Stanley Park Forest Management Plan

"That Stanley Park's forest be a resilient coastal forest with a diversity of native tree and other species and habitats, that allows park visitors to experience nature in the city."

– Forest Vision Statement, Stanley Park Restoration Plan

Report to be presented to the Park Board
March 23, 2009

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Executive Summary

The Stanley Park Management Plan is intended to provide an overview of the types of management activities that are required to realize the vision statement first published in the Stanley Park Restoration Plan (Vancouver Park Board, April 2007). This statement seeks to attain a balance between the safe enjoyment of the park and the continued functioning of the urban forest. Ecosystems function in complex ways at the best of times, but within the context of an urban park and shifting climatic norms the job of understanding their current and future condition becomes a difficult scientific challenge. Additionally, the interaction with park visitors and workers adds several more layers of complexity. It is therefore necessary to break down the management activities into modules which represent different disciplines of knowledge. In this document, each module has stated goals and objectives, and a brief sketch of their relevance to the achievement of the vision statement. These modules pertain to three somewhat separate functional categories:

Forest maintenance modules speak of day to day activities not much different from what has been done for the past twenty years. They include the tree hazard and wood debris management programs.

Forest protection work modules, whose need was clearly demonstrated by recent storm events, outline essential objectives that seek to reduce the likelihood of large-scale forest changes which would compromise the forest's value to Stanley Park for many years. Rapid changes should also be guarded against because of significant costs associated with their correction. The windthrow, fire, forest health, and invasive species modules fit into this category.

Forest enhancement modules address opportunities to enhance the forest by undertaking work which is beneficial to wildlife or forest development, as achieved through habitat creation projects and the practice of silviculture.

Appendices are intended to provide operational level guidelines and instructions so that field work can be conducted to current standards, be they of the forestry or ecological professions. Adaptive management must be used to ensure that changing conditions and our increased understanding will allow for the modification and improvement of park management practices. Therefore the appendix section is intended to be an actively changing resource as the professional knowledge base continues to develop.

As part of its consultative agreement, the University of British Columbia (UBC) has conducted extensive forest survey and mapping work which is in an advanced stage of development. The maps will be a key component in the translation of ground data to field decisions and longer term planning and costing. During the restoration work, a substantial library of maps has been created. They provide the necessary baseline work to manage future park forest operations work through a geographic information system (GIS).

Although the storms of 2006 / 07 were devastating, the extensive media coverage and subsequent community discussion forums generated a great deal of interest in the forest. The community now better understands the complexity of issues set before park managers, and their input should continue to be actively engaged. The Stanley Park Ecology Society has continued with its public education role, and has become more participatory with its involvement in stewardship. UBC's Faculty of Forestry is a research and educational body of international repute. Significant insights into the changing forest and the impacts of forest management can be gained through the continuation of this new relationship. The forest management plan will contain guidelines on how forest managers can structure future interactions with the public, park partners, and the academic community in order to make the most of these available contributory resources.

Forest Management Plan Rationale

The Vancouver Park Board has the duty to care for this resource in such a way that risks to people and property are reasonably managed. Also, there are certain events that occur naturally, such as forest fires or major blowdowns, that would have an unacceptable catastrophic impact on the park. Intervention becomes prudent when the likelihood of these events becomes unreasonably high.

The forest, while historically affected and manipulated by humans, remains a vibrant coastal rainforest of significant beauty with important ecological properties. A balance between human safety and forest ecology must be maintained.

Stanley Park's forest has changed considerably since European settlers arrived. At that time, the forest had roughly equal quantities of cedar, Douglas fir, and hemlock. Spruce, true fir and pine were in greater abundance. Due to logging activity and other influences, many parts of the forest are currently dominated by hemlock, a tree which is shorter lived and less resilient to storms and diseases than the other tree species.

Humans continue to impact the forest. A network of roads and trails causes fragmentation, and alters water flows. Invasive exotic plants, diseases, and animals may be accidentally introduced at any time. The monitoring of these known threats can inform proactive management strategies.

There is an increased global understanding of the importance of all organisms and processes within a forest, not only its trees. The Stanley Park Ecology Society has been leading monitoring programs that continue to yield informative local results. This new information can be infused into forest management decision making activities in order to offer improved protection and enhancement strategies for all of the forest flora and fauna.

Goals of Management Plan

1) Maintain the conditions that foster a resilient forest with a diversity of native tree and other species and habitats within the forest.

2) Reduce the risk of personal injury or property damage caused by failing trees or tree parts to a reasonable level.

3) Establish guidelines and work prescriptions that strike an appropriate balance between the healthy functioning of a forest ecosystem, and people's safe enjoyment of the park.

4) Establish resilient and healthy forests in the areas blown down in 2006.

5) Protect the forest from large disturbances or from ecological threats.

6) Manage the forest in such a way that wildlife species and their habitats are protected or enhanced.

7) Maintain the forest's contribution to reduction of atmospheric greenhouse gases by managing it for maximum productive health.

8) To provide a legacy of maps, data, and information that will form a baseline for ecosystem monitoring and public education.

Introduction

Stanley Park is Vancouver's oldest and largest park. The forest is a central feature within it. Close to 300 hectares of coastal temperate rainforest provide a place for Vancouverites and visitors to explore an impressive patch of nature within walking distance of the downtown core of the city. One can stroll down corridors of Douglas fir trees fifteen stories tall, gaze at centuries-old tree trunks larger than in any other municipal park in Canada, or witness eagles raising their young in the treetops. It is a place for learning, recreation, healthy exercise and mental relaxation. It is a remnant island of one of the largest and most ecologically productive forests on the planet.

While natural processes still sustain their vibrancy, urban encroachment has irrevocably changed the complex pathways of ecological function. Keystone species such as elk and bear have long been extirpated from the park. Nobody knows for certain how many smaller creatures of importance have disappeared. Early logging removed many of the healthiest cedar spruce and fir, leaving behind conditions that contributed to an overabundance of hemlock, a much shorter-lived tree. Early park managers sometimes took very controlling measures in an attempt to enhance aesthetics. Trails, roads, a provincial highway, and the city itself have fragmented ecosystems which rely upon connectivity. New species of animals, plants and fungi have become naturalized here, generally at the expense of those already present. Added to these stresses are air pollution, climate change, and ever increasing human activity penetrating the most remote corners of the forest. Incremental degradation from a combination of all these factors has occurred and will remain a threat to the park's ecosystems. Medium scale disturbances caused by wind storms or forest fires can threaten not only ecosystems, but park visitors and structures. Climate change and extreme air pollution, along with their accompanying biological shifts, have the potential to cause the most harm.

Over seven million visitors come to the park each year – many more if you count people traveling through the park on Highway 99. Most come close to, or enter into the forest. It is the Park Board's duty of care to take reasonable measures to safeguard these people. The windstorms of 2006 / 07 were a clear reminder of the potential dangers posed by the forest. The subsequent threats of fire, insect damage, and invasive plants forced the Park Board to spend considerable time and money rectifying the damage. A forest fire, or another windstorm, could cause similar damage and pose a risk to human life and property. There will always remain the potential for insect or disease outbreaks which, if reaching infestation proportions, could cause widespread setback of the forest canopy. Larger cleanup resources would have to be portioned if the park were to remain safe for visitors. More worrisome still is the considerable possibility that a highly invasive insect which is under federal quarantine protection might one day try to establish itself in the forest. The mandated actions of the Canadian Food and Inspection Agency have resulted in several preemptive forest clearing operations in major centers such as Toronto and Halifax. The hardship and loss of park beauty would be devastating for a long time.

This management plan tries to 'walk the line' between maintaining a long-term functioning ecosystem, and a park environment that is both safe and enjoyable. It contains recommendations for both the protection and enhancement of the surviving natural processes. It also recommends the continuation and extension of forest management activities that help to guard against dangerous and catastrophic changes to the forest, particularly to its largest elements – the trees.

There will be times when the values of natural functions and park management are consistent with one another; at other times they may be more or less contradictory. For this reason, the forest has been divided into *'Management Emphasis Areas'*. They are termed *'Safety Emphasis Areas'*, *'Regeneration Emphasis Areas'*, *'Wildlife Emphasis Areas'* and *'Resilience Emphasis Areas'*. Within each area the value of forest safety, forest resilience, and biodiversity are given different priorities according to the usage of the area. As a basic example, snags may be left for cavity nesting birds in the area adjacent to Beaver Lake, but not if the area is adjacent to the causeway. These values determine the goals and objectives for each area, which flow through to activities and even to the timing of activities. They are not mutually exclusive; there will be activities appropriate for all emphasis areas, but the prioritizing of activities will be assisted by this categorization. All activities relate back to the fulfillment of the park forest Vision Statement:

"That Stanley Park's forest be a resilient coastal forest with a diversity of native tree and other species and habitats, that allows park visitors to experience nature in the city".

Changes in forest resilience will be gradual, and will take place project by project over patches of the forest one at a time. It will take longer than twenty years to achieve the vision. Natural disturbances may occur at any time, and are expected to continue throughout the work. In many cases they will present an opportunity to accelerate the process, as has happened in the aftermath of the 2006 storm. The path toward the vision will be lengthy, and likely fraught by setbacks. Violent storms may again bring down trees, and fires are always a danger. It is reasonable to expect that a determined effort will bring positive changes to the forest by incremental changes and through responsive actions, such that the public will be able to enjoy Stanley Park's forest well into the future.

Professional Services Agreements

The University of British Columbia (UBC) Faculty of Forestry was engaged to provide consultative and other professional services to the Park Board during the development of this plan. Field work such as vegetation and woody debris surveys, data analysis, and mapping was conducted under faculty supervision. The thoughts and ideas of forest managers, researchers and professorial staff were collected and considered, and form the core of the scientific knowledge that informs this document and the recommended practices therein. Registered Professional Foresters and Biologists have reviewed the final content.

The Stanley Park Ecology Society (SPES) also contributed mapping and consultative services important to this document. The wildlife and invasive plant modules were written by members of SPES staff. Their technicians' field surveys on a wide array of biological features have added greater breadth of knowledge to the non-arboreal elements of the forest, and will guide forest protective and enhancement activities.

Management Strategy

Progress toward achieving the goals and objectives in this document depends upon a comprehensive management strategy. Detailed annual work plans should be prepared and submitted with capital and

restoration funding requests. Monitoring of ecosystem threats and developments is required in order to establish priorities and optimize resources. Computer mapping programs are most apt for summarizing this data. Work activities will require coordination, direction and inspection. Results should be catalogued and analyzed.

The current record keeping system needs to be enhanced if it is to fully capture all the recommended activities. Monitoring, mapping, and work records will enable periodic review of the directions in which the forest is moving, and the effectiveness of work activities. Critical assessment will then be possible, leading to adjustments in the types, methods, intensities and frequencies of work activities. The practice of following these steps will form the core of a successful adaptive management program.

Recent collaborations with UBC and SPES have shown that underutilized expertise and resources lie at Stanley Park's doorstep. Biological research, monitoring, mapping, and invasive plant control are all functions in which these agencies have proven competence. Their contributions would clearly be beneficial to the management of the Stanley Park forest.

Recommended management strategies

- Continue the development and integration of computer mapping and information management systems (Geographic Information Systems) into forest operations work.
- Practice an adaptive management program that facilitates the feedback of new information and analysis results back into the plan.
- Develop and coordinate relationships with other agencies such as UBC and SPES.

One of 36 interpretive signs placed around the park in wake of 2006 windstorms.

Management Emphasis Areas

In a large space such as Stanley Park, there is a considerable gradation of public usage patterns and expectations. Some areas are visited frequently while others are so remote that it is very rare for anybody to pass by. On a different level, the natural makeup of the forest varies substantially as well, ranging from cliff bluffs to ravines, and from homogenous stands of planted trees to multi-aged mixed species stands. Management practices should reflect this varied pattern of park use while respecting the range of ecosystems within the forest.

Management Emphasis Areas are those sites where park usage patterns, distinctive work requirements, or ecological preconditions suggest that a similar emphasis be placed upon management objectives. The objectives are not exclusive to each other, but can act as a guide to decision making. They may utilize unique sets of work practices or restrictions, or may be used to set activity priorities.

> ***Safety Emphasis Areas:*** Near enough to well used portions of the park for tree failures to cause damage or injury. The correction of danger trees and the fostering of resilience are on a higher priority level than in other areas of the forest.
>
> ***Regeneration Emphasis Areas*:** Blowdown patches from the 2006 / 07 storms, or smaller openings created by other recent storms, where the primary emphasis is to ensure the successful colonization of a well adapted community of trees and understory. Other values such as wildlife habitat and resilience are intended to benefit from the proper management of this establishment period.
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> ***Wildlife Emphasis Areas:*** Riparian areas and wetlands, bogs, forest edges, deciduous stands, bluffs, veteran trees, and ephemeral raptor nesting trees have been identified as having a particularly high value to wildlife. Protection and enhancement activities are given a higher level of consideration than in other areas of the forest. Sub-area specific strategies are detailed in Table 8.1 (Appendix 8).
>
> ***Forest Resilience Areas*:** Areas where subtle interventions that improve forest resilience are employed where most necessary, but where the allowance of natural processes is generally favored. These areas are defaulted to the remainder of the forest. Priority activities are to favor resilience by undertaking practices that reduce threats of major disturbances (e.g. thinning to enhance wind resistance, fire fuel reduction, insect mating disruption) as suggested by forest conditions.
>
> ***Views and other special areas:*** Three areas near Prospect Point (see Map 11.1, Appendix 11) contain attractive water and mountain views that were opened up by the 2006 storm. Maintenance of these corridors would be an asset to the park visitors' experience.

Map 11.1 (Appendix 11) is a depiction of suggested boundaries of management emphasis areas. This map is a visual guide only, and more detailed ground level assessment is advisable. *Safety Emphasis Areas* are determined in the field and are dependent upon tree height and other tree hazard related factors. The *Regeneration Emphasis Area* boundaries may shift when more storm openings occur, and as the 2007 planted trees become established. Some of the *Wildlife Emphasis Area* boundaries are related to unchanging features such as riparian and wetland areas or bluffs, but included within them are more ephemeral protection areas around raptor nests or bird colonies. Future park managers will make judgments on the continuation of view corridors.

When boundaries overlap, which they often will, a more complex decision making process must be employed. The emphasized values of all overlapping areas must be considered on a situational basis. Where a *Safety Emphasis Area* is involved, the wellbeing of the public and workers must be held as the highest priority. As an example, a dead snag may be left to naturally deteriorate in an area away from trails; but it would not be removed or retained for a shorter period if situated where people frequent.

Target Stand Conditions

Plant communities exist across a range of maturity levels, in varied growing environments. Taken in its entirety, this variation contributes greatly to the biological diversity of the park and to the corresponding opportunities for human enjoyment. Areas of similar such attributes are termed stands. This grouping of areas with similar properties simplifies the complex forest enough to make meaningful condition assessments and management decisions. In order to determine how well a stand is moving along the path to achieving the resilience and diversity mandated within the vision statement, a set of target conditions have been devised for comparison purposes. These target conditions are based upon the range of species representation, spatial pattern, horizontal structure, and density found in healthy forests matching existing plant communities, maturity levels, and growing conditions.

Whenever an area of forest is approached with the objective of meeting one or more goals of the modules, an assessment of its current condition is compared with its target stand condition (Appendix 12). Major deviations from the target, that are applicable to the work at hand, should be addressed. Corrections, often subtle, can thereby be made with every activity. As examples; understory diversity would be enhanced as a part of invasive control work if it is not already within the target ranges. Deciduous trees might be planted after plantation thinning where they are currently low in representation.

The philosophy behind the generation of these target stand conditions is the development of a diverse and resilient forest, with plant communities ideally suited to the underlying environmental conditions. The described targets emphasize a forest structure with a moderately open canopy that will: 1) promote wind firmness of individual trees, and 2) enhance opportunities for regenerating trees and a range of understory plant species (such as Vine maple, Salmonberry, Sitka mountain ash and Sword fern). It is expected that a rich diversity in floral composition will also lead to increased niche opportunities for faunal species.

In order to facilitate development of an appropriate range of stand diversity, the archetypal descriptions are intentionally flexible. It is intended that stands, as recognized by lines on a map, will also contain considerable internal variability, and that no one position within a stand will or should perfectly conform to the written descriptions. It is also important to recognize that stand boundaries are often indistinct, and become more so as stands age. The spatial gradation from one stand type to another is often a desirable feature that should be embraced through appropriate application of the stand management objectives. Very young stands are important to recognize as they are at a stage of development where managers have the greatest opportunities to shape long-term outcomes.

The strip of land along the top of the bluffs, extending from Siwash Rock to Prospect Point, experiences high winds, salt spray, and open sunshine. Shrub species such as Ocean spray (*Holodiscus discolor*) and Wild rose (*Rosa nutkana*) are found growing naturally here, an indication that the growing conditions are quite similar to the shorelines of Point Atkinson and the Gulf Islands. This indicates that the entire community of plants that attractively laces shorelines in the southern Georgia Strait would thrive in this location. This management plan proposes that this plant community be enhanced along the top ridge of these bluffs, as shown on Map 13.1 (Appendix 13).

Full descriptions of the stand objectives can be found in Appendix 12.

Module 1 - Tree Inspection and Safety Management

Goals

To reduce the risk of personal injury or property damage caused by failing trees or tree parts to a reasonable level, while sustaining a healthy forest ecosystem. The focus is to be on observable defects in trees.

Objectives

Visually inspect all high usage areas at least once each year.

Remain vigilant to new tree hazards as they may occur throughout the season.

Efficiently correct known hazards on a priority basis.

Policy

The Park Board tree inspection policy (June 7, 1993) was approved by the Park Board in June 1993. In part, it reads:

"Park trees in high usage areas (e.g. facilities, trails and roads) are inspected annually for signs of defects which could result in their failure. Trees that are evaluated as hazardous are prioritized and scheduled for corrective action." (V.P.B. 'Tree Inspection Policy')

Inspection, record keeping, and mitigation

In order to prioritize tree hazard mitigation work, a hazard rating system is used that combines the assessed likelihood of tree or branch failure with the likelihood of its causing injury or damage. Trained arborists walk the park and inspect every tree that has the potential to fall into an area used by people. Arborists look for defects which could indicate imminent tree or branch failure. Those trees with a high combined hazard and target rating are tagged and mapped.

Information pertinent to the tree condition, and the recommended corrective action, are recorded and stored. Worksheets can be produced from these records. Photographs or other forms of historic record-keeping tools are used where appropriate.

An arborist assesses the amount of decay in a large tree near Malkin Bowl.

Imminent hazards that come to the attention of arborists, whether inside or outside the inspection program, are attended to as soon as available resources allow.

Hazard abatement generally consists of designated crews which address listed trees by the order of their rating, first attending to those in the highest hazard rating category. Types of abatement activities consist of, but are not limited to: dead or broken branch removal, crown weight reduction pruning, the attachment of metal reinforcements, or whole tree removal. Historically, several dozen large trees are removed each year, and several hundred are pruned or dead-wooded.

Module 2 - Log and Debris Dispersal

Goals

To provide timely cleanup of debris on a balanced priority of need basis.

To balance efficiency with environmental, aesthetic, and community needs.

Objectives

After storm events:

Quickly restore access throughout the park on a prioritized basis.

With larger blowdowns, first assess the amount of coarse woody debris (> 12 cm diameter) from both before and after the event.

Retain within the ecologically appropriate range of course woody debris.

During routine work:

Trails and turf areas should be cleared to a level of cleanliness appropriate to the park locale.

Felled danger trees in areas of elevated fire risk (trailsides, internal access trails, fuel type S1-S2) should have branches bucked and the logs laid to ground level.

Felled danger trees away from areas of fire risk may be left intact, especially in wet areas.

Discussion

The responsive actions to be taken regarding the cleanup of fallen or felled trees, or tree parts, vary on a situational basis. Factors affecting these actions are: urgency of cleanup, location of debris, size and type of debris, amount of material, and community demand for specialized community uses.

The order of operations after a major storm event should be prioritized on the basis of the following hierarchy.

Storm cleanup order of operations:

Priority	Activity	Area type
1	Emergency / rescue access	Personal first aid and rescue routes
2	Park and through park access	Causeway Service yard, major park access roads and driveways, electrical and communication conductors Seawall Minor roads and driveways
3	Park functionality	Sports facilities, gardens, major trails Parking spaces

4	Fire risk	Areas of high ignition probability during fire season
5	Aesthetic	Passive use areas, beaches Forest trailsides, watercourses

Some tree parts have environmental, monetary or social value. Other tree parts are a disposal liability. The value of a tree part along this scale is individually specific, so decisions on its disposal should be situational and versatile.

Plant parts that are retained or returned to the forest are valuable for animal habitat, moss and liverwort growth, moisture retention, understory development, and nutrient recycling. Retention or return are appropriate wherever the benefit exceeds the damage, provided that the action is safe for workers. Factors limiting the retention or return of material are fire risk, safety, and equipment availability. Small blowdowns in ***Wildlife Emphasis Areas*** generally should be left as they are. Those in other management areas also may be left as they are, or they may be bucked to ground level and replanted, depending on the surrounding fire fuel type. Smaller material should be run through a chipper and blown into the forest wherever appropriate, but chip deposition depth should be limited to about 10 cm to allow for the survival of current understory plants. In the event of a large blowdown where specialized log moving equipment is utilized, coarse woody prescriptions should be developed on a site ecology specific basis. While target debris levels should be set, there should also be standards that mandate a high level of variability for the number and arrangement of retained logs and stumps. Researchers have surveyed the forest floors of different ages of coastal forests, similar to that of Stanley Park, and determined large scale averages. The chart below presents these averages. Given that variation is both natural and beneficial for wildlife habitat, the prescribed amount of retention material should be within ~ 20 % of these averages. Prescribed ranges are kept below 12 kg / sq m reduce fuel loading in times of extreme fire risk.

Age of forest	Average course woody debris found in natural forests (kg /sq m) (Feller, 2003)	Prescribed range (kg / sq m)
0 - 4	14	8 - 12
5 - 9	15	8 - 12
10 - 29	13	8 - 12
30 - 49	5	4 - 6
50 - 69	8	6 - 10
70 - 89	7	4 - 8
90 - 250	4	3 - 5
> 250	10	8 - 12

From time to time, unusual pieces of wood either fall down or are cut down for safety reasons. These pieces may be of rare size, shape, or species. Where they do not provide significant environmental value, consideration can be given to making them available to local First Nations, wood craftsmen, and artists. They may also be utilized for local environmental enhancement projects.

In 2007, a store of unique or individually valuable pieces of wood was created. Its presence was advertised to the public at large and to community woodworking 'not for profit' societies, and a giveaway date was set. Much of this wood found its way into willing hands.

After larger storm events, there may come about a third circumstance where significant quantities of merchantable wood either fall from the forest, or must be removed for forest resilience reasons. This occurred in 2006 / 07, but it has also occurred on several other occasions. Extremely large storm events,

which are hopefully very rare, may require dedicated restoration plans, but more regular storm events can be managed within Park Board operations. There are direct costs associated with the cleanup operation (overtime, crane lift trucks, etc.) and subsequent forest recovery work. These costs can be offset by sales of merchantable logs.

Material removed from site that is of non-merchantable quality, but is nonetheless suitable for firewood, is currently trucked to a depot at Spanish Banks. The public is allowed to cut and remove the wood on a first-come, first-serve basis. Some of the cleanup material satisfies none of the above criteria and is sent to a landfill site.

Recommendations

Wood debris and logs should continue to be dispersed by a variety of situational-dependent methods, as suggested in the flow chart of Appendix 3.

Merchantable timber should be sold through an intermediary, within the statutes of the BC Forestry Act. Merchantable logs that are being sold should be cut to a length that maximizes their value, and their butts should be marked with the Park Board timber sales stamp. Any profit from such sales should be directed toward the established 'Stanley Park Forest Management Fund'.

Where pieces of unusual wood are to be freely allocated to outside agencies, groups, or individuals, priority should be given to environmental enhancement projects, or to artists producing works that will be on display in public places.

In the event of another 2006 scale blowdown, where debris cleanup is required, a range of retained coarse woody debris should targetted. Optimally, a mix of species, size, and decay levels would be left on the forest floor, scattered in random fashion. Special prescriptions for wildlife habitat reasons may be applied where appropriate.

Module 3 - Windthrow Management

Goals

To reduce the potential of windstorms impacting park visitors or staff.

To reduce the potential of windstorms causing damage to park infrastructure or to the forest at large, while maintaining natural forest functioning.

Objectives

Assess the vulnerability of different parts of the forest to wind damage caused by routinely recurring windstorms.

Identify the areas within the park where impacts of windthrow are most significant.

Develop and implement area and stand specific strategies to help reduce the likelihood of personal injury, property damage, or substantial tree loss.

Discussion

Wind damage includes major branch loss, stem breakage, or uprooting. Windthrow occurs when storm winds penetrate a forest to an extent rarely experienced, and exert forces that cause healthy trees to topple. This often begins where there are pre-existing tree defects such as root rot or stem decay, or severely restricted roots. As trees fall and the canopy opens, more wind is allowed into the sensitive interior causing a progression of tree failures. Falling trees impact other trees, causing them to break or fall in a sort of 'domino effect'. Windthrow stops when the spreading damage encounters either a wind resistant stand of trees, or when the storm winds ebb.

Stanley Park is in a relatively wind-exposed location. Historically, damaging winds have come from the southeast (e.g. Hurricane Frieda) and from the west (e.g. December 2006). High winter winds are typically associated with the passage of Pacific low pressure systems and associated fronts. Stanley Park is also exposed to easterly winter outflow winds, to summertime on-shore winds, and to thunderstorm activity. Researchers at UBC have made significant advances on the subject of identifying the factors of windthrow risk. With our growing understanding of these factors and of their relative weighting, our ability to predict future events is improving. (Landquaye-Opoku and Mitchell 2005, Scott and Mitchell 2005). These factors relate to individual characteristics of trees, stand levels, soil, and topography. Many studies have also evaluated the effectiveness of mitigating treatments.

Future storms may come from different directions and may cause a different pattern of canopy opening. Edge boundaries from previous disturbances may be breached, leading to further damage. Predictive modeling, when enhanced with field assessments and with an understanding of historical patterns, can provide important guidance regarding stand vulnerability throughout the park. Current advances in windthrow modeling have increased our ability to assess stand vulnerability near newly created edges. While catastrophic windthrow cannot be prevented without proactively cutting down all tall trees, the frequency and extent of damage can be diminished by conducting a set of preventative actions. Catastrophic windthrow can also be diminished by remaining cognizant of wind damage factors, and by performing such regular operations as hazard tree management, planting, and trail maintenance. These preventative actions should be implemented primarily within the safety, regeneration, and resilience management areas. The ***Safety Emphasis Areas*** should take first priority.

As an unmanaged stand of trees in the coastal forest grows following a disturbance, there is much competition between individuals. In a continuing process, the number of large trees over a given area decreases. Those which can best obtain sunlight and nutrients thrive, while those less fortunate gradually get suppressed by their neighbours. These suppressed trees may die and then fall, or they may have enough resources to become very tall, slender, and top-heavy. Such trees become increasingly unstable until they predictably break or uproot. While this process may be desirable from a wildlife habitat point of view, it is not suitable in the *Safety Emphasis Areas*. A measure of a tree's weakness is the height-to-stem diameter ratio. While many factors combine to determine the limit of this ratio, it should be considered a factor within the hazard tree management program.

The likelihood of windthrow is heightened for several years after a major event. Surviving trees are subject to wind forces to which they are unaccustomed. Some will have had their roots damaged and will therefore be susceptible to pathogens. The newly created forest edge should be treated to prevent a spread of the damage in subsequent storms. The best suited technique of windfirming these newly created edges involves the pruning of remaining branches in a spiral pattern, especially near the top portion of the crown. This reduces the wind forces acting on the crown. Properly pruned trees will regrow the lost foliage, and will have the time needed for their stems and root systems to adapt and acclimatize to greater wind forces. The number of branches removed depends upon the species of tree, its position within the newly created edge, and the amount of branch loss during the storm. A sample windfirming prescription is contained in Appendix 4. Variations of windfirming techniques have been shown to reduce new edge failure rates by 40 % (Rowan C. 2003).

The windfirming tree work that was conducted as part of the 2007 park restoration followed a prescription drawn from field inspections, but was augmented by the results of computer modeled assessments of vulnerability. Only one of the newly created edges was breached by subsequent storms. This was a small area that was shown by the model to be vulnerable, but was not yet attended to because of little risk to the public at that location. All edges have since been treated.

A surprising amount of wind resilience can be designed into a forest at its early growth stages. Care should be taken to avoid a forest structure where trees are crowded, racing against each other for a bigger share of the sky. A planting strategy where trees are placed in small clusters, with open spaces between clusters, has been shown to develop trees which retain their lower branches. This makes the stems stronger, and brings about a more favourable weight distribution. Another strategy is to use different species within each cluster. Trees of varied species have different sway properties in the wind, which helps to dampen motion during storms.

There are existing stands of trees which have been planted so densely that they are becoming susceptible to windstorms. The long term viability of these clusters can be enhanced through the application of a judicious thinning program, as described in Appendix 10.1. The advantages are wind resilience, a more vibrant understory, and faster growth for the remaining tree. Work prescriptions should include cautionary actions to prevent an increase in fire, insect or disease risk.

Recommendations (general)

Continue the Hazard Tree Management Program

Investigate the usefulness of software tools that inform decision-making (e.g. WindCalc)

Recommendations (*Safety Emphasis Areas*)

a While performing hazard tree assessment work, consider the height-to-stem diameter of suppressed trees. Remove trees with such tall and slender dimensions that they are likely to be unsustainable, or those that will soon grow into that range.

b Where light conditions are adequate for the recruitment of canopy trees, plant Douglas fir, redcedar or Bigleaf maple in secure mineral soil. Clear competing vegetation around replacement trees only long enough to ensure their health.

c Consider ditching, draining, or culvert expansion as a means for improving soil conditions in places where impaired drainage restricts roots.

i & j See below. Use most conservative thinning regimes when working in *Safety Emphasis Areas*.

Recommendations (*Regeneration Emphasis Areas*, i.e. new forest openings)

d Windfirm canopy trees adjacent to new openings by spiral pruning. Appendix 4 includes a sample prescription.

e Plant trees in clusters of three to five. Gaps between clusters, and between stand edges and clusters, should be within a range of eight to ten metres. Resulting density will be 300 – 500 seedlings per hectare.

f Use at least two species per cluster, in order to increase future wind dampening effects.

g After seedlings are free to grow, thin clusters down to one or two trees, for an overall forest density appropriate for the stand objective.

h Reduce densities of natural hemlock regeneration where hemlock competes with other species, in order for the stand to achieve target objectives.

Pruning can decrease likelihood of wind throw in high risk areas.

Recommendations (*Forest Resilience Areas*)

i Tree stands planted between 1988 and 1998 should be considered for thinning, depending on their current conditions. Appendix 10.1 includes a recommended prescription.

j Tree stands planted in the post-Hurricane Frieda era of the 1960s should be considered for thinning, depending on their current conditions. Appendix 10.2 includes a recommended prescription. Cost benefit analysis suggests that the priority of these stands is secondary to that of stands planted after 1988.

Module 4 - Fire Management

Goals

To reduce the likelihood of uncontrolled fires burning the forest, and to minimize the extent of damage and risk to park visitors caused by escaped fires.

Objectives

Continue to strengthen and implement the existing Stanley Park Fire Management Plan.

Implement an ecologically sensitive fuel reduction program that is responsive to changes.

Discussion

Wildfire is a relatively rare natural occurrence in coastal forests, but is more common near human habitation. Stanley Park experiences a high number of fire starts, either accidental or by arson. On average, three to four fires start in an average year. For perspective, that is a rate, by area, almost 140 times greater than within the Chilliwack Forest District as a whole. Fire in the urban forest interface is a threat to persons, property, and the aesthetics of the forest. Smouldering ground fires will emit high levels of carbon monoxide, as well as potentially dangerous levels of airborne particulate matter. Depending on wind direction, smoke from a Stanley Park fire will reduce visibility and disrupt vehicular traffic. A high intensity fire can spread very quickly and spark new fires ahead of its front, and in buildings. Even if persons and property are protected, a wildfire can cause widespread devastation to the forest that is an eyesore for many years.

It is for these reasons that fire in Stanley Park should be prevented and suppressed.

Fire Management Plan

The Park Board currently has a Fire Management Plan, albeit one that is distributed over several documents. Updating and repackaging the document is recommended. Since it is a municipal park on federal land, the provincial Wildfire Act (SBC2004) and the Wildfire Regulation (BC Reg. 38/2005) do not legally apply to Stanley Park. Nonetheless, much of their accumulated information and many of their recommended procedures are directly applicable and should act as a guide. After the disastrous Kelowna forest fire in 2003, the provincial government commissioned a review of the events with the aim of preventing recurrences of that severity (Filmon, 2004). The lessons and recommendations from that inquiry have been also taken into consideration.

The three elements of the Fire Management Plan are: preparedness, prevention/detection, and suppression. A considerable amount of work on each of these elements has already been done over the last twenty years, and is summarized below:

Preparedness	Prevention / Detection / Protection	Suppression
Interagency collaboration Communications and media plan Infrastructure Pre-fire season preparation Fuel and fire risk mapping Staff training Firefighting equipment upgrades	Fire watch patrols Bylaws, Prohibition schedules Fire weather monitoring Public awareness protocols Communication with local air services Enforcement of camping prohibitions Fire fuel hazard abatement	Park evacuation procedures in event of fire Staff level hand tools for extinguishing controlled fires Vancouver Fire & Rescue Services wildlands equipment Metro Vancouver Rapid Attack Team MoFR water bombers

Strategies

Preparedness

Review the Fire Preparedness Plan annually.

Continue meeting with the Vancouver Fire and Rescue Services and the South Coast Interface Committee on a regular basis to maintain and improve interagency cooperation.

Ensure that the Stanley Park Fire Preparedness - Media Communications and Media Plan be maintained in a ready state and followed should events require. Included in this plan is a contact list which must be updated before every fire season.

Replace missing trail markers at intersections to assist Fire Department crews with way finding.

Erect a system of gates and barricades to prevent unauthorized vehicular access to the trail system.

Maintain a database of fire start locations to assist in fire prevention efforts.

Conduct periodic mock fire event exercises to test equipment, communications strategies, and staff readiness.

Update fuel type maps every five years (the most recent is from 2007).

Conduct annual flushing and testing of the fire hydrant system.

Follow fire season preparation protocols annually (see Appendix 5).

Post and update Fire Danger warning signs at major entrances to the park. Monitor Fire Danger Class reports from the MoFR Capilano dam weather station daily.

Use Fire Danger Class levels to determine the need for, and frequency of Fire and Rescue Services Patrols. Appendix 5 contains prescribed response levels.

Issue warning notices to all parties conducting work in the forest, when the Fire Danger Class level reaches 'High', and again at 'Extreme'. Notices should contain descriptions of applicable work restrictions.

Work with the Police and Fire and Rescue Services Departments to ensure that the City and Park Board fire related bylaws are observed.

Prohibit uncontrolled camping in the forest due to the difficulty of monitoring for fire bylaw compliance.

Fuel Reduction

Chip or remove trailside and park edge pockets or piles of fine fuels (< 30 cm diameter).

Reduce, disperse, or lower to ground level excessive slash in areas with fuel type S2 (see Appendix 5).

Remove deadfall, wood piles, and shrubs of flammable species from within 10 metres of flammable structures (FireSmart BC, 2005).

In areas where ignition probability and potential consequences are high, consider the trailside removal of low branches and dense hemlock scrub growth that create a fuel ladder effect within areas of fuel types of C2, C3, and C4.

Vancouver Fire and Rescue Department responds to a fire caused by lightning.

Module 5 - Invasive Species Management in Forested Ecosystems

Goal

To promote resilient and diverse forest ecosystems in Stanley Park by managing and controlling alien invasive species in a timely, environmentally sensitive and effective manner.

Objectives

Regularly monitor forested areas and surroundings to ensure that emergent invasive plant infestations are recognized before they have a significant impact on ecosystems.

Prioritize management efforts to focus on invasive species according to their potential and realized threats to forest ecosystems.

Apply the best management practices for invasive plants while taking into account legal requirements, impacts on park ecosystems, as well as the safety of park staff, volunteers and visitors.

Discussion

Invasive plants are non-native species that pose undesired or negative impacts on native biota and ecosystems, managed landscapes and/or human health. These species are able to spread quickly, grow rapidly, and thrive in their new environments, resulting in impacts to environmental, economic and social systems. (Examples include English ivy, Japanese knotweed and Himalayan blackberry.)

Invasive species contribute to habitat loss. They are able to shade-out, smother and displace native plants that provide valuable habitat in our ecosystems. Some of these plants also produce toxic substances that inhibit the growth of native species. Others can alter water flow, cause erosion, or increase fire hazard. Invasive plants causing each of these issues can be found in Stanley Park's forest today.

Management of invasive plants should take a multi-pronged approach that recognizes the immediacy and extent of the threat. Some newly introduced plants should be eradicated quickly, while established plants should be contained. Prioritizing actions to deal with potential or realized infestations is imperative to ensure timely and effective measures in managing invasive plants. The following table lists key traits to consider when developing these plans:

Factors	Lower priority	→	Highest priority
Size of area infested	Large	Medium	Small
Density in invaded areas	> 40% coverage	10-40% coverage	<10% coverage
Degree of establishment	Well-established	Somewhat established	New introduction/ just getting established
Potential negative impact	Low	Medium	High

Examples of invasive plants that are in the highest priority category for control or eradication are Knotweed (*Polygonum* spp), Purple loosestrife (*Lythrum salicaria*), and Giant hogweed (*Heracleum mantegazzianum*).

By implementing Best Management Practices (BMPs) in the management, control and removal of invasive plant species in Stanley Park, the Vancouver Park Board (VPB) and its partners will be poised to successfully manage invasive species in a way that takes into consideration legal requirements (such as the breeding bird season as legislated in the Wildlife Act), and promotes practices that minimize impacts to Stanley Park's ecosystems and recreational values. This may include mulching and replanting after an invasive plant pulling exercise.

Stanley Park's ecosystems should be regularly monitored for changes in vegetation with the help of mapping aids such as a GIS system, and Global Positioning System units. Study plots will reveal the geographical extent of each invasive plant, its rate of spread, and the effectiveness of control measures. At least one followup visit to the site of each control exercise is warranted in order to ensure localized eradication. Depending on the success of treatments, different management techniques may need to be applied. Invasive plant monitoring is an excellent activity for volunteers.

Throughout the management process, it is important to maintain strong ties with partners, researchers, regional groups and other agencies involved in invasive plant management to remain up-to-date on invasive plant concerns, to share best management practices, and to contribute to initiatives at a regional level. In 1998, the VPB adopted a Volunteer Policy that describes the relationship between volunteer work and union work. Invasive plant pulling and monitoring in the park has been conducted within that policy since that time.

The Stanley Park Ecology Society (SPES) and volunteers have worked alongside park staff, providing background and physical assistance for invasive plant control. The cooperative relationship between the VPB and SPES will help to ensure that the strategies are applied effectively.

There are several introduced animal species in Stanley Park. These include species of mammals, birds, amphibians, reptiles, and insects. Although there is no management strategy currently in place to deal with most of these species, there is a need to better understand and control their populations in the future. The negative effects of some, such as bullfrogs (***Rana catesbeiana)*** and red-eared slider turtles ***(Trachemys scripta elegans***), are well documented in other areas, and are a concern also in Stanley Park.

Preventative Strategies

Do not dispose of garden waste within or near the forest edge.

Liaise with park gardeners to guard against the importation of new threats.

Avoid the importation of soil material into or near the forest unless it is verified as being weed free.

Avoid exposing bare soil during trail and road maintenance operations. Cover any incidental scalpings of forest soil with mulch (> 5cm).

Monitoring and Control Strategies

Maintain and annually audit the current inventory of invasive plant colonies.

Encourage volunteer groups to assist with control programs. Additional funds for work may be obtained from private and public organizations, and from trusts.

Conduct eradication or control projects on a priority basis.

Eradicate new threats when numbers are at introductory levels.

Follow the best management practice recommended in Appendix 5. Whenever possible, schedule activities for the period immediately following cessation of vegetative growth.

Replant areas disturbed by invasive pulling/digging with appropriate native understory plants, as per Appendix 6.

Module 6 - Forest Health Factors

Goals

To manage the health of the forest such that severe insect or disease infestations, or abiotic disorders, do not cause tree losses constituting catastrophic changes to the ecology of the forest.

Objectives

Identify and understand which forest health factors represent significant threats to StanleyPark, and remain current as environmental conditions change.

Develop and implement monitoring protocols for threatening insects and diseases.

Implement biorational control strategies when population levels reach the point where damaging infestation is imminent.

Discussion

An unhealthy forest is one that is going through rapid change from its current condition to that of another which is less diverse and less robust in its production of biomass and biota. If the management plan is to improve resilience and diversity, it must be able to guard against agents of insects and diseases which bring about such rapid change. These undesirable agents may be in the form of invasive pests, which almost always reduce forest health, or they may be in the form of indigenous pests which are opportunistic to some new environmental stress. Forest managers must be aware of the difference between those insects and fungi which are merely speeding up the cycling process, killing a weak tree here and there, and those which can cause long-term reduction in forest health.

The University of British Columbia has been conducting intensive studies within the park as part of the restoration work according to its consultative agreement with the VPB. Insect trapping work by Dr. John McLean has provided us with the good news that there have been no captures of the most serious quarantined pest insects. Further good news is that there has not been a rapid increase in numbers of indigenous insects that can also pose a threat. Forest technicians found many of the well known pathogens that attack hemlock or cedar, but found no indications of Douglas fir root rot.

Nevertheless, vigilance is required. The plethora of stumps in the park can be a source of energy for insects and diseases which may later move to healthy trees. Climate change and an aging tree population are preconditions for damaging infestations. Both these factors are at work in the Stanley Park forest. Monitoring is essential if there is to be hope of warding off a major problem before it exceeds our ability to control it. Species specific monitoring protocols for all expected problems in our forest have already been developed, but require customization.

Control strategies need to be consistent with the biodiversity and habitat protection goals within the vision statement, and with the City of Vancouver Pesticide bylaw.

Expected Threats

Insects	Diseases
Douglas fir bark beetle	Mistletoe – hartigii stem rot
Hemlock looper	Butt rots (various)
Invasive insects (long horned beetle, gypsy moth)	Laminated and Shoestring root rot

Dwarf mistletoe (*Arceuthobium tsugense*) / *Phellinus hartigii*

This species is very common in the park, primarily on hemlock trees. Dwarf mistletoe causes 'witches broom' disfigurements on branches, and vectors a serious heart rotting fungus called *Phellinus hartigii*. This heart rot is responsible for many tree failures.

Butt rot (*Heterobasidion annosum*)

This is a root rotting fungus that attacks all conifers, primarily hemlock. It is common throughout the park, and causes whole tree failure. It is difficult but not impossible to detect.

Insect traps are checked on a regular basis.

Laminated root rot (*Phellinus weirii*)

This is a root rotting fungus that attacks entire stands of Douglas fir. It spreads from tree to tree. Pre-emptive tree removal is considered necessary to cease its spread. Though its presence was not noted in 2008 surveys of the park, it is probably present, and a vigilant watch of Douglas fir crowns and upturned roots should be kept. Trees damaged by the 2006 windthrow are at higher risk.

Shoestring root rot (*Armillarea* species)

This is occasionally found in the park on either hardwood or softwood trees. It causes tree mortality. There is likely to be a heightened risk of contracting this disease within the blowdown areas.

Douglas fir bark beetle (*Dendroctonus pseudotsugae*)

Pheromone traps are used to confirm the presence of this beetle at sub-infestation levels. It has the ability to breed in large numbers when there is a source of Douglas fir logs, but most of these logs were removed for this reason during the restoration work. An infestation has the potential to cause mortality under high population pressure. See the 'Bark Beetle Management Guide Book' at http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm for more information.

Western hemlock looper (*Lambdina fiscellaria*)

There have been periodic outbreaks of this foliage feeding caterpillar, with numbers building up over several years prior to widespread tree mortality. The last infestation was in 1959, but the insect is present

in the park and remains a potential threat. See the 'Hemlock Looper Management Guide Book' at http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/defoliat/chap4c.htm for more information.

Exotic insects

The Canadian Food Inspection Agency (CFIA) monitors for threatening invasive insects. None has been found in Stanley Park since the 1992 Asian Gypsy Moth discovery, but an eradication program would be mandated should certain insects or diseases be found. Significant threats include, but are not limited to:

Gypsy moth	(*Lymantria dispar*)
Asian long-horned beetle	(*Anoplophora glabripennis)*
Sudden Oak Death	*(Phytopthora ramorum)*

For more information see http://www.for.gov.bc.ca/hfp/gypsymoth/history.htm, http://www.inspection.gc.ca/english/plaveg/pestrava/anogla/asialonge.shtml and http://www.inspection.gc.ca/english/plaveg/pestrava/phyram/sodmsce.shtml

Recommendations

Manage forest insects and diseases using an Integrated Pest Management approach.

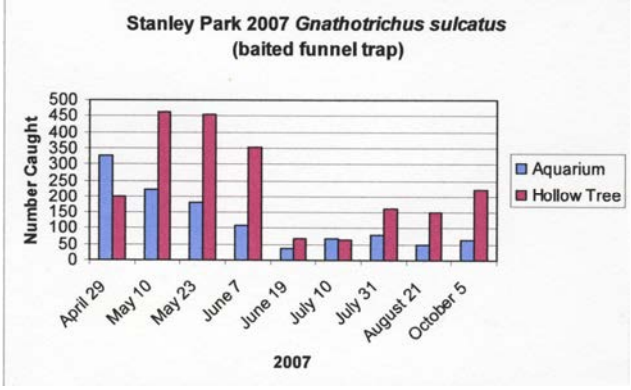
Develop or adapt existing monitoring programs for all of the expected threats. Utilize the advice of forest health professionals when setting up monitoring protocols and thresholds of action.

Implement monitoring programs. Students in resource management programs can be tapped as potential monitors.

Develop a GIS data storage system to track and manage data from monitors.

Implement control strategies when action threshold populations are reached. Prescriptions for control action should include the following elements:

- An ecological cost/benefit analysis
- Minimization of disruption to non-target organisms
- A public consultation plan
- Effectiveness monitoring



Data for trap counts provide useful information on threats to the forest.

Module 7 - Managing for Wildlife and Habitat in Forested Ecosystems

Goal

To manage for the stewardship and enhancement of wildlife species and their habitats within Stanley Park forested areas.

Objectives

Establish *Wildlife Emphasis Areas* within the park.

Ensure that the Forest Management Plan conforms with all applicable Federal and Provincial legislation related to wildlife and fisheries habitats.

Protect those species with special status (such as 'Species at Risk') and their habitats.

Facilitate projects that protect or enhance wildlife and their habitats.

Discussion

While all of Stanley Park's forest is important to wildlife, forests with a diversity of stand ages and structural complexity are particularly beneficial. Veteran trees, snags, and fallen logs add to this complexity. *Wildlife Emphasis Areas* are those areas of the forest of high importance to the ecological integrity of the park. They may be areas of productive or rare habitat, or they may provide essential corridors for movement. Maps are used to indicate designated areas. Please see Map 11.2 (Appendix 11) for a more detailed description.

Wildlife Emphasis Area Types

Wetlands, Watercourses and Riparian Zones

These provide essential habitats for many species of wildlife including waterbirds, migratory songbirds, small mammals, amphibians, fish and aquatic invertebrates. Riparian zones are areas of mostly deciduous vegetation directly adjacent to watercourses. They are areas where several habitats can be found in close proximity, and are important corridors for wildlife movement. Coarse woody debris is an especially important habitat component.

Bird Colonies, Raptor Nests, and Veteran Trees

Stanley Park has important habitat features favoured by colonial nesting birds and birds of prey, including a large number of veteran trees that were established prior to logging. Rocky cliffs and large stands of mature trees in close proximity to the seashore provide valuable breeding habitat for cliff nesting species such as pelagic cormorants, colonies of great blue herons, bald eagles, and other birds of prey. Veteran trees are found throughout the park and provide an important habitat for many species including raptors, bats, and flying squirrels.

Rare Forest Habitats

A small, remnant old growth forest stand is found adjacent to Tunnel trail and Pipeline Road. Its veteran trees have persisted in the park since before logging, and provide an essential habitat for many species including bald eagles, owls, bats, and flying squirrels.

Deciduous groves composed of species like Red alder or Big leaf maple provide a valuable habitat for forest birds and other animals that rely on early seral forest stands. These groves are somewhat rare in Stanley Park. They are areas of particularly high biodiversity and wildlife use.

Skunk cabbage site associations have very wet and nutrient rich soils which are particularly sensitive to compaction. These areas provide an important habitat for many rainforest species including amphibians, shrews, and insects.

Rocky Outcrops - Surficial Geology

These areas of the park are found primarily along the steep slopes near Prospect Point and Siwash Rock. They provide nesting and refuge habitat for a variety of species including peregrine falcons, cormorants, guillemots and gulls.

Ecotones

These are edge habitats which provide special refuge, breeding and feeding opportunities for wildlife. Shrub-forest edges are the most productive for wildlife in Stanley Park, but all edges are preferred habitats for certain species of breeding birds, aerial predators, grazers and small mammals.

Operations in Wildlife Areas

The Forest Management Plan must balance the needs of wildlife with other issues of the urban forest such as public safety and fire risk. For ***Wildlife Emphasis Areas***, wildlife and habitat guidelines and practices will be given high consideration during regular park maintenance activities. See Appendix 8.5 (operations worksheet) for further details. Where Management Areas overlap, each area's recommendations will be considered and decisions will be prioritized. For example, if a ***Safety Emphasis Area*** and ***Wildlife Emphasis Area*** overlap, the priority may be given to safety operations (such as hazard tree removal); however, due to the sensitive nature of the habitat, special attention should be paid to the methodology and timing of these activities.

Monitoring Wildlife Activity

Long-term management will require that wildlife and habitats are inventoried, mapped, and monitored. During the restoration process, inventories were completed in blowdown areas by professional biologists for Species at Risk. The Stanley Park Ecology Society has been adding to this baseline information and continues to work on several wildlife inventory projects both independently and in collaboration with academic institutions and professionals in the field.

Sensitive Species and Species at Risk

Some wildlife species are more sensitive than others to the effects of human disturbance, climate change, and changing forest conditions, and consequently will be monitored more closely. These groups include: bald eagles, great blue herons, amphibians, bats, raptors and invertebrates.

Species at Risk are species that have population characteristics, population trends, or distributions which indicate that they require special attention. In BC, these species are identified by the Conservation Data Center (CDC) which assigns them a global and provincial ranking. Those species added to the Red and Blue lists require more formal designation either provincially under the BC Wildlife Act, or nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). For a list of Species at Risk in Stanley Park see Appendix 8.4.

Red-listed species and red-listed ecological communities are Extirpated, Endangered, or Threatened in British Columbia. Blue-listed species and blue-listed ecological communities are of Special Concern (formerly Vulnerable). Yellow-listed species and yellow-listed ecological communities are secure.

Recommendations

Follow recommendations in Appendix 8.5.

Module 8 – Establishing New Stands

Goals

To establish after a disturbance a diversity of new native trees which will be resilient against further disturbances, while protecting ecological values. Survival and growth rate should be enhanced by using a variety of tools and methods.

To establish new forest stands in small parcels of current forest edge which at the present time serve no recreational, aesthetic, or operational purpose. Early successional species should be used when planting new areas.

Objectives

Plant trees that will start the area on a path toward achieving the stand objectives, as determined by the site growing conditions.

Control the competing vegetation that would kill or slow the growth of planted trees.

After the trees have become sufficiently large and healthy that they no longer require the brushing of competing vegetation, selectively thin their numbers to desired stocking levels. Transplanting to other locations may be considered.

Discussion

There are three basic categories of areas that will require stand establishment treatment: small stands established between 2002 and 2006, blowdown areas from the 2006 / 07 storms, and future stands that will be planted in the future.

> The tree planting that occurred in response to the 2006 storm was conducted according to written prescriptions that were intended to realize the vision statement of the Stanley Park Restoration Plan and subsequent Forest Management Plan. The prescriptions contained the following elements:
>
> Source seed for all stock from trees growing in a similar biogeoclimatic subzone.
>
> Nursery stock growing in 615 containers was used.
>
> Each site was to receive a mix of native species suited to the site series and local conditions.
>
> Planting pattern was in clusters, using irregular clumpy or scattered spatial distribution.
>
> Wide spaces (8 - 10 m) were left between clusters to allow shrub layer development and the retention of lower tree branches.
>
> Planters selected optimal micro-site conditions for each tree while adhering to above guidelines.

These elements were suited to the extensive planting following the 2006 storm, but they do not address all possible future situations. Denser planting, the use of larger container stock, or even natural regeneration might be appropriate elsewhere. Understory enhancement planting may require a significantly different

planting regime. Therefore only general planting guidelines are provided under 'Planting Recommendations'.

The soil nutrient and moisture regimes within the forest tend to be very advantageous to growth of all species. Shrubs, grasses, and crawling vines will overwhelm tree seedlings unless they are cut back for several years. The threat posed to seedlings is correlated to the aggressiveness of the competing species, the amount of available light, and the moisture-nutrient status of the soil. In many areas, competing vegetation will have to be brushed away, using hand or power tools, if the seedlings can be expected to survive. Estimates of brushing needs are as follows:

High light exposure/high moisture-nutrient status	-	years 1 , 2 , 3 , 4, 5 , 8
High light exposure/low moisture-nutrient status	-	years 1 , 2 , 3 , 5 , 10
Low light exposure/high moisture-nutrient status	-	years 1 , 2 , 3 , 5
Low light exposure/low moisture-nutrient status	-	years 1, 3, 5

The seedlings are quite small for the first two years and are at risk of being inadvertently cut by the vegetation brushers. Since the competing vegetation also tends to be immature, hand tools such as brush hooks and machetes are generally the most effective tools. Power tools are more efficient when the pressure from the competing vegetation is stronger and the seedlings can be spotted. Optimal timing for vegetation control is late spring. Work should be completed as quickly as possible after this time in order to maximize the benefit of the remaining growing season. Late spring is also a time for bird nesting activity, so hand tools should be the method of brush control within the peak bird breeding activity months of May and June. Breeding bird surveys are advisable during these months.

Often, naturally occurring regeneration assists in the achievement of stand objectives. Desirable plants growing among the planted stock should be flagged to prevent cutting during brushing operations. Seedlings are particularly jeopardized by invasive plants when there is full sun exposure. Invasive plant control activities should be prioritized in these areas.

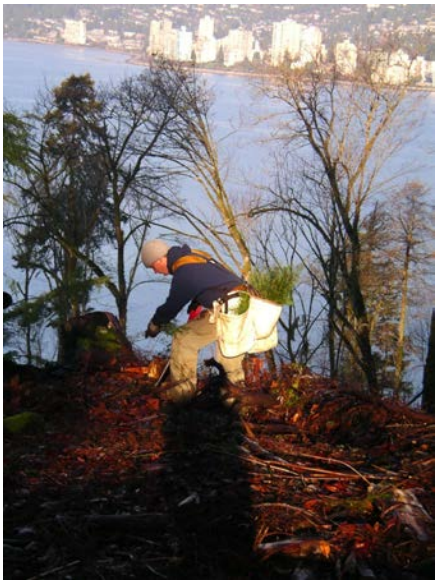
Planting Recommendations

Develop situation specific prescriptions before conducting any planting activities. Prescriptions are based upon site series analysis and an inventory of existing vegetation.

Ensure that prescriptions will move the area toward its target stand condition, with minimal post-planting intervention.

Implement planting strategies during the optimal season for establishment. Use applicable planting practices described by the Ministry of Forests and Range (BC Silviculture Manual. 1999).

Conduct post-planting surveys for early detection of erroneous planting practices. Monitor establishment success after one year. Plant an added quantity if mortality is excessive.



Young tree are planted to help areas meet stand objectives.

Brush Control Recommendations

- Premark brushing sites to safeguard desirable natural regeneration.
- Train beginning brush controllers in plant identification and optimal control methods.
- Brush back native vegetation only if it threatens the viability of the planted stock.
- Aggressively control invasive plants in seedling establishment areas.
- Target brushing activity for the end of the spring vegetative growth period. Employ a large crew to complete work quickly, before seedlings become lost.
- Use hand tools when brushing around small seedlings.
- Schedule only hand brushing work during the months of May and June.
- Conduct breeding bird surveys prior to brushing in May or June.
- In the final year of brushing, tree clusters should be thinned down to one or two trees per cluster, to achieve the stand objective density.

Module 9 – Established Plantation Treatments

Goals

To increase future wind resilience of established plantations by thinning the stand density to a level where trees can retain their side branches and develop strong stems.

To enhance wildlife habitat by opening the forest floor within plantations to more sunlight.

To hasten the development of plantations toward their stand objectives by increasing tree growth and species diversity.

Objectives

Determine which plantations will benefit significantly by the application of thinning treatment, and determine the most effective order in which to treat the plantations.

Bring stand density in these plantations down to a level that will achieve the stated goals.

Discussion

Two goals within the Forest Management Plan are the enhancement of wildlife habitat, and the reduction of the potential for windstorms to cause damage to the forest. A low impact strategy to positively direct the development of human-originated plantations is to reduce tree density. Until 2007, plantation work involved the planting of trees at a very close spacing, with the expectation that they would be thinned manually at a later date. This work was conducted, and should continue to be conducted, on a programmed basis if the treated stands are to achieve the vision of this plan. Failure to do so would result in plantations full of poorly structured trees with tall and slender stems, top heavy with a tuft of branches located only near the tips. Additionally, insufficient light would permeate their canopy to nurture the shrub, herb, and moss layers beneath.

Thinning should be conducted after the trees are tall enough to compete with the resultant regrowth of shrubs, which would be (depending on the site richness) between four and six metres in height (at eight to fifteen years of age). Thinning should be done before the trees reach a size when they become too difficult technically to cut down. After they reach the height of about ten to twelve metres (at about thirty years), tree felling may result in dangerous hang-ups. The remaining trees can themselves become vulnerable to wind damage. Many of the plantations are stocked with Douglas fir whose stems at that age are too large to run through the portable chip grinder. Removal from the stand is costly and risks damaging retained trees, yet leaving stem logs over 30 cm in diameter provides breeding material for bark beetles. Work should therefore be conducted during a tree's juvenile stage, according to stand specific prescriptions. There are approximately ten hectares of plantations within this workable maturity range that are eligible for thinning treatments.

Recommendations

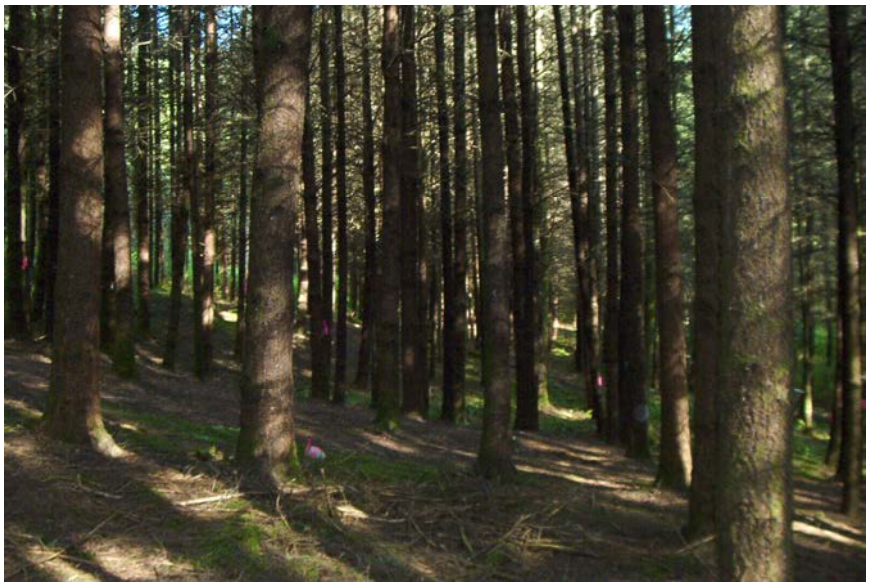
Perform cost-benefit analysis on a plantation-by-plantation basis in order to determine the need and priority for treatment.

Thin eligible conifer stands according to stand specific prescriptions (see Appendix 10).

Survey and collect tree and understory data prior to and subsequent to thinning treatments.

Survey and collect wildlife data prior to and subsequent to thinning treatments.

Assess impacts of thinning treatments and make necessary adaptations to thinning regimes.



A 35-year-old forest plantation with 500 stems per hectare: the trees are losing their crown depth, and little or no light penetrates to the forest floor.

A plantation of the same age with only 250 stems per hectare: trees are more wind-resilient, and the forest floor has profuse growth. (Malcom Knapps Research Forest)

Module 10 – Climate Change

Goal

To maximize the forest's contribution to reduction of atmospheric greenhouse gases by managing it for maximum productive health.

Objectives

Prepare for expected changes in weather patterns by implementing management practices that reduce the likelihood of catastrophic fire, insect/disease outbreak, or windthrow.

Adapt tree planting and silvicultural practices, including invasive plant control, such that they are effective under today's climatic conditions, and also under those projected for the future.

Set up twenty permanent sample plots within the forest to monitor ecological change over time, thereby guiding further adjustments to the management plan.

Discussion

The Intergovernmental Panel on Climate Change (IPCC) reports that "a global assessment of data since 1970 has shown it is likely that anthropogenic warming has had discernible influence on many physical and biological systems. Major changes in ecosystem structure and function, species 'ecological interactions', and species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services" can be expected. It is therefore important that the Park Board work toward global sustainability by protecting the forest for its contributions to the global atmosphere. At the same time, it must guard against the negative effects that are likely to result.

The Stanley Park forest has a landscape level role in the sequestration and storage of greenhouse gases. The coastal temperate forest has some of the highest carbon stores in Canada, averaging 311 tonnes / hectare (David Suzuki webpage). Estimates of 600 tonnes / hectare of carbon from some parts of Stanley Park have been made (Blackwell, 2007). Fast growing stands of trees, notably the post-Hurricane Frieda Douglas fir stands, are growing very rapidly and are helping to remove greenhouse gases from the atmosphere. Other areas are likely to be giving off more greenhouse gases than they are absorbing, but they nonetheless continue to store carbon in the form of slow-to-rot cedar logs. An occurrence of forest fire, disease outbreak, or a large scale windthrow event will cause a surge of carbon release. Therefore, the maintenance of a healthy forest in Stanley Park is the best way to maximize its net greenhouse gas benefit.

Vancouver's mean annual temperature is expected to rise between 1.5 and 3 degrees Celsius over this century. The summers are expected to be hotter and drier than in the recent historical past (Dr. S. Aitken, Director of Forest Gene Conservation, UBC, personal communication, 2008). Those species which are adapted to such conditions will do well, but those requiring damper summers will weaken and decrease in population. A study of pristine west coast temperate forests, released in 2009, found that the rate of tree mortality has been doubling every seventeen years. Climate models by Hamann and Wang (2006) predict that the coastal forest ecosystem in which Stanley Park now resides will shift northward and to higher elevations. Based upon these predictions, our Western red cedar is expected to struggle on the drier sites that it is now capable of occupying, and perhaps to decrease significantly in numbers, but it will probably continue to be viable on wetter sites. Hemlock could face a similar shift. Douglas fir is adapted to more interior forest areas that are currently hotter and drier than Stanley Park will be at the end of the century,

so it will be capable of expanding its coverage within the park. The shrub and herbaceous layers are expected to experience similar upheavals. The wet nature of large parts of the park gives hope that few species of plants and animals will disappear completely, but that is a speculative statement.

Assuming climatic projections are correct, the frequency of catastrophic forest fire is likely to increase. Whether insect and disease outbreaks will increase in frequency and intensity is open to conjecture, but it is well established that stressed plants are more vulnerable. Also, invasive plants that are accustomed to growing in open, sun-exposed environments may have a stronger competitive advantage over indigenous plants.

There is much speculation that warming ocean temperatures will increase the severity of storms by adding more kinetic energy to the atmospheric/hydrospheric system. Research on tropical hurricanes in the southern US revealed that the "increase in the most severe storms – category 4 and 5 hurricanes, which have doubled since 1990 – was directly linked to the rising temperatures of tropical oceans, which warmed globally by 1 degree F during the same period. Warm water vapor rising from the sea helps energize massive storms" (Curry J. Science 2005, 309 1844-1846). Hurricane Frieda, which caused widespread damage throughout the lower mainland in 1962, was generated in tropical waters.

The extent of climate change and its effects on the forest are not completely understood. Adaptive management techniques that are both proactive and appropriately responsive should be employed.

Glossary of Terms

Abiotic factors: the non-living components of the environment, such as air, rocks, soil, water, peat, and plant litter

Adaptive management: adaptive management rigorously combines management, research, monitoring, and means of changing practices so that credible information is gained and management activities are modified by experience.

Alien invasive species: non-indigenous species (e.g. plants or animals) that adversely affect the habitats they invade economically, environmentally or ecologically (IUCN).

Best management practices: are techniques, methods, processes, activities, incentives or rewards that are more effective at delivering a particular outcome than any other technique, method, process, etc. The idea is that with properr processes, checks, and testing, a desired outcome can be delivered with fewer problems and unforeseen complications. Best practices can also be defined as the most efficient (least amount of effort) and effective (best results) way of accomplishing a task, based on repeatable procedures that have proven themselves over time for large numbers of people.

Biodiversity: the diversity of plants, animals, and other living organisms in all their forms and levels of organization, including genes, species, ecosystems, and the evolutionary and functional processes that link them.

Birds of prey: any of various predatory carnivorous birds such as the eagles, hawks, falcons, owls or vultures.

Blowdowns: uprooting by the wind. Also refers to a tree or trees so uprooted.

Brushing: a silviculture activity done by manual or mechanical means to control competing forest vegetation and reduce competition for space, light, moisture, and nutrients with crop trees or seedlings.

Canopy cover: the forest cover of branches and foliage formed by tree crowns.

Climate Change: *Climate change,* more commonly known as *global warming,* is caused by the emission of heat trapping gases produced by vehicles, power plants, industrial processes and deforestation. As these gases build up, they act like a big blanket, over-heating the planet and threatening our health, our economy and our environment.

Cluster planting: the practice of planting seedlings in groups of two to five, with larger gaps between clusters.

Competing vegetation: vegetation that seeks and uses the limited common resources (space, light, water, and nutrients) of a forest site needed by preferred trees for survival and growth.

Conifer: cone-bearing trees having needles or scale-like leaves, usually evergreen, and producing wood known commercially as 'softwoods'.

Conservation: management of the human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations

of future generations. It includes the preservation, maintenance, sustainable utilization, restoration and enhancement of the environment.

Coarse woody debris: sound and rotting logs and stumps that provide habitat for plants, animals, and insects and a source of nutrients for soil development.

Culvert: a transverse drain pipe or log structure covered with soil and lying below the road surface.

Danger tree: a live or dead tree whose trunk, root system or branches have deteriorated or been damaged to such an extent as to be a potential danger to human safety.

Deadfall: A mass of fallen timber and tangled brush.

DBH (diameter at breast height): the stem diameter of a tree measured at breast height, 1.3 metres above the ground.

Deciduous: perennial plants which are normally leafless for some time during the year (BC Gov).

Disturbance: a discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

Ecological health: both the occurrence of certain attributes that are deemed to be present in a healthy, sustainable resource, and the absence of conditions that result from known stresses or problems affecting the resource.

Ecological integrity: the quality of a natural unmanaged or managed ecosystem in which the natural ecological processes are sustained, with genetic, species and ecosystem diversity assured for the future.

Ecotone: a transition area between two adjacent ecological communities usually exhibiting competition between organisms common to both.

Ecosystem: a functional unit consisting of all the living organisms (plants, animals, and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size-a log, pond, field, forest, or the earth's biosphere-but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or range ecosystem.

Edge: the outer band of a patch that has an environment significantly different from the interior of the patch.

Even-aged stand: a stand of trees consisting of one or two age classes.

Forest health: a forest condition that is naturally resilient to damage; characterized by biodiversity, it contains sustained habitat for timber, fish, wildlife, and humans, and meets present and future resource management objectives.

Forest type: a group of forested areas or stands of similar composition (species, age, height, and stocking) which differentiates it from other such groups.

Forest fuel management: the planned manipulation and/or reduction of living or dead forest fuels for forest management and other land use objectives (such as hazard reduction, silvicultural purposes, wildlife habitat improvement) by prescribed fire, mechanical, chemical or biological means and/or changing stand structure and species composition.

Habitat: the place where an organism lives and/or the conditions of that environment including the soil, vegetation, water, and food.

Habitat enhancement: any manipulation of habitat that improves its value and ability to meet specified requirements of one or more species.

Hazardous or danger tree: a tree or any component of a tree that has sufficient structural infirmity to be identified as having a high risk of falling and causing personal or property damage.

Hydrology: the science that describes and analyzes the occurrence of water in nature, and its circulation near the surface of the earth.

Indigenous: Native; produced, growing, or living, naturally in a country or climate; not exotic; not imported.

Forest inventories: a survey of the forest area to determine data and species for specific purposes such as planning, evaluation, or management.

Keystone species: a species that plays an important ecological role in determining the overall structure and dynamic relationships within a biotic community. A keystone species presence is essential to the integrity and stability of a particular ecosystem.

Merchantable timber: tree or stand that has attained sufficient size, quality and/or volume to make it suitable for harvesting.

Mesic: Of, characterized by, or adapted to a moderately moist habitat.

Mineral soil: soil consisting predominately of, and having its properties determined by, inorganic matter. Usually contains less than 20 percent organic matter.

Native species: (see indigenous)

Pest: any forest health agent designated as detrimental to effective resource management.

Pheromone: any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

Planting: establishing a forest by setting out seedlings, transplants or cuttings in an area.

Plot: a carefully measured area laid out for experimentation or measurement.

Prescription: a course of management action prescribed for a particular area after specific assessments and evaluations have been made.

Regeneration: the renewal of a tree crop through either natural means (seeded on-site from adjacent stands or deposited by wind, birds, or animals) or artificial means (by planting seedlings or direct seeding).

Resilience: the ability of an ecosystem to maintain diversity, integrity and ecological processes following disturbance.

Riparian areas: an area of land adjacent to a stream, river, lake or wetland that contains vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas.

Seed source: the locality where a seedlot was collected. If the stand from which collections were made was exotic, the place where its seed originated is the original seed source.

Seedling: a young tree, grown from seed, from the time of germination to the sapling stage, having a DBH equal or less than 1 cm.

Seral stage: any stage of development of an ecosystem from a disturbed, unvegetated state to a climax plant community.

Silviculture: the art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands. Silviculture entails the manipulation of forest and woodland vegetation in stands and on landscapes to meet the diverse needs and values of landowners and society on a sustainable basis.

Stand density: a relative measure of the amount of stocking on a forest area. Often described in terms of stems per hectare.

Stand dynamics: the study of changes in forest stand structure over time, including stand behavior during and after disturbances.

Stewardship: caring for land and associated resources and passing healthy ecosystems to future generations.

Stream: a watercourse, having an alluvial sediment bed, formed when water flows on a perennial or intermittent basis between continuous definable banks.

Succession: the gradual supplanting of one community of plants by another, the sequence of communities being termed a sere and each stage seral.

Species at Risk: a list maintained by the Government of Canada that commits the government to protect wildlife species and their habitats. Addition of species is done annually by the Minister of the Environment, based on a report from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent committee of wildlife experts and scientists. The list contains five categories for species: special concern, threatened, endangered, extirpated, and extinct.

Thinning: cutting made in an immature crop or stand primarily to accelerate diameter increment but also, by suitable selection, to improve the average form of the trees that remain.

Topography: the physical features of a geographic area, such as those represented on a map, taken collectively; especially, the relief and contours of the land.

Understory: any plants growing under the canopy formed by other plants, particularly herbaceous and shrub vegetation under a tree canopy.

Veteran tree: in growth and yield, a tree that is at least 30 years older than the age of the main stand. In multi-layered or complex-layered stands, a tree that is at least 100 years older than the oldest sample tree of the main stand.

Watershed: an area of land that collects and discharges water into a single main stream through a series of smaller tributaries.

Wetland: a swamp, marsh or other similar area that supports natural vegetation that is distinct from adjacent upland areas.

Wildfire: an unplanned or unwanted natural or human-caused fire, or a prescribed fire that threatens to escape its bounds.

Wildlife habitat: areas of land and water that support specific wildlife or groups of wildlife.

Wildlife tree: a tree or group of trees that are identified in an operational plan to provide present or future wildlife habitat. A wildlife tree is a standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include large diameter and height for the site, current use by wildlife declining or dead condition, value as a species, valuable location and relative scarcity.

Water table: the planar, underground surface beneath which earth materials, as soil or rock, are saturated with water (dictionary.com).

Windfirming. Used to stabilize the forest on the edge of a recent blowdown or clearcut. Branches of the remaining trees are selectively pruned to reduce the impact of the wind long enough for the trees to strengthen their root systems and main stems.

Windthrow: uprooting by the wind. Also refers to a tree or trees so uprooted.

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Features weed alerts, resources and information on invasive plants in B.C.
<http://www.agf.gov.bc.ca/cropprot/weeds.htm>

Ministry of Forests and Range Invasive Alien Plant Program:
Tools, tips and resources for invasive plant management in B.C.
<http://www.for.gov.bc.ca/hra/Plants/index.htm>

The Nature Conservancy The Global Invasive Species Program:
<http://tncinvasives.ucdavis.edu/esadocs.html>

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