minor	To 4

* Invasive, do not plant
** Please note that the depth and character of the roots are determined more by soil conditions than species characteristics.
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Plants Commonly Found on Puget Sound Shoreland Sites (Shrubs, small trees)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat **	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height(ft)
Oregon grape	Mahonia spp.	Native	Evergreen	Shallow-moderate	Good	Good	Minor	To 6
Butterfly bush	Buddleia spp.	Non-native	Deciduous	Moderate	Fair	Fair	Yes	6
Red huckleberry	Vaccinium parvifolium	Native	Deciduous	Moderate, wide	Good	Fair	Yes	To 12
Evergreen huckleberry	Vaccinium ovatum	Native	Evergreen	Moderate, wide	Excellent	Good	Minor	To 8
Devil's club	Oplopanax horridum	Native	Deciduous	Wide, shallow	Fair	Good	Yes	To 12
Serviceberry	Amelanchier alnifolia	Native	Deciduous	Deep, wide	Excellent	Fair	Yes	12+

* Invasive, do not plant
** Please note that the depth and character of the roots are determined more by soil conditions than species characteristics.
Greenbelt Consulting, Vegetation Management: A Guide for Puget Sound Bluff Property Owners

Plants Commonly Found on Puget Sound Shoreland Sites (Trees)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat **	Erosion control quality	Capacity to Sprout	Mature height(ft)	Longevity (years)
Oregon white oak	Quercus garryana	Native	Deciduous	Deep, sparse	Good	Minor	60	200+
Grand fir	Abies grandis	Native	Evergreen/ Conifer	Moderate	Good	No	200+	300+
Douglas-fir	Pseudotsuga menziesii	Native	Evergreen/ Conifer	Deep	Good	No	200+	300+
Bigleaf maple	Acer macrophyllum	Native	Deciduous	Deep, wide	Excellent	Yes	60	200+
Red alder	Alnus rubra	Native	Deciduous	Shallow-moderate Tolerates wet sites	Fair	Yes	50-100	65
Bitter cherry	Prunus emarginata	Native	Deciduous	Shallow-moderate	Fair	No	50	50
Western hemlock	Tsuga heterophylla	Native	Evergreen/ Conifer	Shallow-Moderate	Good	No	150	300+
Sitka spruce	Picea sitchensis	Native	Evergreen/ Conifer	Shallow-moderate Tolerates wet sites	Good	No	100+	300+
Western red cedar	Thuja plicata	Native	Evergreen/ Conifer	Moderate, wide Tolerates wet sites	Good	Yes	100+	350+
Pacific madrone	Arbutus menziesii	Native	Evergreen/ Broad-leaved	Deep, wide, tenacious	Excellent	Minor	70+	200+

* Invasive, do not plant
** Please note that the depth and character of the roots are determined more by soil conditions than species characteristics.
Greenbelt Consulting, Vegetation Management: A Guide for Puget Sound Bluff Property Owners

Plants Commonly Found on Puget Sound Shoreland Sites (Trees, cont.)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat **	Erosion control quality	Capacity to Sprout	Mature height(ft)	Longevity (years)
Pacific yew	Taxus brevifolia	Native	Evergreen/ Conifer	Deep, wide	Excellent	Minor	30+	250+
Willow	Salix spp.	Native	Deciduous	Moderate, wide Tolerates wet sites	Excellent	Yes	50+	60
Black cottonwood	Populus trichocarpa	Native	Deciduous	Wide Wet sites	Fair	Yes	140	200
Shore pine	Pinus contorta	Native	Evergreen/ Conifer	Deep, wide	Good	No	30+	200
Western white pine	Pinus monticola	Native	Evergreen/ Conifer	Deep, wide	Good	No	150+	250+
English holly	Ilex aquifolium	Non-native	Evergreen/ Broad-leaved	Moderate	Good	Minor	40	150

* Invasive, do not plant
** Please note that the depth and character of the roots are determined more by soil conditions than species characteristics.
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Appendix B — Glossary

ASPECT: The direction a particular slope is facing.

BLUFF FACE: The sloping portion of a high bank (see Illustration 1)

BLUFF RETREAT: The rate at which a bluff or shoreline is eroding as a result of surface erosion and/or mass soil movements. Used by some regulatory agencies to guide setback requirements.

BLUFF TOE: The base of a bluff where it meets the beach (see Illustration 1).

BRANCH WHORLS: The circular growth of branches around the same point on the trunk of a conifer.

BROAD-LEAVED: Having flat leaves rather than needles as conifers do.

BUFFER: A protective strip of vegetated land

CLEAR-CUT: A timber harvest method that removes all the trees on an area in one operation.

CONIFER: A cone-bearing tree with needles rather than leaves (i.e., pines, firs, hemlocks)

CREST: Upper edge or margin of a shoreline bluff (see Illustration 1).

CROWN CANOPY: The branches and foliage of a tree.

DEBRIS AVALANCHE: A form of landslide where a water-saturated upper soil layer and the vegetation growing on it slides over an underlying less permeable subsoil creating a relatively shallow, narrow slide scar, usually two to three feet deep and 15 to 30 feet wide.

DECIDUOUS: Losing leaves or needles in the fall.

EARTHFLOW: A rapid mass movement of a flowing assemblage of saturated soil, vegetation, and associated debris.

EROSION: The wearing away of land by action of wind or water.

EVAPORATION: The process whereby moisture is turned to water vapor and removed from a surface. Rate increases as humidity decreases.

EVAPOTRANSPIRATION: The loss of water through a plant's leaves or needles from the body of the plant due to evaporation and transpiration.

EVERGREEN: A plant that retains its needles or leaves for more than one growing season

EXOTIC PLANT: A plant that has been introduced into a region where it is not normally found

FLORA: The plants of a region.

GLACIAL TILL: Term commonly used to emphasize glacial origin. See Till.

GROUNDWATER: Water within the pores between soil particles. Usually a permanent groundwater table is evident. This is a source of water for wells and springs. If water percolating through the soil encounters barriers such as clay or hardpan before reaching the permanent groundwater table, a perched water table may form.

HARDPAN: A hard, impervious layer of soil (often clay-rich), or iron-oxide cemented material. In Puget Sound the term is commonly used by drillers and contractors to describe glacial till.

HERBACEOUS: Non-woody plants such as ferns, nettles, and foxglove.

HORIZON: One of a particular layer of soil (e.g., the organic-rich "a" horizon) as used in soil science.

HYDROLOGY: (In the context of this guide) Refers to the properties, distribution, discharge, re-charge, and movement of surface and sub-surface water.

IMPERMEABLE: Unable to permit water or roots to move through freely (see Impervious Surface).

IMPERVIOUS SURFACE: A soil or surface through which water, air, or roots penetrate slowly or very little (that is, concrete, compacted soil).

INTERDEPENDENT: A group of plants that by growing together protect each other from disturbance by wind, erosion, or other natural processes. Shallow rooted trees will often remain windfirm because they form a wide, spreading root mat. (See Illustration 7.)

JACKSTRAWED: A group of trees that has lost firm rooting through wind, land movement, or excessively wet soils and appears chaotic or no longer oriented toward the light.

LANDSLIDE: The downhill movement of a mass of soil or rock, usually wet or saturated, that results in episodic erosion. (Sometimes simply referred to as "slide," but also including falling or flowing masses as well.)

MASS SOIL MOVEMENT: See Landslide.

NATURAL LANDSCAPE ELEMENTS: Natural watercourses, topography, hydrology, and vegetation that comprise a particular site.

NON-NATIVE PLANT: See Exotic Plant.

OVERSTORY: The portion of a plant community that forms the upper-most crown cover or canopy.

PERCHED WATER: Groundwater that accumulates over an impervious soil layer from rainfall or other sources that finds release on bluff faces. Perched water is released on bluff faces as seeps or springs.

PIONEER SPECIES: Plants that colonize disturbed sites after land clearing, logging, fire, or landslides. They are normally replaced over time by other species. Alder, willow, and fireweed are common examples.

PLANT COMMUNITY: An inter-related and inter-dependent assemblage of vegetation having structural and species diversity (i.e., Western red cedar, Western hemlock, salal, Oregon grape, Evergreen huckleberry, Sword fern, mosses, and lichens).

REGENERATION: 1) The process by which an area is restocked with plants. 2) Young trees, either naturally seeded or planted.

SEEPS: See Perched Water.

SHEAR STRENGTH: A measure of the ability of a soil to resist forces that tend to separate it from its position on a slope and cause it to move.

SILVICS: The study of life history and general characteristics of forest trees and stands in relation to environmental factors.

SLOPE: The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by the horizontal distance, multiplied by 100. Slope is also measured in degrees (90 degrees being vertical) or as a ratio. A 100% slope would be 45 degrees or 1:1.

SOIL COMPACTION: Reduction of the total pore space in a soil. Results in a soil that retains less water and resists root penetration. Soils with high clay content are more easily compacted than sandy soils.

SOIL CREEP: A process of slow, downslope movement over a long period of time.

SOIL HORIZON: See Horizon.

SOIL SLUMP: A deep-seated mass movement of soil. The mass moves down and rotates, leaving a concave depression above.

STRATA: A layer of soil or rock.

STRATIGRAPHY: The sequence or order of rock or soil layers in a geologic formation.

SUCCESSION: The process of replacing one plant community with another over time (that is, alder to Douglas-fir to Western hemlock).

SUCCESSIONAL SPECIES: The plant species that comprise a plant community in a given successional stage (for example, early successional species are alder, willow and Bitter cherry).

SURFACE WATER: Rain, snowmelt, lawn sprinkling, or other additions to the soil surface. Also refers to lakes and streams (in contrast to groundwater).

THINNING: .... Tree removal in a forest stand that reduces tree density and numbers in a given area. Most discussions of thinning stress increased growth and yield of timber.

TILL: .... Unstratified glacial drift consisting of unsorted, intermixed clay, sand, gravel, rock, and boulders. Generally well-cemented and impermeable.

TOE OF SLOPE: .... See Bluff Toe.

TOPOGRAPHY: .... The physical features of a surface area including relative elevations and the position of natural and human-made features.

TRANSPIRATION: .... The process by which water vapor is lost to the atmosphere from living plants.

TREE FAILURE: .... A tree or portion of a tree that collapses as the result of some structural weakness such as root rot, dead branches, mechanical wounds, or other causes.

UNCONSOLIDATED MATERIALS: Geologic materials such as sand, gravels, and mixed sediments whose particles are loose and uncemented.

UNDERCUTTING: .... The removal of material at the base of a steep slope or cliff by the erosive action of waves, running or seeping water, or windblown sand.

UNDERMINED ROOTS: .... Roots that are not firmly anchored due to soil removal or loss, beneath and/or around them. Can affect both live and dead trees or stumps.

UNDERSTORY: .... Trees or other plants that tolerate reduced-light conditions and normally grow beneath the overstory.

UPLANDS: .... The tops of bluff areas usually developed for home sites.

WATER TABLE: .... The level at which soil and/or rock is saturated with water. Can be seasonal. Water table can be altered by changes in hydrology.

WINDTHROW: .... Trees blown over by the wind. Often caused by thinning or adjacent clearing.

Appendix C — For More Information

Elisabeth C. Miller Library, Center for Urban Horticulture
University of Washington, GF-15
Seattle, WA 98195
206/543-8616 (Continuing Education 206/685-8033)

International Society of Arboriculture
Pacific Northwest Chapter
P.O. Box 15729
Seattle, WA 98115
206/365-3901

Plant Amnesty
906 NW 87th Street
Seattle, WA 98117
206/783-9813

Puget Sound Water Quality Authority
P.O. Box 40900
Olympia, WA 98504
800/547-6863

Washington Native Plant Society
P.O. Box 576
Woodinville, WA 98072

County Planning and Engineering Departments — Usually located at your county courthouse.

Public Utilities — Your utility may have information in published form.

Soil Conservation District Offices — Usually located at your county seat, check the phone book.

Washington State University Cooperative Extension Offices — Usually located at your county courthouse.

U.S. Army Corps of Engineers
Seattle District
P.O. Box C-3755
Seattle, WA 98124
206/764-3742

U.S. Environmental Protection Agency
1200 - 6th Ave.
Seattle, WA 98101-3188
206/533-1200

U.S.D.A. Soil Conservation Service — Check the phone book for an office near you.

Washington Sea Grant
University of Washington, HF-05
Seattle, WA 98195
206/543-6600

Washington State Department of Ecology
Shorelands & Coastal Zone Program
P.O. Box 47600
Olympia, WA 98504-7600
206/459-6836

Washington State Department of Natural Resources — Contact the nearest regional office.
P.O. Box 47000
Olympia, WA 98504-7000
800/527-3305

Washington State Department of Wildlife
P.O. Box 43200
Olympia, WA 98504-3200
206/753-5700

Appendix D — Recommended Reading

Arno, S.F., Hammerly, R.P. 1977. *Northwest Trees: Identifying and Understanding the Region's Native Trees.* The Mountaineers, Seattle.

Associated General Contractors of Washington. 1988. *Waste Disposal and Erosion/Sediment Control Methods.* A.G.C. of Washington, Seattle.

Brown, G.E. 1972. *The Pruning of Trees, Shrubs and Conifers.* Faber and Faber, London.

Canning, Douglas J. 1991a. *Shoreline Bluff and Slope Stability: Management Options.*

1991b. *Marine Shoreline Erosion: Structural Property Protection Methods.*

These are Shorelands Technical Advisory Papers, Numbers 1, 2 & 3. Shorelands and Coastal Zone Management Program, Washington State Department of Ecology, Olympia.

Downing, J. 1983. *The Coast of Puget Sound: Its Processes and Development.* Washington Sea Grant, University of Washington Press, Seattle.

Harris, R.W. 1992. *Integrated Management of Landscape Trees, Shrubs and Vines.* 2nd Edition. Prentice-Hall, Englewood Cliffs, New Jersey.

Kruckeberg, A.R. 1982. *Gardening With Native Plants of the Pacific Northwest: An Illustrated Guide.* University of Washington Press, Seattle.

Kruckeberg, A.R. 1991. *The Natural History of Puget Sound Country.* University of Washington Press, Seattle.

Michigan Sea Grant College Program. 1988. *Vegetation and Its Role in Reducing Great Lakes Shoreline Erosion.* Report # MICHU-SG-88-700.

Shigo, A. 1986. *A New Tree Biology: Facts, Photos, and Philosophies on Trees and Their Problems and Proper Care.* Shigo and Trees Associates, Durham, New Hampshire.

Sunset. 1983. *Pruning Handbook.* Lane Publishing, Menlo Park, California.

Tainter, S.P. 1982. *Bluff Slumping and Stability: A Consumer's Guide.* Report #MICHU-SG-82-902. Michigan Sea Grant, Ann Arbor, Michigan.

Terich, T.A., M. Schwartz, and J. Johannessen. 1991. *Coastal Erosion Management: Annotated Bibliographies on Shoreline Hardening Effects, Vegetative Erosion Control, and Beach Nourishment.* Western Washington University for Shoreland and Coastal Zone Management Program, Department of Ecology, Olympia.

Terich, T.A. 1987. *Living With the Shore of Puget Sound and the Strait of Georgia.* Duke University Press, Durham, North Carolina.

Thorsen, Gerald W. 1987. *Soil Bluffs + Rain = Slide Hazards.* Washington Geologic Newsletter. 15(3):3-11.

U.S.D.A. Forest Service. 1992. *Long-Range Planning for Developed Sites in the Pacific Northwest: The Context of Hazard Tree Management.* FPM-TP039-92. Portland, Oregon.

U.S.D.A. Soil Conservation Service. 1987. *Soil Erosion by Water.* Agricultural Information Bulletin 513.

U.S.D.A. Soil Conservation Service County Soil Surveys (various).

Washington State Department of Ecology. 1978. *Coastal Zone Atlas of Washington* (several volumes).

Washington State University Cooperative Extension Bulletins

EB440 *Trees of Washington*

EB1157 *Construction Damage to Trees*

EB1619 *Pruning Trees: A Guide for Homeowners*

PNW184 *Thinning: An Important Timber Management Tool*

PNW195 *Impacts of Forest Practices on Surface Erosion*

PNW209 *Slope Stability on Forest Soils*

PNW217 *Compaction of Forest Soils*