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# PROCEEDINGS SIXTEENTH MEETING CANADIAN TREE IMPROVEMENT ASSOCIATION:

## PART 2

# COMPTES RENDUS LA SEIZIEME CONFERENCE DE L'ASSOCIATION CANADIENNE POUR L'AMELIORATION DES ARBRES:

## PARTIE 2

SYMPOSIUM:

THE CONTRIBUTION OF FOREST GENETICS TO THE URBAN ENVIRONMENT

LA CONTRIBUTION DE LA GENETIQUE FORESTIERE AU MILIEU URBAIN

UNIVERSITY OF MANITOBA
WINNIPEG, JUNE 27-30, 1977

UNIVERSITE DU MANITOBA
WINNIPEG, 27 AU 30 JUIN, 1977

## COVER PHOTO

Hedge garden[1/] at Agriculture Canada, Morden Research Station, Manitoba.

Left foreground: *Thuja occidentalis* 'Brandon Pyramidal'.

Right foreground: Columnar *Populus tremula* 'Erecta'.

## PHOTO DE LA COUVERTURE

Jardin d'exposition de haies[1/] à la station de recherche d'Agriculture Canada à Morden, Manitoba.

Premier plan de gauche: *Thuja occidentalis* 'Brandon Pyramidal', (en pyramide).

Premier plan de doite: *Populus tremula* 'Erecta', (en colonne).

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[1/] Reference: Hedges for the Prairies. Agriculture Canada Publication 1153, revised 1974. H.F. Harp and W.A. Cumming, revised by H.H. Marshall and W.A. Cumming.

PROCEEDINGS OF THE SIXTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 2

SYMPOSIUM ON

# THE CONTRIBUTION OF FOREST GENETICS TO THE URBAN ENVIRONMENT

Held jointly with the

GENETICS SOCIETY OF CANADA

and the

CANADIAN BOTANICAL ASSOCIATION

UNIVERSITY OF MANITOBA

WINNIPEG, MANITOBA

June 26-30, 1977

EDITORS: A.G. CORRIVEAU AND C.W. YEATMAN

Part 1 Minutes and Members' Reports.

Distributed to Association members and available to others on request.

Part 2 The Contribution of Forest Genetics to the Urban Environment.

Distributed worldwide to persons and organizations actively engaged or interested in forest genetics and tree improvement.

Produced by the

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Department of Fisheries and the Environment

for the

Canadian Tree Improvement Association

Ottawa 1978

COMPTES RENDUS DE LA SEIZIEME CONFERENCE DE

L'ASSOCIATION CANADIENNE POUR L'AMELIORATION DES ARBRES

PARTIE 2

SYMPOSIUM SUR

# LA CONTRIBUTION DE LA GENETIQUE FORESTIERE AU MILIEU URBAIN

Tenu conjointement avec les réunions de

LA SOCIETE GENETIQUE DU CANADA

et

L'ASSOCIATION BOTANIQUE DU CANADA

UNIVERSITE DU MANITOBA

WINNIPEG, MANITOBA

26 au 30 juin 1977

REDACTEURS: A.G. CORRIVEAU ET C.W. YEATMAN

1ère partie — Procès-verbaux et rapports des membres.

Distribués aux membres de l'Association et au public sur demande seulement.

2e partie — Symposium: la contribution de la génétique forestière au milieu urbain.

Distribué à l'échelle mondiale aux personnes et aux organisations activement engagées ou intéressés dans la génétique forestière et à l'amélioration des arbres.

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Ottawa 1978

PROCEEDINGS OF THE SIXTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

Enquiries may be addressed to the authors or to Dr. N.K. Dhir, Executive Secretary, C.T.I.A./A.C.A.A.

The Seventeenth Meeting of the Association will be held in Grand Falls, Newfoundland, August 27-30, 1979. The theme of the meeting is based on the title for the Symposium, "Tree Improvement in the Boreal Forest - Today and Tomorrow". Canadian and foreign visitors will be welcome. Further information will be distributed in fall 1978 to all members and to others on request.

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TO: Dr. N.K. Dhir, Executive Secretary
Canadian Tree Improvement Association
Alberta Forest Service
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COMPTES RENDUS DE LA SEIZIEME CONFERENCE DE

L'ASSOCIATION CANADIENNE POUR L'AMELIORATION DES ARBRES

Gracieuseté de l'Association

Les demandes de renseignements peuvent être adressées aux auteurs ou à Dr. N.K. Dhir, secrétaire exécutif, C.T.I.A./A.C.A.A.

La dix-septième conférence de l'Association aura lieu à Grand Falls, Terre-Neuve, du 27 ou 30 août 1979. Le thème de la rencontre est basé sur le titre pour le symposium, "L'amélioration des arbres de la forêt boréale, aujourd'hui et demain". Le visiteurs canadiens et autres sont les bienvenus. De plus amples renseignements seront communiqués aux membres et autres personnes qui en feront la demande dès l'automme 1978.

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CONTENTS/CONTENU

# WORD OF WELCOME

Welcome to the symposium of the sixteenth meeting of the Canadian Tree Improvement Association.

Because of the continuously larger fraction of the human population living in big cities, the concern of man for the quality of his surrounding environment has been increasing.

As scientists and workers involved in the genetics and the improvement of trees, we are asking ourselves what is actually and what could be the contribution of forest genetics to the urban environment. We have chosen these questions as the theme for this year's symposium. During the next hours, our invited speakers will attempt to help us to find answers. To start off our discussion, Dr. Bruce Dancik of the University of Alberta will introduce us to this subject.

Armand G. Corriveau,
Chairman, Symposium on
the Contribution of Forest
Genetics to the Urban
Environment.

## MOT DE BIENVENUE

Bienvenue au symposium de la seizième rencontre de l'Association Canadienne pour l'Amélioration des Arbres.

A cause de la fraction de plus en plus importante de la population humaine vivant dans les grandes villes, l'intérêt de l'homme envers la qualité de son milieu de vie s'est considérablement accrû.

En tant que scientifiques et travailleurs impliqués dans la génétique et l'amélioration des arbres, nous sommes amenés à nous demander quelle est et quelle pourrait être la contribution de la génétique forestière au milieu urbain. Aussi avons-nous choisi ces questions comme thème du symposium de cette année. Au cours des heures qui vont suivre, nos conférenciers invités tenteront de nous aider à trouver les réponses à ces questions. Pour débuter nos discussions, je demanderais au Docteur Bruce Dancik de l'Université d'Alberta de bien vouloir entamer le sujet.

Armand G. Corriveau,
Président du symposium sur
La Contribution de la Génétique Forestière au Milieu
Urbain.

## INTRODUCTORY REMARKS

We are pleased that you could attend this symposium on the contribution of forest genetics to the urban environment, which is certainly a topic of interest to many foresters and tree breeders.

Paradoxically, Canada is a forested country with a relatively low population, yet Canada is truly an urban country -- a great majority of residents live in urban environments whether they want to or not. For a variety of reasons, these people like or demand trees and shrubs around their home and urban environment for ornamental or aesthetic purposes, for shade, for noise and visual insulation values, and for countless other purposes. These demands are expressed in the market-place; woody plants in cities are extremely valuable. I imagine that an economic analysis of programs for genetic improvement of urban trees in comparison with forest trees might leave some forest tree breeders without their program!

These valuable trees often have a rough time in cities. Urban environments are very "unnatural" for many of our native and introduced species. The selective forces acting upon natural populations of forest trees are often very different from the environmental pressures of the city. Indeed, as one of our speakers will mention today, adult trees in the city often die sooner than they would in a natural habitat.

In the papers this afternoon, we are going to hear about some of the problems and potentials for urban tree breeding -- about some of the traits we can breed for and the species we have chosen and might choose. Many programs (as we saw yesterday at Morden) are actually underway and well-established, yet there seems to be room for more work. The forest tree breeders in the group should be able to contribute ideas on species, sources, and strategies of breeding for these valuable programs. The geneticists might add some comments about diversity. The ecologists may have some comments on site. Without any further delay, let's get to the papers.

Bruce P. Dancik

# EVALUATING AND BREEDING URBAN TREES FOR THE PRAIRIES

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ABSTRACT

Urban trees have attracted increased attention due to the growing urbanization of developed nations and consequent increase in disease and environmental problems afflicting urban plantings. The present report discusses some of the conflicting demands placed on urban plantings. As a result of research on trees for colder regions, several new tree selections have been introduced by the Morden Research Station. This includes a cultivar of an introduced elm (*Ulmus*) species which does not succumb to the causal fungus of the disease known as Dutch elm disease (*Ceratocystis ulmi* (Buism.) C. Moreau). Testing and breeding of trees for prairie towns and cities are discussed in the context of tree species available for colder climates.

RESUME

Une attention grandissante est accordée aux arbres vivant en milieu urbain à cause de l'expansion urbaine des nations développées et des problèmes pathologiques et environnementaux des arbres introduits dans ce milieu. Cette communication expose certaines des utilisations contradictoires que l'on exige des arbres plantés. En conséquence des recherches effectuées sur les arbres adaptés aux régions froides, plusieurs nouveaux génotypes sélectionnés ont été introduits dont un cultivar d'une espèce exotique d'orme (*Ulmus*) résistant au champignon de la maladie hollandaise (*Ceratocystis ulmi* (Buism.) C. Moreau). L'auteur discute de l'essai systématique et de l'amélioration des arbres en fonction des espèces disponibles adaptées aux climats rigoureux.

## INTRODUCTION

Current developments in evaluating and breeding shade trees are a result of the trend away from planting native American elm (*Ulmus americana* L.) made necessary by the introduction, spread and devastating effect of Dutch elm disease (*Ceratocystis ulmi* (Buism.) C. Moreau). American elm was favored as a deciduous shade tree due to its availability from native stands, ease of transplanting, pleasing growth form, and adaptability to a wide range of soil and climatic conditions. There was a general lack of interest in both native and exotic trees introduced by the federal Experiment Farms and Tree Nurseries. Although it was shown that other trees could be grown, American elm remained the predominant boulevard shade tree. This period of development in the Canadian prairies lasted until about 1950 and it is not surprising that 90-95% of older shade trees consist of American elm. The approaching threat of Dutch elm disease to this species caused a gradual change in planting practices until ash (*Fraxinus*) became the dominant genus in new plantings. These ash plantings, like those of elm, consisted mostly of naturally regenerated seedlings of variable quality collected locally.

At this time it would be well to point out some of the conflicting demands to which urban tree plantings are subject. The commercial nurseries are increasingly involved in growing shade trees. They are interested in trees that are readily propagated from seed, cuttings or buddings, trees whose growth rate permits a profit in the growing operation, and trees which will transplant with a high rate of survival. The customer, whether private or municipal, is primarily interested in low initial cost and rapid growth. The trained plantsman, whether he is called an urban forester, municipal arborist or horticulturist, has several interests often overlooked in the urban setting. Let me list four of these priorities.

1. Trees should be of known geographic source (provenance) so as to possess adaptability to the planting site. As an illustration, green ash (*F. pennsylvanica* Marsh.) originating from stands in the southern U.S. is not adapted to northern localities although local originations of the same species will grow very well. The importance of seed and cultivar origin is, in my opinion, well understood by foresters who are familiar with provenance research, and by horticulturists who are familiar with tests by hardiness zones. Unfortunately, commercial nurseries tend to purchase seed of variable origin from many different suppliers and tend to move nursery stock great distances, both of which often result in plantings of unadapted trees.

2. Trees should be uniform in any one planting. Since most seedlings show a range of variation in size and form and many improved selections have been discovered, there has been a shift to asexually propagated cultivars with known genetic potential. It must be remembered, however, that the use of seedling rootstock will still result in small variation in grafted plantings. True clonal plantings can be obtained only with own-rooted plants or in cases in which clonal understocks can be used.

3. Related to the subject of uniformity is the need for trees to be suited to the available space. Limited tree crown space due to factors such as overhead wires and narrow streets will dictate use of a smaller or narrow-crowned trees. Similarly, newer suburban developments point to the need for smaller shade trees which are in harmony with modern building trends.

4. A fourth concern of particular significance is the avoidance of monoculture in urban trees. For example, there is a trend to replace American elm monoculture with green ash monoculture. The use of several kinds of trees will limit the possible effects of insects and diseases.

When we intensified shade tree research at Morden, about 1970, we were concerned with developing sound recommendations for several alternatives to American elm. Research was needed on propagation procedures, identification of new selections and seed sources, and to demonstrate and evaluate shade trees under actual boulevard conditions.

In carrying out this program, existing municipal, arboretum and native plants were evaluated. Over 60 test entries were assembled for inclusion in the Prairie Regional Shade Tree Evaluation Program (PRSTEP) for testing in three prairie capitals (Winnipeg, Regina and Edmonton). Of the 60 entries, more than 30 represented new selections or seed sources which had not been evaluated previously in prairie wide tests. All entries were propagated in our research nursery at Morden either from seed or by budding on rootstocks. The aim was to grow about 50 trees of each entry so that 12 trees would be available for distribution to each of three sites with a few replacement trees remaining. The first phase of propagation research and production was conducted for the most part between 1969 and 1974. Trees of boulevard size were distributed in 1974, 1975 and 1976 with a few slow-growers still remaining for distribution. Our cooperators, consisting of municipal governments in each city, have played an important role in planting, maintaining and evaluating the new plantings. The results of PRSTEP trials can be seen already in the introduction of several new cultivars and increased interest in more diversified boulevard plantings.

I would like to refer now to some of the shade trees suitable for Canadian culture and discuss the potential for further improvement. Some examples are illustrated in Figures 1 and 2.

Two native ashes, green ash and black ash (*F. nigra* Marsh.) have proven to be widely adaptable for Canadian culture, including the prairie provinces. Two improved cultivars, 'Patmore' green ash and 'Fallgold' black ash, are 1975 introductions possessing superior foliage characters and they are also seedless (staminate) cultivars. Both introductions are readily propagated by budding on seedlings of green ash. A third ash species, the Manchurian ash (*F. mandshurica* Rupr.) from northeast Asia, has performed well in shade trials. The best selection of this species is a seedless clone which we hope to introduce shortly. A third Canadian species, the white ash (*F. americana* L.) deserves additional research. It is probable that hardier native seed sources and clones could be used to extend the range of this species into prairie Canada. Most commercial white ash originated in areas some distance from the northern limits of the species. Hybridization of these hardy ash species could conceivably result in superior hybrids which would combine selected characters from each parent.

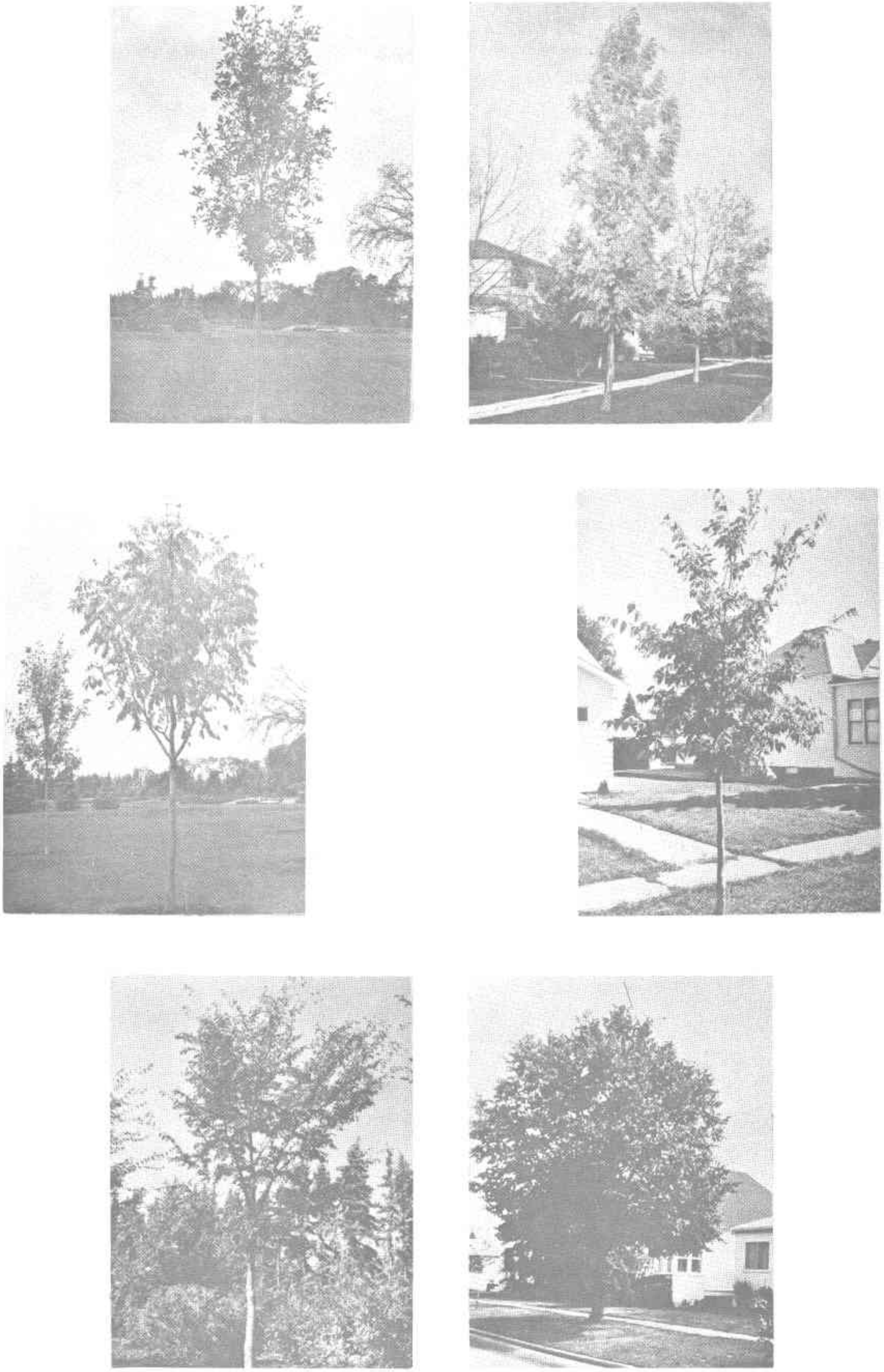

**FIGURE 1.**-- Large growing boulevard trees: 'Patmore' green ash (upper left), 'Fallgold' black ash (upper right), Manchurian ash (centre left), 'Delta' hackberry (centre right), 'Jacan' elm (lower left) and American basswood (lower right).

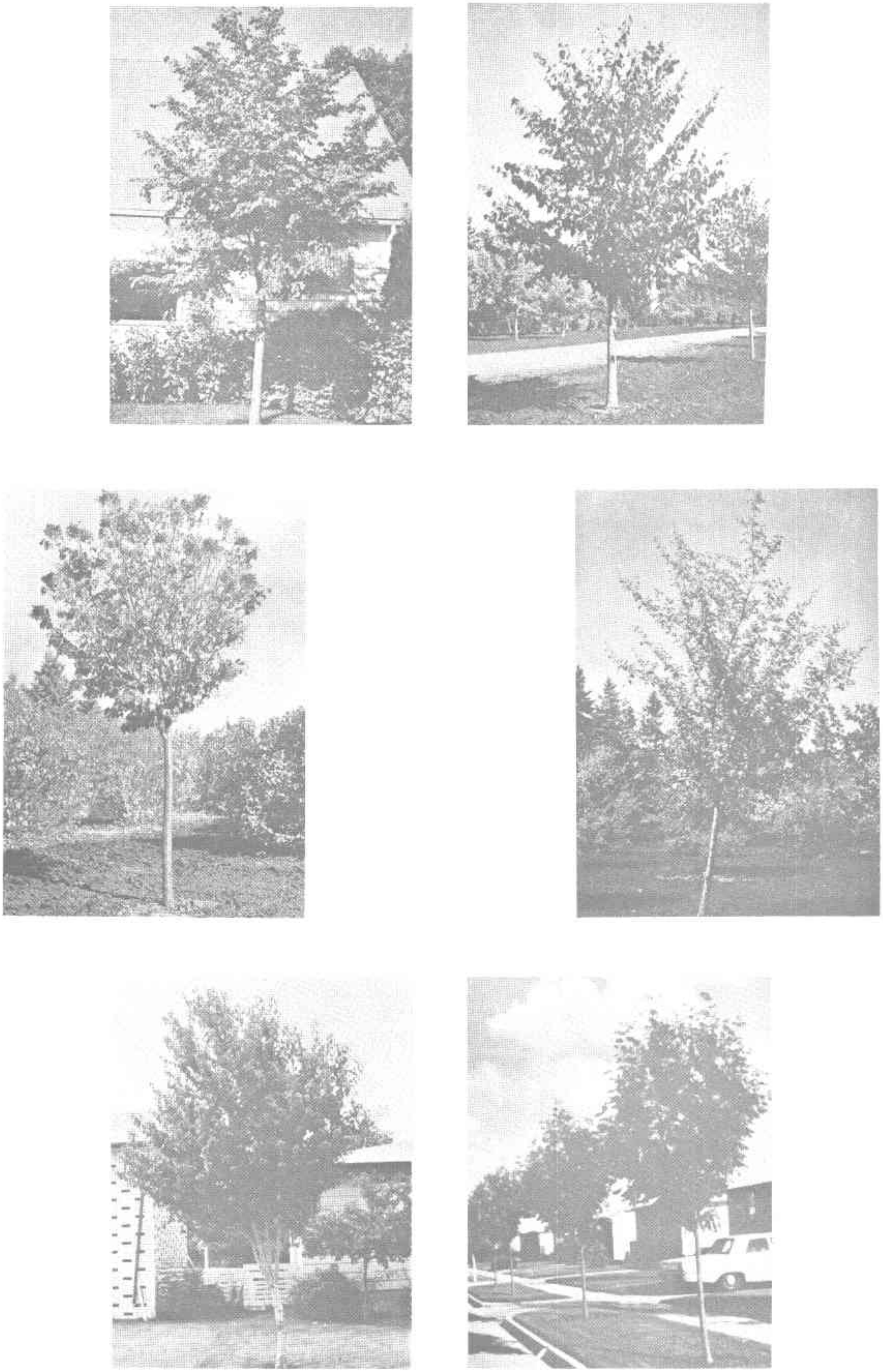

**FIGURE 2.** -- Smaller growing boulevard trees: Mongolian linden (upper left), 'Dropmore' linden (upper right), 'Ivory Silk' Japanese tree lilac (centre left), 'Snowbird' hawthorn (centre right), Amur cherry (lower left), and Mountain ash (lower right).

The native hackberry (*Celtis occidentalis* L.) has not received the attention it deserves. A native seed source from the isolated outlier stand at Delta, Manitoba is hardy to Zone 2B of the Canadian Plant Hardiness map. The 'Delta' seed strain was introduced by the Morden station in 1977. This seed strain is from selected trees originally growing at Delta. Superior clones have been selected but their asexual propagation needs further study.

Several species of linden (*Tilia* spp.) have become more popular in recent years. Lindens have a wide natural distribution in North America, Europe and Asia. Basswood, the American linden (*Tilia americana* L.), is native to eastern Canada and occurs naturally as far west as south central Manitoba. The species appears to be adapted to a wide area of Canada. No cultivars have been introduced from the native prairie stands so further selection is warranted. *Tilia cordata* Mill., the little leafed linden, has variable hardiness and further study of northern Scandinavian and Russian provenances may give strains even hardier than those currently available. Hybridization of the two preceding species produced the Dropmore linden from which a segregating generation of seedlings has been grown. Many interesting seedlings have been selected from this $F_2$ population and these give evidence for inreased hardiness and quality. One smaller-growing linden, the Mongolian linden (*T. mongolica* Maxim.), is valuable for planting sites requiring a smaller tree. This species is also valued for its vase-shaped crown, healthy foliage and exfoliating bark.

Japanese elm (*Ulmus japonica* (Rehd.) Sarg.), a hardy Asiatic species, may well be the answer to the quest for a disease resistant elm with the growth form of the native American elm. 'Jacan' elm is a new cultivar released by the Morden Station in 1977. This cultivar has proven tolerant to Dutch elm disease inoculation at the Canadian Forestry Service Sault Ste. Marie laboratory. Japanese elm can be propagated from seed or by budding on Siberian elm rootstock.

Several other large-growing trees deserve mention. Silver maple (*Acer saccharinum* L.), bur oak (*Quercus macrocarpa* Michs.) and Amur cork tree (*Phellodendron amurense* Rupr.) are receiving attention. Selection is needed to improve hardiness, chlorosis resistance and branch strength in silver maple, growth rate and transplant ease in bur oak and seedling uniformity in cork tree. Sugar maple (*Acer saccharum* Marsh.), Norway maple (*Acer platanoides* L.) and red oak (*Quercus borealis* Michx.) all are somewhat lacking in hardiness and adaptation for prairies.

Several groups of smaller-growing shade trees are available for situations that call for trees of limited size. For example, the Amur maple (*Acer ginnala* Maxim.) and tatarian maple (*A. tataricum* L.) are suited to almost all regions of Canada with the exception of areas subject to iron chlorosis. Several hawthorns (*Crataegus* spp.) perform well including *C. chlorosarca* Maxim., *C. caessia* Ashe and the 'Snowbird' double-flowered cultivar.

The flowering crabapples (*Malus* hybrids) grow well over a wide geographic range, as do the hardy flowering cherries (*Prunus* spp.). Among the best of the hardier cultivars of flowering crabapplies are pink-flowered 'Selkirk' and Red Splendor', and white-flowered 'Rosthern'. Flowering cherries, including the hardy Amur species (*Prunus maackii* Rupr.) and May day cherry (*P. padus* L.), have grown into attractive, small trees. Other small trees include the Ussurian pear, (*Pyrus ussuriensis* Maxim.) Japanese tree lilac (*Syringa amurensis japonica* (Maxim.) Fr. & Sav.) and mountain ash (*Sorbus* spp.).

In conclusion, progress has been made in encouraging the culture of a wider range of shade trees. Several new cultivars have recently been introduced which should make a real improvement over seedlings of the same species. Many problems associated with urban plantings, including salt damage and air pollution, will require increasing surveillance and research in the future. Hopefully, trees will be identified which will meet aesthetic requirements and yet will survive in the urban environment of the future.

# GENETIC IMPROVEMENT OF TREES FOR THE URBAN ENVIRONMENT: CHALLENGES AND OPPORTUNITIES

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## ABSTRACT

The demand for trees and shrubs for urban environment is increasing with growing urbanization in every country. As trees in the urban environment are subjected to a multitude of stresses there is need to use principles of genetics for their improvement so that they may withstand such stresses. The criteria for their selection are discussed and the goals of tree improvement for urban environments are stated, with a discussion of the challenges and opportunities involved. To explain the possibilities and problems, three examples are given of genetic improvement of trees, viz. for tolerance to sulphur dioxide and improvement of maples and elms.

## RESUME

A cause de l'urbanisation croissante dans tous les pays, la demande d'arbres et d'arbustes capables de vivre en milieu urbain augmente. Comme les arbres vivant dans ce milieu sont soumis à une multitude de stress, il faut faire appel à la génétique pour améliorer leur résistance à ces facteurs. L'auteur traite des critères de sélection, définit les buts de l'amélioration des arbres destinés au milieu urbain et parle des défis et des possibilités que cela comporte. Dans le but d'expliquer les possibilités et les problèmes de l'amélioration génétique des arbres, trois exemples sont donnés: amélioration de la tolérance à l'anhybride sulfureux du pin blanc, amélioration génétique de érables et amélioration des ormes.

## INTRODUCTION

Forest and man have long been incompatible with each other. The history of human civilization is in part the history of diminishing forest frontiers. The forest lands have been cleared by man not only for their wood but also for agriculture, habitation, avoiding dangerous animals and for destroying refuges of armies in warfare.

As human society became industrialized the realization of the loss of intangible aesthetic, hygienic and prophylactic values of forests also grew with the increasing distance between man and his forests. With the growth of urbanization and metropolises man lost a certain charm and intimacy with the forests that the ancients possessed. For generations Walt Whitman's view had prevailed in the western world about nature and its beauties - birds, trees, flowers and water - that a certain free margin, and even vagueness, perhaps ignorance and credulity, helps your enjoyment of these things. We have now reached a stage in which these elements are in danger of destruction and have become more vital to human society than ever before. This has produced an awareness of the need to bring man and his forests together again in urban surroundings. However, a large gap exists in the knowledge about the methods of achieving this objective. Genetic improvement of trees is a much needed method for the selection or creation of trees adapted to urban stresses. The role of forest genetics in the restoration and maintenance of forests in the urban environment is the thesis of this paper.

## DEFINITIONS

Two definitions appear necessary, those of 'urban environment' and 'urban forestry'. For lack of a better definition I would define 'urban environment' as 'the sum total of all the physical, sociological and aesthetic factors influencing the existence and development of human populations in urban habitats, i.e. cities'. These factors do not act independently but act and interact together as well as on human populations. Jones and MacArthur (1976) have defined 'urban forestry' as 'the management of trees and forests in urban surroundings'.

## POPULATION TRENDS AND PROJECTIONS

Urbanization is a characteristic of the modern age. The urban and suburban land area in the United States may exceed 121 million ha (300 million ac.) with 85 percent urban population by the year 2000 (Pickard 1971). The Canadian population in 1966 was 74 percent urban (Zsuffa and Calvert 1976) which would increase to 94 percent by the year 2000 (Canada. Statistics Canada 1973). Such a high concentration of human population in metropolitan areas calls for a realistic assessment of their needs for urban forests and arboriculture. According to Marlow's framework (Marlow 1954) human needs are arranged according to their motivating precedents. Lower and basic needs have to take precedence over higher needs. The scheme consists of the following five levels, with the needs rising in value from bottom to top:

Higher order - 5. Self-actualization (e.g. creativity, knowledge, self-realization)

4. Status (e.g. self esteem, respect for others)

3. Social (e.g. family, love, association)

2. Safety (e.g. protection from deprivation, discomfort, illness and the unfamiliar)

Low order - 1. Subsistence (e.g. food, water, shelter, rest).

This concept has an important bearing on public attitudes towards the management of urban environment. Hunt (1973) stated that the North American people with their high standard of living may not exhibit much concern for lower needs. However, even in this land of plenty there are people at all levels on the scale, though the greatest majority would be between 2-4. In this heterogeneous population of urban dwellers there is great need to know the requirements and likes and dislikes of the majority and plan for their satisfaction. This makes the task of urban forestry planning very difficult.

## CRITERIA AND GOALS

While increased productivity and improved wood and fibre quality continue to be the main goals of non-urban commercial forest management, the goals of forestry for urban environment aim at satisfying a complex of tangible and intangible values. Although the main criterion is to grow what the people need even this decision is not easy. The needs would differ with the urban community and the status of the needs of the people in that community on Marlow's scale (Marlow 1954). We can set these goals in general terms by saying that urban forest management should aim at selecting trees with various growth rates and forms so as to satisfy varying tastes of city dwellers. Such trees should be adaptable to the multiplicity and complexities of planting sites, where they are exposed to many stresses. The urban stress factors are summarized in Fig. 1. It is also important to explain that more than one of these stress factors often operate in most urban environments and some aggravate the effects of others. For example, tolerance to pests and diseases is weakened by adverse site conditions and by air pollution. The requirements of paramount importance for selecting trees in urban forestry are resistance or tolerance to pests and diseases, air pollution, intense heat, drought, soil compaction, de-icing salts, and storm damage (either by virtue of wood quality, crown shape or branch angle).

Considerable literature has accumulated on the particular kind of damage caused to individual species by such stresses. This literature has been reviewed by Santamour (1969, 1971) and Heggestad, Santamour and Bernstein (1972).

## CHALLENGES AND OPPORTUNITIES

In tree breeding the most critical challenges are long periods of time to sexual maturity, irregularities in flowering and fruiting of trees and frequent destruction of these flowers and fruits by insects or other pests. Tree breeders for the urban environment are confronted with the following additional challenges:

1. Urban trees have high unit cost and value which justifies the expectation of 100 percent survival under the prevailing circumstances which are usually adverse.

2. Urban trees must be capable of being produced on a large scale by nurseries and must be tested for a long time to produce satisfactory varieties which will win public approval according to somewhat subjective criteria.

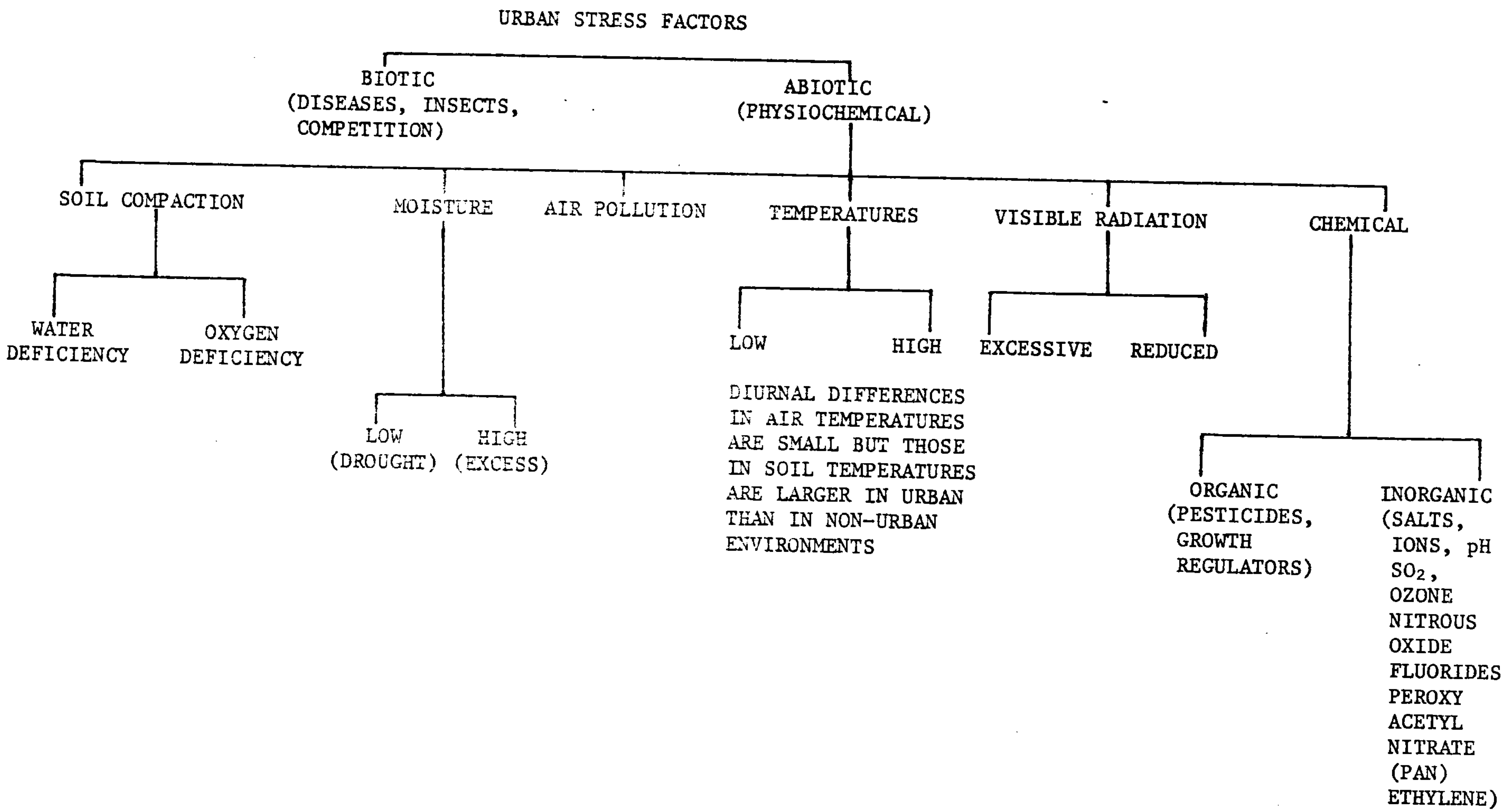


Fig. 1. Urban Stress Factors. (Modified from Roberts, 1976)

3. Trees have to be developed for environments that are often alien. Many of these environments are man-made and their physiological effects on trees are not completely understood. For example, search for a genetically superior variety tolerant to a specified stress becomes difficult without a proper understanding of the physiological effects of the causative agent.

4. Though a larger variety of plant material is available, economic, biological and ecological factors compel nurserymen to grow species or cultivars that have commercial viability, have proved adaptability to urban situations or require only limited quantities of pesticides. This restricts the base from which to select for tolerance to a new stress, such as a new pest, disease or pollutant.

5. Mass propagation of useful varieties, particularly hybrids, is sometimes not possible due to the desire and the need to produce uniformly good material, which can only be produced by vegetative propagation - rooting of branches or grafting. These practices are not possible or easy in some species. For example, nurseries have not shown much interest in the propagation of the new blight resistant chestnut hybrids developed by the Connecticut Agricultural Experiment Station. The major reason for this apathy has been the lack of successful propagation techniques. Propagation by seed is impossible, the hybrids do not root well from cuttings and grafting is only slightly more effective. So, the superior genotypes developed after more than 40 years of breeding and testing are by themselves not meeting the urban requirements. The challenge is to continue research until the constraints on propagation are overcome.

6. Sometimes an accepted variety must have an especially appealing shape or 'personality' (weeping, fastigiate, columnar, globe, vase-shaped, etc.). Such forms often result from mutations and can be reproduced vegetatively only or partially by control-pollination, both of which may be difficult or even impossible in the species concerned.

Notwithstanding the above challenges tree breeding for urban areas has the following opportunities also:

1. Natural populations of trees have large variation in stress tolerance and this provides vast possibilities for selection and breeding. Such differences in adaptability exist among species as well as among races and individuals within species and may be exploited to advantage. For example, pollution tolerant varieties of a species can be developed by detection of variation in the existing natural stands and the selection and breeding of superior races and individuals. Evidence of variation in tolerance to air pollutants has been found in 15 tree species through controlled experiments in fumigation chambers and also by comparisons in nature after pollution episodes.

2. When genetic diversity in a species has been detected it is possible to maintain it as a safeguard against possible disasters of new pests and diseases.

3. Increasing use of rooting hormones and improvements in cloning techniques such as tissue and cell culture have made possible propagation of superior genotypes by cloning, so that uniformly tolerant varieties can be propagated. Some success is also possible by control-pollination if cloning is difficult.

4. Resistance to pests and diseases can be developed by selection as well as hybridization, resulting in crops that are suitable for different circumstances, as will be illustrated later in the case of the Dutch elm disease.

5. The results from basic in-depth studies on stress tolerance of trees are now available which the geneticist may use in the development of breeding programs for species for tolerance to the specific stress.

## EXAMPLES OF GENETIC BREEDING IN URBAN FORESTRY

After explaining the main problem I proceed to give three examples of genetic improvement in the context of urban forestry. They describe research on three different levels. One is an example of basic research on tolerance of a species to pollutants. The second is the improvement of a genus by selection and breeding. The third is the improvement of an individual species for resistance to a specific pathogen.

### Genetic Control of Sulphur Dioxide and Ozone Tolerance in Eastern White Pine

Houston and Stairs (1973) obtained estimates of the upper limits of genetic control (repeatability) for resistance of *Pinus strobus* L. to sulphur dioxide and ozone. Tolerant and sensitive clones were isolated and fumigated for six hours with a mixture of 2.5 pph m of sulphur dioxide and 5 pph m of ozone. Response was evaluated by (1) needle elongation, (2) index of evaluation of total foliage injury and (3) index for evaluation of individual needle injury. Repeatability values for these characters were 0.468-0.597, 0.818 and 0.799 respectively. These results show that the tolerance-sensitivity reaction to combined sulphur dioxide-ozone exposures is under strong genetic control in *P. strobus*. Hence, selection of parent trees that are tolerant or sensitive to low or moderate ambient levels of these pollutants can be successfully accomplished.

### Maples

Maples, with 150 species and great diversity in size, crown shape, fruit characteristics and leaf size, are ideal for urban use (Mulligan 1958, May 1961, 1962). Most of them are easy to transplant. They are long-lived and suited to a range of various soil conditions (Irwin 1973). The necessary intra-specific variation exists in most species, which makes them very suitable for improvement.

The most intensively studied species is sugar maple (*Acer saccharum* Marsh.) that varies considerably in timber quality (Kriebel 1968), winter hardiness, tolerance to summer heat and drought, chilling requirements, time of onset of dormancy, branching habit, growth rate and sugar concentration (Kriebel and Gabriel 1969). Similar variation has been documented by Townsend (1976) for red maple (*A. rubrum* L.) and by Wright (1949) for silver maple (*A. saccharinum* L.).

Townsend (1976) reviewed research on inter-specific hybridization in *Acer* since 1941 and reported varying results in different cases. Out of the 35 inter-specific hybridizations attempted by Wright (1953), *A. platanoides* x *mayrii* and *A. platanoides* x *cappadodicum* grew vigorously after outplanting and showed hybrid vigour in the tenth year (Wright 1962). *A. negundo* x *henryi* hybrid would be promising as an ornamental tree in warm temperate climate because of its foliage, which remains pink or red during the summer.

Townsend (1976) suggests a hybridization program among the following species to develop cultivars of smaller sizes: *A. argutum* Maxim., *A. buergerianum*, *A. campestre* L., *A. callipes* Maxim., *A. carpinifolium* Sieb. & Zucc., *A. circinatum* Prush., *A. ginnala* Maxim., *A. griseum* Pax., *A. nikoense* Maxim., *A. spicatum* Lam.

Elms

Elms would be the favourite trees for urban use except for their susceptibility to the infection by Dutch elm disease (*Ceratocytis ulmi* (Buism.) Moreau).

Santamour (1972, 1974) showed the possibility of hybridizing the fall and spring flowering elms to utilize the disease resistance of the fall-flowering Chinese elms in many new combinations.

Heybroek (1976) summarized the development and release of Dutch elm disease tolerant clones of elm, starting with the work of Dr. Christine Buisman (1928-30). Fig. 2 is a schematic development of the breeding program for the newly released elm variety PLANTYN. Resistance was developed step by step over two generations and three rounds of selection. The variety was obtained in 1964 and entered the field test stage in 1967. By 1975 it had been planted in 24 replicated field tests, each containing many clones. These tests are designed to evaluate growth, shape and general health of the clones under varying conditions, including exposure in coastal areas.

Their release in 1971 was suspended because of the discovery of a new and more virulent strain of the pathogen in Great Britain and its apprehended movement to North America. Four clones were tested in Great Britain, Holland and U.S.A. in an international cooperative experiment, as a result of which two were released in 1975 and named PLANTYN and LOBEL and a third was added later and called DODENS. These clones were formerly identified as numbers 496, 454 and 494 respectively. Though they are not perfect they are stated to be better than the prevailing cultivars.

The clones developed by selection in the above manner offer no insurance against a new disease or a new strain of *C. ulmi*. A parallel program, known as the Wisconsin elm-breeding program, aims

THE "PLANTYN" ELM AND AN EXAMPLE OF ITS USE IN THE BREEDING PROGRAM

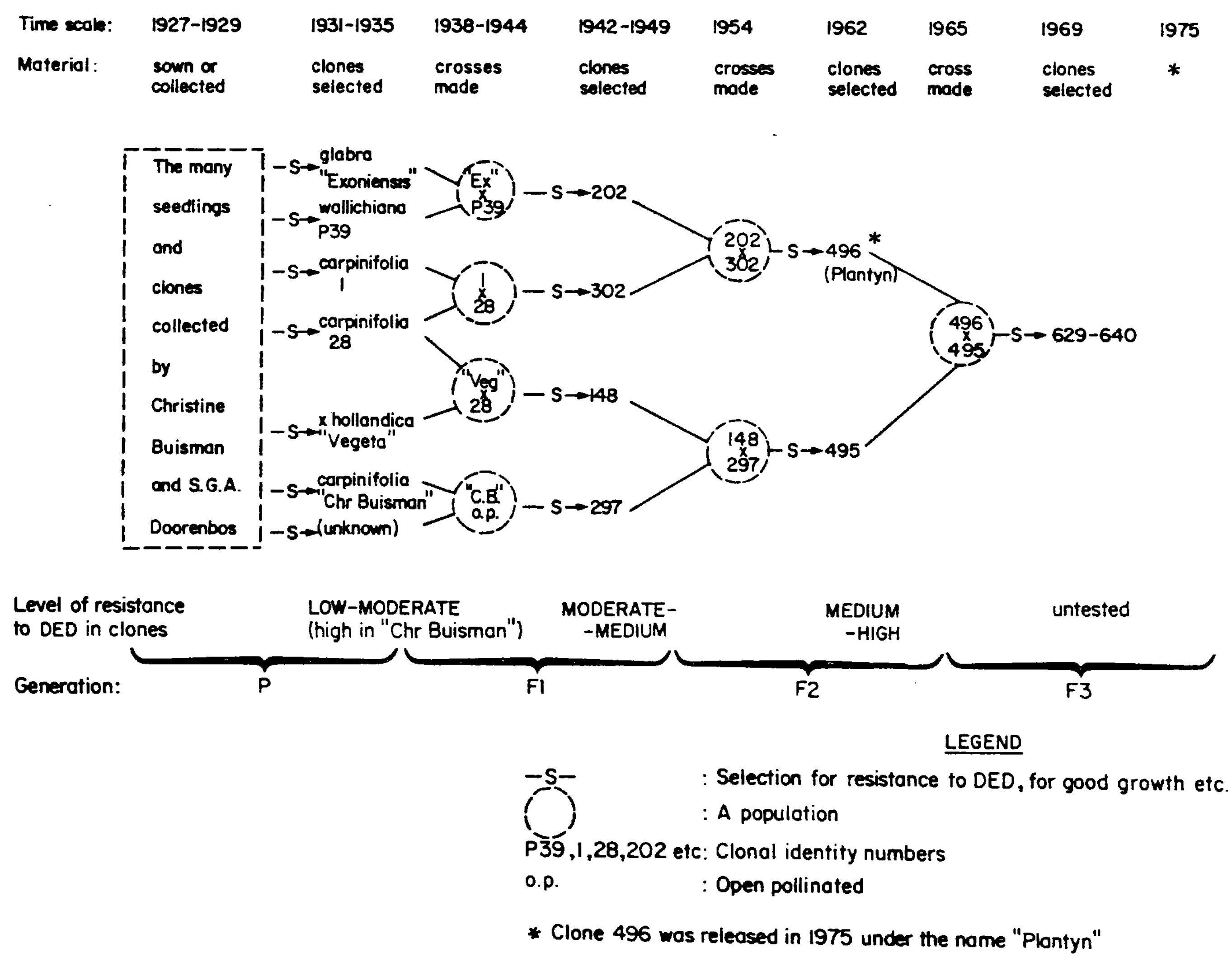


Figure 2. Schematic development of the breeding program for the newly released elm clone 'Plantyn'. (Adopted from Heybroek 1976).

at producing seed-propagated material from the backcross (*U. pumila* x *japonica*) x *japonica*. A seedling population of elm that has less than 10 percent of susceptible individuals is regarded as acceptable for disease resistance (Lester and Smalley 1972, Lester 1975). This is a practical example of the superiority of a seedling population produced by hybridization in comparison with a clonal population obtained by direct selection.

## CONCLUSION

Increasing urbanization has directly and indirectly created a set of needs for an expansion of urban forestry. The trees and forests in the urban environment are subject to several biotic and abiotic stresses which have been summarized in the paper. The challenge to geneticists is to develop varieties and clones of the commonly used species which would be tolerant to these stresses. It is particularly urgent to develop tolerance to pollutants within selected genera and species. Considerable information is available on the physiological effects of pollutants and the genetics of tolerance which can be utilized profitably in the selection and breeding of tolerant varieties and clones. Creation of more disease and insect resistant varieties is also important because of the increased susceptibility of urban trees to damage by these agents as a result of abiotic stresses.

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# DESIRABLE TRAITS FOR CITY TREES

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## ABSTRACT

Observations in the Boston area indicate that water shortage, construction, wind, soil compaction and pollution cause stresses on trees growing in the city shortening their life and affecting their health. New genetic strains are needed which will withstand stress, salt and other pollutants, transplant easily, grow well without pruning, tolerate compacted soil, and have a better resistance to fungi, viruses and insects.

## RESUME

Des observations effectuées dans la région de Boston indiquent que les déficiences en eau dans le sol, les constructions, les vents, la compacté du sol et la pollution causent aux arbres, vivant dans la ville, des stress tels que leur santé est affectée et leur vie écourtée. De nouvelles variétés génétiques pouvant supporter les stress de toute sorte, le sel et les autres polluants, pouvant se transplanter facilement et développer une belle forme sans élagage, pouvant s'accommoder d'un sol durci et avoir une résistance accrue aux champignons de carie, aux virus et aux insectes sont nécessaires.

## INTRODUCTION

Urban forestry is a multidisciplinary approach to an old art. The desirable traits for city trees relate directly to the parameters of the urban ecosystem, as forest trees relate to theirs. City trees are subject to physical and human pressures that never existed in Evangeline's forest primeval.

Observations in Boston indicate that several factors stand out. The average survival of a city tree is 10 years (Foster 1978). Engineers are the commonest cause of urban tree death. A tree pit in the sidewalk is like a flower pot in the desert.

For plant material that evolved in the dulcet woodland, the adaptive problems are enormous. Genetic variants are needed, but developing them for the hostile environment is a problem.

The quickest improvement would be to educate engineers and planners to build planting pockets that can sustain reasonable biomass production. It is easier said than done. The man-made city was not created for growing things. Trees have arrived by popular demand, planted willy-nilly wherever a spot could be found. It takes more than just a hole in the concrete to get a tree to grow in an ecosystem that has special stresses, some of which are listed below.

## HEAT ISLAND EFFECT

The microclimate of cities is different from the forests, plains and suburbs. By and large, cities are warmer. The heat island is caused by the added energy used to heat buildings, run autos and power equipment. Also, concrete absorbs additional heat from sunlight and holds it. At night, smoke, smog and $CO_2$ inhibit outward radiational energy flow.

In addition to the warmth, tree trunks are bathed in direct and indirect sunlight winter and summer. Cells that should remain frozen and dormant during winter thaw and re-freeze. Frost cracks and sunscald are common, particularly on young trees. Dormancy triggering may be upset, resulting in winter kill. In summer, the sun heats pavements and buildings by day. There is slow cooling at night. More water is necessary for healthy growth. It is rarely available.

## WATER STRESS

City trees often adopt the desert growth habit, with small leaves, shorter internodes, thick stems, stunting and premature seed production (Brown and Zimmerman 1971). Water is the limiting growth factor. The average 1 m by 1 m tree pit has inadequate surface to absorb enough water. Cracked sidewalks are often the only reason older sections have decent trees. Soil compaction is endemic. Water is not absorbed efficiently.

In parks water stress is not so acute as in sidewalk pits and planters. But the over-walked-on, compressed soil doesn't absorb water well. There is rarely adequate air exchange available to the roots, either. Rainfall is not usually adequate to cover summer evapo-transpiration. Underground water is neatly piped into sewers by overzealous engineers. The Boston Park Department spent over $100,000 in the Boston Common, to divert water from leaf-scorched trees into an elaborate sewerage system and out to the bay. Root damage caused by the 1.5 m trenches was enormous and loss of future water was worse.

The cumulative result of all these factors is that water-stressed city trees misread the seasons. Spring growth ceases too early. They suffer summer leaf scorch. The loss of leaf tissue compromises food manufacture for the next year's growth. It becomes a self-generating cycle of decline.

A problem that cannot be corrected genetically, but is worth noting, is flooding with irrigation systems engineered for putting greens, not forests. In 1971, on Boston's Commonwealth Avenue, a new sprinkler system for old majestic trees was set to deliver 61 cm of water in 3 months. The average rainfall the trees were used to for this period was 27.1 cm. The calculated evapo-transpiration rate was 42.1 cm. The trees are on a filled tidal bay that does not drain. Many of the once majestic trees are in decline with sparse leaves and extensive dieback from root rot. Constitution Park in Washington, D.C., built for the bicentennial, has similar problems with poor drainage and too much water from a new sprinkler system.

## WIND STRESS

Tall buildings funnel the prevailing winds making minor wind tunnels. The speed and turbulence of the wind increases as the buildings get taller. The canyon effect is worsened. Dessication and water stress are augmented, and shredding may be seen on tender leaves.

## CONTINUING CONSTRUCTION

Statistically, more trees are actually killed by the direct and indirect effects of constant building than any other single factor. The public works departments are the main culprit. Changes in the runoff water patterns, the underground water table, and wind velocity, compound the damage done to roots during construction. Engineers and contractors do not understand the need for a water table, underground aquifer recharge, adequate root runs, air and water exchange. They dig and re-dig the city. Continuing construction is the rule rather than the exception.

Construction specifications that outline procedures for "Protection of Existing Trees" are interpreted by contractors as, "Try not to back the bulldozer into them". Under the dripline seems to be the preferred place for parking trucks and eating lunch. Even a contractor enjoys the shade of a fine old tree. Unfortunately, the compacted soil he leaves behind frequently precipitates decline.

## POLITICS

Trees may be a sign of loving municipal care, but in fact they usually take a back seat to other budget needs. The exception is election years with massive planting programs. Then the young trees are usually forgotten and left to fend for themselves. They are rarely watered, even during their first year after transplanting. In fact, the pressures of politics, not arboricultural expertise, determines the health of city trees. Emergency pruning is usually done. Corrective pruning and repairs are seldom, if, ever done. The crowns are left to grow in whatever shape they will and scaffold branching is poor.

## AUTOMOBILES

On Boylston Street in downtown Boston, 73% of the young trees had auto wounds. In the whole area, 61% of all sidewalk trees were damaged by cars. Another 33% were vandalized or had broken branches. Urban trees have to self-heal as wounds are rarely attended to by municipal maintenance crews. The wounds often provide a point of entry for fungus. Ideally, trees should not be planted at curbside but they are. As long as municipal practices prefer the curb for tree pits, there will be a need for genetically engineered new trees that heal quickly, and resist fungi.

## STRESS RESPONSE

The cumulative effect is that city trees grow less, mature too early, and die too soon. They become very susceptible to fungus, virus and insect damage. This syndrome is known as "the stress response of city trees". It means that the trees just don't do well because of the combination of special stresses of the city ecosystem. The decline and death of sugar maples in most eastern American cities is attributed to stress response combined with a particular sensitivity to salt.

## POLLUTION FACTOR

Pollution intensifies the above-mentioned problems, particularly the stress syndrome. There is evidence pollution sensitizes trees to infection (Holmes 1977). Salt is the worst offender. One can almost measure a city's winter snow-melting salt bill by summer leaf scorch. Because less than adequate water is available in cities, it compounds the effect of salt injury. Gaseous pollutants (sulphur dioxide, ozone, oxides of nitrogen, fluorides, PAN and ethylene) take their toll, also, of leaf tissue and vigor. Trees, already under stress from the other insults of the city environment, don't have the reserve to tolerate this additional insult of pollution.

If other growing conditions are good, large trees will grow huge and vigorously in polluted cities. In the Boston Public Garden, which has a high underground water table and good soil, there are big specimens of sophora, gingko, elm, beech and oak trees. A locust 8 stories high, and English elms 10 stories high grow in a downtown cemetery that dates from colonial times. The trees are not watered nor particularly cared for there, but because of the graves, their roots are never disturbed. They grow in spite of pollution. However, trees not so protected from cars and construction, cannot tolerate high levels of pollution without a decrease in health and vigor.

Another pollutant problem in cities is particulate ash. It is especially troublesome to evergreens. There are few old evergreen specimens in cities. Deciduous trees are also affected but because they put out new leaves each year, they tolerate high ash levels better.

## BEST TREES FOR CITIES

In city tree populations, the overabundance of elms, maples and lindens do not mean that these species are necessarily the best adapted to cities. Actually they represent the fads and fashions of arboriculture, which, like every profession, has its fashions. One year, a certain tree is queen, only to fall into disfavour for a new courtesan. Elms are subject to Dutch elm disease. Most maples are salt intolerant, and their vigorous roots uplift sidewalks and get into sewer and water pipes. Lindens often require pruning for straight trunks. This is no problem in parks, but can be on streets. All three are planted under electric wires, and on too small sidewalks. As they grow too large, they require expensive and continual pruning. These trees are fine where there is room.

It is important to use a greater variety of species and clones. Monocultures are dangerous. They encourage disease and fungus epidemics which decimate the tree canopy. Old favourites need not be discarded, but choices enlarged. Currently there is fascination with Japanese species ... sophora, zelkova, gingko and amur cork tree. They have drawbacks ... shape, transplant problems, gingko needs water. But they seem to do well, perhaps because the fungi that attack them haven't found their way here yet.

Drought resistant trees and those that transplant well are popular ... shademaster locust, greenspire linden, ... marshall's green ash. In 1977, callery pear seems to be this year's perfect street tree in size, shape, toughness and pollution resistance. Where salt is not a factor, maples are fine, in the right places, where they can grow to their full size.

Few trees on streets are true to their promise, however. They do not live out their life expectancy. Some of the shorter-lived species would serve equally well on city streets. New varieties of high-headed, fruitless crabs, virus-resistant cherries, and drought-resistant dogwoods are needed. *Malus baccata* is seldom grown as a high-headed specimen but would make an excellent street tree. A fruitless horse chestnut, that doesn't scorch in summer, would be useful, too.

Mature size is a problem. There are few trees that will grow in the city and also become large and majestic. Many broad plazas and wide avenues demand such trees for architectural scale. Oaks and planes are large trees that will grow well in cities. Oaks, however, are extremely hard to move. Red oak and pin oak are reputed to have fibrous roots and should move more reliably, however, city realities being what they are, all oaks have a chancy survival rate in actual practice. When they finally do take hold, they are excellent city trees. Plane trees are currently having fungus problems, but one could not re-forest cities without them. They are a major street tree in New York, London and Paris.

Fortunately, many varieties of medium sized and smaller trees exist which will grow to a certain desired shape and mature size. Unfortunately, too few possess the needed genetic toughness to withstand city conditions.

## GENETIC NEEDS OF CITY TREES

To summarize, the desirable traits that are needed for city trees are:

1. Withstand water stress, particularly when newly planted;
2. Transplant easily;
3. Trees that develop a single leader and a good open scaffold without help;
4. Fungus, virus and insect resistance;
5. Self-healing wounds;
6. Trees that can transpire in compacted soil.

Most scientists seldom have cities available to them for testing. However, a good test plot would be in holes, 1 m b 1 m, in the middle of a paved parking lot on the south side of a large building.

The charge to tree geneticists is not easy, however, the total city ecosystem is not easy for trees.

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# IMPROVING THE ADAPTATION OF MAPLES AND ELMS TO THE URBAN ENVIRONMENT

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## ABSTRACT

Maples comprise the most frequently planted group of urban trees in North America. Research with red maple has demonstrated opportunity to improve its tolerance to cold, drought, air pollution, and *Verticillium* wilt, and has shown great variation in straightness, flushing, colouration, and growth rate. Elms offer the greatest potential of all landscape trees for adaptation to the urban environment because of their inherent ability to tolerate urban stresses. Elms bred and selected for resistance to Dutch elm disease and for horticultural desirability are being evaluated and released. Future research is needed to improve genetic superiority in transplantability and tolerance to de-icing salts and soil compaction.

## RESUME

Ce sont les érables qu'on plante le plus souvent dans les villes d'Amérique du Nord. Les recherches faites sur l'érable rouge ont montré qu'il était possible d'améliorer sa tolérance au frois, à la sécheresse, à la pollution atmosphérique et à la flétrissure verticilienne; elles ont également permis de noter des variantes énormes au point de vue de la rectitude, du débourrement, de la colouration et du taux d'accroissement. De tous les arbres paysagers, l'orme est le plus susceptible de s'adapter à l'environnement urbain à cause de sa capacité naturelle à tolérer les stress urbains. Des ormes hybrides et sélectionnés pour leur résistance à la maladie hollandaise et leur attrait du point de vue de l'horticulture sont actuellement évalués et mis sur le marché. Il faudra d'autres recherches pour améliorer leur supériorité génétique sur le plan de la capacité à être transplantés ainsi que de la tolérance aux sels et au tassement du sol.

## INTRODUCTION

Evolution of tree species has created biotypes with the ability to survive under forest conditions. Unfortunately, trees adapted to these natural situations do not necessarily possess characteristics that enable them to grow well and maintain their vigor in the "unnatural" urban environment, with its many pests, environmental stresses, and vandalism.

It is evident that if we expect to have trees surviving in urban situations, we need a technology based on tree genetics, physiology, and pathology. Genetics research at our laboratory over the past several years has been concentrated on the potential for genetically selecting or manipulating those "survival" characteristics important in an urban environment. Our research has emphasized maples (*Acer*) and elms (*Ulmus*) because these genera offer the variability necessary to improving their overall adaptability to urban conditions.

## MAPLE RESEARCH

With about 150 species, the genus *Acer* offers great diversity in size, shape, leaf and fruit characteristics, and leaf coloration (Townsend 1976). Maples comprise the most frequently planted group of urban tree species (Gerhold and Steiner 1976). Most of the 170 *Acer* cultivars currently available for metropolitan planting have been selected for aesthetic superiority rather than for adaptability and tolerance to urban stresses, none has resulted from a systematic program of breeding and selection. Unfortunately, little genetic research has been carried out to evaluate and improve those characteristics important for adaptation to the urban environment.

In view of these realizations, we began an extensive provenance and progeny test of red maple (*Acer rubrum* L.) in 1971 (Townsend 1974a). We collected seed from individual parent trees from throughout the natural range of red maple. Data taken over the past five years have shown wide variation in height, cold hardiness, straightness, time of flushing, onset of dormancy, and many other morphological and physiological traits. Generally, we found that the northern progenies at the Delaware, Ohio plantation show the most reddish autumn colour, earliest flushing and budset, and least winter injury. Sources of the genetic variation were statistically attributed to geographic areas, or "populations", as well as to the parent trees within the geographic area. Therefore, a combined family and clonal selection program should be effective.

*Verticillium* wilt is an important disease on many maples. In 1973 we found significant variation among half-sib families of red maple in their tolerance to the *Verticillium* fungus (Townsend and Hock 1973). This was the first reported instance of intraspecific variation in a tree species in tolerance to this disease, and it indicated the potential for genetically increasing this tolerance through selection and breeding.

With red maple, also, we have shown significant genetic variation in tolerance to an important air pollutant, ozone (Townsend and Dochinger 1974). In a related study, I found that ability to tolerate ozone was negatively correlated with the ability to "sorb" ozone from the air (Townsend 1974b). The red maple half-sib family that showed the highest sorption ability also displayed the greatest susceptibility to ozone injury. We have also found that certain progenies of red maple can tolerate drought because of their low transpiration rates and readiness to stop growing under dry conditions (Townsend and Roberts 1973).

To date we have found genetic potential for breeding and selecting maples against three major urban stresses: *Verticillium* wilt, air pollution, and drought. These studies have laid the groundwork but we have a long road ahead in selecting and breeding maples for metropolitan regions. Data from permanent red-maple progeny test plantations maintained by NC-99 regional research cooperators in Ohio, Indiana, Iowa, Michigan, Wisconsin, and Minnesota will soon be forthcoming, and should help to broaden the knowledge for maple improvement.

## ELM RESEARCH

Several researchers (Heybroek 1966, Lester and Smalley 1972, Santamour 1974, and Townsend and Schreiber 1975) are actively developing elm clones resistant to Dutch elm disease. A major obstacle now is convincing nurserymen to grow these elms and arborists to buy them. Unfortunately, many plantsmen have forgotten that elms are premier plant materials that possess traits important for survival in urban areas. Their inherent vigor, hardiness, and tolerance to stresses are probably unsurpassed among urban tree genera.

I cooperate with Dr. Lawrence Schreiber, a plant pathologist, in the elm improvement program. Our objective is to release superior elm clones that either can be propagated as cultivars or can be used as superior parents in a seed orchard. Our breeding program has developed more than 60 combinations of hybrid elms (Townsend 1975). We have demonstrated hybrid vigor in growth rate as well as increased resistance to Dutch elm disease. We have developed a diversity of clones with uncommon parentages to avoid the genetic uniformity that can result in a breakdown in pest resistance. We realize, however, that the nurseryman and arborist want elms that have more than adaptability to environmental stresses and diseases (Collins 1976). Desirable horticultural attributes must be included, such as attractive and desirable shape, size, fruit and leaf colour, and suitable growth rate. One of our recent crosses has yielded a hybrid that is remarkably beautiful, fast-growing, and disease-resistant. This cross, between Siberian elm (*Ulmus pumila* L.) (♀) and a Dutch selection, N274 x 215 [(*U. hollandica* 'Vegeta' x *U. carpinifolia*) x (*U. pumila* x U. *carpinifolia*)], shows great promise as a source of superb urban clones.

In the future, we will evaluate and release to the nurserymen those clones that we develop through our long-term breeding and selection program. One such tree, the 'Urban' elm (Schreiber and Main 1976) has been released to wholesale nurserymen by Dr. Schreiber. One American elm selection of Schreiber's, Delaware No. 2, compares well with several disease-resistant, non-American elm clones (Townsend and Schreiber 1975). This tree is currently being propagated and tested and should be released within the next several years.

Recently, we found significant variation among North American strains of *Ceratocystis ulmi* (Buism.) C. Moreau, the Dutch elm disease fungus, in severity of disease symptoms these strains produced (Schreiber and Townsend 1976). This variation in aggressiveness originally caused us great concern. However, we have screened our selected clones to both aggressive and non-aggressive strains of the fungus and so far these clones have held up quite well. Fortunately, also, there has been a lack of interaction between genotypes and isolates (Townsend and Schreiber 1976). This lack of interaction facilitates testing for disease resistance among a wide variety of elm genotypes, and means that long-term resistance to the fungus will likely be sustained.

## RESEARCH NEEDED

A primary need is research on intraspecific variation of many maple species. For example, little is known about genetic variation within such promising species as trident maple (*Acer buergerianum* Miq.), hedge maple (*A. campestre* L.), Amur maple (*A. ginnala* Maxim.), and paperbark maple (*A. griseum* Pax.). Provenance studies would lay the foundation for some rapid initial improvements in these species.

Nurserymen and arborists need research information on tolerance to deicing salt. Tolerance to both soil salt and salt spray will be important (Dirr 1974, Lumis *et al.* 1975). Adaptation to soil compaction (Patterson 1976) and transplantability (Kozlowski 1976) also need improvement. Some initial work with red maple has shown potential for developing selected rootstocks adapted to soil stresses (Gerhold *et al.* 1976).

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# WOODY PLANT IMPROVEMENT AND TESTING PROGRAMMES FOR CANADIAN URBAN ENVIRONMENTS

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ABSTRACT

A survey of 100 Canadian plant breeding and testing organiations indicated that 40 are now engaged in urban related tree improvement programmes. Research Stations of Agriculture Canada, several Research Centres of the Canadian Forestry Service, a number of provincial agriculture and forestry agencies comprise the governmental component of a national urban-tree testing system. Arboreta, botanical gardens and university biology departments plus a few commercial nurseries and municipalities complement the larger governmental units that make up a trans-Canadian programme. Geographically the foregoing centres and units are well dispersed to serve urban Canada.

As recommendations to amalgamate the tree improvement personnel and facility resources now available, the authors suggest an extension of the present inventory to enlarge the known list of contributors to urban tree betterment, that individual project data retrieval be sophisticated, and that those concerned utilize the offices of the Canadian Tree Improvement Association to serve as coordinator for all woody plant improvement studies related to urban situations.

RESUME

Une étude portant sur 100 organismes candiens impliqués dans l'amélioration et l'essai des plantes indique que 40 d'entre eux travaillent actuellement à des programmes d'amélioration des arbres en milieu urbain ou périurbain. Les stations de recherche d'Agriculture Canada, plusieurs centres de recherche de Service canadien des forêts et un certain nombre d'organismes provinciaux s'occupant d'agriculture et de foresterie forment l'élément gouvernemental d'un système national d'étude des arbres en milieu urbain. Les arboretums, les jardins botaniques, les départements de biologie des universités, quelques pépinières commerciales

et les minicipalités complètent les unités gouvernementales plus importantes qui composent un programme trans-canadien. Du point de vue géographique, les unités et centre précédents sont bien dispersés pour desservir le Canada urbain.

Dans le but de réunir les installations actuellement disponibles et le personnel travaillant à l'amélioration des arbres, l'auteur propose qu'on augmente le répertoire actuel de ceux qui collaborent à l'amélioration des arbres en milieu urbain, qu'on perfectionne le recouvrement des données de chaque projet et que les personnes concernés utilisent les bureaux de l'Association canadienne pour l'amélioration des arbres pour coordonner toutes les études sur l'amélioration des plantes ligneuses qui se rapportent à des situations urbaines.

## URBAN NEEDS

One of the more important natural amenities requisite to livable human settlements is provided by attractive, hardy and well maintained trees, shrubs and associated woody vegetation. Although edible fruit production and other utilitarian derivatives of ornamental trees and shrubs are not as important in Canada as in some of the less developed world nations, new arborescent species for the Canadian urbanscape must possess a high degree of versatility. In addition to improving those trees once primarily considered for their shade and aesthetic benefits, a new array of woody plants is being sought to provide multiple benefits.

Woody plants to be utilized within the near Canadian cities, towns and villages must be chosen to produce fruit for wildlife and man; fibre for energy and primary or secondary forest products; and environmental buffering (abatement of sound, air currents, temperature extremes and pollution debilitation). These attributes will have to be coupled to conventional shade tree values. Selection strategies and survival capabilities for the foregoing potentials would be complicated enough under exurban environments, but trees bred or selected to "produce" within metropolitan ecosites must incorporate other components of hardiness. They must also be drought resistant, tolerant to atmospheric and soil pollution, and possess growth characteristics of both root and stem systems to enhance minimum maintenance.

At present, the Canadian landscape architect and his associates, the commercial nurseryman and the landscape contractor, are afforded only a limited number of species and their cultivars that meet most of the foregoing requirements. But the potential of superior taxa to be derived from our Canadian dendro-flora is great as are reinforced benefits to be gained from intensified coordination between our tree improvers.

In response to the needs of shade tree industry and to inventory contemporary urban tree improvement and endeavours, it is the intent of this paper to summarize current urban oriented programmes, identify the organizations concerned, and suggest further cooperative efforts. Although the original suggested title of this paper was "Tree improvement and testing programmes at Canadian arboreta and botanical stations", analysis of the returned questionnaires accompanying the present study revealed a much broader scope of urban tree improvement activities at many other tree oriented organizations.

Before examining the questionnaire responses it is appropriate to review the Canadian answer to earlier urban challenges and look at the total thrust of North American urban tree improvement activities.

## CANADIAN RESPONSES

Breeding and selection programmes of trees destined for the Canadian urban arena are supported by a number of governmental agencies, professional organization, commercial nurseries and private individuals.

Within the decade 1968-1977 tree improvement endeavours in Canada have begun to respond to the needs of landscape architects, contractors and nurserymen as well as commercial, municipal and utility arborists. Of the several national research groups working with user agencies, the Canadian Tree Improvement Association (C.T.I.A.) is emerging as a prime coordinating organization. There are, however, a number of independent woody plant improvement endeavours that if more closely allied with C.T.I.A. would contribute to the greater solidarity and effectiveness of a unified Canadian urban tree programme.

## RECENT URBAN TREE IMPROVEMENT ENDEAVOURS

Of the several research programmes designed to meet the needs of the North American shade tree industry, amenity tree selection ranks high. Although a comprehensive inventory is yet to be conducted of all urban forestry research activities in Canada, it is our premise that a similar pattern of research projects and general categories exist to those found in the United States. Andresen (1973) examined over 4,500 forestry, ornamental horticulture and related American research projects from which 993 were selected as germaine to the shade tree industry. Of the 15 general categories aggregating from the review, the selection and physiology of shade trees ranked second (14.0%) in percentage of total projects. In addition projects including shrubs for urban planting numbered 29 or 2.9%. First (21.8%) in the assembly were projects directed to shade tree insects and controls including overtones to perfect resistant tree species and cultivars. As soon as practicable, we, in Canada, should conduct a similar survey to determine current urban forestry research developments.

We may find, as occurred in the United States, that earlier and contemporary street tree evaluation and testing programmes blend basic physiology and resistance to disease and insect studies with genetic and morphological aspects of potentially useful shade tree species and cultivars.

In Canada, prompted by the Dutch elm disease disaster, Jorgensen (1967) began work on urban tree improvement studies. His preliminary investigations in 1961 led to the "Superior Shade Tree Programme" in Ontario. His five steps to get better trees into urban soil included: (1) field selection, (2) vegetative propagation of likely candidates, (3) trial plantings, (4) evaluation of test specimens with certification of the best selections, and (5) distribution to commercial growers. In his article on urban arboriculture, Jorgensen (1975) concluded that governmental agencies and the nursery industry should join forces to provide a much broader array than now available of street trees for metropolitan planting.

Selecting shade trees for urban Canada was also discussed by Zsuffa and Calvert (1976) at the Vancouver United Nations Habitat Forum. They also reviewed the history and current state of the art of shade tree selection. They suggested preference for new selections should be given the entities of the great number of native Canadian species and their potential cultivars. Exotic species would still be important in special situations but when and wherever possible native adaptives should be planted. Calvert[1] also prepared an analysis of species selection strategies for the Petawawa genetics programme. His document recommended both an urban forestry and production forestry approach. However, final disposition of the new urban vegetation thrust at the federal level is still to be determined. Continuing administrative reorganization of the Canadian Forestry Service within the new Department of Fisheries and Environment will necessitate programme adjustments throughout the national network of stations and centres.

Pollard (1976), in his catalogue of current urban forestry programmes being conducted by the Canadian Forestry Service, listed several shade tree related research projects. The Northern Forest Research Centre is screening trees suitable for boreal settlements; a testing-demonstration arboretum is being established at the Great Lakes Forest Research Centre; work is underway within pollution resistant forms of larch and spruce at the Newfoundland Forest Research Centre; and urban tree seed investigations are under test at the Petawawa Forest Experiment Station. As with Calvert, Pollard hopes to see a greater urban forestry involvement within all the Canadian Forestry Research Centres, Experiment Stations and Institutes, but as indicated earlier firm policy decisions are yet to be made. Perhaps the Canadian Tree Improvement Association could exert pressure to promote motivation and direction?

Before discussing our survey of Canadian urban tree research and reinforcement of the foregoing review, citation should be made of the recent landmark symposium, "Better Trees for Metropolitan Landscapes" (Santamour *et al.* 1976). Over 200 participants from 24 of the United States and from Canada, the Netherlands and Sweden met to discuss development and dissemination of genetic information on urban woody vegetation. Topics included selection, breeding, propagation, and production of genetically superior urban trees. The primary objective of the symposium was to provide up-to-date information about tree

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[1]Calvert, R.F. 1976. Hardwood genetics and breeding. Study No. PS-6-079. Draft document on file with Petawawa Forest Experiment Station, Chalk River, Ontario.

selection, cultural practices, evaluation and testing techniques, and tree-breeding methods for trees to be used in urban environments. Most important and also central to the present paper, the presentations both oral and printed were designed to improve communications and coordination among researchers, arboretum directors, arborists, foresters, tree breeders, and commercial nurserymen.

## THE CANADIAN SURVEY

### Questionnaire Specifics

Our questionnaire, structured to inventory woody plant improvement research with urban implications, was mailed to 100 Canadian botanically oriented research institutions on January 1, 1977.

In the introductory paragraph of the questionnaire, we advised recipients that they were being contacted to determine whether or not work was underway or planned that involved improvement, testing and evaluation of woody plants for urban situations. We emphasized that results of the survey would be compiled, collated and distributed to all respondents with the intent to enhance the collective endeavour of Canadian woody plant improvement research and application of findings. Among the questions asked that relate to "the Contribution of Forest Genetics to the Urban Environment" theme of our 1977 C.T.I.A. symposium were:

1. Who are the principal investigators working on urban tree or other woody plant selection, protection, physiology, pollution reaction and related programmes?
2. What genera, species and cultivars are under study?
3. What is the title of the research?
4. How many man years are devoted to the project(s) and what fiscal budget is allocated?
5. What is the duration of the project or planned initiation?
6. Are any future projects planned or anticipated?

### Comments on Questionnaire Responses

Of the 100 initial mailings, 71 were completed and returned. Thirty-four were not involved in research for urban situations and 37 responded in the affirmative. Also, three unsolicited agencies volunteered data for a total of 40. Categories of response tabulated by reporting agency are summarized in Table 1.

As might be anticipated, the research stations of Agriculture Canada, in a transcontinental endeavour, contributed to most of the urban woody vegetation research generated at the Federal level. At present their arboriculturally directed programmes deal mainly with

Table 1  Canadian agencies and organizations engaged in urban oriented tree improvement and selection programmes. Data based on response to questionnaire mailed to 100 known units and volunteered information.

| Agency or Organization | Plant Groups and Projects under Study | | | | | | |
|---|---|---|---|---|---|---|---|
| | Trees | Shrubs | Vines, Ground Cover | Angiosperms | Gymnosperms | Maintenance or Nursery Techniques | New Projects[1] Planned |
| FEDERAL | | | | | | | |
| Agriculture Canada | | | | | | | |
| British Columbia, Vancouver | X | | | X | | | X |
| Manitoba, Morden | X | X | X | X | X | X | X |
| New Brunswick, Fredericton | | X | | X | | | X |
| Nova Scotia, Kentville | | X | | X | | | X |
| Ontario, Harrow | X | | | X | | | |
| Ottawa | X | X | | X | X | | |
| Vineland | X | | | X | | | |
| Saskatchewan, Swift Current | X | X | | X | X | X | |
| Canadian Forestry Service | | | | | | | |
| Ontario, Chalk River | X | | | X | | | X |
| Sault Ste.Marie | X | | | X | | | X |
| Quebec, Ste.Foy | X | | | X | | | |
| PROVINCIAL - Ministries of Agriculture | | | | | | | |
| Alberta, Brooks | X | X | | X | X | X | |
| British Columbia, Surrey | X | X | X | X | | X | |
| Victoria | X | X | X | X | X | X | X |
| New Brunswick, Fredericton | | X | | X | X | | X |
| Nova Scotia, Truro | X | X | X | X | X | X | X |
| Ontario, Maple (Min.Nat.Res.) | X | X | | X | X | | |
| Simcoe | X | | | X | | | |
| Vineland | X | X | X | X | X | | X |
| Saskatchewan, Indian Head | X | | | X | X | X | X |

[1] Virtually all projects are to continue into 1978. All projects have an administrative coordinator.

Table 1 (Cont'd)

| Agency or Organizations | Plant Groups and Projects under Study | | | | | | |
|---|---|---|---|---|---|---|---|
| | Trees | Shrubs | Vines, Ground Cover | Angiosperms | Gymnosperms | Maintenance or Nursery Techniques | New Projects Planned |
| **ARBORETA, BOTANICAL GARDENS OR UNIVERSITIES** | | | | | | | |
| Alberta, Edmonton, Devonian Bot. Gard. | X | X | X | X | X | X | X |
| British Columbia, Vancouver, U.of B.C.Bot.Gard. | X | X | X | X | X | X | X |
| Manitoba, Winnipeg, U.of Manitoba Arboretum | X | X | | X | X | X | X |
| Ontario, Downsview, York U. York U. Arboretum | X | X | X | X | X | | X |
| London, U.West.Ont. Dept.Plant Sci. | X | | | | X | | |
| Guelph, U.of Guelph Arboretum | X | X | X | X | X | X | X |
| U.of Guelph Dept.Env.Biol. | X | X | X | X | X | X | X |
| Hamilton, Royal Botanical Gardens | X | X | X | X | X | X | X |
| Mississauga, Erindale College Arboretum | X | X | X | X | X | X | X |
| Rexdale, Humber College Arboretum | X | X | | X | X | X | X |
| Sudbury, Laurentian U.Biol.Dept. | X | X | | X | X | | |
| Toronto, U.of Toronto, Faculty Forestry | X | | | X | X | X | |
| Quebec, Montreal, Macdonald College Morgan Arboretum | X | X | X | X | X | X | X |
| Ste.Foy, U.of Laval | X | X | | X | X | X | |
| Saskatchewan, Regina, Wascana Centre Auth. | X | | | X | | | |
| Saskatoon, U.of Saskatchewan Dept. of Hort.Sci. | X | X | X | X | X | X | |
| **MUNICIPALITIES** | | | | | | | |
| Nova Scotia, Halifax | X | X | X | X | X | X | |
| **COMMERCIAL OR PRIVATE NURSERIES** | | | | | | | |
| Alberta, Beaverlodge (Beaverlodge Nursery Ltd.) | X | X | X | X | X | | |
| Ontario, Etobicoke (Sheridan Nurseries) | X | X | | X | X | X | |
| Kakabeka (Bert Sitch Arboretum) | X | X | | X | X | X | |
| Saskatchewan, Saskatoon (Carrot Valley Nursery) | X | X | | X | | X | |

angiospermous ornamental and fruit producing trees; ornamental and wildlife shrubs; and vines for various uses. Several new programmes are being planned in further recognition of surging urban demands for superior woody plants. As a forestry adjunct to urban woody plant improvement, the Canadian Forestry Service is concerned only with trees at present, concentrating on broadleaved species for metropolitan environments.

Five of our provinces also are working on urban related woody plant investigations. As with the Federal government, most provincial research is administered under the aegis of agricultural ministries, Ontario is also identifying work at a forestry research station.

Arboreta and botanical gardens (which are usually affiliated with or supported by provincial ministries or universities) or university biology departments with vegetation management and/or conservation missions, incorporate the most comprehensive testing and demonstration programmes of all the major categories surveyed. The Morden Arboretum of Agriculture Canada distributes test materials to, and coordinates with, sister levels of Federal and analogous provincial and university organizations. Under the supervision of Dr. W. Ronald, the cities of Edmonton, Regina and Winnipeg have each received for evaluation 12 trees of 60 taxa thought hardy to the prairie provinces.

We suggest that more municipalities than Halifax and the foregoing three are performing some type of urban tree testing - especially in evaluating species hardy to local environments. Our survey probably missed many municipal parks departments not included on the tree-improvement agency lists used in this study. Cities such as Montreal, Quebec, Toronto, Victoria, and Vancouver are examples. The same comment applies to commercial and private nurseries. Many interesting and significant empirical or replicated trials are undoubtedly underway at Canadian tree nurseries, but our survey revealed only three. Staff at other greenspace refugia as cemeteries or golf courses often evaluate trees but reports are difficult to garner from modest foremen or groundskeepers. Private estate gardens in urban areas would also yield valuable data.

A listing of genera, species, varieties and cultivars of those woody plants under test by the foregoing organizations and individuals is too long for presentation here. Such an inventory would lend itself to computer data storage and retrieval system.

## Summary Observations

In summary of the urban tree improvement programmes we inventoried, the following generalizations are offered:

1. Research stations, arboreta and other woody plant testing facilities are adequately distributed throughout or adjacent to the heavily urbanized zones of Canada.

2. There seems to be a good species mix under test that includes shrubs as well as trees of both angiosperms and gymnosperms.

3. A high proportion of testing organizations incorporate a balance of selection, testing and maintenance components in their woody plant programmes.

4. More accurate measures are needed of man-year and dollar research investments to establish precise cost/benefit ratios.

5. A number of constituencies are yet to be inventoried to develop a comprehensive list of Canadian workers concerned with urban vegetation improvement.

6. Complementary to the foregoing list of workers, a bibliography is needed of Canadian urban tree improvement literature and contemporary projects. Further, a compendium should be assembled of taxa under test.

## CONCLUSIONS

Canadian tree breeding and improvement researchers apparently have emerged from the bush to face the needs and demands of urban man. However, production directed foresters and horticulturists view the urban challenge with apprehension and trepidation. Current fibre and fruit tree research that was planned and initiated a decade or more ago cannot be abandoned in favour of new amenity-tree endeavours; personnel and fiscal constraints on all programmes are introducing a chronic, management-by-crisis environment; and the requirements of the urban dweller are usually spelled in general and vague terms lacking the precision of production requests. In short, a challenging but probably frustrating experience can be expected by those who enter the urban arena.

To overcome some of the difficulties, we can optimize our resources by closing ranks and enlisting more membership in the Canadian Tree Improvement Association. Better orchestrated cooperation and coordination could enlarge the array of taxa under test and maximize solidarity of our workers. Closer ties with sister organizations such as the Ontario Ornamentals Research Committee, the proposed National Botancial Garden System for Canada and the American Plant Records Centre should pay handsome dividends.

At present, tree breeders in general and more specifically their colleagues concerned with city trees lack the political clout to influence policy and decision makers at provincial and national levels to the programming needs of comprehensive urban tree improvement. If a unified front can be presented by one potent organization such as our C.T.I.A., backed by comprehensible data that illustrates current and potential benefits and values of our research, we should have an impact on future planning. Those of us who are interested should "think urban" and explore opportunities still available through a number of urban oriented fund granting agencies.

In closing, I would like to remind you that tree breeders compose one of the stronger groups of the urban forestry team and can do much to enhance the environment of Canada's urbanites.

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## PROCEEDINGS PART 1 - MINUTES AND MEMBERS' REPORTS

## COMPTES RENDUS PARTIE 1 - PROCES-VERBAUX ET RAPPORTS DES MEMBRES

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ACTIVE MEMBERS/MEMBRES ACTIFS

1977

CANADIAN TREE IMPROVEMENT ASSOCIATION

ASSOCIATION CANADIENNE POUR L'AMELIORATION DES ARBRES

| | |
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