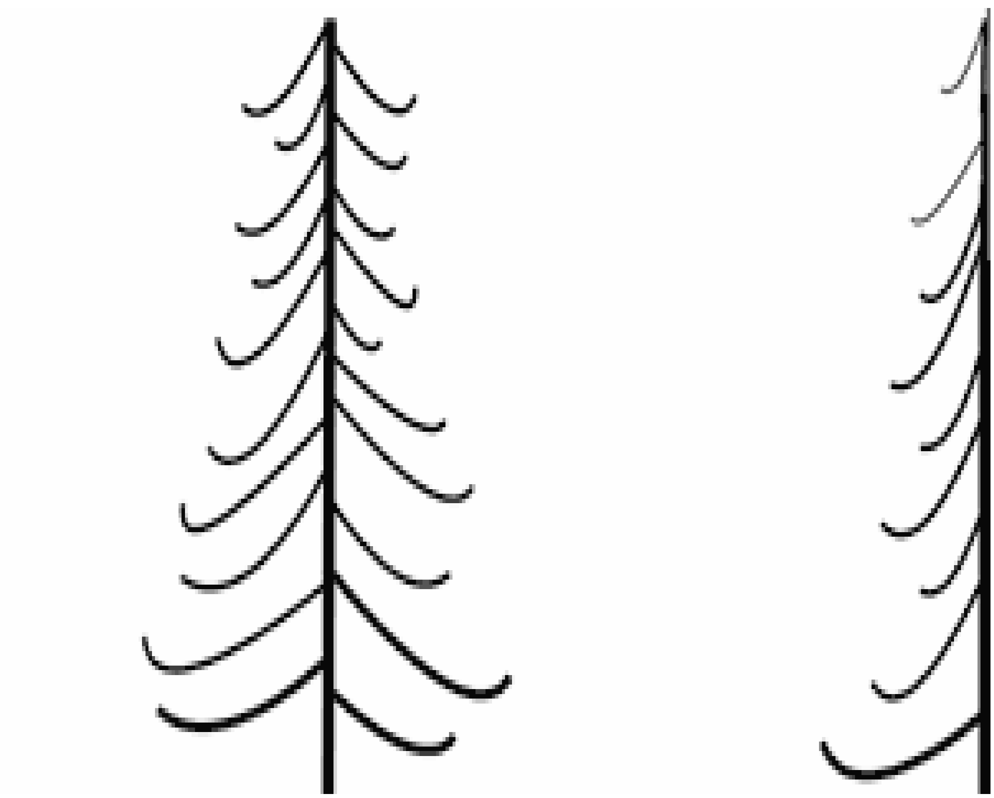
CLIMATE CHANGE ADAPTATION OPTIONS FOR TORONTO'S URBAN FOREST



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About the Clean Air Partnership
The Clean Air Partnership (CAP) is a registered charity that works in partnership to promote and coordinate actions to improve local air quality and reduce greenhouse gases for healthy communities. Our applied research on municipal policies strives to broaden and improve access to public policy debate on air pollution and climate change issues. Our social marketing programs focus on energy conservation activities that motivate individuals, government, schools, utilities, businesses and communities to take action to clean the air.

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FOREWORD

This report is part of a four part project, *Adapting to Climate Change in Toronto,* undertaken by the Clean Air Partnership (CAP) in collaboration with the City of Toronto. CAP is working with the City to incorporate adaptation to climate change into program planning and implementation to reduce the vulnerability of the city and its inhabitants from the impacts of climate change. This project includes:

Phase 1: Scan of Climate Change Impacts on the City of Toronto
The scan pulls together current research on the expected climate change impacts on various sectors within Toronto, and highlights changes that are already underway. The report is available at **www.cleanairpartnership.org/climate_change.php**.

Phase 2: Cities Preparing for Climate Change
This report examines what other leading cities are doing to tackle expected climate change impacts, and identifies strategies that appear promising for Toronto and other cities.

Phase 3: Decision-Makers Workshop
Two workshops were held, one in November 2005 and the other in June 2006, with Toronto decision-makers to identify areas where the City could develop and implement adaptation strategies.

Phase 4: Adaptation Strategies
A menu of adaptation options for two areas: a) the Urban Forest, and b) Heat (and it s impacts on health and energy use) have been developed in collaboration with City of Toronto staff and other interested stakeholders. This report outlines adaptation options for Toronto's urban forest.

EXECUTIVE SUMMARY

Urban trees and forests form an important part in the defense of cities against climate change. They provide shade on hot days; cool nearby buildings and ambient air; moderate the need for air conditioning and related stress on electrical transmission systems; reduce stormwater runoff, erosion and surface water pollution; and minimize smog formation.

However, climate change makes it harder for urban trees to survive and mature and to provide protection from the impacts of hotter weather, intensified storms, and other effects of global warming. Even without climate change, urban environments are difficult for trees, especially those planted alongside city streets and near large buildings. City trees are beset by the heat reflecting off concrete and other hard surfaces, by restricted area for root growth, insufficient water, soil compaction, road salt, and mistreatment.

While City budgets provide for increased tree planting to try and expand Toronto's tree canopy, comparable resources are not yet available for watering and maintenance to ensure that new trees survive and grow to maturity. As a consequence, many trees fail to live long enough to provide the benefits outlined above. Similarly, there is no contingency for storm-related tree damage which is increasing under climate change, and so clean-up of fallen branches, pruning of broken limbs and replacement of uprooted trees reduces the budget for expanding the tree canopy.

The majority of urban trees are located on private property. The City has limited knowledge about the number and status of these trees and limited influence over their conditions and care. Another challenge is the low level of species diversity in Toronto's urban forest, which makes it more susceptible to invasive insect pests and other problems.

Climate Impacts on the Urban Forest

Climate change is already beginning to exacerbate the stressors on urban trees and add urgency to the need for additional resources to protect and expand the urban forest. Climate change is bringing hotter summers that stress newly planted trees and increase the requirements for watering. Climate change is also expected to result in more variable precipitation, making it more difficult to rely on rainfall to provide the water needs of trees. Milder winters are allowing the proliferation of insect pests, and mid-winter warm spells can result in budburst followed by a freeze that damages new growth. Concentrations of ground-level ozone are also expected to increase with the onset of hotter summers. High concentrations of ozone damage leaves and slow down growth.

Growing seasons are lengthening as climate change proceeds. This leads to a northward migration of trees and plants. However, it is not clear that more southerly species of trees will fare well in Toronto's climate, which will continue to have winter cold spells not common to southern regions. Tree damage is expected to increase from more frequent episodes of intense rainfall, freezing rain and higher wind velocities expected under climate change.

Adapting the Urban Forest to Climate Change

Adapting to climate change means taking measures to reduce vulnerability to the expected impacts of climate change or take advantage of any opportunities that arise – a longer growing season, for example. In many cases, adaptation options are initiatives that are already under consideration or underway, but need to be ramped up to provide protection from the impacts of climate change. For instance, a key adaptation strategy for dealing with the impacts of hotter summers on the urban forest is to water trees. While this is already being done to some extent by City staff and a few neighbourhood groups, the scope of the watering needs to be expanded to protect trees from the heat waves and drought expected to occur more frequently under climate change.

Other climate change adaptation measures for the urban forest include:

- Monitoring and recording tree and ecosystem dynamics to document how trees are responding to climate change and identify particular strengths and vulnerabilities;
- Planting trees tolerant of warmer and drier summer conditions as well as trees resistant to pests that are spreading as a result of warmer winters;
- Increasing the availability and planning of diverse species of trees to improve the resilience of the urban forest;
- Providing incentives for improved tree maintenance on private lands, and opportunities for neighbourhood organizations to plant and care for trees in suitable public and private areas;
- Reviewing and improving strategies for coping with pest invasions;
- Extreme weather response plans for managing damage to trees following storms;
- Reducing damage to trees from increased flooding and erosion due to intense rainfalls, by various ground stabilization and flood control strategies; and
- Proactive design of parks and natural spaces to minimize damage from the impacts of increased use under warmer conditions.

To develop an effective adaptation program the City needs to have a comprehensive of trees on both public and private lands. This will allow City foresters to determine where species diversity needs to be increased and where canopy cover should be expanded, identify priority trees for preservation, and assess how well-suited various tree species and/or planting techniques are for the urban environment.

Given the large number of Toronto's trees that are situated on private property, support and involvement of home- and land-owners is essential. Moreover, many community groups and individuals are keenly interested in enhancing the urban forest. This interest and energy could be tapped for monitoring, watering and tree maintenance activities – expanding the reach of an overstretched urban forestry staff.

If the City's stated goal of doubling the existing tree canopy is to be reached – especially under the increasingly stressful conditions of climate change – then a much larger investment of financial and human resources will be necessary for tree planting, monitoring, watering, pruning and damage and pest control. Other City departments will also need to be involved in creating the conditions in which trees can grow and thrive. Planning has an important role in determining the conditions in which street trees are planted. Transportation Services and Toronto Water may need to revise digging and paving practices near existing trees and their root systems.

Research, tests and trials are necessary to help determine which trees can best survive and mature under a changing climate, and what conditions are necessary to aid this process.

And finally, the City needs to be ready with emergency planning to respond to situations like the ice storm of 1998 (which damaged140,000 trees and completely destroyed another 5,000 trees on Montreal's Mount Royal alone), tornados, thunderstorms and other extreme events on the increase under climate change.

1. INTRODUCTION

This report outlines a menu of adaptation options to reduce the impacts of climate change on the urban forest in the City of Toronto.

A working committee comprised of City of Toronto staff, university researchers, and tree advocates advised the authors in the preparation of this report. Committee members provided expertise on the current state of trees in Toronto, current management practices, ongoing research, and potential measures to reduce the impacts of climate change on the urban forest.

Drawing on suggestions from the committee, the *Scan of Climate Change Impacts on the City of Toronto* and adaptation planning lessons from other cities, this report presents a series of adaptation options to reduce the impacts of climate change on urban trees.

2. TORONTO'S URBAN FOREST

Toronto's Urban Forestry Services, the Toronto and Region Conservation Authority and community members manage several millions of trees within the City of Toronto. The City's Urban Forestry staff are responsible for the management of 500,000 City-owned street trees and 2.5 million trees in parks, ravines and natural areas. Urban Forestry staff regularly conduct tree inspections, evaluations, protection, pruning, fertilizing, watering, removal of old or hazardous trees, and planting (City of Toronto 2007a).

THE CITY OF TORONTO MANAGES 2.5 MILLION TREES IN PARKS, RAVINES AND NATURAL AREAS AND 500,000 STREET TREES.

Source: www.wideview.it

Even more trees are found on the private property of universities, corporate headquarters, and home owners. The management of privately-owned trees is regulated through a Ravine By-Law (regulates development in and protects ecological features of ravines) (City of Toronto 2003) and a Private Tree By-Law (regulates injury or removal of privately owned trees which measure 30 cm in diameter or more as measured at 1.4 m above ground level) (City of Toronto 2004).

These trees are very valuable to the city. They make the city attractive, increase property values, provide shade and cooling in summer, absorb air pollutants, reduce stormwater runoff, and provide a host of other important services.

3. THE URBAN FOREST AND CLIMATE CHANGE

Urban trees provide a unique opportunity to address both climate change mitigation and adaptation. Urban trees function as a mitigation option by absorbing carbon dioxide and some other pollutants from the atmosphere. By cooling ambient air, urban trees also contribute to reduced energy use for air conditioning, which decreases greenhouse gas emissions from fossil fuel electricity generation.

The urban forest can also help communities reduce the impacts of a changing climate, by reducing heat gain in buildings through shading, cooling ambient air temperatures through evapotranspiration, and providing stormwater control. A recent study examining urban heat island mitigation strategies in New York found that street trees are one of the most effective strategies to cool ambient air (Rosenzweig *et al.* 2006).

The cooling benefits of urban trees increase exponentially with increased leaf area of the urban forest (Kenney 2000). The greater the canopy of the urban forest, the more carbon dioxide that can be sequestered, the more air pollutants that can be removed, and the greater the provision of shade. For these reasons, increasing the number of large, healthy trees in urban environments is highly desirable to reduce the impact of and adapt to climate change. Toronto's urban forest currently provides approximately 17% canopy coverage; however, the City is committed to doubling the tree canopy to 30 to 40% (Ubbens 2006).

Trees are also vulnerable to the impacts of climate change and will require strong management and conservation programs to ensure their survival in increasingly inhospitable urban environments. The survival of urban trees and their ability to provide benefits are greatest when trees are well-maintained and healthy. A healthy urban forest consists of multi-age trees, where young and middle aged trees survive long enough to mature and replace older trees. A healthy forest also incorporates a broad range of genetic and species diversity, which is the best defense against pest and disease outbreaks. These factors will be explored in more detail later in the report as they are vital for reducing the vulnerability of the urban forest to climate change.

4. CURRENT URBAN FOREST STRESSORS AND MANAGEMENT CHALLENGES

There are a number of existing stressors on urban trees and challenges to urban forest management that make it difficult to maintain a healthy, multi-age, multi-species forest and make trees more vulnerable to the impacts of climate change. These stressors and challenges include:

4.1 POOR GROWING CONDITIONS

Healthy trees require ample room for their root systems. However, trees planted along streets or sidewalks or alongside buildings seldom have enough room below ground (Kenney 2006). The soils in which these trees are planted are nutrient poor, compacted, and unable to drain properly. Street trees seldom receive enough water, and are subject to extreme heat from nearby pavement and other hard surfaces, road salt and other stressors. Developers continue to arrange for planting of trees in these extremely inhospitable environments despite the low survival odds. These trees never reach full maturity and therefore fail to provide intended social and environmental benefits.

4.2 INADEQUATE TREE MAINTENANCE

There is also a lack of public understanding of the considerable care urban trees require to be able to survive and mature in the stressful urban environment. Urban trees on private and public land need to be watered, pruned and monitored for disease, pests, and stress arising from heat and air pollution.

Many urban trees are planted by contractors who must water and maintain the trees for two years after they are planted. However, in an urban environment, trees require a longer period of care and many trees die five to seven years after planting. Tree gators – slow drip irrigation bags – could help solve the problem of watering, but are costly when used on a city-wide scale. Another maintenance challenge is that there are a number of programs to help City residents plant trees, but not to help with their maintenance. This leaves the City with more trees than their maintenance budget can handle.

4.3 NO CONTINGENCY FUND FOR STORMS

Moreover, there is no contingency fund for storms, which means clean-up costs have to be taken out of the capital budget, diverting funds from tree planting, maintenance and other activities that could expand the tree canopy and improve its health. The intense rainstorm of August 19, 2005, for example, cost Urban Forestry Services $600,000 for the clean up of fallen trees and branches (Ubbens 2006).

4.4 INADEQUATE KNOWLEDGE ABOUT THE VALUE AND STATUS OF URBAN TREES

There is a significant lack of knowledge about trees in the urban environment, about their needs and value (Kenney 2006). While most city dwellers appreciate treed streets, relatively few understand their value for cooling ambient air, reducing air pollution and reducing stormwater runoff and flooding from intense rainfall.

The City (similar to the vast majority of municipalities) does not have a comprehensive inventory of the trees under its jurisdiction – though some neighbourhoods have conducted street tree inventories on their own. Even less is known about the 80-90% of trees on private property (Kenney 2005).

4.5 LOCATION OF URBAN TREES ON PRIVATE PROPERTY

Most urban trees are located on private property. Private lands are not only the most common tree locations, they are also the most productive because for the most part they provide better conditions for tree survival and maturation.

MANY TREES ARE LOCATED ON PRIVATE PROPERTY.

Source: www.cyburbia.org/gallery/data/6426/side_street.jpg

Many large institutions such as universities, hospitals, or corporate headquarters have large numbers of trees on their properties. A recent report revealed that forestry staff at the City and at the University of Toronto were unable to identify their counterparts at the other organization, exposing the lack of communication between the City and a prominent institution in the centre of Toronto with responsibility for thousands of trees (Mersereau 2003).

With an inadequate appreciation of the value of urban trees, some homeowners and landowners may regard trees as a nuisance in the way of construction projects, expanded driveways or patios, or sunny gardens. A few homeowners are tempted to remove large trees for fear that they will topple on their homes or vehicles during a storm.

The number of trees on private property makes it important to engage private landowners, but their numbers make it difficult to engage this group (Kenney 2005). The challenge lies in trying to convince landowners to keep their trees for the benefit of the urban forest (Hart 2006).

4.6 LACK OF BIODIVERSITY

While there are many tree species in the City, a relatively small number of species make up the majority of the urban forest. In Toronto, the Norway maple is the most common tree, with green ash and honey locust clones also making up a significant portion of the urban forest (Kenney 2005). This relatively low level of species diversity leaves the urban forest more susceptible to invasive insect pests and other problems.

Urban Forestry faces constraints in the extent to which it can increase the diversity of City trees. While some cities run their own nurseries, this is an expensive endeavour, and the City of Toronto opts to buy trees from commercial nurseries. This restricts the choice of trees to those available at the nurseries, which select stock on the basis of market trends. Nurseries are, for instance, still selling ash trees, even though the emerald ash borer is moving northeast from the Windsor area (Hart 2006).

4.7 INSUFFICIENT POLICY PROTECTION FOR TREES

Municipal zoning by-laws regulate what can be built on private property and dictate the use, size, height, density and location of buildings. They do not, however, regulate minimum requirements for green space and make no allowance for natural processes. This leads to trees being planted in poor growing conditions such as compacted soil, in spaces with too little room for root growth, in soil of insufficient nutrient quality, and left without enough permeable surface to allow water to percolate to tree roots.

Moreover, the building department does not have much power to protect existing trees. If a tree is to be removed to make room for a building, the permit cannot be withheld as long as the construction requirements are sound (Ubbens 2006). Toronto's new, voluntary *Green Development Standard* does encourage the retention of native soil on site and the provision of 30 cubic metres of good soil for trees (City of Toronto 2006a). However, urban forestry staff still have very little jurisdiction to protect existing trees, and to ensure proper conditions for tree growth.

5. CLIMATE CHANGE IMPACTS ON THE URBAN FOREST

Climate change is already beginning to exacerbate the stressors that confront urban trees and adds urgency to the need to address the challenges that City staff currently face in managing the urban forest.

5.1 HOTTER SUMMERS

The hotter summers associated with climate change, are expected to have major impacts on trees in urban areas. Trees are already under stress from extreme heat (Ubbens 2006) and the expected rise in summer temperatures will exacerbate this situation. Newly planted trees are particularly vulnerable to heat and drought conditions, and require regular watering to survive, especially in the first three to five years after planting.

5.2 MORE VARIABLE WINTER TEMPERATURES

Milder winters and increased variability of winter temperatures under climate change (Franklin 2007) can negatively impact trees. Warm weather too early in the year can trick trees into triggering bud or bloom formation. When the warm spell is followed by a cold snap, the new growth often dies.

Milder winters also allow insect pests that are normally killed during cold spells to overwinter. As a result, pests with a more southerly range will be able to move north, and foreign pests introduced via shipping have a greater likelihood of surviving (Greifenhagen and Noland 2003).

5.3 MORE VARIABLE PRECIPITATION

As climate change progresses, precipitation patterns are expected to become more variable (Koshida *et al*. 1999; Meteorological Service of Canada 2005), making it more problematic to rely on rainfall to provide trees with water at regular intervals.

5.4 INCREASE IN GROUND-LEVEL OZONE

Concentrations of ground-level ozone are expected to increase with the onset of hotter summers. High concentrations of ozone can damage tree leaves and slow down growth, and in combination with drought conditions can leaves trees and other plants more vulnerable to pathogenic fungi and pests such as the Asian long-horned beetle.

5.5 THREATS TO BIODIVERSITY

Growing seasons are lengthening as the climate gradually gets warmer. This leads to a northward migration of flora as plants move to locations with conditions more favourable for their survival. However, because climate change is occurring faster than vegetation can migrate (MacIver 2005), the change in climate is more likely to lead to stressed plants, vegetation dieback and a loss of native biodiversity. In the Toronto area, we are likely to see more southern species move into the region. Although these species may be better adapted to the warmer average temperatures, they may not fare well in Toronto's winter climate, which is subject to periods of cold extremes not common to more southerly regions.

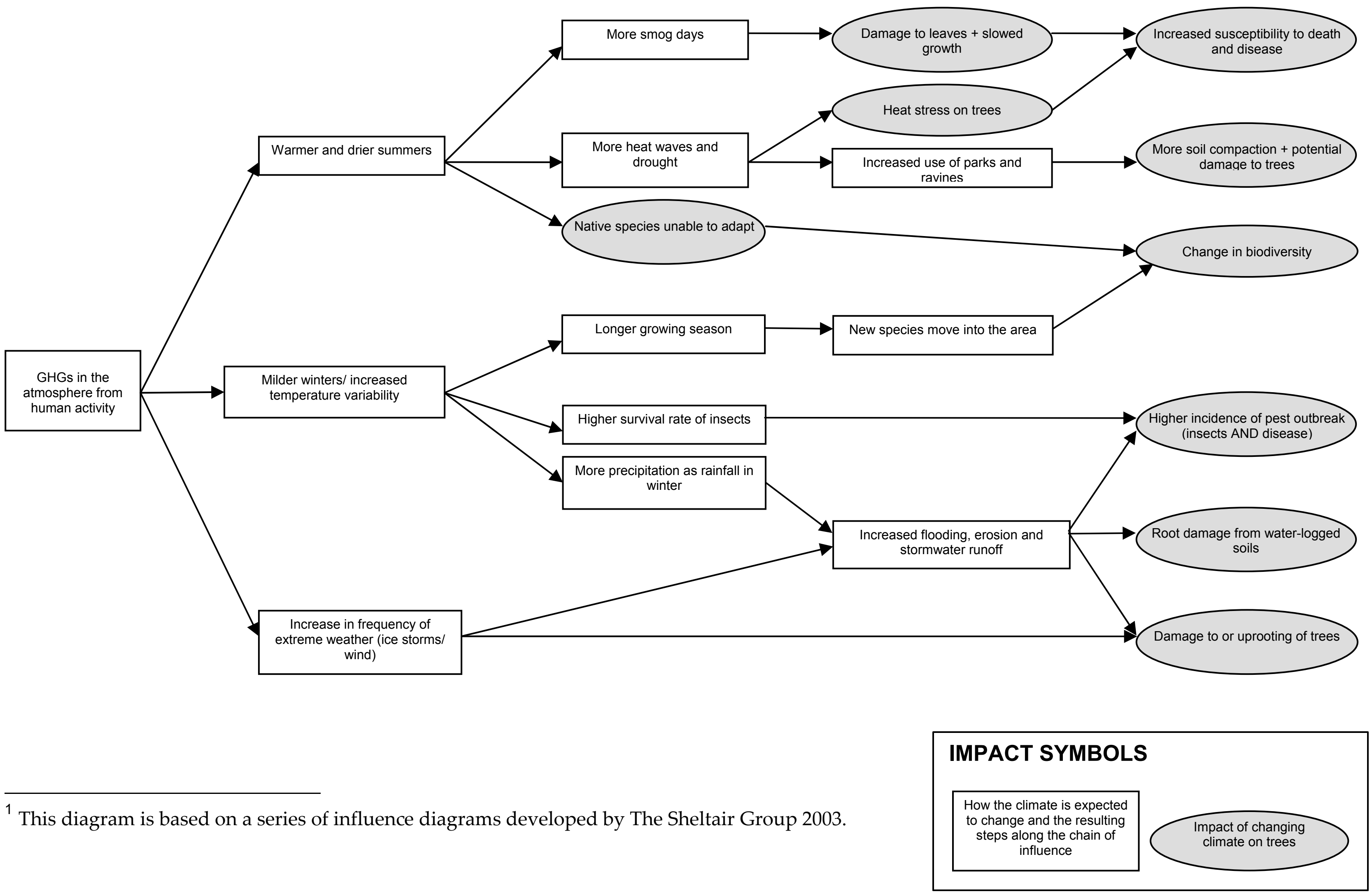
5.6 TREE DAMAGE FROM INCREASED FREQUENCY OF EXTREME WEATHER

The expected increase in ice storms and high winds will take its toll on trees, taking down branches or entire trees altogether. An ice and wind storm in early March 2007 took down hundreds of limbs and a number of trees throughout the city. Extreme weather in combination with a host of other urban stressors has the potential to seriously devastate Toronto' urban forest.

5.7 SUMMARY OF CLIMATE CHANGE IMPACTS ON TREES

The impacts of climate change on the urban forest are summarized in Figure 1 on the next page. This diagram illustrates the various steps by which climate change is expected to impact urban trees and forests. The diagram is meant to be read from left to right. The rectangular boxes represent changes in the climate and in human and plant/animal activity. The ovals represent the impacts of these changes. While the diagram is a somewhat simplified overview of progress of climate change impacts (it ignores minor variables and forces) it does set the stage for identifying and prioritizing key impacts and points of intervention to reduce the effect of climate change on the urban forest.

FIGURE 1: SUMMARY OF LIKELY CLIMATE CHANGE IMPACTS ON THE URBAN FOREST IN THE CITY OF TORONTO[1]



[1] This diagram is based on a series of influence diagrams developed by The Sheltair Group 2003.

6. ADAPTING THE URBAN FOREST TO CLIMATE CHANGE

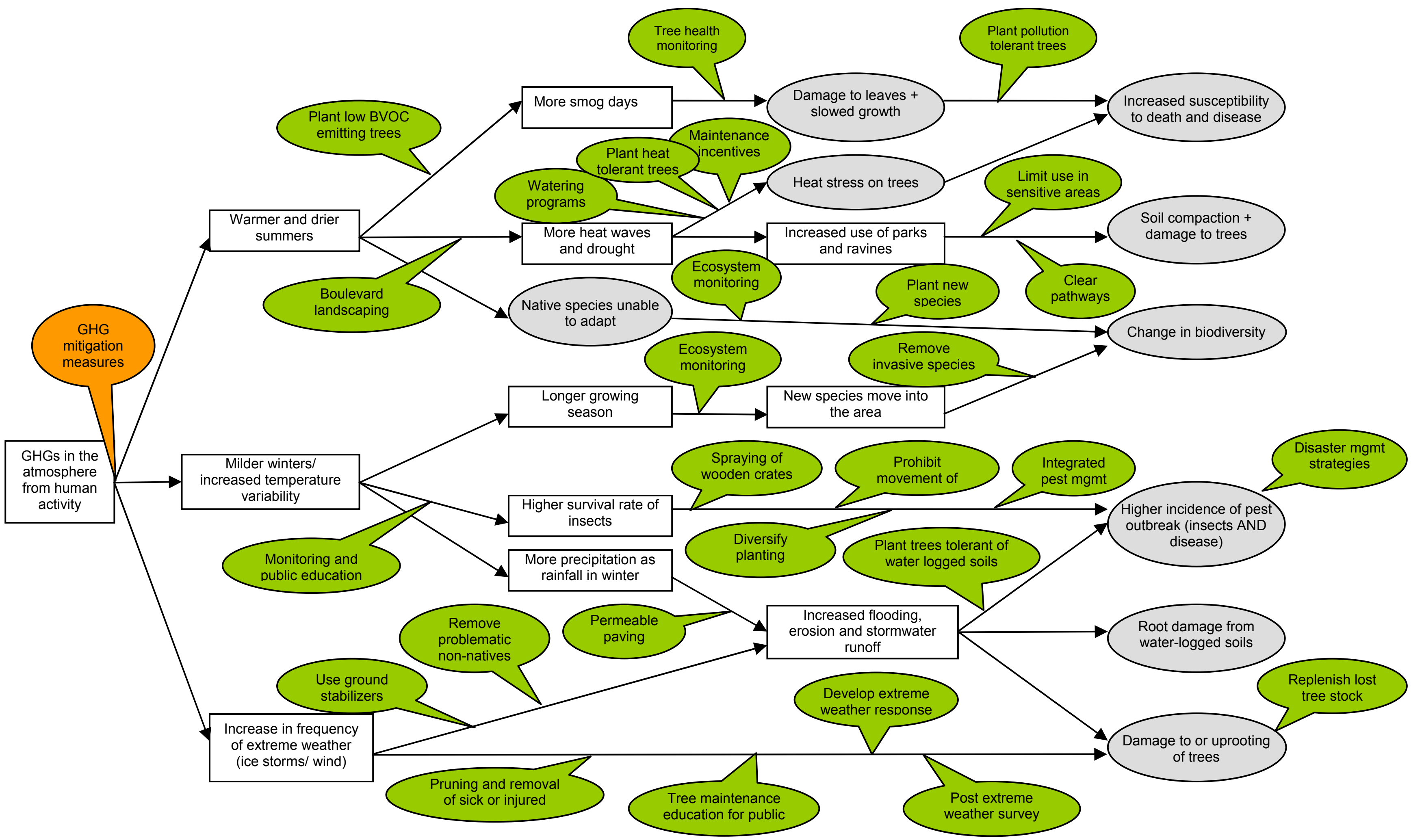
Adapting to climate change means taking measures to reduce the vulnerability of a system or sector to the expected impacts of climate change. In the case of the urban forest, such measures include tree health monitoring, watering programs, and modifying plantings, among others.

In many cases, adaptation options are initiatives that are already under consideration or underway, but need to be ramped up to provide protection from the impacts of climate change. For instance, a key adaptation strategy for dealing with the impacts of hotter summers on the urban forest is to water trees. While this is already being done to some extent by City staff and a few neighbourhood groups, the scope of the watering needs to be expanded to protect trees from the heat waves and drought expected to occur more frequently under climate change.

Toronto's Urban Forestry staff is widely acknowledged to be knowledgeable, skilled and good mangers of the urban forest given the resources available. Their efforts are enhanced by a number of community groups, tree advocates, and local residents that have taken it upon themselves to collect data on and maintain the trees in their neighbourhoods. However, in the face of climate change, these efforts will need to be expanded to cover more ground and will need to be conducted with greater frequency. The adaptation options presented in this report are not in the main new recommendations. However climate change creates a new urgency for resources to expand the urban forest and provide it with the means to survive and thrive.

Figure 2 illustrates these adaptation options, superimposed on the impacts diagram from Figure 1. These adaptation options reduce or eliminate the effect of the impact to the *right* of the point of intervention. This highlights the importance of focusing adaptation efforts as high up the influence chain as possible – the higher up the chain, the more effective the strategy. Community groups can potentially be involved in actions further up the chain, such as watering and tree health monitoring. This reduces the need for later actions, which can be quite costly and are often borne by municipalities. The measures presented in this diagram will be discussed in more detail in the pages that follow.

FIGURE 2: ADAPTATION STRATEGIES FOR THE URBAN FOREST IN THE CITY OF TORONTO



7. CLIMATE CHANGE ADAPTATION OPTIONS

A broad overview of adaptation options for the urban forest is provided below. A number of these measures are already being conducted to some extent by Urban Forestry staff and community members. The authors have highlighted these to the best of their knowledge. Where applicable, examples of what other communities are doing have been included.

7.1 ADAPTING TO HEAT AND DROUGHT STRESS

Heat and drought already stress Toronto trees and under climate change these conditions are expected to get worse. Planting trees more tolerant of heat and drought conditions, watering programs, planting methods that reduce soil compaction and public incentives to encourage tree planting and maintenance are various ways in which the City can and has begun to adapt.

7.1.1 PLANT HEAT TOLERANT TREES

Trees planted adjacent to buildings (which reflect heat onto trees), along roadways and parking lots, near underground utilities (which can raise soil temperature) and in containers will be subject to additional heat stress over and above trees in parks and ravines. Planting heat tolerant trees in these sites can increase survival rates. Species more tolerant of heat and drought conditions include the hedge maple, the London planetree, and the silver linden (Appleton *et al.* 2000). Selecting tree species based on what grows well in cities south of Toronto – and have summer conditions similar to what Toronto will experience in the future – may be a good place to start new tree selection.

7.1.2 EXPAND CITY PROGRAMS FOR TREE WATERING AND MAINTENANCE

The City of Toronto does some watering of newly planted trees; however, this is often not enough. Various City departments have budgets for tree planting, but only Urban Forestry has a budget for tree maintenance. In Chicago, another city subject to extreme summer time heat, tree gators are used on young trees to ensure that the trees receive enough water (Hyde Park 2006). These bags are zipped around the base of the tree and filled with approximately 20 gallons of water, which slowly drips out over a 6 to 10 hour period. Mulch and "brush blankets" are other effective options to prevent

TREE GATORS CAN BE USED ON YOUNG TREES DURING PERIODS OF DROUGHT TO ENSURE THEY RECEIVE ENOUGH WATER.

Source: www.gardeninggiftguide.com/tgator_junior_pic.jpg evaporation and keep moisture in the ground and are already being used for new tree plantings in the city.

7.1.3 SUPPORT AND EXPAND NEIGHBOURHOOD WATERING PROGRAMS

Neighbourhood watering awareness programs can lessen the watering burden on the City and increase the survival rate of trees. Examples of such initiatives can be found in Toronto, Winnipeg, and Chicago. In Toronto, both the Harbord Village Residents' Association (HVRA) and GreenHere have undertaken initiatives to involve the community in tree stewardship, tree pruning and watering (GreenHere 2007). In Winnipeg, the *Adopt-a-Tree* program funded by Green Streets Canada, aims to reverse the decline of elm trees along a major roadway. Activities include tree inventories, education, and maintenance. Community members can adopt a tree and help pay for these activities by pledging $1,000 per year for five years (City of Winnipeg 2007; Coalition to Save the Elms 2007). In Chicago, a community organization called the Nichols Park Advisory Council runs a publicity campaign to recruit volunteers during periods of drought to water trees in parks and neighbourhoods (Franklin 2007). These examples of proactive community involvement illustrate how a City can tackle problems of heat and drought on a neighbourhood level.

7.1.4 PROVIDE TREE MAINTENANCE INCENTIVES

Because tree maintenance can be a financial burden for private landowners, a tax incentive for property owners to maintain the urban forest could encourage more participation from community members (Kenney 2006). The Ontario Ministry of Natural Resources provides this kind of tax incentive to rural land owners with four hectares or more of forest, and who agree to follow a Managed Forest Plan for their property (Ontario Ministry of Natural Resources 2007). Participating landowners pay only 25% of the municipal tax rate for residential properties. A similar incentive for the management of urban trees could be a very effective way to engage private property owners in the City. This may be best suited for home owners on ravine lots, or large institutions such as universities.

In San Francisco, the City grants sidewalk (boulevard) landscaping permits to property owners, which allows them to convert a portion of sidewalk in front of their property into a landscaped area (City and County of San Francisco 2006). Trees, plants with low-water needs and those appropriate to the climate are encouraged. Granting ownership over the area creates a greater likelihood that the property owners will also maintain the landscaping. This option may be most viable in neighbourhoods that have a strip of land between the sidewalk and the street.

7.2 ADAPTING TO STRESS FROM AIR POLLUTION

Hotter summers will very likely lead to a greater concentration of ground-level ozone, which can be detrimental to plant growth and health, leaving trees more susceptible to death and disease. Planting trees with a greater ability to stock air pollutants, planting trees that emit low levels of biogenic volatile organic compounds (BVOCs), routine tree health monitoring, and planting more disease tolerant trees are ways in which the City can adapt to and prepare for air pollution-related stress on trees.

7.2.1 MONITOR TREE HEALTH

Routine tree health monitoring is necessary to ascertain the level of stress on trees from polluted air, to observe how this changes over time, and to measure the extent to which trees are being attacked by pests and disease. Community volunteers and neighbourhood groups can be trained to conduct the monitoring – a cost-effective way to ensure that trees on private property are checked- while also increasing the number of street trees that are monitored. Monitoring results can be used to inform how various tree species fare under air pollution and how the species composition of the urban forest may need to be changed to increase survival rates.

7.2.2 PLANT POLLUTION RESISTANT TREES

One way to deal with increasing levels of air pollution is to plant trees more resistant to polluted air and those with a greater ability to remove (or stock) air pollutants. Trees that have higher than average levels of carbon sequestration (4.6 kg/yr) include *Tilia* species (Silver linden and Carolina basswood), blue spruce, and Robusta and Siouxland hybrids (Poaletti *et al.* 2003). To increase the effectiveness of pollutant removal by trees, they should be planted in close proximity to pollutant source, and efforts should be made to reduce early tree mortality as large trees can remove more pollutants than smaller ones (Rowntree and Nowak 1991). Research will need to be conducted to determine which combination of trees provides the greatest benefit in Toronto's environment.

7.2.3 PLANT PEST RESISTANT SPECIES

Planting trees that are more pest resistant can reduce the susceptibility of trees stressed by air pollution to pest outbreak. Pest-resistant species include the trident maple, the Chinese pistache and the Chinese podocarpus. Trials should be run to determine the suitability of these and other pest-resistant trees for Toronto. While pest-tolerant trees can increase the resiliency of the urban forest, the ultimate goal should be to increase species diversity as this is still the best natural defence against insect and disease outbreaks.

7.3 RESPONDING TO CHANGES IN BIODIVERSITY

As the climate gradually warms and the growing season lengthens, plants are beginning to migrate northward. However, because the climate is changing more quickly than plants can move, plant stress, death and a loss of native biodiversity are likely to outpace northward migration. Monitoring population and ecosystem dynamics, planting more resilient or climate appropriate species, and removal of problematic non-native species are ways in which the City can adapt to these changes.

7.3.1 MONITOR AND REPORT ON TREE AND ECOSYSTEM DYNAMICS

Routine monitoring of tree population changes and ecosystem dynamics are extremely important to document how plants are coping with the changing climate. It is important to benchmark existing biodiversity and then monitor how this changes over time. Training volunteer community members or engaging community groups to track these changes can be an effective way to obtain data over a large land area. Currently, the Association for Canadian Educational Resources (ACER), the Humber Arboretum Arborvitae, and the Meteorological Service of Canada are documenting how various tree planting combinations are responding to the current climate in Toronto with the help of community volunteers (ACER 2006). Because Toronto is warmer than the surrounding countryside, the city serves as a climate change laboratory in which the effects of a changing climate on tree population dynamics can already be monitored. Results from this study are expected to be available soon.

MONITORING TREE HEALTH CAN PROVIDE IMPORTANT INFORMATION ON HOW TREES ARE COPING WITH THE CHANGE IN CLIMATE.

Source: www.environment hamilton.org/images/trees DSCN1060.jpg

7.3.2 PLANT NEW TREE SPECIES

Based on the monitoring results, new tree species or planting combinations may need to be pursued. If certain native trees are no longer able to cope, more climate appropriate or southern tree species will need to be planted to ensure the continuity and health of the urban forest.

7.3.3 REMOVE INVASIVE SPECIES

A warmer climate will also likely lead to incursions by invasive species that choke out their indigenous counterparts. Depending on the nuisance factor of these species, their removal may be necessary to ensure that native species can continue to grow. The City of Toronto already follows this practice in High Park and the city's ravines (City of

Toronto 2006b). However, with the climate undergoing change, the distinction between native and non-native will become more blurred in the next decades. This may make species that are not native to the area the most resilient choice for the foreseeable future.

7.4 ADAPTING TO HIGHER INCIDENCE OF DISEASE AND PEST OUTBREAKS

Milder winters are already leading to a higher survival rate of insects, whose population and range are normally kept in check by cold temperatures. Global shipping practices, combined with stressors such as heat, drought, and air pollution will increase the exposure and susceptibility of trees to disease and pest outbreaks. Routine monitoring, kiln drying or fumigating wooden crates at ports, prohibiting the movement of wood products, planting trees more resistant to disease, and disaster management strategies (such as cutting down infected trees) are ways in which disease and pest outbreaks can be and are controlled.

7.4.1 MONITOR TREES

Routine monitoring of trees can lead to early detection of disease and pest outbreaks. Because of the time consuming nature of this activity, engaging the public and community groups to monitor trees in their neighbourhood can significantly increase the speed at which outbreaks are detected. In response to the Asian long-horned beetle outbreak the City of Toronto produced fact sheets, posted large signs along roadways, and set up a hotline to solicit public involvement (City of Toronto 2006c). In combination with monitoring and tree removal efforts, this has managed to control, but not eradicate the beetle (Toronto 2007b).

THE ASIAN LONG-HORNED BEETLE DEVASTATED TREES IN TORONTO AND VAUGHAN.

Source: www.uvm.edu/albeetle/identification/albfemaleb.jpg

7.4.2 TREAT WOODEN CRATES AND PROHIBIT MOVEMENT OF WOOD PRODUCTS

Given that Toronto receives many goods by rail and ship, spraying or kiln drying wooden crates upon arrival is one way in which the intrusion of foreign pests and disease can be curbed. Similarly the movement of tree products can be prohibited out of areas or regions that are currently dealing with an outbreak. This was the case in parts of Toronto and Vaughan in 2003 where the Asian long-horned beetle outbreak devastated deciduous trees.

7.4.3 PLANT DISEASE- AND PEST-RESISTANT TREES/DIVERSIFY PLANTING

Planting trees more resistant to disease and pests is another option to deal with a higher incidence of outbreaks. However, given the uncertainty about the target of future outbreaks, some of these trees may end up being unexpectedly susceptible to new diseases. Diversifying planting is a better long-term option as it provides a more natural way to slow down or prevent the movement of disease and pests.

The options mentioned above are part of what is called an "integrated pest management strategy". This involves the use of many different techniques in combination to control pests, with an emphasis on methods that are least harmful to the environment and most specific to particular pests. Pest-resistant plant varieties, regular monitoring for pests, targeted use of pesticides, natural predators of the pest, and good stand management practices may be used singly or in combination to control or prevent particular pests. Pesticides are applied in such a way that they pose the least possible hazard, and are used as a last resort when other controls are inadequate.

7.4.4 DISASTER MANAGEMENT STRATEGIES

When an outbreak is no longer easily contained, disaster management strategies come into play and typically involve removing infested trees to prevent the spread of the pest or disease. In Toronto and Vaughan, trees infected with the Asian long-horned beetle were cut down, and in Windsor trees were removed around an area infested with the Emerald Ash Borer so as to establish a "firebreak" and prevent further movement of the insect (City of Windsor 2007). The latter case was not successful, unfortunately.

THE EMERALD ASH BORER IS THOUGHT TO BE MOVING UP TO TORONTO FROM WINDSOR.

Source: http://tncweeds.ucdavis.edu/photos/agrpl03.jpg

7.5 REDUCING DAMAGE TO TREES

An increase in the severity and frequency of wind and ice storms is likely to cause a significant amount of tree damage as climate change progresses. The ice storm of 1998, which damaged hundreds of thousands of trees in Montreal and Ottawa, serves as a warning about the impact of extreme weather on urban forests. High winds routinely take down branches and can even uproot trees.

Regular tree pruning, home and land owner education about proper tree pruning, education campaigns, post-extreme weather surveys, extreme weather response plans and replenishing lost tree stock are ways in which damage to the urban forest due to extreme weather can be reduced.

7.5.1 PRUNING REGULARLY AND REMOVE SICK OR DAMAGED TREES

Proactive tree pruning to remove vulnerable limbs, and the removal of sick or damaged trees[2] can minimize damage from extreme storms. It also reduces the clean up efforts after storms and can prevent property damage when branches are knocked down. The City of Toronto already conducts regular maintenance of trees on City-owned land, but does not tread on private property. For this reason public education and home and land owner involvement in the regular and proper pruning of trees is essential.

7.5.2 EDUCATE HOME AND LAND OWNERS ON TREE PRUNING

Education about proper tree pruning and care after an extreme weather event is also important. A study on the impact of the 1998 ice storm on tree mortality reported that damage to trees was exacerbated by people who were unfamiliar with pruning techniques, yet still decided to remove damaged tree limbs. Furthermore, many trees that had a chance of surviving were removed altogether as residents feared damage to their property should the tree collapse (McCready 2004). This fear was based on anecdotal information and news reports rather than an informed assessment of the risk.

7.5.3 DEVELOP EXTREME WEATHER RESPONSE PLANS FOR TREES

Emergency planning for climate change should include extreme weather preparedness and response plans that prescribe a series of actions to be undertaken in the event of a major storm where tree damage is extensive. Such plans would outline the roles and responsibilities of various agencies, departments and levels of government. McCready (2004) outlines a series of measures that could be incorporated into a preparedness and response plan to deal with tree damage when extreme weather hits.

A STORM IN MARCH 2007 TAKES DOWN A NUMBER OF TREES IN TORONTO'S HIGH PARK.

- Determine who should be involved (agencies, groups, levels of government) and what each partner can bring to the table (i.e. financial and human resources);
- Hire a program coordinator to work with the many different groups and agencies involved;
- Have trained staff assess and inventory tree damage;
- Provide a list of arborists for each municipality to assist in damage assessment and clean-up efforts;
- Establish a toll-free number and staff to deal with public inquiries;
- Prepare press releases and extension notes;

[2] Sick or damaged trees should be inspected by a trained arborist to determine whether the tree presents a hazard and removal is truly necessary.

- Prepare and deliver workshops for home and land owners on tree care after a major storm;
- Assign work crews to assist in the clean up of parks, trails, roads, and waterways; and,
- Provide on-site advisory service for home and land owners.

7.5.4 DEVELOP REGIONAL/PROVINCIAL LEVEL DISASTER RESPONSE PLAN FOR TREES

The urban trees and forest committee consulted for this report identified the need for a regional or provincial level plan in Ontario to deal specifically with urban forestry issues. As disaster impacts stretch beyond municipal borders such a plan would, in addition to the points mentioned above, assist in determining which jurisdictions are hardest hit in the event of a disaster and which other jurisdictions could be called upon to provide aid and resources.

7.5.5 REPLENISH LOST TREE STOCK

If a significant number of trees are lost it will be necessary to replenish the lost tree stock. Tree selection will depend on a number of factors such as the current or forecasted climate, current or predicted outbreak of disease and pests, and the rate at which trees grow, among others.

7.6 ADAPTING TO INCREASED FLOODING AND EROSION

As the intensity of storms and rain events increases under climate change, there will be more flooding and erosion of streams and riverbanks. Erosion can leave tree roots exposed to air, vulnerable to pathogenic fungi and subject to other disturbances such as human traffic. It also destabilizes trees, and if they do not fall immediately, they may topple the next time wind speeds rise. Flooding leaves trees vulnerable to pathogenic fungi, hinders growth, and can eventually lead to death. Using ground stabilizers (see below), removing problematic non-native species, using permeable paving and planting trees more tolerant of water logged soils are ways in which damage to trees from flooding and erosion can be reduced. Eliminating additional stressors on trees that have sustained a period of flooding is also recommended.

EROSION CAN LEAVE TREES VULNERABLE TO TOPPLING OVER.

Source: www.barron-palo-alto.ca.us

7.6.1 USE GROUND STABILIZERS

A number of ground stabilizing methods can be employed to reduce erosion, particularly in ravines and along waterways. Biodegradable mesh, crib walls (logs with holes for willow and dogwood cuttings) and herbaceous understory plants (such as wild ginger or wild strawberry) can be used to control erosion. Both the City of Toronto and the Toronto and Region Conservation Authority are already using these methods to reduce erosion in riparian areas.

7.6.2 REMOVE PROBLEMATIC NON-NATIVE SPECIES

Removal of problematic non-native species such as the Norway maple can also reduce vulnerability to soil washout. Norway maple has been a preferred street tree in Toronto for many years due to its tolerance of compacted soils and salt. Unfortunately, this species has found its way into Toronto's ravines, where it creates dense shade and prevents understory plants from growing (Podolsky 2004). This leaves the soils vulnerable to washout and erosion.

7.6.3 USE PERMEABLE PAVING

The increase in urbanization and paving generates large amounts of stormwater run-off which can overwhelm rivers, streams and low-lying areas. Impermeable surfaces create 8-10 times more run-off than permeable surfaces (Greater Vancouver Regional District 2005). Using permeable paving can greatly reduce the incidence of flooding and erosion by allowing rainwater to seep into the earth where it falls.

7.6.4 PLANT TREES MORE TOLERANT OF WATER LOGGED SOILS

As rain events become more intense under climate change, areas that typically do not flood may become more consistently water logged. In these areas, trees more tolerant of saturated soils should be planted. Examples of water tolerant species include red maple, black ash and green ash. Their applicability to Toronto will need to be determined, particularly in light of the expected onset of the Emerald Ash Borer.

7.6.5 REDUCE ADDITIONAL STRESSORS AFTER FLOODING

Trees are more susceptible to pest and disease outbreaks after periods of flooding. For this reason, additional stressors should be minimized 1 to 3 years after the fact, with particular priority given to high value trees. This means removing dead or severely cankered branches, delaying corrective pruning until the late dormant season, applying low-nitrogen fertilizers, aerating the soil, mulching, and watering during extended dry periods (Iles and Gleason 1994).

7.7 ADAPTING TO INCREASED STRESS ON PARKS AND RAVINES

As summers become hotter under climate change, and heat waves more persistent and frequent, people and their pets will seek refuge from the heat in parks and ravines. Not only will there be more visits early in the morning or after dark, but park use will likely intensify earlier in the spring and extend later into the fall and winter. These natural areas can be negatively affected by the increase in use, primarily from soil compaction and traffic in sensitive areas. Limiting use via physical barriers and/or signs, and providing clearly marked pathways can minimize the impact of increased traffic in sensitive areas. Traditional winter park activities may need to be modified and restructured as milder winters result in the absence of ice and snow.

8. CONCLUSIONS AND RECOMMENDATIONS

A well-maintained and healthy forest will go a long way to enhance the success of any climate change adaptation strategy for urban forests. As discussed earlier, urban trees already face a number of stressors such as soil compaction, insufficient water, air pollution, and inadequate space for roots to grow. Climate change will exacerbate these stressors, making the need to address these challenges more urgent. The following recommendations suggest ways in which some of these challenges can be addressed.

8.1 CONDUCT A COMPREHENSIVE TREE INVENTORY

There is an urgent need to develop a comprehensive inventory of trees on both public and private lands in the City of Toronto to assess tree species, size, condition, and location. This information can be used to develop a comprehensive conservation and management plan for Toronto's urban forest in the face of climate change. It will allow City foresters to determine where species diversity needs to be increased and where canopy cover should be expanded, identify priority trees for preservation, and assess how well-suited various tree species and/or planting techniques are for the urban environment (Kenney 2005). University level forestry students and community groups are ideal candidates to help with such a task.

ASSESSING TREE CONDITION IS A KEY PART OF A TREE INVENTORY.

Source: Association for Canadian Environmental Resources

A tree inventory can also inform how limited resources should be spent. For example, resources can be used to replace dying trees every few years, which would result in small trees with little or no environmental or social benefits. Or the same resources can be invested in maintaining existing trees, resulting in larger trees with greater environmental and social benefits. An inventory can help decision-makers assess the needs of trees, and can aid in determining how resources are best spent given the overall goals of achieving a healthy urban forest (Podolsky 2004).

In addition to documenting existing tree locations conditions and species, it would also be useful to document sites suitable for planting additional trees, so measures can be taken to preserve these locations. Friends of the Don East (FODE) recently conducted a neighbouhood survey of several streets in Cabbagetown, Riverdale, Leaside and East York in 2002 and found 129 locations where more trees could be planted (FODE 2003).

8.2 EXPAND COMMUNITY INVOLVEMENT

Given the large number of Toronto's trees that are situated on private property, support and involvement of home- and land-owners is essential. "Sustainable urban forests depend to a large degree on sustainable private forests" (Clark *et al*. 1997). In his presentation at a recent ACER conference[3] Kenney (2005) posed a very important question: "How can we harness the public's enthusiasm for tree planting to carry out tree inventories?" And taking this notion a step further, how can we tap into this energy to get people engaged in tree maintenance?

To address the issue of community involvement in tree inventories, Andy Kenney and Danijela Puric-Mladenovic, developed Neighbour*woods*. This tool allows lay people to gather technical data on trees species, size, condition and location in a consistent and comprehensive manner. FODE used this tool to conduct the 2002 inventory mentioned earlier and it has also been used by a non-profit organizations in Hamilton and Sarnia. Volunteers in the Town of Mitchell completed an inventory of 100% of the private and public trees in their community of 4,000.

THE COMMUNITY CAN PLAY AN IMPORTANT ROLE IN TREE INVENTORIES AND HEALTH MONITORING.

Source: www.leaftoronto.org

As already mentioned, public tax incentives have the potential to get the community more involved in tree maintenance. Because pruning and other measures can be costly and

[3] ACER, the Association for Canadian Environmental Resources, held a conference in April 2005 to address the issue of forests and climate change.

time consuming, tax credits or other incentives would help alleviate some of the burden. A tax benefit is already available to rural land owners who have woodlots 4 hectares or greater in size. Such a benefit may be provided in the City for properties such as ravine lots or large institutional grounds that have a large number of trees on site and where the landowner has committed to providing stewardship for the urban forest in their vicinity.

Providing data on the value of properties with and without trees is another way in which people could be convinced to care for trees, and when contemplating their removal, to keep them. This data could be obtained from the real estate industry (Casselman 2006).

Wherever possible, tapping into existing neighbourhood groups is an effective way to engage a community and piggyback on networks that already exist. Business Improvement Associations (BIAs) may provide support, given their interest in improving the attractiveness of their immediate vicinity. In Toronto's west-end, for instance, the Bloorcourt Village BIA hires a summer student every year to water street trees (Koumoudorous 2007). Community members that live near or across from parks are another subset of the population that can be tapped to assist with tree maintenance. These community members often identify strongly with their parks, and will likely be willing to assist with tree care.

In Chicago, community members are being engaged in tree maintenance through a certification process. An organization called Open Lands trains and certifies community volunteers to be *TreeKeepers*. A course is held twice per year to teach skills such as planting, pruning and mulching. After completing seven classes, the students must pass a final exam and hands-on skills tests. The students then become part of a volunteer corps that convenes for regular work bees to care for city trees in public parks, on city streets, and at other public spaces (Open Lands 2007).

Efforts to engage large institutions such as universities, hospitals and corporate headquarters in tree management programs will also have to be made. Given that these locations are often comprised of large green expanses, there is great potential for trees to reach maturity and provide ample canopy coverage.

8.3 INCREASE MAINTENANCE BUDGET AND ACTIVITIES

There is a clear need to increase the budget for tree maintenance at the City. Simply planting trees that will need to be replaced every five years or less is a poor use of public funds and makes it very difficult to increase the tree canopy in Toronto – a task that it is increasingly important as summer temperatures climb. Immature trees provide few environmental and health benefits, nor do they have the aesthetic value of mature trees. Adequate funding for maintenance of urban trees is essential to adapt to and prepare for the challenges of climate change that lie ahead. The budget process must recognize that the cost to establish trees must be accompanied by long-term funding to maintain and sustain that tree throughout its life.

8.4 EXPERIMENT WITH NEW GROWING CONDITIONS

Experimenting with new growing conditions to provide more room for roots to grow is essential to increase the robustness and survival rate of urban trees. James Urban, an international expert on urban trees, recommends planting trees in the easy places first – anywhere cars don't drive – and where there is more room than the small cavity usually provided for street trees (Urban 2004). This may still be along curbs and roadways, but will probably require deviating from the straight lines that usually govern how trees are planted. Tree roots can be given more room through the use of trenches or root paths that provide room for roots, and engineered soils designed to accommodate healthy root growth while still meeting the load-bearing requirements for roads and sidewalks.

8.5 CONDUCT TESTING AND TRIALS

While a number of trees species were identified in this report as tolerant to specific stressors, testing of new tree planting combinations within the City is the best way to determine the most appropriate combinations for the future. Furthermore, because site conditions can vary greatly within an urban environment, it may be necessary to evaluate planting locations on an individual basis. It may be preferable to test new tree combinations and species in parks, where there is more control over the health and survival of trees (Hart 2006). However, given the difficult growing environment that streetscapes present, boulevard and tree pit plantings will also need to be tested. Tree planting trials that begin now would yield results in 20 to 30 years.

STREETS ARE AMONG THE HARSHEST ENVIRONMENTS FOR TREES TO GROW.

Source: Clean Air Partnership

8.6 ZONING

Zoning by-laws in the City will need to be revisited to determine how they can be better formulated to provide sufficient green space for natural processes, such as healthy tree growth. The *Toronto Green Development Standard* is a good start in that it provides guidance for those developers that agree to follow the standards voluntarily. Nevertheless, more legislative power to require developers to follow these guidelines and preserve existing trees would significantly benefit the urban forest. In the City of Chicago, the Bureau of Forestry has established measures to encourage developers to preserve existing trees. If a construction design stipulates that a tree will be removed, the tree is assessed and assigned a dollar value, which the developer must pay to the City.

Recently, 5 Chicago trees were assessed at a combined value of $30,000. This measure has been encouraging developers to re-visit their designs and preserve existing trees (McCarthy 2004). Some developers may still choose to remove the trees and pass the additional costs onto the consumer. A more effective way to prevent tree loss would be to require the developer to maintain the leaf area of the existing trees, preferably by retaining them. If the trees cannot be kept, then enough trees must be planted elsewhere so that there is not net loss in leaf area (and therefore no net loss of benefits) (Kenney 2007).

Reducing the vulnerability of the urban forest to climate change means that trees must be regarded as urban infrastructure as vital as our roads, power lines, and water pipes. Only then can we achieve a healthy, dynamic urban forest that will be better able to withstand the rigours of a changing climate. Maintaining healthy green infrastructure becomes even more crucial as trees can play a significant role in helping urban areas deal with the impacts of climate change.

8.7 DEVELOP A REGIONAL DISASTER RESPONSE PLAN

There is a need for a regional or provincial level disaster response plan to deal specifically with urban trees. Because disasters do not obey municipal boundaries, a regional coordinating body would be highly beneficial in assessing the amount of damage on a regional level and to ascertain which communities are in a position to help others in the event of destructive extreme weather.

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