WOODY PLANT RESPONSE TO THE ENVIRONMENTAL CONDITIONS OF THE URBAN STRIP DEVELOPMENT IN WINNIPEG

A Practicum submitted to the Faculty of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Landscape Architecture.

by

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ABSTRACT

The practicum provides an overview of plant response to thirty-one environmental conditions.

The information is presented in matrix format which is divided into three major plant groups, (twenty trees, twenty shrubs, and nine vines).

Two examples of a generic case study are presented which demonstrate the usefulness of the data file to assist the landscape architect, contractor, or student in the selection of species for sites found in the hot, dry and windy sections of urban developments.

ACKNOWLEDGEMENTS

To Ted McLachlan, Cindy Cohlmeyer, and John Stewart, I would like to thank each of you for the tremendous energy, patience, and encouragement which you shared with me. Only in retrospect does one realize the level of sacrifice to comment, and to meet over and over and over again. It truly was an honour and a privilege to work with this committee.

To my parents, I would just like to say that the practicum would never have had an end, had it not been for your love, support, and never ending understanding. Therefore, this project is dedicated with all my love to the two of you.

Robert

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1.0 INTRODUCTION

1.1 BACKGROUND

Traditional determinants of plant selection in the built environment of the prairies are based primarily on:

Species Availability: Plant selection has been limited to the current supply at the local nurseries, which is a result of market trends and grower preferences.

Species Performance: Plant selection has been limited to species which respond favourably to regional climatic conditions, (i.e. winter injury, drought tolerance etc.).

Design Requirements: Plant selection has been limited to microclimate improvement (see Herrington, 1978 or Smith, 1978).

The urban strip during the summer, (ie. shopping malls, service stations, fast food outlets), is characterized by hot, dry and windy conditions which make plant growth difficult when traditional determinants of plant selection are used.

To be effective, plant selection must demonstrate an awareness of the relationship which exists between plant response and environmental conditions. Plant response is a multi-dimensional reaction to environmental conditions of stress, (both regional climate and microclimate), of plant physiology, and of landscape maintenance.

However, because of the complex interrelationships which exist between environmental conditions and plant response, a lack of understanding has restricted its use in plant selection. Knowles, (1975), and Oosterhuis, (1978), do not address the situation in their often recommended woody plant manuals for the Canadian prairies.

1.2 PROJECT OBJECTIVES

The main objective is to assemble a woody plant data file which is an expression of plant response to a set of environmental conditions, typical of the urban strip in Winnipeg.

A second objective will test the appropriateness of the tool in decision making. In this regard, a generic site will be developed and case studies involving plant selection presented.

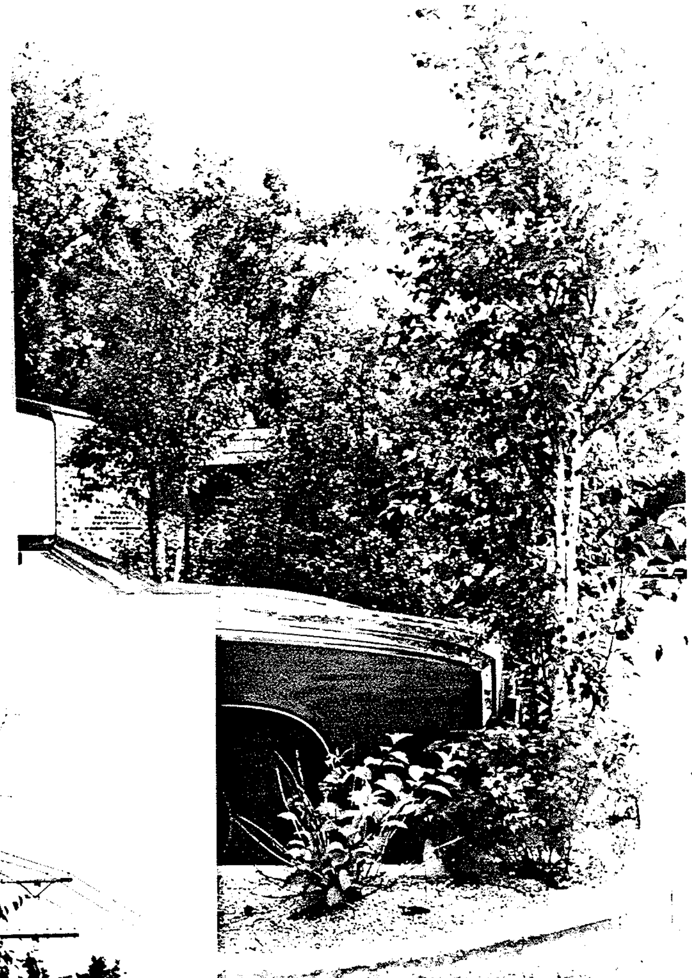
It is hoped that this file will help landscape architects, contractors and students to avoid repeat plantings and economic mistakes commonly associated with incorrect species selection.

1.3 PROCESS REVIEW

Initially a representative list of woody plants, (i.e. trees, shrubs, groundcovers/vines), for the Winnipeg region was created, (see 2.4 PLANT LISTS). By representation, it was suggested that the plants were common to nursery catalogues, or to local indigenous plant communities.

The file was organized on the basis of plant form, and environmental conditions, (physiology, stress and maintenance). A matrix was used to record plant response, using information from documented sources, (i.e. books, periodicals, etc.).

2.0 DEFINITION OF TERMS



2.0 DEFINITION OF TERMS

This chapter outlines the background terminology which is used throughout the practicum. Each subsection of environmental conditions is outlined with significant information, then the individual factors are defined. Finally, the list of representative plants for the Winnipeg region will be displayed.

2.1 PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

This section describes the physical attributes of plants which through the process of growth will have a direct impact upon the microclimate and subsequent growth patterns of adjacent plants.

Growth Rate is the vertical increase in growth, unless specified differently, (see Dirr, 1983, p.2).

Fast: in excess of 60 cm per growing season.

Medium: between 30 and 60 cm per growing season.

Slow: less than 30 cm per growing season.

Longevity is a measurement of life expectancy which is useful when considering species domination.

Long: 80 years or more.

Medium: 40 to 80 years.

Short: 49 years or less.

Root Character is a relative measure of root depth in the soil. It is significant where competition from other plants is present; or where building materials may influence root development; or where soil compaction causes a reduction in soil aeration.

Shallow: to a depth of 30 cm.

Medium: from 30 to 60 cm.

Deep: beyond 60 cm.

Limb Strength indicates susceptibility to limb breakage.

High: limbs composed of dense intercellular spacing, and structurally resilient trunk/limb/branch formations.

Low: weak or brittle wood, (relatively large intercellular spacing), and/or structurally weak 'V' crotches of limbs.

Form or Habit describes the normal or natural growth, in an open environment prior to any form of pruning, (see Dirr, 1983, p. 2). It is significant for the effect which the plant mass will have on adjacent areas in terms of altering microclimate.

Round/Spreading: the plant is circular, or the width of the plant is somewhat greater than its height.

Pryamidal: the width of the plant is greatest near the ground and tapers to the apex.

Vase: the width of the plant is greatest near its apex and tapers to the ground.

Branching Density is a measure of the degree of openness which exists between the leaves, stems, and other plant parts. It is significant because it provides an indication of the relative amount of light, wind, and precipitation reaching the ground.

Dense: amount of leaf and stem material severely limits visibility, light penetration, and air circulation.

Open: amount of leaf and stem material slightly limits visibility, light penetration, and air circulation.

Leaf Foliation Period is the process of leaf growth from the bud stage onward during the growing season.

Early spring: the first half of May.

Mid spring: the last half of May.

Late spring: the first half of June.

Leaf Defoliation Period is the process of leaf abscission.

Early autumn: the last half of September.

Mid autumn: the first half of October.

Late autumn: the last half of October.

Leaf foliation/defoliation is important because leaf cover has an impact on the immediate microclimate beneath the plant. These periods are average approximations because seasonal fluctuations vary from year to year.

<u>Nitrogen Fixing</u> refers to the ability of a plant to stimulate dry weight accumulation, (biomass yield), which over a period of years may increase soil nitrogen supplies. Current research has not as yet determined the utility of nitrogen fixing plants. Gordon and Dawson, (1979, pp. 88-90), suggest that in some applications nitrogen fixing plants are of benefit.

High: plants fix nitrogen.

None: plants do not fix nitrogen.

<u>Native Habitat</u> is the environment to which a plant has evolved, and which characterizes the environmental conditions for optimal growth.

Dry Upland Environment: dry soils, low water table, open to winds, high evaporation, temperature fluctuations, and high pH levels.

Moist Environment: moist, well drained but not porous soils, neutral pH levels.

Riverbank Environment: moist to wet soils, high water table, topography protects from wind, low pH levels.

Source is the derivation of the plant stock, which is important because not all plants are available through commercial nurseries.

Indigenous: occurring or living naturally in the area, not introduced.

Naturalized: occurring or living naturally in the area, and introduced.

Ornamental: non-native plants, or native plants in varietal or hybridized form used in the landscape industry.

Nursery Availability is an indication of present relative market supply.

High: above 70%.

Medium: 40 to 70%.

Low: below 40%.

2.2 ENVIRONMENTAL STRESS

Environmental conditions of stress are classified, (see Levitt, 1972), either as 1) biotic which encompasses infection or competition with other organisms, or 2) physiochemical which includes the effects of radiation, water, temperature, chemical substances, wind, etc., (see Figure 2.1).

Stress often sets in motion a sequential and complicated series of metabolic disturbances which affect all areas of

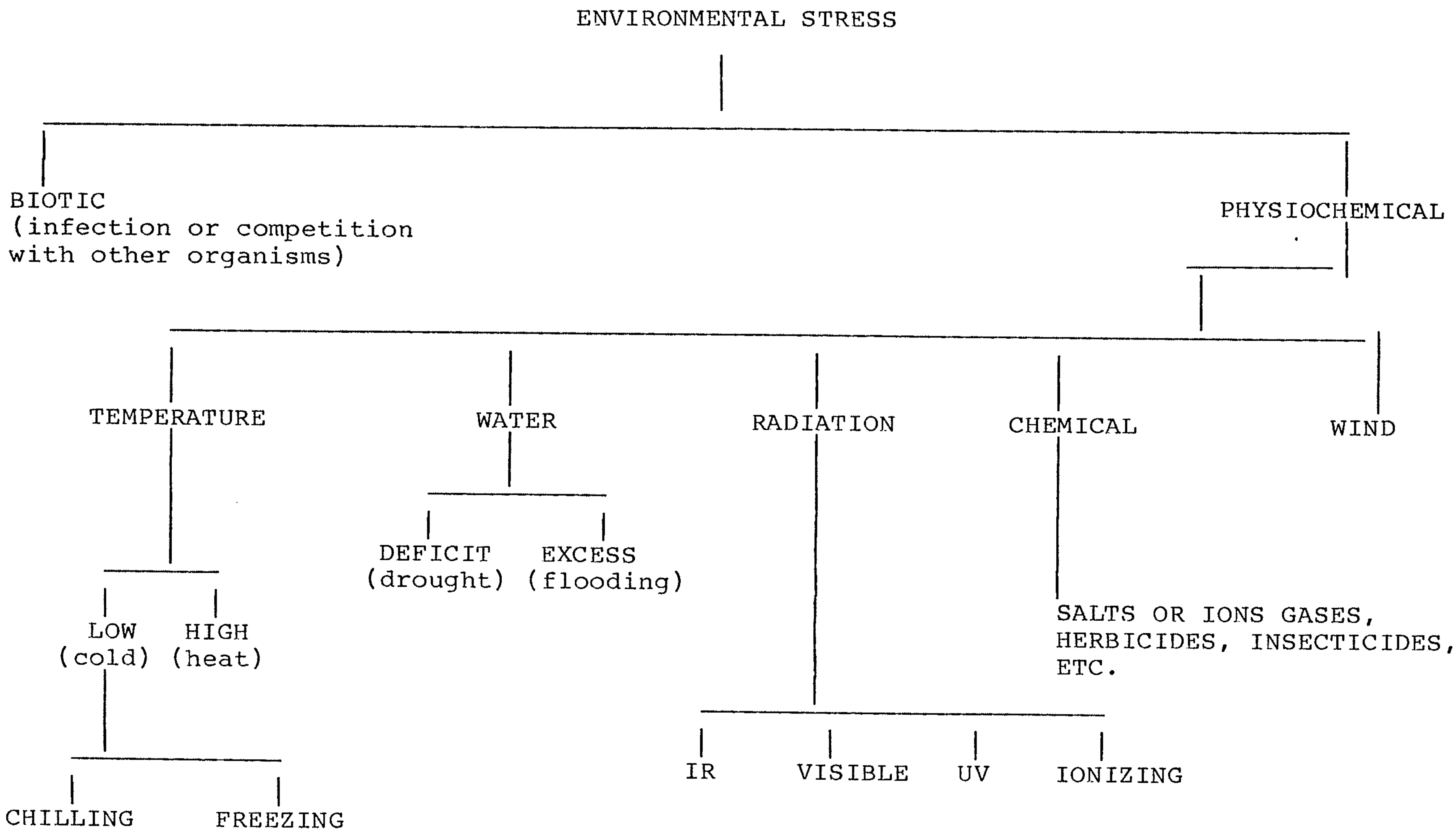


FIGURE 2.1 RESPONSES OF PLANTS TO ENVIRONMENTAL STRESSES, (Levitt, 1972).

the plant, (see Kozlowski, 1979, p. 18). Kozlowski notes, (p. 13), the effects of stress on trees will vary as the phenological and physiological status changes.

Stress Resistance may be defined as the response which is necessary to resist a force per unit area, (either positive or negative). Stress resistance can be differentiated into two forms:

(i) Stress Avoidance is the form which allows a plant to exclude the stress, either partially or completely, by means of a physical barrier which insulates its living cells from the stress, or by a steady state exclusion of the stress, (Levitt, 1972, pp. 10-11).

(ii) Stress Tolerance is an ability to prevent, decrease, or repair the injury induced by the exterior force, (Levitt, p. 12).

The two kinds of resistance become clearer when they are considered in relation to specific stresses, see Figure 2.2. Although Levitt limits differentiation to Avoidance and Tolerance, the matrices in the next chapter include an intermediate stage which suggests that a continuum exists between the two poles.

Drought Tolerance refers to an ability to maintain growth processes, (i.e. photosynthesis), in the absence of an

STRESS		CONDITION OF RESISTANT PLANT CELLS EXPOSED TO THE STRESS AND SURVIVING DUE TO: AVOIDANCE	TOLERANCE
(i.)	Low, (chilling,) temperatures	warm	cold
(ii.)	Low, (freezing), temperatures	unfrozen	frozen
(iii.)	High temperatures	cool	hot
(iv.)	Drought	high water potential	low water potential
(v.)	Radiation	low absorption	high absorption
(vi.)	Salt, (high concentration)	low salt concentration	high salt concentration
(vii.)	Flooding, (oxygen deficiency)	high oxygen content	low oxygen content

FIGURE 2.2 STRESS RESISTANCE DIFFERENTIATION, (Levitt, p. 12).

adequate supply of moisture for a prolonged period. Therefore, plants which have adapted through evolution to xerophytic conditions would exemplify drought tolerance.

High: no apparent injury.

Low: recurring evident injury, extreme browning of leaves, twig dieback.

Heat Tolerance is the ability to withstand the repetitive but temporary periods (hours), of heat in excess of 45°C. Damage usually is confined to sunscald, stem lesions (see Kozlowski, 1979, p. 37), or protoplasmic breakdown of internal tissues, (see Andresen, 1975, p. 70).

High: no apparent injury.

Low: recurring evident injury.

Artificial Light Tolerance is the ability to maintain seasonal growth processes regardless of the influence of night lighting. This stress has become significant with the advent of high pressure sodium lighting. Not only are day lengths effectively increased, (extending photosynthesis and respiration etc.), but perception of seasonal variation becomes blurred. Flowering may be earlier, or prolonged, fruiting slower, and leaf abscission delayed, (see Quigley, 1979, p. 505). Thus plant hardiness may be jeopardized. This condition is not just limited to trees, because more sites are using night lighting to accentuate building foundation planting.

High: no apparent injury.

Low: recurring evident injury.

Shade Tolerance is the ability to grow in indirect light or less than six hours of sun per day.

High: an ability to grow leaves adapted for low light levels.

Low: an inability to develop expectant size or form of leaves, flowering, or setting of fruit (see Harder, 1981, p. 50).

Wind Dessication Tolerance is the ability to maintain growing tips and leaf margins without drying out or becoming brittle.

High: buds, leaves remain green.

Low: highly susceptible to bud and leaf tip/margin browning due to excessive moisture loss through these peripheral areas.

Windthrow Tolerance is the ability to withstand wind turbulence without becoming up-rooted. It refers to trees and large shrubs, (3+ metres), which are under greater stress from wind turbulence, although in wide unobstructed areas even small plants may be affected.

High: possession of either deep tap roots or, wide spreading, fibrous, shallow roots which provide structural stability.

Low: possession of shallow, non fibrous and spreading roots.

Pest Tolerance refers to the ability of a plant to withstand the damage caused by insects; insects characteristically remove sap from leaves or soft shoots by means of sucking mechanisms; or skeletonize leaves by chewing.

High: has few pests and/or can tolerate damage.

Low: Has one or more serious pests which seriously inhibit growth and/or health.

Disease Tolerance reflects the ability of plants to withstand diseases which are caused by bacteria, viruses,, and fungi. They can be divided into three categories: wilts, cankers and foliage diseases. Cankers most often attack plants already under stress. Wilt and foliage disease, (i.e. blights), are very often poisonous in their own right, (see Harder, 1981, p. 110). Guide tolerances are the same as for Pest.

Soil Compaction Tolerance reflects an ability to withstand a reduction in soil pore space which is due to the actions of humans and their machines.

High: plant suitability to heavy, nonporous, oxygen deficient or waterlogged soils, (see Feucht, 1982, p. 11).

Low: plant suitability to more porous, oxygen rich soils.

Lime Induced Iron Chlorosis Tolerance is a nutritional deficiency which is characterized by the yellowing or blanching of leaf colour. It results when high pH levels in clay soils restrict the uptake of iron, (see Horst, 1984, pp. 44-46).

High: natural foliage colouration.

Low: recurring inter-veinal yellowing of leaves.

Plant Competition Tolerance is the ability to maintain expected growth levels when in competition with other plants.

High: plants are characterized by aggressive growth.

Low: below expectant growth levels.

Mechanical Injury Tolerance is the ability to regenerate roots, limbs or branches injured by maintenance equipment etc.

High: plants which are capable of limb, branch or root regeneration.

Medium: regeneration through suckering.

Low: incapable of regeneration by any means.

Salt Tolerance refers to the ability to endure the debilitating effect of salt poisoning.

High: no branch dieback.

Low: complete branch dieback, evidence of tufting and lack of flowering of deciduous species, (see Lumis, 1973, p. 476).

Pollution Tolerance is the ability to withstand SO_2 contamination, (see Norby and Kozlowski, 1981, p. 31).

High: little damage results.

Low: continuous damage resulting in branch dieback.

Winter Injury Tolerance reflects the ability to adapt to severe deprivations of temperature, and/or significant losses of plant moisture during late winter.

High: no appreciable damage.

Low: complete dieback to snow line.

2.3 MAINTENANCE REQUIREMENTS

Selection for drought and shade tolerance, root depth and growth rate guarantees survival. It does not guarantee healthy and vigorous growth from May through October; or suggest the effort/cost which is required to maintain the plants. For example, *Ulmus pumila* is recommended for dry conditions. However with the high seed production and germination rates, the effort required to remove the seedlings negates the benefits of reduced irrigation.

As Ian Wray writes, (1981, p. 14),

> . . . Creating a new landscape is not just a matter of spending money on trees, shrubs and grass. Landscape is organic; it needs to be carefully managed and maintained, so that it endures and matures. Forget maintenance and the best design will soon degenerate into a semi-derelict mess.
>
> . . .Despite its importance, landscape management and maintenance is a neglected subject. No one seems interested in asking the crucial questions: How should we design with a view to future maintenance, and who should be involved in this?

Because the built environment typically exhibits excessive investments only during the initial establishment phase, plant selection must reflect the expected level of plant maintenance.

Root Pruning Requirement refers to the removal of water-seeking roots from sewers, or roots which may cause serious damage to sidewalks or pavements.

High: frequent pruning required.

Low: no pruning required.

Seedling Removal Requirement is the intensity of effort which must be employed to remove plant seedlings which have become established within the immediate vicinity of the original plant.

High: heavy seed producer with a high germination rate.

Low: low seed producer with a low germination rate.

Waste Removal Requirement refers to the work effort required to remove branches, leaves, fruit, etc., from ground surface areas using a gas powered vacuum, (see Copley, 1983, p. 14).

High: presence of trash.

Low: Absence of trash.

Transplanting Difficulty is the intensity of care required during shipment and afterwards.

High: tap root, and/or sparsely rooted, difficult to establish.

Low: easily established.

2.4 PLANT LISTS

Trees:

Acer ginnala	Amur Maple
Acer negundo	Manitoba Maple, Box Elder
Acer saccharinum	Silver Maple
Betula papyrifera	Paper Birch
Celtis occidentalis	Hackberry
Fraxinus pensylvanica	Green Ash
Malus spp.	Crabapple
Ostrya virginiana	Hophornbean
Picea pungens	Colorado Blue Spruce
Pinus sylvestris	Scots Pine
Populus X jackii 'Northwest'	Northwest Poplar
Prunus pensylvanica	Pin Cherry
Prunus virginiana	Chokecherry

Quercus macrocarpa	Bur Oak
Sorbus spp.	Mountain Ash
Syringa reticulata	Japanese Tree Lilac
Thuja occidentalis	Eastern White Cedar
Tilia americana	American Basswood
Ulmus pumila	Siberian Elm
Viburnum lentago	Nannyberry

Shrubs:

Amelanchier alnifolia	Saskatoon
Amorpha canescens	Leadplant
Amorpha fruticosa	Indigobush
Caragana arborescens	Common Caragana
Caragana pygmaea	Pygmy Caragana
Cornus spp.	Dogwood
Cotoneaster lucida	Cotoneaster
Crataegus spp.	Hawthorn
Elaeagnus commutata	Silverberry, Wolf Willow
Hippophae rhamnoides	Seabuckthorn
Lonicera tatarica	Tatarian Honeysuckle
Physocarpus opulifolius	Common Ninebark
Potentilla fruticosa	Potentilla, Cinquefoil
Ribes alpinum	Alpine Currant
Rosa X hybrida	Hybrid Hardy Rose
Sambucus racemosa	Elder
Shepherdia argentea	Silver Buffaloberry

Spiraea spp.	Spirea
Syringa prestoniae	Preston Lilacs
Viburnum trilobum	Highbush Cranberry

Ground Covers/Vines:

Celastrus scandens	Bittersweet
Clematis X 'Jackmanii'	Jackman Clematis
Juniperus communis	Common Juniper
Juniperus horizontalis	Creeping Juniper
Lonicera X 'Scarlet Trumpet'	Scarlet Trumpet Honeysuckle
Parthenocissus quinquefolia	Virginia Creeper
Rubus idaeus	Raspberry
Vinca minor	Common Periwinkle
Vitis riparia	Riverbank Grape

NOMENCLATURE

Knowles, R.H., Woody Ornamentals for the Prairie Provinces. Edmonton: University of Alberta Press, 1975.

Scoggan, H.J., Flora of Manitoba. Bulletin #140, Biological Series #47, Canada Department of Northern Affairs & National Resources, 1957.

3.0 PLANT FILE

3.0 PLANT FILE

3.1 THE FILE

The following matrices display each environmental condition along the top side of each sheet, while the plants are listed by scientific and common name across the left of each sheet. The approximate height and spread of each plant in metres is provided below the common name on the first sheet of each plant section.

The degree of fit between each variable and woody plant is represented by a large or small case letter. The letter represents the source of the information, (all sources are listed at the end of this chapter). Large case letters refer to documented information, whereas small case letters refer to this writer's own interpretation of the source. For example, when a source states that a plant exhibits a high degree of drought tolerance, then a large case letter is designated. However, when the source makes reference to a plant which is indigenous to an upland porous soil habitat with medium to high wind dessication tolerance, then a level of drought tolerance would be assumed, and a small case letter would be designated.

Because plant and environmental conditions vary between sources, the high to low valuations should be seen as a continuum.

LEAF DEFOLIATION PERIOD
- Early autumn
- Mid autumn
- Late autumn

LEAF FOLIATION PERIOD
- Early spring
- Mid spring
- Late spring

BRANCHING DENSITY
- Dense
- Medium
- Open

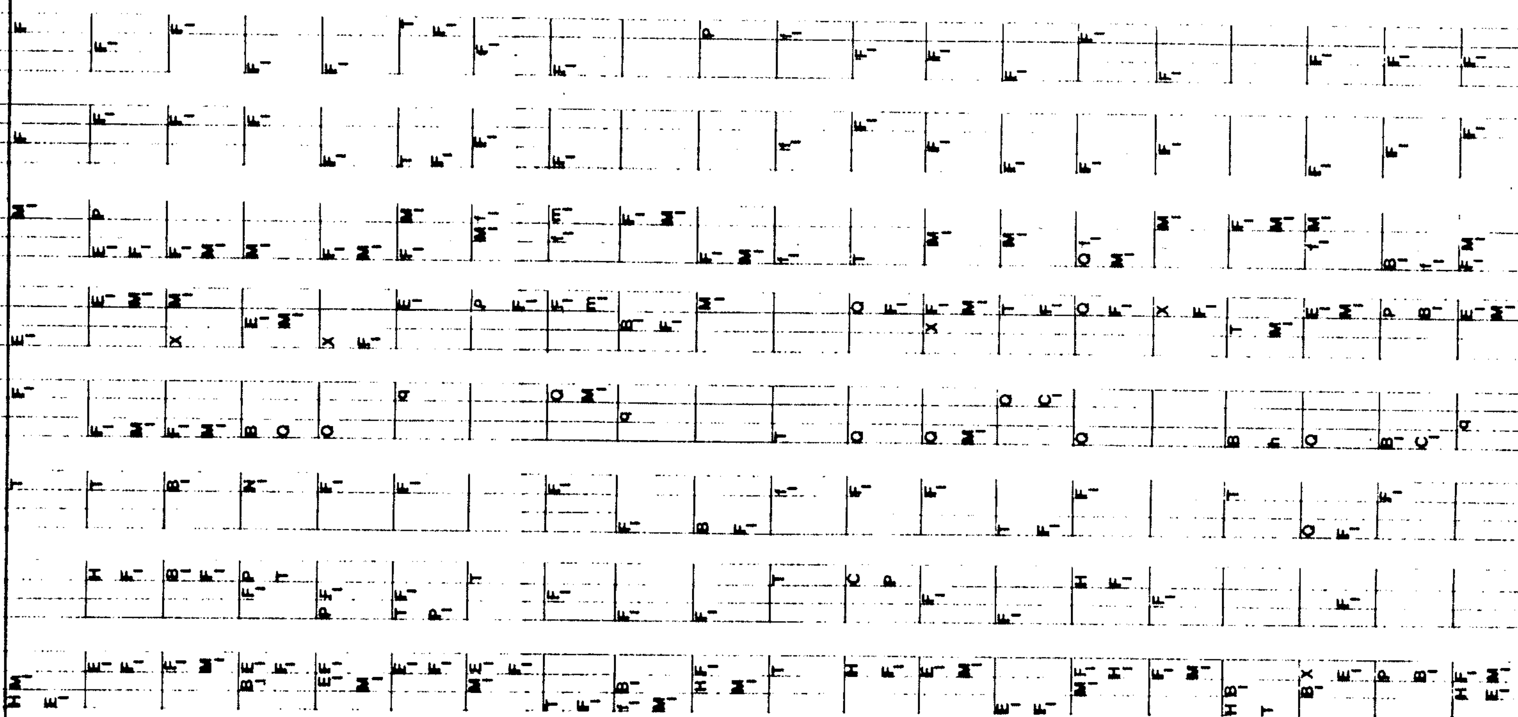
FORM OR HABIT
- Round/Spreading
- Pyramidal
- Vase

LIMB STRENGTH
- High
- Medium
- Low

ROOT CHARACTER
- Shallow
- Medium
- Deep

LONGEVITY
- Short
- Medium
- Long

GROWTH RATE
- Fast
- Medium
- Slow



PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

MATRIX 3.1

TREES

- Acer ginnala, Amur Maple, 6 metres high, 4 metres spread
- Acer negundo, Manitoba Maple, Box Elder, 17 metres high, 12 metres spread
- Acer saccharinum, Silver Maple, 18 metres high, 14 metres spread
- Betula papyrifera, Paper Birch, 12 metres high, 9 metres spread
- Celtis occidentalis, Hackberry, 15 metres high, 14 metres spread
- Fraxinus pennsylvanica, Green Ash, 17 metres high, 10 metres spread
- Malus spp., Crabapple, 6 metres high, 8 metres spread
- Ostrya virginiana, Hophornbeam, 15 metres high, 8 metres spread
- Picea pungens, Colorado Blue Spruce, 18 metres high, 7 metres spread
- Pinus sylvestris, Scots Pine, 18 metres high, 6 metres spread
- Populus X jacki 'Northwest', Northwest Poplar, 22 metres high, 10 metres spread
- Prunus pennsylvanica, Pin Cherry, 6 metres high, 6 metres spread
- Prunus virginiana, Chokecherry, 8 metres high, 5 metres spread
- Quercus macrocarpa, Bur Oak, 14 metres high, 8 metres spread
- Sorbus spp., Mountain Ash, 6 metres high, 6 metres spread
- Syringa reticulata, Japanese Tree Lilac, 13 metres high, 12 metres spread
- Thuja occidentalis, Eastern White Cedar, 3-8 metres high, 1-5 metres spread
- Tilia americana, American Basswood, 16 metres high, 10 metres spread
- Ulmus pumila, Siberian Elm, 11 metres high, 11 metres spread
- Viburnum lentago, Nannyberry, 8 metres high, 3 metres spread

PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS	Acer ginnala Amur Maple	Acer negundo Manitoba Maple, Box Elder	Acer saccharinum Silver Maple	Betula papyrifera Paper Birch	Celtis occidentalis Hackberry	Fraxinus pennsylvanica Green Ash	Malus spp. Crabapple	Ostrya virginiana Hophornbeam	Picea pungens Colorado Blue Spruce	Pinus sylvestris Scots Pine	Populus X jacki 'Northwest' Northwest Poplar	Prunus pennsylvanica Pin Cherry	Prunus virginiana Chokecherry	Quercus macrocarpa Bur Oak	Sorbus spp. Mountain Ash	Syringa reticulata Japanese Tree Lilac	Thuja occidentalis Eastern White Cedar	Tilia americana American Basswood	Ulmus pumila Siberian Elm	Viburnum lentago Nannyberry
NURSERY AVAILABILITY																				
High availability	P		P	P		P	P	P	P	P	P		P		P		P	P	P	P
Medium availability																				
Low availability		P			P							P		P		P				
ORIGIN																				
Indigenous								P				P		P						
Naturalized	P	P	P	P	P	P			P	F-	T				P	F- L-	T	P	F- L-	F- T
Ornamental							P P-						P-							
Native HABITAT																				
Dry upland environment														K						
Moist environment	E- N-	1-	H 1-	P A-	K 1-	H 1-	N-	A- P-	H F-	F- N-		F-			Q M-	M-	K O	F- M-	F- M-	Q P
Riverbank environment					E-	K					F			F-		F-		Q		
NITROGEN FIXATION																				
High																				
Medium																				
None		R-		R-																

MATRIX 3.2

TREES

MATRIX 3.3

ENVIRONMENTAL STRESS

TREES	Disease Tolerance (High / Medium / Low)	Pest Tolerance (High / Medium / Low)	Windthrow Tolerance (High / Medium / Low)	Wind Dessication Tolerance (High / Medium / Low)	Shade Tolerance (High / Medium / Low)	Artificial Light Tolerance (High / Medium / Low)	Heat Tolerance (High / Medium / Low)	Drought Tolerance (High / Medium / Low)
Acer ginnala Amur Maple	E	E F			Z C			C Z
Acer negundo Manitoba Maple, Box Elder	M	T M		B	H F			K B
Acer saccharinum Silver Maple	M	C f M	f n		F M			P
Betula papyrifera Paper Birch	C	T M		P f	M F	D		R T
Celtis occidentalis Hackberry	M C	F P	f n	H	K F		F	P K L
Fraxinus pennsylvanica Green Ash	d M	B m	f	U	H F M		U	T C
Malus spp. Crabapple	P	C X f	f n		F M			Z
Ostrya virginiana Hophornbeam	B M	B M	f n	f	F Q M E			F M
Picea pungens Colorado Blue Spruce	C	f	F N		H F	D		T F
Pinus sylvestris Scots Pine		F	f N		H F	D		Z B
Populus X jacki 'Northwest' Northwest Poplar	X	X			F Z			Z
Prunus pennsylvanica Pin Cherry	F	F			H F Q			C
Prunus virginiana Chokecherry	M P	M P Z	f n		Z F M			Z
Quercus macrocarpa Bur Oak	m	m	N		F M			P B G
Sorbus spp. Mountain Ash	M P	B f M	f N		F M			P Q
Syringa reticulata Japanese Tree Lilac	M	X M	f X		F M			
Thuja occidentalis Eastern White Cedar	M	M	K	H T	H M			G T
Tilia americana American Basswood		C	f N		M F			X
Ulmus pumila Siberian Elm	P	d M	f n		F M	D		L N
Viburnum lentago Nannyberry	M	P M	U	P	M			U

ENVIRONMENTAL STRESS	Acer ginnala Amur Maple	Acer negundo Manitoba Maple, Box Elder	Acer saccharinum Silver Maple	Betula papyrifera Paper Birch	Celtis occidentalis Hackberry	Fraxinus pennsylvanica Green Ash	Malus spp. Crabapple	Ostrya virginiana Hophornbeam	Picea pungens Colorado Blue Spruce	Pinus sylvestris Scots Pine	Populus X jacki 'Northwest' Northwest Poplar	Prunus pennsylvanica Pin Cherry	Prunus virginiana Chokecherry	Quercus macrocarpa Bur Oak	Sorbus spp. Mountain Ash	Syringa reticulata Japanese Tree Lilac	Thuja occidentalis Eastern White Cedar	Tilia americana American Basswood	Ulmus pumila Siberian Elm	Viburnum lentago Nannyberry
WINTER INJURY TOLERANCE																				
High	H F	T F		f	F	A F	F	f	F		A	F	F	F	F	F	A	F	f J	T F
Medium			f							P							B		P	
Low																				
POLLUTION TOLERANCE																				
High			B g						g								g			
Medium											g		g		g		O			
Low		g		g		g		H		K								F H		
SALT TOLERANCE																				
High				V		H E			V V		V									
Medium	V	h	V V	V h		h S	V		h	T V			V	T V	T V V	V	S V	V	T	
Low		R V	T		V					V				V				C V	V	s
MECHANICAL INJURY TOLERANCE																				
High		r M																		
Medium												f	f M			M	O			h
Low														P				M		f
PLANT COMPETITION TOLERANCE																				
High																	K			
Medium			K																	
Low																				
CHLOROSIS TOLERANCE																				
High		P														N				
Medium									n											
Low	P		P				P			n					P					
SOIL COMPACTION TOLERANCE																				
High		I R	E R			R X											I			
Medium						I					I									
Low					R				I					K P						

TREES

MATRIX 3.4

MAINTENANCE REQUIREMENTS

MATRIX 3.5

TREES	TRANSPLANTING DIFFICULTY: High Difficulty / Medium Difficulty / Low Difficulty	WASTE REMOVAL REQUIREMENT: High Requirement / Medium Requirement / Low Requirement	SEEDLING REMOVAL REQUIREMENT: High Requirement / Medium Requirement / Low Requirement	ROOT PRUNING REQUIREMENT: High Requirement / Medium Requirement / Low Requirement
Acer ginnala, Amur Maple				
Acer negundo, Manitoba Maple, Box Elder				
Acer saccharinum, Silver Maple				
Betula papyrifera, Paper Birch				
Celtis occidentalis, Hackberry				
Fraxinus pennsylvanica, Green Ash				
Malus spp., Crabapple				
Ostrya virginiana, Hophornbeam				
Picea pungens, Colorado Blue Spruce				
Pinus sylvestris, Scots Pine				
Populus X jacki 'Northwest', Northwest Poplar				
Prunus pennsylvanica, Pin Cherry				
Prunus virginiana, Chokecherry				
Quercus macrocarpa, Bur Oak				
Sorbus spp., Mountain Ash				
Syringa reticulata, Japanese Tree Lilac				
Thuja occidentalis, Eastern White Cedar				
Tilia americana, American Basswood				
Ulmus pumila, Siberian Elm				
Viburnum lentago, Nannyberry				

MATRIX 3.6

PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

SHRUBS	Amelanchier alnifolia Saskatoon 3 metres high, 3 metres spread	Amorpha canescens Leadplant 1 metres high, 1-2 metres spread	Amorpha fruticosa Indigobush 3 metres high,	Caragana arborescens Common Caragana 5 metres high, 4 metres spread	Caragana pygmaea Pygmy Caragana 1 metres high, 1 metres spread	Cornus spp. Dogwood 3 metres high, 3 metres spread	Cotoneaster lucida Cotoneaster 4 metres high, 3 metres spread	Crataegus spp. Hawthorn 5 metres high, 4 metres spread	Elaeagnus commutata Silverberry 3 metres high,	Hippophae rhamnoides Seabuckthorn 4 metres high, 3 metres spread	Lonicera tatarica Tatarian Honeysuckle 4 metres high, 4 metres spread	Physocarpus opulifolius Common Ninebark 3 metres high, 3 metres spread	Potentilla fruticosa Potentilla, Cinquefoil 1 metres high, 1 metres spread	Ribes alpinum Alpine Currant 2 metres high, 4 metres spread	Rosa hybrid Hybrid Hardy Rose 1-2 metres high, 1 metres spread	Sambucus racemosa Elder 3 metres high, 3 metres spread	Shepherdia argentea Silver Buffaloberry 5 metres high, 4 metres spread	Spiraea spp. Spirea 1 metres high, 1-2 metres spread	Syringa X prestoniae Preston Lilacs 4 metres high,	Viburnum trilobum Highbush Cranberry 3 metres high, 4 metres spread
LEAF DEFOLIATION PERIOD																				
Early autumn								F												
Mid autumn	F-	F-	F-	F-	F-	F-						F-	F-	F-		F-	F-			
Late autumn							F-		F-	F-	F-							F-	P	F-
LEAF FOLIATION PERIOD																				
Early spring				F-	F-	F-	F-				F-	F-		F-		F-				
Mid spring	F-							F	F-	F-			F-					F-		
Late spring		F-	F-														F-		P	F-
BRANCHING DENSITY																				
Dense																				
Medium					P		F- M-	N			F- M-	H M-	P M-	B- M-			F-	M-	H P	H F-
Open			F-	M-		M-			P	H F-										
FORM OR HABIT																				
Round/Spreading	F- R-	H F-	P	H M-	N P	B-	H M-	F P		H F-	F- M-	H M-	H M-	B- M-						
Pyramidal																P F-	F-	F- M-	P	H F-
Vase									F-											
LIMB STRENGTH																				
High																				
Medium																				
Low																				
ROOT CHARACTER																				
Shallow	F-																			
Medium																				
Deep		F		P				F P												
LONGEVITY																				
Short		F-	F-																	
Medium																				
Long																				
GROWTH RATE																				
Fast	F-		F-	HE- M-				S			F- M-	HF- M-								
Medium		F F-	H			M-	H M-		F-	F-			HE- M-	HM F-		F-		H M-		HF-
Slow					P	F F-	F-						H	M-			F-		H	

MATRIX 3.7

PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

SHRUBS	NURSERY AVAILABILITY: High	Medium	Low	ORIGIN: Indigenous	Naturalized	Ornamental	Native HABITAT: Dry upland environment	Moist environment	Riverbank environment	NITROGEN FIXATION: High	Medium	None
Amelanchier alnifolia Saskatoon	P				R			F R				R
Amorpha canescens Leadplant			P					L		P		
Amorpha fruticosa Indigobush			P					L		P		
Caragana arborescens Common Caragana		P			F			L		H Y		
Caragana pygmaea Pygmy Caragana	P				L					Y		
Cornus spp. Dogwood	P				P			R				R
Cotoneaster lucida Cotoneaster	P				H L			H F				
Crataegus spp. Hawthorn			P		L			F				
Elaeagnus commutata Silverberry			P		P			F R		U R		
Hippophae rhamnoides Seabuckthorn			P		H F			F		H Y		
Lonicera tatarica Tatarian Honeysuckle		P			H F			M				
Physocarpus opulifolius Common Ninebark	P				M			M				
Potentilla fruticosa Potentilla, Cinquefoil	P				H R			H M				R
Ribes alpinum Alpine Currant	P				F L			M				
Rosa hybrid Hybrid Hardy Rose	P											
Sambucus racemosa Elder	P				F			F				
Shepherdia argentea Silver Buffaloberry		P			J			Y		Y		
Spiraea spp. Spirea	P							M				
Syringa X prestoniae Preston Lilacs	P					L						
Viburnum trilobum Highbush Cranberry	P				H L			H				

MATRIX 3.8

ENVIRONMENTAL STRESS

SHRUBS	DISEASE TOLERANCE	PEST TOLERANCE	WINDTHROW TOLERANCE	WIND DESSICATION TOLERANCE	SHADE TOLERANCE	ARTIFICIAL LIGHT TOLERANCE	HEAT TOLERANCE	DROUGHT TOLERANCE
Amelanchier alnifolia Saskatoon	Low: F	Medium: F	Medium: f		Medium: Z R			High: Z R
Amorpha canescens Leadplant	High: F	High: F		Low: f	Medium: F; Low: F		High: W	High: W L
Amorpha fruticosa Indigobush	Low: H	High: F		Low: f	Low: H F		High: W	High: H N
Caragana arborescens Common Caragana	High: H M	High: H M; Medium: N		High: N	Medium: M; Low: Z L		High: W	High: H M
Caragana pygmaea Pygmy Caragana	High: d	High: d		High: N			High: W	High: H N
Cornus spp. Dogwood	Medium: M	High: M; Low: d			High: Z; Medium: M; Low: R			Low: R
Cotoneaster lucida Cotoneaster	Medium: M; Low: H	Medium: N M; Low: H		High: h F	Medium: M; Low: H F		High: W	High: W Z; Medium: f
Crataegus spp. Hawthorn	Low: P	Low: P		High: F	Low: F Z			Medium: Z
Elaeagnus commutata Silverberry, Wolf Willow	Low: R				Low: F R		Low: F	High: F; Medium: R
Hippophae rhamnoides Seabuckthorn		Low: M	Low: f		Low: H Z		High: W	High: W L
Lonicera tatarica Tatarian Honeysuckle	Low: f M	Low: W			Medium: F M			High: Z
Physocarpus opulifolius Common Ninebark	High: M	High: M			Medium: H M		High: W	High: H M
Potentilla fruticosa Potentilla, Cinquefoil	High: H M	High: H M		Medium: N	Medium: M; Low: H R			High: E R
Ribes alpinum Alpine Currant	Medium: M; Low: h	Medium: M; Low: h	Low: f		High: H; Medium: M			
Rosa hybrid Hybrid Hardy Rose		Low: d						
Sambucus racemosa Elder	Low: d	Medium: d			Medium: Z; Low: F			Low: Z
Shepherdia argentea Silver Buffaloberry	Medium: d	High: d		Medium: N	Low: Z F		High: W	High: N P
Spiraea spp. Spirea	Low: M h	Medium: M h		Low: Z	Medium: M; Low: F H			High: M
Syringa X prestoniae Preston Lilacs	Low: d h	Medium: d; Low: h		Medium: N				Medium: P
Viburnum trilobum Highbush Cranberry	Medium: H	Medium: H; Low: B I			Medium: H Z			Low: H

MATRIX 3.9

ENVIRONMENTAL STRESS

SHRUBS	Winter Injury Tolerance: High	Winter Injury Tolerance: Medium	Winter Injury Tolerance: Low	Pollution Tolerance: High	Pollution Tolerance: Medium	Pollution Tolerance: Low	Salt Tolerance: High	Salt Tolerance: Medium	Salt Tolerance: Low	Mechanical Injury Tolerance: High	Mechanical Injury Tolerance: Medium	Mechanical Injury Tolerance: Low	Plant Competition Tolerance: High	Plant Competition Tolerance: Medium	Plant Competition Tolerance: Low	Chlorosis Tolerance: High	Chlorosis Tolerance: Medium	Chlorosis Tolerance: Low	Soil Compaction Tolerance: High	Soil Compaction Tolerance: Medium	Soil Compaction Tolerance: Low
Amelanchier alnifolia Saskatoon	F					Q		V													
Amorpha canescens Leadplant	F							F F													
Amorpha fruticosa Indigobush	F																				
Caragana arborescens Common Caragana	H F						H V						T			N T					
Caragana pygmaea Pygmy Caragana	F															N T					
Cornus spp. Dogwood	F								V V					P							
Cotoneaster lucida Cotoneaster	F																				
Crataegus spp. Hawthorn	Z						H		V V												
Elaeagnus commutata Silverberry	F							R			H F		P	R		T					
Hippophae rhamnoides Seabuckthorn	F						H F				T P		P			T					
Lonicera tatarica Tatarian Honeysuckle	F						V V			Z											
Physocarpus opulifolius Common Ninebark	F																				
Potentilla fruticosa Potentilla, Cinquefoil	H F						V								R	N T					
Ribes alpinum Alpine Currant	F			X			V														
Rosa hybrid Hybrid Hardy Rose									V												
Sambucus racemosa Elder	F								V		F										
Shepherdia argentea Silver Buffaloberry	F						V	H			F		P			N T					
Spiraea spp. Spirea	F							V	H									N			
Syringa X prestoniae Preston Lilacs	N															N T					
Viburnum trilobum Highbush Cranberry	F								H V												

MATRIX 3.10

MAINTENANCE REQUIREMENT

SHRUBS	TRANSPLANTING DIFFICULTY (High Difficulty / Medium Difficulty / Low Difficulty)	WASTE REMOVAL REQUIREMENT (High Requirement / Medium Requirement / Low Requirement)	SEEDLING REMOVAL REQUIREMENT (High Requirement / Medium Requirement / Low Requirement)	ROOT PRUNING REQUIREMENT (High Requirement / Medium Requirement / Low Requirement)
Amelanchier alnifolia Saskatoon	[illegible]		[illegible]	
Amorpha canescens Leadplant	[illegible]			
Amorpha fruticosa Indigobush	[illegible]		[illegible]	
Caragana arborescens Common Caragana	[illegible]			
Caragana pygmaea Pygmy Caragana				
Cornus spp. Dogwood	[illegible]			
Cotoneaster lucida Cotoneaster	[illegible]	[illegible]		
Crataegus spp. Hawthorn	[illegible]			
Elaeagnus commutata Silverberry	[illegible]			
Hippophae rhamnoides Seabuckthorn	[illegible]			
Lonicera tatarica Tatarian Honeysuckle	[illegible]		[illegible]	
Physocarpus opulifolius Common Ninebark	[illegible]			
Potentilla fruticosa Potentilla, Cinquefoil	[illegible]			
Ribes alpinum Alpine Currant	[illegible]	[illegible]	[illegible]	
Rosa hybrid Hybrid Hardy Rose	[illegible]	[illegible]		
Sambucus racemosa Elder	[illegible]			
Shepherdia argentea Silver Buffaloberry	[illegible]			
Spiraea spp. Spirea	[illegible]	[illegible]		
Syringa X prestoniae Preston Lilacs				
Viburnum trilobum Highbush Cranberry	[illegible]			

PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

MATRIX 3.11

GROUNDCOVERS/VINES

	Celastrus scandens Bittersweet 6-10 metres high	Clematis X 'Jackmanii' Jackman Clematis 3 metres high 1 metres spread	Juniperus communis Common Juniper 8 metres spread	Juniperus horizontalis Creeping Juniper 0.1 metres high, 8 metres spread	Lonicera X 'Scarlet Trumpet' Scarlet Trumpet Honeysuckle 4 metres high,	Parthenocissus quinquefolia Virginia Creeper 10 metres high,	Rubus idaeus Raspberry 1 metres high, 3 metres spread	Vinca minor Periwinkle, Myrtle, Barvenok 0.1 metres high, spreading	Vitis riparia Riverbank Grape 9 metres high
LEAF DEFOLIATION PERIOD									
Early autumn							F		
Mid autumn	F					F			F
Late autumn		F			F				
LEAF FOLIATION PERIOD									
Early spring		F							
Mid spring	F				F	F			
Late spring							F		F
BRANCHING DENSITY									
Dense	M								
Medium									
Open									
FORM OR HABIT									
Round/Spreading						M		N	
Pyramidal									
Vase									
LIMB STRENGTH									
High									
Medium									
Low									
ROOT CHARACTER									
Shallow			F				F		
Medium									
Deep		F		F					
LONGEVITY									
Short							F		
Medium									
Long									
GROWTH RATE									
Fast	B M					B E	F	N	F
Medium	F	F		F					
Slow			F		F				

PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS

MATRIX 3.12

GROUNDCOVERS/VINES	Celastrus scandens Bittersweet	Clematis X 'Jackmanii' Jackman Clematis	Juniperus communis Common Juniper	Juniperus horizontalis Creeping Juniper	Lonicera X 'Scarlet Trumpet' Scarlet Trumpet Honeysuckle	Parthenocissus quinquefolia Virginia Creeper	Rubus idaeus Raspberry	Vinca minor Periwinkle, Myrtle, Barvenok	Vitis riparia Riverbank Grape
NURSERY AVAILABILITY									
High		P	P	P		P		P	[illegible]
Medium					P				
Low	P						P		
ORIGIN									
Indigenous	P						P		
Naturalized			H	H		H		P	P
Ornamental		P			P				
Native HABITAT									
Dry upland environment			P- F-	P-					
Moist environment	E- L-	F- M-	H	H	F-		F-		
Riverbank environment									F-
NITROGEN FIXATION									
High									
Medium									
None			R-	R-					

MATRIX 3.13

ENVIRONMENTAL STRESS

GROUNDCOVERS/VINES	Celastrus scandens Bittersweet	Clematis X 'Jackmanii' Jackman Clematis	Juniperus communis Common Juniper	Juniperus horizontalis Creeping Juniper	Lonicera X 'Scarlet Trumpet' Scarlet Trumpet Honeysuckle	Parthenocissus quinquefolia Virginia Creeper	Rubus idaeus Raspberry	Vinca minor Periwinkle, Myrtle, Barvenok	Vitis riparia Riverbank Grape
DISEASE TOLERANCE									
High									
Medium	P	H P							
Low	H					T P	F		
PEST TOLERANCE									
High									
Medium									
Low	H P	H	T	T		H P			
WINDTHROW TOLERANCE									
High						H			
Medium									
Low									
WIND DESSICATION TOLERANCE									
High	H		H			H			
Medium									
Low									
SHADE TOLERANCE									
High		F				H B		T N	F
Medium	D M								
Low	H	F			W F		F		
ARTIFICIAL LIGHT TOLERANCE									
High									
Medium									
Low									
HEAT TOLERANCE									
High									
Medium									
Low								P	
DROUGHT TOLERANCE									
High	H B		T P	P P		W M			
Medium		W			W				
Low		H						N	

ENVIRONMENTAL STRESS	Celastrus scandens Bittersweet	Clematis X 'Jackmanii' Jackman Clematis	Juniperus communis Common Juniper	Juniperus horizontalis Creeping Juniper	Lonicera X 'Scarlet Trumpet' Scarlet Trumpet Honeysuckle	Parthenocissus quiquefolia Virginia Creeper	Rubus idaeus Raspberry	Vinca minor Periwinkle, Myrtle, Barvenok	Vitis riparia Riverbank Grape
WINTER INJURY TOLERANCE									
High	H F	h				H F	F		F T
Medium									
Low								T P	
POLLUTION TOLERANCE									
High									
Medium									
Low									
SALT TOLERANCE									
High						h V			
Medium									
Low									
MECHANICAL INJURY TOLERANCE									
High									
Medium	F								
Low									
PLANT COMPETITION TOLERANCE									
High	H					h			
Medium									
Low									
CHLOROSIS TOLERANCE									
High									
Medium									
Low									
SOIL COMPACTION TOLERANCE									
High									
Medium		h							
Low									

MATRIX 3.14

GROUNDCOVERS/VINES

MAINTENANCE REQUIREMENTS	Celastrus scandens Bittersweet	Clematis X 'Jackmanii' Jackman Clematis	Juniperus communis Common Juniper	Juniperus horizontalis Creeping Juniper	Lonicera X 'Scarlet Trumpet' Scarlet Trumpet Honeysuckle	Parthenocissus quinquefolia Virginia Creeper	Rubus idaeus Raspberry	Vinca minor Periwinkle, Myrtle, Barvenok	Vitis riparia Riverbank Grape
TRANSPLANTING DIFFICULTY									
High Difficulty									
Medium Difficulty									
Low Difficulty									
WASTE REMOVAL REQUIREMENT									
High Requirement									
Medium Requirement									
Low Requirement									
SEEDLING REMOVAL REQUIREMENT									
High Requirement									
Medium Requirement									
Low Requirement									
ROOT PRUNING REQUIREMENTS									
High Requirement									
Medium Requirement									
Low Requirement									

GROUNDCOVERS/VINES

MATRIX 3.15

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4.0 TEST APPLICATIONS

4.0 TEST APPLICATIONS

4.1 THE GENERIC URBAN STRIP SITE

The urban strip site embodies in the broadest of terms the concept of 'indust-real', (see Toffler, 1980, p. 99-115), where site organization reflects the maximization of spatial resources to facilitate the repetitive distribution of products/services to consumers. In order to do this, each site is given over to standardized exterior circulation corridors which designate specific activities for vehicles and pedestrians. This results in a ubiquitous landscape of asphalt, concrete, and stone pavements. The unusable fragments of the site fabric, (i.e. peripheral areas, and/or buffers between adjacent circulation zones), are usually vegetated to channel or separate movement, and to soften the rigidity of this 'indust-real' landscape. However, many landscape plantings have failed to perform to expected levels of growth because of an inadequate concern for plant response to environmental stress.

The environmental conditions of these urban strip developments are characteristically desert-like. It is hot, dry and open, (windy), from June through September. As Michael Miess (1979, p. 101) asserts, these environmental conditions are determined on the basis of the following factors:

- lower humidity resulting from accelerated runoff.
- greater heat absorption of most building fabrics

compared with natural soils.

- variations in airflow caused by buildings.
- energy input from natural and artificial sources.
- the pollutants in the atmosphere.

Because most of the precipitation falls onto paved surfaces, most drain immediately through storm sewers, the remaining moisture is rapidly depleted either through soil evaporation (when mulches are absent), or through daily plant requirements (transpiration). In the latter case, ". . . it is estimated that a single birch may transpire 90 gallons of water a day", (see Harder, 1981, p. 19). Therefore, if watering programs by artificial means are not available, or prolonged periods of drought persist, then the symptoms of reduced water availability arise. Droughts cause plants to divert energy from biomass production to the process of respiration, and thereby reduce the plants demand for moisture. With continued drought, photosynthesis can be affected when turgor pressure effectively falls below the threshold where the guard cells of stomata fail to open and subsequently, the diffusion of carbon dioxide slackens. If conditions prevail, then the plants exhibit dieback, or become susceptible to other stress conditions.

Drought conditions can be further aggravated by the accumulated heat which results when vertical or horizontal surfaces conduct heat, (i.e. metal, concrete), or store heat, (i.e. wood, brick, asphalt). Meiss, (pp. 102-103), notes that ". . . concrete is about 100 times as conductive as loamy soil and 50 times as conductive as a sandy one. The heat storage capacity of concrete is 5 times a loam and 1.25 time a sand." Halverson and Heisler, (1981), have recorded that

> . . . summer temperatures under trees planted in holes cut through an asphalt cover in a parking lot and in soil beneath the surrounding asphalt were higher than soil temperatures under trees at a control site.
>
> . . . summer temperature exceeded the control by 3°C beneath the parking lot trees and up to 10°C beneath the asphalt cover at a depth of 15 cm. below the surface.

Heat which is radiated from the pavement into the soils can inhibit absorption, (see Edwards, 1981). This situation becomes severe when soil beds are of an insufficient volume.

Compounding the problem of heat gain from radiation is the repetitive release of heat from parked vehicles, which at restaurants begins with breakfast and continues unabated until late evening.

In unobstructed areas, wind velocity increases, or becomes focused between closely associated buildings. Transpiration and evaporation are increased due to the warm dry dessicating winds. Thus plants exhibit a peripheral drying which may lead to wind pruning, or to stunting of growth.

A second concern arising from air flow is windthrow. The oscillation of the upper plant creates undue forces on the root zone which may result in the dislocation of the plant roots, and the disruption of nutrient/water uptake by feeding rootlets. This problem is commonly associated with newly planted areas, but is also associated with shallow root systems.

With the advent of high pressure sodium night lighting, not only are day lengths effectively increased, but perception of seasonal variation becomes blurred. Flowering may be earlier, or prolonged, fruiting slower, and leaf abscission delayed. Even plant form may become altered as the stem axis turns towards the light source, (see Quigley, 1979, p. 505).

The accumulation of salt on the site results from two different processes. First vehicles deposit salt in parking areas or splash it on woody plants during mild winter days. Damage occurs in early spring when plant metabolism is on the increase, (see Lumis, Hofstra, Hall, 1973, p. 476). Second, where landscape maintenance, (summer irrigation), is not prevalent, excessive evaporation of soil moisture concentrates soil salts within the root zone.

Due to heavy pedestrian use of these sites, soil compaction is a serious concern. Clay soils are of low porosity. Thus compaction results in a reduction in space for oxygen and water, which in turn causes feeding rootlets to die, (see Feucht, 1982, p. 11).

Harder, (1981, p. 97), notes that compacted clay particles are more chemically active with an enhanced ability to substitute positively charged ions, (i.e. hydrogen, potassium, calcium, ammonium and magnesium etc.), for water. This effectively dessicates the rootlets.

Experience has shown that parts of these sites are neither hot, dry, nor open. Instead they are cool, moist and sheltered. These oasis conditions exist along the north and east walls of buildings. Here the duration of the sun is restricted to either early morning or late afternoon, when the productive light intensity is minimal. Thus, most of the environmental conditions related to radiation and moisture are reversed.

4.2 APPLICATION OF THE FILE

Successful utilization of the file is dependent upon an awareness of the limitations of the documented sources. For example,

> We must point out that sensitivity ratings are not absolute. There are many variables that will affect a species' sensitivity rating including the genetic make-up of the plant species, environmental conditions and location during exposure, and the age of the plant when exposed. Whether the experiments were conducted in a laboratory or in the field and whether environmental parameters were controlled in the field . . . the initial source of the stock before the experiment began is important, . . . Other environmental stresses present during experimentation will all affect relative sensitivity.

Review, (Beckerson, Cain, Hofstra, Ormod, and Campbell, 1980, p. 299). Therefore, plant selection must be tempered with caution.

Application of the file is dependent upon the following guidelines: when the information for a particular environmental condition is incomplete, (less than seventy-five percent), then the variable should be omitted from the evaluation. However, when the same variable concerns either one plant or an abbreviated list of plants for which the completion exceeds seventy-five percent, then the variable may be re-included.

A thorough understanding of the on-site problems and conditions is necessary in order to describe growing conditions. The more complete the description, the easier to select and assign the correct plants.

When plants have been selected for a specific location, their expected impact upon existing plants should be tested through an application of the file.

4.3 PLANT SELECTION - A FIRST EXAMPLE

A large asphalt parking lot requires the installation of shade trees to ammeliorate the hot conditions.

With respect to 'PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS', the important concerns are:

Growth Rate	medium to fast - quick growth to promote shade, and quick regeneration.
Longevity	medium to long - insures permanence.
Limb Strength	medium to high - strength infers greater public safety, and reduced liability.
Root Character	medium to deep - fewer temperature, moisture and soil compaction problems.

With respect to 'ENVIRONMENTAL STRESS', the important concerns are:

Drought	medium to high - trees capable of reduced water requirements.

Heat	medium to high - minimum protoplasmic disturbance.
Artificial Light	medium to high - reduced photoperiodic problems.
Wind Dessication	medium to high - minimum leaf browning or twig dieback.
Pest	medium to high - healthy trees remain vigorous, less susceptible to other forms of stress.
Disease	medium to high - same as above.
Soil Compaction	medium to high - fewer root injuries encountered.
Chlorosis	medium to high - requirement to avoid nutritional stress.
Mechanical Injury	high - reduce replacement, and aesthetic loss costs.
Salt	high - reduce plant replacement, or maintenance costs.

With respect to 'MAINTENANCE REQUIREMENTS' the important concerns are:

Root Pruning	medium to low - minimum maintenance.
Seedling Removal	medium to low - minimum maintenance.
Waste Removal	medium to low - minimum maintenance.
Transplanting Difficulty	medium to low - minimum maintenance.

Because of the shortage of plant/variable information, (see Figure 4.1), there are no evident tree selections. However, even if the information were complete, the result would still have reflected mere plant tendencies. In addition, most of the primary references vary from the geographical context of southern Manitoba. Even 'intra species diversity'

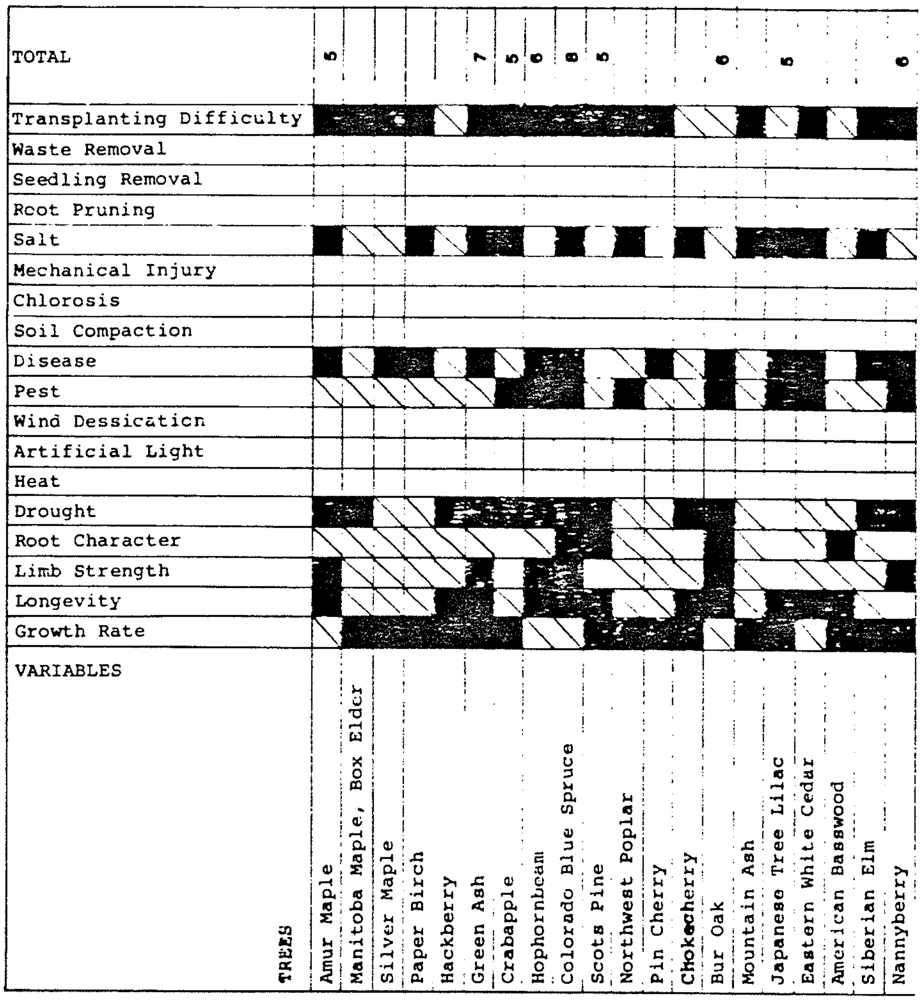

Figure 4.1 'TREE SELECTION MATRIX'

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suggests that plant response to stress is never homogeneous, (i.e. Birch Dieback). Therefore, for the data file to remain objective and useful, it must be used as a guide for decision making.

On the basis of plant sensitivity, two distinct sets of trees from Figure 4.1 appear to meet the criteria to some degree. First, Green Ash, Hophornbeam, Blue Spruce, Scots Pine, Japanese Tree Lilac, Nannyberry, Amur Maple, Crabapple and Bur Oak display the greatest tendency towards meeting the required parking lot conditions. Selection would depend upon design application, aesthetic choice, and of course nursery availability.

Judicious use of the data file should not end here, because the user runs the risk of becoming too dependent on a limited number of species. This underscores the current dilemma of 'Dutch Elm Disease' in Winnipeg. Mixed use may prevent a future epidemic and extend species usefulness, (see Ronald, 1985). Because the file enlightens the user to plant sensitivity, he/she must re-evaluate the on-site conditions, so as to ameliorate them. This would then allow presently non recommended plants to survive without the debilitating effects of stress. Only then is the full capacity of the data file realized.

The second group of plants from Figure 4.1 (which do not favour the programmed conditions), could survive if some changes in planting design, and/or maintenance practices were observed. For example, Hackberry, Manitoba Maple, Siberian Elm, and Chokecherry are all capable of surviving drought conditions. Yet for the most part, their problems are related to disease and pest infestations, which can be controlled through adequate surveillance and spray maintenance programs. The second half of this group which includes American Basswood, Paper Birch, Silver Maple, Eastern White Cedar, Pincherry, and Mountain Ash are not particularly drought tolerant. For these plants the means of reducing drought stress may be accomplished by restructuring the planting environment. To facilitate this, the user must review plant physiology and develop guidelines which could then be implemented into the design programs.

In the case of American Basswood, the tree has a tendency to prefer moist well drained or wet soils, and to develop relatively deep roots. Therefore, the designer may choose to excavate a deeper and wider area of ground which could be back-filled with a more porous soil mix, (which would conduct less heat energy than adjacent compacted gravel areas). The surface of the planting area could be covered by a seven to ten inch mulch which would effectively reduce soil evaporation, and soil temperatures. A trickle irrigation system could be installed to augment natural precipitation inputs. To that end, the site grading could be altered to reduce off-site runoff, and promote soil moisture infiltration. Unfortunately this species is highly intolerant of salt pollution. Thus, its use in the parking lot would seem quite impractical unless the client was receptive to one or both of the following guidelines. First, if the lot could be reduced in size by a couple of spaces, the additional area could be used to enlarge the planting zone and perhaps reduce direct spray of salted water onto plants. Second, a temporary burlap fence or wall could be installed during the winter months to reduce wind velocity and to act as a barrier to salt spray. Such a device could be designed, (form, colour, etc.), so as to enhance the aesthetic appearance of the lot during the winter.

In the case of Paper Birch, the above guidelines could be instituted but with one alteration. A deeper pit should be excavated so that an eighteen to twenty-four inch bed of large, washed gravel could be installed. The gravel would allow the pit to drain in the event of over watering, (either natural or artificial). Resulting in soil oxygen depletion and subsequent root dieback. The same result could be achieved if weeping tiles were installed. Because Birch has a shallow root system, the presence of a significant mulch which will not compact becomes an important consideration. Either wood chips or pea gravel are excellent examples. However, as the chips decompose, more must be added. Another concern is containment. If the area is heavily used by children, then the mulch may be spread into other areas.

While reviewing 'Nursery Availability' from matrix 3.2, it is interesting to observe that four of the five species which are present in less than forty percent of the nurseries are capable of resisting droughty conditions. It seems unfortunate that these species for one reason or another are omitted form nursery catalogues. Bur Oak, although it is slow growing, a heavy seed producer in alternate years and somewhat difficult to transplant, is nevertheless of high limb strength, highly resistant to drought, windthrow, pests, disease and winter injury. Perhaps innovative planting design guidelines should be included, (where appropriate), to promote either the planting of whips or of seed. This could lead to the development of evolving landscapes, (albeit only the trees), which could offer another dimension to landscape management. It may prove more visually enjoyable and perhaps energy efficient, (see Hough, 1983, p. 55). As older specimen trees decline, younger trees of varying rates in the substratas, would in time mature, decline and in turn be replaced by something from below. The cost of tree removal remains, but the cost of replacement in terms of both labour and aesthetic loss, may conceivably be reduced. In addition, because the plants are grown from younger entities, transplanting and/or acclimatization difficulties are greatly diminished or reduced.

If indigenous plants are continually omitted from planting plans and supply sources, then the contemporary urban landscape is unjustifiably robbed of plants which not only could improve plant diversity, but also enhance the ambient environment, and ultimately influence our perception of nature in cities. To this end M. Hough, (1982, pp. 156-157), relates

> Conventional landscape planting based on . . . species planted in standard well drained nursery soils and standard horticultural procedures, tend to create static design solutions. Maintenance procedures provide no basis for continuing and evolving plant associations for the future. The experience of the Dutch landscapes based on natural succession management techniques offers a creative alternative that is in tune with social need and provides long-term low-maintenance landscapes.

4.4 PLANT SELECTION - A SECOND EXAMPLE

A rectangular planting bed immediately adjacent to a brick windowless north wall of a local restaurant requires a planting of shrubs which are suitable for a medium to high shade environment.

With respect to 'PLANT PHYSIOLOGY AND ENVIRONMENTAL CHARACTERISTICS', the listed terms are: growth rate, longevity, root character, foliation period, defoliation period, nitrogen fixation and native habitat.

With respect to 'ENVIRONMENTAL STRESS', the listed terms are: artificial light, shade (medium to high), pest, disease, soil compaction, chlorosis, mechanical injury, and salt.

With respect to 'MAINTENANCE REQUIREMENTS', the listed terms are: seedling removal, waste removal, and transplanting difficulty.

From Figure 4.2, 'Shrub Selection Matrix', Common Caragana, Buffaloberry, Elder, Leadplant and Spirea, although

VARIABLES \ SHRUBS	Saskatoon	Leadplant	Indigobush	Common Caragana	Pygmy Caragana	Dogwood spp.	Cotoneaster	Hawthorn	Silverberry, Wolf Willow	Seabuckthorn	Tatarian Honeysuckle	Common Ninebark	Potentilla, Cinquefoil	Alpine Currant	Hybrid Hardy Rose	Elder	Silver Buffaloberry	Spirea	Preston Lilacs	Highbush Cranberry
TOTAL		7		8							8	8		6		7	8	7		7
Transplanting Difficulty	\	■	■	\		\	■	\	■	■	■	■	■	■	■	■	■	■		■
Waste Removal																				
Seedling Removal																				
Salt	■			■		\		\	■	■	■		■	■	\	\	■	\		\
Mechanical Injury																				
Chlorosis																				
Soil Compaction																				
Disease	\	■	\	■	■	■	\	\	\		■	■	■	\		■	■	■	\	■
Pest	■	■	■	■	■		\	\			\	■	■	\	\	■	■	■	\	■
Shade	■	\	\	\	\	■	\	\	\	\	■	■	\	■		\	\	\		■
Artificial Light																				
Native Habitat	■	■	■	■		■	■	■	■	■	■	■	■	■		■	■	■		■
Nitrogen Fixation	\	■	■	■	■	\	\	\	■	■	\	\	\	\	\	\	■	\	\	\
Defoliation Period	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
Foliation Period	\	\	\	■	■	■	■	\	\	\	■	■	\	■	\	■	\	■	\	\
Root Character																				
Longevity																				
Growth Rate	■	■	■	■	■	\	\	■	■	■	■	■	\	\	■	■	■	■	■	■

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Figure 4.2 'SHRUB SELECTION MATRIX'

possessing a strong overall rating, do not respond favourably to the shade variable. Thus it becomes abundantly clear that equally weighted variables in this matrix format can create misleading results. To reduce the impact of this problem, either the designer must over-ride the results, or assign weighted values to each variable prior to the evaluation. With a limited total number of plants in the file, an over-ride system is far easier to maintain. Here, the objective is to develop a priorized framework or skeleton which is used to assign species to different tiers on the basis of compatibility with the most important environmental condition(s). Therefore, Honeysuckle, Common Ninebark, and Cranberry, (because they respond favourably to shade and the majority of the other factors), would be defined as members of the first tier.

Then the question arises, which species should be rated for the second tier? Other shade tolerant plants with minute environmental problems must be selected next. From Figure 4.2, both Alpine Currant and Saskatoon could be assigned to this second tier as long as detailed installation and maintenance specifications are strictly adhered to by all contractors.

For example, the transplanting difficulty of Saskatoon is restricted to native stock which lacks a sufficiently fibrous root system. Therefore the designer should specify nursery plants which have been grafted onto Cotoneaster root stock. However it's important to inspect the installed conditions to ensure that all grafts are located sufficiently below the soil surface to prevent the Cotoneaster from emerging, (see Ronald, 1985).

The third tier would be composed of the group which included Common Caragana etc. These plants would survive, but growth would be characterized by diminished flowering, fruit or seed setting, and smaller leaves with elongated branching habits.

Subsequent tiers would be composed of plants whose shortcomings could be diminished through design or maintenance options. However, limits vis a vis economies of return in terms of the energy expended to maintain such species would ultimately determine utilization. For example, the Dogwood spp. could overcome many of its shortcomings if regular and reliable site management were available.

In the eventual planting design, the largest proportion of plants should reflect those species from the most significant tiers. Lower ordered tiers become important as a means of maintaining species diversity.

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5.0 SUMMARY

5.0 SUMMARY

Judging by the number of blank spaces in the file, a great deal more research must be undertaken before plant selection will be made easier. Unfortunately, the vast majority of current research on species sensitivity is largely concentrated around the industrial centres of Ontario, and the American Northeast. A significant proportion of the information appears to have been generated as a byproduct concern of the larger industrial/urban issues, (i.e. water quality, air pollution and acid rain etc.). Perhaps it will require issues of this magnitude to effect a similar awareness in Manitoba.

The utilization of a matrix format which assigns a value of equal weighting to each variable has created severe limitations in the decision making methodology. The original concept had favoured an equal weight approach because the plant which proved to be most favourable to the greatest number of factors should in theory have been the most suitable plant. However, problems arise when one or two key variables are over-ridden by a larger number of factors. For example, a plant may be ranked quite high, (nine out of ten factors), yet that one variable may be of such significance that in reality, it generates a contradictory outcome. That is, the other variables in actuality do not effectively perform to the anticipated levels of growth. Therefore, some sort of weighting system must be devised to overcome this problem.

In spite of the above limitation, the file does present the opportunity to avoid the usual pitfall of relying too heavily on the ubiquitous shade tree, drought resistant shrub, or aggressive ground cover. Excessive dependence on a few plants suggests a higher incidence of weakness, whereas limited use may prevent a future epidemic and extend species usefulness. Therefore effective utilization of the file should enlighten the user to a conscious awareness of plant sensitivity, which should activate a conscientious restructuring of site conditions to promote the successful application of third and fourth tier plants.

Application of the file has been organized for use in the built environment of Winnipeg. However, it could easily be adapted where the environmental conditions, (regardless of regional climatic disparities), are similar, (i.e. the hot, dry, and windy conditions), of urban strip sites in Calgary, Toronto, or Montreal.

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