This chapter is part of
"A Manual of Integrated Pest Management for Urban Landscapes in British Columbia"
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and submitted to the B.C. Ministry of Environment, Lands and Parks, Victoria B.C.

CHAPTER 3
TREES OF PARKS AND BOULEVARDS:
THE APPLICATION OF INTEGRATED PEST MANAGEMENT

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THE APPLICATION OF INTEGRATED PEST MANAGEMENT

INTRODUCTION

Trees have many functions in urban areas. There is the visual pleasure of looking at them: they provide a basic contact with nature and heighten the pleasure of the surroundings. Dense, tall and wide plantings of trees reduce noise levels. Trees act as windbreaks so that heavier dust particles can settle out, reducing airborne particulates and air pollution. Trees give us much appreciated shade and help control erosion and traffic direction.

Trees are also worth a lot of money: the value of a landscape tree larger than 20 cm (8 in.) in trunk diameter is based on the cost of a replacement tree, making many landscape trees worth hundreds and thousands of dollars. This value is important in residential and public areas. In 1989, the U.S. forest Service estimated the presence of trees increased the market value of homes from 7 to 20 percent. A different study conducted in 1990 indicated 61 million street trees in the United States with an aggregate value of $18 to $30 billion.

Integrated Pest Management for landscape trees can be used by every person working with trees by combining knowledge and techniques from a variety of fields. The goal is to maintain healthy trees and reduce damaging pest populations. A good IPM program accepts the presence of some pests because mature healthy trees can sustain a certain level of pest activity without measurable damage.

An IPM program for landscape trees ensures the proper trees are planted at the proper place, good care allows the young trees to grow into healthy mature trees, appropriate fertilization helps mature trees through hardship, and good pest management is done through monitoring and selection of appropriate treatments. This chapter discusses the elements of IPM as it applies to trees by looking at specific cases from British Columbia.

A) SELECTION OF TREES

Selecting plants that adapt well to their intended site and fulfill their intended landscape function is extremely important to the success of a planting and the ease with which it can be maintained. The quality of young plants is also a crucial factor. The importance of selecting the right tree is illustrated by the procedure in place at the Parks and Recreation Department, City of Victoria. The information was provided by Michelle Gorman, IPM Coordinator and Yvan Caron, Deputy-Superintendent for Horticulture.

i) Selecting trees in Victoria

Every year, the City of Victoria purchases tree whips from commercial nurseries. The whips are then planted and grown for a few years in the City's nursery until large and healthy enough to withstand stress of street life and the unavoidable damage from human activities.

From a list of tree species prepared by the City Arborist, a group of 11 people in the Parks and Recreation Department developed a selection of species that was felt would "both enhance the Victoria landscape and ensure the survival of the trees given our unique environmental conditions" (Caron, 1993). The selection process involved various people with different expertise in the Department, including gardeners, horticulturist and pest managers.

The selection was made after consideration of a number of different factors:

Fluctuations of weather from wet cool winters to dry hot summers.

Pollutants such as carbon monoxide and road salt.

Wind especially on sites receiving salty mist from the ocean.

Soil conditions such as pH, compaction, sandy or clay.

Drainage of water being good or poor.

Restrictions of height, width, and the presence of utilities.

Resistance to diseases and pests.

Growth habit and size.

Maintenance requirements such as pruning and watering.

These criteria refer to site specific conditions. For example, the cliffs on Dallas Road, close to down-town Victoria, are on a windy site with dry and shallow soil. Trees planted in this area will be different than trees planted close to a shopping centre on Douglas Street, on the north side of the city. Gardeners were asked to think 3 years ahead where trees will be planted and to select species that will grow well in the site selected.

ii) Selecting healthy trees

Planting a diversity of species and cultivars is important because trees are not all susceptible to the same pests. A mixture of species and cultivars ensures that some trees survive if a serious pest attack occurs. Also, insect populations or disease spores can spread more rapidly and build up to higher numbers when only one type of trees is lining an entire street. Foresight was showed in Victoria when mature trees (now 30 to 40 years old) were planted in an alternating pattern on many streets. For example, some streets are planted with Hawthorn / Flowering Plum / Hawthorn / Flowering Plum etc.

Box 3-1: The 20-10 Rule

A rule of thumb, called the 20-10 rule, says to plant
no more than 20% of trees from the same family, and
no more than 10% from the same genus.

Michelle Gorman, IPM Coordinator for the City of Victoria, looked at tree species for their resistance to diseases and pests. She used the experience of field personnel within the region and monitoring notes from previous years to highlight what problems have historically affected the various tree species. The same information is available for other regions in North America and can be found in reference books that describe pest problems along with cultural requirements and growth habit.

Some species of trees are known to have pest problems and are best avoided. It is not realistic to expect pest-free plants for all circumstances, but when possible the species selected should be species with few or no pest problems. Obviously, future maintenance will be lower if the tree is well adapted to the site.

Another part of Mrs. Gorman's work is to inspect the trees being purchased. She visits the nursery if the trees are bought in the Victoria area to select the specimens. If trees come from another region, they are inspected upon delivery. Trees are examined for the presence of disease, serious insects or any other condition that may create future problems.

Unsatisfactory trees are returned and replaced. A problem tree can be planted and not grow for many years, wasting the investment in money and care. As well, a sick tree acts as a source of disease inoculum or as breeding ground for insect pests, jeopardizing the health of other trees.

iii) Selecting native trees

Another selection criterion is to use native or indigenous plants. Trees native to the area will often do well with minimum care. For example, native trees withstand the annual fluctuations of temperature and precipitation in the area. Imported trees, however, must be assessed to ensure they can withstand specific aspects of the climate such as the lowest expected temperature. The use of natives should be encouraged whenever possible, complemented by other species that can adapt to the site selected. It should be noted that native trees may not perform as well as non-native trees: for example, some native trees do best under arid conditions where they do not have to compete with irrigated turf grasses, an unusual condition in the urban landscape.

A simple way to assess how a mature tree will look and grow is to observe other mature specimens in nearby parks, botanical gardens, street plantings and private gardens. Trees growing well in one set of conditions can be expected to perform well elsewhere if given a similar set of conditions.

Box 3-2: Specifications for acceptance of nursery trees at the time of delivery

PURPOSE: To obtain vigorous, healthy trees which can be easily trained into attractive trees with structurally strong roots and crowns.

SPECIFICATIONS: The buyer may choose and / or modify the following sections depending on the species, the landscape site, and the intended function of the tree.

1- All trees shall be true to type or name as ordered and shall be individually tagged or tagged in groups by species and cultivar.

2- All trees shall be healthy, have a form typical for the species or cultivar, be well-rooted, and be properly trained.

3- All trees shall comply with Federal and Provincial laws and regulations requiring inspection for plant diseases and pest infestations and clearance be obtained before planting trees delivered from outside the region in which they are to be planted.

4- The rootball of all trees shall be moist throughout and the crown shall show no signs of moisture trees.

5- Tree crown (round headed) for broad-leaved, decurrent trees:
a- the crown has a single, straight trunk that has not been headed or that could be pruned to a leader, with potential lateral scaffolds radially distributed around the trunk, the lowest scaffold height depending on the tree species and the intended landscape use, and the scaffolds not more than 2/3 the diameter of the trunk, measured 25 mm (1 in.) above the branch;
b- the minimum acceptable length of the most recent season's shoots are as specified;
c- it is desirable to have the tree stand upright without support with small temporary branches along the trunk below the scaffolds.

6- Tree crown for broad-leaved or coniferous, central trunk trees:
a- the crown has a single, straight trunk with no double leaders and no vigorous, upright branches competing with the leader;
b- radial and vertical distribution of branches to form a symmetrical crown.

7- Roots, container, boxed, balled and burlapped for all trees regardless of species or mature size.
a- Check that the tree is free of roots visibly circling the trunk, and free of "knees" (roots) protruding above the soil;
b- If in a tapered container, the root-ball periphery should be free of circling roots larger than 6 mm (1/4 in.) in diameter and a bottom mat of roots 6 mm (1/4 in.) or larger;
c- Untie the tree trunk from the stake: the trunk should not touch the top rim of the container;
d- Tip the root ball or container on its side and with a small jet of water expose the roots within 50 mm (2 in.) of the trunk to a depth of 65 mm (2.5 in.) below the topmost root attached to the trunk. The trunk and main root(s) should be free of circling roots and kinks. Replace soil washed from around the trunk with a similar soil mix.

8- In case the sample trees inspected are found to be defective, the buyer reserves the right to reject the entire lot or lots of trees represented by the defective samples.

9- The buyer shall be notified when plants are to be shipped at least ten (10) days prior to the actual shipment date.

Adapted from California Department of Transportation, "Standard Specifications", in Harris, R.W., "Arboriculture: Integrated Management of Landscape, Trees, Shrubs, and Vines", Prentice Hall Inc.(Englewood Cliffs, NJ), 2nd Edition, 1992.

B) MAINTENANCE CARE OF TREES

Next in importance to appropriate species selection is proper care of the trees. Good maintenance is essential in the establishment of newly planted trees or to preserve mature trees.

i) Care of young trees

Site preparation

The survival of the transplanted tree depends on the ability of the root system to resume normal root growth. Weeks or months before the tree is to be planted, have the soil can be analyzed and, if necessary, add required amendments to improve the soil structure or increase the available nutrients. Till the soil or, at the very least, dig a large planting hole to break up compacted soil and enable roots to growth quickly.

Organic amendments such as manure and compost are added to soil to improve the structure, water retention capacity and to add nutrients. However, in long-term studies from American universities, trees and shrubs planted without organic soil amendments developed more extensive root systems and stronger top growth than those planted with amendments. Seedlings grown with amendments appeared healthy and well shaped, but they were about half the size of the test group after a few years. When only the planting hole is amended, the tree roots tend to remain in the hole, thus limiting the size of the plant. For trees to benefit, the soil of the entire planting bed must be amended (Ellefson, Stephens and Welsh, 1992).

Planting for good drainage

When the soil has a tough, compacted layer or hard pan a few inches below the surface, this prevents root penetration and causes poor drainage. This can be corrected by penetrating through the impervious layer by making a small hole 60 to 90 cm deep with a crow-bar at the base of the planting hole.

When the top of the roots is below the level of the surrounding soil, water will collect around the trunk in all but sandy soils. Crown rot will frequently occur in such situations. To avoid this, the top of the root ball should be elevated 2.5 to 5 cm above the soil (Harris, 1992).

Staking

No staking is necessary for conifers and other trees with limbs close to the ground, or small trees with upright growth habits. For other trees, staking may be necessary to anchor the tree until the roots can support it, to protect from windthrow and to prevent vandalism. Trees in heavily used areas are protected with metal grillwork or substantial barriers, while other trees are anchored by tying them between two low stakes.

Staking trees can present disadvantages. Trees without stakes develop thicker trunks with the additional movement they experience in the wind, while rubbing from the stake injures the bark and invites beetle damage or attack by microorganisms. Low staking will hold the lower trunk, keep the roots from moving, while permitting movement of the upper part.

Watering

The soil around the tree should be thoroughly soaked with water at the time of planting. This is most critical for trees planted during warm or windy weather, when loss of soil moisture is rapid. Watering also reduces the stress from excessive moisture loss from the foliage.

A tree thoroughly watered at planting should not need irrigation until two to four weeks after growth begins, or only to rewet the root ball and a little of the surrounding soil. Early in the growing season, roots grow into moist soil while the top has few leaves. Overwatering during this time can endanger root growth and function.

Soil aeration and weed control

Soil compaction by people or machinery leads to aeration problems for tree roots. On young trees, this can affect the availability of soil oxygen for the roots.

A mulch of organic material, such as wood chips or bark, set on the soil allows aeration and prevents compaction from human traffic. The mulch also provides the initial weed control around the tree, since herbicides, lawn mowers and string headers can damage young trees.

ii) Care of mature trees: watering

Landscape plants probably suffer more from moisture-related problems than from any other cause. Water is required for the photosynthetic production, for the transportation of food, for the turgidity of roots and shoots, and for the cooling of plants via transpiration. Even well-adapted trees need the occasional watering in hot weather to compensate the transpiration from the large foliar crown.

With too little water, most plants wilt noticeably. Leaves that were once shiny become dull, bright-green leaves fade or turn gray-green, and leaves may fall early. A severe drought period results in the death of fine feeder roots and root hairs, those portions of a tree responsible for uptake of water and nutrient. Once damaged, the feeder roots cannot be revived by supplementary water. Drought symptoms may not be evident until a year or two later, and the drought predisposes the tree to secondary invasion by pests and diseases.

Excess water from irrigation or precipitation will result in yellowing of the foliage and wilting. The excess water replaces oxygen in the soil for sustained periods, resulting in root damage. In Coastal areas of B.C., high rainfall leaches many soluble nutrients, especially nitrogen, zinc, iron, and accelerates soil acidification.

The water need of a tree is determined in a number of ways. An accurate assessment is obtained from soil-moisture sensors or calculation of evapotranspiration. When these methods are not available, the assessment is done in other ways, such as plant appearance and feel of the soil. A young tree is observed until the first signs of wilting appear, and subsequent irrigation schedule can be set at one day less than the wilting interval. For an established tree, watering starts when the leaves are wilted in the morning following a hot day. Deep and slow watering encourages the development of tree roots at great depth into the soil.

Moisture adequacy can also be assessed by feel of the soil. Roll or squeeze a small sample of soil into a ball. The soil is too dry when it cannot mold into a ball. The soil is too wet when the ball is formed but does not crumble with rubbing. The soil has the right moisture when the moulded ball crumbles when rubbed. Sandy soils will crumble even when wet.

iii) Care of mature trees: pruning

Pruning is part of the normal maintenance program of the tree and should be done at least every 2 to 3 years. Proper pruning can relieve the tree of dead and dying branches, remove disease inoculum, improve tree vigour, compensate for root loss, and help a valuable shade tree to retain its desired form. However, improper pruning is a major cause of tree decay and can trigger insect attack.

The work of Dr. Alex Shigo, retired plant pathologist for the U.S. Forest Service, demonstrated that trees have effective systems for defending themselves against disease organisms that enter the trunk through dead, dying or improperly pruned branches.

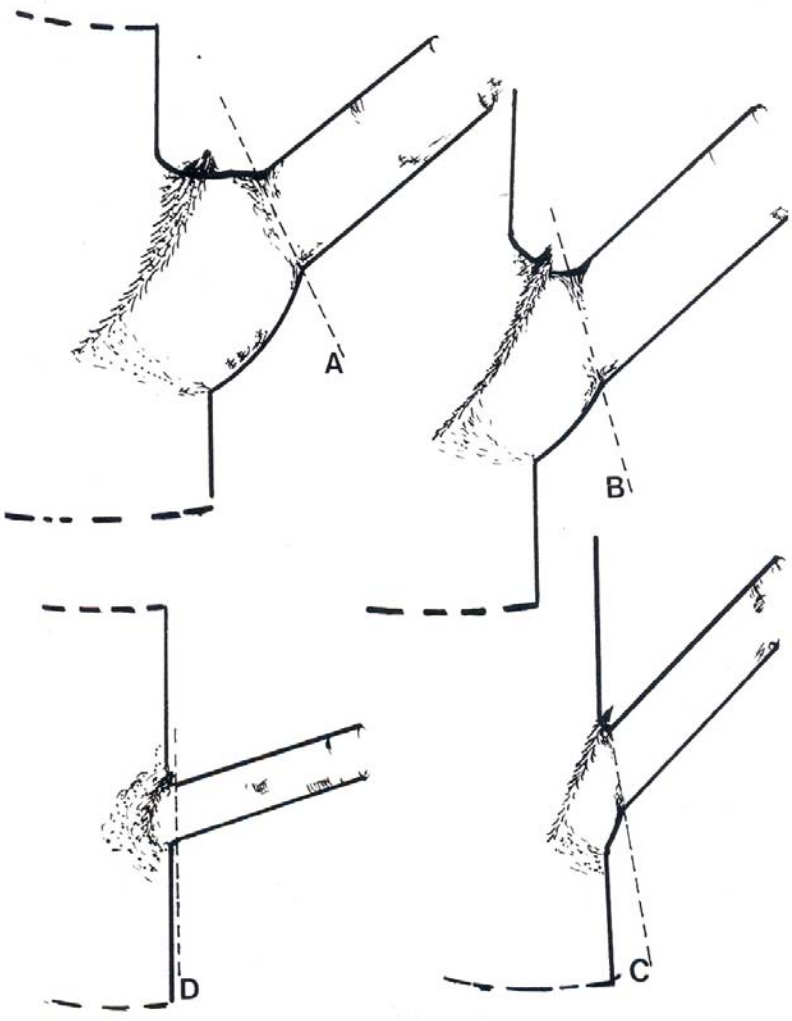
The front line of the tree's defence system is located in a swollen collar of wood located at the point where the branch grows out of its supporting limb or trunk. After branches die, internal boundaries form that resist spread of pathogens from the dead branch into the tree. The internal position of the boundary is seen externally by a boundary where the branch meets the living collar of the trunk.

When the proper pruning cut is made, a circle of healthy callus forms completely about the cut within one growing season after the cut. On a living branch, the pruning cut is made behind the branch bark ridge in the branch crotch. Flush cuts are not recommended, as they start over 14 serious tree problems, including decayed wood, cracks, and cankers. On a dead branch, never injure or remove the living collars that circle the dead branch. A pruning cut that removes the branch protection boundary causes extensive trunk decay after 1 or 2 years.

Improper pruning and topping cuts are often heavily coated with a great variety of materials that are called wound dressings. When cuts are proper, there is no need for any dressing because the natural protection boundaries resist the pathogens. When cuts are improper, no amount or type of material will stop decay, and the dressing may protect the pathogens already in the rotted wood.

Box 3-2: Dr. Shigo on pruning of trees

The branch bark ridge is the key to proper pruning.
The pruning tool should be placed outside the branch bark ridge and the cut made at an angle to the outside of the branch collar. The branch collar should not be removed or injured during pruning. Pruning this way will ensure the "branch protection zone" is not removed, and the tree can heal the pruning cut.



The size of the collar
determines the correct position of the pruning cut.
The collar may be large (A), medium (B), or flat (C and D).

Source: Shigo, Alex L., "100 Tree Myths", 1993.

iv) Care of mature trees: fertilization

Fertilizers can help trees replace soil minerals that are lost through leaching and absorbed by the roots. Decomposition of fallen leaves in the forest recycles most of the minerals taken up by the trees but the leaves around shade trees are usually removed. The soil around shade trees, therefore, can become deficient in common soil elements.

Fertilizer application, along with soil improvement, is part of a successful tree maintenance program. Tree fertilization is done to increase the size of small trees as rapidly as possible, to maintain the healthy appearance and vigour of mature trees, to rescue declining trees and to cure specific nutrient deficiencies (Pirone et al, 1988).

Fertilizers are available in a wide variety of forms. Fertilizers may be organic such as manures, or may be inorganic mixtures of salts, such as potassium nitrate. Commercial fertilizers are rated as to their proportions of nitrogen, phosphorus, and potassium (such as 5-10-10), the three main plant nutrients. Some fertilizers also supply small amounts of micronutrients such as iron, zinc, boron and others. Micronutrients are an essential part of plant growth, but may be toxic in excess amounts.

Common nutrient problems in British Columbia are listed in Box 3-4.

The nutrient status of the soil can be accurately measured from a sample submitted to a reliable laboratory. The soil tests indicate the status of the major and minor plant nutrients, and include information on other soil characteristics such as salinity and acidity. A number of private laboratories are found in the Lower Mainland and the southern Interior. The laboratory must be contacted for information about the proper collection of the sample.

Application of fertilizer is timed so that nutrients are available for periods of rapid growth. For spring growth, application to the soil is made in the late winter or early spring 4 to 6 weeks before bud break. Foliar sprays are made after leaves begin to expand, whereas trunk implants are done after leaves are fully expanded. Applications made in late summer or early fall may stimulate new growth in some tree species, retard hardening off and make the plant susceptible to damage by cold weather.

Application methods

Fertilizers are applied in a variety of ways. Slow-release formulations are widely used to fertilize trees and shrubs. Nutrients are released gradually over approximately 1 year following application. Broadcast application of fertilizer on the ground is an effective method of fertilizing trees where ground vegetation is absent or not of concern, as in a commercial tree nursery. Foliar application of fertilizer is used to supplement but not replace soil fertilization. Foliage fertilization is most effective in helping to correct micronutrient imbalances, such as iron deficiency, or to achieve a rapid but temporary "greening" of foliage.

One method of application investigated in recent years is injection, defined as "the forceful introduction of liquids into freshly punctured, incised or drilled wounds through the bark into the outer sapwood via syringes or other pressurized units" (Stipes and Campana). With this method, fertilizer nutrients are injected inside the tree and carried by the sap stream. Small holes are drilled in the bark to introduce an "implant", a gelatin capsule containing a small amount of a soluble product. Implants are commercially available in British Columbia containing fertilizers, insecticides and fungicides.

The benefits include rapid translocation of the product in the target tree without risk of drift on the environment. The drawbacks include the time-consuming drilling of holes and development of decay at entry sites. Implants should be used with great care as this technology is new and field research in its infancy.

Box 3-4: Common nutrient problems in British Columbia

B.C. soils normally have adequate supplies of most of the essential elements. An exception would be nitrogen, a major element highly water-soluble and required in substantial amounts.

NITROGEN (N)

This element is nearly always in short supply for maximum tree growth. Lack of nitrogen results in small yellow foliage and generally reduced growth. Other plants, notably turf, compete with trees for available soil nitrogen.

Nitrogen is also often overused. High levels encourage rapid plant growth, but succulent growth is often attractive to aphids and scale.

PHOSPHORUS (P)

Adequate levels of phosphorus for tree growth are present in nearly all soils. However, phosphorus becomes unavailable to plants when the soil pH is out of the range 5 to 7.

Phosphorus promotes root growth and can be recommended for injured trees. Supplying nitrogen to an injured tree promotes succulent growth, adding to the stress of the injured roots and making the situation worse.

POTASSIUM (K)

Most soils contain enough potassium for tree growth.

IRON (Fe)

Commonly deficient in urban landscapes, where it may be present in the soil but will be unavailable to the roots, because the soil is acid, alkaline, or water-logged.

Deficiency is readily recognizable by interveinal yellowing of leaves. This is a complete uniform yellowing with a definite green vein. When the deficiency is severe the green in the veins may disappear.

ZINC (Zn)

Zinc deficiency is also fairly common among cultivated trees and large shrubs, either because the soil pH is alkaline (mostly in arid areas of the Interior), because the topsoil was removed or because of high phosphate applications.

Symptoms include small leaves, blind wood on last year's growth and a cluster of normal leaves at the terminal end of affected limbs. Sometimes called "little leaf" because of the smaller and narrower leaves.

BORON (B)

Needed in small amounts by plants to help flower and fruit set, but tends to be low in native B.C. soils. It is highly soluble and leaches away with rainfall.

Deficiency symptoms may be observed as a failure of leaves to develop properly in the spring. Under extreme conditions die back of shoots may occur.

Adapted from: Pirone, P.P. et al, "Tree Maintenance", Oxford University Press (New York, NY), 6th Edition, 1988.

and Edwards, Linda. Integrated Crop Management Inc. Okanagan Centre, B.C. Personal Interview. July 22, 1993.

Table 3-5: Soil conditions when nutrient deficiencies are likely to occur

Soil condition	Unavailable nutrient
High pH (alkaline)	Boron, calcium, copper, iron, phosphorus, zinc
Low pH (acid)	Boron, calcium, molybdenum, phosphorus, potassium
Coarse sandy	Boron, calcium, magnesium, nitrogen, potassium, zinc
Leached (high rainfall)	Calcium, molybdenum, nitrogen
Wet (poorly drained)	Iron, manganese, nitrogen
Organic	Copper, zinc, manganese
Low organic matter	Potassium
Sodic	Calcium
Calcareous	Copper, iron, manganese, zinc, magnesium

Source: Pirone, P.P. et al, "Tree Maintenance", Oxford University Press (New York, NY), 6th Edition, 1988.

v) Care of mature trees: Plant Health Care

In recent years, a new concept has emerged among arborists to combine the practices of IPM with an emphasis on the plant and the factors that affect its health and vitality.

The "Plant Health Care Management System" was developed by the National Arborist Association, the International Society of Arboriculture and the U.S.D.A. Forest Service, three organizations based in the United States. The goal is to increase public awareness of the environmental and ecological importance of trees, and also to help tree care professionals examine and rethink their management practices.

The foundation of Plant Health Care is provided by the natural defensive system of the plant. Healthy, vigorous plants growing in optimum conditions have an effective defensive system, and this defensive system limits injury from insects and diseases. Use of supplemental chemical treatments is reserved as a last resort and only when natural plant defences have failed.

The concept of Plant Health Care was also tailored to meet the needs of consumers. Tree care professionals design environmentally-sound programs and provide the quality of tree and shrub care desired by the client. For field practitioners, Plant Health Care stresses the importance of proper management practices with trees and other landscape plants, to reduce the need for pesticides.

Box 3-6: Using Plant Health Care in Coquitlam

Michael Nihls is the Superintendent of Parks Operations for the City of Coquitlam. He adopted the Plant Health Care approach and provides this explanation:

"One the biggest obstacle facing municipal turf managers and pesticide producers is the wide spread public perception that pesticides are bad news for the environment. While the public is increasingly becoming aware of the ecologically responsible benefits of I.P.M. programs, many uninformed members of the public and some environmental advocacy groups still attach a negative connotation to the term *pest management*.

A new name, with a focus on *plant health* and elimination of reference to pest management, may help us manage this negative perception.

The plant health care approach focuses primarily on preventative measures, those that encourage plant vigour and healthy balanced growth, rather than treatments for diseases and insects. In this framework chemical applications, like drugs in human health care, are only one tool in the arsenal for plant health maintenance."

Source: Nihls, M., "Managing Municipal Turf in the Nineties", Presentation to the Environmental Turf Seminar (Vancouver, B.C.), January 14, 1993.

vi) Care of mature trees: the urban environment

Urban environments stress shade trees and other landscape plants. High temperatures, restricted air movement and highly disturbed soils are typical of urban conditions, just the opposite of forest conditions where most trees evolved. Arborists should be concerned about the effects of the urban environment, as it may provide the explanation for many problems affecting shade trees.

Soil compaction

An example of urban environmental impact is soil compaction from pedestrian or automobile traffic. As the soil becomes denser, it is increasingly impervious to surface water and gas exchange. Root growth is severely limited in compacted soil. In mild cases, the affected trees appear normal for several years and then display early fall coloration or minor twig dieback. In severe cases, trees decline and eventually die after several years.

Compacted soil can be most effectively prevented by keeping foot and automobile traffic away from shade trees. The soil can be loosened to an approximate depth of 15 to 20 cm with a crowbar-type instrument, or organic matter can mixed to lighten the soil (Tattar, 1989).

Construction activities

Construction activities cause site changes that can lead to the decline and eventual death of established trees. Most injuries result from a change of grade or from mechanical injury to the trunk and the roots.

Raising the grade or filling over the roots of trees often results in suffocation of the roots. For example, if the tree trunk seems to enter the soil without any widening, like a telephone pole, fill materials may have been placed over the roots. Fresh asphalt or concrete on a street or sidewalk next to a tree are clues of recent trenching and possible root damage.

Construction injuries often results in damage to the roots. Trees show various symptoms such as small leaf size, premature fall coloration, dieback of twigs and progressively larger branches. In many cases, the crown can be lightly thinned to remove dead and dying branches. Phosphate fertilizer can be applied to encourage root growth, but the addition of nitrogen, which primarily stimulates foliage production, should be avoided.

Salt toxicity

Another serious stress results from the application of salt to icy roads in winter, which then burns nearby trees during spring thaws. Snow containing salt should be piled away from the dripline of trees if possible. Water can be applied in the spring to leach the salt from the surface ground. Salt-tolerant species should be selected for plantings close to roadsides.

Pollution

In the immediate and foreseeable future arborists will need to be very concerned about the effects of environmental pollution on shade trees. Not only is accumulation of pollutants greatest where there is the highest concentration of people and industry but emissions of some air pollutants are increasing. Trees are adversely affected by a wide variety of environmental pollutants. Among the most important of these are sulphur dioxide (SO_2), ozone (O_3), fluorides (F), oxides of nitrogen (NO_X), and particulates such as salt spray or heavy metals. Many of the air pollutants come from automobile exhausts and exhaust stacks of factories.

Susceptibility of trees to pollutants varies greatly with species, age, pollutant dosage and other interacting factors. Conifers are usually more susceptible than broad-leaved trees to air pollutants, and the needles exhibit patterns of necrosis and chlorosis. On broad-leaved plants, leaves may develop interveinal necrotic areas, marginal or tip necrosis of the upper surface or silvering of the lower surface.

Long periods of exposure to low levels of pollution result in chronic injury, which may be hard to distinguish from other forms of poor growth. Affected plants are low in vigour and fruit yield, leaves are pale green and leaves and fruit color early and more brightly and drop earlier. Affected plants are usually more susceptible to other disorders.

The most obvious solution to the problem is to reduce pollutants at their sources. If not possible, trees and shrubs that are most tolerant of the expected pollutants should be planted. As an example, the susceptibility of trees to sulphur dioxide is presented in section B of Chapter 9: "Appendices".

Research has showed that irrigation practices can affect plant sensitivity to air pollutants: spraying sensitive plants with water during and after toxic exposures may reduce pollution injury (Harris, 1992). The relationship between nutrition and susceptibility to air pollution is unclear, but observations indicate that plants grown at moderate fertility levels are usually the most tolerant.

Box 3-7: Managing for city pollution on Granville Island

Granville Island is a tourist center in the heart of Vancouver where hundreds of persons will converge every day. Keeping plants healthy and attractive for the eyes of visitors is the responsibility of Martin Harcourt and his company, Mainland Landscaping and Gardening Ltd.

Granville Island is a major challenge for a landscape manager. The island is located directly under Granville Bridge and receives hundreds of pounds per year of dust and pollutant particles falling from the bridge. Parking lots and roads cross the island and many trees are surrounded by black-top.

Trees are damaged by bumping cars, inconsiderate visitors or from vehicles parked over the roots. On one occasion, diesel trucks on a construction project were blowing their exhaust into the crown of a tree. Tissue analysis later confirmed abnormal sulphite readings in the plants.

The damage from this extreme case of urban environment goes from a change of the foliage color, to reduced growth, to the death of the tree in some cases. During a hot summer spell, a tree looking healthy one day was losing foliage the following day!

Removing the traffic from the island is not an option. For Harcourt, the way to proceed is to feed the plant and allow the trees to grow in the polluted environment. His program includes organic fertilizer for long-term micro-nutrient, granular synthetic fertilizer for the immediate flushing response, water to the trees through "ports" (pipes installed in the ground to directly access the roots from the surface) and flushing of the leaves with water in the early hours of hot summer days.

Source: Harcourt, Martin. Mainland Landscaping and Gardening Ltd. Vancouver, B.C. Personal Interview. July 13 and August 12, 1993.

C) EXAMPLES OF INSECT AND DISEASE PESTS OF TREES

A good Integrated Pest Management program for urban trees monitors for pest problems, identifies any found, establishes an action threshold and selects the most appropriate treatment strategy. Many of these activities require research through local experts, specialized books, magazines and scientific journals. Suggested references are listed in Chapter 9.

Some insect and disease problems found in British Columbia have resulted in specific IPM programs. Examples are presented in the next pages. The information is not a recipe to be transposed in other situations, as different factors may require different approaches.

i) Cypress Root Rot in Victoria and Vancouver

Symptoms

Many native evergreen trees in the Victoria and Vancouver areas exhibit symptoms linked to a root rot. Lawson cypress (*Chamaecyparis lawsoniana*) is very susceptible, but other trees such as junipers are also affected. The foliage of an affected tree will wither and discolour, turning successively chlorotic, bronze, and brown. Foliar discoloration is often preceded by slight wilting during warm days in spring.

Diagnosis

The responsible pathogen has been identified as *Phytophthora lateralis*, an unspecialized pathogen that destroys root tissues. Weakened roots lead to nutrient deficiency and, after 2 to 4 years, to plant death. *P. lateralis* attacks trees of any size or age, entering succulent roots, foliage, or wounds and spreading in the inner bark and cambial region. The infected inner bark turns cinnamon brown in contrast to the healthy cream color.

Infection

Although infection can occur at temperatures between 3 to 25^{o}C, the pathogen is most favoured at 15 to 20^{o}C. Both aerial and root infections occur beginning in late autumn and are most frequent in early spring, as the disease is associated with wet weather.

Chemical control

In Victoria and Vancouver, the use of pesticides is severely limited because of environmental concerns. Many residents contact City Hall whenever pesticides are applied on public land. This public attitude is forcing the personnel of the Parks and Recreation Department to investigate other options when serious problems are encountered.

Biological control

Root rot is a difficult disease to control as the affected parts cannot be easily removed to prevent the spread. Future techniques may include the use of a bacteria (*Enterobacter aerogenes*) establishing itself before the disease agent in unaffected roots and releasing natural fungicides. This biocontrol agent has been successfully tested against other types of root rots. In experiments conducted by Agriculture Canada, diseased trees treated with the bacteria remained alive and productive for 3 years while untreated trees died.

ii) Hawthorn Leaf Blight in Victoria

The residents on one street in Victoria were unhappy with the appearance of street trees in their neighbourhood. Leaf spots were quite apparent. An initial brown specking would evolve into small holes, followed by the dying of the leaf and even defoliation of the tree. The residents petitioned the city to remove the trees.

Diagnosis

The disease was identified as *Entomosporium mespili*, a leaf blight affecting many different plants worldwide. In this case, the hawthorn trees (*Crataegus oxyacantha 'Paul's Scarlet'*) were seriously affected. The lesions for this disease begin as minute dots and when fully developed appear as brown to gray irregular spots 2-5 mm in diameter. Lesions may be scattered or so numerous that they coalesce to form large dead blotches. If plants defoliate before midsummer, new leaves may grow, and these soon also become infected.

Host plants vary widely in susceptibility: the Washington hawthorn will be only lightly spotted while nearby 'Paulii' English hawthorns are completely defoliated.

Monitoring

Michelle Gorman, the IPM Coordinator for the Parks and Recreation Department, instituted an IPM program as her approach to the problem. The first element was regular monitoring. She assessed 60 trees located on 3 adjacent streets. She designed the assessment system to fit her requirements: trees are visually inspected and the severity of the symptoms is rated as 0 (no symptom), 2 (some brown spots), 4 (more spots) to 10 (defoliation).

The monitoring provided a better understanding of the disease and how the trees were affected over time. Some trees were observed to recover the year following serious defoliation.

The monitoring also tracked disease progression and identified other contributing factors. For example, some leaf hoppers were seen on infected trees: were the insects the vectors of the disease and responsible for the spread from tree to tree? Or were they attracted to an already weakened tree? Were trees suffering from drought stress more affected?

A total of 1,883 hawthorns trees were listed on the Victoria city inventory, comprising approximately 11% of the boulevard trees.

Treatment selection

The treatment selection was based on the monitoring information, on the knowledge of the disease and on the wishes of area residents. For example, the disease was known to spread in the fall from infected leaves to non-infected leaves: one approach was to vacuum the fallen leaves from the ground to reduce the disease pressure the following year. However, hawthorn leaves are quite small and this work was time-consuming.

Another approach was to apply fixed copper in the fall and the following spring. This product is an accepted natural fungicide known to be very effective against many diseases.

Possibly, the trees could outgrow the disease. Monitoring had indicated that trees with a severe leaf drop for 4 to 6 years were in a better condition in 1993. Watering possibly helped the hawthorns withstand the disease and build-up tolerance: trees watered by area residents showed less disease symptoms.

iii) Jumping Gall Wasp on Oaks in Victoria

Symptoms

Wherever oaks occur, they are attacked by a group of small insects called gall makers. These insects cause deformities, known as galls, of various shapes, sizes, and colors on leaves, twigs, bark, flowers, buds, acorns and even the roots of the tree. The galls are better known than the insects that produce them. The majority of gall makers that attack oak are wasps, but in some cases flies are responsible.

Life cycle

The jumping oak gall, caused by the gall wasp *Neuroterus saltatorius*, is tiny and globular on the underside of white oak leaves. The galls, each of which contains a single larva, drop to the ground when they have matured. The activity of the insect inside the gall makes it jump repeatedly a few centimetres off the ground. After overwintering, a population of female *N. saltatorius* wasps emerge from the galls. Eggs are then laid in the newly opening buds. A few weeks later, blister-like swellings appear on the young white oak leaves. Wasps that emerge from these blister-like galls are both males and females. After mating, females lay their eggs in the leaves and galls appear about 40 days later.

Damage

Galls are caused by powerful plant growth-regulating chemicals or other stimuli produced by the insect that react with plant hormones. The inner walls of the gall are rich in protein and provide and abundance of food to the larvae residing inside the gall. The larvae are protected from parasites and predators by the abnormal plant tissue that surrounds them. The galls may become so numerous that they cause discoloration or premature loss of leaves.

Monitoring

This insect was first recorded on Vancouver Island around 1986 at Thetis Lake. From this location, it moved into the City of Victoria by 1991 and is now seriously attacking the population of native Garry Oaks (*Quercus garryana*). The oaks are the pride of coastal areas of British Columbia, as they are found only in specific climates close to the sea.

Chemical control

The insect is commonly found in California where it does not present a serious threat, possibly being kept in balance by parasitism. A systemic insecticide, applied by injection or brushed on the trunk, will provide chemical control of the pest. However, a practical ban on pesticides within City territory is forcing Parks management to look at other solutions.

Biological control

Entomologists at the regional centre of the Canadian Forestry Service, in Victoria, attempted to identify the predator / parasite complex that controls the gall wasp in California and Oregon State, the native home of the pest. Parasitism is found to increase in areas around Victoria where the wasp has been established the longest. This may indicate the parasites could provide long-term control of the gall wasp.

iv) Cherry Bark Tortrix in Vancouver

The cherry bark tortrix (*Enarmonia formosana*) has been recognized as a bark-boring pest of trees since 1837 with a range from Ireland to Siberia. This moth was not positively identified in North America until 1990, but it had become thoroughly established prior to its recognition in the Lower Mainland area of British Columbia.

The serious damage to ornamental and fruiting cherries of his customers convinced Mac McNair to investigate this pest. McNair is a specialist working with Arbour Care Tree Service, a private company in pest management and landscape maintenance in the Vancouver area.

Identification

An early part of the investigation was a research of scientific papers published in Europe and North America since 1940. This search provided an accurate identification of the insect. The adult is a small brown moth that is inconspicuous when at rest on the trunk of a tree. The larva will go through five instars. The fifth-instar larvae will be pinkish-brown, with a darker brown head, similar to the larva of the codling moth. The insect overwinter as 3rd, 4th or 5th instars. There is one generation per year with adult moths emerging from May to September.

Damage

The eggs are laid inside or near cracks or wounds in the bark of the trunk or lower limbs of the host tree. The newly-hatched larvae will immediately crawl into cracks and start new tunnels or widen existing ones within the tree. Dissection of old, tortrix infested boulevard cherries in Vancouver indicated damage did not extend past the upper phloem layers. The larval feeding will cause direct damage to the tree, and the weakened tree will become more susceptible to secondary pests or unfavourable weather conditions.

Monitoring

The first signs of the cherry bark tortrix in the Vancouver area are usually found in early May. Small reddish-brown tubes, about 1/8" in diameter and up to 1/2" in length, will protrude from cracks in the trunks of cherry trees. These tubes are especially common near the base of the trunk, at pruning wounds, in bacterial cankers, or where branching occurs. The tubes are made of silk and covered in "frass" (larval excrement). These are the chambers in which larvae pupate. Male moths can be caught in pheromone (sex attractant) traps available from Phero-Tech Inc., Delta, B.C.

Control

Control is directed towards the larvae and may take the form of non-pesticide treatments, such as sealing cracks with Tanglefoot as soon as frass tubes appear in the spring. This treatment should inhibit both adult emergence from pupae and egg-laying by female moths. The most popular and effective control in Europe, Russia, Siberia and Ukraine has been provided by Trichlorfon, an organo-phosphate insecticide not registered for this use in Canada.

Box 3-8: The decline of ornamental cherries

The cherry bark tortrix attacks various members of the family *Rosaceae*. Older trees with deeply creviced bark or previously injured trees are more readily entered. In Vancouver, the damage to flowering cherries is a reflection of a specific situation: the City of Vancouver alone has approximately 30,000 street cherries, mainly mature, top-grafted ornamentals. This, in conjunction with the many thousands of backyard cherries, has created a virtual "monoculture" condition for the bark tortrix.

In the Lower Mainland, the flowering cherries are suffering severe dieback and premature mortality: this is viewed as a disease complex, with the common characteristics including swelling at the graft union and decreased crown vigour over a period of several years, followed by death.

A variety of factors may be responsible:

- climatic unsuitability (extended wet winter and spring conditions)
- genetic weakness (material selected for heavy spring flowering, not survival)
- insect pests (winter moth and cherry bark tortrix attacking new growth)
- pathogenic diseases (some scientists say bacterial canker is the main cause).

Source: McNair, M., "Cherry Bark Tortrix", Mimeographed paper, April 1992.

v) Caterpillars in British Columbia

Many species of butterfly and moths are found throughout British Columbia.

The common insects include the tussock moth (*Orgyia pesudotsugata*) on Douglas fir, true firs and ornamental spruces; the apple-and-thorn skeletonizer (*Anthophila pariana*) on mountain ash, cherry, apple and pear; fall webworm (*Hyphantria cunea*) on most deciduous shade and fruit trees; the obliquebanded leafroller (*Choristoneura rosaceana*) on many broad-leaved trees and shrubs; and the winter moth (*Operophtera brumata*) around Vancouver.

Damage to plants is done by larvae feeding on the foliage. Thus, knowledge of the life cycle for each species is important to target the monitoring efforts. For example, the fall webworm has one generation per year. The eggs hatch during the summer and the larvae stay in a group to spin a web for shelter while feeding. Monitoring is done in summer months to locate branches with webs. Satisfactory control is obtained by cutting the limbs with webs.

The obliquebanded leafroller has two generations per year. The insect overwinters as partially grown larvae which resume feeding in early spring. The second generation is found in August and September. Thus, monitoring for this insect is done twice during the year. The leafroller causes some damage by feeding and rolling of leaves for protection. However, it is often found in low numbers and is not threatening to the health of attacked trees. Education of customers and tolerance of low pest level are appropriate approaches in this case.

The apple-and-thorn skeletonizer has three or four generations each year. The insect populations build up quickly on the host trees and may cause serious damage to the foliage. Monitoring is to confirm the presence of the young larvae, the vulnerable stage for least-toxic treatment options such as B.t.

Box 3-12: The use of B.t. for caterpillar control

Bacillus thuringiensis is a commercially available bacterial species that causes disease in certain insects. The variety *kurstaki* (B.t.k.) is effective only against the caterpillar (larval) stage of moths and butterflies in the insect order lepidoptera. This will include hundreds of species of caterpillars that feed on plants, including "worms" that attack vegetables, "loopers" found on melons and lettuce, armyworms and webworms that eat the leaves of lawn grasses, gypsy moth larvae and tent caterpillars found on trees and shrubs and the larvae of moths that attack stored grains.

B.t. is a bacterial stomach poison that must be eaten by an insect to be toxic. When the crystal endotoxin inside the spore is ingested by an insect with the proper gut pH, the crystal dissolves. The subsequent poisoning causes the insect to stop feeding and may also lead to paralysis. The bacterial spores invade the insect's body cavity and will eventually kill the insect. A caterpillar that ingests B.t. may live for several days, but does not continue feeding. Dead and dying caterpillars turn a dark color and may remain attached to the leaves for a few days.

With the current commercial formulations, B.t. is broken down within one to several days by sunlight and repeated applications may be necessary. It is most effective if applied on caterpillars during their first and second instars, when they are still small. Thus, it is critical to monitor the plants and recognize the various stages of the insect targeted.

B.t. is generally considered harmless to humans and is non-toxic to the natural enemies. It is a least-toxic insecticide approach that can be part of any IPM program for caterpillar control.

Source: Olkowski, W., S. Daar, H. Olkowski, "Common-Sense Pest Control", The Taunton Press (Newtown, CT), 1991.

vi) The Orton System in Vancouver

When you have 93,000 trees under your direct care, how do you monitor them effectively? The IPM Co-ordinator for the City of Vancouver faced this problem every year. On the one hand, a sample procedure is not practical within a city: every tree should be examined, because the one tree suffering from vandalism is the tree noticed by the residents. On the other hand, there is no provision in the budget for technicians to look at every tree on every street during every week. Another approach was needed.

The approach described here is based on phenological data and indicator trees. Some insects attack tree species at the same time as other plant species are flowering. By continually adding regional information, the accuracy is improved and serves as a guide during the year to focus the monitoring efforts for specific pests.

The system is called "Coincide: The Orton System of Pest Management, Timing Pest Management with Ornamental Plant Development" and originates from the United States. It is based on the use of degree-days and phenological data. Insects are known to develop based on the amount of heat experienced: on a warm spring day, the insect development is faster than on a cool spring day.

The unit of measurement is the degree-day (^{o}D). Laboratory studies define the required number of "degree-days" for an insect to complete a specific part of its development. The same rational exists for the development of plants (also called phenology): plants will bloom after the accumulation of sufficient heat and light.

Indicator plants that are in full bloom at a known degree-day accumulation can be compared to the required degree-days for insect emergence. The visual observation of indicator plants is done quickly and provides a definite advantage over the weekly monitoring of thousand of trees. The system is still under development but is currently operational.

Table 3-10: Monitoring Oystershell Scale with Orton

Oystershell scale is found throughout B.C. on dogwood, hawthorn, wild rose and many other hosts. If present in large numbers, it reduces the vigour of the plant as a result of the sap sucking.

The vulnerable stage of the insect occurs when the newly hatched crawlers are moving on the plant in the spring. This stage is associated with an accumulation of 200 to 350 degree-days (base 10^{o}C). Treatment is applied when *Spiraea X vanhouttei* (bridal wreath spiraea) has finished bloom.

Information gathered in Illinois for the Orton System support the use of *Spiraea X vanhouttei* as an indicator plant: it is commonly grown, the blossoms are showy, and the plant is easily recognizable from a distance. Full bloom occurs at 150 to 300 degree-days.

An alternate indicator for the vulnerable stage of the oystershell scale is the horsechestnut (*Aesculus hippocastanum*) in late bloom with some blossoms brown.

Source: Orton, D.A., T.L. Green, "Coincide: The Orton System of Pest Management", Plantsmen's Publications (Flossmoor, IL), 1989.

vii) Scale in Penticton

Scale insects on ornamental trees and shrubs are numerous in British Columbia and can cause various types of problems. They consume plant sap and weaken plants when their populations exceed a certain density. Plants weakened by scale infestations show a general chlorotic appearance and become more susceptible to infestation by insects and diseases. Certain scale insects excrete honeydew which supports growth of unsightly sooty mold.

Managing scale infestations is a major component of the work Linda Edwards does with the City of Penticton. Her private company, Integrated Crop Management Inc., has been working since 1989 doing weekly monitoring and recommendations for pest problems.

Identification of the pest is important. There are many different types of scale to be found in British Columbia: Lecanium scale, oystershell scale, cottony maple scale, San Jose scale, pine needle scale, juniper scale and rose scale are found commonly on ornamental trees and shrubs. Each has a different life cycle, appearance and favourite hosts.

Upright junipers are found to be very susceptible to juniper scale and require constant attention. The management of scale on these plants will involve the following elements:

- Monitoring early in the season on a weekly basis to confirm the presence of eggs, crawlers or adults. Monitoring is done by visual observation of the twigs, with the help of a 16X magnifier hand lenses.

- Identification varies with the species. In many scale species, the eggs and adults are protected by a hard shell. The young insect emerging from the egg is called a crawler: it moves on the plant looking for a place to establish and feed on the sap.

- Threshold is established from plant appearance, pest numbers and distribution and general experience with local conditions.

- Selection of treatment depends on the time of year, the stage of the insect and the proximity to high public traffic. When appropriate, a mixture of oil and insecticide is applied in the spring to control overwintering immatures. During late spring and summer, monitoring of susceptible plants determines when the crawlers are visible and in what numbers. This stage is the most vulnerable and is controlled with a chemical insecticide or, in public areas, an insecticidal soap.

Table 3-11: The use of oil for scale control

Oil is often applied in the dormant season to control or prevent many pest problems. Although it is seen as a cure-all remedy by many pest managers, a dormant oil application can also be a total failure because of improper timing or improper diagnostic of the problem.

A valid IPM program using dormant oil takes into account the vulnerable stage of the pest. Many scale species over-winter as immatures under a scale cover. It is only when they start to breathe in late spring that an oil application will suffocate them. Oystershell scale overwinters as eggs under the shell. An oil application has no effect on the protected eggs, and this pest is best controlled with a soap spray at the crawler stage in May or June.

No spraying is done in Penticton for the pine needle scale as it is heavily parasitized. Finally, the use of oil for insect control is done with great care. The product causes damage to foliage of deciduous and evergreen trees when used under specific conditions. Label instructions must be followed in all cases.

Source: Edwards, Linda. Integrated Crop Management Inc.. Personal Interview. July 22, 1993.

viii) Elm leaf beetles in Penticton

What is a prettier sight than strolling down a street where towering elm trees are arching over and providing memories of old New England towns? The City of Penticton, in the Interior of British Columbia, can provide such scenery with a major street graced by American elms (*Ulmus americana*). The trees, however, are attacked every year by the elm leaf beetle.

Identification

The insect overwinters as adults in protected places outdoors. The adults are dull olive-green with a darker stripe on the side of each wing cover, about 6 mm long. Eggs are yellowish and pointed, laid in clusters on the leaves. The larvae feed on elm leaves before pupating on the ground or in crotches on the trunk. In Penticton there is usually one generation per year.

Damage

Larval feeding results in a skeletonization of the foliage. The upper surface of the leaves and the veins are left intact. Badly affected leaves turn brown and drop from the tree prematurely.

Control with conventional pesticides

For many years in Penticton, the control of the elm leaf beetle was done with the application of chemical insecticides over the whole tree. These sprays controlled the beetle; however, they resulted in outbreaks of scale and aphid insects. These caused blackened foliage and branches, honeydew dripping on sidewalks and general poor tree health. The pest management program shifted to spraying to control the scales and aphids.

Four or five pesticide applications per year were not providing satisfactory results. Scale and aphids remained in high numbers, resistance to pesticides was suspected. A different approach was needed and the Parks Department contacted Linda Edwards, of Integrated Crop Management Inc., a private IPM company based in Okanagan Centre.

The initial IPM approach was to stop all spraying for scale control, except one application of oil and insecticide in the early spring. Parasites and predators, probably killed by earlier pesticide spraying, came back to the elm trees and provided season-long control of the scales and aphids. However, within 2 years the leaf beetle population soared and became the main problem again.

Control with least-toxic methods

Unfortunately, there are no effective biological controls for leaf beetles. Since 1991, the management program for this pest has been based on weekly monitoring of the trees and research into possible treatments. There has been strong support of city officials for use of least-toxic methods.

For trees located near the lake, the population of elm leaf beetle is very low. These trees are not sprayed, but show little feeding damage at the end of the summer. Possibly, the windy conditions on the lake-side prevent the establishment of the beetle.

On other trees where there are very damaging larval feeding levels, the insecticide carbaryl is applied as a 1 foot-wide band on main and secondary branches. The beetle larvae descending to pupate at the base of the trees crawl through the band and are either killed or become unable to pupate. Vacuuming the pupae to reduce the population has also been done.

In 1993, experiments were initiated with a formulation of *Bacillus thuringiensis* (B.t.) developed for the control of Colorado potato beetle. Initial results show an acceptable kill of larvae. This product is pest-specific and does not give residual effect against the aphid and scale predators. It also has no mammalian toxicity and is more appropriate in areas of high public traffic.

In 1993, some elm trees were sprayed with carbaryl as a comparative treatment for the testing of the B.t. formulation. The selected trees border the lots of private car dealers unhappy with leaf beetle droppings on their car. The pesticide application resulted in a marked increase in the aphid and scale population, higher levels of honeydew on the foliage and droppings on the cars. The experiment validated the IPM approach of reduced pesticide use for leaf beetle control and the urgency of finding a least-toxic method of control.

ix) Peach tree borer in the Okanagan

In 1991, many peach fruit trees and shrubs were being returned by unhappy customers to a commercial nursery in the Okanagan. The damaged plants were showing brownish frass mixed with jelly-like gum at the base of the trees. The tentative diagnostic indicated damage from peach tree borer. A conventional calendar spray program for this pest was unsuccessful and a private IPM consultant was hired to work on the problem.

Site diagnosis

To ensure the proper timing of spray applications, sex pheromone traps were set out throughout the property where peaches, apricots and other shrubs are grown. The examination of returned trees confirmed the early diagnosis: larvae were those of the borer, cream collared with brown heads and when mature reaching 30-40 mm in length.

Site monitoring uncovered another problem. One bed of *Prunus cistena* (purpleleaf sand cherry) was heavily infested with the borer. These landscape shrubs were not growing well and the owner attributed the problem to soil nematodes. In fact, the shrubs were not doing well because of borer damage. They were also an ongoing source of infestation for the adjoining peach trees.

Identification

The peachtree borer (*Synanthedon exitiosa*) attacks plants in the genus *Prunus* throughout North America. The larva feeds on the inner bark at the root crown, where it often girdles the tree. It overwinters as a larva at the base of the tree and will emerge as adult anytime from June until September.

Because of the life cycle of the insect, it is necessary to inspect pheromone traps at weekly intervals starting in June. The males are attracted to the sex pheromone, are trapped by the glued surface, and can then be identified. They are clear-winged moths that resemble very large wasps. The forewings have a smoky coloration and the hind-winds are clear.

Threshold

Damage threshold is very low with this insect: one male caught in the trap is sufficient to initiate treatment. A registered product applied to a tree or shrub will kill any adult emerging from the trunk or landing on it to lay eggs. The effect lasts for 3 weeks. Monitoring of traps is resumed once the insecticide residual effect is over.

Accurate timing of the spray plus treatment of both the *Prunus cistena* and the peach trees reduced damage to almost zero.

x) Crabapples and codling moth in Penticton

Identification and Damage

The codling moth is the most damaging pest of apples in British Columbia. The moth adult is about 9 mm long, gray in color with a copper collared spot on the tip of each forewing. The coppery spot separates this insect from other moths of similar size and shape.

The damage is done by the larvae feeding inside the fruit and infested apples must be culled. Injured fruits have entry and exit holes plugged with dark masses of frass.

Control with conventional pesticides

Conventional control requires numerous applications of toxic organo-phosphate insecticides every year. Industry and government organizations are attempting a long-term control solution of this pest with the sterile-release technology.

The sterile-release program requires the rearing of million of moths each week that are sexually sterilized by gamma radiation and released into orchards to breed with wild moths. Mating of wild and sterile moths does not result in any offspring, reducing the codling moth population.

However, for the program to work, the wild moth population must be reduced to very low levels. For the City of Penticton, the obligation is to prevent moth breeding that could infest area orchards. A secondary host of the moth is the crabapple tree. Many of these were planted across the city for the beauty of the spring bloom and their removal would leave whole sections of the city without landscape trees.

Where 2 or 3 insecticide treatments were the norm, the lower threshold requires 6 or 7 sprays per season. Thus, a long-term less-toxic solution to the codling moth problem creates short-term problems for pest managers. First, the high number of sprays in parks and on boulevards is unacceptable during the tourist summer season. Second, other non-chemical options are more expensive. Both put a strain on the limited city budget.

Control with least-toxic methods

To meet the challenge of the pre-release clean-up program, a three-part program was developed by Linda Edwards, the private consultant doing pest management work for the City. First, trees producing very small crab apples were identified and no work performed on them, as the codling moth will not attack or survive in these fruits. Second, small trees are manually stripped of their fruit under a work-creation project employing Penticton residents.

Third, fruit is removed from larger trees by an early season spray of a commercial thinner. The product is Fruitone N, a non-toxic growth regulator, and is commonly used in apple orchards to remove unwanted fruit from the trees early in the season. After two years of test for efficacy and possible phytotoxicity, Agriculture Canada allowed the unregistered use of the product under the Minor Use Program "for fruit set thinning of ornamental crabapples (...) for use only as a component of an integrated pest management program to control codling moth in British Columbia" (Registration number 14630).

Box 3-9: The Minor Use Program

Pesticides are registered in Canada for use against specific pests on specific crops. The registration follows extensive studies for efficiency, residue, secondary effects, etc. Agriculture Canada will accept unregistered use of pesticides where special circumstances and field data warrant. The User Requested Minor Use Label Expansion program, commonly called the Minor Use program, will provide funds to facilitate this registration process.

For example, Dipel, a commercial formulation of B.t. (*Bacillus thuringiensis*), is registered for the control of fruittree leafrollers on apples. A Minor Use registration was granted in 1993 for use of Dipel to control early season obliquebanded leafrollers on red raspberry. The product can now be used instead of more toxic pesticides.

Although this program is also available for products applied in urban areas, no funds are available to support the needed research work. The onus is on Park Departments and private consultants to undertake the field and paper work needed to register least-toxic products for use in urban areas.

Source: Agriculture Canada. "User Requested Minor Use Label Expansion (URMULE) - Registrations", *Pest Management News*, 5(2), 1993.

xi) Dieback and Decline of Ornamental Trees

Dieback and decline diseases occur when trees, stressed and altered, are attacked by secondary organisms. The symptoms include death of buds and dieback of twigs, beginning at the margin of the crown, then progressing inward and downward. Eventually, whole branches dieback and the tree declines to the point of dying.

The dieback often results from the effects of stress alone, and when stress abates, the dieback process often ceases and trees recover. The decline phase is the consequence of secondary organisms attacking the stress-altered tissues. Control measures should focus on preventing or reducing stress effects rather than on direct actions against the organisms.

In urban situations, drought is an important stress factor. Urban trees are often grown in restricted spaces for their roots, or subjected to sudden changes in water tables and drainage patterns, or affected by root and stem injuries. Other important urban stresses include soil compaction in the root zone and competition with turf for water and nutrients.

Two examples from British Columbia illustrate the concept of dieback and decline. In the Lower Mainland, flowering cherries suffer severe dieback and premature mortality. Responsible factors include climatic unsuitability, genetic weakness, insect pests and pathogenic diseases. An important predisposing condition is graft union incompatibility developing over time in certain varieties.

Control methods for two factors associated with this syndrome are being investigated. The application of cooper sprays is presently recommended to control the bacterial disease. In Vancouver, this treatment was applied to high value cherry trees in parks with limited success. The control of the tortrix moth is seen as a possible way to prevent the spread of the disease.

In Penticton, mature maple trees show burning of the leaf edges, drying and fall of the leaves and dieback of branches at the top of the trees. The initial stress factor may have occurred around 1983 when street paving damaged the surface roots. More recently, a high underground water table was lowered by natural climatic conditions. The affected trees became weaker and many seemed attacked by the disease Verticillium wilt.

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