Managing the Urban Forest in the Lower Mainland of British Columbia

by

Michael Robin Gardner, R.P. Bio.

(C. For. Faskally Forester College 1965)

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Name: Michael Robin Gardner, R.P. Bio.

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Examining Committee:

[redacted]

Dr. J. C. Day
Senior Supervisor
Professor
School of Resource and Environmental Management

[redacted]

Dr. Mark Roseland
Limited Term Assistant Professor
School of Resource and Environmental Management

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Managing the Urban Forest in the Lower Mainland of British Columbia

Author: [redacted]
(signature)

Michael Robin Gardner
(name)

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(date)

ABSTRACT

Residential growth in the Lower Mainland of British Columbia is being driven by population expansion. This is fuelled by a buoyant economy, and immigration from eastern Canada and the Pacific Rim.

The traditional source of agricultural land to accommodate municipal expansion on the outskirts of Vancouver became unavailable following a 1972 moratorium on the development of farmland in British Columbia. The effect of this land freeze was to drive new housing onto the largely forested slopes surrounding the Fraser River floodplain. This factor, coupled in the last two decades, with an increasing demand for urban greenspace and housing areas with forest character has prompted many communities and some developers to adopt forest retention programs within, or contiguous to, housing enclaves.

This study examined the context of urban forestry as it applies to housing development tree retention. It examines the legal and design processes that encourage tree retention using a large development in the City of Port Moody as an example. The study found that the desire for tree retention has not been matched with informed sub-division or housing design, construction implementation, or subsequent forest stand management. The result has been damaged structures and declining urban forest assets.

Planned reconciliation of the environmental needs of trees versus the site engineering needs of cost-effective development can improve the implementation success of sustainable tree-retention programs. In the long term, neglecting the risk of interface fire, or the need for silvicultural strategies and tree safety programs, will precipitate extensive loss of urban forest resources from natural or manmade causes. This is equally as true of trees on public lands as it is on collectively owned or private and commercial property.

Lower Mainland communities must develop comprehensive urban forest programmes. These should emphasize legal, planning, and informational tools, resource potential assessment methods, professional expertise, and public interest in urban forestry. A simple twelve-part model is developed to provide a context in which viable, adequately funded municipal urban forest programmes can be initiated and sustained.

Acknowledgements

I wish to express my gratitude to Dr. Chad Day who, over many years, has encouraged me to search for new dimensions in resource management and who has allowed me significant latitude to pursue my various studies throughout these years.

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To Lea Price goes a very deep expression of thanks for long-standing moral support during difficult and sometimes chaotic days, as well as time and talent in the recording of data and preparation of figures.

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1.0 INTRODUCTION

The complex interface of urban, suburban and rural community growth with the forested lands of the Lower Mainland of British Columbia is poorly understood. It presents a planning, design, and management challenge to urban foresters and all other professionals involved in executing the housing development process on lands with existing tree cover.

Protection and retention of woodland, parkland, wetlands, creek and river flood plains, ravines, and open meadows clearly contribute to the quality of metropolitan life by enhancing the aesthetic character of urban development, and by providing rich recreational opportunities for inhabitants. Visual screening, separation of conflicting use areas, noise abatement, shade and wind shelter (fig. 1) represent some of the other well know attributes of vegetation buffers (Robinette, 1972). Preserving the integrity of the natural hydrological cycle, water quality, and watershed integrity has both economic benefits and recreational advantages, while recognition of wildlife corridors and habitats can also help to maintain urban ecological diversity. Yet these benefits are undermined by professional ignorance, developer greed, public inattention or misplaced trust, and unenforced development requirements due to lack of public official vigilance.

Much thought has been expressed on the relationship of man to the natural environment, with a common thread suggesting that man has failed to recognize his natural habitat as an all-encompassing entity worthy of diligent stewardship. As Simonds (1961) stated: "divorced from his natural habitat, (man) has almost forgotten the glow and exuberance of being a healthy animal, and feeling fully alive." To maintain and improve the visual and treescape quality of our environment is, in effect, to impress a visual image of our historical identity on the collective mind of society. While public interest in tree preservation is widespread, present management methods lag far behind public expectations.

FIGURE 1 As housing developments encroach into forested lands, treed buffer strips form part of the urban forest between housing enclaves.

This paper examines one component of the environmental protection opportunities in the developing urban fringe; the preservation of woodland character where housing is introduced into existing forested lands. Public expectation is for more immediate access to the urban forest and the benefits which they offer (Schroeder 1990). The study reported here examines the general context of urban forestry and suggests that it is comprises of a number of sub-systems each with unique management needs. Taken together they comprise a region's urban forest assets. New housing site development in wooded land is but one of these sub-sets (Table 1). There are planning and design processes that support this sub-system (Table 2) but they must work in tandem to be successful. This practice of tree retention is examined in the context of a hillside development in the City of Port Moody, B.C. The results and consequences both for the resource and public or private land holders is reviewed. It is determined that present methods of planning, site preparation, clearing, and post-clearing management applicable to a variety of developments on wooded lands in much of the Lower Mainland of British Columbia are presently inadequate.

Urban forest retention on development sites entails early identification and analysis of the forest resource, coordinated planning of roads, lots, services or other land use areas, supported by enforceable demarcation of retention zones or individual trees designated for protection. A critical component in the process is the professional evaluation of appropriate species for retention. This must be coupled with an assessment of a variety of factors: retention zone ecological and physical viability related to windthrow hazard; water table and drainage considerations; and species composition; age-class diversity; density of growth; individual tree safety; and any underlying topographic development constraints placed on the site. Detailed clearing specifications and drawings depicting tree retention zone boundaries are critical to the success of urban forest protection efforts. Additional rigorous control through continuous clearing supervision, installation of temporary snow fencing, enforced builders' guidelines, municipal by-laws, and similar controls are also essential if retained trees are to remain viable and safe throughout the life of a sub-division.

Many well-intentioned efforts to preserve woodland character have failed (fig. 2) due, in part, to a lack of understanding of the dynamic nature of the forest resource and the behaviour of individual tree species. Most fail due to a lack of coordinated planning and implementation procedures (fig. 3). Forest retention must be viewed as more than just a planning or design component. It must be treated as part of a holistic landscape management strategy. Once retention has occurred, there remains the long-term responsibility, acceptance, and maintenance of an impacted yet dynamic tree resource. It must be "managed" by both the residents of the neighbourhood in which it is situated and, in the case of trees on public lands, by the appropriate Parks Department.

Schroeder suggests that this increasing management need is occurring at the very time that greenspace funding is under ever-increasing stricture. A difficulty that urban foresters must face is not only a paucity of understanding on the part of the development community and regulators on how best to retain and maintain trees but also an inherent difficulty in demonstrating the value and costs of urban forest lands. Cobham (1990) suggests quantification is elusive but provided some insights in 1990. Miller (1988) reviews individual tree valuation, property value increases, urban woodland and amenity values and legal valuation methods but none provide explicit valuation for housing area tree retention. Song and Loomis (1984) examine amenity values in a comparative review but fail to include the passive benefits from neighbourhood urban forest. Most recently Newark (1993) calculated that urban forest lands could be worth $49,500 per hectare (for institutional lands) and as little as $3,500 for transportation corridor lands. Urban forest losses as a result of the 1991 Oakland hillside fires is estimated at $26.5 million. Clearly there are significant monetary values that can be attached to urban forest resources. Determining these values and keeping in perspective maintenance costs should assist the urban forest community better justify adequate funding.

FIGURE 2 Well-intentioned tree retention efforts often fail since tree needs are little understood and the planning, design and construction continuum inadequately provides protection for the remaining tree cover.

1.2 Urban Forestry
Definitions

Urban forestry is but one small part of the practice of forestry. It is also one of the most recent to be derived from the broad range of aspects seen to be encompassed by the core term: forestry (Table 1).

A variety of definitions have appeared for urban forestry. It must be recognized that considerable confusion, and perhaps even less agreement, exists over what the total involvement with this special form of forestry should be called than almost any other aspect of forestry. The terms "urban forestry, amenity forestry, forestscape, forest greenbelt, urban woodland, municipal forestry, city forestry, metro forestry and community forestry" are all often used.

The term "Urban Forestry" was first coined by Jorgensen in 1967 but a definition of what was meant by the term was omitted. This defect was not overcome until 1970 when a paper published by the same author defined urban forestry as:

> a specialized branch of forestry that has as its objective the cultivation and management of trees and forests for their present and potential contributions to the physiological, sociological and economic well-being of urban society. These contributions include the overall ameliorating affect of trees on their environment, as well as their recreational and general amenity value.

This term is now accepted by the Canadian Forestry Service as the approved version for implementing environmental and amenity forestry research. It is clear this definition does not deal entirely with city trees or with single tree management. Rather it considers tree management in an entire area influenced by, and utilized by, the urban population. Such an area would normally include the watershed and recreational areas serving an urban community as well as those undeveloped areas lying between the established boundaries of nearly contiguous municipalities.

TABLE 1

THE PRACTICE OF FORESTRY: ITS CLASSIFICATION INCLUDING THE PLACE OF URBAN FORESTRY

(after the Oxford System for Decimal Classification of Forestry, 1954).

FACTORS OF THE ENVIRONMENT. ALSO: • General botany, biology, zoology and ecology.	**SILVICULTURE.** • The formation, composition, tending and treatment of stands and trees.	**HARVESTING TREES.** • Logging, transport, storage, handling and utilization of wood.
FOREST INJURIES AND PROTECTION. • Damage caused by insects, disease, animals, fire and man.	**FOREST MENSURATION.** • Measurements of site, tree age, volume, growth and structure.	**FOREST MANAGEMENT.** • Theory, principles, methods and economics.
MARKETING OF FOREST PRODUCTS. • Economics. • Trade and selling forest products.	**FOREST PRODUCTS AND THEIR UTILIZATION.** • Wood structure and properties. • Conversion to products. • Wood preservation.	**FORESTS AND FORESTRY FROM A SOCIO-ECONOMIC VIEWPOINT.** • Forest policy. • Urban forestry. • Legal and labour aspects.

An urban forestry definition prepared by the Society of American Foresters Urban Forestry Working Group in 1972 is similar in many respects to that given by Jorgensen. In order, however, to encourage the public participation which should be essential to urban forestry programs, the Society of American Foresters definition includes 'public education' as an integral part of the definition and thus provides a specific thrust toward a broader understanding of urban forestry by the general public (Miller 1988).

The Society of American Foresters definition further notes that:

> In its broadest sense, urban forestry embraces a multi-managerial system that includes municipal watersheds, wildlife habitats, outdoor recreational opportunities, landscape design, recycling of municipal wastes, tree care in general and the future production of wood fibre as new material.

Shafer and Moeller (1979) have suggested that the underlying premise involved in urban forestry is:

> Delivering benefits to people through management of forest resources in and near the city.

It can be said that urban forestry is the management of tall growing vegetation in urban and urbanizing areas. It would also include relatively undisturbed natural forest areas around the periphery of towns and cities. In that urban and suburban area man has significantly affected the "natural" ecosystem by creating areas for residence and commerce. It becomes clear that all discrete components of the urbanizing treescape should be included in any appropriate definition. Thus a simple way of clarifying the situation without being either inclusive or exclusive, is to view the urban forest as comprising single trees, groups of trees and associated vegetation within and adjacent to urban areas and to view the urban forest as being made up of a number of sub-systems (Gardner 1983). These are further described in Part 4.1, page 13, and in Table 2.

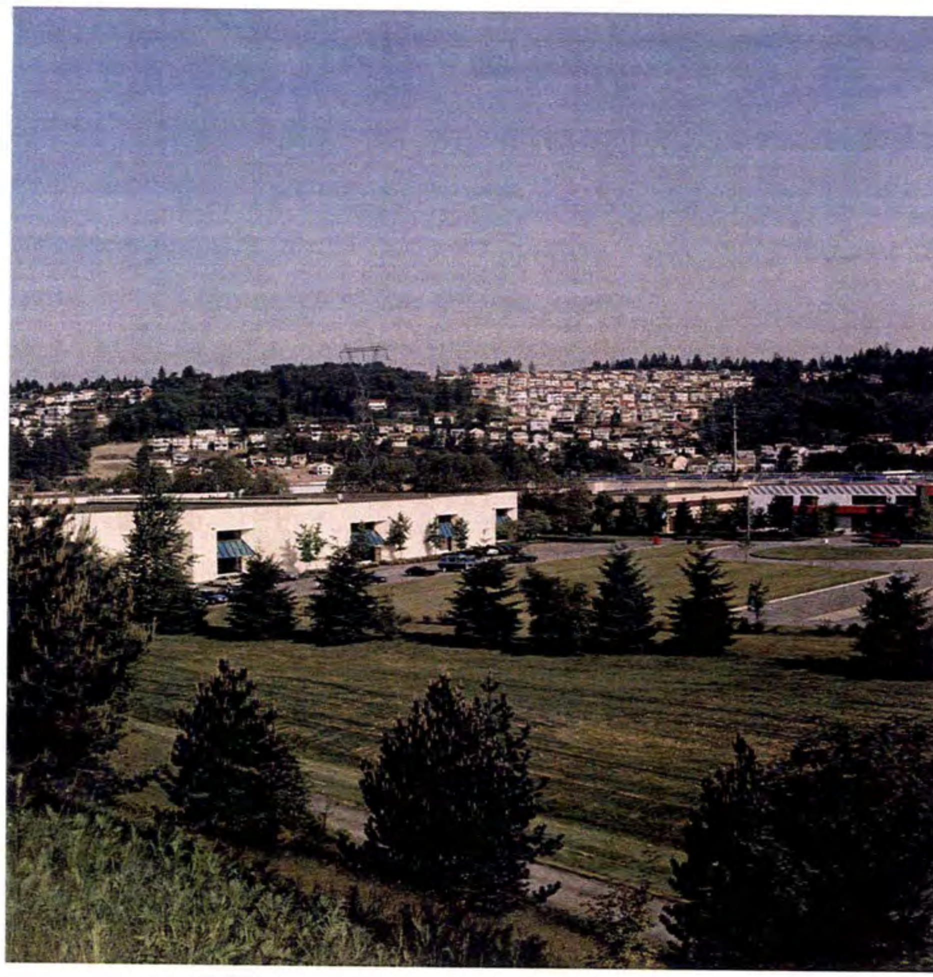


FIGURE 3 On the right is a development with no tree cover retained while left of centre is a visually pleasing development well integrated into forest cover.

1.3 Brief History of Urban Forestry

While the encroachment of cities into surrounding wooded lands occurred throughout North America since man started building cities, early expansion often dictated the complete removal of all trees. The City of Vancouver, for example, passed a *Clearing and Tree Destruction Bylaw* in 1890 to ensure comprehensive clearing and control of fire hazards. It was often only those sites that posed particular construction or access difficulties that were left with the tree cover intact. Few municipalities are fortunate to have areas such as Stanley Park in Vancouver or Central Park in Burnaby left as remnants of the original forest.

A landmark report published by the U.S. Commission on Education in Agriculture and Natural Resources in 1967 referred to the need for foresters to be responsive and sympathetic to an increasingly urban America (Commission on Education in Agriculture and Natural Resources, 1967). The rationale was that the urban trend would continue into the foreseeable future and that foresters would be forced to respond to the demands of growing urban constituencies.

One year later the Citizens Advisory Committee on Recreation and Natural Beauty, chaired by Laurance S. Rockefeller (1968), submitted its second annual report to the President of the United States. Part of the report focused on the theme that city trees constituted a resource that was not being adequately cared for. They recommended that:

> an urban and community forestry program be created in the United States Forest Service. The program should encourage research into the problems of city trees, provide financial and technical assistance for the establishment and management of city trees and develop federal training programs for the care of city trees.

It was also suggested that:

> the U.S. Forest Service should create an urban and community forestry program in cooperation with the states to protect, improve, and establish trees in community, suburban and urban areas. A Federal and State program would provide technical and financial assistance to local governments, organizations and individuals to establish and manage trees and related plants in community parks, open spaces, streets, greenbelts, and on private properties.

With the acceptance of this report by then President Nixon came official recognition of urban forestry in the United States. In 1968 a task force was forme dat the request of the Secretary of Agriculture but it was not until 1971 that an actual legislative proposal, the Sikes *Urban Environmental Forestry Act* came before the U.S. Congress. (Archibald 1973). It proposed that the U.S. Department of Agriculture Forest Service provide the leadership and program coordination with seed funding of $5 million. In 1972 a modified *Urban and Community Forestry Act* was passed by the Senate, but Archibald notes that it was substantially less than the comprehensive proposal of 1968.

The USDA Forest Services' Urban Forestry Assistance Program began its tenth year of operation on 1 October 1981. The program, in conjunction with State Foresters, is designed to promote urban forest and related vegetation management in and around that nation's approximately 2,000 communities. Despite early doubts (Mayne 1976), its intent was able to expand under funding from the *Cooperative Forestry Assistance Act* of 1978.

Other significant developments included the *California Urban Forestry Act* of 1978 wherein that legislature found and declared that:

(a) Trees serve as a vital resource in the urban environment and as an important psychological link with nature for the urban dweller.

(b) Trees are a valuable economic asset in our cities. They help maintain or increase property values and attract business and new residents to urban areas.

(c) Trees play an important role in energy conservation by the modification of temperature extremes, humidity, and winds. This role is particularly important in reducing the amount of energy consumed in heating and cooling buildings and homes, and potentially in producing a local fuel and energy source.

(d) Trees directly reduce air pollution by removing airborne particulates form the atmosphere and helping to purify the air.

(e) Trees also help reduce noise, provide habitat for songbirds and other wildlife, reduce surface runoff and protect urban water resources, and enhance the aesthetic quality of life in the city.

(f) Growing conditions in urban areas for trees and associated plants have worsened so that many California cities are now losing more trees than are replaced.

The movement in Canada to urban forestry has been somewhat slower. An Urban Forestry Program was set up at the Forest Management Institute in Ottawa with Professor Jorgensen as its first director. The status of the program is now unclear. For some time the Canadian Institute of Forestry had an Urban Forestry Working Group but it too appears to be in abeyance. By comparison, the Society of American Foresters' similar working group is very active.

One important act of the British Columbia Legislature has influenced urban forestry in this province. On December 21, 1972 the provincial government issued *Order-in-Council 4483*, freezing the development of all farmland in British Columbia.

Early in 1973, *Order-in-Council 157* defined the scope and nature of the freeze. The Orders in Council, issued pursuant to Section 6 of the *Environment and Land Use Act*, were designed to halt the spread of urbanisation into agricultural areas. By 1972 urban sprawl had overtaken much valuable farmland and threatened the continued production of food within the province. The following year the government replaced the ad hoc land freeze with a formal agricultural land protection system: the *Land Commission Act*. It was subsequently changed in 1977 to the *Agricultural Land Commission Act*.

The *Agricultural Land Commission Act* is a fairly complicated land use control statute and its provisions are not important here. The impact of this legislation is, however, of significant importance to urban forestry in the Province of British Columbia. By severely diminishing the stock of arable land being used for housing, urban development has been forced onto the timbered, steeper slopes around many municipalities. This, in turn, has necessitated many municipalities to address the management of treed lands and the interface of such lands with urban development.

The Greater Vancouver's land resources are extensive (Greater Vancouver Regional District 1993). The region has a land area of 6,571 square kilometres of which 5,130 (78%) are in watersheds, parks belonging to all levels of government, the Agricultural Land Reserve and similar green zone lands. While the region's land resources are extensive, the amount of land suitable for urban development is not. Only 1,441 square kilometres (22%) of the region might be suitable for urban development. Of this 307 square kilometres (5%) are already in use leaving only 1,134 square kilometres for other urban development. The Agricultural Land Reserve accounts for 1,278 square kilometres (19%) of the total region. Parks, forests and mountainous areas, some 3,852 square kilometres. 59% looks a very impressive proportion, however, urban forest is only a small part of this total. How small is not presently known and should be. Moreover, the rate of loss is also not known.

1.4 Sub-system Components of the Urban Forest

Miller (1988) has likened urban forestry to a continuum ranging from that in rural landscapes to that in urban centres. This observation was made in the context of the types of professions involved in urban forestry and examined only broad categories of land use. Table 2, following, provides a more comprehensive picture of the sub-systems that comprise the practice of urban forestry.

The street tree sub-system of most communities has probably received the most intensive level of management within the broad definition of the urban forest. The park sub-system probably has the longest history of management, going back to the managed "commons" and community woodlots or forests of Europe.

It is also possible to extend the management concepts developed there to embrace the urban forest and the various sub-sets as they occur on the periphery of urban communities today. In this case, the urban forest would include such discrete components as regional parks, watershed, community forests, wildlife and ecological designated lands and multiple use forests.

The focus of this paper is restricted to the development site sub-system over which a municipality or city has some direct measure of oversight and planning control and excludes Crown or regional government lands. This is not to suggest that they are unimportant. To the contrary, these lands such as regional watershed areas and provincial forests associated with urban communities warrant a full discussion on integrated multiple use and management all of their own.

Only recently have trees and vegetation on urban private lands, both residential and institutional, been actively considered part of the municipal urban forest. Here an important sub-system is obviously that relating to residential areas where the treescape will make an extremely important contribution to the visual character of an

TABLE 2

THE PRACTICE OF URBAN FORESTRY: ITS CLASSIFICATION BY COMPONENT PARTS

STREET TREES.
- Establishment.
- Maintenance.
- Removal.
- Replacement.

PARKS WITH TREE COVER.
- Safety inspection.
- Hazard removal.
- Underplanting.
- Age and species manipulation.
- Replacement.

RECREATIONAL LAND WITH TREES.
- Safety inspection.
- Large caliper planting.
- Specimen tree care.
- Improvement of treed clumps.

LARGE COMMERCIAL AREA LANDSCAPE.
- Safety.
- Reinforcement planting.
- Weed control.
- Tree surgery.

LARGE INDUSTRIAL AND EDUCATIONAL FACILITY GROUNDS.
- Safety inspections.
- Specimen tree care.
- Silvicultural management.

GREENBELTS AND ENVIRONMENTALLY SENSITIVE AREAS.
- Fire protection.
- Severe windblow removals.
- Limited replanting.

HAZARD LANDS ALIENATED FROM DEVELOPMENT.
- Inspection for decline.
- Fire protection.

RAVINE LANDS UNSUITABLE FOR COST-EFFECTIVE DEVELOPMENT.
- Removal of windblow in water courses.
- Bank stabilization.
- Fire protection.

RIGHT-OF-WAY CORRIDORS.
- Utility protection.
- Canopy manipulation.
- Hazard tree removal.
- Small tree planting.

LARGE LOTS AND ACREAGES ALREADY DEVELOPED.
- Assessment.
- Retention agreements.

Public education and aid.

NEIGHBOURHOODS WITH MATURE TREES AND SMALL LOTS.
- Public education on dangers of topping.
- Education and aid on safety and replacement.

NEW DEVELOPMENTS IN WOODED LANDS.
- Assessment.
- Retention area design.
- Clearing supervision.
- Safety inspection.
- Long-term management.

landscaping.

A further similar sub-system is that relating to the larger grounds encompassing many institutional facilities such a colleges, hospitals, military installations and prisons. To this might be added the landscape or small blocks of wooded land associated with large industrial facilities such as oil storage areas, major hydro sub-stations, mills and fabricating plants. As encroaching urbanisation occurs, these facilities are often displaced leaving behind wooded development sites.

An important sub-system is that associated with municipal land set aside as greenbelt or protection areas. Examples are along foreshore or river banks, flood plains, bog lands or terrace rims where environmental interest, hazard mapping or restrictive zoning has suggested retention in a largely natural condition. To this we might well add ravine land in which building has been excluded by zoning or prevented by high construction costs.

Another identifiable sub-system relates to urban oriented recreation lands. Here ski areas and golf courses might comprise the majority of such lands, perhaps supplemented with such areas as those with bike paths or exercise circuits where trees, or groups of trees, have been planted at strategic points.

Right-of-way lands can be identified as an important sub-system that contribute to the overall treescape of a community to a greater or lesser extent. This depends on the type of land alienation, the width and number of corridors, the utility or transportation mode and the level of maintenance exercised by the user.

Finally, a critical sub-system is the new development site component (fig. 4). Here a municipality has the opportunity to reflect changing public attitudes to livability and to firmly regulate tree retention on existing forested sites or stipulate greenbelt

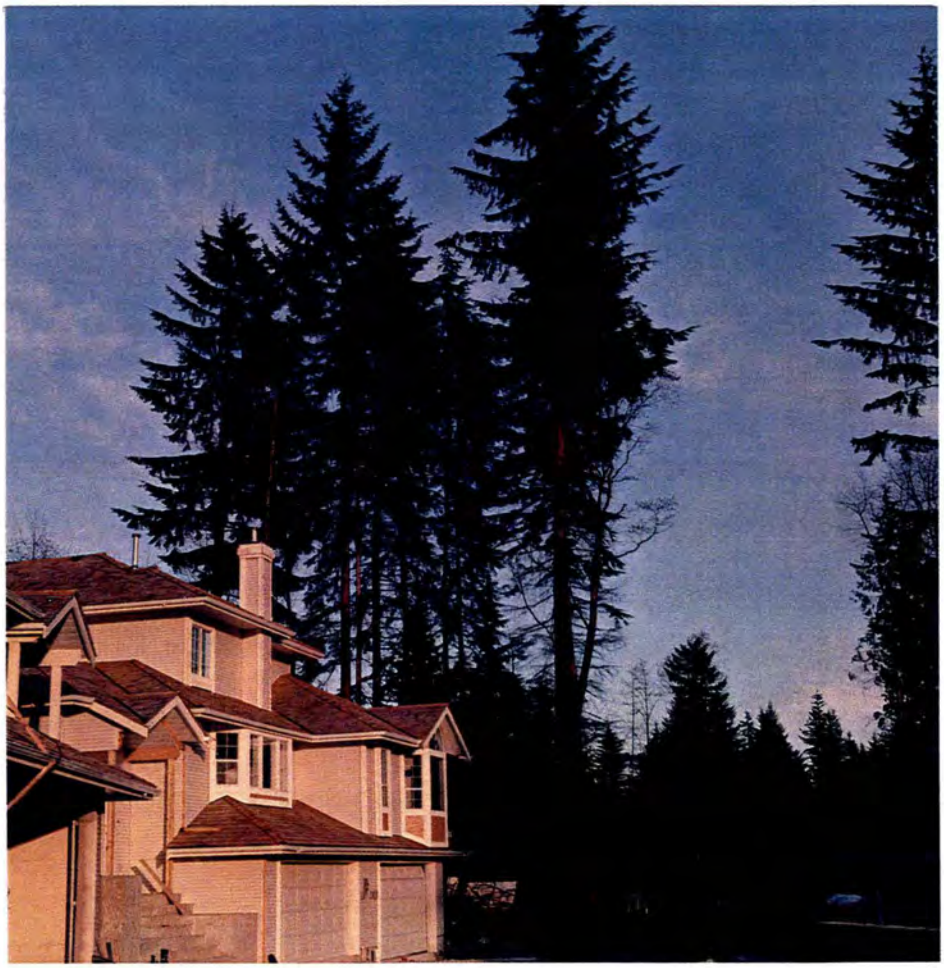


FIGURE 4 Cluster housing designs allow small compartments of forest cover to remain in a development as viable ecological units.

establishment on tracts with no trees or on sites with unsuitable or unsafe existing trees.

As can be readily seen, much of the "urban forest" described here may not always be under the direct control of a municipality. Thus, any management package that does not have sufficient flexibility to promote the integrity of the total treescape, without resorting to the normal, complex, administrative and legal constraints used, for example, in the planning field, will be forever frustrating to those intent on implementing a community tree programme.

In new development sites, however, a municipality has significant planning, negotiation, administrative and regulatory power at its disposal. A focus in this paper is how to match design for treed character, site opportunities, site construction supervision issues, and the realities of existing tree resources on individual parcels, in a manner that will best ensure the safe retention, establishment, and management of treescapes in the future.

FIGURE 5 The Heritage Mountain Development, in the north of the City of Port Moody, B.C., showing the location of four new neighbourhoods.

1.5 General Management of the Urban Forest

Many writers have examined the role and benefits of trees in the urban environment. Harper (1983) suggested that they contribute environmental, aesthetic, economic, and community character values. Grey and Deneke (1978) listed four broad categories; climate amelioration as well as engineering architectural and aesthetic uses. To a similar list, Bernatzky (1978) added physical and mental health. Sinton (1971) proposed that urban society draws spiritual renewal from contact with the natural environment.

The overall treed character of any municipality based on impressions created by "vegetation", rests not only in the resource base created on public land and the treed lands it requires retained in new developments. It also rests in the retention, planting and maintenance of trees and other landscaping on private land. As the bulk of such areas are around private homes and industrial developments, some management objectives should be centred on residential and commercial land. Since such land is "private", and we have a long tradition in Canada of recognizing the individual freedoms that accompany land ownership, the emphasis in the context of tree management on such land must be on public education. This must encourage citizens and companies, including those developing property, to maintain trees as a vital component of the overall treescape of each community.

Four components embody the important pre-requisites that will ensure the appropriate atmosphere for orderly implementation of an urban forestry program and the development of a treed, verdant character to a municipality.

(i) elected officials must support a healthy, expanding, vibrant community treescape and a willingness to financially support specific tree oriented-programs at budget time,

(ii) there must be clear, explicit policies developed by elected representatives that provide appointed officials the mandate to carry out such programs,

(iii) programs must be set in a cohesive management framework that integrates conflicting municipal departmental and public needs and differing responsibilities toward an overall goal of a desirable community treescape, and

(iv) a municipality must have clear standards and methods, as well as sufficient staff, adequately supervised, in order to carry out the individual tasks that comprise the separate projects embodied in its urban forest program.

If any of these components does not exist, a municipality cannot hope to have a viable urban forest resource that engenders civic pride and sets a positive example for private, commercial and industrial development.

It is possible to apply a simple test: ***Are trees in the community to be considered an asset or a liability? If the answer is an asset, then the community can readily justify:***

(a) some investment in the resource,
(b) development policies and plans that promote and retrain tree resources, and,
(c) comprehensive management of the resource.

The following chapters set out the various processes that encompass a successful tree retention program. They draw on the experience of a very large development area on treed lands in the City of Port Moody, B.C. (fig. 5).

2.0 The Planning Process

2.1 Introduction

The orderly development of land in the Province of B.C. can be traced back to 1867. At that time the *Constitution Act*, formerly the *British North America Act*, provided for the division of legislative powers in Canada between the federal parliament and the provincial legislatures. Under the act, the legislatures were given almost complete control over land use within each province.

The *Constitution Act* gave the provincial legislatures the power to "regulate" property and civil rights in each province (s. 92(13)) and *"generally all matters of a local or private nature in the province".* Under sections 92(13) and 92(16), the province was given the task of regulating the use of land in B.C. The province was also given complete control over the public lands it owned. The Act further gave the province exclusive authority over *"the management and sale of the public lands belonging to the province and the timber and wood thereon"* (s. 92(5)). Thus the early management of trees flowed to the province by legislative authority.

Moreover, in 1982 an amendment was added to the *Constitution Act* (at Section 92A(1)(6) that allowed "in each province, the legislature may exclusively make laws in relation to ... forest resources". All of these powers were later entrenched in the new Canadian Constitution adopted in 1983 (*Constitution Amendment Proclamation* 1983). "Since the *Constitution Act* of 1867 also gave the province authority over "municipal institutions in the province", the mechanism was in place for the province in turn to delegate to the local level of government much of the operational authority to control land use in the public interest. That public interest has now evolved to a stage where the *B.C. Municipal Act*, which empowers British Columbia municipalities to regulate development, has recently been extended to provide for the specific protection of trees in the urban environment.

The Minister responsible for the new addition *(Municipal Amendment Act (No. 2) 1992 at Part 28 Division (4.1)), the Honourable Robin Blancoe* quoted in Hansard (1993) in second reading of the Bill, introducing the addition, noted that:

> Many British Columbians are increasingly concerned about the protection and preservation of trees. A provision of this legislation establishes a new scheme under which municipalities are authorized to protect trees valued by the community. The aim of the scheme is to empower municipalities with general bylaw-making authority, which they can adapt to their particular needs in protecting trees in urban areas. In general terms, this legislation adds a new division to the Municipal Act by creating the tree-protection scheme and consolidating some existing authority.
>
> This legislation empowers municipal councils to pass one or more different bylaws requiring permits for tree removal and for restricting the cutting, removal and damaging of trees. It also empowers municipal councils to require the replacement of trees and to require security deposits to ensure that trees are replaced and maintained. As well, this legislation empowers municipal councils to pass bylaws identifying and protecting trees that are significant for their heritage, landmark or wildlife habitat values. Of course, the municipal authority has its limits in this bill. Landowners may take their concerns about tree-cutting bylaws to the local board of variance. As well, the legislation cannot be used to prohibit all land uses or development that may otherwise be permitted by zoning.
>
> This tree legislation addresses the concerns of municipalities and the public, who have been pressing for action as growth pressure in urban areas heightens the impact of tree removal on heritage, aesthetics, views and the environment. It was also developed in consultation with the Union of B.C. Municipalities, which has actively sought protection for trees in urban areas.

The legislation contained in *Bill 77* allows a municipality, by by-law applicable to all or part of a municipality, to generally protect trees. It can do so by prohibiting cutting or damaging trees and regulating replacement, or maintenance, and by enabling cash bonds to be required for security to ensure contractor or developer performance (s. 929.01). The Bill allows a municipality to regulate, by permit, tree cutting and removal (s. 929.02), to identify significant trees (s. 929.03), hazardous trees and shrubs (s. 929.04), replacement or removal of these at an owner's expense (s. 929.05), and to levy assessments for inspections (s. 929.06).

2.2 The Authority for Planning

The provincial government is the principal authority overseeing land use in the province. The Legislature has almost unlimited powers to regulate the use of land in British Columbia. Through legislation, the Legislature has delegated these powers to various bodies, such as the provincial Cabinet, ministers of the Crown, municipalities and regional districts, and administrative tribunals such as the Agricultural Land Commission. The Legislature has, however, ultimate supervisory authority over these bodies as it can amend the legislation under which the agencies operate.

The *Municipal Act (1979)* gives the provincial government specifically, the Minister of Municipal Affairs and Housing broad powers to supervise local and regional governments in exercising their land use control responsibilities. However, where a Council (except the Vancouver City Council which is governed by the *Vancouver Charter*) or Regional Board has enacted any zoning, sub-division or master plan by-law, the Minister of Municipal Affairs may, if he is "of the opinion that all or part of a by-law is contrary to the public interest of the province" notify the Council or Board of his objections to the by-law. He may order the Council or Regional Board to alter such a by-law. If the Council refuses to amend the by-law as ordered, the minister may unilaterally amend the by-law. However, an appeal lies to the Lieutenant Governor in Council from an order of the minister. His decision is final.

Provincial legislation provides for the establishment of local government in all urban or semi-urban communities within the province. Pursuant to the *Municipal Act* the Cabinet may, by Letters Patent, incorporate the residents of any area into a municipality. Municipalities may also be established under specific Acts such as the *Resort Municipality of Whistler Act (1975)* or the *Vancouver Charter (1953)*. The responsibilities and powers of a municipality are defined in its incorporating statute, if there is one, and the *Municipal Act* - which applies to all municipalities incorporated under any statute - except Vancouver. Additional powers are granted to specified municipalities under the *Municipalities Enabling and Validating Act.* The *Vancouver Charter* is the main statute applying to the City of Vancouver.

A municipal council is the key authority controlling land use within each municipality. The *Municipal Act* gives the council power to create official community plans, enact zoning by-laws and sub-division controls, and establish building regulations. A number of specific planning methods can be employed by a council to ensure or encourage urban forestry retention areas in a community.

Amenity Area Agreements

Agreements between council and a developer can set down and control conditions a developer must meet if they are to develop land. Through agreements between municipal government and developer, comprehensive development of land is possible, with the advantage of flexibility in planning for sensible provision of adequate green space, forested or not.

Preferential Tax Assessments

Assessing the land at a lower rate for taxation purposes may be used to encourage land to remain in a particular use. Developing a golf course with treed areas would be an example of such an inducement.

Metropolitan Tax Base Sharing

This is a method where each municipality in a region keeps part of the tax revenue and pools the rest with other municipalities. It has the effect of encouraging regional planning by allowing a municipality to put land into certain uses, which may yield less tax revenue than others. Such taxation practices could be widely expanded in British Columbia to encourage preservation of green space.

Tax Concessions

The *Greenbelt Act* of 1979 permits owners of greenbelt lands, and improvements, to enter into agreements with the Crown and obtain property tax reimbursement for gifts of such lands or for gifts of money to manage greenbelt lands.

There are also a number of mechanisms whereby a municipality may encourage retention of the urban woodland character by acquisition of some rights while private individuals or corporations retain title to the lands:

Easements

The most common example is the right of way, where a community acquires the right to use a person's land, or right over land, for special purposes rather than for occupation. Easements have application for access over open space in the Lower Mainland. Conservation easements could be purchased or leased, as may easements for a variety of recreational uses. Utility easements presently contribute substantial greenspace and, in some cases, urban forest in the Lower Mainland.

Transfer of Development Rights

Transfer of development rights is a method of preservation of environmentally important areas with equitable compensation for owners. The development right is one of the numerous rights included in the ownership of real estate, which permits owners to build or develop on their land. Any form of zoning regulation which results in loss of development rights by outright zoning of open space, could be asking an individual land owner to accept economic loss for the general population. Incentive for the transfer of development rights would achieve the desired open space. A land owner could potentially realize equal or better development potential elsewhere.

Covenants

These are registered conditions on the title restricting the use of land to the benefit of another piece of land or to the community at large. For instance, a restrictive covenant may ensure the retention of an area of urban forest between a shopping centre and an established community of homes. Covenants flow with the title of the land and limit the use of the land, or deliberate removal of vegetation, even to subsequent owners. Enforcement appears to be the weakest element of this kind of land management strategy when intended to ensure preservation of treed areas.

Gifts

A community may receive gifts that contain covenants restricting the use to which the gifted land may be put, such as a woodland or waterfront park. Wide publicity asking for such public spirited gestures may yield results. A number of park parcels have already been dedicated by residents around the province but no examples of urban forest donations are known.

Parkland Provision of Sub-division Approval

The *Municipal Act* (s. 992) stipulates that owners of land being sub-divided shall at their option provide, without compensation, parkland not to exceed 5% of the land proposed for sub-division or pay to the municipality an amount that equals the market value of the land that would be required for provision of parkland. However, the option to pay rather than provide does not apply when an official community plan is in place containing pre-determined policies and designations concerning the location and types of parks envisaged when the community plan was adopted. This requirement for parkland provision is waived for projects consisting of less than three lots, or where lots are being consolidated. When a municipality has levied a development cost change to acquire parkland as allowed for in the *Municipal Act* (s. 983, 995 and 986), it is not obligated to spend that money within the boundary of the proposed sub-division. Thus, parkland, greenspace, or urban forest land can be derived in another part of the community through the municipal development process. Since a municipality has the power to assign fees to cover the costs of administering and inspecting works (*Municipal Act* s. 988), professional assistance can be obtained and paid for when urban forestry concerns are at issue.

2.3 Community Expectations and the Community Plan

In British Columbia a community plan is a statement of broad policy guidelines for the future development of a specified area. An official community plan usually has two components: a text articulating general policies and objectives, and a map illustrating the effect of the policies on locations within the planning area.

As a rule, an official plan is an imprecise instrument for land use control. It applies to a large geographic area rather than a specific tract of land. It contains general policy direction rather than precise regulations. The official plan is designed primarily for planning agencies in establishing more specific land use controls, such as zoning and sub-division by-laws. Part 29, Division (1) of the *Municipal Act* allows for city councils to adopt an official community plan (OCP). The *Municipal Act* gives this definition of an OCP at s. 945(1). *A community plan is a general statement of the broad objectives and policies of the local government respecting the form and character of existing and proposed land use and servicing requirements in the area covered by the plan.*

Section 945 of the Act sets out a detailed list of specific matters which the plans must deal with, from the location of major land uses to the protection of the environment. These are discussed on page 39.

Official community plans do not require provincial government approval. However, if a plan relates to lands in the Lower Fraser River Flood Plain, it must be approved by the Minister of Municipal Affairs and Housing under Section 187 of the *Municipalities Enabling and Validating Act* (1960).

The official community plan, standing on its own, has little effect on a private individual or parcel of land. The plan has legal effect only because it influences future by-laws of a Council; it has no independent legal effect.

Section 996 of the *Municipal Act* requires a sub-division approving officer to take cognizance of the official community plan when dealing with a proposed sub-division. Sub-divisions conflicting with the plan could be refused approval. Although a Council must not act in a fashion contrary to an official community plan, it is under no obligation to implement the proposals contained in the plan (s.949(1)).

In Port Moody, for example, most of the past tree policy direction emanates from the 1984 *Official Community Plan* and a background report titled Urban Forestry Study, The Villages, Port Moody, B.C. (Gardner 1980). Since implementation of the Official Community Plan, Port Moody has had a broad tree retention policy, based on policies in the *Areas of Environmental Sensitivity and Hazard* (policies 1, 6, 7, 9, 11, 12), *Land Use Policies and Area Development Plans* (policies 5, 24, 30, 31, 33), and *North Shore Development Area* (policies 3, 17, 20, 22, 23, 24, 25, 26, 27). Of these directives, Policy #20 in the North Shore Development Area set out the basic direction for tree retention in stating "The unique forest character of the North Shore of Port Moody shall be maintained as much as possible".

This demand was also reflected in the 1984 *Official Community Plan* by the statement that:

> A key objective of the planning process has been to identify development approaches and methods which will retain as much of the forested character of the hillside as possible, while still permitting the residential densities which are need to finance road building and site servicing (page 113).

This expectation was later explicitly outlined in the Heritage Mountain Neighbourhood Development Plan (1987). Specific tree retention leaving strip widths were stipulated.

The purpose of a community plan then, is to provide policies to guide future development in a comprehensive and planned pattern. A plan must take into account the capacities and limitations for development in terms of topographical restraints, existing land use and ownership patterns, tree or vegetative cover status, public utilities and service structures, transportation systems and the economic base.

To be successful, a community plan must achieve three basic objectives. It must provide:

- Consistency with regional, provincial and other government planning policies;
- Maximum opportunity. A plan must be devised to offer the people of the community, present and future, a wide range of opportunity and choice in employment, living environments, education, community services, housing, and the use of leisure time; and
- Flexibility and adaptability. In an era of rapid social, economic and technological change, future needs and circumstances cannot be predicted with complete confidence. Thus, while certain principles must remain inviolate, a plan must have the capacity to adapt to new conditions.

A key intent of any plan with regard to continuity of expectation must be sustainability (fig. 6). Without this maxim, the character that underpins the desirability of a municipality or neighbourhood will be transitory and thus antipathetic to the very social stability that local government wishes to engender.

Key sustainable development objectives suggested, for example, by the latest Port Moody Heritage Woods Neighbourhood Development Plan (Davidson 1992), and intended to reflect public expectations, include:

- Providing for a balanced community that includes a range of housing types, as well as commercial and recreational opportunities in close proximity,
- Evolving toward people-oriented communities that feature a human scale, ample land devoted to greenspace and flexibility to adapt to the needs of changing demographic and economic characteristics,

FIGURE 6 An expectation of many who move into forested lands is that this verdant environment will remain in perpetuity.

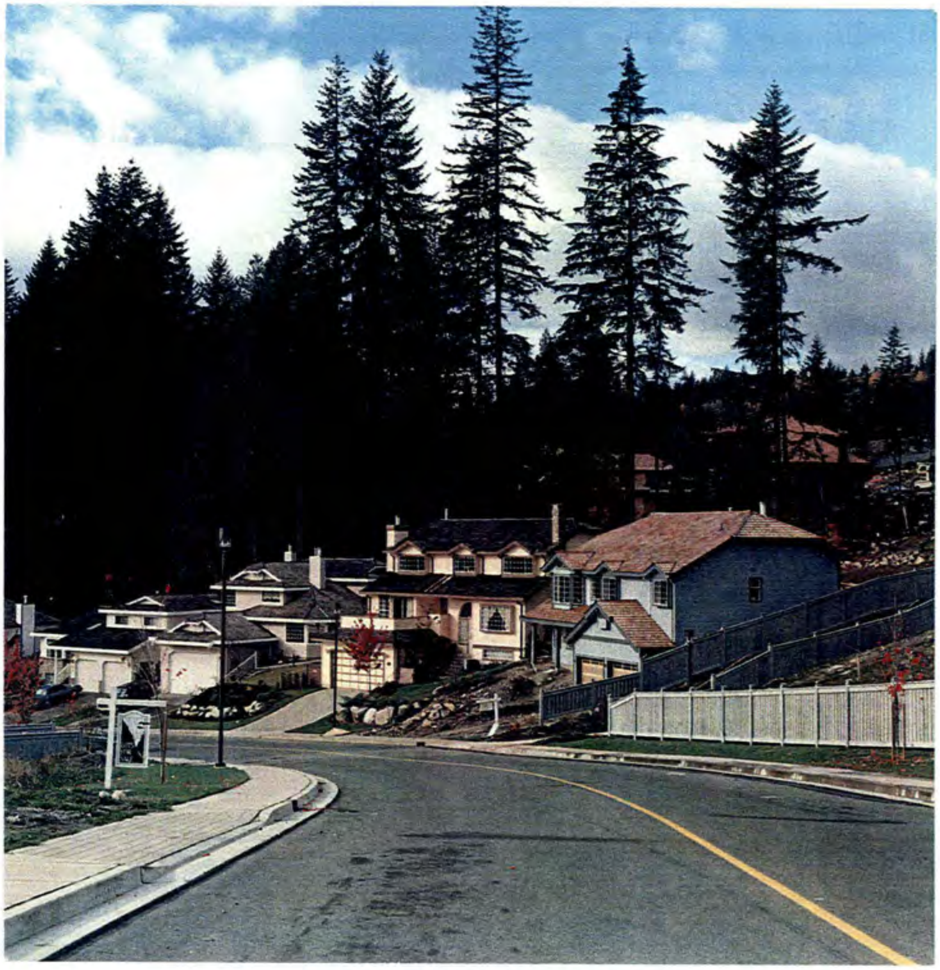


FIGURE 7 An indication of how forest character can be imparted to a typical Lower Mainland development is when clumps of trees are retained in steep ravines between lots.

FIGURE 8 When blocks of mature trees are left on steep, unbuildable slopes, they contribute significantly to the close and distant impressions of forest character.

- Reducing a community's reliance on the private automobile by providing a hierarchy of transportation options including public transit, cycling and walking,
- Reducing the need for unnecessary vehicle trips by promoting mixed use development and using land more efficiently through intensification,
- Protecting and enhancing green space, significant ecological features, and natural habitats including tree retention areas, ravines, natural watercourses, and similar high value or unique areas.

In the more specific sense of developing tree retention objectives that reflect the evolution of retaining tree character in Port Moody development sites, Dunster (1993), in considering Urban Forest Policy for the city, has identified four policy goals to implement the 1992 Official Community Plan expectation of "maintaining the forest character of Port Moody". These are:

GOAL 1 To provide a comprehensive, and clearly defined set of policy statements and by-laws dealing with trees and their associated environments, and related environmental issues on public lands and private lands throughout the City of Port Moody,

GOAL 2 To clearly describe the standards, specifications, and procedures that the City of Port Moody expects both public and private developers to meet before, during, and after developments affecting treed areas and associated environments,

GOAL 3 To design, and integrate into the urban forestry policy, other environmental aspects, such as the ecological viability of tree retention corridors, greenbelts, and ravines, wetlands, and other environmentally sensitive areas, and to provide a well though out and balanced strategy for retaining and enhancing "the forested character" of Port Moody over the short and longer terms, and, GOAL 4 To establish a policy framework and the basis for a management plan, so that, as funds permit, the urban forestry policy can be refined, and additional sections implemented, to meet the present and future needs of the urban forest and associated environments, the residential community, and further developments.

Thus a community plan provides a framework for guidance on how a community will develop and what attributes or principles will be emphasized. The first community plan influenced early development in the initial neighbourhood in protecting trees on ravine banks (fig. 7) and steep slopes (fig. 8) on Heritage Mountain.

The latest community planning process evolved from careful examination of the eight years of experience guided by the initial community plan stipulations. While the 1984 intent was sustained by design presentations during sub-division approval, the process quickly became suspect. This occurred since greater density of single lots was desired by developers as the market for large homes diminished in a faltering economy.

The actual execution of clearing once lot layouts had been agreed upon, though retaining fewer trees than initially expected, was accomplished with reasonable success. Subsequently, a succession of intrusions into the treed areas constantly reduced their viability and resulted in eventual widespread windblow. This was an outcome not envisaged by the technical and policy framers of the first community plan. It clearly pointed to the need for more comprehensive, vigorous planning policies, more detailed retention specifications, and vigorous enforcement. The overall planning and design process in most communities is shown in Table 3.

TABLE 3

THE DESIGN AND PLANNING PROCESS: COMPONENT PARTS AND ACTIVITIES

RESOURCE ASSESSMENT.
- Cover type determination.
- Age classes of trees.
- Site topography and constraints.
- Tree location and value in relationship to development.

DEVELOPMENT DESIGN.
- Housing type and density.
- Lot sizes and arrangement.
- Support facilities, roads.
- Parks and greenbelt.
- Development character.
- General areas of tree retention located.

REZONING APPLICATIONS.
- Presentation of written brief.
- Compliance with the Official Community Plan.
- Compliance with the municipal zoning bylaw.
- Presentation of application.

APPLICATION EXAMINATION.
- Public Signage.
- Municipal department review.
- Design panel review.
- Staff report to council.
- Receipt or rejection by council.

APPLICATION HEARINGS.
- Bylaw first and second readings.
- Advertisement.
- Public hearing with proponent rebuttal.
- Greenspace issues aired.
- Third reading expectations noted.

APPLICATION MODIFICATION.
- Municipal staff make recommendations.
- Conflicts or opportunitites for tree retention re-examined.
- Design team and developer work on concerns and solutions.

APPLICATION ACCEPTANCE.
- Staff report to council.
- Inclusion of tree retention or replanting commitments.
- Council acceptance or rejection of compromises.
- Third reading, if acceptable.

DEVELOPMENT PERMIT APPLICATION.
- Environmental sensitivity identified including trees.
- Compliance with development area bylaw identified.
- Conflicts with bylaw identified.

REVIEW OF CONCEPTUAL PROJECT PROPOSAL.
- Review by municipal and provincial departments.
- Review by advisory bodies.
- Determination of issues.
- Report to council.

DEVELOPMENT PERMIT HEARING.
- Issuance of permit, need for hearing or rejection determined.
- Specific issues, problems and timetable determined.
- Designs solidified.

APPLICATION MODIFICATION AND REFINEMENT
- Presentation of detailed working drawings.
- Resolution of conflicts.
- Detailed professional reports finalized.
- Treed areas designated.

DEVELOPMENT PERMIT APPROVAL.
- Approval and special conditions attached.
- Municipal Act Section 215 Restrictive Covenants registered on title.

LOT SALES OR HOUSE AND LOT SALES.
- Infrastructure construction.
- Site clearing & grubbing.
- Site stripping & fencing.
- Tree inspection.
- Spoil movement.

HOUSE CONSTRUCTION.
- Basement excavation.
- Rough grading.
- Driveways built.
- Local site drainage.
- Tree protection.
- Debris disposal.

LANDSCAPE INSTALLATION.
- Fencing.
- Final grading, irrigation.
- Specialized grade works.
- Ornamental trees planted.
- Turf installation.
- Clean-up.

HOMEOWNER OCCUPANCY.
- Occupancy permit.
- Safety inspections.
- Personalized landscape.
- Small tree planting.
- Greenbelt clean-up.
- Yard maintenance.

2.4 Types of Sub-divisions

Legislative control over the sub-division of property in British Columbia exists to ensure that new urban areas are developed in accordance with sound planning principles. Such planning is necessary for two main reasons: (i) to ensure the provision of basic services, such as sewers and water, and (ii) to take into account environmental factors so that the project will be physically sound and conform to the development goals of the community.

The core legislation governing sub-division of land in British Columbia is contained in the *Land Titles Act 1979*. The Act contains provisions concerning the physical set-up of a sub-division and stipulates the procedures which must be followed before a sub-division plan may be formally approved.

There are three types of sub-divisions, each with unique features:

1. Fee Simple

A land estate in which a land owner is entitled to the entire property, with unconditional power of disposition except as limited by the original Crown Grant or contained in any other grant or disposition from the Crown. In a fee simple sub-division, separate indefeasible titles for each lot are created and registered under the *Land Title Act*. During sub-division the lots created may contain or abut treed areas. Tree retention may be accomplished by covenant that then flows with the title.

2. Strata

This is a development where fee simple land is divided into multiple units, with all the owners having a right to use common elements. Separate ownership is confined to the individual units. Bare land strata lots can be created under *British Columbia Regulation #75/78 Bare Land Strata Regs.* whereas all other types of strata lots are created under the *Condominium Act* (1979). In each case common property may contain treed elements, while the strata lot may also contain trees or adjoin treed lands.

3. Cooperative Corporation

Under the *Real Estate Act*, it is permissable to sell shares in a land-owning company. The company share method of land ownership is called a "cooperative corporation". The cooperative corporation must be registered under the *Company Act*. If the shares are offered for sale or lease, Section 50 of the *Real Estate Act* takes effect and an approving officer's consent is required. This type of development is primarily used for recreational development. Treed lands are often included.

In assessing the community acceptance and compliance with community expectations of any proposed development, municipal planning departments, or local approving officers in the case of Crown lands, have wide powers of persuasion. These can be used to encourage a developer that certain design expectations must be met. Stringent conditions can be imposed during the development permit process. These include the protection of vegetation including trees, and of greenspace, the protection of forested lands, as well as the dedication of parks, before layout approvals are given and any construction proceeds. Guidelines for design, landscape, water management on site, and tree boundaries for clearance and retention are agreed to with the developer.

In general, the city planner, in conjunction with the municipal engineer, parks and recreation representative, school board trustee or representative and the other affected city departments, will assess proposed developments for:

- general layout and character,
- access to the lots being created ,

- access to water and to lands located beyond any initial sub-division proposal,
- adequacy of sewer, water and other services,
- size and shape of lots,
- adequacy of buildable area and building mix,
- natural hazards such as avalanches, erosion, flooding, landslides, debris . torrents, mud flows, subsidence, and rockfalls,
- adequacy of parks and public open spaces including greenbelt and urban forestscape,
- preservation of natural features including marine foreshore, streams, lakes, erodible banks, trees and vegetation,
- compatibility of the overall sub-division pattern with adjoining neighbourhoods and greenspace,
- opportunity for further or future sub-division and implications for further greenbelt connections, and
- engineering viability.

Once most, or all, of these topics have been addressed, a project will proceed, often through a public information meeting for larger developments, to a public hearing. When acceptable to the general public or at least to technical representatives of the municipality, a project will move forward for final approval by the elected council. It is during this process that greenspace land is solidified into real terms of location, percentage of total development and final type of use.

2.5 Zoning and Its Impact on the Urban Forest

Zoning is the principal urban land area control in British Columbia. Zoning bylaws are established pursuant to provisions of Section 963 of the *Municipal Act*, which governs regional, district and municipal operation. Zoning can play an influential part in how an area will be shaped by development of land, both in the public and the private domain. It is during the zoning process that the spatial relationship of development to greenspace is set out following the general guidance afforded by the overall Community Plan.

The essence of zoning is the creation of special zones within a municipality to which special regulations apply. The *Municipal Act* authorizes a council to "divide the whole or any portion of the area of the municipality into zones". Zoning statutes only permit a council to regulate specified matters within the zones. These are discussed below. Another statutory constraint is the official plan previously discussed. A local government cannot pass zoning bylaws which conflict with a municipality's official community plan.

Zoning provisions do give council the power to regulate a land use and prohibit any use in any zone. The power to regulate and prohibit uses within a zone means, in effect, that zoning bylaws will generally list the permissable uses for each zone and prohibit all others. Under the *Municipal Act* all permitted or prohibited uses must be clearly defined in the zoning bylaw. The courts will not allow a municipality to prohibit all uses of privately-owned land so that it may be used only for public purposes. A municipality must expropriate or purchase land if it wishes to limit the use of land for public purposes such as parkland, green space or urban forest reserve.

The following items are considered in the establishment of land use zoning applications:

- the promotion of health, safety, convenience and welfare of the public,
- the prevention of the overcrowding of land, and preservation of the amenities peculiar to any zone including its landscape character,
- the securing of adequate light, air and access,
- the value of land and the nature of its present and perspective use and occupancy,
- the character of each zone, the character of the buildings already erected, and the peculiar suitability of the zone for particular uses,
- the conservation of property values, and
- the preservation of water quality, lakes and streams.

The general purpose of zoning bylaws is to guide the growth of the region in a systematic and orderly manner for the ultimate benefit of the community as a whole. This is intended to ensure that the various uses made of the land, water, buildings and structures of the community, develop in proper relationship to one another, while having due regard for the general considerations set out in the *Municipal Act*.

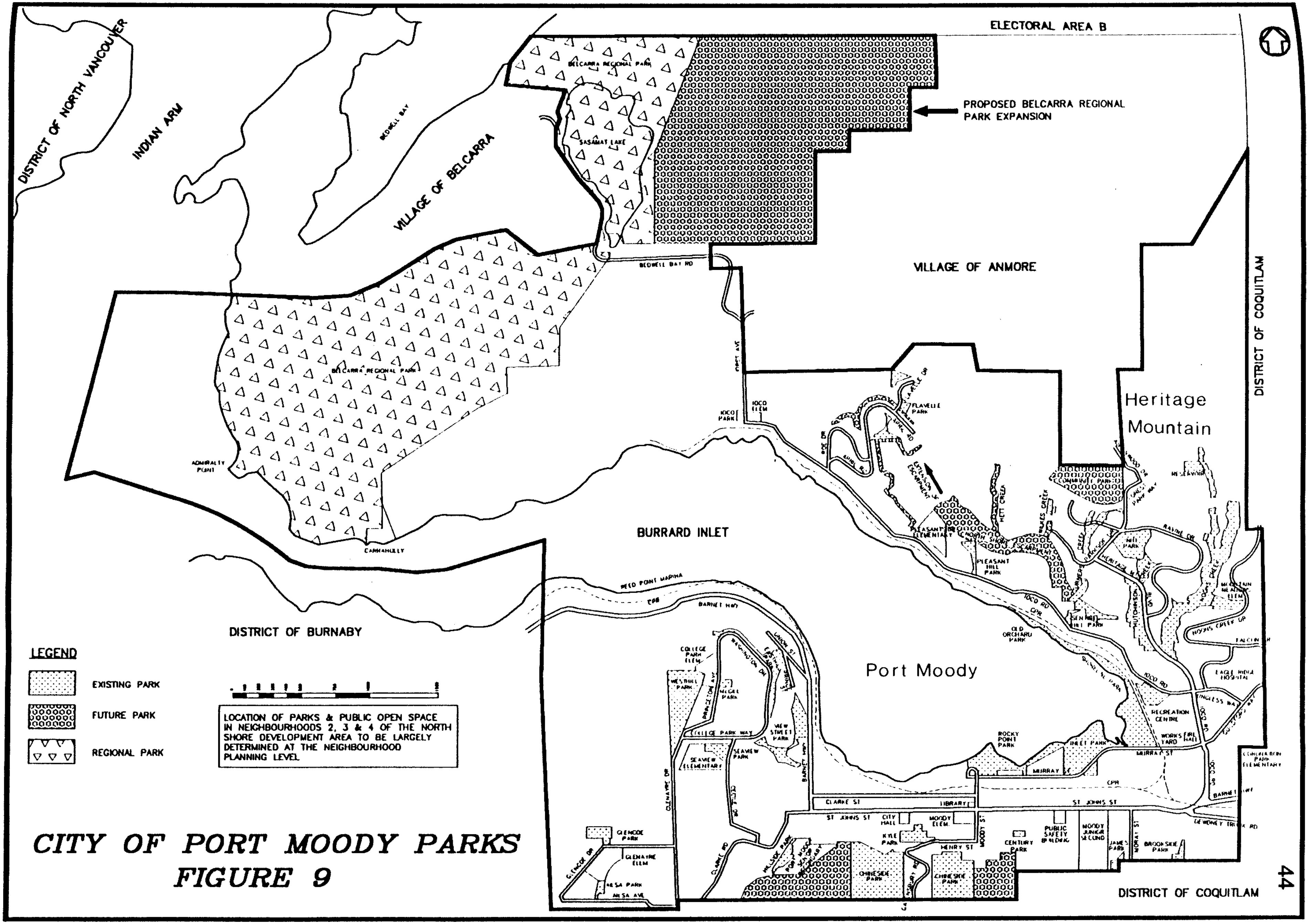
The *Municipal Act* makes the provision that a local government shall not adopt a community plan bylaw, rural land use bylaw, or rezoning bylaw without holding a public hearing on the bylaw. This is to allow the public to make representations to the local government respecting matters contained in the proposed bylaw. The provision of this public hearing allows that all persons or groups who believe that their interest in property would be affected by a proposed bylaw are afforded a reasonable opportunity to be heard or to present written submissions respecting all matters contained in a bylaw that is the subject of the hearing.

2.6 The Port Moody Experience

The City of Port Moody is located 30-kilometres south-east of Vancouver at the head of Burrard Inlet, immediately adjacent to the largely undeveloped Coastal Mountains (fig. 9). Increased demand for housing in the area has led to rapid sub-division of sloping lands heavily forested with mature second-growth coastal species. A developer and city council responded to existing planning policies formulated to preserve woodland character within these proposed housing developments. A report by this writer was prepared to evaluate forest-retention opportunities and related concerns of water management, slope stability in relationship to tree removal, and ravine area problems (Gardner & Peepre, 1980).

The tree resource on the 311-acre Heritage Mountain tract is typical of the predominately coniferous re-growth which occurs on original forest cutovers in coastal British Columbia. The clearing and construction activity associated with the introduction of housing into such forest areas can significantly impact the feasibility of tree retention. Done carefully, trees can often be retained; done poorly, the eventual loss of any tree cover is almost inevitable. As a general rule, the retention of single trees is unwise. A more successful approach is the retention of patches of trees. The degree to which patches of trees can be retained is dependant on a number of factors which will always predicate the degree of success. These factors, and their applicability to each of the development plans of Heritage Mountain, are briefly discussed below.

The most important factors are those associated with the economics of development. These are driven by market forces and dictate the expected yield from any particular site. This, then, translates into decisions on road layout and servicing costs, including their relationship to topography, and, of course, lot sizes and lot shapes. These latter factors all significantly influenced tree retention. The fewer cuts, fills, and servicing corridors through trees, the better tree retention can be



CITY OF PORT MOODY PARKS
FIGURE 9

accomplished. Similarly the larger the lots, and the more they can be pie or similarly shaped, as opposed to rectangular, the greater are the opportunities for tree retention.

Following the development expectations are those policy issues which are adopted to regulate land use. Requirements of a Community Plan are a common mechanism which can markedly control tree retention. Such a plan was in place for Heritage Mountain. Thus, requirements can be further implemented by the intensiveness of planning and supervision enacted to regulate site use and clearing practice. Importantly, the more explicitly public safety requirements can be acknowledged, the clearer will be the judgments on specific tree retention. These must be based on the acceptance of liability either for individual homeowners or by the Municipal Parks Department.

Finally, it is worth recognizing some strategic planning approaches which affect tree retention. The first approach is the question of time versus tree retention. If the tree resource is not suitable for tree retention now, particularly for safety reasons, this does not mean that no trees on this land must be the inevitable, permanent, outcome. The land base can be retained and new trees planted, thus providing, in the longer term, a treed character to an area. A second strategic approach examines the general tree resource potential for retention versus actual conditions in specific sites. Here it becomes not a question of whether to clear or not to clear trees, but rather how to most effectively thin to remove dead, dying, and diseased trees and those that are poorly rooted, while retaining the best trees in clumps or buffer strips.

The developer purchases land, in the case of Port Moody, from the Crown. Market analysis is used to determine housing type, size, and finishes. Land cost and servicing cost are determined and saleable product costs developed. The more units per area, the greater the potential profit. Small lot sub-divisions maximize profit but at the expense of appearance and character. City council and the developer must reach a balanced compromise in such cases.

3.0 The Design Process

3.1 Introduction

New or replacement commercial, industrial, and residential developments are currently underway in many areas of the Lower Mainland of British Columbia. Many of these developments involve urban forestry issues, encompassing either clumps of trees to be retained, or single trees standing alone. Consequently, the workload for qualified urban foresters and arboriculturalists knowledgeable of tree retention needs and constraints is also increasing. Design teams, however, often lack this expertise.

The need for skilled design professionals is expected to increase even more as municipalities and provincial agencies gain a better appreciation about the role of trees in urban and suburban settings and as the move toward regulatory control of tree retention and replacement intensifies. However, many major obstacles remain before successful urban forestry programmes can be implemented as a routine part of the design and development processes. These problems can be simply classified into three main parts: the need for better design teamwork including the use of trained arborists, the need for designs which better consider the needs of trees, and the need for sensitivity to skills and knowledge about trees on the part of all design team members.

The Need for Design Teamwork

There are many players involved in planning, design, and implementation of any new residential or industrial development. These include planners, architects, engineers, landscape architects, and the development community. Typically, there is a mix of participants from the private sector, from municipal, and sometimes provincial governments. Together, these people develop a concept, refine it to a plan, submit it for approval to a municipality, amend it as required, and then translate the planned actions into reality on the ground. All of these efforts require teamwork, cooperation, understanding, and a shared belief that the development in question can be successfully achieved if the players work together.

Note, however, that the list above does not mention the role of the urban forester or arboriculturalist. In Canada, both roles have yet to be fully recognized in the urban and suburban setting. As a result, much of the current work undertaken by arboriculturalists and urban foresters tends to be mitigative and retroactive and not design in nature.

It is not at all unusual for an arboriculturalist or urban forester to be called in **after all the design work is completed and approved.** Nor is it unusual for arborists to be called in as the physical developments are underway, with the expectation that they will be able to easily save trees on site, with little effort or cost. Sadly, reality often fails to meet expectations. It is professionally irresponsible to accept the legal implications of recommending tree retention on a site when the trees clearly have shattered roots, major stem scars, lifted, damaged, or undercut root mats, leaning stems, or obvious defects due to insects or disease.

Yet, all too often designers, planners, architects and other players including landscape architects with some botanical training believe that as long as a tree is green it must be healthy and safe. Clearly, the scope of teamwork needs to be expanded to include expert advice on tree retention at the very start of a project; **not after** housing units are laid out on paper and approved; **not after** the architects and municipal planners have agreed on density issues, setbacks, and other trade-offs; and certainly **not after** a development is underway and site excavation is in progress or, worse still, completed.

Tree retention issues need to be carefully evaluated and discussed not only with the design team, but also with the municipal planning staff. This should occur **before or along with** questions of density, building set-backs, building locations, utilities, driveway locations, road layouts, and final landscape design. If there were more input on tree retention at this stage, there would be not only large savings of time and money, but more importantly, more and safer trees remaining on development sites.

There are a few signs of hope that the full teamwork required is being recognized. Increasingly, developers request the assistance of arboriculturists or urban foresters early in the planning process, although this input could still be moved back to the initial planning stages to achieve a greater effect. At the same time, many municipalities are developing or refining tree retention and urban forestry policies and by-laws. The City of Vancouver, for example, now requires an arboricultural assessment of a site before any planning approvals and development permits will be issued. This must include an inventory of the existing trees on site as well as a plan for tree protection before, during and after development. If retention is not possible, specific obligations are placed on developers for replacement planting (Vancouver Planning Department, 1992).

These are forward, positive steps. Arborists and urban foresters are finding an increasingly positive role to play in shaping the forested landscapes of new developments. The key will be to apply design skills diligently to help achieve more realistic tree retention plans which afford more attention to the ecological needs of trees, and not just the economic needs of the developers, planners, and building designers.

3.2 Design Expectations and the Urban Forest

The most important design factors are those associated with, and driven by the economics of development. These are driven by market forces and will dictate the expected financial yield from any site. Anticipated profitability then translates into decisions on road layout, servicing costs, both also a function of topography, and of course lot sizes and lot shapes. These latter factors all significantly influence tree retention. The fewer cuts and fills and servicing corridors through trees, the better tree retention can be accomplished. Similarly the larger the lots, and the more they can be pie or similarly shaped, as opposed to rectangular, the greater are the opportunities for tree retention.

Following from development expectations are policy issues which are adopted to regulate land use. Requirements embodied in an official community plan are a common mechanism which can markedly control tree retention. These broad policy requirements can be further implemented by the intensiveness of planning and supervision enacted to regulate site use and clearing practice. Finally, the more definitively public safety can be acknowledged, the clearer will be the judgements on specific tree retention, based on explicit acceptance of liability either by individual homeowners or by municipal parks departments.

Land topography and soil type are the most influential non-tree resource factors which affect tree retention. Steep, unbuildable slopes, and areas of ready soil erosion clearly predetermine some areas where tree retention is desirable. This is recognized in many developments where ravine edges require a tree-retention strip on either side as part of the design layout.

Soil type is of considerable importance since it will influence tree rooting characteristics and hence stability in strong winds. Compacted silts and the surface nature of much drainage on Lower Mainland sites results in the reality that few trees are well rooted in the shallow soil overlying compacted till layers.

The tree resource itself, its age-class diversity, species diversity, height, rate of growth, spacing, degree of undergrowth and understorey, and general condition, including freedom from disease and insects, all greatly influence the success, of tree retention design in, or adjacent to, housing areas. Clearly, very tall, thin, closely spaced trees of one species, on a poor rooting medium, are a much more difficult contender for retention than areas of well proportioned, well grown, widely spaced trees of a variety of species growing on well drained, deep rooting soils.

Certainly design guidelines can identify an overall picture of areas notable or preferable for tree retention. The composition of the development site, suitability of the tree resource, and land form constraints will dictate actual retention areas. Typical areas for retention in plan design are:

- Ravine banks and at top of slopes. This applies to rivers, creeks, and major tributaries,
- Areas where the topography is steeper than 20%. In some cases estate lots of larger size can be integrated into those areas,
- Large irregular shaped lots, deeper lots, and spaces between lots where patches of trees remain undisturbed,
- Walkways between and within housing clusters where width and the tree resource allow,
- Townhouse sites,
- Undevelopable sites and right-of-way corridors,
- Major arterial roadway cuts and buffer strips,
- Park sites,
- Heritage trees and sites of interest due to age, size, spacing, shape, strategic location,
- Public facility environs such as schools and community buildings where large parking lots and large treed areas are feasible.

3.3 Land Form and Retention Constraints

Ravine Land

Ravine areas are often of unique natural landscape character but rarely reach their full potential. This can be ascribed to the fact they are "left over" land and fall somewhere on the scale between park and derelict land. Ravine land is often vulnerable to encroachment, tree removal, windblow, erosion, and fire risk. Unauthorized dumping, water pollution, noxious weed growth, and rampant brush growth are also common.

A detailed inventory of large and small ravine land should be conducted and the tree resource assessed. Plans should be made for immediate and future management. Ravine land should be specifically mentioned in any park bylaw and specific provisions included to control dumping and tree cutting. Potential for recreational usage such as interpretative walks should be explored since ravines offer natural features and plant diversity often unique to an area, particularly when the surrounding land is built-up. Management objectives should support and enhance the natural characteristics of each valley, water body, and tree resource. The latter is particularly important since some steeper ravines were typically not logged in the first cutover and larger trees of heritage interest remain (fig. 10). Trees should also remain at 'top of bank', back for at least 15 to 20 meters on either side, to ensure erosion control and stability.

Steep Slopes

In areas where the topography is steeper than 20%, larger estates lots can be integrated into the landform. This will produce bigger, irregular shaped lots, deeper lots, and spaces between lots which provide locations where patches of trees can remain undisturbed.

Pondage Areas

Water management of larger development sites often utilize existing low spots as part of the overall scheme. Detention for major runoff events is an example. Such areas provide opportunities for both tree retention and aquatic ecosystem enhancement if properly designed. Small, or 'vest-pocket', parks can develop around the focal point of the detention works if properly designed and planted.

Rock Outcrops

Many locations in the Lower Mainland have bluffs on exposed rock outcrops on the surface while the overlying soil depth may be limited, Douglas Fir, in particular seems able to exploit rock fissures for rooting. Other species are less well adapted to this environment but may remain in pockets of topsoil if they are open grown and well rooted.

Side-Hill Cuts

The steep nature of the terrain in the south coast mountains, where much of the new development in the Lower Mainland is occurring, necessitates major side-hill cuts to obtain acceptable grades for arterial and collector roadways. Uphill and downhill residual land, too steep for construction, is often created within the road right-of-way. On the low side, tree retention is possible and on the uphill side replanting and top of bank retention may be feasible. While trees in the road right-of-way must grow or be left in a safe condition as a principle concern, benefits of noise, dust, and visual screening can accrue to developing roadside greenbelts.

FIGURE 10 This 135 cm. diameter fir is typical of some of the large heritage growth left during original logging and that can now contribute historical and treescape benefits in some retention areas.

FIGURE 11 Design and field reality clash when grade changes ignore root plate circumference at significant distance from the base of tree boles.

FIGURE 12 Although the initial appearance of small hemlocks left as single trees may be attractive, the practicality of successfully retaining such trees during the construction phase is remote.

3.4 Tree Resource and Inherent Constraints

The tree resource has some design constraints that cannot be altered. Some are generic and some are site-specific. In both cases, trees need space and security. Generic constraints are those physiological factors that all trees must, to a greater or lesser extent, embrace. Trees must have sunlight, unpolluted air, nutrients, water, growing medium, intact roots, and cambial tissue to survive. All of these factors can be impacted by inappropriate design. Grade changes and service corridor excavation intrusions kill trees (fig. 11). Construction practice that allows the contamination of tree root areas by fuel or concrete residue, prolonged ponding of water or complete preclusion of surface recharge slowly kill trees. Fire and compaction will kill trees more quickly. Tree retention expectations that ignore these fundamentals will not be successful.

Designs that require minimum setbacks from tree roots or stems that are within the tree drip-line for foundation installation, driveways, or patio cribbing will ensure rapid death or instability of retained trees. Lack of excavation equipment control that allows temporary fill piles on tree root areas or substantial bark removal from stems, because building separation clearances, or uncontrolled temporary travel-ways did not reflect or protect tree needs, will kill or irreplaceably damage trees intended for retention.

Site-specific constraints that must be accounted for in the design stage are topography, which will influence grading, lot layout, and the actual presence or absence of trees for retention. In addition, the quality of intended retention stands must influence the site design. If tree preservation is marginal, allowance must be made early in the pre-clearing stage to create, supplement, or enhance retention areas. Design, in isolation, without any field inventory or accurate survey of the land and its tree resource will not be successful. This practice is commonplace in many Lower Mainland development sites although the gradual adoption of municipal by-laws is having some positive effect.

3.5 Tree Retention Versus Replanting

Where it is obvious that tree retention is not practical, either because there are no trees at all or existing trees are of doubtful use, there are still two strategic approaches which can affect tree retention. The first approach is the question of time versus tree retention. If the tree resource is not suitable for retention at the time of development design, particularly for safety reasons, this does not mean that no trees on this land must be the inevitable outcome. The land base can be selected, retained, and new trees planted, providing, in the longer term, a treed character to a housing development area.

The second strategic approach examines the apparent tree resource potential for retention versus actual conditions in specific sites. Here it becomes not a question of whether to clear, or not to clear trees. Rather the issue is how to most effectively thin to remove dead, dying, and diseased trees as well as those that are poorly rooted, while retaining the best trees in viable clumps or buffer strips.

The design process must be flexible enough to accommodate tree retention objectives over a time scale well beyond initial submission for planning approval. Moreover, it must not proceed in isolation from the practical realities of any present trees and their condition. Retention for retention's sake, while ignoring the safety and arboricultural feasibility of keeping existing trees, is neither good design nor wise urban forestry. This problem is, however, commonplace. The preservationist mentality overlooks the dynamic and variable nature of most urban forest sites. The concept of removal and trade-off replanting at the expense of retaining mediocre, yet existing trees, is an extremely difficult idea to impart at public meetings. The atmosphere is rarely conducive to large-scale development in the first place.

Neighbourhood designs can also take the "path of least resistance" for present gain at the expense of long-term greenspace management. This strategy invariably yields poorly treed lands that incur public or private restorative costs not borne by developers.

Planting, or logging and replanting, thinning and underplanting are effective treed area retention strategies over the long term. Economic factors prevail for a developer. The question is, who should shoulder the burden of responsibility? Should a community provide incentives for the more complex alienation of acceptable housing lands in favour of keeping treed areas? Most design decisions and council approvals are driven by existing conditions. If they are favourable from a resource location standpoint, and the tree species suitable for retention, it is much more palatable for all concerned to argue for, and agree to, existing tree retention.

On land with scattered trees, or transitional species such as alder with a short lifespan and few endearing visual qualities, it is far more difficult to establish tracts of land separated out for greenbelt or passive tree clumps than it is for housing. Even active recreational parkland is at a premium, so passive land for "non-productive" returns is doubly difficult to protect. Sound design reasoning must support the strategies of partial or total removal and replanting. The tactics of thinning and underplanting, particulary early in the development site cycle do hold promise for some areas, and are more early definable during the design approval process than raw land alienation for some future planting activity. However, community expectations, the official community plan guidelines, and development economics, must be reconciled during this design phase of a project.

The key is to designate early in the design process those areas that can forgo development yet contribute significantly to the tree scape character of an area. Strategic visual location, special separation from land uses incompatible with housing, such as transportation corridors, topographic considerations, and abutting alienated lands are examples where the existing vegetation cover notwithstanding, it is possible to plant or remove thin underplant to provide an island, grove, thicket, pocket park, copse, buffer strip or similar retention area.

It must be clear prior to any public presentation of a project what the eventual treed character of an area is anticipated to be and, importantly, how it will be obtained. the more explicit the design rationale, the more truthful the graphics used to portray a project and the more sincere the development proponent is, by demonstrating how area swill be paid for, stocked and managed, the more likely public acceptance.

3.6 The Port Moody Experience

The proposed Port Moody development extends over 800 acres of moderate to steeply sloped land and is characterized by mixed stands of *Pseudotsuga menziesii* (Douglas Fir), *Thuja plicata* (Western Red Cedar), *Tsuga heterophylla* (Western Hemlock), and extensive tracts of hardwood including primarily *Alnus rubra* (Red Alder), *Acer circinatum* (Vine Maple) and *Acer macrophyllum* (Big-Leaf Maple). Groundcover and shrub layers are generally dense and represented typically by *Polystichum munitum* (Western Sword Fern), *Gaultheria shallon* (Salal) and *Rubus spectabilis* (Salmonberry). The site is dissected by a large number of creeks, deep ravines, seasonal run-off swales, and springs. The soil structure is characterized by generally thin glacial till over hardpan clay and bedrock, resulting in shallow rooted trees of all species, relatively weak topsoil development, and moist, poorly drained conditions.

The initial site investigation included an intensive timber cruise to determine the economic value of the stand and to map vegetation boundaries, coupled with a detailed assessment of forest retention constraints.

A comprehensive literature search was also completed to develop vegetation species profiles, determine optimum sizes of retention zones, assess windthrow hazard, and gather data on other relevant environmental factors such as prevailing winds, precipitation, soil characteristics, and possible slope instability hazards. The data collected permitted the development of realistic guidelines with respect to the variable tolerance of individual tree species to windthrow, juxtaposition of retention zones relative to road and lot patterns, safe widths for leave-strips, and ravine area protection zones.

The preliminary plans for the development were evaluated and then compared to the vegetation retention guidelines. A number of recommendations were outlined to optimize tree retention. Adjustment of road alignments, housing mixes and lot configurations, park locations and size, pedestrian easement, establishment of a "heritage tree" preserve, buffer strips, back lot retention areas, control during construction phases, restoration of forest cover on disturbed lands, and ravine management were all addressed in these recommendations.

Following report submission, detailed planning and engineering studies were commenced for the project. Road allowances were cleared first, and detailed site investigations to determine retention zone boundaries were completed, together with lot plans and retention specifications. In coastal environments the dominate species are often in excess of 40 metres in height as was the case with the predominant Douglas fir and present a serious hazard to subsequent homeowners not windfirm.

Western hemlock which are the least windfirm and are prone to root rot. Douglas Fir and western red cedar, which are regarded as more windfirm, make up the predominant overstory with Douglas Fir accounting for 90% of the upper canopy. Removal of the dominant trees from a retention area in order to eliminate hazards was not without problems. The suppressed lower canopy trees were found to be vulnerable to exposure stress as well as being prone to blowdown. Hardwood retention strips, particularly red alder, were often irregular or unattractive in appearance, and subject to mass windthrow or stem breakage from both wind and wet snow similar to the instability of narrow hemlock stands. The retention area designs attempted to reflect the predominant cover types and retain fingers or bands of trees. Douglas Fir cover types were primarily selected and maintaining the integrity of specific areas governed retention boundaries.

The Port Moody experience yielded some specific insights into the constraints and opportunities which attend tree preservation attempts in the coastal second-growth stands now so typically exposed to housing development. The general design principals gleaned on this larger site follow:

- The size and location of potential retention areas is limited by tree species, tree height, soil conditions, and in turn, by aesthetic considerations and tree wind-firmness. Tree retention areas were possible throughout the proposed Port Moody North Shore development site. However, the design urban forester was not in a position to establish or effect trade-offs between housing density and layout policy and tree preservation,

- The proposed prime tree retention areas in ravines and along the escarpment concurred with previous soil stability studies and were designated for retention,

- As development design proceeded, further retention areas such as arterial buffer strips, parks, secondary streams and other visual buffers around residential parcels were established. Additional fingers or islands of trees varied in size and location according to vegetation type and site design,

- The opportunities for additional retention areas were found to be significantly greater in cluster housing developments than in single-family zones,

- The retention of single trees on lots cannot be recommended due to problems with tree stress during construction from mechanical damage, changes in grade, soil compaction, and other site disturbances factors,

- Final delineation of prime retention zones and additional minor retention islands and fingers was undertaken during the final sub-division design process and verified in the field, according to the constraints imposed by tree species, tree heights, soil conditions, and retention area objectives,

- When the existing resource was to be retained, it was determined that criteria for tree retention should be formalized. In this way all design team members had a clear picture of opportunities and constraints. However, if the development strategy and design preclude the recommended retention opportunities, then preservation of a smaller land base for later restoration planting should be realized,

- Flexibility in housing type, servicing, or setback guidelines can be beneficially applied to maximize retention possibilities. It took time to reconcile differing site needs, but it was found that team consideration of issues along with municipal planning staff could bring mutually acceptable outcomes,

- Following the final delineation of prime retention areas, road allowances should be logged and cleared first, to allow further study, and demarcation of any additional retention islands,

- All areas not identified as retention zones should be clear-cut. Timber should be piled at landings and brokered for maximum revenue. A forest fund should be established by the developer and funds surplus to the costs of clearing should be retained for site restoration.

- Large areas should be logged in one phase, and those areas not designated for immediate development should receive interim restoration treatment. Logging of small parcels over a number of years would result in uncertain financial returns, and probably significant reduction in any restoration trust fund,

- Tree clumps of coniferous growth identified during the design process must be large enough to remain and form a sense of forest character. Careful attention to clearing practice must be required along with appropriate surface water management,

- Hardwood areas are doubtful candidates for retention, certainly in the long-term. Conversion to a much higher proportion of conifers is required. Short-term retention or partial retention is a function of the actual trees left after road and house site clearing. Retained tree band-width influences successful retention probability and is one of the most critical design findings from Port Moody,

- Early establishment of new coniferous groupings with native appearance or complete existing unsound tree clearance and informal landscape planting may provide more tangible benefits,

- Greater design consideration must be given to practicable serviceability and buildability particularly on sloping sites. Tree retention areas without significant width and protection from intrusions will not survive the exigencies of site contractors whose need is to move quickly and efficiently with as little constraint as possible,

- Tree clumps, while determined by species constraints to some extent, cannot be less in width and depth than twice the equivalent of the tallest tree in the stand, and

- Tree green belts originally intended to be 20 meters deep lost edge trees to wind and construction activity, and failed. "Leave" strips appear to need to be no less than 50 metres wide.

The Port Moody tree retention experience, while the subject of extensive study throughout the period 1986 to 1993, has not yielded designs that carried through the construction continuum successfully. Repeated intrusions into "leave" areas by site contractors and poor site supervision was pervasive. In the fall of 1992 unusually wet weather and high winds caused extensive windblow.

4.0 The Forest Process

4.1 Introduction

The fundamental purpose of forestry is to make forests permanently useful to mankind. Through the practice of silviculture as urban forester guides the development of the forest in order that this purpose can be achieved (Hawley and Smith, 1960). It includes control of stand composition, control of stand density, programs of restocking unproductive areas, stand protection and salvage, management of time versus tree cover, and protection of the site and dependant benefits. Sadly, the practice of silviculture has been little understood either in the productive forests of British Columbia and hardly at all understood in the management of urban forestry, as seen in the Lower Mainland. Yet it is fundamental to the execution of the long-term management objectives such as maintenance of tree cover in perpetuity that must underlie retention of urban treed lands.

Silviculture is the combination of the art and science of producing, sustaining and tending forested lands as well as the theory and practice of controlling forest composition toward some pre-designated objective (Toumey and Korstian (1947)). Unlike productive forestry where fibre production for harvest is the main objective, possibly with some ancillary objectives of watershed, wildlife, landscape or recreation intent as well, urban forest is managed to encourage municipal and neighbourhood objectives. These are as much psychological and perceptual in nature as they are ecological. Preservation of the appearance of forest character, shade, prevention of erosion, separation of housing enclaves, noise reduction, spatial balance, parkland protection and similar objectives predominate. A general feeling of well being is engendered by the urban forest for the urban resident (Hull 1992(a), 1992(b), Dwyer 1991). Silvicultural practice must thus reflect the intent of safely maintaining the urban forest in a similar state over long periods without the appearance of significant change.

4.2 Tree Species Suitable for Retention

It is all too easy to rank native conifers and typical deciduous trees in the Lower Mainland by some numerical factor that suggests suitability for retention. Such a process ignores the variability of site aspect, past forestry practice, environmental factors, such as exposure, micro-site factors of sun, soil, sustenance, genetic factors of individual trees, competition, species diversity, age, health and, in the case of extensive clearing, time of year. There can be no simplistic rule of thumb that identifies tree species as retention candidates. Rather all factors including retention block sizes, construction controls, and intended post-construction silvicultural practice, if any, will dictate what tree retention is viable.

Notwithstanding the need to recognize the importance of site suitability and construction management, some tree species appear to have some pre-disposition to survival while others react in fairly predictable fashion to stress factors. Common Lower Mainland tree species are identified in Appendix A. Consistently observed tree reactions, on a wide variety of sites, to typical tree retention designs and clearing practices are recorded in this appendix to guide the reader.

In summary, typical Lower Mainland species may be ranked as follows:

•	Douglas Fir and true firs	Very suitable
•	Western Red Cedar	Suitable when well rooted and not impacted by grade change or soil disturbance.
•	Hemlock	Always of concern even when apparently healthy.
•	Alder species	Weak, transitional tree.
•	Big Leaf Maple	Suitable with a caution on limb breakage.
•	Western Dogwood	Must remain undisturbed and protected.
•	Vine Maple	Very suitable.
•	Black Cottonwood	A transitional species.

4.3 The Place of Silviculture in Urban Forestry

All too often the management of retention area trees is done in ignorance of any silvicultural knowledge of the dynamics of stand composition or stand development. It is important for greenspace managers to realize that urban forests are made up of many trees varying in size, age, and general character. Some of these characteristics have important significance in the silvicultural management of species and require particular consideration.

It is not possible to discuss forest trees in an urban environment at all without the use of the term *tolerance.* This word is used in forestry in a somewhat different sense from its use in general biology, where the tolerance of a plant or animal can be to any number of factors. In forestry, when there is no specific reference to any one type of tolerance, the term refers to the adaptive ability of the tree to survive under deep shade. Trees which have this capacity are referred to as *shade tolerant.* Those which lack this ability, *light-demanding.* Their differences are not limited to this one characteristic; they commonly have a whole train of related characteristics which set them off fairly sharply from each other. There are not two well-defined classes, however, many species are of *intermediate* tolerance.

Silvically the most important differences between typical tolerant and typical intolerant trees as suggested by Baker (1950) are as follows:

- Tolerant trees reproduce and form understories beneath canopies of less tolerant trees or even beneath their own shade; intolerant trees reproduce successfully only in the open or where the canopy is largely broken,

- When tolerant trees form an understory they are very persistent, clinging to life in spite of very small growth for many years. When finally released, they develop very well unless the suppression has been very long and severe. Tolerant trees can survive in very close proximity to each other and with remarkably small root systems. Intolerant trees die out rapidly, and if released before death, often respond sluggishly to release,

- Tolerant trees have heavy crowns of several leaf layers, the innermost remaining functional in very low degrees of light. Intolerant trees have thin, open crowns of well-lighted leaves,

- Tolerant trees clean their boles of side branches relatively slowly, as the leaves remain functional in low light and keep the twigs and branches alive. Intolerant species clean their trunks rapidly, even when growing in an isolated position in full light,

- Fully stocked stands of tolerant species tend to have more stems per acre than stands of intolerant trees of equal age and height,

- Owing to the way in which intolerant trees lose their lower branches, the bole tends to be more cylindrical than that of the tolerant tree under equal conditions of stand density; the latter tend to be more cone-shaped, and

- Juvenile height growth tends to be more rapid in intolerant trees than in associated tolerant species.

These characteristics vary with growing conditions. Young trees always present a picture of greater tolerance than old, the differences sometimes being very pronounced. Trees growing on moist, rich soils appear more tolerant than the average of the species. Tolerance also appears to be greater in the southern part of the range of many species.

Crown density offers a fundamentally sound means of determining tolerance, as a greater number of living leaves or needles persisting in the interior of the crown under conditions of poor lighting increases the apparent density of a tree crown. The most direct method of determining density is subjective, and it cannot be called accurate in any sense of the word, although the difference between extremely dense and very open crowns is obvious to the casual observer. With experience a skilled estimator can provide consistent crown closure and crown growth percentages compared to an ideal crown size.

The rapidity with which a tree trunk clears itself of lower branches, especially in thin open stands, is held to be an excellent indicator of the degree of tolerance, since the death of lower branches appears to be chiefly caused by lack of light. Intolerant trees clear themselves of branches readily; tolerant trees in the open may be clothed with branches to the ground and never loose any lower limbs.

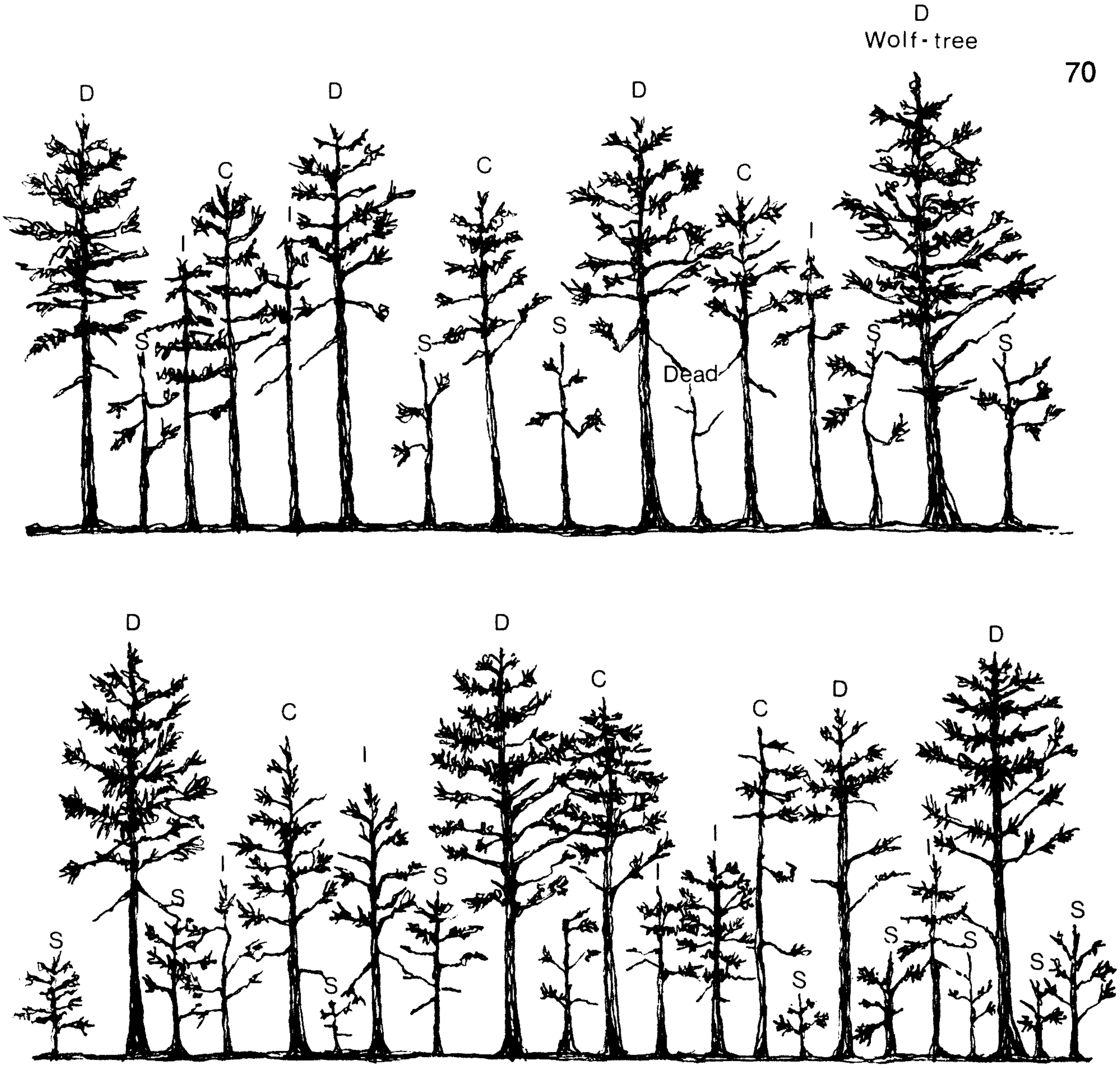
Rapid juvenile growth is characteristic of intolerant trees, while tolerant species grow more slowly. This holds only for growth in full sun or under light canopies. In deep shade, the ability of the tolerant species to persist may give it greater height growth, although its nature is to grow even more slowly than the intolerant species, which is heavily penalized by low light intensity. This characteristic of rapid growth varies with different forest regions and sites. However, rate of growth of different species is greatly and irregularly affected by differences in soil and other local conditions. It cannot be taken unreservedly as a dependable criterion of tolerance.

In even-aged urban forests Baker (1950) proposes a simple classification involving the recognition of five crown classes based on their position in the canopy (fig. 13).

- **Dominant trees**. The crowns of dominant trees rise somewhat above the general level of the canopy, so that they enjoy full light from above and, to a certain degree, laterally. Sometimes in even-aged stands, but far more often in imperfectly even-aged stands, the largest dominant trees, for lack of lateral competition from codominants, grow to be coarse, heavy-limbed, broad-crowned trees that are called *wolf trees* and are considered undesirable members of the stand since they overtop and crowd more desirable trees,

- **Codominant trees**. These are not quite as tall as dominants. Their crowns receive overhead light, but they may be hemmed in to a certain degree laterally by dominant trees. They are nearly as thrifty as dominants and, with them, comprise the main canopy of an urban forest. Their drawn-up height may be disproportionate to their stem diameter.

- **Intermediate trees**. These crowns occupy a definitely subordinated position and are subjected to sharp lateral competition from crowns of the two previous classes, although they receive some direct overhead light through holes in the foliage canopy,



Crown classification applied to an even-aged stand (above) and to an uneven-aged stand (below).

D - Dominant trees

C - Codominant trees

I - Intermediate trees

S - Suppressed trees

FIGURE 13

- **Suppressed or overtopped trees**. These are definitely submerged members of the forest community having no free overhead light. They exist by virtue of the sunlight that filters through the canopy or the skylight that may be received through some chance break. They are week, slow-growing, and generally poorly rooted.

- **Dead trees**. Collapse to the ground may have occurred but not necessarily. Careful inspection of upper crowns of standing trees must be made to recognize these hazardous trees, particulary in close grown stands.

This simple classification system is basically very old; the sub-division of the even-aged stand into trees of the upper level, dominant and codominant, and subsidiary levels is very obvious, and references to suppressed trees may be found as early as the fifteenth century in German forest ordinances (Baker 1950). The classification which is now used was apparently first formulated by Burekhardt in 1847 but as it was not published it was little known, so that Kraft in 1884 is generally credited with authorship of the scheme. It is an important concept when, in tandem with species tolerance, it is used to determine the retention potential of any given stand of trees.

The proportion of each crown class found in the urban forest does vary with species tolerance, age, cutting history, and density of the stand. In stands starting with heavy reproduction a large number of trees must sooner or later pass into suppression and die. How rapidly this takes place depends upon tolerance and site factors. In stands with large numbers of codominant and suppressed trees, effective stand retention is a challenge. Thinning and removal must be carefully planned.

The foregoing classification has often been forced upon the trees in uneven-aged stands, but it proves somewhat unsatisfactory. The difficulty is most serious in the case of trees which are dominant within their own general age group but not with reference to the stand as a whole. *Dominant* under these circumstances may lose some of its connotation, for in an even-aged stand it indicates a permanently outstanding tree, but in an all-aged stand a dominant can be overcome and suppressed by its neighbours. In uneven-aged stands both age and crown position need to be considered.

By understanding the nature and characteristics of stand development, particularly in the even-aged stands in the Lower Mainland of B.C. (fig. 14), the urban forest manager may assess and plan a management regimen best suited to the long-term objective of tree retention in those areas selected for forest character protection.

Where the stand development is the direct result of previous disturbance, replacement stems tend to initiate during a relatively short period. (Oliver 1981). However, a forest with a relatively narrow range of tree ages can display the vertical spacing stratification and stem diameter distribution normally associated with uneven or all-age forests. Oliver challenges the conventional wisdom that a "climax" species is predestined to dominate an area. This is an important consideration and suggests that several different forest communities can potentially inhibit the same area for an indefinite period. Where the urban forest stand manipulation objective is to ensure forest cover in perpetuity, a careful examination of stand composition is clearly warranted to ensure that any cutting practices are not removing viable long-term residents that can contribute intermediate or long-term canopy to an urban forest stand.

By understanding the interaction of the trees in the urban forest canopy, the urban forester can manipulate woodland to reflect the management objective of sustainability. By understanding the present stand conditions it is possible to rationally adopt intervention prescriptions that will support and reinforce that objective. Troup (1928) in his exposition on silvicultural systems noted that they embody three main ideas: determining a method of forest regeneration, the form of the trees produced, and the orderly arrangement of those trees. This will ensure succession of age-classes represented in appropriate proportions, density, and distribution.

4.4 Species and Age Class Diversity

Tree retention has as its fundamental intent retention or enhancement of existing forest character while accommodating the intrusion of housing development. The spatial separation of clusters and the maintenance of trees on unbuildable or environmentally sensitive sites assumes that some forest cover will be retained in perpetuity.

Second growth forest stands predominate in the Lower Mainland of B.C. Cutover practice over wide areas, subsequent seed deposition, the periodic influence of fire, and the consequent even-aged regrowth has left large tracts of closely grown single species stands. Crown closure is commonplace, both silvical and floral diversity minimal. Understorey regeneration of seedling trees, except filling in blowdown patches, is also minimal. This is not a stable, bio-diverse, prescription for a forest stand able to withstand urban pressures or cutting intrusions in perpetuity.

Areas of disturbance recolonized by alder, and to a lesser extent hemlock, are the most obvious areas requiring a program to establish a broader spectrum of species. What is required is a variety of sizes and ages that will grow up to replace the fairly short-lived nature of the pioneer first-growth trees. Solid blocks of even-aged hemlock and, to a lesser extent Douglas Fir, also require careful thinning, the introduction of other shade tolerant conifers, and manipulation to ensure deciduous species can establish.

By ensuring age class diversity (fig. 15), the chances of tree retention area loss through decline or windthrow all at one time is significantly reduced. By ensuring species diversity, the possibility of complete loss due to disease, insect infestation and, to some extent, ground fire is diminished. Neither age nor species diversity will unfortunately protect against major crown and ground fire. On the benefit side, diversity brings with it ecological stability and visual advantages so necessary in an urban locale.

4.5 Stand Management for the Urban Forest

Unlike production forestry, urban forestry has a management objective to retain at least the appearance of forest character if not full forest cover in perpetuity. This is of course at odds with the natural, dynamic nature of the forest, which passes through cycles of growth and decline over time. At some periods it is also very susceptible to insects, disease and the ever present danger of interface fire.

The urban forest must therefore be managed using a suitable system of culture that provides for limited harvesting (fig. 16), natural regeneration, artificial replanting, weeding, and maintenance of the desired species of trees in a stand of suitable structure. This, in turn, can only be done through an orderly system of treatments. The options available are two-fold; those that maintain an uneven stand composition and those that essentially produce even-aged replacement trees in felled blocks of various sizes.

A selection system of management involves the removal of mature and immature trees either singly, or in groups, at intervals. Natural regeneration is established almost continuously. The objective is maintenance of an uneven-aged stand, with trees of different ages or sizes intermingled singly or in groups. This system is aesthetically pleasing, but is difficult to apply successfully unless the stand structure is favourable. It also requires fairly frequent, complex and expensive interventions into greenbelt areas.

Individual (single) tree selection involves the removal of individual trees rather than groups of trees. In mixed stands it leads to an increase in the proportion of shade-tolerant species in the forest. It is not a very viable or suitable approach in most urban forest situations except when dangerous trees must be removed.

Group selection, on the other hand, can be used to maintain a higher proportion of the less shade-tolerant species in a mixture than individual tree selection. For this purpose larger harvest groups are more effective than smaller ones. In western timber types where stands are open or trees are very tall, the groups may be as large as a hectare in size. When groups are of maximum size, they resemble small clearcut patches. The group selection system is distinguished from clearcutting in that the intent of group selection is to ultimately create a balance of age or size classes in intimate mixture or in a mosaic of small contiguous groups throughout the urban forest.

All of the remaining forest stand management systems - shelterwood, seed-tree, and clearcutting - provide for even-aged management and result in stands of trees of about the same age. In each of these systems, it is important to carefully plan the size, shape, and dispersion of the harvested areas to meet urban forest management objectives. They are not generally applicable on a wide area scale.

In the shelterwood system, the mature overstory in the stand is removed in a series of cuts a number of years apart. Regeneration of the new stand occurs under the cover of a partial forest canopy. A final harvest cut removes the shelterwood and permits the new stand to develop in the open as an even-aged stand. This system provides a continuing cover of either large or small trees. It is especially adapted to species or sites where shelter is needed for new tree reproduction, such as north facing slopes, or where the shelterwood gives the desired regeneration an advantage over undesired competing vegetation. It will be appropriate in conversion of single species hardwood stands such as alder. The harvested trees will have significant firewood values.

The seed-tree system involves harvesting nearly all the timber on a selected area in one cut. A few of the better trees of the desired species are left well distributed over the area to reseed naturally. When feasible, the seed trees are harvested after regeneration is established. This system applies mainly to conifers and does not meet the general intent of retaining forest character in an area.

Clearcutting is obviously harvesting, in one cut, of all trees on an area for the purpose of creating a new, typically even-aged stand. The area harvested may be a patch, stand, or strip large enough to be mapped or recorded as a separate age class in planning for sustained tree cover. Regeneration is obtained through natural seeding, through sprouting of trees that were in or under the cut stand, sometimes known as coppice, or through re-planting or direct seeding. This system requires careful location of boundaries to fit the landscape and appropriate cleanup of debris to improve the appearance of the harvested area.

In the case of the Lower Mainland, the predominant species, coastal Douglas Fir, requires moderate temperatures and mesic regimes, as shown by its presence commonly on southerly slopes near the northern portion of its altitude range, and on northerly slopes in the souther part. Almost pure stands are more common in the central portion of its range than toward the periphery. The associates, western hemlock and western red cedar appear more frequently in the west and north; true firs and mountain hemlock are more abundant at higher elevations (Williamson 1979).

Douglas Fir rates as intermediate in shade tolerance but demands more light than its associates. It is considered a subclimax species. Left untouched, old-growth stands of Douglas Fir are usually replaced by more shade-tolerant trees, especially western hemlock, unless natural catastrophes such as wildfires and windthrow intervene. It is called a "fire" species because wildfire has often been involved in its natural regeneration. Fire may stimulate seed production, cause the release of seed from cones, eliminate competitors, and create a more suitable seedbed. Historically, wildfires have burned large fir areas, giving rise to extensive even-aged stands.

Poria root rot is the most important disease of coastal Douglas Fir. The disease occurs in patches up to an acre or more where affected trees die or are blown over alive. Occasionally, serious epidemics of the Douglas Fir bark beetle decimate large areas. This destructive insect often gets started in areas of blowdown and then spreads to other stands. Careful attention to insect or disease symptoms and to aggressive pest management tactics is certainly an urban forestry priority.

Douglas Fir produces heavy seed crops at 5- to 7-year intervals and light to medium crops more frequently. Seed dissemination is variable and hard to predict. New seedlings benefit from light shade but once established, coast Douglas Fir grows best in full sunlight.

Silvical characteristics and regeneration requirements of coastal Douglas Fir all point toward use of even-aged management and a silvicultural system adapted to it; clearcutting, seed-tree, or shelterwood. Clearcutting is certainly the most commonly used system for harvesting coastal Douglas Fir and, in small patches, may be the most appropriate to deal with damaged area replacement in the urban forest.

Failures in natural restocking have occurred, however, especially on hot dry south slopes, on areas where frost is a hazard, or where the seed source is inadequate. Therefore, almost all forest clearcuttings are now regenerated artificially. Shelterwood cutting can be used where stand and site conditions are particularly suitable. Re-planting presents an opportunity to introduce genetically improved seedlings which are becoming increasingly available. Clearcutting in patches favours wildlife by providing needed browse or protection which still maintain suitable cover in adjacent uncut areas.

Shelterwood or selection cutting on the other hand does have application where it is a priority of the management objective to maintain a continuous forest canopy. Examples are areas of high recreation use, historic and scenic areas, streamside stands, and stands along arterial roads. In these situations, individual mature trees as well as defective and diseased tress can be cut. Periodic removal of selected trees in the reserved strips along stream banks can minimize blowdown across watercourses. Williamson (1979) suggests that shelterwood stands should invariably consist of the most vigorous dominants and codominants (fig. 13). Shelterwood density should vary according to the protection requirement of new seedlings, wind hazard, and aesthetic requirements. It should also be used to maintain species diversity by utilizing careful extraction of trees to be removed.

The seed-tree system is generally impractical in the urban forest because exposed trees tend to uproot during late fall or winter storms and it does not conform to the objectives of maintaining tree cover. It may have some applicability for limited area thinning around paricularly desirable specimen trees.

Orrum (1972) has noted that "in woods where amenity is all-important, selective felling and shelterwood systems can be used without arousing much adverse comment, because there is no abrupt change involved nor is an area apparently devastated".

Certainly, effective stand management will predicate the long-term need for intrusion into developing blocks of trees and also the degree to which stand tending cost will drive maintenance budgets.

At present the rush to preserve urban forested lands had clouded the understanding or recognition of the need to exert explicit management regimes on the treed areas that remain after housing construction. Tree decline is often subtle to start with. Lack of any management plan or improvement intervention will be absorbed by some stands for some time. Even aged stands are particularly vulnerable, however, to catastrophic failure from both biotic and abiotic causes. Comprehensive stand management programs in Lower Mainland urban forest areas are not yet evident in any municipality.

4.6 Stand Tending Considerations for the Urban Forest

There are a number of important stand tending activities which attend comprehensive management of the urban tree resource. Few are practised at present in the Lower Mainland of B.C. despite extensive tracts of urban forest land being set aside in many municipalities. This trend will no doubt continue until decadence or major civil liability awards are made against land management agencies or owners, most likely strata corporations or municipal parks departments. Insurance claims as a result of tree failure, tied to lack of due diligence in maintenance practice, will awaken the respective types of council responsible.

Hazard tree removal is the most obvious stand tending need. Edge trees may be predominant in this category, particularly on 'new' edges, but unsafe trees well set back into treed blocks are also an important consideration, particularly in tall timber.

Identification of windthrow or windbreak potential (see also Appendix A) due to disease must be a priority. Thinning of suppressed, diseased, dead and spacing of codominant trees to allow adequate growing room, while reducing under growth competition, is also an important stand tending activity.

Pruning of hazard limbs, unbalanced crowns, overextended limb length for diameter, a known problem in Douglas Fir, is an activity that is practised but not extensively. Safety consideration may justify the cost but little else. Crown topping, causing loss of apical dominance and multi-leadered tops is a stand tending practice to avoid. Contrary to popular opinion, it probably does not improve windfirmness and may reduce overall vigor. It will certainly produce an unsafe, failure prone, crown.

In more juvenile stands, spacing to allow stem and crown development may be required, but the practice is expensive, and probably only practical in replant areas rather than retention areas. Manipulation to ensure species diversity may also necessitate some of this work but again it is probably confined to disturbed areas.

Planting, fertilizing, protection from ungulate feeding, and weeding are tending activities for younger or newly planted areas, including areas being underplanted to improve specimen composition or diversify age classes (fig. 17). At present none of these practices are widespread in urban tree retention areas, although the techniques are becoming more and more utilized in areas of productive forest tenure in British Columbia.

An important stand tending consideration is the impact of wind on stands. the continuous stress occasioned by constant wind results in an increase in mechanical tissues and consequently trees better fitted to resist blow down (Toumey and Korstian 1947). However the occasional high winds off all regions can cause windfall and windbreak (Furst 1893). Such high winds may come only once every 250 or 300 years (Graham 1990). Toumey and Korstian note ten conditions that predispose trees to windblow. One is opening dense stands by thinning. Ruel and Pin (1993) found that size, species and vigour were determining factors. A relationship between tree failure and the proportion of living trees with one physical or pathological defect blowdown density was observed. Clearly stand maintenance must encompass not only constant inspection for windthrow hazard trees, signs of incipient failure such as root mat lifting but also careful control of stand intrusions. A particularly watchful eye must be kept on newly exposed edge trees. See also Table 4 and 5.

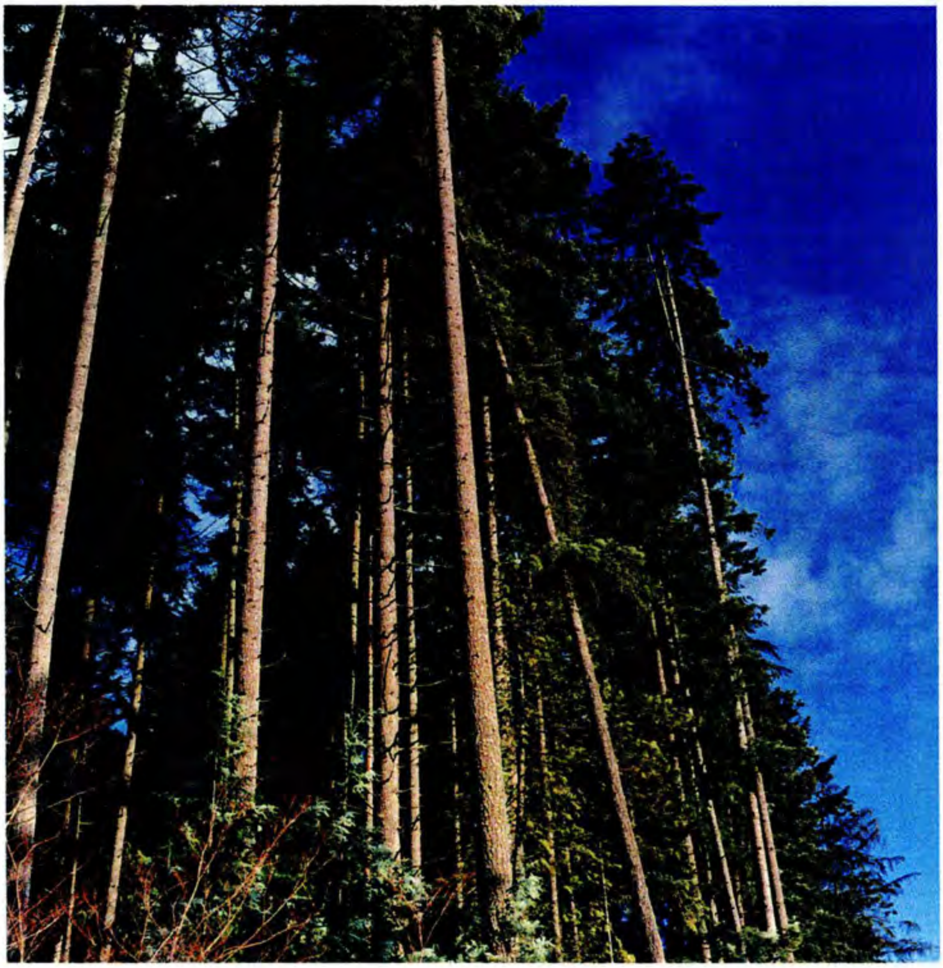


FIGURE 14 Close view of tall Douglas Fir typical of the largely even-aged, second-growth forest cover in many Lower Mainland development sites. Most trees have self pruned their lower stems, leaving little but the upper growth in green branching.

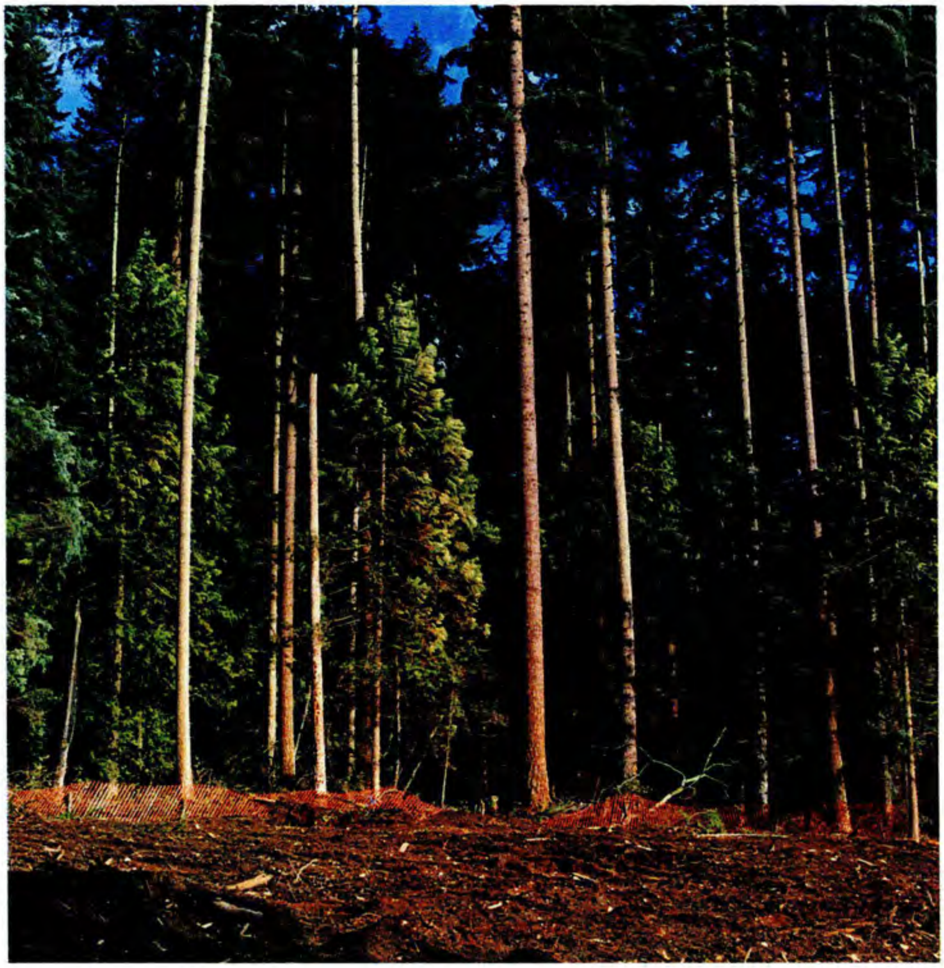


FIGURE 15 The more uneven-aged the stand, the more suitable for retention, and the better the opportunity for retention in perpetuity.

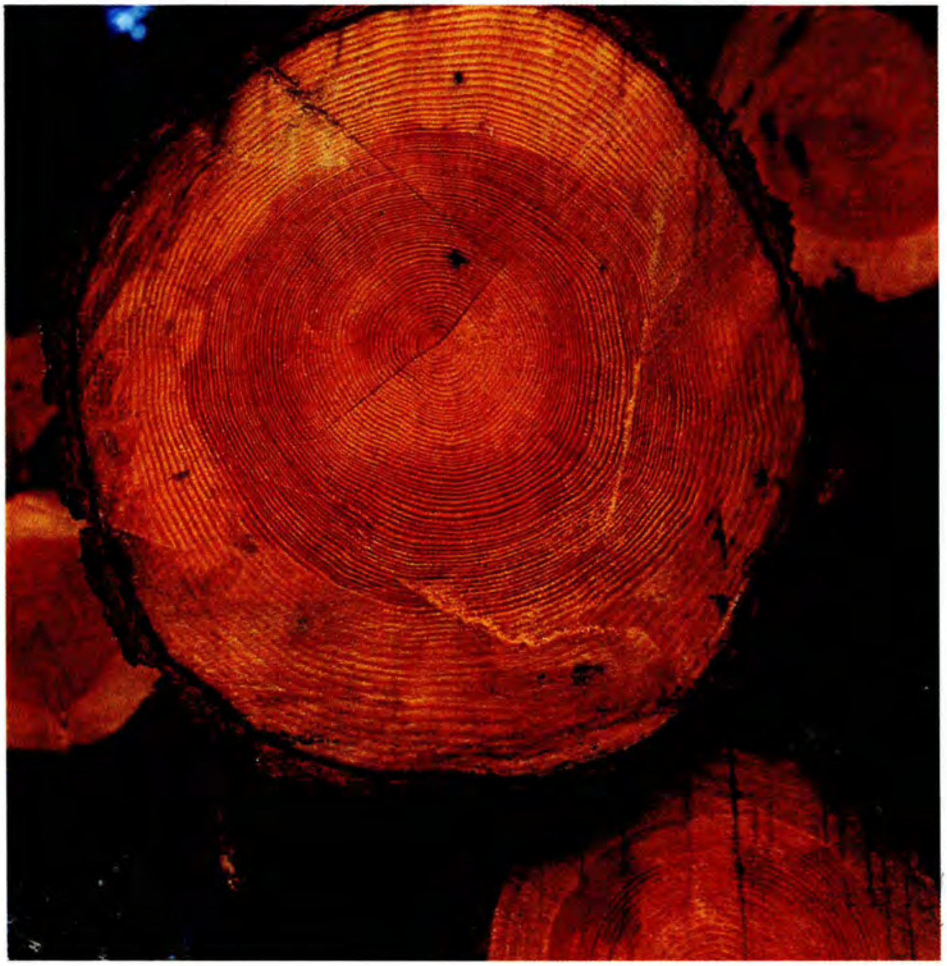


FIGURE 16 A typical butt end of a Douglas Fir cut on Lower Mainland second growth stands. Growth has been rapid and ring counts indicate an age slightly over 100 years. Most accessible first growth was cut in the late 1800's around Vancouver.

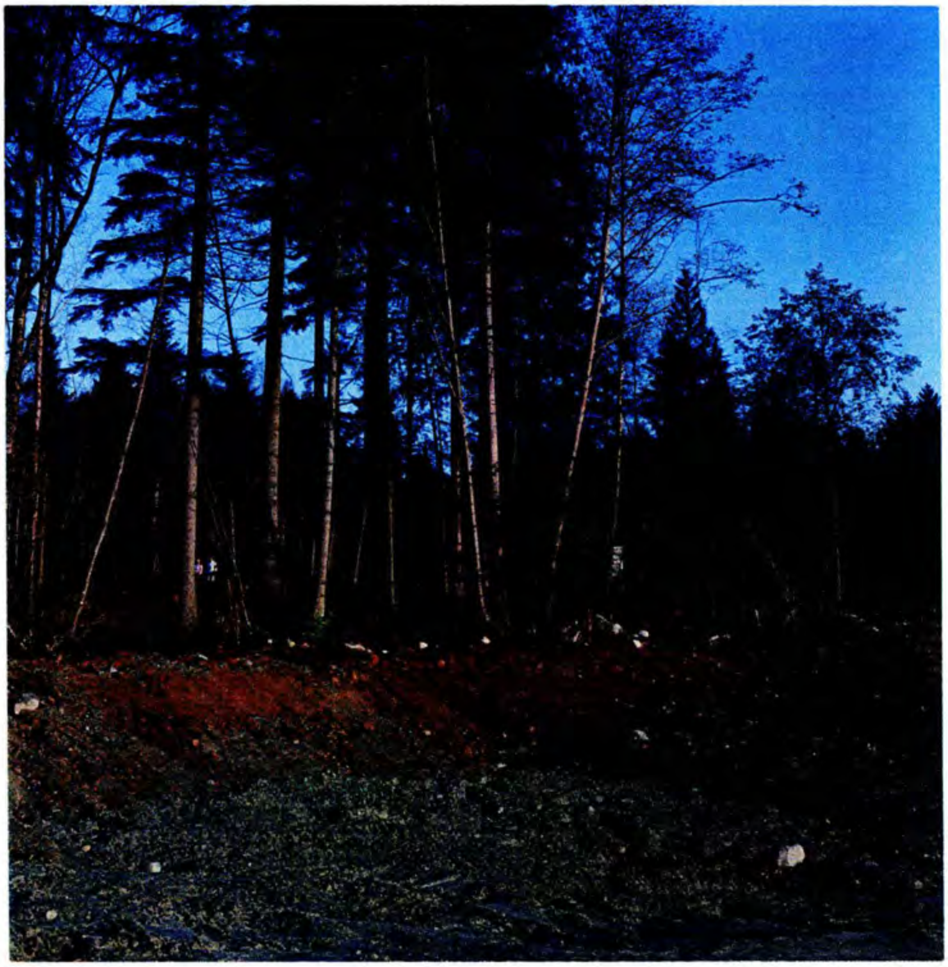


FIGURE 17 Where few trees are left, yet a patch of retention ground remains, this can become a good candidate for future underplanting with tree seedlings and other native ground cover.

5.0 The Construction Process

5.1 Introduction

As the awareness of urban forestry issues develops in the urban setting, it is becoming increasingly obvious that despite good intentions, not all tree retention efforts are successful. A large part of this problem lies in the specialization of individual development site team members. Rarely do team participants have the skills or interest needed to ensure construction protection for trees.

All too often, it seems that the planned designs shown on paper are based on the rather dubious notion that if it works on paper it will surely work on the ground. We know this is not true. Successful planning and design work not only anticipates problems and presents them on a paper layout, but also makes sure they are carefully dealt with during the translation of plans into working drawings, specifications and action on site.

This is best achieved when the planners and designers fully understand the needs of trees in their initial tree retention designs. Yet, construction drawings are encountered that have tree retention clusters within one metre of a building footprint, or next to the sewer and underground service lines. Equally unnerving is seeing retention trees that are well away from buildings and service areas but inherently weak due to previous physical or environmental site disturbances.

Examples are fencing off for retention a clump of hemlocks that are predominately growing on nurse logs (fig. 18), leaning, and have stem rots, or retaining a narrow band of spindly Douglas Firs no more than two to three trees wide. Such trees, from within previous forest conditions, where the same trees were part of a tightly knit canopy, are now a recipe for windthrow. Another example is excavating for installing underground car parking facilities which require cutting off all the roots

FIGURE 18 Nurse logs often support new growth of hemlock and cedar trees. These are always suspect from the standpoint of stability.

on one side of a tree because of Workers' Compensation excavation slope rules, shotcreting, backfilling and then paving the final surface, all in the expectation that the retained tree will bravely withstand such abuses without any immediate or, more insidiously, long-term chronic damage. As Clark (1990) has noted, many trees on construction sites die from the results of compaction. This is caused by thoughtless proliferation of temporary roads or tracks on site, the uncontrolled storage of soil, imported construction materials, and the constant traffic movement of construction equipment.

These problems are encountered all the time, yet most can be easily avoided, if there had been input from an arborist or urban forester at the initial planning stages, and then careful teamwork and involvement throughout the project to ensure planned actions become reality on site.

The problem may not originate with the construction team. The design may have been inherently unsound. The relationship from the initial survey to the control points for construction may be weak. This is not uncommon. When tree retention is practical to plus or minus a meter, yet construction accuracy may be no better than a similar error, clearing and retention boundaries may well create construction conflicts. Many construction drawings leave wide latitude for site engineering placement of services. What may have ben a suitable retention zone is also a readily accessed trench right-of-way for services. Without enforcement or penalty, there is no dis-incentive to shortcuts in time and distance.

It is during the clearing, grubbing, road construction, site servicing, house basement excavation, house construction, and debris disposal phases of development that most tree retention expectations are nullified.

5.2 Tree Clearing versus Tree Retention: Practical Considerations

Physical and environmental disturbances on a development site are a continuum, each phase having its own unique impacts on the surrounding vegetation. One can consider tree removal and greenbelt retention to have four main examination phases that predicate successful execution and safety of tree retention after design and approval.

The first phase is the assessment of boundaries establishing the municipally mandated setback and cut areas agreed to in the planning process, and the subsequent removal of trees within the area to be cleared. To the extent that judgement can be made on the retention or removal of edge trees, realistic choices must be made about which trees can stay and which will be lost. This judgement must be based on local experience with tree falling and clean-up practices on other projects. Trees of obvious hazard to workers in or, near to retention areas or bands are also identified at this time.

The second phase of inspection should follow site top soil stripping. It is during this critical time that the need for removal of trees on the interface between retention zones and the construction zone will be determined, since it will now be possible to identify trees with damaged roots and edge trees unlikely to be windfirm. Every effort should be made not to incur additional costs on the part of the development before the second phase is completed. Otherwise, the clearing contractor could be repeatedly back on site taking out a tree here and a tree there. This is a very expensive, and an unnecessary, cost to the development.

The third phase of site development, to which the arboriculturalist or urban forester must typically give considerable attention, is driven by two considerations: safety for workers on site and costs to the development. This phase, which encompasses site servicing, is the time at which tree roots may be damaged by service trenches. The excavation is often backfilled without the stability of the retained trees being known or professionally assessed. Tree safety may have been compromised but not be readily apparent. The field costs in simple takedown and removal of large trees before the buildings are established are acceptable, and, this inspection provides that any newly created large hazard trees can still be removed by standard felling practices.

The fourth phase comes after foundation, excavation, and construction work is completed. Here, edge disturbance and sidecasting of spoil can affect tree health. Bark may be lost from equipment activity, causing sufficient loss of cambial tissue and an open entry for decay organisms. This, in turn, will lead to a subsequent loss of vigor and create potentially hazardous trees in a timespan as short as a few years or as long as decades.

Since time will have elapsed since the original clearing and seasonal weather conditions will, most likely, have placed some stresses on trees remaining, retention areas require a careful examination at this juncture. The crown canopy will have been opened up and new edge trees exposed. Wind, or wind coupled with soil moisture increases, provide incipient windthrow conditions. Tall, close grown trees, with small root systems, trees in shallow or rocky soils, and lower canopy trees newly exposed are all candidates for loss in strong winds. While such trees should have been largely identified in the third phase of inspection; changes in tree stability are continuous and re-inspection must be ongoing, at least until after the first one or two seasons of winter winds.

A post construction survey is often useful to identify any final concerns. However, removal of big trees at this time is a costly and difficult enterprise. To the extent possible, such trees should have been dealt with by removal in an earlier phase before the erection of any structures.

FIGURE 19 Major grade changes not only affect root structures, but significantly change soil moisture. Subsequent loss of tree vigor or actual decline and death is a likely outcome in instances similar to this.

5.3 Stripping and Installation of Services

Construction disrupts trees probably more than any other human activity. Construction activities directly affect trees and their other dependent environmental elements. Their health may be affected immediately by the construction activity, or it may decline progressively. Sometimes evidence of this may not appear until years after construction has been completed.

Because of the time that often occurs between damage and symptom onset, construction injury is frequently missed or misdiagnosed. The major categories of direct construction injury are grade changes, trenching, and surface grading. There are, however, ways to prevent and minimize all types of construction injury.

Grade Changes

The ground level, or grade, around trees is often raised or lowered during construction (fig. 19). Raising the grade even a few centimetres can result in root suffocation and eventual death. A tree's most active roots grow close to the soil surface and when the grade is raised, gaseous exchange is restricted and root function impaired. The health affects on a tree are related to the nature and depth of the fill and how much of the total root area is involved and for what length of time.

Lowering the grade even a few centimetres can result in severing and removal of many of the surface roots. The health effect of this is related to how deep the grade is lowered and how much of the root system is removed (Tattar 1991). Equipment movement in the root area will also significantly contribute to soil compaction, another cause of root die-back.

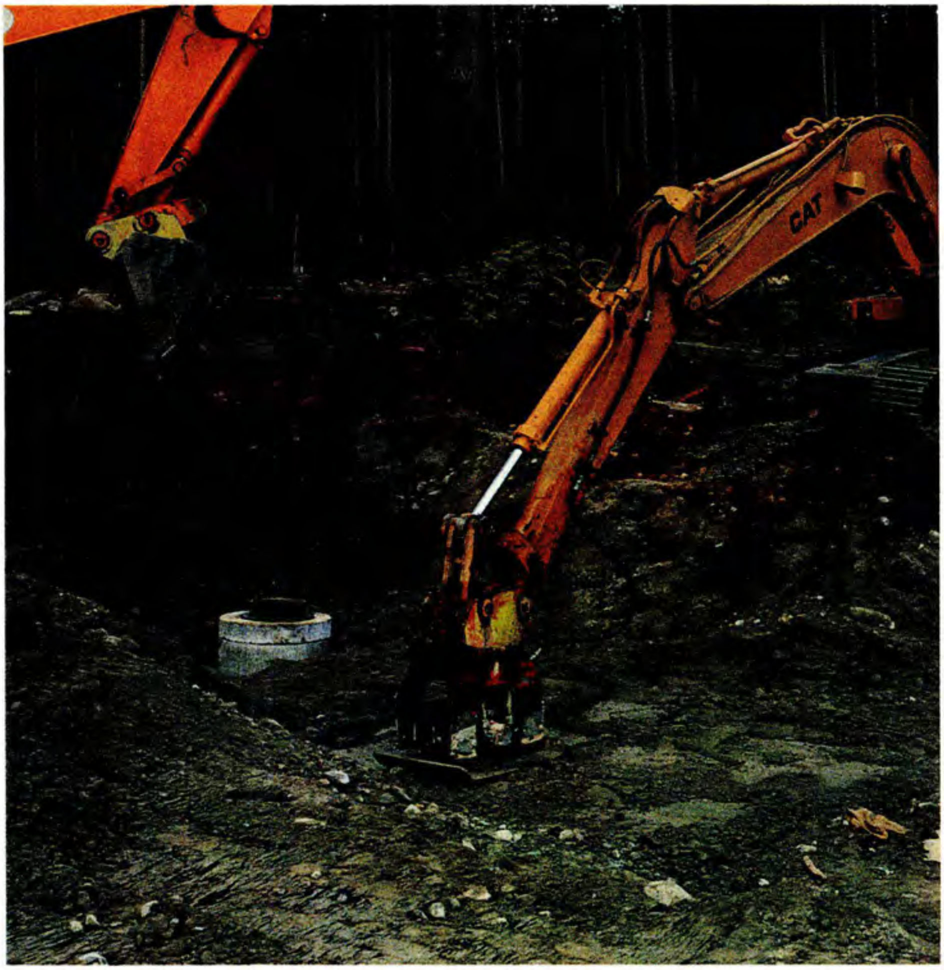


FIGURE 20 Trenching for service installation not only can cut across intended retention areas leaving them vulnerable to wind damage but it also impacts edge trees.

Both types of grade change affect soil moisture. Raising the soil level tends to cause a rise in ground water levels. This results in less oxygen around roots. Lowering the soil level tends to cause ground water to move away from the exposed area and produce moisture deficiency stress on the remaining roots. Grade lowering can also make entire trees susceptible to blowdown because of severed support roots.

Trenching

Removing soil in a narrow path with a backhoe or other earthmoving equipment is one type of grade lowering (fig. 20). Trenching is a common form of injury around construction sites, but it is often overlooked because there is little evidence of it after construction. Some injuries are obvious, such as fill injury where the trees "telephone pole" into the ground without a basal flare. Grade lowering injury caused by trenching is indicated by sharp changes in soil levels and exposed, broken roots. However, trenching injury is hard to detect because all of the resulting damage is underground. Subtle signs of disturbance, such as narrow, different-colored patches of thin topsoil or sub-grade material, inspection vaults, or utility riser boxes can be clues to past trenching activities.

The health effect of trenching is related to the amount of root system that has been cut. In general, the closer the trench is to the tree, the more severe the injury. Miller (1993) has reviewed the suggested standards for separation from tree bases. Most suggest at least 25 cm per centimeter of trunk diameter. Like grade lowering, trenching can decrease soil moisture, especially if construction occurs during the growing season and the trench is left open to drying winds and sun for an extended period.

Construction equipment may lift the whole tree by the root mat or crack major roots with little exterior evidence. Trees so affected are extremely dangerous and difficult to detect. A site inspection is the only effective deterrent.

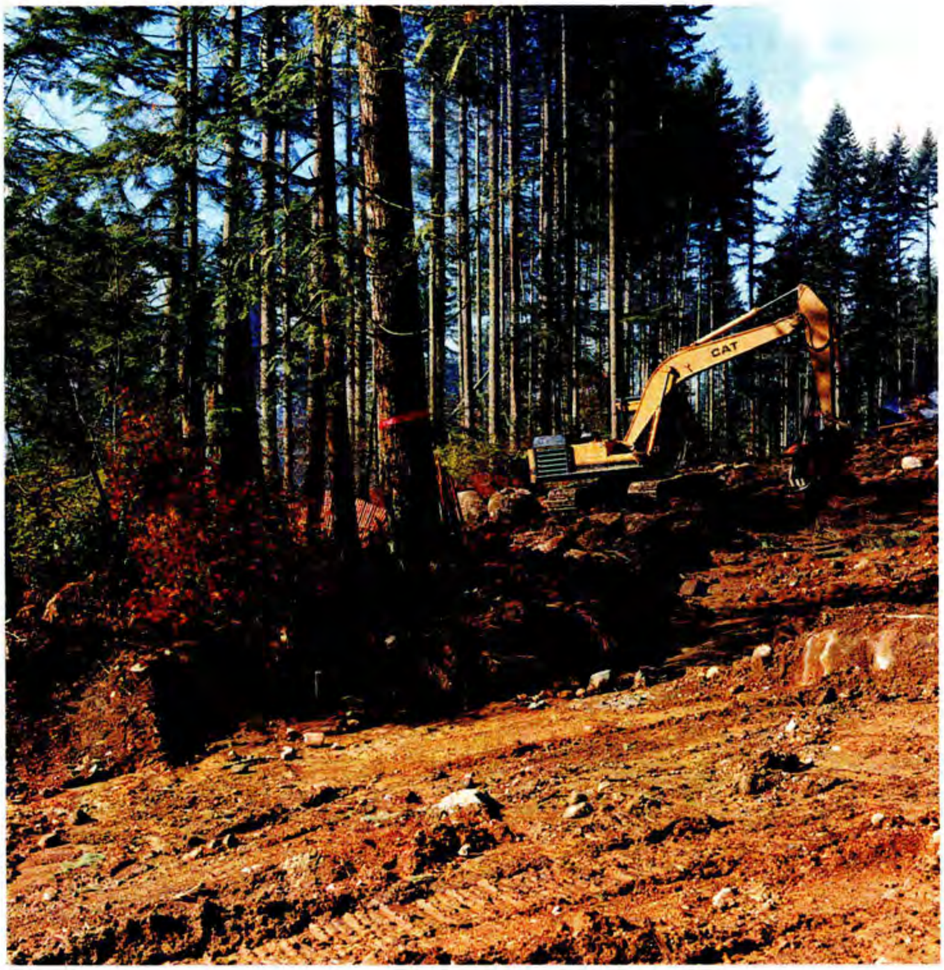


FIGURE 21 Surface grading with its associated compaction and grade changes can quickly be fatal to species such as Western Red Cedar.

Surface Grading

Because active roots and some supporting roots lie mostly in the top few inches of soil, severe injury can result from apparently minor soil disturbances. It is common construction practice during site preparation to remove woody shrubs and small trees with a bulldozer blade (fig. 21). The bulldozer also smooths any minor irregularities in soil levels. This is often done to prepare for formal landscape or lawn establishment.

When surface grading occurs around trees, there can be considerable root injury as well as disruption of soil moisture and temperature levels. The degree of injury is again related to how much of the root system around each tree has been disturbed. Surface grading injury often goes unnoticed and symptoms of the impact slow to develop.

Homeowners may have purchased the lot because of the trees, but they are usually aware of a disturbance only when they see wounds on the lower trunk and buttress roots. These wounds are usually of minor health consequence to the trees compared to the root injury and soil disturbances caused by surface grading. Progressive crown dieback may be the first sign of an extremely hazardous tree.

Preventing Construction Injury

If at all possible, construction should be avoided around key trees or areas of trees. Because this is often impossible, efforts must be directed toward minimizing injury during and after the construction. The best way to prevent construction injury is for skilled professionals to be involved during the detailed site planning stages. This requires cooperation among the arborist or urban forester, the developer, the site engineer, the contractor and his or her subtrades, and the landscape architect of record.

The effects of construction on trees can be minimized if not avoided. The simple rule is to prevent as much root injury and soil disturbance as possible. Grade changes can often be minimized or even prevented by retaining walls that preserve the original grade around trees. Planting wells, often illustrated in gardening and aboriculture books, have little value in alleviating major grade change problems. They only keep a small area around the trunk at the original grade, and the rest of the root system is still covered by fill.

Tree repair

Once severe construction injury has occurred, it is difficult to save trees. Unfortunately this is precisely when the urban forester is usually called and asked to remedy dying or hopelessly injured trees. Timing is critical because many trees have the ability to respond to repair especially if they had been healthy and vigorous before construction injury. However, even they soon begin to decline and become susceptible to weak pathogens and secondary insects.

A wide range of tree repair techniques can be practised. Important examples are:

- Removal of shattered limbs with clean cuts followed by exposed tissue protection with a non phyto-toxic paint,
- Removal of shattered roots similar to limb removal,
- Drop-crotch pruning to sound side branches to reduce crown height or partial crown thinning in conifers,
- Stem wound repair to removing shattered bark, to clean to sound cambial edges and treatment with non phyto-toxic paint,
- Crown and limb tree surgery using bracing rods or wires in high value, specimen trees,
- Water table management appropriate to the species and prior hydrologic regimens, regular deep watering if required,

- In tree sprinkler systems that reproduce high humidity conditions for high value, specimen trees,
- In-ground liquid fertilizing with high phosphorus fertilizers that promote tree root growth,
- Root area mulching to manage soil moisture loss and fine root desiccation,
- Stem cavity cleaning, often coupled with secondary insect management,
- Branch fork cavity drainage and cleaning to reduce limb breakage,
- Forked crown removal in conifers. Double or, infrequently, triple crowns are produced after leader loss. Multiple crowns can be thinned to a single dominant leader,
- Crown thinning rather than topping. Between 10 and 30 per cent of crown foliage and limbs can be removed in order to diminish wind resistance in trees exposed to windblow hazards.
- Inspection for root rot. A variety of fungi are responsible for root rots. Reduction in branch growth, discoloration or thinning of foliage and resinosis on bark at ground level are symptoms of stress. Fruiting bodies at the tree base may indicate infection. Tree removal and species replacement may be indicated.
- Inspections for stem decay. Fruiting bodies may be seen on the tree stem. Construction wounding may produce entrance courts for fungus. Topping stem wounds and large dead branches may allow stem decay. Tree removal may be required.

The tree professional must recommend removal when the degree of injury and the resulting state of decline indicate that there is little chance of recovery. In many cases, an injured tree may constitute a hazard, because the remaining roots cannot support the upper stem and crown. Removal is then urgently required to protect life and property.

5.4 Pre-Construction Inspection, Clearing, and Hazard Tree Identification

Tree species composition, and age-class structure and distribution will provide important clues to both hazard tree and healthy tree retention opportunities, but topographic, climatic and edaphic factors closely associated with each woodland community should be regarded as the controlling elements. Drainage characteristics of a site during construction are important as some tree species are unable to withstand draw-down or increases in the water table, while certain soil profiles may indicate the dependence of vegetation on surface recharge. The physiological and structural characteristics of individual tree species on the site should be assessed with regard to potential for retention given the design plans. Certain species, for example red alder, are sensitive to sun or wind exposure resulting from clearing, while others such as hemlock are prone to incipient root rot, insect, pests, branch decay and stem breakage. The density and number of stems per unit area may only become apparent once clearing of large treed areas is underway and site survey points established. The single most important factor in successful tree retention in the Lower Mainland is to maintain retention areas free of intrusion from any construction activity (fig. 2).

Site Preparation

Retention zone flagging is required to mark clearing boundaries. It is often scheduled to follow initial stand entry following road centre-line clearing, in order to facilitate field location of reference points. Preliminary house lot surveys are also advantageously completed at this stage to allow realistic boundary flagging and demarcation of individual retention trees or groups of trees. A clear system of flagging to designate retention zone edges, selective thinning areas, and protection of individual specimens is essential to control extraction, skid-road bulldozing, or felling operations. Effective flagging must take into account the biophysical constraints identified during the retention design phase, and the safety of individual trees.

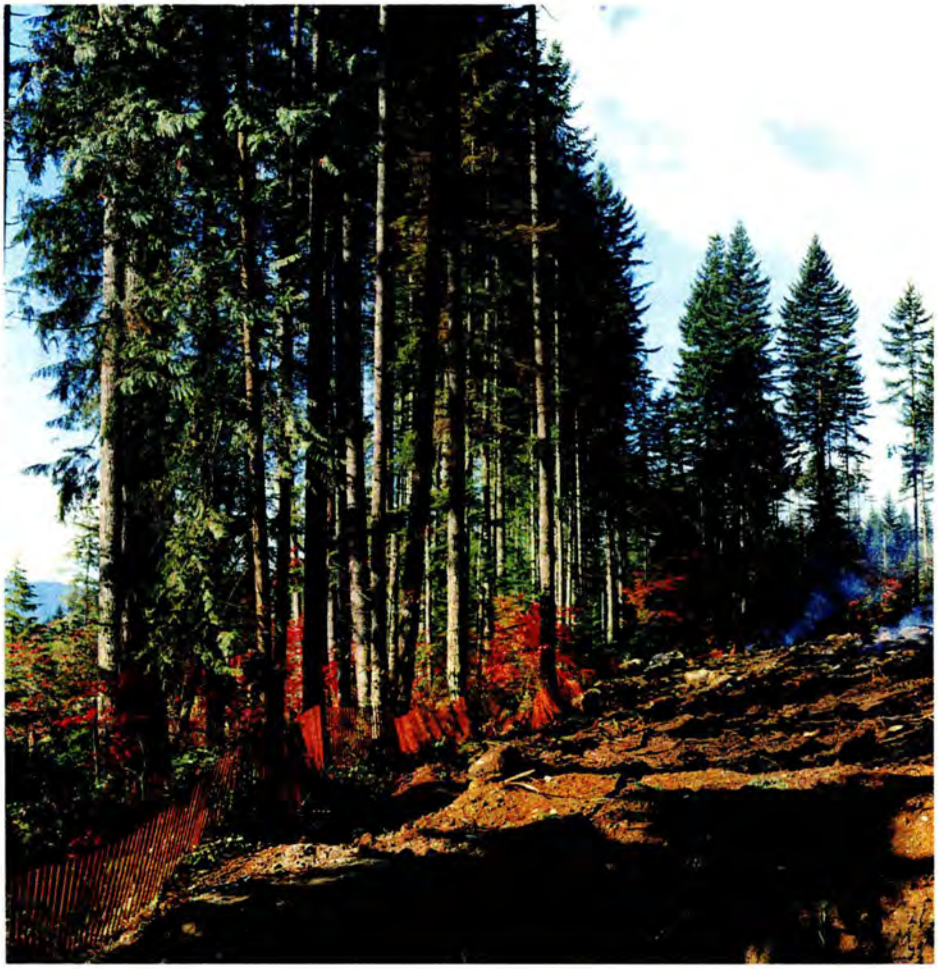


FIGURE 22 A physical barrier to indicate clearing boundaries such as this snow fence often effectively curtails clearing and construction incursions into leave areas.

Flagging is the first field activity to reconcile and assimilate the site development goals with the actual tree resources at known surveyed locations on the ground. It is here that design assumptions may not survive the realities of actual field conditions.

Feathering of woodland edge areas, marking of dead, diseased, or decadent trees, identification of thinning requirements, opening views, determination of hazards to buildings or rights-of-way, assessment of worthwhile specimen trees, and possible special methods of tree retention required during clearing operations are some of the important components of the site preparation phase.

Clear cutting followed by intensive restoration as opposed to the option of selective cutting, or patch retention, should be re-assessed, if site and safety condition decisions made in the context of site preservation and financial constraints differ from field findings. In areas where large trees present a windthrow hazard, cutting and careful removal of logs will permit retention of the land base, complete with some groundcover and shrub layers. Restoration planting with a selected dominant species mix may then follow immediately if it is determined that the feasibility of the original design is now suspect. This is a critical issue and must be confronted by all parties to the original design, despite whatever planning and political commitments were made in the development approval process.

Final contract drawings and site specifications should be explicit to avoid unnecessary equipment damage to trees and provide greater control over contractor operations. Clearing or logging specifications should include stipulations that ensure the following desired practices:

- Environmental protection during construction to avoid spillage of toxic wastes,

- Appropriate debris disposal methods to avoid spoil dumping on sensitive root or environmental areas or scorching of foliage from very large burn piles,

FIGURE 23 Deep excavations require that edge trees are removed from the top of banks so that no root severance is likely to propagate windblow.

- Appropriate felling and bulldozing techniques to ensure that retention zones are not damaged or cluttered with clearing debris,

- Physical protection of root and trunk areas during clearing,

- Control over equipment movement, location of burning piles, and decking of logs to protect trees, or areas of trees, designated for retention,

- Control of excavations so that adequate separation between deep cuts and tree roots can occur. Hazard tree removal is vitally important in these circumstances.

- Control of temporary roads and access points to protect tree root areas,

- Penalty clauses to enforce protection of retention zones, coupled with clear authority invested in contract supervisor to stop work if job practices are unsafe or threatens design expectations, and

- Selective thinning and clearing along forest edges to ensure an aesthetic and natural appearance.

A complete urban forestry specification for construction site clearing and stripping management is given in Appendix B.

Clearing

Adequate supervision during clearing phases is usually necessary on all sites. Equipment operators are normally not familiar with the objectives of environmental protection on specific sites. Contractor briefings should be held and should include

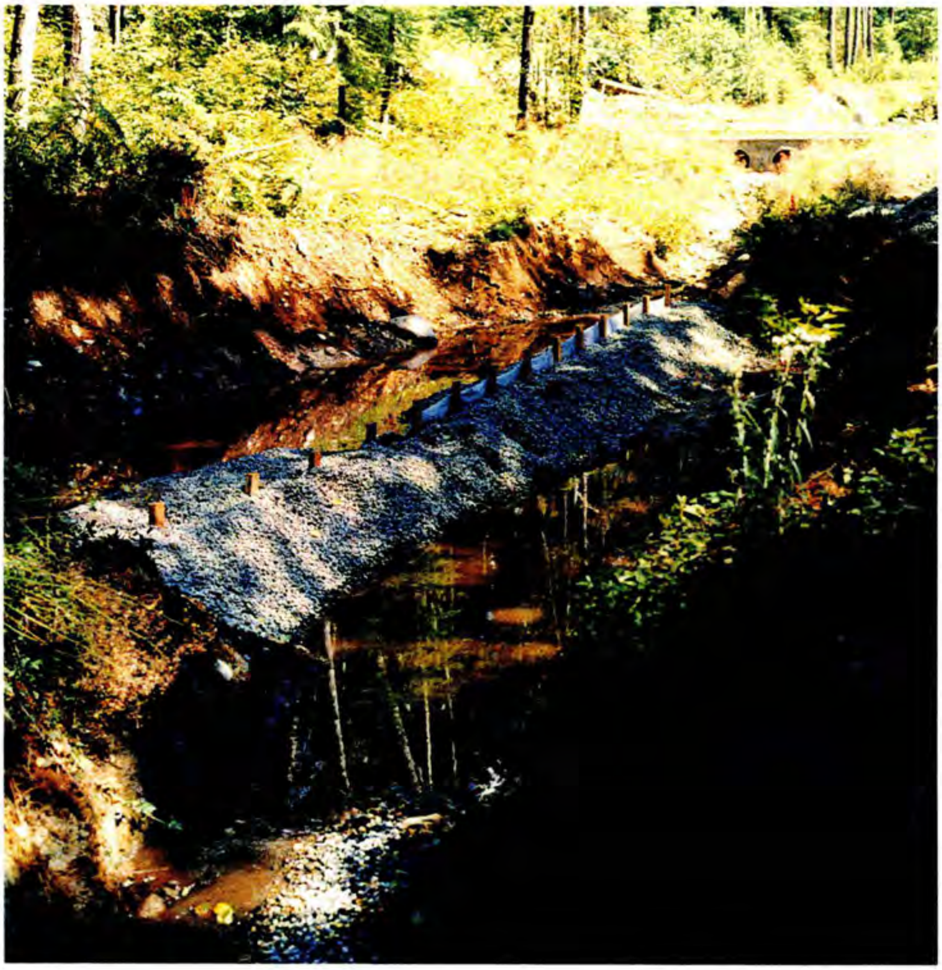


FIGURE 24 Water management on site not only for silt control in the interest of water quality but also to reduce localized ponding and saturation assists the health and survivability of trees in retention areas.

the equipment operators and fallers as the field interpretation of flagging will often be done by them rather than any site supervisors. As the forest area is opened up, some revision to retention boundaries may be appropriate, particularly in large stands of mature trees where the visual or practical effect of cutting may not be apparent during the flagging stage.

Merchantable timber should normally be piled according to species and trucked off-site, although the method of marketing is a matter of preference and depends on local conditions. Required timber marks, fire regulations, permits, and stumpage rates established by the appropriate Forestry Service office should be investigated and applied as necessary. The returns from the sale of logs or of firewood may be utilized to finance replanting, or establish a trust fund for long-term forest restoration and management by either the municipality or landowner.

The completion of initial clearing will result in a freshly exposed forest edge. A stabilizing period where blowdown may occur, without property destruction, must be allowed. Services and other ground level construction may occur as the trees along edge areas are monitored, assessed, and removed as necessary. Preliminary erosion control measures such as seeding with fast germinating annual grasses or agronomic species will help to prevent soil loss, root exposure, and gully formation on sloping lands. Terracing, retention ponding, silt traps, wattling, waterbars, and other techniques for water control may be necessary as interim measures in heavy runoff, unstable, or extreme slope zones.

Control During Construction

Experience gained from the residential development site clearing in the Port Moody case study suggests that successful woodland retention is accomplished as much through control during the pre and post-building construction phases, as control during the 'logging' operations (fig. 25). Constant site inspection, by a tree

FIGURE 25 Soils compaction around tree roots must be prevented during all phases of forest clearing and construction.

professional whose sole purpose it is to monitor retention tree health and environmental conditions, appears necessary.

Inspectors must also constantly be alert to soil compaction or removal caused by heavy equipment movement over root zones (fig. 26), excessive cut or fill around individual trees (fig. 23) or along the leading forest edge, abrasion of trunks, branch breakage, and disruption of water supply areas. Although remedial measures such as tree well construction, corrective tree surgery or application of wound dressing are relatively well known, the methods for effective control and damage prevention during construction are much less evident in the literature (Pirone, 1972). Building siting and the relationship to adjacent lots may have to be modified in the building construction phase to minimize the potential interference of root systems with service trenches, as well as permit stockpiling of stored soil away from tree drip-lines. Temporary snow fencing must be utilized to protect forest edges from equipment movement, sub-soil dumping, or spillage of toxic wastes. Water management on site must allow for major rainfall without causing ponding in tree retention areas (fig. 24).

However, these measures will only be followed if contractors are either informed and responsive to the relationship between the forest and the development site, and if rules are rigidly enforced through contract specifications and penalties. Builder guidelines are a useful tool for provision of this information, yet developer control is often relinquished after lot sale, and the site supervision opportunity throughout the period of site activities, negated.

Municipal tree cutting by-laws, if enforced, may be effective against outright destruction of trees during construction, but are impractical to mitigate stress related mortality caused by site clearing and subsequent construction activity.

5.5 The Port Moody Experience

Field identification of appropriate retention zones, and marking of individual trees for protection was found to be a technical decision based on field conditions, rather than solely a design element on paper conceived to improve views or screen use areas. Furthermore, the normal life expectancy of tree species must be weighed against the time horizon normally attributed to urban developments. A method of construction management must be enacted that (i) ensures tree protection in perpetuity or (ii) removes trees of doubtful windfirmness or health within a concise, authoritive decision-making system on site, notwithstanding all of the good intentions built into the original design, otherwise delay and frustration will characterize the clearing activity.

The Port Moody case study illustrated a number of factors which should be considered in the selective clearing and the general construction process:

- Modification in servicing plans, road gradients, and lot layout in the field may have a pronounced positive effect on realizing retention opportunities and reducing construction damage,

- There must be a single authority on site with the ability and responsibility to make firm, definable judgements on retention boundary alterations,

- Retention zone flagging is improved when lot corners have been surveyed, as individual trees and clumps of vegetation may be more accurately plotted,

- Continuous blocks or strips of trees to remain must be of a size sufficient to resist windthrow after construction, edge damage and hazard tree removal,

- Tree species play a significant part in final clear or retain decisions. Even with

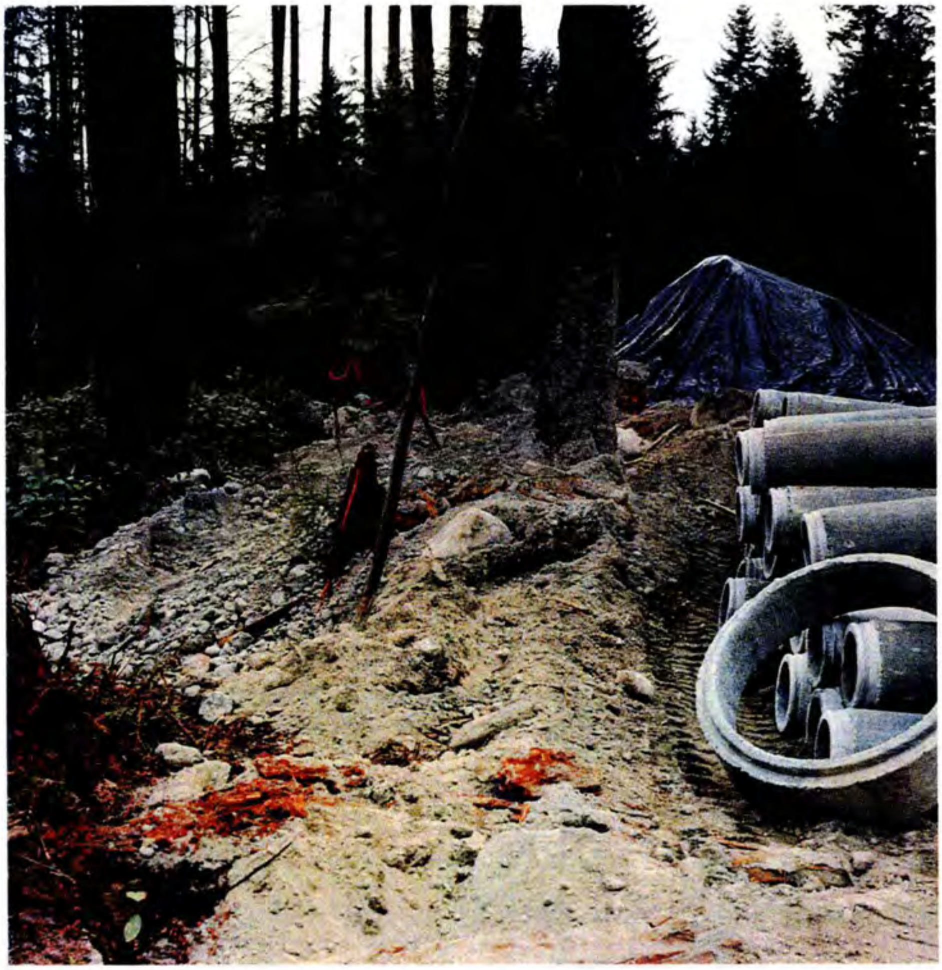


FIGURE 26 Constant supervision and enforcement is required to ensure that protection zones are not entered by construction workers or equipment.

a good inventory, ultimate knowledge of cover types and their specific location is not known until clearing proceeds,

- Large or dangerous trees may be removed from retention areas without adversely affecting the integrity of vegetation to remain, if done by skilled contractors and equipment operators,

- Protection of retention zones with fencing or other physical barriers is critical to keeping contractors out of retention areas. Fencing must be attached securely 'tie-wrapped' to metal fence posts and not tied to reinforcing bar where it quickly falls down. Fencing such as "pig" wire is superior to snow fence but may not be cost effective in large developments. Properly installed plastic snow fence is acceptable.

- The installation of all site services, but particularly storm drains, water and sewage, all of which require major excavations and side casting of material, must be strictly managed. Potential impacts on retention areas must be directly and constantly supervised to prevent safety hazard creation which would otherwise go undetected.

- The retention of single trees in front lot areas is difficult on small city lots as equipment damage and excessive cut or fill may follow during the house construction period. Single tree retention was generally unsuccessful (fig. 27),

- Retention zone planning should commence concurringly with final road and lot layouts to ensure optimum tree preservation opportunities are realized,

- Flagging of retention zones is expedited by accurate road or lot survey markers that allow accurate boundary demarcation,

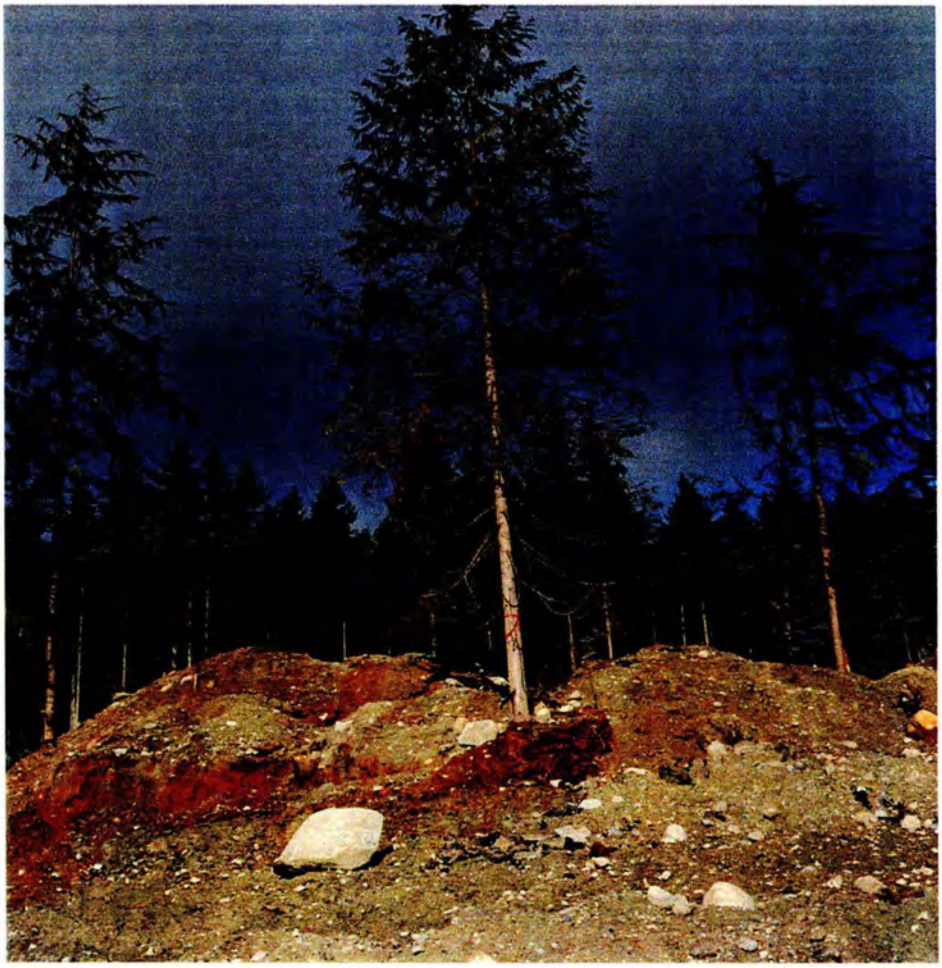


FIGURE 27 Single trees under-cut by grade changes will typically not survive.

- Site briefings with contractors and their equipment operators must provide a clear outline of retention goals and objectives. If clearing specifications have been developed, they should be reviewed. If any new staff come to the site, they should be briefed. Penalty implications should be discussed,

- Informed, constant, supervision is critical to ensure adherence to flagged retention areas and general environmental protection,

- Boundary flagging must be properly supported on separate stakes and not tied to retention trees. It must be consistent throughout the site,

- Flagging must be spaced closely and of sufficient color, quantity and placed at a height to be visible to equipment operators,

- Tree removal methods that allow for felled trees to be directed out of retention areas, rather than into or across them, should be used,

- Extraction practices that create as little residual damage to trees retained as possible must be employed,

- On-site burning piles for non-merchantable wood or debris disposal must be carefully placed and controlled to prevent retention tree damage or forest fire risk (fig. 29),

- On site water management is critical; a pre-plan should be developed prior to clearing. No retention area should be flooded by surface runoff. Windblow increases significantly if this problem occurs,

- All site water courses should be maintained and logging debris constantly removed. Siltation control must be adopted,

- As much understorey should be retained in retention areas as possible, to maintain the ecological integrity of each block. Watertable, soil temperature, and species diversity will be maintained,

- The practice of clearing every piece of understory to 'landscape' areas should be prohibited. After successful tree retention, separate landscape contractors with highly urban landscape skills and equipment can cause irreparable damage, if not controlled,

- Constant vigilance is required when clearing contractors obtain the complete felling yield in clearing areas, otherwise high value retention trees will be removed for profit,

- Single retention trees are extremely difficult to protect. Built barriers of wooden stakes and crossbars should be constructed outside the tree crown drip line. Inspection of single trees and their immediate environs must occur throughout the construction cycle,

- Boundary fencing installation in retention areas to demarcate property boundaries should be strictly controlled; work should be done by hand. Retention trees should not be removed without express permission of the site engineer,

- Irrigation system trenching that can impact tree roots must be strictly regulated,

- Incidental site equipment such as backhoes and fork lifts must be controlled so that root compaction, grade changes and bank damage does not inflict its toll on retention trees, particularly edge trees,

- Selection of appropriate equipment is important, for example, bulldozers are not adequate for shaping forest edge areas, and machines with buckets such as construction hoes that can pull material away from the edge are preferred (fig. 28),

- Final cleanup should ensure that debris on the edge of retention areas if properly collected and disposed of. It should not encourage housebuilder or homeowner disposal by burning or pushing it over onto ravine banks,

- Subsequent house basement excavation spoil management must be vigorously supervised to ensure that housebuilders and related subtrades do not breach protection zone fencing with equipment, soil or minor trenching,

- Imported material to the site including topsoil, drain rock, sand, pipe and construction material must not be piled on or close to tree stems or root areas,

- In sites where pre-load is required, edge drainage is extremely important where fill abuts tree retention areas since water ponding and tree death or saturated soil instability will result,

- Temporary road placement is extremely important to control. Contractors and sub-trades should not be allowed to determine access to a site where this will infringe on root areas,

- Design guidelines that stipulate the expected levels of quality and performance required by the developer of house builders and buyers, such as those used by Barbican (1980) should be rigorously enforced,

- Relaxation by municipal planning departments of the final building footprint setback or of driveway locations can contribute to beneficial tradeoffs in the retention of small clumps of trees,

- Clear, explicit signage should be erected at appropriate intervals within the areas of retention noting the purpose of the area and penalties for encroachment.

The Port Moody clearing and retention process was followed from the time of initial clearing in the spring of 1989 through the winter of 1989/90 until the winter of 1990/91. At this latter time, significant winds that caused widespread blowdown in other parts of the Lower Mainland caused little tree loss in the retention areas at Heritage Mountain, giving rise to expectations that an equilibrium had been reached in the stand. This was not to be. A few trees blew down in the fall of 1991 followed by significant losses accompanied with building damage in early 1992. This latter windblow occurred after a combination of strong southeasterly winds and heavy saturating rains. While disappointing, this outcome was not unexpected.

Poor site management and a variety of incursions into retention areas for drainage, sewer and storm drain installation, lot grading, landscape cleanup, and fence installation by site development forces as well as removal of substantial edge trees by the municipality to cut a major arterial road right-of-way to full width, significantly reduced stand width and density. Historic evidence from prior windblow in the area clearly showed that southeast winds caused large tree losses in previous decades. The open stands were particulary unstable following first, large through cuts for servicing and then incipient loss of support integrity caused by water ponding in many root areas. In the month after initial clearing, (Table 4) windblow in late April and early May played the predominant role in stand losses. The high proportion of Douglas Fir is accounted for by the single species nature of the stand. Eleven trees were deliberately removed for safety reasons. Three large sound trees were found to have been taken by the felling contractor inside protection areas. The remaining twenty trees blew over. Much of this loss was related to wet conditions or shallow soils overlying rock where loss of one major tree triggered a cascade loss.

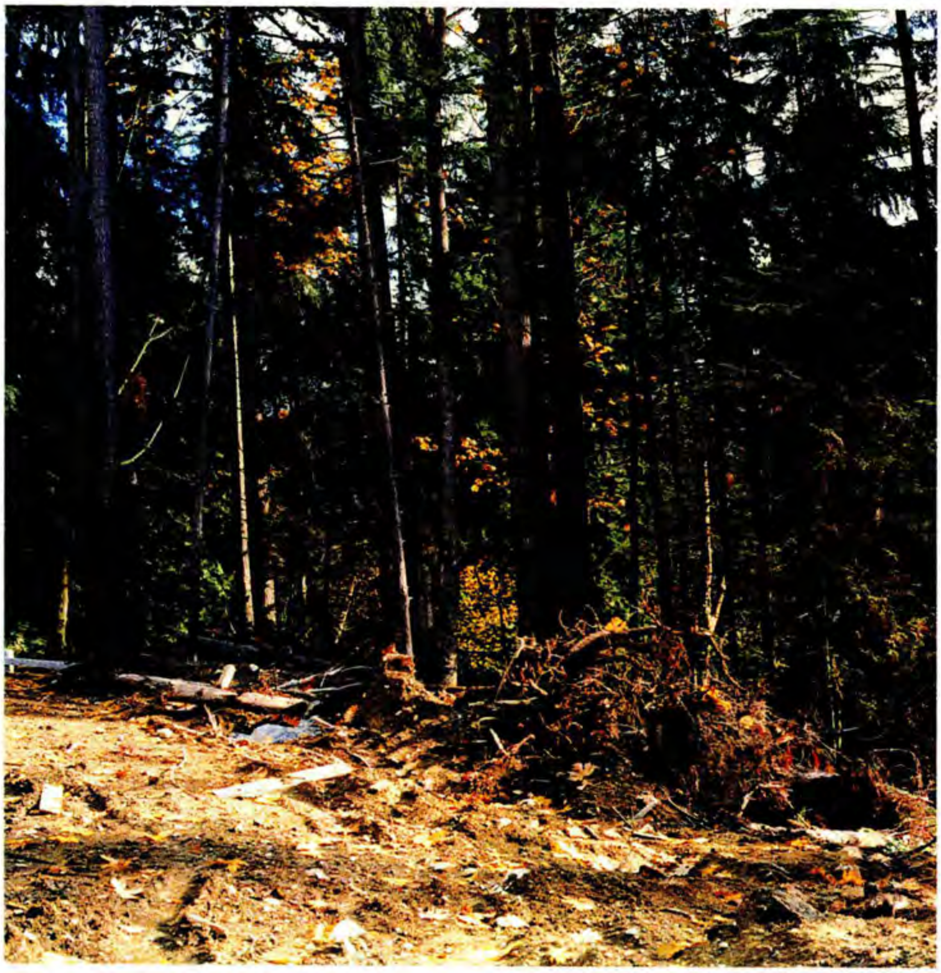


FIGURE 28 Debris left behind after initial clearing along retention strip edges must be carefully removed. Large hoes with an opposable thumb able to carefully extract material are ideal for this work.

In the winter of 1989/90, (Table 5) much of the loss from the Douglas Fir, some ten major trees, was due to construction perfidy. Most of the remaining loss was from edges of the retention areas or was caused by wet conditions. Though few hemlock or cedar made up the stand, they made up almost 30% of the winter losses.

TABLE 4

LOSS OF GREENBELT TREES AT PARKLANE HERITAGE MOUNTAIN DEVELOPMENT, CITY OF PORT MOODY, B.C. ONE MONTH AFTER FINAL CLEARING BY SIZE AND CAUSE

Species	Diameter Centimeters	Comments
Douglas Fir	43	windblown within stream
	48	windblown within stream
	38	windblown within stream
	61	felling take inside flagging
	81	felling take inside flagging
	33	hazard tree
	33	hazard tree
	46	reason unknown
	36	windblow middle of block
	25	windblow middle of block
	41	windblow middle of block
	46	windblow north edge
	46	windblow south edge
	43	windblow middle of block
	25	hazard tree
	30	hazard tree internal decay
	23	hazard tree internal decay
	33	hazard tree
Hemlock	30	windblow
Douglas Fir	41	windblow tree in wet spot
Hemlock	56	windblow tree in wet spot
Douglas Fir	56	windblow tree in wet spot
	36	hazard tree
	43	hazard tree
	36	hazard tree
	81	felling take inside flagging
	41	hazard tree
Cedar	20	hazard tree
Douglas Fir	81	felled for service right-of-way
	69	windblow all on surface rock as a group
	58	windblow all on surface rock as a group
	38	windblow all on surface rock as a group
	56	windblow all on surface rock as a group
	48	windblow all on surface rock as a group
	41	windblow north edge

TABLE 5
LOSS OF GREENBELT TREES AT PARKLANE
HERITAGE MOUNTAIN DEVELOPMENT, CITY OF PORT MOODY, B.C.
DURING WINTER OF 1989/90 BY SIZE AND CAUSE

Species	Diameter Centimeters	Comments
Douglas Fir	24	cut, felling take inside flagging
	30	vine maple also cut
	79	on stump
	66	cut, felling take inside flagging
	81	cut, felling take inside flagging
	66	cut, felling take inside flagging
	43	windblow root upturned
	76	cut, felling take inside flagging
	48	windblow root up on edge
	86	wet side by road, reason unknown
	48	windblow
	25	edge tree, felling take inside flagging
	36	old cut by construction forces
	66	old cut by construction forces
	48	old cut by construction forces
	28	old cut by construction forces
	36	windblow root disturbed
	58	windblow top on road edge
Hemlock	51	windblow middle of block
Douglas Fir	41	windblow south edge of block
Hemlock	23	windblow partially on log
Douglas Fir	48	windblow edge tree north edge roots
	41	windblow roots decayed north edge
	25	windblow north edge
	38	windblow north edge
Hemlock	51	windblow south edge root disturbed
Douglas Fir	46	windblow south edge
	41	windblow south edge
	36	windblow south edge
Hemlock	33	windblow south edge root decay
Cedar	23	windblow south edge
Hemlock	25	windblow north edge
Douglas Fir	25	windblow north edge
Hemlock	20	windblow middle
Douglas Fir	36	cause unknown
	43	windblow north edge roots disturbed
Cedar	46	windblow south edge on log
Hemlock	25	windblow south edge
Douglas Fir	43	old edge tree cut prior
Hemlock	13	windblow south edge

6.1 Fire in the Urban Forest

Introduction

The province of British Columbia and Washington State were plagued by extensive forest fires from 1902 to 1907. A combination of several factors, such as the carelessness of settlers intent on clearing their lands, and the ill-preparedness of loggers to stop such fires as occurred in their operations, resulted in thousands of charred acres. The Yacolt fire of 1902, which burned over 200,000 acres, stirred property owners to action. All who owned forest properties in the Pacific Northwest knew that something would have to be done before even greater loss of life and property resulted from the carelessness which was then the order of the day. (Cowan 1961).

The British Columbia of today is still at risk -- perhaps more so. A forest manager suggests that the present situation is "a recipe for disaster". (Sheldon 1992).

> The interface intrusion problem is growing in leaps and bounds. Our collective ability to deal with the problem and issues is not focused. It is common to hear the statement from many agencies that we know it's a problem but there is nothing we can do. The Ministry of Forests have their problems as well. The lack of authority and limitation of where funding can be directed does legally limit the role of the Ministry of Forests in the interface areas. In most cases the lands involved are private and we are not equipped or trained to fight structural fires. Legally we are bound tightly, but morally we are all deeply involved with the issue at hand. I personally believe that no one agency or group could ever possibly deal with an issue of this magnitude in isolation. There are just too many factors and jurisdictional issues to be considered. There is a need for all the players to become involved. When we become involved we must concentrate on what can be done, not emphasize what we can't do.

Most of the urban fringe areas now being developed for housing, and recreation have been burned by forest fires in the recent past, there is no reason to expect that

FIGURE 29 Fire in an urban forest from any source, including clearing slash disposal, is always of great concern, because of the danger of rapid spread to surrounding residences or commercial street .

these areas will not be immune to future fires. Each year there are more than 2500 forest fires in British Columbia. Although most of them are far from centres of population, many threaten or actually burn homes, summer cottages and cabins.

A few examples are noteworthy:

Electrical storms that cause lightning strikes and fires in the Lower Mainland forested watersheds for example are not uncommon, particularly during the summer months. Because fires are the serious threat to life and property immediate action must be taken to put them out, regardless of their location.

On August 10, 1990 there were 52 lightning strikes and 11 fires in the Capilano watershed. On August 21 this year an electrical storm produced 79 lightning strikes, 33 in Capilano watershed, 27 in Seymour and 19 in Coquitlam. There were three fires in Seymour and one in Coquitlam (GVRD News 1992).

On August 11, 1971, a discarded cigarette started a fire that raced through 3 km of timber and dry grass in less than two hours. After crossing an Indian Reserve, the fire entered the village of Lillooet, destroyed 10 homes, a community hall and a church (B.C. Forest Service 1993).

On July 28, 1992, the Duncan Forest District and local community fire authorities were jointly challenged by an interface fire in the City of Victoria. The surrounding community was also directly at risk (B.C. Forest Service 1993).

The fire broke out on the midslope of a hill in the park. Gusty winds, steep topography, dense brush and forest provided the necessary ingredients for a serious situation. The Saanich Fire Department "pulled all stops" when the fire was reported and rolled fire engines and personnel from three stations. Despite hydrants in the vicinity and a 10,000 gallon on-site water reservoir, and rapid response from the fire department, the fire spread quickly uphill in the park.

Public reporting of the fire through Zenith 5555 and by request for assistance from the Saanich Fire Department activated B.C. Forest Service five suppression forces.

Air tanker action and coordinated attach on the ground by the fire department supported by Forest Service wildfire and interface crews, brought the fire under control. Fortunately it was confined within the park and did not impact park values to a great degree or spread to surrounding homes.

On August 27, 1992, the Maple Ridge and Mission Fire Departments responded to a house fire in Mission. This structure fire quickly spread into the surrounding timber. The fire departments quickly requested assistance from the B.C. Forest Service to assist in fighting this interface fire. (B.C. Forest Service 1993). The house was completely destroyed and the fire consumed three hectares of adjacent timber before being brought under control. In the year 1992 there were four forced evacuations in B.C. communities due to interface fire (Provincial Emergency Program 1993).

Urban fire departments are well equipped to fight structure fires but ill-equipped to fight forest fires. Yet interface fire requires the combined ability and resources of both municipal and Forest Service fire teams to work collectively. Moreover, techniques available to forest managers for control of fires in their areas are suitable for the management of forest fires, but not to control fires in homes and buildings.

The most efficient approach, for example, for the protection of forested areas, is often the establishment of control lines at a point where control will be most effective and economical. These control lines are areas containing no combustible material, or areas from which this type of material has been removed. These lines take advantage of geographical features, such as rock outcrops, swamps, or lakes,. Once housing and development is introduced into these areas, this type of fire control is not possible. In addition, the limited fire fighting resources that are available are spent protecting homes, and this results in a greater potential for large scale forest destruction.

The proliferation of developments situated in or surrounded by wooded lands lacking adequate forest fire protection is a cause of concern to all protection agencies. Some developments in the province are creating a blueprint for disaster. These areas must be protected from fire. Such protection will only come about through the co-operation of fire protection agencies, municipalities and developers. They must each include some fire safety measures in their planning in order to protect both themselves and the forests from forest fires. All share the responsibility of preserving life and property in these interface areas by planning for fire protection.

In the Lower Mainland significant interface fire potential risk is found in the upper reaches of West Vancouver and the District of North Vancouver, in Burnaby, particularly around Burnaby Mountain, in Port Moody on Heritage Mountain, around the Villages of Anmore and Belcarra, in the new developments of Coquitlam and Maple Ridge, as well as south of Delta at Point Roberts.

The desirability of living in a lush, treed environment, must be balanced against the risk. In a high fire hazard year, with forest service resources widely deployed, the risk of an extensive urban interface forest fire on the south coast is considerable.

Not only must a fire fighting infrastructure be in place between the respective first response agencies and appropriately tested, but public education as to the risk and need for enforced burning bylaws needs to be addressed on a regional basis. The more complex area of evacuation initiation, management and organization must also be addressed so that the loss of life and injury experienced in recent California coastal fires is not repeated in the Lower Mainland.

6.2 Early Legislative History

Vancouver, New Westminster and Port Moody, the early townsites in the Lower Mainland, were literally carved out from the forest. Tree retention for aesthetic or environmental reasons was not a consideration. Timbered lands were for harvest and once the timber was removed, the more favourable sites were assigned for commerce and housing. The buildings were, not surprisingly, constructed of wood. Fire was an ever present danger.

The early concern for tree management in Vancouver was to ensure that:

> No owner of any land within the City Lands shall suffer to remain on his land any tree, logs, brush or underwood that may from their nature or proximity to other premises be dangerous to life or property.

Excerpt from *By-Law No. 106* written in longhand
City of Vancouver, 1890

The Tree Destruction By-Law, as it was then termed, was short. In addition to the quoted first section, six more spelt out serving of notice to comply with an Order by City Council, action if owners failed to comply, collection of costs and conviction if guilty of failing to comply, with fines up to $100, and two months in jail with or without hard labour.

This by-law was revised as *By-Law 197* in 1894 and then added to with new provisions as *By-Law 964* in 1912. In 1913, 964 was repealed and replaced with *By-Law 1052* providing a definition section including descriptions of a "Person" or "Owner", the "City" and "Council". The whole question was then revisited in 1922 with the repeal of 1052 and enactment of *By-Law 1525.* This by-law still exists to regulate trees in the City of Vancouver. It was not until 1990, in a City Manager's report (Managing Trees in the Development Process), that City Council returned to regulate any trees other than street trees in Vancouver.

6.3 The Oakland Hills Experience

On October 20, 1991, a centre of low pressure area stalled off the California coast. The result was a foehn wind that, at speeds in excess of 110 km per hour, blew down from the crest of the Oakland-Berkeley Hills. Coupled with record high temperatures well into the nineties, the hot, dry winds gusted and swirled through five-years of drought-dry brush and groves of freeze-damaged Monterey Pine and Eucalyptus groves.

The 1600-acre East Bay Fire began under suspicious circumstances. Sunday morning, October 20th, at approximately 11:00 a.m. near the site of a brush fire brought under containment the previous afternoon, embers from an undetermined source were blown into bone-dry brush and onto nearly residential shake roofs by swirling winds of twenty to twenty-five miles per hour. The fire was out of control in a few minutes, jumping an eight lane "firebreak" (Highway 24).

In a matter of hours, this major conflagration would leave twenty-five people dead, 150 injured, destroy 3,354 single family dwellings, and 456 apartments, and cause damages in excess of one billion dollars, the most costly urban-wildland fire in U.S. history (Federal Emergency Management Agency 1992).

The Almeda County neighbourhoods of Claremont, Rockridge, Grizzly Peak, Broadway Terrace, Montclair, and the City of Piedmont were evacuated during the fire. Adjacent streets and freeways were clogged with residents trying to get out, while sightseers, emergency personnel and fire fighters were trying to get in.

The 2,000 degree fire affected utility systems including power, gas, telephone, and water. Loss of power early in the fire, caused by burning powerlines and melting underground services, also affected water system pumping plants. A total of eight pumping plants lost power on Sunday afternoon. Portable pumps and emergency generators were installed by Sunday evening as soon as the conflagration and the Oakland Fire Department permitted access. Ten water system reservoirs were drained at the peak of the fire as a result of an unprecedented demand from fire fighting units, fire prevention measures by homeowners, and broken water service connections.

The fire split into three fingers, north toward the Claremont Hotel, south toward Broadway Terrace, and east toward Orinda. All three fingers of the fire remained out of control through the night and into the morning of October 21st. By that morning, the eastern finger of the fire was assessed as ten percent contained, while the remaining two fingers burned out of control (Federal Emergency Management Agency 1992).

Twenty helicopters and ten air tankers had been called into action Monday, October 21st. Three hundred law enforcement officers helped to control the flow of personnel and equipment throughout the fire area. Over 370 fire unit and 1,000 fire personnel were on the fire line by Monday afternoon.

Later that same day, cooler temperatures settled in as the reduced winds shifted to the west. In the early evening of October 21st, the conflagration was declared contained with no active fire head burning. As night approached, fog moved in over the burn area, temperatures fell and humidity increased. Several hot spots were extinguished during the night. The East Bay Fire was not officially declared under control until 8:00 a.m., Wednesday, October 23, 1991, some seventy hours after its inception.

Over 10,000 people were evacuated from Oakland-Berkeley Hills communities during the fire. Five American Red Cross shelters were established, four in Oakland and one in Berkeley. Approximately 1,300 individuals registered at the shelters, with 450 staying the first night.

Relief costs exceeded $2.4 million, with final costs estimated to top $3 million. The Red Cross and United Way fund campaigns were supported by $3 million in public donations and over 2,0000 volunteers assisted at relief centres.

Of the 11,055 people living in the fire area, at least 5,000 were left homeless. The average price of the 3,354 single family dwellings destroyed was $360,000 for a total cost of $1,207,440,000. Four hundred fifty-six apartment units were destroyed. In addition, 2,000 automobiles were also destroyed.

The continuing threat of fire remains along the California coast. While shrub and tree species differ, the predisposing factors of retention of flammable vegetation in close proximity to housing developments, dry summer conditions, propensity for strong on-shore or outflow winds, poor roof maintenance and roof shakes or shingles untreated with fire retardant materials, leave portions of many Lower Mainland communities in B.C. also unprepared and at risk.

There can be no doubt that the risk of urban interface fire in any heavily wooded community must be taken very seriously. This understanding is not new.

> In 1922, a study of a fire in Berkeley, California, revealed the fact that the fire spread completely out of control when the relative humidity dropped below 30 per cent. Bush Osborne, Jr., a member of the United States Forest Service, and Dr. Julius Hoffman published a paper showing conclusively that fires and low humidity, now called "fire weather", were closely related. A fire occurring under such conditions was almost bound to get out of control. (Cowan 1961)

6.4 Building Codes

The laws regulating the construction, alteration and maintenance of buildings are an important part of any land use control system. Such laws have a direct bearing on the safety, aesthetics and economics of land development.

Building regulation provisions are contained in the *Municipal Act* and *Vancouver Charter*. Other statutes which may affect building regulation and safety are the *Health Act* and the *Fire Services Act*. In municipalities a council has wide powers over building regulation. In unorganized areas, pursuant to the *Local Services Act*, section 3(i), the Minister of Municipal Affairs has the same powers as a council with respect to building regulation. In the *Building Safety Standards Act* at s.734(c) provision is made for areas of high risk to be identified and specific building requirements to be stipulated.

Instead of preparing building regulations and implementing them by by-law, a council can, in certain circumstances, adopt national building Codes. Under the *Municipal Act* a municipal council may, to an extent not inconsistent with the Act or its Regulations or other provincial statutes, adopt the B.C. Building Code and the National Fire Code of Canada. The codes may be adopted by reference to any particular date of issue or any specified issue of the code. The Vancouver Charter also allows that council to adopt the National Building Code of Canada and other similar standards.

Adoption of the codes, or parts of the code, by a council then allows for specific fire safety concerns to be addressed. Two typical examples pertinent here are those relating to specifications for fire resistant roofing materials and requirement for exterior fire resistive materials or specific building separations. No comprehensive program of interface fire risk and specific building code provisions has been adopted for the Lower Mainland. Hopefully, the fire experiences in California will prompt organizations such as the B.C. Association of Fire Chiefs to address local hazards and recommend modification of specific interface fire mitigative measures for buildings.

6.5 Risk Management

While consideration of the public aspects of fire protection are taken into account during sub-division design, such as fire hydrant spacing, this does not free the homeowner, in areas of forest retention, from all responsibility for consideration of forest fire risk. There are a number of actions that each resident can consider:

House Construction

- Fire protection should be built into a home. Roofs and exteriors of buildings should be of fire resistant materials, such as asphalt-rag, felt-roll roofing, tile, slate, asbestos-cement, sheet metal, aluminum or fire retardant-treated wood shingles or shakes. Openings under eaves, attic and floors should be screened to prevent accumulation of flammable material. Chimney or stovepipe openings should be covered with not greater than 6.5 mm mesh ember screens.

Fire Insurance

- The B.C. Ministry of Forests or a municipality are not responsible for any loss or damage to buildings or personal belongings which result from a forest fire. The responsibility for such loss or damage lies with the homeowner. It is, therefore, to be recommended that homeowners purchase a fire insurance policy that will suite their particular needs and specifically protect from this type of loss.

A Contingency Neighbourhood Plan

- Discussions should be held with neighbours to develop plans for the control of fires that may threaten an individual's or neighbour's property. Before fire strikes, homeowners should make sure that all concerned are aware of the safest, most direct route to open country or a place of safe cover. Local fire department personnel or the municipal emergency program coordinator will assist in developing these plans.

Fuel Breaks

- Homeowners should consider the need for perimeter fuel breaks. In most cases all that is needed is a shaded fuel break where all dead or downed vegetation is removed. Low growing groundcovers such as *Galtheria* or *Vaccinium* can be considered. Natural fuel breaks such as barren rock, streams, lakes or swamps are also of prime importance.
- Fuel breaks should be located on flat areas since the steeper the slope, the wider the fuel break needs to be.

Ornamental Plantings

- Plant material such as cedar, *Thuja sp.*, false cypress, *Shamacyporis sp.* and upright junipers, *Juniperus sp.*, which can "roman candle" and draw flame up the face of buildings should be avoided in foundation plantings.

Fuel Storage

- Storage of flammable liquids such as gasoline or diesel for equipment should be kept in fireproof storage during fire seasons.
- Heating oil quantities should be drawn down to a minimum during fire season to reduce fuel load.
- Propane storage should be carefully controlled.

Disposal Practice

- Open burning during fire season should be avoided and local burning instructions rigorously observed. Offenders should be reported to fire authorities.

Exterior Protection

- A garden hose with nozzle, long enough to reach all structure exteriors should be pre-connected.
- If a pressurized water system is not available, a large barrel of water and a 10 litre pail will provide some protection.

- A ladder long enough to allow access to the roof should be stored in a convenient location.
- A round point shovel or a Pulaski tool (combination axe-mattock) are very effective in preventing the spread of ground fire and should be stored in a convenient place.
- An exterior inspection of the homes should be made each spring to remove overhanging tree limbs, leaves, moss and needles from the roof and gutters. A fuel free area should be maintained around a home and flammable material lodged against buildings or under foundations removed.
- Chimney or stove pipes should be clean, free of creosote, and a check made of the ember screens over these outlets to ensure they are in good working order.

Personal Protection

- All important documents should be stored in a fireproof safe. Alternate copies should be stored off-site in an appropriate location including all insurance papers and photographs of assets.
- All critical computer records should be backed up frequently and stored off-site. This is particularly important for home businesses.
- In addition to a known escape route(s) from property, residents should keep a "grab and go" bag of essentials and sentimental items in case of forced and unplanned departure.
- A plan for dealing with pets and domestic livestock should be developed.
- During high fire danger, the radio or similar alert system should be monitored.

These, and similar simple preparedness strategies or activities are widely acknowledged by fire departments and forest protection specialists as important preventative or planning measures and they do reduce interface fire risk and aid in personal response.

6.6 Urban vs Forest Fire Fighting

Fire fighting in an urban setting, principally for structure fires, differs considerably than that required for forest, woodland and urban greenspace retention areas. Thus, both wildland and urban firefighting teams have problems that can be encountered in an urban/wildland interface fire situation due to lack of standardized equipment or training. The standardization or compatibility of equipment, terminology, and training is critical if a crossover from one jurisdiction to another in a fire situation is to happen smoothly and without confusion.

The equipment that needs to be standardized or compatible can be broken into the following distinct groups:

1. Hose and nozzles
2. Pumps
3. Foam
4. Personal protective equipment
5. Training
6. Techniques

The first major concern is that of hoses and hose threads. Fire departments usually use a standard hose thread. These sizes range from 1-1/2 inches to 2-1/2, the size of hoses range from 1-1/2 to 3 inch. These hoses are designed to carry large volumes of water at high pressure. Most municipal fire department apparatus is equipped with standard threads and hose sizes though not all departments carry compatible hose diameters. Note: metric sizing is not presently used by fire departments.

The Forest Service typically uses a quick coupling or instant coupling for their hose thread. The hose sizes range from 3/4 to 1-1/2. The hoses are designed to carry lower volumes of water at lower pressure. Longer hose runs than a typical municipal structure fire requirements are commonplace.

Fire departments need to be capable of converting their standard fire hose ports on fire trucks to quick couplers by using adapters so mix-ups and connection problems are greatly reduced. Fire departments with forest interface fire risk need to carry or have on hand in their fire hall a minimum amount of Forestry type hose, in the order of 200 to 400 meters.

Urban fire departments tend towards heavy duty, abrasion resistant fire hose, while forestry fire departments tend towards light-in-weight fire hose. Urban fire hose has been found to be extremely difficult to pull through forest areas.

Portable floating pumps are important for both forestry and fire departments alike. Water availability in urban sub-divisions can become very short in supply due to overuse by residents hosing down roofs and fire departments hooking up to hydrants. Power outages which are most certain to occur shut down pump houses feeding reservoirs. Portable floating pumps can be used to suck out water from swimming pools or ponds in order to supply enough water. The average swimming pool, for example, holds 135,000-180,000 litres of water.

Porta-tanks or bladders for both Forest Service and fire departments are an important consideration due to the lack of water at many fire sites. Large water tank trucks or fire trucks can then be used to carry water from creeks or pools to the porta-tanks (Romford 1992).

Foam is an effective woodland ground fire suppressant material. However an urban fire team has requirements for foam that include hydrocarbon and alcohol fire protection (class "B"). A forestry fire department requires only class "A" foams. These are less expensive and must normally be stored in larger quantities for fire fighting in woodland settings. Few city fire departments give consideration to this aspect of interface fire control.

Urban fire fighters require much more personal protective equipment than a wildland fire team due to the more hazardous nature of the typical fire fought. Clothing worn by fire departments for structure fires is a must, but, when it comes to forest fires, the bunker gear worn by fire department firefighters is obviously very hard to work in. Large rubber boots are no match for steep terrain and slippery forest floor conditions. Good Vibram soled leather boots are more appropriate. Leather boots give good support to ankles as well as good traction on uneven greasy ground. Heavy jackets and pants are very bulky and extremely hot to work in when the temperature is around 30-40 degrees C. Fire resistant Womex coveralls such as worn by the Forest Service crews are much more suitable for forest fire activity. Few urban fire departments have this clothing. Head gear can remain the same and in this way municipal fire department crews can be distinguished from forestry crews.

Most municipal fire departments are also lacking in hand tools used in forest fire situations; small bladed shovels, hoes, picks, hand axes and mattocks are all needed in the control of interface fires, both for fighting surface fire and suppressing smouldering subsurface roots.

Perhaps above all, training beforehand with members of the opposite wildland and urban team to properly understand what the other side does, is of critical importance. Each side must understand the philosophy of the other side's fire fighting techniques, which differ markedly, if the ever present danger of large interface fires is to be effectively reduced and response of combined forces is to be effective. Moreover, the integration of air tankers, command structures, radio nets and ground forces must be practised. In addition, the logistics of rapid area evacuation, traffic management, transportation and temporary settlement of residents in areas consumed or threatened by fire must be exercised and coordinated with all of the agencies recognized in the Memorandum of Understanding for interface fire example given in Appendix C of this manuscript.

6.7 Inter-Agency Agreements

It is quite clear that techniques for fighting structure fires and forest fires, the equipment used and the clothing worn differs. However, fires start in structures and burn into the forest. Forest fires burn into built-up areas often with devastating results. The interface between forest and urban environment is always at risk. The Protection Branch of the Forest Service and the typical urban municipal fire departments both have extensive resources. How best to apply these to the common end of effective interface fire suppression?

Mutual aid agreements and training together are the two cornerstones of effective urban forest fire protection and response. In British Columbia the seriousness of the interface fire problem and how it can be dealt with resulted in a major symposium in 1992. Speaking at a panel on interagency agreements, Wilburn (1992) suggested that initially there are some difficulties between the two response agencies but that once credibility is established, some simple rules can be formulated for agreement development.

Wilburn asks: What are some of the pitfalls of agreements?

1. That big brother (i.e. Forest Service, Department of Natural Resources, other agencies) is trying to take over my authority and responsibilities.
2. If we have an agreement there will be more trust between us.
3. By signing an agreement we will be forced into working together.
4. They want an agreement because they don't think we can do the job.

When these kinds of attitudes and perceptions show up at the mention of agreements, the real problem usually is lack of personal credibility and trust between the parties, yet there is little doubt that, faced with a major urban forest interface fire, both must work together.

When preparing an agreement Wilburn suggests:

1. Keep it simple.
2. Remember the agreement is for both parties.
3. What are the protection boundaries?
4. Who protects improved versus unimproved land?
5. Structure protection, who is responsible?
6. Reimbursement if any, when, to whom, and at what rates?
7. Who furnishes what equipment/liability, claims, etc.?
8. How is command of the incident handled?
9. Effective date of agreement, who is authorized to enter into such agreements, and when or how may agreements be cancelled.

Fire protection mutual aid agreements are not a cure all, but just another tool to be used to improve communication, cooperation and understanding between agencies, fire protection districts, law enforcement, emergency program coordinators, and others that come together in a common mission during an urban interface incident.

These agreements provide a formalized mechanism for protocols, tactics, departmental operating procedures, equipment incompatibilities, resources and cross-agency expectations to be discussed and concerns aired. Davis (1959) set out fourteen basic "jobs" of any fire control organization. These are:

(i) Policies and objectives,
(ii) Foundation information on occurrence, causes, people and forest impacts; as well as the conditions that lead to forest fire,
(iii) Prevention of man-made fires,
(iv) Hazard reduction strategies,
(v) Detection and reconnaissance,
(vi) Communications,
(vii) Transportation to and from fire sites,
(viii) Fire danger rating systems,

(ix) Equipment and supplies,

(x) Selection and placement of men and machines,

(xi) Dispatching systems,

(xii) Fire suppression methods,

(xiii) Research, and

(xiv) Administration.

The full text of a generic interface fire agreement that addresses many of these topics suitable for use by B.C. communities and the B.C. Forest Service is given in Appendix C.

7.0 Maintaining the Urban Forest - The Municipal Perspective

7.1 Introduction

Urban expansion in the Lower Mainland is continuing at a rapid pace. The Greater Vancouver Regional District suggests that 80% of the 80,000 people who come to live in British Columbia each year come to live in the Lower Mainland. Yet this growth is occurring at a time when each level of government is pressed to stabilize tax increases and lower deficits. Service suffers. This is not new, in the previous decade August Heckschar (1981) noted that:

> The problem of park commissioners is that they are almost invariably at the bottom of the budgetary totem pole. When the crunch comes - and after days it not only comes but seems to remain as a permanent fact of life - parks departments are the first to be cut. While mayors hesitate to make slashes in the police force or the sanitation workers, they see parks as the place where the axe can fall with least immediate harm to the public,
>
> In vain the parks commissioner pleads with his chief, telling him that a few extra dollars spent on parks will bring a large return in the pleasures of civic life, and will also improve his political image. Against the harsh realities of budget-cutting, the case for amenities rarely prevails,
>
> The mayor's rejoinder is to do more with less - to increase the productivity of park workers and to introduce more efficient systems of management, ... and,
>
> With city budgets so hard-pressed, the transfer of open spaces to a larger government entity may appear attractive. In cities where county and state share park responsibilities with the urban government, the city's share of the green spaces is nearly always the dirtiest and most unkempt. The county does better, and the state can appear a model park-keeper. Something is lost, nevertheless, when the management of a local park is not in the hands of the locality itself. The city may be poor, but it is apt to be healthily responsive to community groups and pressures.

There is not doubt that the do more with less or even less with less leaves the present day park or urban forest manager with some complex priority assessment difficulties.

Managing trees, particularly in recently disturbed areas of even-aged trees, mature stands of trees and areas of shallow soils with tall, poorly rooted trees is actually managing risk. There can be no guarantee that trees will remain without windblow, particulary under unusual and arduous weather conditions. Stem failure or crown loss are not entirely predictable occurrences. Yet, municipal liability grows with every case where the courts find for the individual citizen as against the public body.

Grey and Deneke (1978) have noted that there are two forms of management: that which is done *for* the forest to maintain health and vigour; and that which is close to the forest to prevent undue interference with the activities of man. This distinction is important as much of what is done for the forest is directed towards its betterment. By contrast a great deal of what is done in the name of "maintenance" is detrimental in nature. Utility pruning, root removal, groundcover cutting for aesthetics or security reasons, and removal of deadfall are common examples.

The urban forest has three fundamental management needs: planting, stand maintenance and removal. Grey and Deneke suggest that planting is the most publicly acceptable form of management need in the urban forest. Maintenance is the most costly since it deals with workload intensive activities such as growth control, damage control and pest management. The most controversial activity is tree removal. People in close proximity to trees tend to be protective of them. The sound of a chainsaw doing safety or improvement cutting does not differ from one handled for destruction. The precepts of improvement cutting and stand manipulation must flow to the public so that the objective of management in perpetuity and the tactics employed are understood and not undercut by precipitous public action.

7.2 Professional and Legal Responsibilities

The urban forest manager employed, either by the public service or in private practice, is faced with awesome professional and legal responsibilities. This has become more pressing in Canada as the litigious tendencies of the United States have crept north and Canadian courts have made ever increasing awards to civil ligations in a wide variety of damage suits.

While the civic employee can hide behind the curtain of insurance protection maintained by a municipality, no such defence is afforded the private urban forester or arborist. Error and omissions insurance for these professions is almost unobtainable. For those professions such as planners, engineers, foresters and landscape architects, who have legislation government name or practice use, the public can have some sense of confidence in professional integrity. No similar process extends to arboriculturists at present, although a North American program of certification is in place. Urban forestry is an every improving science. A professional obligation must, therefore, be to currency of knowledge. There can be no expectation to be a full, trusted participant in a design team, for example, if the most up-to-date understandings on tree physiology, safety and management are not understood.

Two aspects of safety are important. The first is the safety of the resource. Tree failure, while not completely predictable, can be significantly reduced by regular, detailed and knowledgeable inspection programs. The second aspect is safe delivery of service. Forestry activities are carefully governed by the Workers' Compensation Board of British Columbia. Certain clothing, personal protection, work practice and reporting requirements must be met. Those working on urban forestry activities, municipal or contract employees, must be skilled, properly trained and knowledgeable about urban forestry techniques. The legal implications of not adhering to a vigorous professional program of safety first will be a program that fails the "reasonable error" test and carrying forward to grounds for negligent conduct with all of its onerous outcomes.

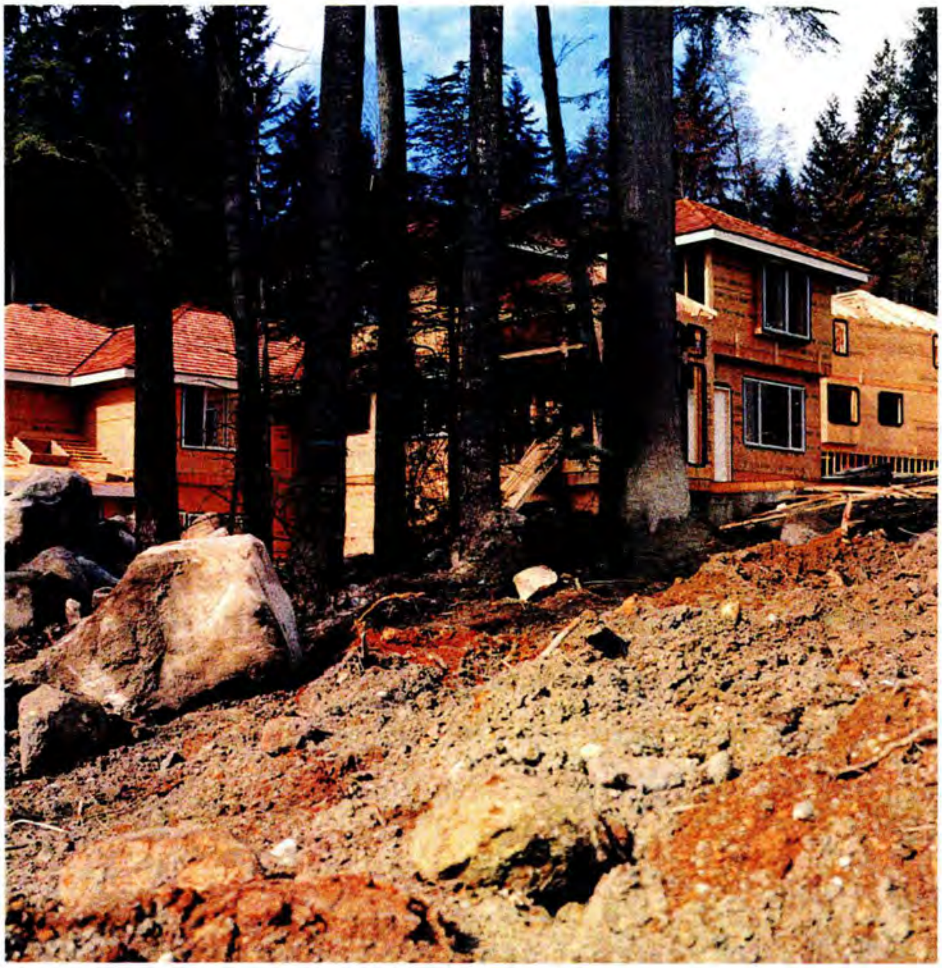


FIGURE 30 Inspection of retention areas impacted during construction is extremely important during initial home occupancy. Tree decline will be readily evident through bleeding, bark loss or foliage discolouration.

7.3 Inspection, Care and Custodianship

Inspection, on a regular basis, is the very essence of effective urban forest management (fig. 30). The resource is constantly changing over time. Without an inventory of content and condition, the urban forest manager has no context in which to judge change. Knowledge of the degree of changes, the nature of changes and the impact of changing conditions in the forest will provide the key clues on the need for intervention into the natural processes and evolution of retained treed areas or urban forest established by planting. Harris (1983) provides a detailed diagnostic checklist to assist in condition analysis by site and symptom recognition. The cradle to grave concept developed to manage hazardous chemicals is a model applicable to the case of the urban forest, from seedling support to mature tree removal and utilization. The urban forest manager has a custodial duty to apply the best knowledge, techniques, and employee skill to the many facets of urban tree management.

So far it appears that much urban forest land in the Lower Mainland of British Columbia is not intensively managed. Rather it is viewed as residual or derelict land with trees that will look after themselves. The risks associated with this style of management are significant. They are personal, public, municipal, corporate and, of course, resource depletion oriented.

While the development of master plans that set out expectations and criteria for management of the urban forest resource can be an explicit, written, voice to custodial intentions, they are not always so. The Delta Parks and Recreation Master Plan (1989), for example, while full of lofty goals and actions required, does not mention trees once in 63 pages.

7.4 Maintenance in Perpetuity

Since commercial harvest is clearly not the main objective of urban forest activities, it can be postulated that stability of the benefits, actual or perceived, that urban forest areas offer to the adjacent community must underlie the public expectation of both management objectives and tactics. Contrary to this desire is the dynamic nature of the forest, ever growing, changing, diminishing, and regrowing, as it is buffeted by the influences of man and the exigencies of the natural elements. Cobham (1990) has suggested that amenity woodlands go through three phases: mature, senile and re-establishment. To this could be added immature, the period when initial establishment has occurred, trees are outstripping shrub growth, and are competing with each other for light, space, and nutrients. This is normally the period of fastest growth through mid-life for most tree species. It is also the period when the stand tending activities that follow are of prime importance. These are:

- Fire protection,
- Weed control,
- Growth regulation,
- Fertilizer applications,
- Mulching,
- Irrigation, drainage or water management,
- Pruning, clearing or lower limb removal,
- Thinning, danger tree removal,
- Replacement planting, underplanting or inter-planting, and,
- Insect and disease control.

All of these activities contribute to the continued health and growth of a developing urban forest (Hibbard 1989). Once the stages of maturity or senility are reached, active replacement strategies must be undertaken before decadence and the forces of nature conspire to create wholesale losses. Here is the time to employ the silvicultural techniques discussed in a previous chapter.

By employing active intervention in to the phases of growth and development of the urban forest, it is possible to maintain forest cover for extensive periods and to meet the exsection of urban residents for permanency and safety.

8.0 Living with the Urban Forest: The Homeowner's Perspective

8.1 Introduction

A homeowner purchases their property with a modicum of information about the exterior, except for lot boundaries and the possible location of utility valves. Most lots are sold without landscape. This is a homeowner's cost. If there are large existing trees, they are probably viewed as an asset, at least at first. No information will be supplied as to their history, construction impacts sustained, species, eventual height or crown size, and inherent defects. The same will hold true for lots which abut private treed areas, strata common areas, or public lands.

The typical homeowner will not view trees as a dynamic element in their immediate environment, unless particularly interested in trees. Common garden knowledge will not alone serve well. Knowledge of ornamental trees will not be particularly helpful in understanding urban forest trees. For the most part, post-construction tree decline caused by hidden damage such as compaction, grade changes or root severance will not be evident to a new owner distracted by the rosy glow of new home ownership. Rather than an asset, the retained urban forest, single tree, clump or greenbelt may be an incipient hazard. A hazard which may bring phycological stress once trees show symptoms of distress or unimagined legal and insurance ramifications if trees cause personal or property impacts.

With severely damaged trees, dieback and death come sooner rather than later. With trees that are released through thinning, clearing or improved moisture or fertilization from lawn management, new growth may, in a few seasons, change a once sunny lot to a shadow of its former self. The homeowner may not have purchased a static garden accoutrement but rather an expensive liability, unknowingly and with no advice.

8.2 Homeowners and Strata Corporations: The Leave or Remove Dilemma

Lawsuits have become a way of life. And more and more cases involve trees. Liabilities and court rulings vary with site location and type of owner. For example, urban tree owners often have greater responsibilities for inspecting trees and correcting problems than do rural owners. Planted trees usually entail greater liability than naturally occurring ones.

Liability for causing or allowing a tree failure accident to occur should be a major concern for homeowners and strata corporations. During the 1980's, courts gave more and more awards to tree failure accident victims. While the average amount of the awards has levelled off, the plaintiffs are winning more often and record award amounts are still occurring. An $8 million Michigan case was found in favour of the family of a young child killed by electrocution due to a tree knocking down an electrical service during a storm (Cool 1991). This author suggests that:

"The best defence is a good offence" is a common legal saying. It is very true in regard to tree accident prevention. There are five premises to keep in mind.

Premise #1: The owner is liable; whether or not they provided good tree care,

Premise #2: No acts of nature prevail; this defence is disappearing throughout North America, even if a storm caused the tree failure,

Premise #3: Injured parties will be compensated; even if the tree owner provided good tree care, courts often find that not good enough tree care was provided, if the tree failure resulted in an accident,

Premise #4: Good tree care is good accident prevention; it is the result that counts, and finally and possibly most importantly,

Premise #5: **Liability Can Be Reduced But Not Avoided**; good tree care will greatly reduce tree hazards and will reduce court awards.

Proper tree care includes maintaining the appropriate tree species in appropriate places for greatest tree vigour and reduced risk, and establishing appropriate tree maintenance standards. These standards must include employing trained personnel, ensuring appropriate work practices, regular inspections, comprehensive documentation of work done, and effective notification response.

Are there trees for which an owner does not have liability exposure? The answer is that if trees are on, or even closely adjacent to, a garden, site, grounds easement, common property, or right-of-way under the owner's responsibility, then the owner is liable for them. It does not matter if the guests who might be injured are invited for a fee or for free.

In the case of a strata corporation, who have employed a company with a duty to maintain and manage their property, the corporation will find that liability, while generally falling on the manager's employment agency, can also fall on the corporation members personally. There is a trend for more property managers to hold malpractice or errors and omissions insurance or to have an employment contract holding the property manager and their employment agency free from liability to the extent the law will allow. Because this type of insurance is quite expensive and difficult to find in the general insurance market some managers and firms have chosen not to carry it. In this case the corporation and its subscribers may find they are held to be partially liable.

Property managers of sites with trees must act under two basic assumptions:

Assumption #1: That they are a professional property manager but not an expert with the direct responsibility for tree care. They should thus engage reputable consultants and contractors.

Assumption #2: There is a degree of tree care, in effect a standard, that applies in each locale. It is continually being set by peers, by legal procedure and case law, and by plaintiffs.

Because of these assumptions, continuous education and training of property managers, property workers and any supervising garden and grounds' committee is of great importance in building a good offence. Cool (1991) also notes that the backbone of a property owner's or property manager's protective cloak should be a formal, written maintenance plan for tree care on their property.

If a property owner or strata corporation and its property manager, should there be one, decide to utilize a consultant or contractor for tree work, there is no automatic protection from liability. Care must be taken in selection of a reputable firm and in the nature and form of any agreement for services.

The Use of Consultants and Contractors

The following conditions may cause or exacerbate tree accident lawsuits:

- Employment of contractors and consultants that lack adequate insurance or proper qualifications and expertise for a specific case,
- Failure to obtain detailed, legally sound, contracts from contractors and consultants,
- Failure to know and follow local, provincial and federal regulations,
- Lack of qualifications or appropriate training and skill level on the part of employees of a consultant or contractor,
- Use by contractors of inappropriate or improperly maintained equipment,
- Encroachment by contractors onto other parties property or damage to other trees,

- Failure to maintain adequate records of work undertaken,
- Errors, omissions or falsification on insurance or workers' compensation claims,
- Errors or omissions in reports or court testimonies, and
- Failure to carry adequate third party insurance.

The liability problems associated with ownership of land with trees follows in three parts. It is based on a similar format suggested by Cook (1987).

Potential Problems for Tree Owners

It behooves every property owner to determine their responsibilities and liabilities implicit in holding land title. The following problems for homeowners or strata corporations with trees on common property may result in insurance claims or lawsuits. Damages by and to trees as listed below in the two sections following,

Nuisance trees

- These include trees that emit unpleasant odours; that are chronically infested with insects or diseases, that are noxious as in having poisonous seeds, hayfever causing pubescence, or obnoxious as in bearing suckers, berries, or thorns; and trees that are attractive to children, who may climb and fall from them.
- Trees that conflict with utility lines, rights-of-way and access easements. Trees protected by local by-laws, or that interfere with a neighbour's view or accessibility to sunlight.
- Removal or pruning of trees very close to the lot boundaries on one property resulting in a reduction of a neighbouring properties shade, privacy or property value.
- Failure to maintain trees in safe condition with consequential failure, causing damage or bodily harm,
- Trees that reduce enjoyment of private property, for example those that

continuously drop leaves into swimming pools or provide roosting for flocking birds such as starlings, and,

- Trees that obstruct driveway vision, road signs, pedestrial safety or grow into the travelled property of others.

Damage to Trees

The following damage to trees may result in insurance claims or lawsuits:

- Tree pruning or felling by trespass. For instance a person who goes onto a neighbour's property to prune, or a contractor who takes a tree on the wrong side of a property line.
- Chemical damage. Such damage can result from substances including fertilizers, herbicides, some insecticides, industrial or household wastes, deicing salts, concrete and cleaning materials that are directly applied in one location but travel through aerial drift or runoff into root areas.
- Water damage, where water from one property deposited onto another causing ponding and tree death,
- Lowered water tables that can result from increased drainage away from a site such as that caused by nearby construction causing premature tree death, and,
- Physical damage from soil compaction by vehicles and equipment, vehicle accidents, vandalism, fire and related heat or toxic fumes, mudslides, and large animal browsing.
- Physical damage to roots or crowns through negligent use of equipment.

Damage by Trees

The following damage caused by trees may result in insurance claims or lawsuits:

- Falling trees or tree parts that cause damage or injury to people, property, or both. Possible causes include; stony fruits, slippery plant parts, such as petals and fleshy fruits; and pollen or pubescence that causes allergic reactions,

- Invasion of, and damage to, property, or improvements, by overhanging limbs, leaning and expanding trunks, suckering and roots. Such damage may be to roofs, fences, walks, gardens, foundations, ponding, driveways, or drainage and sewer pipes,
- Damage to vehicles or pedestrians by thorns, limbs, leaning trunks, roots, or bark exfoliation and fruit drop,
- Accidents caused by obstructed views of oncoming traffic, roadway hazards, signs, or signals, and,
- Loss of, or damage to, utility services caused by failure to maintain trees or tree roots.
- Trees that shed in high winds or shred and reduce the enjoyment of gardens, patios, or swimming pools.
- Deposition of cones, leaves, needles, twigs and branches into roofs or into drains causing flooding or continued need for roof maintenance.
- Shade cast onto roof areas causing continual moss, slime, mold, wetness or decay in shakes, shingles or wooden roof members.
- Psychological fear caused by the appearance, size, condition, location or creaking or bending that renders an adjoining neighbour in a constant state of concern.

A property owner or strata corporation is faced with risk associated with trees. Some will propose that the simple answer is to remove the potential risk by removing the offending tree or trees. This will not be a unanimous solution since many will prefer to weigh the benefits against the risk and choose for tree retention. Informed tree care then becomes the 'good offence' postulated by the old legal maxim.

8.3 Encroachment and Forest Edges

Since a developer of property wishes to maximize the design effect and thus saleability of each lot, the general tendency is to include or incorporate a proportion of any adjacent greenbelt into the apparent lot size. Fencing to separate the two is often limited to post and low-rail or no fence at all is installed. The subsequent homeowner enjoys the appearance, at least, of property that converges with the urban forest. Since no legal or physical marker separates the private property from public or common strata lands, garden or "yard" extension is commonplace.

The urban forest edge is often newly crated and trees that were once surrounded by neighbours now must face the physical and physiological rigours that exposure brings. This is further exacerbated by the homeowner who, after landscaping their frontage, may wish to garden on those edges adjacent to the greenbelt.

Small structure building and associated foundation construction, grading, lawn construction, weed control with herbicides, new drainage, and similar activities bring similar problems to those identified as concerns during construction of a sub-division such as trenching, excavation, and soil compaction. Gardening activities such as grade changes, use of systemic herbicides and removal of tree roots further diminishes edge tree vigour.

The most severe effect of encroachment is actual tree removal. Despite covenants, by-laws and peer pressure, tree removal in the urban forest is a constant problem caused by adjacent property owners.

The dynamic nature of tree growth is such that what was first or seasonally thought of as an open, light lot, is found to be even more shaded than when first purchased. Pruning, of dubious standards, or complete tree removal then often occurs. Trees already stressed by construction and clearing exposure are further stressed by homeowner activity and exhibit symptoms which later justify removal. Suppressed trees, yet to respond to release following clearing, are removed for firewood.

Natural regeneration is often seen as "weed growth" and the duff layer is removed to "enhance" the cultivated appearance of a gardened lot. Thus, the urban forest edge is weakened in a dynamic and destructive process. New hazard trees are created and the cycle continues. This process can be aided and abetted by the public land manager. The municipality may condone or create the development of trails into green belt areas but provide no standards of ground protection against erosion or compaction. This encroachment may further weaken edge trees. Where treed areas interface with large public grass areas, constant mowing activity with tractor-towed or large self-propelled grass cutting equipment has been shown to be a major contributor to urban park tree decline (Gardner 1982).

Encroachment loss can be offset by active inspection programs. The thrust of these programs must be two-fold: the early detection of symptoms, and aggressive silvicultural practice to mitigate the effect of edge tree depletion. In the former case remedial tree care may help save some trees after early diagnosis but where this is not possible, tree removal must be undertaken by qualified contractors. Following removal, replanting will assist in mitigating the loss while allowing both age class and species manipulation of the exposed area.

Basic Causes of Unhealthy Trees Due to Encroachment

The following table shows the most common causes and symptoms of ill health. The correct diagnosis of health impacts and the adoption of suitable remedial measures will usually require expert knowledge beyond that of the individual homeowner.

TABLE 6

CAUSE	SYMPTOMS
Mechanical damage to bark.	Fungi mycelia and fruiting bodies. Wet rotting and dry decay of wood.
Damage to branches or tree bole.	Decay of wood, development of internal cavities. Shattered wood ends.
Poor pruning techniques leaving "snags" and torn branches.	Bark canker and stem rot entry. Stem breakage.
Root damage by trench cutting.	Die-back of branches and foliage on one side. Splintered roots. Lifted stems.
Heart and butt rot after fire.	Development of sunken or internal cavity.
Lack of water through local utility excavation, or hard surfacing over roots.	Die-back of upper branches in crown, stag-headed appearance. Discoloured foliage.
Lack of air through burial of roots by grading and subsequent surface compaction.	Die-back of upper branches in crown. Loss of foliage. Discoloured foliage.
"Drowning" of roots following a rise in the water-table or local drainage change.	Die-back of upper branches in crown. Retention of dead leaves or needles. Discoloured foliage.
Pollution from gas, smoke, oil, and agro-chemicals.	Bark lifting, discoloured and dead foliage. Crown top die-back.
Foliage diseases or insect attack.	Leaf curl, discoloured foliage. Shoot tip die-back.
Exposure to sun, drought or frost.	Cracking bark and separation from inner tissue. Stem splits.

A few simple measures incorporated in property covenants or strata association rules can reduce the impact of encroachment.

- Trees, shrubs and groundcover in the vicinity of a completed lot should not be removed or damaged without the approval of the Parks Board, Strata Corporation or similar party having jurisdiction. This includes damage to tree trunks, branches, tree crown and roots, driving in nails, building brackets, fencing supports, hooks, clotheslines or communication aerials. Any significant shortening of limbs or branches must be discussed with the appropriate urban forest manager, and should be carried out professionally,

- The attachment of tools, switch boxes, pipes, lighting, and landscape timbers to trees should not be permitted because it causes severe long-term bole damage,

- The root area of a tree, normally the area of ground below the tree crown plus 2 meters radius measured outwards, must be kept absolutely free from any passage of homeowner vehicles, machine assembly, garages, sheds, piling-up of heavy building materials and hydrocarbon fuels of any kind,

- The trunks of all trees previously standing in the shade, and which were exposed in the course of construction work or hazard tree removal, should be shaded on the side facing the sun. Sunburn occurs mainly on the south and west sides of the trunk. Alder, and dogwood in particular, are desiccated in this way. For protection, the trunks can be wrapped in burlap or in straw protectors. Both protective devices should be kept moist so that they can fulfil their function of reducing bark evaporation-transpiration and vascular tissue death,

- No root over 75 mm diameter should be cut, smaller roots should be cut cleanly and treated with a fungicidal dressing,

- The storage of garbage containers or any heating fuel tanks should avoid any tree root area.

- Ropes, cables, swings, tree steps and houses or other play uses for trees should be avoided.

- Removal of native shrubs, bulbs, natural tree regeneration, mosses, ferns or flowering plants from tree retention areas should be prohibited,

- Garden fires must be kept well away from the trees and roots. Even small quantities of hot air and fumes will cause damage,

- If existing hard paving or black top surrounding a tree is to be removed it must be replaced immediately with top soil before the surface roots dry out,

- A change in the level of the water table will kill a mature edge tree unable to adapt quickly enough to maintain an adequate supply of water and nutrients to a large canopy of foliage. Pondage over tree roots should be prevented,

- The ground level above the root system should not be raised more than 1.5 centimeters in any one year. With a greater depth there is a risk of root suffocation. The material used should be light porous soil with a band of coarse gravel around the base of the tree. The ground under the tree should be loosened before levels are changed,

- Annual tree inspection and maintenance of an active tree maintenance plan and work program should form the core strategy for safety around a property,

- Every significant tree should be covered by a damage penalty clause. The amount of the penalty should be sufficient to be a major disincentive to flagrant tree removal.

8.4 Safety and the Threat of Windblow

Each year members of the general public are electrocuted or injured working in or around trees and utility conductors. In addition, many hours of lost electrical service occur when trees touch or strike overhead power lines and transformers.

A British Columbia Hydro (1992) advert in province-wide newspapers in B.C. noted that:

> Since trees are such an integral part of our environment, power outages caused by falling trees and branches can never be completely eliminated.
>
> However, you can assist in preventing a significant number of these outages. First, by making sure that trees and branches do not contact your service lines (the wires that run from the power line to your house); and secondly, by notifying your local Hydro office of trees on your property which pose an additional hazard to nearby public power lines.
>
> **Your Phone Call Could Keep The Lights On**

While the onus for identifying electrical hazard trees on public land rests with the appropriate authority having jurisdiction, and to some extent with the electrical utility itself, the homeowner can and should be aware that trees and overhead wires clash all the time. Either the lines are disturbed by the trees or the trees are mutilated by continuous and expensive pruning.

Many new sub-divisions are now serviced underground and here the problem is diminished but not completely removed. Service vaults and house services can still be impacted by major trees fouling underground services as they fall or by lifting them out of the ground as plate root systems rotate during windthrow.

Hydro recognizes the risk that some homeowners place themselves in by not heeding the warnings associated with trees and electrical hazard. They note that:

Hydro will inspect the site and consult with you on the appropriate action. If removal of the tree is agreed upon to protect public power lies, Hydro will pay the cost.

But please, don't take unnecessary risks by working near live power lines. Call your local Hydro office or a certified tree trimming company for assistance.

An area of safety often overlooked in the interface between the urban forest and the new property owner with a substantially treed lot is where some portion or finger of retention trees is in close proximity to the structure or its foundation.

Clay soils have been found to significantly swell on wetting and shrink on drying. The two processes are, more or less, reversible. Heaving and subsidence of the surface, and damaging movements of structures founded on clay soil represent the sum of different movements below them. The quantitative response of soil to changes in moisture content depends primarily upon its clay content, but it is also greater the more the degree of compacted clay consolidation during construction. Clay soils are not uncommon in the Lower Mainland and, there are financial trade-offs between the costs of excavation, off-site spoil disposal, cost of replacement back-fill materials and consolidation equipment time, versus the possible long-term implications of building damage on tree roots. Trees in adjoining urban forest areas do regenerate aggressive roots and exploit clay soils, but the development industry does not appear ready to identify tree root damage in the future as a present concern.

It can, however, be safely postulated on the basis of experience in Europe that development sites with trees on shrinkable clay must have a balance between the various income sources of water and the different forms of water loss. This balance, the soil moisture content, varies all the time and, determines the subtle subsidence and heave which each site experiences.

If homeowners are not to experience structure damage to their building foundation when surface recharge in the summer is diminished due to weather conditions, it must be remembered that a mature tree needs the equivalent of about 25 mm of rain a month during the summer months. This represents considerable summer watering, a difficulty with the watering restrictions now impacting many Lower Mainland communities in the summer.

Reynolds (1987) has noted in Britain that notwithstanding:

> the contingency of modern foundation design, recent weather patterns and clay soils which shrink upon drying have given prominence to the damage by the roots of trees which are too close to buildings. In such cases it needs a major investigation to detect whether roots from neighbouring trees are approaching foundations and then to control them by methods short of destroying the trees. But, furthermore, no means of root training that comes to mind would be certain of lasting success.

While there is presently no clear evidence of foundation damage in the Lower Mainland or a direct result of urban forestry practices, there is no doubt a need to be vigilant. The problem has assumed major proportions in parts of the United Kingdom. Reynolds observes that:

> An inexorable series of events involving house-builders, lawsuits, insurers and building societies have served to harden helpful advice into what some folk see as an environmental menace threatening to exclude trees from the British urban scene.

It is now clear from the U.K. experience that trees are able to dry clay soils within the root range to around the dryness of the shrinkage limit. Vertical depth determines the amount of subsidence trees produce, and lateral extent, the distance they will cause soil shrinkage. In this way, drying may penetrate under the edge of pavement or building foundations. While water is available in the soil, the rate of drying is dependent on the drying power of the atmosphere. The amount of water available depends on the soil type, moisture recharge and the rooted volume of a tree or group of trees.

FIGURE 31 Failure of the stem in retention areas is high in hemlock. The potential for failure can often be seen at points of trunk fluting, or where small fructifications are evident.

Every effort must be made to identify potential windblow trees during clearing and construction. Nevertheless the ever evolving nature of the forest, adverse impacts from post-construction activity, and unusual weather conditions can create windblow candidates. Hemlock stem failure is another wind-related phenomenon seen on some Lower Mainland sites (fig. 31).

The homeowner, or strata corporation manager, must be every vigilant for the possibility of wind damage and wind susceptible trees. Large broken limbs hanging in a tree, broken tops and large dead limbs are hazards requiring attention. Each could fall either in high winds or unexpectedly causing injury to adults or children. Visual inspection on a regular basis even with a relatively unskilled eye is helpful in reducing exposure and potential lawsuits.

Larger trees are less susceptible to windblow than smaller trees in the forest canopy. Wolf trees and dominant crowns have exposed these trees to forces that develop good supporting roots. The same is not true of trees of lesser stature, if they are not open grown. Smaller trees below the main canopy are very susceptible to wind damage.

The high winds of November 1991 blew many larger Lower Mainland trees down (Smith 1991). Winds that follow excessive rainfall that soften the ground and winds from an uncommon direction can create massive windblow, even in dense urban forest stands. With a combination of these conditions even the most stable trees may yield. Once larger trees are lost, the remaining canopy may be significantly more vulnerable. Certainly that was the Port Moody experience with larger and larger openings occurring after an initial large tree loss. This can be further complicated by root mat connection where the root-mat listing of one tree may precipitate loss of stability in other trees (fig. 34, 35, 36 and 37).

The homeowner or property manager must inspect root areas for signs of ground displacement, root mat lifting or broken roots in any new cavities close to a tree base. Any concern should be brought to the property or greenbelt manager or, if on a property owner's own lot, professional assistance should be sought from qualified arboriculturists or urban foresters.

Topping is a practice in widespread use in the Lower Mainland, perpetrated in the false belief that it will reduce the likelihood of windthrow (fig. 33).

Newhouse (1992) has suggested "Topping is the worst disease known to trees". Turnbull (1993) has referred to it as "mal-pruning". What the practice does do, particularly in conifers is cause a tree to loose apical dominance and to become multi-leadered. This stagheaded effect produces a weakly attached group of tops, vulnerable to snowbreak or further wind damage. Moreover, the open top is a source of decay entry into the stem causing rot from the top down as time progresses. Crown thinning is a far preferable technique to top removal.

Homeowners and strata corporation managers must be aware that along with land ownership with, or contiguous to, wooded lands comes a responsibility to themselves and to the community to ensure tree safety.

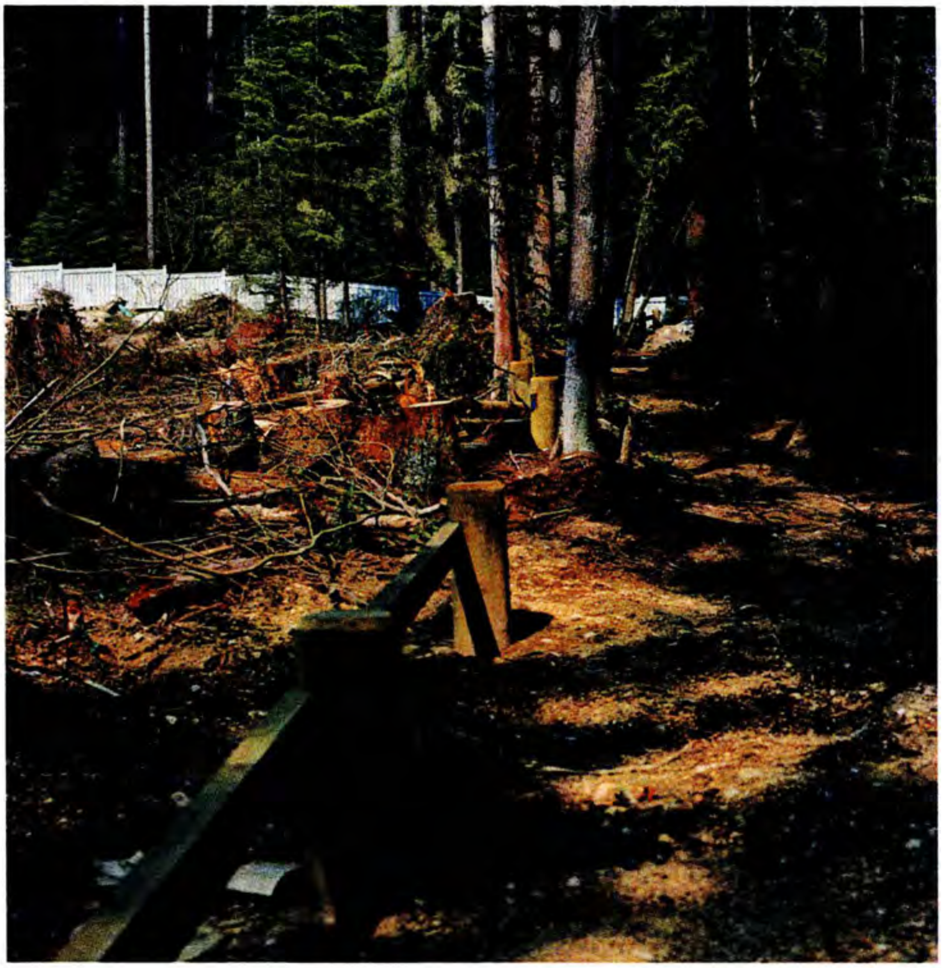


FIGURE 32 The utility of installing private to public delineation by fencing is often offset by the loss of edge trees removed to ensure access.

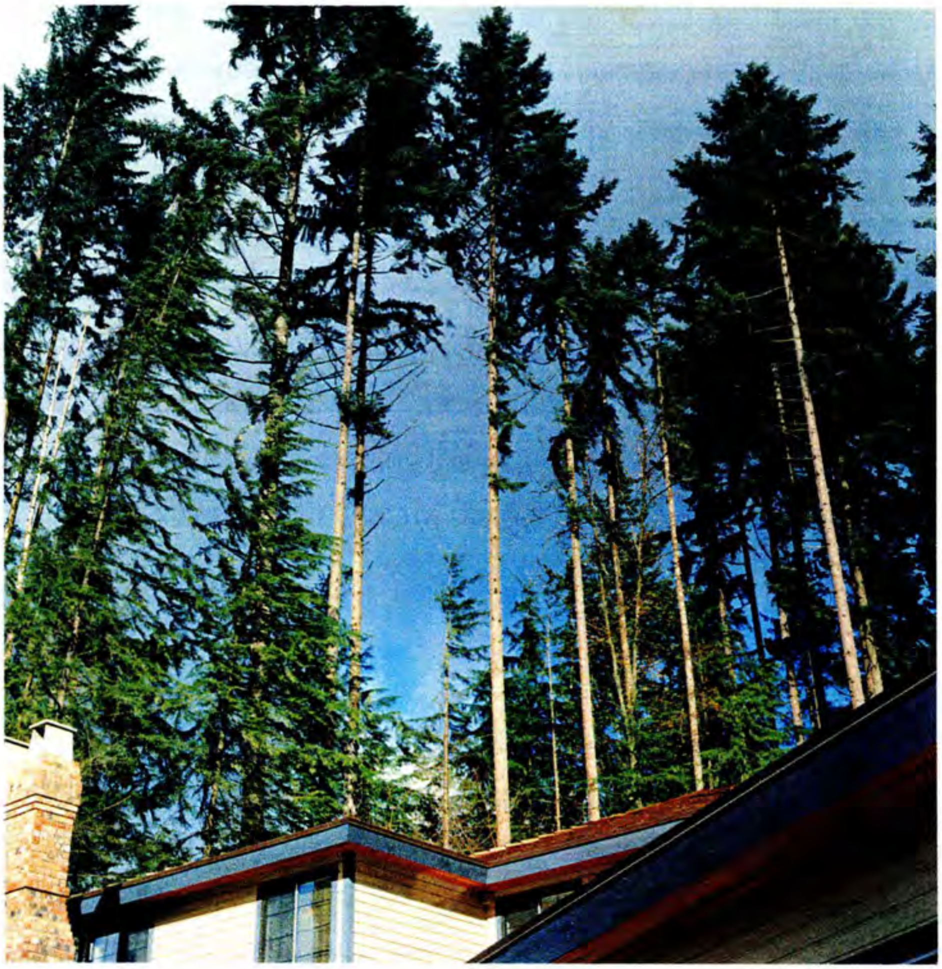


FIGURE 33 Tall branchless trees close to home sites can be unsettling for owners and result in major topping operations which actually reduce the long-term safety of most trees.

8.5 Vandalism

Vandalism in the urban forest can take many forms, some deliberate and some with consequences unthought of by the perpetrators.

The most common of the latter is the formation of pathways and trails which stray throughout an area in a web-like pattern. Here, compaction and loss of understorey or regeneration are inevitable outcomes. Mature tree decline is also a consequence, particularly in and around areas of soft ground.

Removal of understorey through garden encroachment fencing (fig. 32), or deliberate taking for greenery, christmas trees or removal of flowering plants such as current and trillium was also a problem seen in Port Moody. Campfires that cause stem scorch are problems of the urbanite treating the urban forest as wilderness. Fire of any sort is, as previously discussed, a constant danger. Tree house construction, swings, play area, lean-to's, and shelter constructed by campers, hikers and the homeless, all were individual tree impacts.

Actual taking of trees, either smaller regeneration for garden or container use and larger trees for construction of grade changes or firewood are the most deliberate forms of vandalism. While the individual removal of plant material has a minor impact, the incremental taking by many lot owners can reduce both the treescape character of areas and the viability of smaller leave patches.

The disposal of urban waste is an ever increasing problem. The use of the urban forest, particularly when it is accessible without oversight, is an ongoing problem in many communities. Vigorous enforcement of anti-dumping or littering bylaws and public education may help. A similar problem is caused by homeowners with lots contiguous to public lands who take their organic debris and pile it or bury it in the urban forest. Undesirable non-native weeds, vines and garden perennials then become invasive.

Minor vandalism such as carving initials and limb breakage is seen often caused by youth. Here the problem is not so much one of damage *per se* but the need to engender respect for the forest ecosystem so that more major damage will not be a natural behaviour outcome in adulthood. School programs seem worthwhile.

An ever increasing problem exported from the urban environment into the surrounding wooded areas is the use of all terrain summer and winter recreational vehicles. The most pervasive of these are clearly dirt bikes but three and four wheel drive utility vehicles and snowmobiles are also of concern, the latter perhaps less so. These vehicles create ruts that cause channelization and erosion as well as compaction, sometimes over wide areas, or soft areas are avoided by moving further and further into the forest. Some legal relief can be obtained by using the *Trespass Act* and possibly the *Motor Vehicle (All Terrain) Act*, but in both cases, perpetrators must be caught and confronted. A more viable, but certainly more costly, solution is that of fencing an area. Certainly "opportunity" seems to play a large part in the degree to which areas are accessed. Wilson (1979) has noted that public property is the most vulnerable. Protection of these community assets is certainly a matter that all Parks Departments must recognize.

FIGURE 34 Large root mats disturbed by major root severance can precipitate major tree losses as a result of windblow.

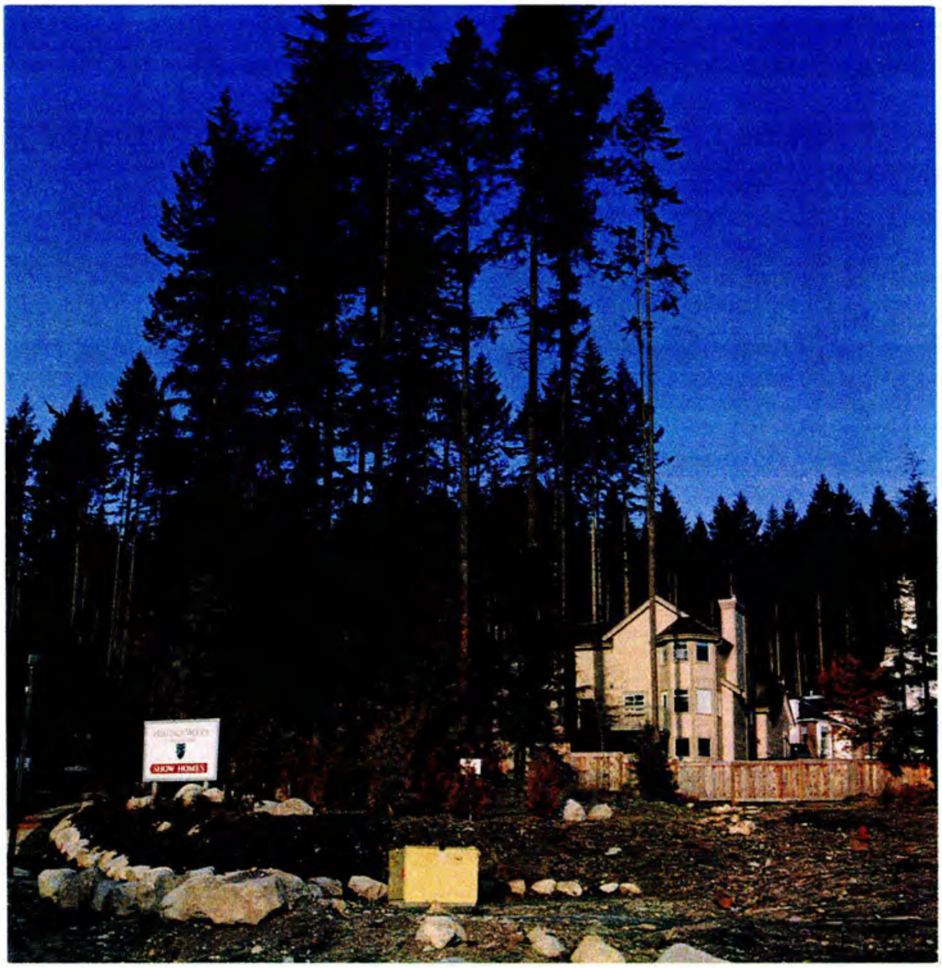


FIGURE 35 In the Port Moody Heritage Mountain experience, large clumps of trees withstood the rigours of major winds in the fall of 1991 and still remain to provide forest character to the development.

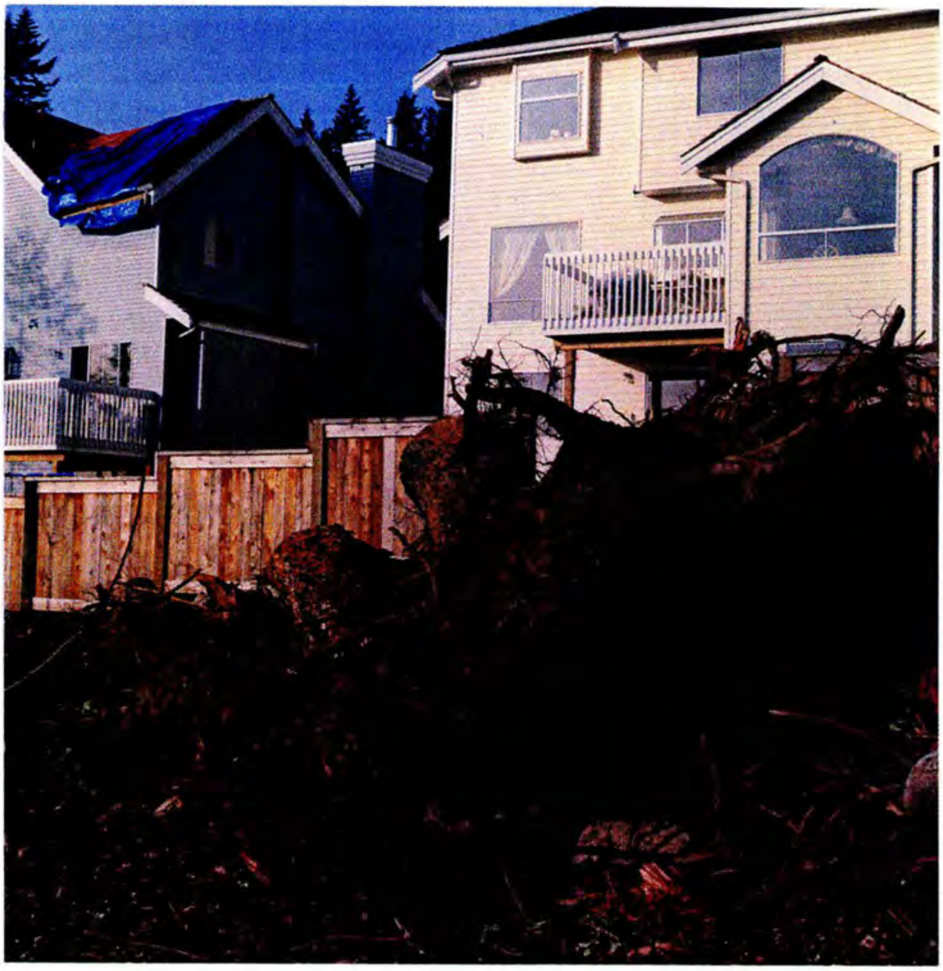


FIGURE 36 Saturated rains combined with southeasterly winds of unusual intensity, and a retention belt originally intended to be a minimum of 20 metres wide, lost many edge trees to construction and eventually blew down almost completely in 1992. Significant housing damage occurred.

FIGURE 37 Eventually the few remaining trees were removed from the greenbelt. However, replanting of the remaining land base is a viable second strategy to provide homeowner noise and visual protection from a future major arterial road.

8.6 Personal Responsibility and the Urban Forest

Inadvertent and deliberate actions can diminish or destroy the urban tree resource. The homeowner with or beside trees has a personal and a community responsibility for the safety, vigor, maintenance, replacement and inspection of their own trees and a responsibility to be vigilant and to report anything untoward in stands of public trees.

Yard activity such as soil additions, cribbing construction, pool construction, pouring of shed and building footings, drainage activity and similar disturbance can yield environmental changes that are not favourable to tree growth. Yard maintenance such as herbicide use, composting, compaction, flower bed root cutting around trees and fence construction can all diminish tree vigor. Disposal fires and barbecues can produce hot air and gases that kill foliage.

The urban forest is a living, dynamic resource that requires positive attention. The homeowner has an active role to play in maintaining the local tree resource and their property value for the future. Community arbor days, neighbourhood tree planting or clean-up activities can enhance the resource and community appreciation of it. Liaison with a parks department through neighbourhood parent or school presentations and additional literature will enhance mutual understanding of needs, area expectations, and resource constraints. Public advocacy in the form of letters of support for local historic trees of value, locations threatened, treed areas in need of management, the need for protected areas on development sites, and greenbelt or park retention and improvement is vitally important. Public support of local tree programs can and does translate into political priorities and departmental budgets.

Finally, greenbelt or urban forest plans for maintenance in perpetuity need local input. Here the property owner or 'guardian by proximity' has the important duty to reflect local priorities and expectations in the care and custodianship of their immediate and community treescape.

9.0 Conclusions and Recommendations

9.1 Introduction

The complexity of urban forest management and the inter-related nature of the continuum of design, construction, protection and maintenance leaves many elected officials and members of the public perplexed by the whole process. Public meetings to evaluate designs for individual developments often degenerate into discussion of individual expectations. These are often unrealistic. Conflicting comprehension of the constraints and opportunities from urban forest management are offered by a host of different professionals each with their own specialized backgrounds and technical knowledge. That knowledge is rarely supplemented with a holistic understanding of the principles of tree management, let alone specific knowledge of individual tree retention requirements. It is, therefore, incumbent on municipalities with an interest in urban forestry to develop a comprehensive plan and program that encompasses the philosophical, programmatic, task emphasis, factual resource information base and that stipulates responsibilities in explicit form for comment and guidance for all who interact with the tree resource.

Two simple models have been constructed as a framework to examine the component parts of comprehensive tree management in a municipality. The associated text poses some challenging questions a municipality may wish to address in preparation for developing a comprehensive urban forest management strategy. The preparation of a municipal Urban Forest Master Plan is suggested and content requirements proposed. One model suggests twelve core topics that an urban forest program must address. The second model examines essential issues. It proposed that planning, design, construction, silviculture and management are key elements in any strategy. Each element is further broken down into four parts. These subdivisions are examined and individual areas of concern identified.

TABLE 7

A MODEL FOR MUNICIPAL URBAN FORESTRY PRACTICE: ESSENTIAL COMPONENT PARTS

PHILOSOPHY. • The underlying principles that support a tree program. • **Civic pride.** • Community spirit. • Cultural stability.	**POLITICS.** • Political platforms. • **Commitment to the environment.** • Tree program goals. • Implementation strategy. • Bylaws and funding.	**POLICIES.** • **Broad program policies.** • Departmental policies. • Safety policies. • Operational policies.
POWERS. • Funding bylaws. • Tree regulatory bylaws. • Development bylaws. • Use of related laws to protect and enhance the resource.	**PEOPLE.** • **Professional training and education.** • **City department development staff awareness.** • **Public education.** • **Developer awareness.**	**PERCEPTIONS.** • Psychological benefits of trees. • Visual benefits. • Physical benefits. • Financial benefits. • Cultural constraints. • Costs of management.
PLANTS. • Benefits and constraints of individual species. • **Silvicultural management in groups.** • Safety, repair, replacement.	**PROBLEMS.** • Lack of appropriate tree resources. • Lack of community interest. • Diminished economy. • **Lack of a comprehensive plan, or adequate funds.**	**PROCEDURES.** • Funding programs. • Records system. • **Resource inventory.** • Standards and guidelines. • Inspection and safety. • Enforcement.
PRACTICES. • Mandate to staff. • Men and expertise. • Methods utilized. • Materials utilized. • Machinery utilized.	**PLANNING.** • **Community Urban Forest Management Master Plan.** • Community Plan requirements. • Neighbourhood plans. • Individual greenspace plans.	**PROSPECTS.** • Finite funding. • Mechanization. • **Community "wellness".** • Local environmental quality. • Increasing urban forest land.

Note: Bold face identifies key requirements.

9.2 Urban Forest Management Models

The need for a simple base model seems to be borne out by the lack of comprehensive, coherent tree management in many Lower Mainland municipalities despite strong public support for a treed environment. The following twelve elements provide a textual framework in which to build an organized municipal urban forestry programme. They are based on an earlier outline (Gardner 1980).

The first model is constructed as a pandect utilizing the parmanon of words starting with the letter ‘p’. This provides a simple prompt for the complex issues that underpin urban tree management. The twelve part model is also shown in Table 7.

The first element in the model is PHILOSOPHIES. These are the underlying concepts of symbolism, the symbolic intent of tending and planting trees that embodies the relationship we have between our urban community and our roots in the distant past. Here man identifies with nature, civic pride, cultural stability, and historical perspective. From a philosophical base, a community builds values. From values are built priorities. Unless there is a strong, well thought out philosophical basis for urban tree retention, planting, and management, there is little to support the effort and funds required to retain and manage urban forest trees.

The next element is POLITICS. All municipal residents have power that relates to politics. In a democratic society politicians reflect electors priorities. Political leadership and emphasis will direct appointed staff. Where the political agenda supports urban forestry, the administrative agenda will follow. Electors should get from politicians a firm commitment to the continuity of urban forestry programmes because words alone mean little without a full fiscal commitment. Then elected officials must adopt a strategy, since without a strategy nothing can be implemented. This should be a formal strategy; a long-term community "Master Plan", so residents know where their community is going. A plan that documents greenspace and urban forestry community objectives, and imposes a timetable or spacial framework in which these objectives will be implemented.

The next component of the model is POWERS. Tree program administrations must concern themselves with both direct powers, controls or bylaws and what may be termed impinging or related powers. What are they intended to accomplish? Are they beneficial or detrimental to the urban tree resource? Does the law support adequate stewardship of the municipal tree resource? Municipalities can use their delegated "powers" to enhance and protect the urban forest and historic trees. They must, however, adopt bylaws for this purpose based on the enabling provisions of provincial statutes. Many municipalities have yet to face this step.

The next "P" is for POLICIES. Policies are either overt or covert. Many municipal departments do not have explicit polices. They are often covert, implied, or worse still, they are assumed. Yet, without knowing the framework of policies underlying an urban tree programme no one, developers, staff or general public, can make any reasonable or rational prediction as to the progress or intended outcome of a programme. This is a question of public accountability. There are two types of policies at the municipal level which predominate. There are those established by appointed officials and those established by elected officials. It is incumbent on those who write tree management polices to write them in a simple form so they can be understood. This will ensure a wide measure of public communication and make certain their content, and intent, is general knowledge. The development community will benefit from such clarity.

The next P in the model is for PEOPLE. This probably is the most important topic, there are so many disciplines involved in the management of urban trees: planners, engineers, architects, horticulturists, foresters, landscape architects, arborists and many more. They each have different backgrounds and different priorities; most have a different understanding on how trees perform. During the process of retaining and managing trees, there is a need to unify these differences and find common ground. One way this could be accomplished is to put together a complete "communications net", a graphic identifying and connecting all those who are involved and detailing how and why these people come to be included. In the City of Vancouver tree programme, for example, there are 18 city departments involved including 11 sub-divisions of engineering: sewers, street lights, utilities and roads, to name but a few. From a tree program "communications net" the common ground of concern became visible. Once it is clear who is involved, and why, and what problems each has, the people element can be the greatest asset any municipal tree retention or urban forest management programme has, rather than the most devisive. Outside city departments there is a whole world of other participants who must be drawn into the "communications and comprehension net". This includes other municipal departments contiguous with the primary municipality, other levels of government, the general public, including special interest groups, the media, industry, commerce, contractors, developers, and equipment operators. A municipal urban tree programme must work with all of them, not in spite of them.

P is also for PERCEPTIONS, which can be translated into "perceived values". There has been a great deal of emphasis in past urban tree management on aesthetics -- the unity, variety, colour, form, mass and effect of trees. More thought should be given to the relationship between urban vegetation and mental wellbeing; to mans oneness with nature. Our thoughts should embrace the more subtle benefits from trees in the city, the intrinsic values of livability, and, importantly, the impact on a sense of community and city pride. The physical contributions that urban vegetation makes should also not be forgotten, particularly as they related to climate modification and air pollution reduction. However it should not be forgotten that some people and some ethnic groups may perceive urban trees in a completely negative way.

The next model P is for PLANTS. Many professionals tend to consider trees in too narrow a vein. A "Profile for Plants" can be developed be outlining information for choosing or retaining the most appropriate trees and ecologically sound units for a particular location. The profile should include information on tree family, genus, species, native or exotic status, what derivation the plants have and, for ornamental specimens, what sort of flowers, fruits, flowers and leaves they produce. It would continue with particulars of bark and trunk, crown shape and branching habit, crown size and height at maturity. It would also list details of tree vigour, growth rate, rooting characteristics, soil requirements, longevity factor, as well as safety and maintenance requirements. In this way, tree managers have a localized reference on plant material.

The next of the alliterative P's is for PROBLEMS. Problems often act as constraints. Political and administrative constraints for example, about what can or cannot be done in tree retention, where, by whom and for whom. Constraints can restrict design opportunities; organizational constraints can cause artificial barriers to solving design team problems; physical constraints can limit space available for, and the location of trees; biological constraints can proscribe the spectrum of species tolerant of urban abuse; legal constraints can retard the development of innovative ideas. Municipalities must have tree management systems which will properly detect and define problems of safety, vigour and sustainabilty, preferably before they proliferate. All programme participants must have the empathy necessary to develop sensitive, appropriate solutions for urban treescapes.

P is also for PROCEDURES. These can be defined as the methodology behind managing trees in the urban environment. Procedure issues include programme funding and budgeting, staffing, work load assessment and analysis resource management record keeping and historic perspectives, predictive techniques for resource assessment treatment as well as programme communication with stakeholders. Such records are important to long-term resource management. Is there an adequate choice of species? Is there a replacement programme for trees that have passed maturity? Do parks department have good communication techniques and do tree managers use all the avenues of publicity open to them?

The next P is for PRACTICES, also it might be termed tasks and techniques. The basic elements of field practice can be outlined under the headings: Mandate, Men, Motivation, Methods, Materials and Machinery or tools. Each of these factors influence the quality and quantity of productivity in field tasks and, ultimately, the condition and success or failures of any urban tree programme.

Mandate: Authority must be given through an arboricultural, parks or urban forestry group in a municipality to individual work teams. Assignments are influenced by practical restraints such as manpower availability and training, as well as overall group structure, through foreman and sub-foreman responsibilities and job title. Although formal responsibilities are typically outlined in individual job descriptions, verbal communication is still relied on for allocating scope, location and type of work. Clarity of interpersonal communication and task follow-up are critically important.

Men: Field staff responsible for an urban tree programme play an instrumental part in attaining its goals and objectives. Closely linked to the actions of staff, both men and women, are their own motivations and expectations. Important considerations for job practice relate to the broadest interpretation of working conditions. Arboriculture and urban forestry attract a particular type of individual, often with above average intelligence, practical knowledge, independence and a pride and interest sometimes lacking in other vocations. These attributes are a characteristic of many employed in municipal urban forestry and this background provides an ideal opportunity to invest in upgrade training and education of the work force.

Methods: In order to undertake the tasks that form the establishment, removal, and replacement of urban trees a number of methods must be employed. Within any method there are a number of discreet steps that collectively accomplish the desired end result. It is possible to detail these steps and produce explicit work standards.

In this way acceptable practice can be reviewed, accepted or rejected. This provides an important step in formalizing approved field practice.

Materials and Machinery: Careful discussion with field staff, review of scientific literature, and the adoption of new techniques coupled with the use of new materials can improve urban forestry practice. Significant advances have been made over the last decade in integrated pest management, arboricultural materials and in mechanizing urban forestry. New equipment for lifting, planting, moving, root pruning, fertilizing, converting and removing trees is on the market. A new family of hand tools for hydraulic pruning, tree surgery, tree decay diagnosis, and applying pesticides is available. Advances have been made in office equipment with personal-computer based tree inventories, computerized landscape graphics and mapping, airphoto interpretation, infra-red colour photography, computer disk (CD) records storage and similar techniques that increase efficiency in urban tree programmes.

The next P in the model is for PLANNING. Planning is a fundamental necessity in the management of a renewable and sustainable resource such as urban forest trees. It provides a strategic outline for planners, managers, developers and the general public who will be programme beneficiaries and it will document intended regional silvicultural and maintenance practice. A municipal urban forest master plan should be prepared which would contain the following components:

1. An *introduction* containing discussion of the use and benefits of trees in urban situations. An outline of the purpose of an Urban Forest Master Plan, a discussion of the plan in relation to the Official Community Plan, and a review of broader objectives for management of green space and urban appearance.

2. A *description* of the municipality that, in addition to the layout of streets and the location of areas of geographical, historical, ecological, environmental, formal park, greenspace, or cultural importance, includes an examination of local climate, history

of the original natural vegetation, and topography.

3. A *description* of the existing urban forest resources and a record of those parts of the municipality with future potential for tree retention or planting including private and public property. In addition to a street tree inventory, a park, greenbelt and encompassed Crown land inventory would also form part of the description of the existing resource.

4. A *discussion* section should review the history of the present urban forest and present an appraisal of its current condition, age, composition, and suitability as a contributor to the character of the municipality. In addition this section would identify areas for tree preservation, areas needing silvicultural renewal of the present resource and areas where modification of the immediate tree environment would be desirable.

5. A *description* of the municipality's tree management strategies and tactics which would outline the adopted goals and objectives for the programme, describe the management criteria and outline the policies that support the programme, document the legislation applicable to the resource and report the procedure for obtaining funds. Additionally this section would state the responsibilities assigned to various departments or sections within the municipality, as well as note implicit responsibilities of others that interact with the urban forestry programme.

6. A *discussion* section should examine constraints affecting tree management, including funding and pace of urban expansion, such as recreational, park or major housing area development. This section would also propose appropriate techniques for public participation in the development of the tree resource and comment on the relationship of the tree programme to other departments, municipal projects or initiatives. Where appropriate, administrative procedures, proposed standards for developments, and similar control topics pertinent to the overall programme, would be included.

7. A *design outline* section would embody landscape and forest designs for the future. Elements of design for future developments would be included in a descriptive section of the plan, and design criteria, design objectives, choice of species and the function of design would be discussed. Specific designs for new plantings, improvement practices, and for replacement plantings would be prepared. Guidelines would be developed for critical locations.

8. A *responsibilities* section would identify principal responsibilities, funding, and the assumptions on which the plan is based. It would include the specific relationship of the plan to other urban developments, the degree of flexibility in the programme, and a discussion of emphasis for priorities. Compatibility with proposed urban engineering improvements, phasing and logistics for new, retention, and replacement tree planting, as well as expected assistance from other agencies or levels of government would be noted. Specific methods for input from the public and the business community would be developed.

9. An *action* section would contain the actual plan timetable for the implementation and execution of the programme with clear milestones outlined. It would document the establishment, replacement and maintenance proposed for both existing and individual parcels of undeveloped, treed land. The plan would also include specific provision for review and revision during the time-span of each component part of the programme.

The final model P is for PROSPECTS. Prospects for the near and far future are hard to predict. It is impossible to accurately forecast what will happen during the likely 50 to 90 year lifespan of trees planted or retained today. They should certainly last into the first half of the 21st Century. Urban dweller emphasis will still be for an improved, safe, greener, low impact and healthy living environment. The scourge of government deficits may continue. With deficits will come reduced municipal budgets but new, focused, priorities. As public expenditures are ever more closely scrutinized skilled, innovative, managers will be required to explicitly state urban forest management objectives. Tree care will have to characterize urban forestry programmes of the future.

- Levels of service will be explicitly tied to values, costs and public expectations,
- Trees, community character, and wellness will remain fundamental issues in urban and suburban communities,
- Public demand will support a quality environment at the local level,
- Any corporate greed or elected official indifference in environmental matters will be overturned by public anger and private, local level, action,
- Retention of greenspace for passive recreation with connectivity of green corridors will remain firmly on the public agenda,
- Issues of liability, responsibility, and accountability will drive improved levels of inspection, silviculture, tree maintenance and safety,
- Professionalism will be paramount. Complexity of the process will not be an adequate public defence tactic for project proponents who fail to deliver on their development promises,
- The high technology computerized ability to individualize information collection and distribution will allow powerful visual, factual, defences to be drawn up for threatened local resources. Trees will benefit, and,
- Articulate public challenge will accompany any paucity of spirit and vision in the development of urban forest and greenspace plans.

The second model, Table 8, examines five key areas of concern that emerge from this paper and the field experience on which much of it is based. Those areas are: *planning, design, construction, silviculture and management.* Each are areas of weakness in the present process of urban forestry activity in the Lower Mainland of British Columbia. The urban forestry literature would suggest that they are not unique. However, this portrayal of the issues in tandem with the process analysis in this study may serve to focus attention on specific problems. in need of policy attention or improved operation practice.

The five areas of concern are further sub-divided into four categories each, with an issue heading. Listed below each heading are essential factors that urban forest managers, faced with continued urban expansion, then must recognize and then address in the urban forestry sub-system: *retention and management of trees in new housing developments on wooded lands.*

TABLE 8

URBAN FORESTRY PRACTICE IN URBANIZING AREAS: ESSENTIAL ISSUES.

PLANNING

CONTEXT.
- Philosophical underpinnings.
- Urban forest conceptualized.
- Ecological validity.
- Public interest/pressure.
- Forest character expectations.
- **Documentation of values.**

VALUES.
- Benefits - physical.
- Benefits - perceptual.
- Benefits - property values.
- Heritage and civic pride.
- **Treed areas as assets not liabilities.**

LAND DESIGNATED.
- Public expectations.
- Official Community Plans.
- Zoning controls.
- **Density trade-offs.**
- Parkland provision of sub-division.
- Incentives and gifts.

LAW.
- Acts & regulations supporting trees.
- Bylaws supporting trees.
- Permits.
- **Enforcement on site.**
- Penalties.
- Restrictive covenants.

DESIGN

SITE OPPORTUNITIES.
- Physiographic attributes used.
- **Resource inventory and analysis.**
- Resource condition and location.
- **Suitability for tree retention.**
- Tree needs understood by team.
- Trade-off principles known.

FINANCIAL CONSIDERATIONS.
- Economics of the marketplace.
- Economics of the site.
- Economics of tree retention.
- Housing type and costs.
- Lot sizes and shapes.
- Flexibility of planning.
- **Profit expected.**

SITE ARRANGEMENT.
- **Lot sizes and shapes.**
- **Non-rectilinear flexibility.**
- **Building separation from trees.**
- **Grading cut & fill minimized.**
- **Placement of services.**
- **Tree needs understood by team.**

MANAGEMENT CONTROLS.
- Explicit builders guidelines.
- **Clearing contract documents.**
- Detailed specifications.
- Pre-determined penalties.
- Equipment operator classes.
- Inspection schedule.

CONSTRUCTION

CLEARING THE SITE.
- Tree removal & utilization.
- Funds generated for planting.
- Grubbing control.
- Stripping control.
- Debris disposal control.
- **Demarcation fencing.**
- Hazard tree removal.

SITE SERVICING.
- Location vis a vis trees.
- Side-casting spoil control.
- **Tree area incursion control.**
- Penalties.
- Site water management.
- Repetitive inspections.

CONSTRUCTION CONTROLS.
- Excavation limitations.
- Physical tree area protection.
- Constant debris management.
- Temporary road control.
- **Insightful site superintendence.**
- Repetitive inspections.

POST-CONSTRUCTION PERIOD.
- Hard landscape installation controls.
- Debris & cleanup management.
- Windthrow safety.
- Edaphic change & impact.
- Inspection intensity.

SILVICULTURE

OBJECTIVES.
- **Sustainability.**
- Bio-diversity.
- Canopy preservation.
- Integrated uses.
- Stand health and vigor.
- **Safety.**

PRESCRIPTIONS.
- Stand composition.
- Age class diversity.
- Crown cover manipulation.
- **Replacement system(s) adopted.**
- Risk and potential for canopy loss.

STAND TENDING.
- Provenance and genetics.
- Natural reproduction, planting.
- Competition management.
- Intensity of practices & tactics.
- Thinning for betterment.
- Hazard tree removal.

BIOTIC FACTORS.
- Vandalism & cutting.
- Dumping & encroachment.
- **Fire protection.**
- Pest Management.
- Urban stress factors.
- Inspection intensity.

MANAGEMENT

PUBLIC UNDERSTANDING.
- Public & local policy.
- Objectives of management.
- Need for interventions & flexibility.
- **Awareness Centre.**
- **Urban forestry program funding.**

COMMUNITY INVOLVEMENT.
- Official Community Plans.
- Public advocacy on needs.
- **Public support for funding.**
- Arbour days & outreach.
- Advisory committees.
- Public tree planting involvement.

PLANS
- **Municipal urban forest plans.**
- Stand management plans.
- Working plans and tactics.
- Private treed lands advice.
- **Regional context & strategy.**
- Green linkages.

EDUCATION AND RESEARCH.
- Municipal parks skill levels.
- Design professions tree knowledge.
- Urban forestry education public.
- Arboriculture certification.
- **Urban forestry, silviculture and protection research.**

Note: Bold face identifies key issues.

9.3 Summary

General Context

The complex interface of urban and suburban housing growth with the forested lands of the Lower Mainland is poorly understood. The benefits of tree retention in housing areas, both perceived and actual, are undermined by lack of professional understanding about the dynamic nature of forest growth, by market forces that dictate the greatest number of units on the smallest area, and by lack of regulatory enforcement of existing legal powers that support tree retention and subsequent management.

There is strong support in the community as a whole for sustainable tree retention and preservation. While some developers have tried to ensure some tree retention in wooded lands, these efforts have often failed. This is mainly due to a general lack of understanding of the physical needs that trees have for a defensible growing area, free of disturbances.

Sustainable tree retention in the wooded lands of the Lower Mainland has become an important issue for municipalities, developers, and the public as a result of provincial legislation directed at preserving arable land from housing encroachment. This, coupled with significant population immigration into the Lower Mainland, has forced sub-division development into the forested slopes surrounding the Fraser River flood plain.

The urban forest surrounding communities encompasses a wide variety of different areas. Many are unique in terms of their resource management needs. Sustained maintenance and preservation of treed canopy characterizes each of the definable sub-systems of the urban forest. Nowhere are the management needs of the urban forest resource more evident and less understood than in developments for new housing.

Planning and Legal Constraints and Opportunities

The change of land from a "natural" state to one supporting habitation and commerce is provided for in a range of statutes and enabling mechanisms. While many of the latter have not been used extensively, recent amendment to the *Municipal Act* now provides municipalities wide powers to ensure retention and preservation of trees, or areas of trees and associated vegetation, both on public and on private lands. These powers, while not yet tested in the courts or subjected to compensation claims review, would serve to help municipalities fulfil community expectations for greenspace preservation set out in official community plans.

The zoning and sub-division processes also provide a municipality with tools that can influence the growth, character, type, and nature of development in a community. A coherent greenspace strategy can, and should, emerge when each part of the land planning process works toward that end.

While retention of some treed lands in developments are thought desirable by many residents, and this support is often strongly voiced at public meetings, tree retention must reflect the practicality and safety of tree retention on any specific site. Where it is unwise, due to environmental, edaphic, or species considerations to retain the existing tree cover, the concept of clear-cutting poorly treed land designated for greenspace and replanting, must be actively promoted.

Design

When tree retention is proposed, it will only be successful where it is linked to comprehensive surveys of the vegetative resource, coupled with sensitive design that integrates infrastructure design and construction with viable vegetation retention boundaries.

The urban forest design process should be an integral part of the continuum that takes forested land and attempts to integrate infrastructure, housing and commerce into it, while maintaining a sense of forest character. At present, the professional expertise necessary to understand trees and how they are impacted by construction is not commonplace in development design teams. Failure of some designs, will hopefully prompt designers to involve urban forestry and arboricultural expertise from the very beginning in all aspects of the planning/design process.

Design criteria, while difficult to specifically develop or apply to every site, must recognize that grade changes and service corridors or trenching can have dramatic negative impacts on tree health, survivability and safety. Viable tree retention is also greatly determined by land topography and soil substrate on which they grow.

A critical and determinant factor in tree retention decisions is the in-place tree resource. Age-class diversity, tree species and height, spacing, and general condition are all key considerations.

Careful site analysis can and should identify natural physiographic features, slope, lot sizes and locations, linkages or corridors, park sites, facility sites or clustered housing layouts. All of these factors influence tree retention opportunities.

Tree retention for retention's sake, while ignoring the reality of the tree resource present, is unwise. A treed character can be readily imparted to an area if appropriate and strategic locations are determined at the onset of the design process. Planting of new trees, reinforcement planting below or within existing trees, and similar silvicultural techniques can provide treed areas over time. Forest character will evolve as species establish and grow.

Urban Forest Stand Management

Silviculture, the development, enhancement and tending of forested lands and the manipulation of forest cover toward the specific urban forest objectives of canopy maintenance in perpetuity is poorly understood and rarely practised in Lower Mainland woodland areas. This will be to their detriment over time. Losses may occur either slowly and almost imperceptibly or catastrophically following high wind, interface crown fire, or pest exposure.

Lack of stand tending strategies and activities is a present silvicultural weakness in managing wooded lands in the Lower Mainland. Many treed areas are purely derelict with no replacement planing, hazard tree removal, composition change, or any other remedial or protection treatment being extended to them.

Construction

The activities of construction, particularly grade changes, excavation, disrupted drainage patterns, and compaction can have devastating impacts on both the growing medium for trees, or in physical damage to trees intended for retention. The difference between design drawings and actual field conditions is often not reconciled to the advantage of tree retention. Unplanned intrusions into protection zones for servicing, or careless maintenance of protection area edges, can cause significant resource loss.

Once clearing and top soil stripping is complete, retention areas must be protected with physical barriers and clear signage. Stiff penalties should be levied if breaches of protected areas occur. Sums of $5,000.00 per breach and $500.00 per tree are not unreasonable. Penalties should be used to restore and replant disturbed areas. Monies should be diverted to a dedicated trust fund for that purpose.

Constant site inspection by a qualified arborist to assess tree safety needs to be built into construction schedules. Inspections that follow initial resource inventory and mapping need to include retention boundary assessment following stripping, following site servicing, and following construction. Post-construction inspection after retention areas have stabilized following seasonal wind exposure is also important.

Where site conditions or the tree resource are found to differ from design expectations and tree removal and replacement are indicated, a formal approval mechanism that simplifies safety considerations, and tree removal, must form part of the construction process, notwithstanding planning and political expectations or prior commitments. The system adopted must safeguard against abuse.

Fire Risk

A topic little recognized in the context of the Lower Mainland is that of interface forest fire. The risk is considerable. Many municipalities have allowed housing development to extend into forested areas but have not prepared fire plans to meet the challenge of an extremely dry summer. While the B.C. Forest Service is keen to work with municipal fire departments, many have not signed agreements for mutual aid or practised together. Many fire departments are ill-equipped and ill-trained to fight forest fires.

Public education on the need to physically and mentally prepare for forest fire conditions in the urban fringe is lacking. Experience from California has not carried forward into activities in the Lower Mainland except where the B.C. Forest Service has actively solicited cooperation or provided literature outlining associated risk. The potential for major forest fires in the Lower Mainland remains.

Urban Forest Maintenance

The urban forest has three fundamental management needs: planting, stand maintenance, and hazard tree removal. All are aimed at stand vigour, crown cover, and treed appearance in perpetuity, as well as public safety. The present level of maintenance management in wooded areas throughout the Lower Mainland is abysmal. There is an ever increasing risk of human death caused by hazard trees, or parts of trees falling on people or property. There is also a significant risk of catastrophic loss of the urban forest if it were subjected to the type and level of winds experienced during Hurricane Freda in 1962. Gusts in excess of 125 kilometres per hour will create significant tree losses in recent development areas. This will be particularly true in very new developments or stands with little or no maintenance.

Many municipality parks departments, most tree companies, and a significant number of design team members in professions related to urban forestry, such as landscape architecture and planning, need to improve their skills and levels of knowledge about basic tree physiology, silviculture and maintenance. Professionals with these skills need to provide outreach instruction to help this process.

Treed Land Ownership

Canada is following the dubious lead of the United States and becoming a more litigious society. Owners of trees must be made more aware of the legal and insurance implications of having treed areas and, in particular, of failing to have a planned inspection and maintenance program. People living in close proximity to treed public lands also need to be assured that a municipality has a consistent management and maintenance program.

Responsibility for the management of the urban forest lies for the most part in the management of municipal lands. Public ownership of urban forest lands predominate in the Lower Mainland. The present levels of maintenance are a reflection of budget apportionment and budgeting of scarce tax dollars. Public involvement, advocacy, and demand is required to move urban forest management toward a more comprehensive management of the resource. Models for holistic management hold some promise in providing a framework for urban forest strategies as we move into the 21st Century.

9.4 Conclusions and Recommendations

This study has examined the continuum from changing community attitudes that vigorously support the retention and development of forest character in existing and new housing developments through to the management needs of the urban forest. Four principal findings emerge from this analysis.

1. A more aggressive, intensive level of forest management is required in most urban forest areas, particularly of public lands in the Lower Mainland, if the objective of retaining forest character through sustained maintenance of treed canopy is to be realized. The general public must assist municipal parks departments to acquire sufficient budget and skilled staff for silvicultural operations. Both public land administrators and private landholders with treed areas should adopt a formal program of inspection, maintenance, and improvement of their tree resources.
2. The design process that presently applies to many attempts to retain trees on housing development sites is flawed. Design team members must become cognizant of what will and will not work for the safe and viable retention of treed areas. Rarely can single trees be retained with success. Designs should reflect natural site features and actively determine where treed character can be economically and visual effective. Municipal planning departments should strive to have effective, efficient, and explicit policies and guidelines on how and when trees can be retained based on community expectations embodied in Official Community Plans and typical pre-development treed sites in their community.
3. Construction site management is a vital key to successful tree retention. Control of clearing and grubbing practice, while important, have less influence than all subsequent disturbances. All intrusions into retention areas that would impact tree roots, the growing medium, or physically damage trees, must be prohibited through fencing and financial penalties. Once delineated, tree

retention areas must remain inviolate. They must be regularly inspected after clearing to determine if stand exposure has created new hazard trees. Informed construction superintendence of sites, coupled with clear construction guidelines, and repetitive municipal enforcement must form the backbone of housing development administration where tree retention is an objective.

4. The urban forest is the Lower Mainland is at risk through fire, exceptional winds and decadence due to lack of adequate maintenance. Stand tending must become a feature of urban forest management. It must be given a similar importance as that presently afforded to intensive recreational area maintenance. However, the silvicultural activities, tactics, and objectives are different. They need to be better understood and applied on both public and private treed lands.

From these four conclusions, two specific recommendations can be made regarding the management of urban forest resources in the Lower Mainland. These are:

Municipalities in the Lower Mainland should individually develop a comprehensive urban forest management strategy for their treed lands. Such assets are pliable, constantly changing and will diminish or disappear if not afforded a degree of public and professional interest. The adopted strategy should include a Municipal Urban Forest Plan integrally tied to the planning and development process. In this way community and planning approval expectations will link to the assumption of responsibility, workload, and maintenance method accountability in the municipal department, normally parks, assigned the role of maintenance management.

In a regional context, the Greater Vancouver Regional District should extend its park development process, through an urban forestry advisory committee, to examine regional approaches to a comprehensive urban forestry stratagem that will marry the efforts of member municipalities into a regional urban forest program for the Lower Mainland of B.C.

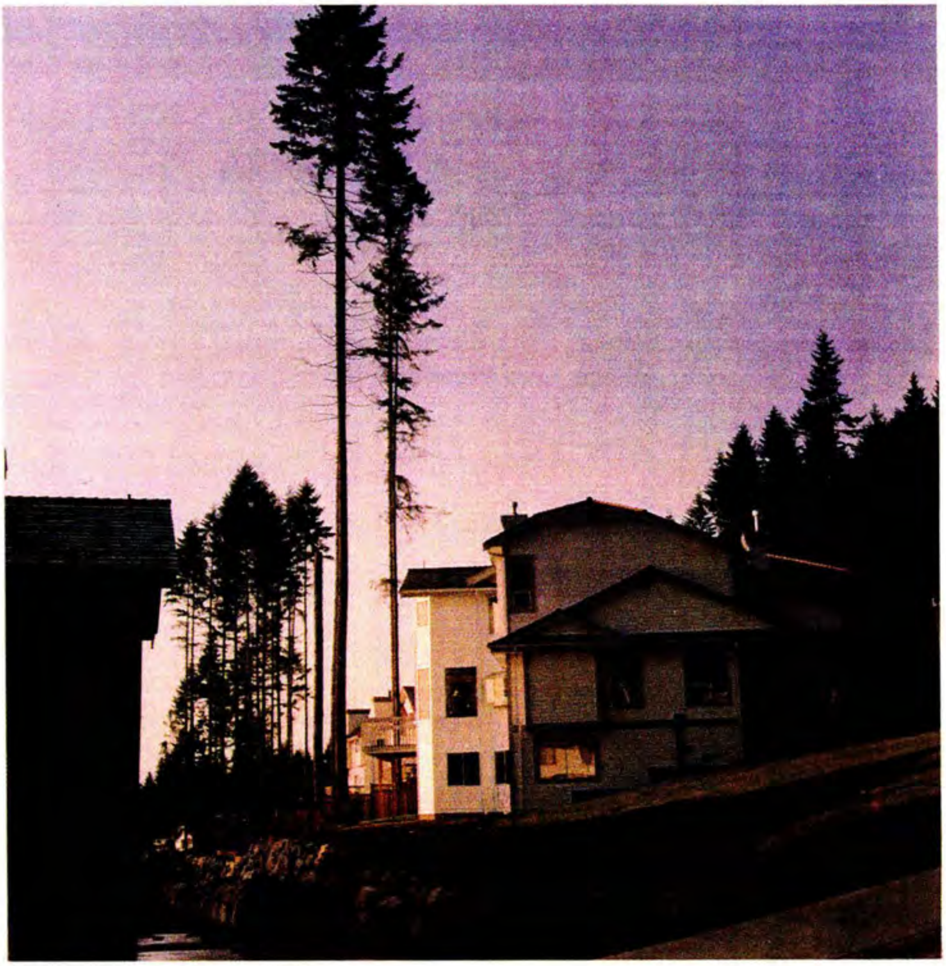


FIGURE 38 Side-yard single tree retention is extremely difficult and long-term survivability is extremely low.

APPENDIX A

Common Lower Mainland Forest Tree Species and Their Suitability in the Urban Forest

Douglas Fir (Pseudotsuga menziesii)

Geographical Range and Climatic Requirements:

Douglas Fir is one of the major timber tree species in coastal southwest British Columbia and excels in this region's humid to very-humid climate. It occurs throughout the rockies to the Pacific from central B.C. to central California and northern Mexico.

Soils, topography, Moisture, Nutrient Requirements:

Douglas Fir does not thrive on poorly drained soils or soils with an impervious layer near the surface. It attains its most luxuriant growth on deep, moist, well-drained sandy loams.

Associated Trees and Shrubs:

Characteristic associates include Red Alder (*Alnus rubra*), Grand Fir (*Abies grandis*), Western Hemlock (*Tsuga heterophylla*), Huckleberry (*Vaccinium parvifolium*), Salmonberry (*Rubus spectabilis*) and Western Thimbleberry (*Rubus parviflorus*). Vine Maple (*Acer circinatum*) occurs as a small tree in moister sites throughout the area.

Reproduction and Growth:

Seed is first produced in appreciable amounts between the 20th and 30th years, with maximum seed production occurring at 200 and 300 years of age. On average, heavy seed crops occur at 5 to 7 year intervals.

Douglas Fir will germinate on almost any seedbed that provides adequate moisture and proper temperature. Moisture requirements are high but the soil must be well-drained.

Douglas Fir regeneration is most successful on shaded northerly aspects. New seedlings need light shade, but once established they grow best in full sunlight.

Douglas Fir is able to maintain a fairly rapid rate of height growth over a very long period of time. On an average site, annual growth is more than 1 m at age 20,. 0.5 m at age 100 and 0.3 m at age 120.

Douglas Fir is very long-lived; ages in excess of 500 years are known.

Douglas Fir has a strong, widespreading, lateral root system in deep loamy soils. Buttressing roots are typical and provide primary stem support.

Reaction to Competition:

Satisfactory establishment and development, Douglas Fir requires more light than Western Hemlock, Western Red Cedar and Grand Fir. It is recognized as a sub-climax species and rarely maintains a climax position. Its widespread occurrence in extensive even-aged stands is caused by fires, clear-cutting and insect attack.

Young seedlings and saplings of Douglas Fir respond to release from competing brush or overstory trees. Trees at pole and small saw timber size respond well to conservative thinning. Douglas Fir that have developed in closed stands are very poorly adapted to radical release.

When exposed, the long slender boles with short crowns are highly susceptible to damage from crown shredding in strong winds, diminished vigor, sunscald, snowbreak, and windthrow.

Principal Enemies:

High winds following heavy rainfall may cause widespread windthrow.

Crown fires are destructive to all ages. The thick bark of older Douglas Fir makes them fairly resistant to ground fires.

Douglas Fir Beetle (*Dendroctonus pseudotsugae*) attacks trees from the large pole stage to maturity. Western Spruce Budworm (*Choristoneura occidentalis*) is a potentially serious pest of Douglas Fir but at present it is absent from the Lower Mainland.

The most serious heartwood decays in young growth Douglas Fir are caused by *Fomes pini*. *Polyporus schweinitzii* causes another common heart rot in young growth Douglas Fir. *Fomes subroseus* heart rot enters via broken tops.

The killing root disease *Poria weirii* is the most serious fungal enemy of Douglas Fir and is of concern in British Columbia since it can cause widespread windthrow in infected stands. Groups of trees may be affected by the disease.

Retention Potential

This species exploits rock cracks and incorporates boulders to form a well-developed root mat with substantial root resistance to windblow. The stem is protected by a tough abrasion resistant bark. Combial wounds heal effectively. Long branches in older trees may be susceptible to high temperatures and branch break. Particularly elongated branches can be pruned to reduce this problem.

Western Red Cedar (Thuja plicata)

Geographical Range and Climatic Requirements:

Western Red Cedar is confined almost entirely to regions having abundant precipitation and atmospheric humidity. This species grows from coastal southern Alaska to northwestern California. Inland, it grows eastwards to the western slopes of the Continental Divide and thence south to the Salmon River Mountains of Idaho.

Soils, Topography, Moisture and Nutrient Requirements:

Western Red Cedar is generally found along stream bottoms, moist flats, terraces, and gentle slopes and in moist gulches and ravines. Northern aspects are optimal for growth. The fertile, occasionally flooded soils of the *Pseudotsuga-Thuja-Adiantum* association is near optimum for cedar growth in the Douglas Fir region.

Associated Trees and Shrubs:

Western Red Cedar seldom occurs in pure stands, and then only over small areas. In Oregon, western Washington and British Columbia, Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*), Grand Fir (*Abies grandis*), Douglas Fir (*Pseudotsuga menziesii*) and Pacific Silver Fir (*Abies amabilis*) are common coniferous associates. Big-Leaf Maple (*Acer macrophyllu*m), Red Alder (*Alnus rubra*), and Black Cottonwood (*Populus trichocarpa*) are frequent deciduous associates at low elevations or near bodies of water or poorly drained depressions.

Dense stands of Western Red Cedar and its associates exclude nearly all subordinate vegetation. The following underspecies are found in coastal forests: Vine Maple (*Acer circinatum*), Oregon Grape (*Mahonia nervosa*), Western Dogwood (*Cornus nuttallii*), hazelnut (*Corylus cornuta*), Salal (*Gaultheria shallon*), Ocean Spray

(*Holodiscus discolor*), Indian Plum (*Oemleria cerasiformis*) and Elderberry (*Sambucus racemosa*).

Reproduction and Growth:

Western Red Cedar is a prodigious seed producer. Good crops are produced every 2 to 3 years.

Germination is better on burned and unburned exposed mineral surfaces than on forest duff. Seedlings survive best under partial shade.

Compared to most of its associates, Western Red Cedar is a slow growing species. Height growth is most rapid before the 30th year and is steadily sustained for up to 200 years.

The root system is shallow and widespreading, but strong. On wet soils, cedar is very susceptible to windthrow. On drier soils it is fairly windfirm.

Reaction to Competition:

Western Red Cedar is rated as a very tolerant tree. It is common for it to reach maturity in the shade. Its growth is retarded in proportion to the density of the shade. Cedar responds well to crown release. Old leaflet loss in the fall may be substantial in the first few years but may not be an indication of loss of vigour.

Principal Enemies:

Western Red Cedar has few important enemies other than fire, which destroys its fibrous bark and shallow root system. It can suffer from magnesium and calcium deficiency.

The Amethyst Cedar Borer (*Samanotus amethystinus*) occasionally kills healthy trees, but usually limits its attacks to injured, stressed or dying trees. Its range is limited to coastal cedar forests. The western cedar bark beetle (*Phloeosinus punctatus*) is a widespread species and attacks trunks and larger limbs, particularly those of stressed trees.

In B.C., wood decay in trees between 50 and 450 years old does not exceed growth increment, but decay in younger stands is more important. The following species of fungi are important in this respect: *Poria asiatica, P. albipallucida* and *Fomes pini.* Stem decay may be followed by secondary insect infestation.

<u>Retention Potential</u>

The tendency of many young western red cedar to grow on waste logs can diminish retention potential. Stem curvature in immature trees sometimes with associated root layering makes the species susceptible to clearing damage on disturbed edges. Large pockets of decay indicate weakened stems.

The largely fibrous root mat is very prone to compaction dieback. Construction equipment travelling over root areas, particularly in damp locations, causing rapid crown dieback evidenced by loss of colour and turgidity of leaflets.

Bark is easily damaged by construction activity and resulting wounds are readily colonized by stem decay organisms. Crown breakage in older trees results in multi-leadering with weak forks. The species does not tolerate grade changes. The species is intolerant of adjacent increased or decreased grade changes. Open grown trees with undisturbed root areas and good crown conformity can be retention candidates. The pendulant nature of lower branches can cause considerable limb breakage from construction equipment or material storage.

Western Hemlock (Tsuga heterophylla)

Geographical Range and Climatic Requirements:

Western Hemlock thrives in the very-humid and mild climate along the Pacific slope of North America from Prince William Sound in Alaska south to northern California.

Soils, Topography, Moisture and Nutrient Requirements;

Western Hemlock thrives best under high rainfall conditions on deep, internally well-drained soils with abundant organic matter.

Associated Trees and Shrubs:

Western Hemlock is usually subordinate in association with Western Red Cedar (*Thuja plicata*), Grand Fir (*Abies grandis*), Douglas Fir (*Pseudotsuga menziesii*), Black Cottonwood (*Populus trichocarpa*) and Red Alder (*Alnus rubra*).

Major understory species include Salmonberry (*Rubus spectabilis*), Huckleberry (*Vaccinium parvifolium*), Salal (*Gaultheria shallon*) and Vine Maple (*Acer circinatum*).

Reproduction and Growth:

Western Hemlock is a very prolific seeder. Heavy seed crops occur every 3 to 4 years. Seedbearing begins between 25 and 30 years. If moisture is adequate, germination under forest conditions is excellent. Germination on old stumps and trunks is often prolific.

Under optimum conditions, trees grow to 0.9 to 1.3 metres in diameter and 53 to 70 meters in height.

The root system is fibrous and shallow, but widespreading. Very large buttressing roots are uncommon. Woody roots are brittle and readily damaged.

Reaction to Competition:

Western Hemlock is rated as very tolerant, more so than Douglas Fir or Pacific Silver Fir. Western Hemlock responds well to release after long periods of suppression. When Western Hemlock develops in a dense, even-aged stand, natural pruning takes place early. Western Hemlock is designated a true climax species.

Principal Enemies:

Chief causes of mortality in young growth Western Hemlock are wind and/or snow causing damage to the crown, with resulting sites for pathogens to enter. Hemlock Looper (*Lambdina fiscell areia*) and Hemlock Sawfly (*Neodiprion tsugae*) are two defoliating pests of the species.

A number of trunk, butt and root rots, including *Fomes annosus*, *F. pini* and *Poria weirii* are important. These decays are more destructive in old growth than in young growth stands.

Dwarf Mistletoe (*Arceuthobium campylopodum*) increases mortality, especially of mature trees, and reduces growth in trees of all sizes.

Retention Potential

Fire and wind cause considerable losses in old growth stands. Thin bark and the occurrence of exposed roots are reasons for a high rate of susceptibility to fire damage. The shallow rooting characteristics of this species result in windthrow being a major destructive element. Stem decay and spiral growth cause bole failure.

Hemlock always require very careful inspection for any evidence of stem fructifications, sunken patches, crown or stem deformity that might signal internal weakness. Root systems on large trees can be comparatively small and shallow, particularly when stands are close grown. Lifting of the root mat of edge trees during grubbing operations or after clearing is a common problem.

Stem damage during construction without immediate remedial tree surgery will render trees susceptible to decay organisms entering this new infection courts which may not cause tree failure for some years.

Rarely should single trees be retained unless small and open grown. Thinning, replacement planting, and underplanting in islands of pure hemlock should be considered to encourage species diversity.

The hazards associated with hemlock retention are considerable and should not be underestimated on any site.

Red Alder (Alnus rubra)

Geographical Range and Climatic Requirements:

This is the major pioneer tree species in the coastal Douglas Fir and Western Hemlock zones of southwest British Columbia. It excels in the region's mild, super-humid climate and occurs from northern B.C. along the coast to northwest California.

Soils, Topography, Moisture and Nutrient Requirements:

Alder tend to be more prevalent on soils with restricted internal drainage, but it is generally excluded from bottomlands subject to periodic flooding. Red Alder is common on most alluvial soils and extends up the lower slopes until accelerated drainage limits tree development. Best growth occurs on deep well-drained loams or loamy sands of alluvial origin.

Red Alder will grow on poor soils and it contributes to the physical and chemical improvement of soils. it is a common pioneer species on disturbed soil exposed during construction activity. The development of a rich mull humus layer improves soil structure and liberates plant nutrients. Soil fertility is further improved through symbiotic fixation of nitrogen by microorganisms contained in root nodules.

Associated Trees and Shrubs:

Characteristic associates include Black Cottonwood (*Populus trichocarpa*), Grand Fir (*Abies grandis*), Douglas Fir (*Pseudotsuga menziesii*), Western Red Cedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*), Big-Leaf Maple (*Acer macrophyllum*) and Vine Maple (*Acer circinatum*).

Major understory species include Salmonberry (*Rubus spectabilis*), Elderberry

(*Sambucus racemosa*), Western Thimbleberry (*Rubus parviflorus*), Indian Plum (*Oemleria cerasiformis*) and Sword Fern (*Polystichum munitum*).

Reproduction and Growth:

Seed production is prolific, with good crops typically every fourth year. Seeds are dispersed through fall and winter and carried great distances by the wind.

Germination and growth are rapid, particularly on scarified mineral soils such as logging trails, cut and fill areas, spoil piles and similar exposed sites.

Red Alder regeneration is favoured by either clear-cutting or large group cutting. Any method of providing full overhead light and exposure of mineral soil will ensure good regeneration if moisture is available.

Red Alder is known as a pioneer species because of its rapid initial growth, which allows it to become established before its conifer associates. Average 5 year old seedlings on good sites can reach 5 m, which 10 year old trees may be 10 m to 12 m high. At about 25 years old, Douglas Fir, its chief competitor, usually overtakes it in height.

It is a short-lived tree, seldom surviving more than 60 years.

Reaction to Competition:

Alder is generally considered an intolerant tree. It is less tolerant than Western Hemlock, Western Red Cedar and Grand Fir.

Principal Enemies:

Red Alder is virtually free from disease for about the first 40 years.

White heart rot (*Fomes igniarius*) is the most destructive disease of the living tree.

Considerable amounts of foliage are periodically consumes by tent caterpillars (*Malacosoma pluviale* and *M. disstria*). Outbreaks usually last for only one year and practically all trees recover.

Retention Potential

Damage by fire is unusual because of the lower amount of litter accumulation below this species, and resistance of the bark to light surface fires.

The root system is shallow and widespreading, but Red Alder is seldom windthrown because in mixed stands it has the protection of conifer associates, and in pure stands density is high and individual trees protect each other. Trees exposed as a result of clearing or thinning are susceptible to windthrow and windbreak.

Exposure will also often cause substantial sunscald on southeast and southerly facing trunks. Substantial dieback or death results. Young trees are significantly impacted by heavy wet snows. Bent or broken stems result.

The species should be viewed as a transitional species only.

Big-Leaf Maple (Acer macrophyllum)

Geographical Range and Climatic Requirements:

Big-Leaf Maple ranges from the mountains of southern California north to B.C. It is best developed on alluvial soils where it occasionally forms pure, dense stands.

Optimum growing conditions occur in the humid and very-humid climates of western Oregon and southern Washington State.

Soils, Topography, Moisture and Nutrient Requirements:

Big-Leaf Maple is found on a variety of soils from deep loams to thin rocky slopes. Deep alluvial soils near streams are optimal for the species.

In B.C. Big-Leaf Maple occurs as a pioneer on hillsides laid bare by slides or fire. In B.C., it rarely occurs at elevations above 300 m.

Associates Trees and Shrubs:

Occasional pure stands are found near streams. This species normally associates with Red Alder (*Alnus rubra*), Douglas Fir (*Pseudotsuga menziesii*), Western Red Cedar (*Thuja plicata*), Grand Fir (*Abies grandis*), Western Hemlock (*Tsuga heterophylla*), Black Cottonwood (*Populus trichocarpa*), and Vine Maple (*Acer circinatum*).

Reproduction and Growth:

Big-Leaf Maple often bears enormous seed crops. Natural regeneration is usually adequate. In the early part of its life it will outgrow Douglas Fir and can survive beneath Douglas Fir until the canopy closes.

Growth rate is rapid for the first 40 to 60 years. Mature trees average about 15 m in height and 0.5 m in diameter.

In almost all habitats, Big-Leaf Maple develops a shallow, widespreading root system with large, tough, main roots and extensive feeding roots.

Maturity is reached in 150 to 300 years.

Reaction to Competition:

Big-Leaf Maple is less tolerant than most of its associates, including Vine Maple, Western Hemlock, Western Red Cedar and Pacific Yew. Tolerance decreases with age. During early life, Big-Leaf Maple can endure considerable shade. Even though this tree makes rapid early growth, it is often overtopped by competing conifers.

Principal Enemies:

Big-Leaf Maple is subject to a wilt disease (*Verticillium* sp.). Summer leaf dieback is also common. It is also subject to heart rot in old age, usually caused by *Fomes* sp. and *Polyporus* sp.

Retention Potential

The species tends to be very windfirm if root systems are undamaged. Summer leaf dieback, though unsightly, does not appear to cause untoward loss of vigour.

Upper limb breakage in winds or wet snow is the most important consideration. Large branches with skewer-like broken ends can descend to the ground in very hazardous fashion.

Decay activity in large fork pockets, wide angle forks and extremely narrow angle forks must be carefully inspected for structural integrity.

Roots are extensive and tough. Use of excavation equipment near trees often results in root breakage and for root shatter with longitudinal splits extending down toward the tree base. Stem splitting can occur.

The species can be retained as a single specimen if carefully protected during construction activity. It appears fairly tolerant of adjacent grade changes.

Vine Maple (Acer circinatum)

Geographical Range and Climatic Requirements:

Ranging from coastal B.C. to northern California, vine Maple requires a humid to super-humid climate to occur widely away from stream banks. Its altitudinal range is below 1,200 m in coastal B.C.

Soils, Topography, Moister and Nutrient Requirements:

In B.C., it attains its largest size on rich alluvial bottomlands, often forming impenetrable thickets of contorted and interlaced trunks that can be many acres in extent. It has a common habit of layering itself from bowed branches that touch the earth and root.

Associated Trees and Shrubs:

It occurs with Western Hemlock (*Tsuga heterophylla*), Western Red Cedar (*Thuja plicata*), Red Alder (*Alnus rubra*), Douglas Fir (*Pseudotsuga menziesii*), Grand Fir (*Abies grandis*), Black Cottonwood (*Populus trichocarpa*), and Paper Birch (*Betula papyrifera*).

Common understory associates include Salmonberry (*Rubus spectabilis*), Salal (*Sambucus racemosa*) and Sword Fern (*Polystichum munitum*). [Vine Maple is an edaphic climax shrub in both the coastal Western Hemlock and coastal Douglas Fir forest types.]

Reproduction and Growth:

Vine Maple is often a coarse shrub but under good conditions it will grow into a tree, sometimes attaining heights of 10 m and diameters of 15 cm. Growth is generally quite rapid. Seed production is moderate. Many thickets, particuarly in wet areas propogate by layering.

Reaction to Competition:

Vine Maple is extremely tolerant of dense shade and often forms a constituent of the coastal forest understory, particularly in areas recently logged over.

Principal Enemies:

Coral spot (Nectria spp.), a common maple disease, can spread from dead wood to live where a tree is prestressed by drought or sudden exposure.

Retention Potential

Loss of vigour due to exposure after removal of overstorey is common. Consequential loss of leaf and twig growth due to coral spot infestation is pronounced in dry years or after surface water diversion. The tree rarely dies and can become an important contributor to forest character. Fall color can be extremely attractive.

Greatest loss seems to occur as a result of past clearing attempts to "clean-up" sites without thought of the ecological benefits that understory contributes to larger tree root areas. The species is an important contributor to lower canopy and hardwood mixture in largely coniferous woodland. Its retention should be encouraged.

Western Flowering Dogwood (Cornus nuttallii)

Geographical Range and Climatic Requirements:

Natural distribution is from southwest B.C. to California and to the western slopes of the Cascade Mountains. In B.C., the Western Flowering Dogwood is found on the Lower Mainland portion of the province and the southern portion of Vancouver Island.

Soils, Topography, Moisture and Nutrient Requirements:

Western flowering dogwood is found in the coastal Douglas Fir and dry coastal Western Hemlock zones. It is often found along streams in the southern portion of its range, and often in open to partially open dense forest below 1,800 m in the northern part of the range. It is well adapted to moist loam soils with adequate humus and fairly low pH (5.5 to 6.0).

If found in a dense forest, it usually possesses a long tapering trunk that supports a thin narrow crown. Trees assume a bushy habit with several leaders in open situations.

Associated Trees and Shrubs:

Western flowering dogwood occurs with a number of western coastal tree and shrub species. Douglas Fir (*Pseudotsuga menziesii*), Grand Fir (*Abies grandis*), Western Red Cedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*), Red Alder (*Alnus rubra*), and Big-Leaf Maple (*Acer macrophylluma*) are common tree associates, while Salmonberry (*Rubus spectabilis*), Vine Maple (*Acer circinatum*), Elderberry (*Sambucus racemosa*), and Sword Fern (*Polystichum munitum*) are common understory species.

Reproduction and Growth:

This species is relatively slow growing, becoming 15 to 30 cm in diameter and 10 m tall in 50 to 100 years. Large trees are 125 to 150 years old. Under good growing conditions, trees can exceed 20 m in height.

Western flowering dogwood has a spreading, shallow root system.

Reaction to Competition:

This species normally prefers full or partial shade, requiring protection from full sun.

Principal Enemies:

Western flowering dogwood is very susceptible to sun damage in winter months. The result of such damage is a checking of the bark and cold damage to the growing tissues.

Botryotinia fuckeliana causes bark canker and *Phytophthora cactorum* causes crown rot and trunk canker. The latter fungus enters via injured tissue.

Retention Potential

The species is a good candidate for retention in undisturbed areas and a poor one when exposed. In present years a leaf fungus complex can cause severe leaf defoliation. Stressed trees and cold, wet weather predispose trees to the fungus. The shallow root system will not tolerate compaction or grade changes. Newly exposed trees will almost always suffer sunscald.

Black Cottonwood (Populus trichocarpa

Geographical Range and Climatic Requirements:

The range of this species extends from southeast Alaska to mountains in souther California. It develops best in the humid climate of the Pacific Northwest.

Soils, Topography, Moisture and Nutrient Requirements:

Black Cottonwood grows in soils ranging from moist gravels and sand to rich humus soils and, occasionally, clays. The largest trees grow at low elevations on deep alluvial soils. The species requires abundant moisture, nutrients and oxygen in combination with a high pH for optimum growth.

Associated Trees and Shrubs:

Black Cottonwood occurs with Douglas Fir (*Pseudotsuga menziesii*), Western Red Cedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*), Red Alder (*Alnus rubra*), Vine Maple (*Acer circinatum*), and Big-Leaf Maple (*Acer macrophylluma*) and Willows (*Salix* spp.).

On good sites, Salmonberry (*Rubus spectabilis*), Stinging Nettle (*Urtica* spp.), Sword Fern (*Polystichum munitum*), Hazel (*Corylus cornuta*), and Elderberry (*Sambucus racemosa*), occur as understory species.

Reproduction and Growth:

Black Cottonwood is generally a prolific annual seed producer. The seed is light and buoyant and can be transported long distances by wind.

Black Cottonwood makes very rapid juvenile growth on good moist sites. It is capable of reaching 15 m in 10 years. In B.C., the species reaches maturity at 150 years.

Reaction to Competition:

Black Cottonwood is the most shade intolerant of its associates. Rapid juvenile growth, which exceeds that of most of its associates, helps it to keep its favourable position in stands.

Principal Enemies:

Late frosts frequently kill or injure Black Cottonwood. Frost cracking provides entrance for decay fungi. After reaching 24 m or more, wind damage becomes a factor in determining eventual height.

Black Cottonwood is very susceptible to fire damage. Wood decay fungi include *Polyporus delectans* and *Pholiota destruens*.

Retention Potential

While typically windfirm, the rapid growth and eventual size of Black Cottonwood relegate it to a transitional species. Branch break and various leaf diseases causing spring and summer leaf drop do not make the tree desirable over the long term.

Aggressive root suckers can cause undesirable woody sucker growth in lawns and floral beds close to retention trees. Damage to driveways, drains and house foundations can be a detrimental aspect of aggressive root growth.

Paper Birch (Betula papyrifera)

Geographical Range and Climatic Requirement:

Paper Birch, with its varieties, has a transcontinental range. In western North America, it extends from Alaska, southwards to Washington and Oregon. Paper Birch is a cold climate species. It seldom occurs when average July temperatures exceed 21°C.

Soils, Topography, Moisture and Nutrient Requirements:

Paper Birch usually grows on podzols derived from glacial tills and is best developed on fresh, well-drained sandy loams. It is cosmopolitan in the more favourable northern parts of its range. In its southern range it is restricted to the cooler sites of higher elevations and steep north- and east-facing slopes.

Associated Trees and Shrubs:

In B.C., this species can grow in pure stands or in association with Western Red Cedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*), Red Alder (*Alnus rubra*), Black Cottonwood (*Populus trichocarpa*), and Big-Leaf Maple (*Acer macrophylluma*).

It is often associated with such understory species as Salmonberry (*Rubus spectabilis*), Thimbleberry (*Rubus parviflorus*), Sword Fern (*Polystichum munitum*).

Reproduction and Growth:

Optimum seed-bearing age is between 40 and 70 years. Seeds are light and may be carried on considerable distance by wind.

Mineral soil and rotten logs are best for germination and initial establishment. Even under favourable conditions, seedlings that survive are only 5 to 10 cm height after the first season. Compared to other *Betula* species, Paper Birch has a long period of height growth.

Individual trees often have a diameter of 20 cm after 30 years. Trees in mature stands average about 25 cm in diameter and 20 m in height. Trees mature in about 60 to 75 years. Paper Birch is considered a short-lived species.

Reaction to Competition:

Paper Birch is an intolerant species. In the natural succession, Paper Birch usually lasts only one generation.

Paper Birch requires overhead light from the seedling stage to maturity. Unless suppressed trees are released early, they soon die.

Principal Enemies:

A condition know as post-clearing decadence often develops where Paper Birch have been exposed by opening of stands. The symptoms include lowered vigour, reduced growth and substantial dieback with resulting twig and branch loss.

The most important rot-causing fungi attacking the species are *Fomes igniarius* and *Poria obliqua*.

Retention Potential

Crown dieback following clearing exposure may be severe on edge trees. Single open trees typically die while those in clumps show significant twig, small branch and leaf loss. In larger retention areas, the tree is a visual asset.

APPENDIX B

Contract Document for
On-Site Selective Tree Clearing and Grubbing
Specifications

1. **Location of the Project**

   Located in the Municiplality of ______________________.

2. **Scope of the Project**

   The project involves the select logging, clearing and grubbing as shown on the contract drawings. The "Area" to be cleared and grubbed is as shown in the attached drawings. For further clarifications contact Site Engineer of record, hereinafter referred to as "Engineer".

3. **Protection of Utilities**

   The Contractor is advised to satisfy him or herself that no existing utilities either underground electrical or gas or similar or any conflicting overhead utilities are to be found on the subject site.

4. **Protection of the Environment**

i) **General**

The Contractor shall familiarize him or herself with the fish and wildlife habitat in the area in which construction work is to be carried out. The Contractor shall be conversant with all other identified environmental or hazardous waste concerns on site.

ii) **Regulations**

The Contractor is advised that he or she shall comply with all federal and provincial regulations so that construction work does not adversely affect the environment or fish-producing streams, rivers, lakes and other bodies of water within the scope of this Contract.

Sections 20, 18, 30, 31 and 33 of the *Federal Fisheries Act* and Section 34 of the *Provincial Fisheries Act* are of particular importance.

A consolidation of pertinent segments of the Fisheries Acts and Amendments in Bill C38 which emphasise habitat concerns is available from Fisheries Offices and the Contract is advised to familiarize him or herself with this document.

iii) **Plan and Schedule**

Minimization of environmental damage can be achieved if construction operations are carefully planned and scheduled. The Contractor shall familiarize him or herself and identify those areas which are sensitive and present potential problems and shall prepare a plan of operations, a work schedule, and an outline of work methods accordingly.

The contractor shall make these available to the Engineer in advance of commencement of each of the operations covered in this contract.

iv) **Water Quality**

Machinery and equipment shall not be operated within the wetted perimeter of any stream, lake or other body of water within the scope of this Contract otherwise than under the explicit written authority of the Engineer.

All work within the scope of this Contract shall be undertaken in a manner which will avoid siltation of any stream, river, lake or other body of water that would be harmful to aquatic organisms.

There shall be no placement of materials in areas where natural drainage or storm water could pond or could erode disturbed materials in inclement weather, and thereby transport polluting materials to any stream, lake or other body of water. Grubbing operations shall be carried out in a manner that will minimize the release of sediment into streams.

Natural drainage patterns shall be maintained and/or controlled throughout the construction operation to minimize silt release into streams, lakes or other bodies of water. Temporary access road and haul roads shall be constructed so they are stable, do not concentrate surface run-off and do not erode to cause serious siltation problems. Crossings of streams shall be properly culverted using backfill of clean gravel or fine rock. The Contractor shall supply, install and remove temporary culverts at his or her own expense. No ponding of water shall be permitted in the root zone or retention trees.

No bark, slash, wood chips, sawdust, organic debris, soil, gas, diesel fuel, oil, grease, ashes or other substances deleterious to aquatic life or trees shall be allowed to enter any fish-bearing stream, lake or other body of water or tree retention area.

There shall be no obstruction placed in any fish-bearing streams during the clearing and grubbing operations. However, should any material be inadvertently placed in the normal high water wetted perimeter of such stream, the Engineer shall be notified immediately and the material removed as directed by the Engineer.

Where no fish-bearing streams, lakes or other bodies of water, or other special use areas are designated, the following general restraints in regard to the protection of any water or drainage course shall apply:

(a) The Contractor shall place, store and/or dispose of all organic material, refuse, ash, petroleum products and other deleterious material so as not to directly or indirectly pollute any natural drainage or water course or depression.

(b) Except as required by the Contract Documents, all inorganic material shall be placed and/or disposed of in a manner not to obstruct or unduly disturb any drainage or water course or depression, otherwise such obstruction or disturbance shall be restored to the original configuration and conditions as reasonably required by the Engineer at no extra cost to the Contract.

(c) All activities within the wetted perimeter of any stream, lake or other body of water shall be kept to an absolute minimum and machinery and equipment shall not be operated within the wetted perimeter of any such water course within the scope of this Contract otherwise than under the written authority of the Engineer.

(d) Removal or disturbance of stream bank trees shall be confined to the limits of the work or as shown on the Contract Drawings or as staked by the Engineer. The movement of equipment shall normally be confined within the indicated and/or staked boundaries. During clearing and stripping operations, equipment shall not be operated within the wetted perimeter of any of the designated streams.

(e) Indiscriminate falling of timber into any stream or other body of water will not be condoned. However, any trees that do accidentally fall into a stream or body of water shall be removed at the first opportunity in a manner that will minimize the disturbance of the stream bed.

(f) Skidding of logs across fish-bearing streams will not be permitted.

(g) The intakes of all pumps or diversions withdrawing water from a fish-bearing system shall be screened in accordance with Fisheries Regulations and the Contractor is advised he or she shall comply fully with these regulations before commencing any water-withdrawal operation.

v) **Equipment Servicing & Fuelling**

Servicing machines in or immediately adjacent to any stream or body of water will not be permitted. Servicing machines near streams or other bodies of water shall be carried out by the Contractor is such a manner as to avoid pollution with gas, diesel fuel, oil, grease, filters or other disposable material.

Fuel spills will not be condoned and in this regard care shall be taken to avoid overfilling machines. Automatic shut-off nozzles shall be installed on all dispensing units. The Contractor shall have proper equipment to transport fuel so that spillage will not occur. The Contractor shall have oil spill abatement equipment on the project satisfactory to the Engineer.

When working near any stream, lake or other body of water, the Contractor shall ensure that all hydraulic systems, fuel systems and lubricating systems are in good repair to avoid leakage of petroleum products.

Petroleum products shall be stored in a special location where spillage can be safely contained without contamination of the surrounding area. Storage of petroleum products will not be permitted in the vicinity of streams or other bodies of water. Fire protection will be maintained at all times at fuel depots.

vi) **Costs**

All requirements of the environment provisions shall be considered incidental to the prices bid for the work under Contract and no other compensation will be made.

5. **Clearing**

i) **General**

Except for trees, understory and shrubs to be preserved as indicated on the Plans or designed by the Engineer, "clearing" shall mean the complete removal and disposal of all standing and fallen trees, stumps, logs, upturned roots, rotten wood and any other vegetation and accumulations of rubbish of whatsoever nature and any other objectionable materials from the area staked out and ordered by the Engineer. Each area to be cleared shall include all those areas as indicated on the plans and as flagged in the field and as ordered by the Engineer either within or without any right-of-way as staked by the Engineer for intersecting public and private road approach. All such areas shall hereinafter be called "The Area". Incursions into retention and/or designated on the plan will carry a per time penalty. The penalty will be established in writing by the Engineer (Sec. 6.ii).

ii) **Landing Areas**

The Contractor shall make all necessary arrangements for areas he or she may require for cold decking merchantable timber. No compensation will be allowed for clearing any areas required for such cold decking.

iii) **Tree Removal**

All trees shall be felled within "The Area" but, in the event of any trees falling outside "The Area", such trees shall be cut up and together with all debris and slash therefrom, brought back to "The Area" and there burned or removed off site as the case may be.

The Engineer shall designate certain trees or understory to be left standing, in which case the Contractor shall take every precaution not to damage or injure such trees or understory in felling adjacent timber, burning or other clearing operations. Removal of individual retention trees will incur a penalty for each tree. This penalty will be established in writing by the Engineer (Sec. 6.ii).

iv) **Slash and Debris Disposal**

All material, slash and debris resulting from clearing operations must be disposed of by burning unless there are specific provisions for otherwise disposing of same.

Unmerchantable timber, stumps, etc., shall not be disposed of by pushing outside the clearing and grubbing right-of-way.

Except as hereinafter provided, all slash and debris shall be piled and burned at points located centrally in "The Area".

The number of fires to be started at any one time shall be limited to the capacity of the Contractor's equipment and organization to provide adequate protection against the spreading of the first to adjacent timber or property.

All burning shall be carried out subject to the provisions of the Forest Act, if applicable, and Regulations thereto. Local burning restrictions, when in place, shall also apply. Fire protection capability shall be maintained on site at all times.

In the event Forestry regulations prohibiting burning, slash, debris, or other surplus materials may be piled along the sides of "The Area" until such time as the controls are rescinded. Burning shall also conform to the requirements of the Municipality of _________. If burning on site is not permitted, all grubbed material, slash and debris shall be trucked from the site. No extras shall be paid for trucking.

6. Tree Retention Areas

i) General

Within the "The Area" designated for clearing there will be a number of tree retention areas. The objective in maintaining these areas or individual trees is to ensure that they impart some treed character to the eventual housing development. It is therefore essential that the trees, understory and shrubs in these areas remain undisturbed and undamaged. To this end a number of stipulations apply. In addition, clearing may be carried out in timed phases.

ii) Retention Areas Designated

All areas where the retention is intended will be initially flagged with survey tape. Before clearing commences these areas will be protected with a physical barrier such as snow fencing. Fencing shall not be attached to retention trees. Reinforcing bar is not an accepable fence support post.

Areas within snow fencing must remain undamaged. Such fencing will follow top of bank retention areas, buffer strips, clumps of trees in pie-shaped lots, backyard treed areas, parketts, parks, walkways and similar areas. Breaches of physical barriers shall carry a penalty. The form, nature and amount of the penalty shall be determined in conjunction with the municipality and the Engineer. The penalty shall form an enforceable annex to this contract.

iii) Felling Practice

Where tree retention areas are designated, every care should be made to ensure adjacent trees are felled away from retention zones. Where trees fall into such zones, care should be taken in extraction to minimize damage to standing trees and understory. Snow fence knocked down shall be replaced. All extraction methods should ensure that damage does not occur to fencing on a regular basis. Bark or root wounds on retention trees shall be, where practical, cut clearly and treated with tree would dressings. Aerosol can protectants are acceptable. Tree repair shall be carried out by skilled staff acceptable to the Engineer.

iv) **Equipment Usage**

Extraction, hauling and clearing equipment must not be allowed to travel over the root area of trees intended for retention. Wherever possible snow fence will be placed to protect root areas. Fencing knocked over must be replaced. No temporary roads or trails shall be allowed without approval of the Engineer.

No fuelling of equipment, draining of oil, or similar procedures that would contaminate soil and be toxic to plant material will be permitted.

Where grade changes or root areas of trees to remain are exposed, the Engineer shall be notified and will instruct the Contractor on remedial measures. Repairs will be carried out by skilled staff approved by the Engineer.

When roots of large trees are exposed and such trees are to remain or when the roots of such trees extend into an area to be grubbed and are exposed and broken, such broken roots shall be cleanly cut and treated with a proprietary tree wound dressing. The Engineer shall be notified of such work.

v) **Burning Practice**

No slash or debris disposal shall be disposed of by burning within a 30 metre proximity to the tree retention area as the heat generated by such disposal will damage retention trees. Appropriate fire protection shall be maintained on site at all times. No unattended fires shall be permitted.

vi) **Temporary Drainage**

No surface drainage should occur in such a manner as to allow the erosion of organic soil in retention areas. Similarly, no drainage pattern should be created that allows the accumulation of standing water or siltation over the roots of the trees in any retention zone.

vii) **Thinning Practice**

Where retention strips, butters, or clumps remain, it is probable that some selective thinning will occur to remove dead, dying, diseased or poorly rooted trees. Such work will be under the expressed supervision of the Engineer. No entry into retention areas for such thinning is permitted without the Engineer or his or her designate in attendance. Unauthorized tree removal will carry a penalty as set out in the appropriate annex to this contract.

vii) **Pre-Clearing On-Site Meeting**

The Contractor shall make himself and his equipment operators available for a pre-clearing meeting to discuss the objectives of tree retention and the methods intended to ensure that all work staff are familiar with the intent of the clearing operations and the drawings delineating the retention areas. Such tailgate meetings cannot be claimed as a contract extra.

7. **Grubbing**

1) **General**

Grubbing means the entire removal and disposal by burning of all stumps, roots and embedded logs to a depth of 0.6 m below the ground line.

Grubbing shall be carried out over the entire "Area" as defined above. Care shall be exercised to leave the ground surface free of ruts or channels which could alter existing drainage flows.

ii) **Clean Up**

The Contractor shall clean up the site to the Engineer's satisfaction as soon as practicable after contract work has been completed.

Control of unauthorized entry during clean up, including permanent barricades comprising cross ditches and log/soil berms shall be constructed across each access point to prevent entry of unauthorized vehicles to the cleared and grubbed portions of "The Area".

Clearning and grubbing shall be paid for at the unit price bid per hectare for grubbing and shall, unless otherwise specified, comprise the full length and breadth of the "The Area" as staked by the Engineer.

8. **Stripping**

Stripping means the removal of all top soil to the grade levels in the contract drawings in the entire portion of "The Area". Stripped material shall be removed to and piled in designated stockpile areas. These must be designated by the Engineer.

9. **Select Logging**

i) **General**

Upon acceptance, execution and signing of a Contract, the Owner hereby grants to the Contractor approval to enter upon the Land and perform all work required to fell, buck, produce into logs, remove and truck merchantable timber standing or lying on the land.

The Contractor covenants to conduct such operations in a good and workmanlike manner in accordance with best modern logging practices and equipment in the area which the Land is situated.

ii) **Logging Returns**

When merchantable timber in the "The Area", as determined by a timber scale conducted under the supervision of a registered professional forester, registered landscape architect or certified arborist, is of a value that exceeds the value of the contract, the Contractor and the Owner shall share the proceeds as set out in the formulae set out in the appropriate annex to this Contract.

iii) **Logging Costs**

The Contractor accepts that any such logs produced from the Land shall be at the risk and responsibility of the Contractor, and without limiting the generality of the foregoing, the Contractor shall be responsible for all costs pertaining to the falling, bucking, yarding, removal of merchantable timber by skidder, scaling, trucking, and the sale of merchantable timber.

The Contractor acknowledges that the Owner shall not be responsible for any of the costs incurred by the Contractor in logging any merchantable timber.

iv) **No Representations Made**

The Contractor acknowledges that the Owner has made no representations to the Contractor as to the nature of the Land or the quality or quantity of timber thereon or as to the difficulty or simplicity of logging the same, all of which matters have been duly investigated by the Contractor prior to the date of entering any bid and before entering into any Contract.

APPENDIX C

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding made the ____ day of ______________, 19__.

BETWEEN:

AND:

SINCE:

A. The Forest Service and the City of ________________ Fire Department wish to enter into a Memorandum of Understanding pursuant to which they will cooperate in attacking, controlling and extinguishing forest fires burning within the boundaries of the City of _________________ and the _______________ Forest District.

b. The Forest Service and the _______________ Fire Department intend that this Memorandum of Understanding will identify their respective roles and responsibilities for their cooperative efforts in attaching, controlling and extinguishing forest fires burning within the _______________ Forest District and City of _________________ boundaries.

The Forest Service and the _______________ Fire Department agree as follows:

ARTICLE I DEFINITIONS

1.01 In this Memorandum of Understanding:

"forest" means land containing timber, shrubs, slash and peat;

"forest fire" includes any uncontrolled fire burning timber, shrubs, slash, roots, stumps, logs, or peat;

"Schedule 'A' Lands" means land within the City of ______________ marked as "Schedule 'A' Lands" on Exhibit 1".

ARTICLE II GENERAL UNDERSTANDING

2.01 Subject to the terms of this Memorandum of Understanding, the _______________ Department is responsible for attacking, controlling and extinguishing all forest fires on Schedule 'A' lands.

2.02 Upon receipt of a report of a forest fire on Schedule 'A' lands, the Forest Service will immediately report the forest fire to the _______________ Fire Department.

ARTICLE III

3.01 Upon receipt of a report of, or upon arrival at a forest fire, the _______________ Fire Department will determine if it can control or extinguish that fire within one (1) hour of attack and immediately notify the Forest Service of that determination. If the Fire Department determines that it cannot extinguish or control that fire within one (1) hours it will immediately request assistance from the Forest Service.

3.02 If the __________________ Fire Department requests assistance from the Forest Service in actioning a forest fire, the Forest Service, in its sole discretion may, subject to existing attack priorities and suppression demands do any of the following:

(a) assist by providing forest fire suppression expertise;

(b) assist by providing forest fire suppression resources; or

(c) assume full direction and responsibility of the suppression action for the forest fire.

ARTICLE IV

4.01 If, pursuant to this Memorandum of Understanding the Forest Service assumes responsibility of the suppression action for a forest fire, the Forest Service in its sole discretion may require the _______________ Fire Department to:

(a) provide assistance in the suppression action for the forest fire;

(b) maintain a liaison officer at the site of the forest fire.

4.02 If, pursuant to this Memorandum of Understanding the Forest Service assumes responsibility of the suppression action for a forest fire, the Forest Service may withdraw its forest fire suppression expertise and resources and return the entire responsibility of the suppression action for the forest fire to the Fire Department when the Forest Service in its sole discretion determines that:

(a) the forest fire is under control; or

(b) its forest fire suppression expertise and resources are needed elsewhere.

4.03 If, pursuant to Section 4.02 the Forest Service returns the entire responsibility of the suppression action for the forest fire to the ________________ Fire Department, the Forest Service will:

(a) maintain a liaison officer at the site of the forest fire; and/or

(b) by notice in writing to the ________________________ Fire Department set out its recommendations for extinguishing, patrolling and safeguarding the forest fire.

ARTICLE V LIABILITY

5.01 Neither part shall be liable to indemnify the other for any loss, damage, personal injury or death occurring as a result of the performance of this Memorandum of Understanding.

5.02 This Memorandum of Understanding and the performance of its terms will not:

(a) create any rights or obligations enforceable by law between the Forest Service and the ________________________ Fire Department;

(b) form the basis for any legal action between the Forest Service and the ________________________ Fire Department; or

(c) extinguish or diminish any subsisting rights or obligations enforceable by law between the Forest Service and the ____________________ Fire Department or between either of those parties and persons not a party to this Memorandum of Understanding.

ARTICLE VI COST RESPONSIBILITIES

The Forest Service and the ______________________ Fire Department will bear their own costs incurred when attacking, controlling or extinguishing forest fires on Schedule 'A' lands.

ARTICLE VII

BURNING PERMITS

7.01 The ______________________ Fire Department shall be responsible for burning permit applications and for administering and controlling all intentional burning on Schedule 'A' lands.

ARTICLE VIII

MISCELLANEOUS

8.01 The Forest Service and the ______________________ Fire Department will update and exchange the following information on or before _________ of each year during the term of this Memorandum of Understanding:

(a) land schedule alienation;
(b) organization charts;
(c) emergency and non-emergency phone numbers; and
(c) listing of key personnel and phone numbers.

8.02 The Forest Service and the ______________________ Fire Department may undertake cooperative proactive forest fire prevention measures in an effort to eliminate "man-caused" forest fires.

8.03 This Memorandum of Understanding shall continue in effect until terminated in writing by either party.

8.04 This Memorandum of Understanding will be reviewed annually on or before __________________ at a meeting of both parties.

8.05 This Memorandum of Understanding may be amended at any time by the parties as evidenced by an exchange of letters and all such letters shall be attached to and form part of this Memorandum of Understanding.

8.06 The Appendices attached to this Memorandum of Understanding provide potential actions or guidelines for each of the following areas:

APPENDIX I	Interface Fire Contingencies and Responsibility Guidelines
APPENDIX II	Fireline Communication Guidelines
APPENDIX III	Media Relations
APPENDIX IV	Urban Interface Coord. Response Plan

IN WITNESS WHEREOF the parties have executed this Memorandum of Understanding on the day and year first above written.

SIGNED, SEALED AND DELIVERED by the District Manager of the __________ Forest District, a duly authorized representative of the Ministry of Forests, in the presence of:	)	______________________________ Name Date
______________________________ ______________________________ ______________________________	)	______________________________ Signature

SIGNED, SEALED AND DELIVERED by the ____________________ ____________________, a duly authorized representative of the City of ____________________, in the presence of:	)	______________________________ Name Date
______________________________ ______________________________ ______________________________	)	______________________________ Signature

M.O.U. APPENDIX I

Interface Fire Contingencies and Responsibility Guidelines

	Task	Agency Responsible
1	Assess fire behaviour, fire potential, formulate plan of attack, implement plan with objective to contain by 10:00 hours the following day.	• Forest Service • Fire Department
2	Engage evacuation of homes, structures, and recreational facilities threatened by fire, advise Regional Fire Commissioner in accordance with directives.	• Emergency Social Services • Fire Department • Policy Agency • Forest Service
3	Divert traffic, clear routes for emergency vehicles and forest Service fire fighting equipment. Provide for the orderly routing of evacuated citizens.	• Police Agency • Provincial Emergency Program • Public Works (if applicable)
4	Establish a command centre.	• Forest Service • Fire Department
5	Deployment of emergency social services to scene.	• Provincial Emergency Program • Municipality (if applicable) • Fire Department • B.C. Ambulance Service
6	Public relations/media coordination.	• Forest Service • Assisted by Fire Department Liaison Officer
7	Residential improvements, evacuated homes, command centre security.	• Police Agency
8	Evacuated victim response centre, i.e., direction re food and shelter.	• Emergency Social Services • Emergency Social Services Fire Department
9	Search and rescue for missing persons.	• Policy Agency • Provincial Emergency Program
10	Implement a disaster plan.	• City of • Provincial Emergency Program
11	Fireline security.	• Forest Service • Fire Department
12	Aircraft management.	• Forest Service

M.O.U. APPENDIX II

Fireline Communication Guidelines

The Forest Service, with the support of the ____________________ Fire Department, will endeavour to secure a single fire command frequency for multi-agency action Wildland/Urban Interface Fires. Interface Command Frequency is 164.910 "Copper Channel".

FIRE COMMAND

PEP Coordinator & ESS	Police Agency	Fire Department	Forest Service Fire Boss	Ambulance First Aid

Each agency will utilize its own frequencies to direct and coordinate its respective resources. The primary Fire Department will coordinate mutual aid assistance with the frequencies it normally uses for that purpose.

M.O.U. APPENDIX III

Media Relations

The Forest Service may dispatch a Fire Information Team to the incident dependant on the seriousness of the situation. The Fire Information Team will deal with all media requests.

The ______________________ Fire Department will provide a Fire Department Liaison Officer to work in concert with the Fire Information Team. The Team will work with each agency on the fire line as approved by the fire command.

M.O.U. APPENDIX IV

Wildland Urban Interface coordinated Response Plan

The following procedures are specific to a multi-agency response on interface fires.

Command Channel

164.910 M.O.F. "Copper Channel"

- M.O.F. will ensure that all response agencies are authorized to use this frequency.
- Fire Department will advise all the response agencies within their district of this channel and radio requirements (Ambulance Services, P.E.P., R.C.M.P.)
- All response agencies should have a minimum of two portable radios capable of utilizing this frequency.

Command Center

- Stationary Command Centre is the ________________.
- Mobile Command Centre and operator will be supplied by ________________ Fire Department
- ____________________ Fire Department may request a mobile command center through their own mutual aid agreements.

Glossary

Arboriculture The cultivation and tending of trees, individually or in small groups, for use and ornament.

Artificial Regeneration The deliberate planting of land which has ceased to bear trees.

Buttressed Tree A tree having projected growths each linking the trunk to a main root.

Brushwood Scrub and waste trimmings.

Canopy Collectively, the mass of branches and foliage formed by the crowns of trees.

Canopy Closure The closing-in of gaps between trees, by normal development of the tree crowns, to the stage where mutual interference, involving competition for light and space, begins.

Clearing An open space in, or removal of, standing forest or woodland.

Coniferous Forest A forest consisting entirely or mainly of softwood trees, usually evergreen.

Co-Dominant

1. Of a crop, having part of their crowns in the upper canopy but not entirely free from competition with their neighbours.
2. Of species, those species in a mixed crop which are selected to take precedence.

Close-Grown Trees, grown so closely together that the normal outward spread of branches is checked.

Crown Cover The area of ground surface covered by the canopy of standing trees; often expressed as a percentage of total ground area.

Coppice

1. (transitive) To fell trees close to the ground with the intention of producing coppice shoots from the stools.
2. (intransitive) To produce coppice shoots.
3. (transitive) To harvest the coppice shoots as a crop of poles and stakes.

Deciduous Forest A forest consisting entirely or mainly of broadleaved trees which, with a few exceptions, lose all their leaves seasonally.

Dominant
1. A single tree projecting above the surrounding canopy.
2. Of a crop, having their crowns above the canopy and leading shoots free of competition by their neighbours.
3. Of a species, that species in a mixed crop which is selected to take precedence.

Edge Tree A tree on the edge of a stand, subject to conditions of light and exposure different from those prevailing within the stand.

Extraction Haulage of trees, timber or poles from stump to a hard road.

Flagging The use of plastic tape tied to stakes or trees to delineate boundaries.

Forestry The science and practice of growing, tending and managing trees as a crop, for timber, shelter, soil conservation or other useful purpose.

Forest Floor The surface of the ground under standing trees.

Ground Cover The carpet of grass, herbaceous plants, forbs, and low shrubs which cover the forest floor.

Grubbing The entire removal and disposal of all roots, stumps, and embedded logs to a depth of 0.6 m below original grade.

Hardwood The timber of any broadleaved tree, whether actually hard or not.

Irregular Forestry A form of forest management in which there is mixed age grouping, no regular plantations which are to be clear felled, and where there is always a complete canopy over part of the site.

Light-Demander A species of tree that requires abundant light for its best development.

Mixed Forest A forest in which there are significant numbers of more than one species of tree.

Mixed Stand A stand consisting of more than one species of tree.

Natural Regeneration The renewal of woodland by natural means, usually from seed fall.

Nurse Crop	A crop of trees grown to encourage the growth of another species by protecting the latter from, for example, wind, frost or strong sunlight.
Plan of Operations	An agreed scheme of work laying down desirable operations in a woodland over a set period, normally not less than five years.
Rotation	The planned or actual interval in years between the formation or regeneration of a tree crop and its final felling.
Root Mat	The full area of root mass at the circumference of the base of a tree usually extending beyond the crown "drip line".
Pure Stand	A stand consisting entirely of a single species of tree.
Stand	A well-defined group of standing trees usually of a similar age, whether established by natural or by artificial means.
Stripping	The removal of top soil down to predetermined grades.
Shelterbelt	A belt of trees and/or shrubs grown, or retained, and maintained for the purpose of providing shelter from wind, sun, snow-drift, salt spray, dust or noise.
Succession	The gradual replacement of one tree crop by another, either by natural processes or by artificial means.
Shelter Wood System	A silvicultural system under which some trees are retained after main felling to shelter young trees coming up below.
Silvicultural System	Any planned sequence of operations for raising trees as a crop or for other beneficial uses.
Suppressed Tree	A tree dominated and restricted by the growth of its taller neighbours.
Suppression	The domination and restriction of the growth of a tree or branches by surrounding trees.
Underplant	To plant or sow trees under an existing stand.
Understorey	The lower layer of a two-storeyed forest.

Undergrowth The stratum of small trees and shrubby plants growing under a forest or woodland canopy.

Urban Forestry The practice of a specialized type of forestry that emphasizes the management of trees for their contributions to physiological, sociological and economic well-being of urban society.

Whip
1. A tall, slender tree in the upper canopy which whips the crowns of its neighbours and will not become a desirable crop tree.
2. A young tree consisting only of a single slender stem, usually of 1 or 2 year growth.

Wind-Blow (n) A tree or group of trees uprooted by wind-blow.

Wind-Blow (v) Blowing down of trees by the wind, particularly of trees which have not previously been exposed to substantial wind force.

Wind-Firm Secure against root disturbance by wind.

Windbreak A shelterbreak or other obstacle used to break the force of the wind.

Wolf A vigorous tree of irregular form occupying more space than its value warrants and checking the growth of potentially better neighbours.

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