

**URBAN ECOLOGICAL ANALYSIS OF
STEPHEN JUBA PARK:
A PRE-DESIGN AND POST-DESIGN ASSESSMENT**

By

Mr. Rajinder Singh

A Practicum submitted to the Faculty of Graduate Studies of The University of
Manitoba in partial fulfillment of the requirement of the degree
of

Master of Landscape Architecture

Department of Landscape Architecture
University of Manitoba
Winnipeg, Manitoba

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FACULTY OF GRADUATE STUDIES

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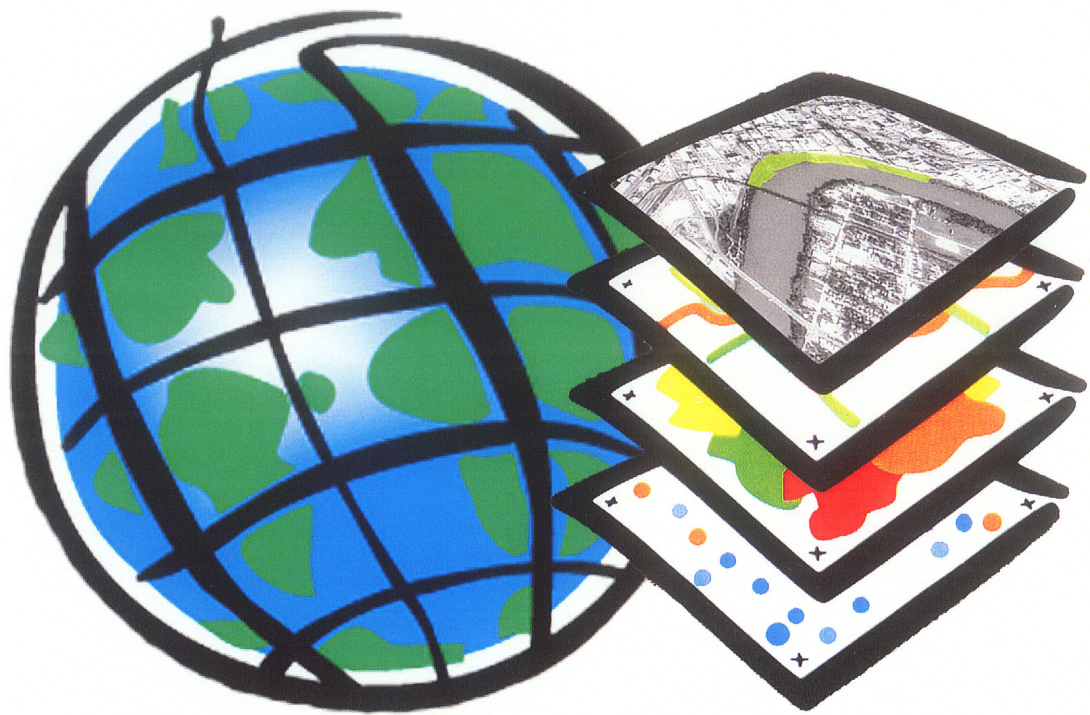
Of

MASTER OF LANDSCAPE ARCHITECTURE

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**Urban Ecological Analysis of
Stephen Juba Park:
A Pre-Design and Post-Design Assessment**

By Rajinder Singh



"never before had he been so suddenly and so keenly aware of the feel and texture of a tree's skin and of the life within it. He felt a delight in wood and the touch of it, neither as forester nor as carpenter; it was the delight of the living tree itself."

Tolkien, J.R.R. The Lord Of The Rings Fellowship Of The Ring: Book Two The Ring Goes South. Great Britain: HarperCollins Publishers Ltd., 2001.

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Introduction

The world is composed of a diversity of scale-variable ecosystems that are linked and function together to support a variety of life. These ecosystems range from ponds to oceans, forests to grasslands, and biomes to the biosphere. Recently, cities have been described as unique and identifiable ecosystems. The urban ecosystem has been described as "a biological community where humans represent the dominant or keystone species and the built environment is the dominant element controlling the physical structure of the ecosystem" (World Resources 2000-2001, 141). Human activities and the built environment dominate the urban ecosystems, but they also contain vital green spaces, such as urban forests, parks and yards that softens the urban experience and provides invaluable recreation, relaxation and psychological benefits (World Resources 2000-2001, 145).

The demands placed on the urban ecosystems are increasing as the world population surpasses 6 Billion to 7.8 Billion in 2025, with 60% of that estimate living in urban centres, which will place high demands on the environment and resources. The influence of these demands reaches far beyond the confines of the city and has an impact upon the global ecosystem functioning. As such, the link between cities and sustainable development is direct. The World Commission on Environment and Development has defined sustainable development as the (Redcliff, 1999, 60):

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Landscape architects play an important role in sustainable development. This role and its relationship with sustainable development has been stated by the Canadian Society of Landscape Architects (CSLA) as follows (CSLA, 2001):

"Landscape architects commit to promoting sustainable development through creative landplanning and design of sites and their associated natural systems. These activities

should support and enhance local, regional, and global health, prosperity and equity for generations to come."

Landscape architects have a number of tools at their disposal in order to promote sustainable development. One such tool is the use of Global Information Systems (GIS). GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems (Korte, 1997, 401).

CITYgreen 4.0 is GIS software that has been developed by American Forests, which is the United States' oldest non-profit citizen conservation organization. Founded in 1875 by citizens concerned about the waste and abuse of their forests, their mission continues to be the improvement of the environment through the introduction of trees and forests (American Forests, 2001). The CITYgreen program performs an Urban Ecological Analysis (UEA) that provides a quantitative analysis of air quality, energy savings, storm water runoff, carbon storage and wildlife benefits of a city's urban forest. The results from the UEA can be used for management and design decisions made in accordance with enhancing the sustainable development of the city. A number of design solutions and decisions may be utilized and implemented to increase the sustainable development of a site, but this practicum chooses to focus on trees as being part of an urban design strategy towards achieving sustainable development. The reason for focusing on trees is because trees can improve air quality, increase energy savings, reduce water run-off, increase carbon storage and enhance wildlife benefits. All of this can be achieved by the simple act of planting trees.

The purpose of this practicum is to demonstrate one method of measuring and calculating sustainability with the use of the CITYgreen program by performing an UEA of Stephen Juba Park located east of the East Exchange District in Winnipeg, Manitoba, Canada. The UEA will be conducted by performing an assessment on the post-design

solution relative to the pre-design. By taking into account the air quality, the amount of water run-off, carbon storage and the wildlife benefits of the site, it is hoped that a valid assessment can be made. Energy savings will not taking into account in this relative assessment due to the non-existence of buildings on site.

The practicum objectives are to first to provide an understanding why the definition of sustainable development is a vague term. This vagueness is attributed to its complex overarching concept that encompasses the economy, environment, health and social well-being of people. The concept of sustainable development allows for the development of various methods and techniques to be utilized in order to calculate sustainable development and to determine how close we are from achieving set goals. Secondly, to demonstrate how GIS technology is a flexible and beneficial tool that can continue to be applied in the realm of landscape architecture. Thirdly, to provide an increased awareness to the political decision makers and the public of what the urban forest is, the benefits it provides and how CITYgreen can be used to determine some of these benefits towards the sustainable development of a city and its citizens. Lastly, to provide a methodology that can be applied to assess the benefits of a proposed design solution for a site.

Literature Review

The purpose of the literature review is to convey to the reader what knowledge and ideas have been established on the topics to be discussed, including their strengths and weaknesses. The ensuing sections of this proposal will provide information on the topic of Sustainable Development, stating its definition, future world trends and the role landscape architects play. Second is the topic of Geographical Information Systems (GIS), also stating its definition and basic characteristics, the history of its evolution, an overview of its users and the role it plays in landscape architecture. Following the GIS section, Urban Forestry will be described, including the history of urban forestry, the structure of the urban forest, government involvement, psychological affects and the role landscape architects have in influencing it. Finally, the methodology for undertaking this assessment will be explained with a site analysis, pre-design and post-design assessment and conclusions.

Introduction to Sustainable Development

The world's current population is 6.0 Billion with an estimated population for the year 2025 to reach 7.8 Billion. With increasing world population growth, stresses on the environment contribute to an increase in both consumption of resources and conversion of land. On average, a person in a developed nation consumes twice as much grain, twice as much fish, three times as much meat, nine times as much paper and eleven times as much gasoline as a person living in a developing nation (World Resources 2000-2001, 27). Population growth is highest in developing nations, especially with populations that rely on the land for survival (Figure 1) (World Resources 2000-

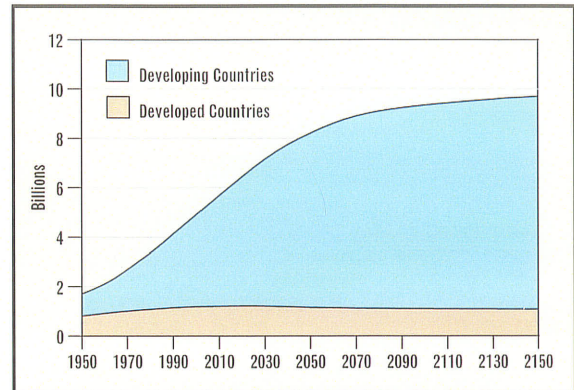


Figure 1. World Population Growth: 1950 to 2150. World Resources 2000-2001. *World Resources 2000-2001: People and Ecosystems: The Fraying Web of life*. Kidlington: Elsevier Science, 2000, p. 28.

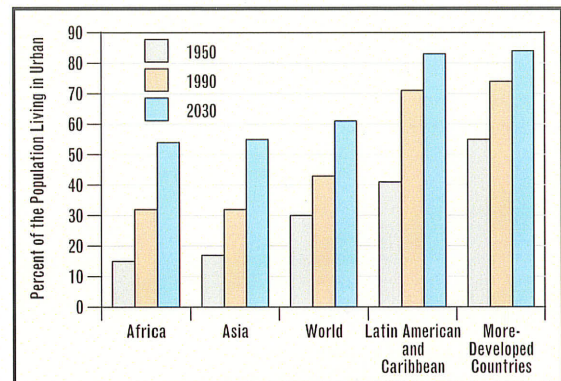


Figure 2. Trends in Urbanization: 1950 to 2030. World Resources 2000-2001. *World Resources 2000-2001: People and Ecosystems: The Fraying Web of life*. Kidlington: Elsevier Science, 2000, 28.

2001, 28). In developed and developing nations, cities populations are reaching greater levels of densities. The reason is because of greater opportunities for improved economic, education, and health resources. Cities are high consumers of natural resources and high producers of waste. By 2030, more than 60% of the world's population will be living in cities (Figure 2) (World Resources 2000-2001, 28). So, for our cities to be able to sustain the increasing populations in urban centres and the demands and consumption of resources, sustainable development policies will need to be adopted and implemented. The first major step towards this was the United Nations

Conference on Environment and Development (UNCED) that was held in Rio de Janeiro, Brazil in 1992, which produced an action plan and strategy titled "Agenda 21."

Agenda 21

Agenda 21 is an Action Plan and Strategy for the world's governments and citizens; and a compendium of environmental and economic problems and proposed solutions to these problems. This document is one outcome from the Earth Summit or the United Nations Conference on Environment and Development (UNCED) that was held in Rio de Janeiro, Brazil, during 1-12 June 1992. Ultimately, Agenda 21 is a greenprint vision for all – governments, non-governmental organizations, women's associations, indigenous groups, business and industry communities and constituencies, youth and seniors – to work together to help the Earth and its inhabitants survive by taking an integrated and holistic approach to the environment and development (Carroll-Foster 1993, 7).

Within Agenda 21, Chapter 7, titled Promoting Sustainable Human Settlement Development, attempts to bring together many issues of human settlement that have often been inadequately addressed. The main objective is:

"to improve the social, economic, and environmental quality of human settlements, and the living and working environments of all people, in particular the urban and rural poor" (Carroll-Foster 1993, 30).

These improvements require technical cooperation, partnerships between different players, and participatory decision-making. In Chapter 7, the sub-heading titled Improving Human Settlement Management, section 7.17 B) Strengthening Urban Data Systems states that:

"... all countries should undertake, with the active participation of the business sector as appropriate, pilot projects in selected cities for the collection, analysis and subsequent dissemination of urban data, including environmental impact analysis, at the local,

state/provincial, national and international levels and the establishment of city data management capabilities" (United Nations 1993, 55).

The application of the CITYgreen software falls under section 7.17 of Agenda 21, which is a pilot project that will collect, analyze, and distribute the data to the decision makers, designers, the public and aid in other aspects of how Winnipeg's urban forests are managed. This practicum will use the CITYgreen program to perform an Urban Ecological Analysis (UEA) that provides a quantitative analysis of air quality, storm water runoff, carbon storage, and wildlife benefits of a city's urban forest. The results from the UEA can be used for management and design decisions made in accordance with enhancing the sustainable development of the city.

The development of Agenda 21 came about through the UNCED process. UNCED was a successor to the landmark Stockholm Conference on the Human Environment (1972), which first put environment on the international agenda. The idea of holding a conference on environment and development arose from the World Commission on Environment and Development (or Brundtland Commission, named after Norway's Prime Minister, Gro Harlem Brundtland) held in 1986. At that time, the Commission advocated the need for the world to move towards sustainable development (Carroll-Foster 1993, 7).

Definition of Sustainable Development

The World Commission on Environment and Development - Brundtland Commission of 1987 has defined the concept of Sustainable Development as:

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Carroll-Foster, 7).

This definition has created some criticisms due to its simplicity. It is argued that the 'needs' of the present generation will vary with future generations, so 'development'

therefore plays a key role because 'needs' are directly linked to 'development' and vice versa. A more rigorous definition of 'needs' would need to specify, for example, the shifts in consumption that distinguish modern post-industrial societies (Redcliff 1999, 60).

This definition has also posed the question as to what should be sustained because what one society deems sustainable, such as air and open space, will be difficult to combine with a society that seeks increased material wealth, even at the expense of increased pollution. The answer to the above question can be answered by saying that present (or future) levels of production (or consumption) will need to be sustainable. The increasing population growth will lead to the increased demands on the environment, and the definition of sustainable development should incorporate this fact (Redcliff 1999, 61).

There has also been support for the definition despite its vagueness. Bert de Vries, a Dutch scientist stated, "Sustainability is not something to be defined, but to be declared. It is an ethical guiding principle." People are in favour of it, while retaining their individual definitions of what it actually means and conceding that they might be hard pressed to agree with others on how we may achieve it (Reid 1995, xvi).

How do we establish which course of development is *more* sustainable? The answer of allowing the societies to decide for on their own is not enough because who will make the decisions and from what basis will the decisions be made? (Redcliff 1999, 60). The Canadian and Provincial Governments answer to this question was the development a national task force and provincial round tables to develop strategies for the implementation of sustainable development principles.

Canadian Government's Role Towards Sustainable Development

When the World Commission on Environment and Development released its report, nations around the world initiated their own strategies for implementing

sustainable development practices. The Canadian government has set up a national task force in 1986 that supported the World Commission on Environment and Development and developed 40 recommendations for industry and government to develop and implement policies at integrating environmental and economic considerations into decision-making. In the recommendations was the development of national and provincial round tables on environment and economy (Sustainable Development Strategy for Manitoba 1998, 8).

The National Round Table on the Environment and the Economy (NRTEE) was legislated by Parliament in 1994. NRTEE is an independent advisory body that provides decision makers, opinion leaders and the Canadian public with advice and recommendations for promoting sustainable development. The members are distinguished Canadians appointed by the Prime Minister of Canada. They represent a broad range of sectors, including business, labour, academia, environmental organizations and First Nations (NRTEE-TRNEE About Us, 2002).

The NRTEE explains and promotes sustainable development by working with stakeholders across Canada. The NRTEE identifies key issues with both environmental and economic implications, examines these implications and suggests how to balance economic prosperity with environmental preservation (NRTEE-TRNEE About Us, 2002).

Their activities are organized into programs with each one overseen by a task force of NRTEE members and representatives from business, government and non-profit organizations (NRTEE-TRNEE About Us, 2002).

The responsibility of the task force is to commission research, conduct national consultations, report on agreements and disagreements, and recommend how to promote sustainability. The NRTEE reviews these reports and recommendations before approving them for public release. The NRTEE members meet quarterly to review progress, establish future priorities and start new programs (NRTEE-TRNEE About Us, 2002).

One of NRTREE's many current topic programs is Urban Sustainability. NRTREE defines Urban Sustainability as the enhanced well-being of cities or urban regions, including integrated economic, ecological, and social components, which will maintain the quality of life for future generations (NRTREE-TRNEE Urban Sustainability, 2002). The Urban Sustainability program aims to catalyze momentum toward alternative or more coherent strategies, based upon sustainable development principles, that improve the quality of life in and competitiveness of Canada's cities or urban regions (NRTREE-TRNEE Urban Sustainability, 2002).

Specific program objectives include (NRTREE-TRNEE Urban Sustainability, 2002):

- To determine a continued and expanded role for the federal government in the improvement of environmental quality in Canadian cities;
- To investigate through innovative research the potential application of Ecological Fiscal Reform (EFR) to urban issues;
- To identify for implementation by the federal government - and, if possible, provincial and municipal governments -- a number of specific policy (e.g., fiscal) measures that support improvements to urban environmental quality while realizing economic and social benefits;
- To develop a methodology for measuring environmental quality in Canadian cities;
- To encourage the adoption of best practices and processes in urban environmental management and economic development;
- To raise public awareness of and broad-based engagement in urban sustainability issues.

These objectives are being fulfilled through two tracks of research (NRTREE-TRNEE Urban Sustainability, 2002):

- Track 1 - EFR in support of urban environmental sustainability; and,
- Track 2 - Indicators of urban environmental quality.

In conjunction with NRTREE, each province created a Provincial Round Table to further establish sustainable development strategies that would be customized towards the provinces own social, environmental and economic goals.

Manitoba Government's Role Towards Sustainable Development

In 1988, the Manitoba government established the Manitoba Round Table on the Environment and Economy (MRTEE). MRTEE has adopted the goal of the implementation of the National Task Force recommendations on environment and economy and development of sustainable development strategies (Sustainable Development Strategy for Manitoba 1998, 8).

The vision for Manitoba is economic growth, which is environmentally sustainable. To assist in achieving this vision, 7 principles and 6 guidelines for sustainable development have been adopted. The principles and guidelines will be used to govern all the actions, activities and decisions associated with the implementation of this strategy (Sustainable Development Strategy for Manitoba 1998, 10).

Principles (Sustainable Development Strategy for Manitoba 1998, 12):

1. INTEGRATION OF ENVIRONMENTAL AND ECONOMIC DECISIONS
2. STEWARDSHIP
3. SHARED RESPONSIBILITY AND UNDERSTANDING
4. PREVENTION
5. CONSERVATION AND ENHANCEMENT
6. REHABILITATION AND RECLAMATION
7. GLOBAL RESPONSIBILITY.

Guidelines (Sustainable Development Strategy for Manitoba 1998, 13):

1. EFFICIENT USE OF RESOURCES
2. PUBLIC PARTICIPATION
3. ACCESS TO ADEQUATE INFORMATION
4. INTEGRATED DECISION-MAKING AND PLANNING
5. WASTE MINIMIZATION AND SUBSTITUTION
6. RESEARCH AND INNOVATION

In 1998, the MRTEE was changed to the Manitoba Round Table for Sustainable Development (MRTSD) (Manitoba 2000, 4). The MRTSD is an advisory body to the Manitoba Government that advises and supports decision-makers in making responsible resource, land use, environment, social and economic development decisions. The

MRTSD is an integral component of the provinces Sustainable Development Strategy (Manitoba 2000, 4).

The duties of the Manitoba Round Table, as legislated by *The Sustainable Development Act* are (Manitoba 2000, 5):

- Creating awareness and understanding of sustainable development;
- Cooperating with public-sector organizations, private industry, non-government organizations and the public to share knowledge and experience;
- Reviewing the principles and guidelines of sustainable development to ensure that they are comprehensive and contemporary;
- Advising on development and review of sustainability indicators;
- At the request of the minister, reviewing existing or proposed policy, legislation, regulations or programs for consistency with the principles and guidelines, and reporting to the minister with recommendations;
- Establishing mechanisms for monitoring and evaluating implementation of sustainable development strategies and activities; and
- Other tasks and activities related to sustainable development, at the request of the minister.

City of Winnipeg's Role Towards Sustainable Development

The City of Winnipeg will commit to sustainable development by (Winnipeg 2000, 22):

- Establishing and adhering to a set of guiding principles for sustainability against which policy decisions and actions can be evaluated;
- Monitoring and reporting on quality of life indicators which assess the balance between social, environmental, and economic goals for the City of Winnipeg; and
- Providing opportunities for full public information and meaningful public participation regarding the City's quality of life indicators and guiding principles for sustainability.

Characteristics of Sustainable Urban Development

In order for a city to begin the implementation of sustainable development principles and policies, the city first needs to meet its citizen's social, environmental, political, cultural objectives, including economic and physical ones. This can be achieved by a city becoming (Rogers 1998, 167):

- A Just City where justice, food, shelter, education, health and hope are fairly distributed and where all people participate in government;

- A Beautiful City, where art, architecture and landscape spark the imagination and move the spirit;
- A Creative City, where open-mindedness and experimentation mobilizes the full potential of its human resources and allows a fast response to change;
- An Ecological City, which minimises its ecological impact, where landscape and built form are balanced and where buildings and infrastructures are safe and resource-efficient;
- A City of Easy Contact and Mobility, where information is exchanged both face-to-face and electronically;
- A Compact and Polycentric City, which protects the countryside, focuses and integrates communities within neighbourhoods and maximises proximity;
- A Diverse City, where a broad range of overlapping activities create animation, inspiration and foster a vital public life.

It has been argued by some that the form of the city can also be used to achieve sustainable urban development. The first is that the city should be compact from core to edge, with large concentrated centres like a medieval city or town – in which case the overall dimensions of such a city may have to be relatively small if good access to open space outside the city for recreational and other purposes is to be achieved (Figure 3a) (Frey 1999, 29).

A potential environmental impact to increasing urban development and densities may begin to limit space for greenery in cities, including trees and shrubs. If the increase in urban development is not carefully managed, it may lead to a loss in urban greenery; but if

landscaping and planting are given priority by developers, planners, and landscape

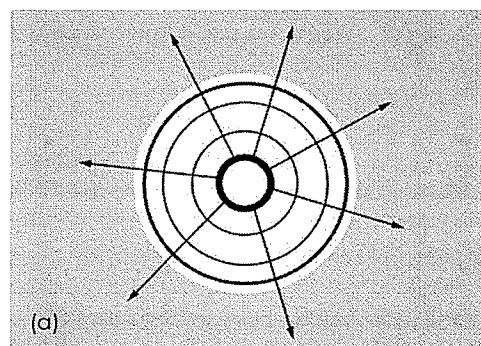


Figure 3a. Alternative forms of sustainable cities: large concentrated center. Frey, Hildebrand. *Designing The City Towards A More Sustainable Form*. New York: Routledge, 1999, 28.

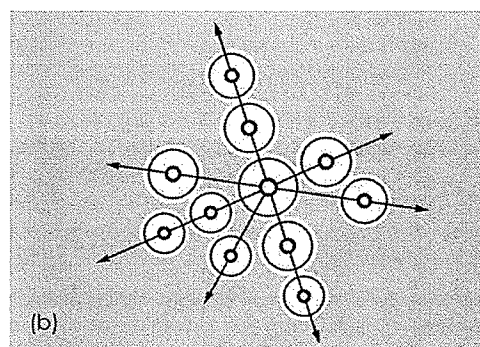


Figure 3b. Alternative forms of sustainable cities: decentralized but concentrated and compact settlements linked by public transport. Frey, Hildebrand. *Designing The City Towards A More Sustainable Form*. New York: Routledge, 1999, 28.

architects from the outset of proposed developments, and polices outline standards, then the losses can be minimized (Williams, 2000, 36).

Others seem to suggest that the city may consist of different compact settlements, which are decentralized but linked by public transport, in which case the open space may be in between the settlements (Figure 3b). The distance between such settlements may vary according to their degree of independence and self-sufficiency (Frey 1999, 29).

Another important aspect to consider in sustainable urban development is the ecology of the city and its relationship to the countryside. Ecologists and environmentalists' main arguments in achieving sustainable urban development are that we cannot only focus on solving the problems of:

- Wasting energy and materials by behavioural changes;
- Pollution and congestion by introducing clean energy; and
- Promoting more energy-efficient public transport, or walking and cycling as alternative modes of transportation.

It's not to say that these are not important, but the relationship of the city to the countryside also changes fundamentally (Frey 1999, 29).

As our cities become polluted and congested:

"Urban society now takes refuge in the countryside in search of fresh air and the natural surroundings that are denied at home. Consequently, unsustainable pressures are placed on environmentally sensitive landscape. The advancing city has often replaced complex natural environments of wood, streams and fields with biologically sterile manmade landscapes that are neither socially useful nor visually enriching" (Hough 1984, 2).

Hough argues further that the city incorporates vast areas of idle and unproductive land. Urban drainage, sewage disposal and other processes contribute to the pollution loads. Parks are determined by horticultural science, not ecology. What is needed is the application of ecology to the process of designing a city. Traditional

urban design has contributed little to the city's environmental health, nor has it created civilising, enriching places to live in (Frey 1999, 29).

The main cause of this is that the past symbiotic relationship between the city and country no longer exists, that city and country have become mutually exclusive. This can be reversed by what we consider waste as a useful resource. Girardet will further examine this issue in the *Cities Metabolism* following section (Frey 1999, 29-30).

Green wedges and woodland parks and natural forests in cities are, or can be if managed properly, more than green lungs or places for recreation (Hough 1984, 148-9):

- They allow interaction of urban and natural processes;
- They play a role in the maintenance of the water regime;
- They play a role in the modification of climate;
- They are outdoor laboratories for teaching forestation;
- They provide timber as alternative fuel, specifically when old trees need to be taken out.

An open space strategy must therefore be part of the design framework for a city to be sustainable. Just as important as compact neighbourhoods and districts with services and facilities in their cores, open spaces need to be accessible by foot, bicycle and short public transportation routes. They also need to be part of a sustainable urban development program of a city, just as much as traffic-calmed streets within development clusters, mixed-use areas and public transport. A city must be sustainable functionally, economically and socially but also environmentally. None of these concerns can be left out in the search for a sustainable city form and structure (Frey 1999, 30-31).

Cities Metabolism

Cities, like other assemblies of organisms, have a definable metabolism, consisting of the flow of resources and products through the urban system for the benefit of urban populations. Given the vast scale of urbanization, cities should begin to model

themselves on the functioning natural ecosystems, such as forests, to assure longterm viability. Nature's ecosystems has essentially circular metabolism in which every output which is discharged by an organism also becomes an input which renews and sustains the continuity of the whole living environment of which it is a part (Girardet 1992, 32).

In a city with a circular metabolism every output can be used as an input into the production system, thereby affecting a far smaller area (Figure 4). Sewage systems can stop being disposal systems for the noxious mixture of household and factory liquid wastes. Toxic liquid wastes are kept separate from "valuable" household sewage and washing powders, cleaners, and bleaches are fully biodegradable. Sewage works are designed to be fertilizer factories rather than as disposal systems for unwanted, often poisonous, discharges. Liquid chemical wastes from factories are treated separately or no longer used, encouraging companies to invest in recycling technology and non-toxic production processes. Household and factory rubbish is regarded as an asset rather than an encumbrance and recycling is integral to the functioning of cities rather than an optional 'add on' feature (Girardet 1992, 23).

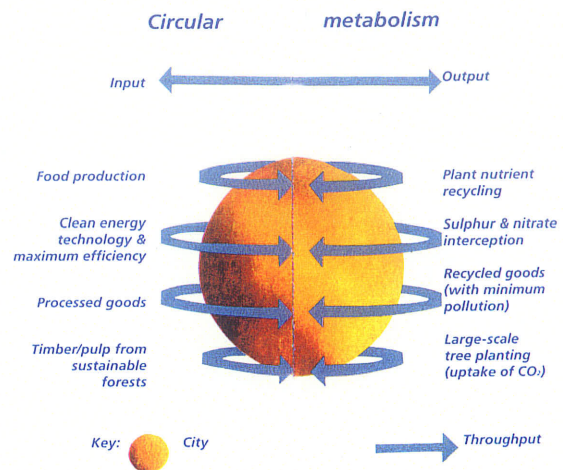


Figure 4. Circular Metabolism.
Girardet, Herbert. *THE GAIA ATLAS OF CITIES: New directions for sustainable urban living*. New York: Doubleday, 1992. p. 23.

and bleaches are fully biodegradable. Sewage works are designed to be fertilizer factories rather than as disposal systems for unwanted, often poisonous, discharges. Liquid chemical wastes from factories are treated separately or no longer used, encouraging companies to invest in recycling technology and non-toxic production processes. Household and factory rubbish is regarded as an asset rather than an encumbrance and recycling is integral to the functioning of cities rather than an optional 'add on' feature (Girardet 1992, 23).

The metabolism of most modern cities, in contrast, is essentially linear, which functions by acquiring resources from vast areas, with little or no thought for the consequences, and disposes of the waste (Figure 5). The input of resources is unrelated to the output. Nutrients are removed from the land as food is grown and never to be returned. In some parts of the world, timber is harvested for construction and/or pulp

without, or very little, reforestation occurring. Raw materials are extracted, combined and processed into consumer goods, resulting in waste that cannot be beneficially reabsorbed into nature. Fossil fuels are extracted at unprecedented quantities or pumped out from the rock strata and refined, burned and released into the atmosphere. As a result, our

present urban-industrial civilization is accelerating environmental destruction with, as yet, hardly imagined consequences for the future of life on Earth (Girardet 1992, 23).

The linear metabolism model of urban production, consumption and disposal is unsustainable and undermines the overall ecological viability of urban systems, for it has the tendency to disrupt the natural cycles. On a planet that is increasingly becoming urban, cities will need to adopt circular metabolic systems to assure their long-term viability and the increasing dependence on the rural environments on which urban productivity depends on. To improve the urban metabolism, the application of ecological system thinking needs to become prominent on the urban agendas. Outputs will also need to be inputs into the production system, with routine recycling of paper, metals, plastic and glass, and the conversion of organic materials, including sewage, into compost, returning plant nutrients back to the farmland that feeds the cities (Girardet 1992, 34).

The transformation from a linear to a circular metabolism will mean that the city has to become an ecosystem in symbiosis with the countryside (Frey 1999, 30).

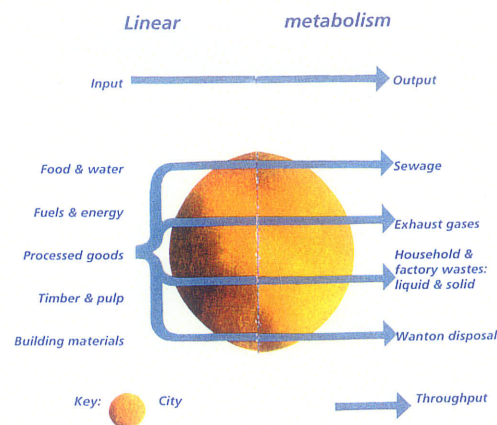


Figure 5. Linear Metabolism.
Girardet, Herbert. *THE GAIA ATLAS OF CITIES: New directions for sustainable urban living*. New York: Doubleday, 1992. p.23.

Role of Designers in Sustainable Development

Cities all over the world are constructing new infrastructure in order to sustain the increasing populations, but at what cost? "People don't always act in the way city planners expect them to act, and behaviour and attitudes are important factors that need to be taken into account in the city-planning process" (Kessler 1996, 68).

"... it is vital that architects, designers, city planners and others involved in the planning and construction of new buildings, etc. form links with the other fields of science in joint efforts to ensure sustainable city development "(Kessler 1996, 69).

The Canadian Society of Landscape Architects (CSLA) has finalized their Sustainability Declaration. The CSLA is committed to the promotion of sustainable development by developing principles, goals, and strategies for landscape architects to follow. Members of the CSLA have identified preservation and restoration of natural systems as central to their professional concerns (CSLA 2002).

Fundamental Principles

- Healthy landscapes are essential to the well being of all life on earth;
- Sustainable development must address economic development, environmental biodiversity and community; and
- Landscape Architects are committed to the development of responsible practice and construction standards, which contribute to the health of natural systems, cultural identity and economic prosperity.

Goals

- To support the integrity of a site, its residents, and its surroundings;
- To advocate responsible design, planning, management and policy decisions with a view to long term implications; and
- To use materials, technologies and techniques which respect the environment.

Action Strategies

- Protect, conserve and restore the ecosystem;
- Promote biodiversity;
- Advocate environmentally-friendly modes of transportation;
- Promote collaboration in community planning, design and management;
- Encourage local, provincial, national and international partnerships that promote healthy world ecosystems;

- Support the development of laws, regulations, standards and guidelines that foster sustainable development; and
- Support continuing professional development that effectively serves the environment.

Activities and advancements in sustainable development have been made and

"... many architects, builders, and others are already looking for alternative materials and technologies that will create economically viable, healthy, efficient and environmentally-sound buildings. Energy consumption, natural-resource use, and pollution prevention are rapidly becoming fundamental parts of city planning and construction" (Kessler 1996, 68).

Landscape architects are skilled in the art of analysing and balancing diverse and often-conflicting interests. The challenge now is to take these skills and begin to incorporate the sustainable development principles and policies into the day-to-day practice. For the landscape profession to develop standards towards sustainable development, consideration will need to be given to the creation and adoption of a formal system for assessing and raising standards of environmental performance (Herrmann 2000, 233).

A technological design tool that can be utilized for assessing environmental performance in achieving sustainable development is the utilization of the CITYgreen program in performing an U.E.A. This GIS program can aid designers and planners on the current state of the city's urban forest and how a proposed design solution(s) and decision(s) may affect the area under consideration and the city as a whole. The data generated by the CITYgreen program can therefore be used to determine if existing and future designs and policies are achieving the established sustainable development guidelines for the city.

Sustainable Development Summary

In summary, with the world's urban population increasing, the demands placed upon our cities and resources will coincide. The United Nations (UN) has seen this as a worldwide concern and has responded by developing a report titled Agenda 21.

Agenda 21 is an action plan and strategy for the world's governments and citizens of environmental and economic problems and proposed solutions to these problems (Carroll-Foster 1993, 7).

Within Agenda 21, an initiative for Improving Human Settlement Management requires the collection, analysis and dissemination of various types of urban data. CITYgreen is such a program that can be used to collect urban data in relation to a city's urban forest.

Prior to the development of Agenda 21, in 1986 the World Commission on Environment and Development (Brundtland Commission) advocated the need for the world to move towards sustainable development. This commission defined Sustainable Development as:

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Carroll-Foster, 7).

With this definition came criticisms that were against and in support of this definition. Criticisms against the definition were that it was simple and did not specify as to what should be sustained (Redclift 1999, 60). In contrast, supporters of the definition stated that it "is not something to be defined, but declared. It is an ethical guiding principle" (Reid 1995, xvi).

For a city to implement sustainable development principles, guidelines and policies:

- A city has to refer to the proposed and/or existing principles, guidelines and policies that have been developed by their various levels of government. There is the Federal (NRTEE), Provincial (MRTSD) and Municipal (City of Winnipeg);

- According to author Richard Rogers, a city needs to meet its citizen's social, environmental, political, cultural objectives, including economic and physical ones;
- A city has to choose a form. A large concentrated center, a decentralized but concentrated and compact settlements linked by public transport, or a combination as recommended by author Hildebrand Frey;
- A city has to re-establish its symbiotic relationship with the country side and develop an open space strategy as supported by authors Michael Hough and Hildebrand Frey; and
- A city has to begin to make the transition from a Linear Metabolism to a Circular Metabolism, according to author Herbert Girardet.

Landscape architects also have an important role in developing, implementing and promoting Sustainable Development principles, guidelines and policies. The Canadian Society of Landscape Architects (C.S.L.A.) has developed a Sustainability Declaration that is committed to the promotion of sustainable development by developing principles, goals and strategies for landscape architects to follow (CSLA 2002).

Sustainable Development does have conflicting social, environmental and economic interests. Landscape architects are skilled in the art of analysing and balancing diverse and often-conflicting interests. The challenges now for landscape architects is to apply these skills and begin to incorporate sustainable development principles, guidelines and policies into the day-to-day practice (Hermann 2000, 233).

Landscape architects also need to consider how to create and adopt a formal system for assessing and raising standards of environmental performance (Herrmann 2000, 233). Once such tool is the application of a GIS program titled CITYgreen in performing an Urban Ecological Analysis (UEA). CITYgreen can generate data for designers and planners on the current state of a city's urban forest and inform on how future design solutions and decisions may affect it. The data and results generated can also be used to determine if existing and future designs are promoting and adhering to a

Sustainable Development

city's current sustainable development guidelines and policies or will require the development of additional ones.

Geographic Information System (GIS)

Definition of GIS

The definition of a Geographic Information System (GIS) is a system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems (Korte 1997, 401).

Data and Information

In the definition of GIS, the word "data" is mentioned. Many people may interchange "information" and "data" as if they were synonyms, but that is not the case especially when dealing with GIS. The word "data" refers to a collection of facts or figures that are linked to places, people, things, events and concepts. The facts and figures can generally be represented as numerical values, alphanumeric characters, symbols and signals. When the data are transformed – by processes such as structuring, formatting, conversion and modeling – to more useful form of output, it is then referred to as "information" (Figure 6) (Lo 2002, 2).

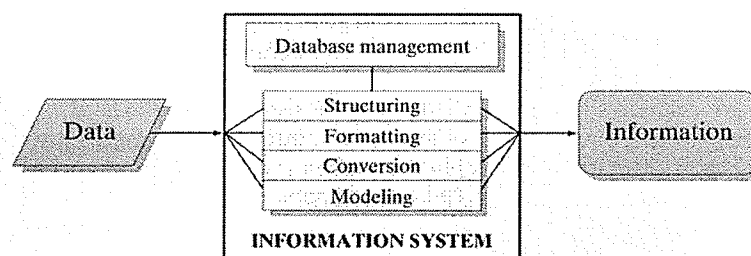


Figure 6. Transformation of data into information using an information system. Lo, C.P., Yeung, Albert K.W. Concepts and Techniques of Geographic Information Systems. Upper Saddle River, New Jersey: Prentice-Hall, Inc., 2002, p. 3.

The conversion of data into information is performed by the user to raise his/her knowledge to a certain level specific for decision-making purposes. When the user

applies this knowledge to form relationships, principles and include personal values and beliefs, he/she develops intelligence (Lo 2002, 3).

Geographic information helps to understand the world around us. It empowers us to develop spatial intelligence for performing logical decision-making. Therefore, any definition of GIS should include not only the data processing, but the analytical capabilities for obtaining spatial knowledge and intelligence as well (Lo 2002, 3).

GIS as a System

Also in the definition of GIS, the word "system" is used and in different contexts means different things. It can be used to describe physical entities, such as "solar system," the "Red River drainage basin ecosystem" and the "human immune system." It can also be used to describe conceptual entities, such as the "democratic system," "free market system" and "client/server computing system" (Lo 2002, 3). All systems, regardless of physical or conceptual, have in common the following characteristics (Lo 2002, 3):

- They are formed or constructed to achieve certain basic objectives or functions;
- Their continuing existence depends on the ability to satisfy the intended objectives – if this ability fails or starts to decline, the system concerned must be upgraded or replaced;
- An individual system is composed of many interrelated parts, which may be operational systems themselves; and
- These parts operate individually and interact with one another according to certain rules of conduct, such as procedures, laws, contractual agreements, and accepted behaviour.

Information systems, when viewed from a functional perspective, are set up to achieve the specific objectives of collecting, storing, analyzing and presenting information in a systematic manner. Structurally the information system has interrelated components that combine data, technical and human resources (Lo 2002, 3).

GIS, a Spatial Information System

The word "geographic" in GIS has two meanings: "Earth" and "geographic space." By "Earth," it implies that all the data in the system are related to the Earth's features and resources, including human activities based on or associated with these features and resources. By "geographic space," it means that the commonality of both the data and the problems that the systems are developed to solve geographically, i.e., location, distribution, pattern and relationship within a specific geographical reference framework (Lo 2002, 4).

The relationship between GIS and other types of information systems is represented in Figure 7. Depending on the nature of the data being processed, information systems can be classified as spatial information systems and non-spatial information systems. Non-spatial information systems are designed to process data that is not referenced to any position in geographic space, such as accounting, banking, human resource management and inventory of goods. Spatial information systems are those designed for processing data pertaining to real-world features or phenomena that are described in terms of locations (Lo 2002, 3).

Spatial information systems that are used for processing and analyzing geographic data can be labelled as GIS. Geographic data are a special form of spatial data that are characterized by two crucial properties (Lo 2002, 5):

- The reference to geographic space, which means that the data are registered to an accepted geographic coordinate system of the Earth's surface, so that data from different sources can be spatially cross-referenced and integrated; and
- The representation at geographic scale, which means that the data are normally recorded at relatively small scales and, as a result, must be generalized and symbolized.

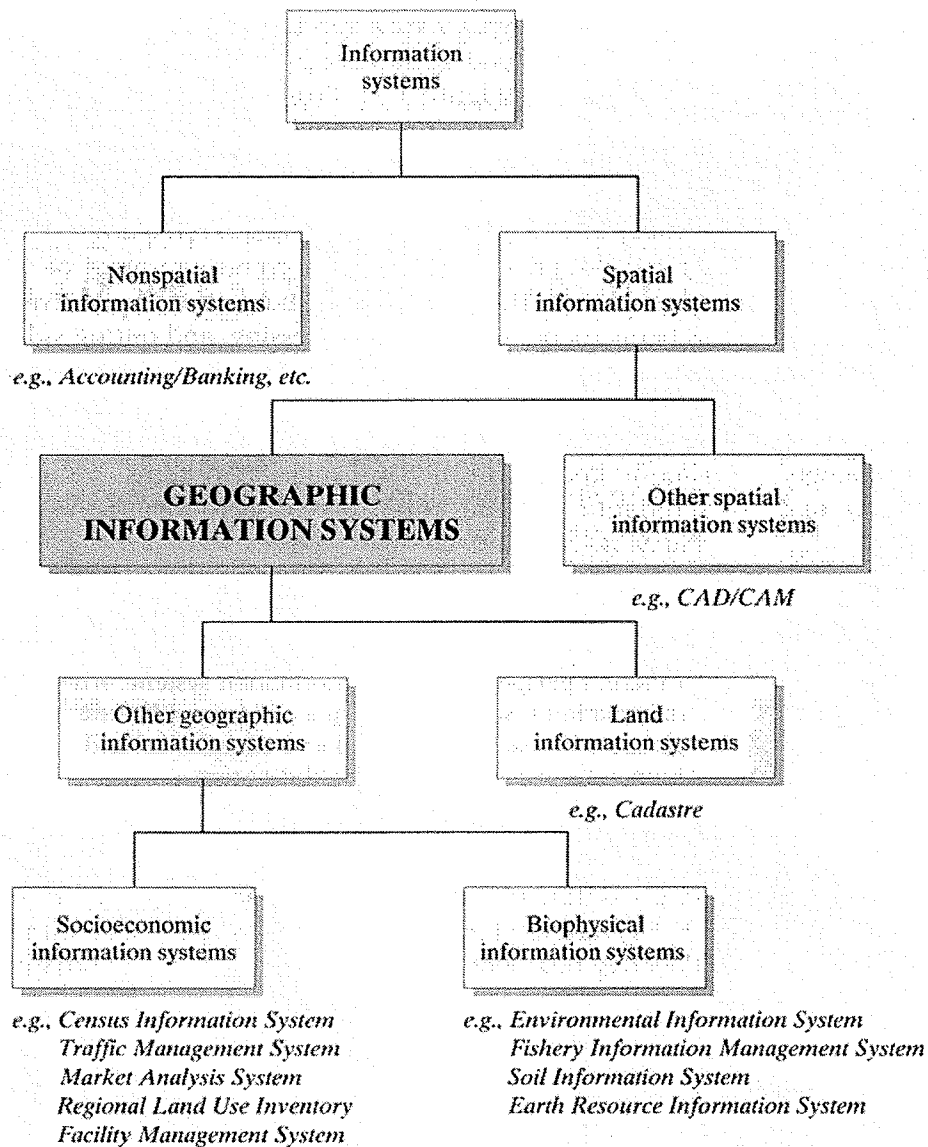


Figure 7. Typology of information systems.

Lo, C.P., Yeung, Albert K.W. Concepts and Techniques of Geographic Information Systems. Upper Saddle River, New Jersey: Prentice-Hall, Inc., 2002, p.4.

GIS, What is it?

In a GIS, objects are referenced on an X-Y coordinate system. The diverse map features are then separated into layers or themes. The objects are described in terms of an identity type, geometric elements, attributes, relations and qualities. Therefore no two objects can retain the same identity (Bernhardsen 1999, 42) and the object's features

can therefore be thought of as the computer's "knowledge" of the object (Bernhardsen 1999, 43). These features related to the graphic data are then stored in a separate database (Korte 1997, 29). A unique feature of a GIS is that it can handle all of the data from these files and treat them as though they were one "seamless" map file (Figure 8) (Korte 1997, 29).

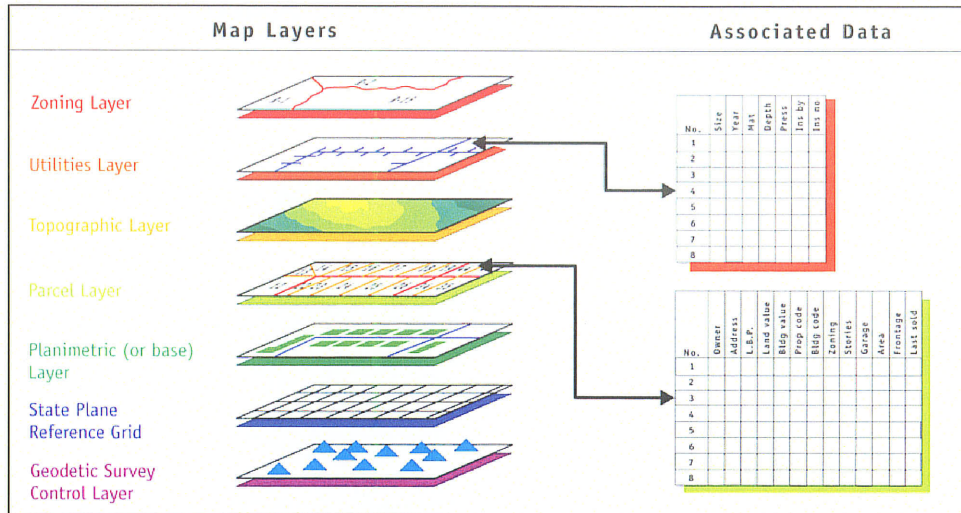


Figure 8. Map layers in a GIS.

O'Looney, John. *Beyond Maps: GIS and Decision Making in Local Government*. United States of America: Environmental Systems Research Institute, Inc., 2000, p.62.

The graphical representation of objects can be simplified into three terms:

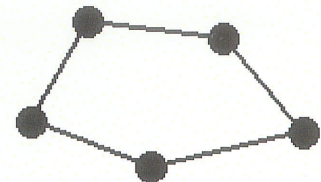
1. A *point* is the simplest graphical representation of an object. Points are non-dimensional but can be displayed by the use of symbols. Examples of a point can be cities, structures or trees.
2. *Lines* (Vectors) connect at least two points. They are used to represent objects that may be defined in one dimension. Examples of *lines* are paths, roads or utility lines.
3. *Areas* are used to represent objects that are defined in two dimensions. They are delineated by at least three connecting lines, which are comprised of points. Examples of areas are parks, golf courses and neighbourhoods. In databases, areas are usually referred to as *polygons*, and so this term is used instead of area (Bernhardsen 1999, 43-44).



1. Point (non-dimensional)



2. Lines (one dimensional)



3. Area (two dimensional)

and environmental protection. NEPA is regarded as the most significant factor in the growing use of GIS in the United States' federal agencies. The increasing involvement of national governments in issues of land management occurred not only in North America, but also internationally (Foresman 1998, 10).

The use of GIS in the military, particularly by the US Department of Defence (DOD), has also aided in the further advancement of GIS technology. These advancements include the collection of satellite imagery, remote sensing, photo interpretation and Global Positioning Systems (Hanna and Culpepper 1998, 17).

The involvement of universities in the development of GIS also began in the late 1950s. The universities that were integral in advancing GIS theories included the University of Washington, Northwestern University, University of Chicago, and Harvard University. Their contributions consisted of the fundamental development of spatial and cartographic theories (Foresman 1998, 13).

GIS Users

The users of GIS can be broken down into four general categories as shown in Figure 10: GIS Managers, GIS Users, GIS Viewers, and GIS Browsers.

- *GIS Managers* are the people that set access privileges, manage individual systems and the GIS databases, and maintain primary contact with vendors. They frequently perform the functions of a GIS user, as well as use "one-of-a-kind" GIS software tools (Korte 1997, 57).
- *GIS users* maintain GIS data and use it to perform various levels of analysis. They also may create quality cartographic maps (Korte 1997, 58).
- *GIS viewers* perform activities that view and query GIS data, but do not perform any editing to the data. They might create and plot simple thematic maps using GIS data (Korte 1997, 58).
- *GIS browsers* occasionally view GIS data on the Internet or the organizations LAN (Local Area Network). They are generally looking only for information content or links to other related web sites (Korte 1997, 58).

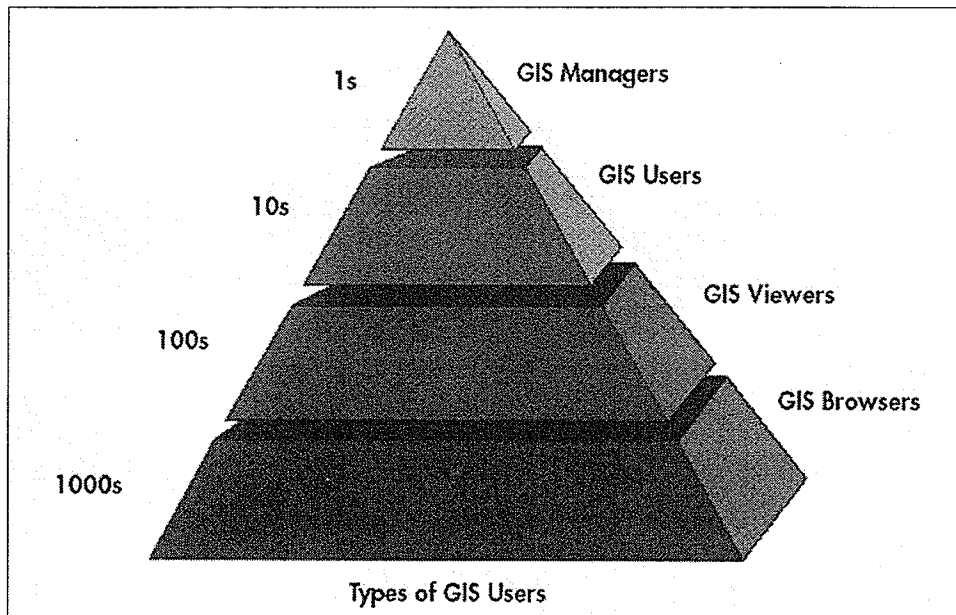


Figure 10. Types of GIS users.

Korte, George B. *The GIS Book*, 4th ed. Santa Fe: OnWord Press, 1997, p.57.

The use of GIS occurs in a number of different professions is indicated in Figure 11. The majority of GIS users are in scholastic or government organizations. This is in keeping with the historical evolution of GIS, which has had its initial usage by government organizations and universities.

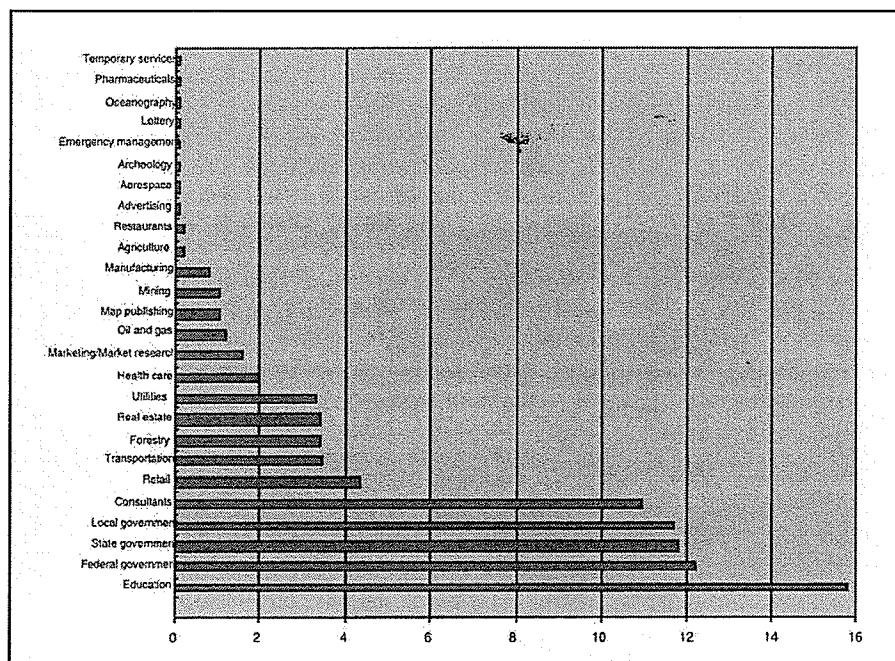


Figure 11. Percentage of GIS users based on profession.

Korte, George B. *The GIS Book*, 4th ed. Santa Fe: OnWord Press, 1997, p.59.

GIS use in Landscape Architecture

In the field of land planning, one of the most important developments occurred in the mid-1960s with the work performed by Ian McHarg for the Ford Foundation at the University of Pennsylvania. Though his technique did not involve the use of computers, it provided the basis for most computerized models used for land planning around the world. This method revolutionized the future of land planning in that it assigns values to themes. A particular attribute is assigned a value that is a measure of the ability of that condition to accommodate a particular use (Hanna and Culpepper 1998, 14). Each value is then represented by a tone or shade on acetate sheets, which are then assembled and laid on top of one another. The darkest areas show the most suitable locations for the proposed use. This process is the origin of the term *suitability mapping*. The method was then quickly adapted and applied to computerized Geographic Information Systems and is still being applied today.

In the early 1970s, landscape architects and planners were at the forefront of GIS development and its use. Unfortunately, over the last twenty-five years, there has been a steady decline in its use by landscape architects. Scientists and engineers have now become the leaders in the development of GIS technology. For landscape architects to become more effective designers and advocates for the environment, they must make use of all the tools available to them, including the use of GIS (Hanna and Culpepper 1998, 19).

Today's landscape architectural firms are beginning to use GIS in a variety of applications, such as: site design, recreation master planning, visual analysis, comprehensive planning, resource management and public advocacy (Hanna 1999, 3). The use of GIS by landscape architectural firms can be attributed to the recent development of powerful and fast processing desktop computers capable of handling extremely large data sets; a wider selection of inexpensive, easy-to-use GIS software; and

the availability of spatial data for free or at minimal cost that can be collected by taking advantage of the internet (Sipes 1997, 82). Also with the increasing environmental awareness by the public and private organizations and with fiscal changes, accountability has become an important aspect of the profession. It is not enough to prepare creative design solutions, or comprehensive plans that incorporate many points of view; landscape architects are required to provide quantifiable proof that the design solutions created will yield ecological, economic, functional, and scenic benefits (Hanna 1999, 1). Landscape architects can now show how their creative designs solutions and can be accountable to environmental concerns by the public and private organizations by utilizing a GIS.

GIS Advantages for Landscape Architects

Landscape Architects have experienced positive responses from computer generated drawings and maps over hand-drawn drawings and maps from the clients. Clients have developed a perception of "if it was drawn by a computer, then it must be correct" mentality. This perception is false because many clients are not always aware that there can be mistakes in the data used to generate the drawings and maps. Even though this may be true in some instances, the majority of the landscape architects do agree that computer generated drawings and maps will receive less scrutiny than hand drawn drawings and maps (Hanna et al. 1998, 104-105).

One overall advantage of using GIS is the ability to combine complex and contrasting types of information in problem solving. This has proven to be beneficial where input from multidisciplinary teams can be merged and manipulated (Hanna et al. 1998, 107).

With current GIS software titles, computer aided design and drafting (CADD) files, for example AutoCAD files, can be imported into GIS programs. For example, CADD files,

such as infrastructure, trees, or building footprints can be imported and used with GIS raster or vector data such as soil types or population census data. This ability of GIS software to import CADD files has been regarded as a positive benefit by landscape architects (Hanna et al. 1998, 108).

The ability to perform "what if?" scenarios, which can be performed quickly and inexpensively, have been considered advantageous. Clients are impressed by the capability of generating "what if?" scenarios. The measuring and reporting functions included in GIS software can give quantities of any mapped condition for analysis, which can then be used to generate cost estimates, yields or carrying capacities (Hanna et al. 1998, 108). CITYgreen has the capability of running various "what if?" design and management scenarios for a city's urban forest.

Another advantage is the ability to change the output image. The scale of the maps can be correct to fit the appropriate paper size. Colour tables, labels and lines can be changed. The images generated in the GIS program can also be exported as an image file into a graphic software application, such as Adobe Photoshop, for finishing (Hanna et al. 1998, 108).

GIS Disadvantage for Landscape Architects

The major disadvantage experienced by landscape architects is with the actual data. When accurate data are made available, analysis and mapping can be completed, but high costs are associated with it. When data is not available, or has inconsistencies, GIS can become difficult to use and can raise doubts among all the design professionals (Hanna et al. 1998, 108). The data suppliers see the provision of data quality as a luxury rather than as a necessity. This is partly caused by the high costs of collecting and maintaining the data and to the difficulty of obtaining data quality information from existing data sets. Many geographic data sets are being used today

with incomplete or no data quality information. Even when quality data are provided, the lack of standards for documenting the information makes it difficult for users to find the data and determine if they are suitable (Lo 2002, 422-423). Until these shortcomings are resolved, GIS users will continue to stay "data-rich and information poor" (Lo 2002, 443).

GIS and Sustainable Development

GIS technology, with its ability to integrate various social, economic, and environmental factors for decision-making use, is a practical tool for achieving the transition to sustainable development (Wiken et al. 1992, 55).

To balance economic development, social development and environmental integrity, it is necessary to adopt an ecosystem approach. With such an approach stresses a holistic view of ecosystems, it can focus on complexities and interconnections, recognize the dynamic nature and infinite of ecosystems, and foster collaboration among all those whose activities affect ecosystems (Wiken et al. 1992, 55).

Foundation. Approaching sustainable development requires the capability to gather information from a variety of sources and bring them together and make it accessible for all the interested parties. A GIS provides the foundation for splicing the world together and for merging the disparate blocks of information held by various groups and agencies (Wiken et al. 1992, 55).

Unifying Force. GIS technology supports a holistic view. To effectively demonstrate an ecosystem perspective, GIS capabilities must be closely tied to basic operations or research, monitoring, analysis, interpretation and reporting. They should direct and modify the way we organize and evaluate information (Wiken et al. 1992, 55).

Leadership/Innovation. The role of GIS has a common heritage with interdisciplinary sciences such as ecology. The application of GIS has allowed many

groups to maintain leadership in environmental management. The extended use and development of GIS technology will continue this leadership tradition (Wiken et al. 1992, 56).

Relationships. To achieve environmentally responsible decision making, a sound understanding of ecosystem relationships is essential. Our current level of ecosystem understanding is limited, and GIS overlays and modeling techniques are fundamental to illustrate ecosystem functions and processes (Wiken et al. 1992, 56).

Alliances/Collaboration. Single agencies or departments cannot achieve an ecosystem or sustainable approach. In building a comprehensive and integrated information platform, GIS's can serve as the neutral base around which alliances can form to address complex environmental problems. Making the information accessible and integrated on a GIS will provide a means to extend collaborative efforts (Wiken et al. 1992, 56).

Balance. Balanced management and credibility often are difficult to achieve because of knowledge deficiencies or administrative bias. We know a fair amount about air, water, and geology, but a lot less about forest, agricultural, wetland and urban ecosystems. GIS databases can help identify these deficiencies and influence future ecosystem monitoring to address such imbalances (Wiken et al. 1992, 56).

Symptoms vs. Structure. Most agencies suffer from over-reliance on crisis management of symptomatic problems. GIS capabilities should help us focus on fundamental structural issues related to the ways ecosystems function. GIS technology should help us achieve a status where a strategy of anticipation and prevention can be constructively utilized (Wiken et al. 1992, 56).

Spatial and Temporal Characteristics. It is difficult to obtain good long-term trend information at present. However, data and monitoring gaps should be identified and agencies should begin to address the voids. Over the long term, ecosystem research,

monitoring and GIS technologies will help us address deficiencies in knowledge and provide a more complete record of environmental conditions and trends. This will help to facilitate improved interpretation and assessment of environmental conditions (Wiken et al. 1992, 57).

Without GIS, the notion of achieving sustainable development through ecosystem integrity would be academic. The tasks typically are broad in scope, geography and detail. A technical mechanism such as a GIS is suited to the sustainable development vision and ecosystem reality, and thereby is essential to environmental management (Wiken et al. 1992, 57).

My Community, Our Earth

A worldwide initiative called My Community, Our Earth (MyCOE) was organized to build a geographically literate generation able to use this knowledge in their everyday lives to bring about true sustainable development in 2002 (Figure 12). The goal was to offer the opportunity for students and international leaders to discover and address real issues in their communities and around the world. The objectives of the program are to (MyCOE, Goals, 2003):

- Conduct an international student project at the high school and university levels to advance geographic learning and to help demonstrate approaches to sustainable development;
- Give students a medium to learn about and to present current sustainable development issues to international leaders;
- Raise awareness internationally of the importance of geography and geographic information system (GIS) technology in dealing with issues of sustainable development; and
- Present results using maps, images, and graphs at international events in 2002 such as the World Summit on Sustainable Development, which was held September 2002 in Johannesburg, South Africa.



Figure 12. MyCOE promotional poster by ESRI.

ESRI. "MyCOE Poster." ESRI: n. pag. Online. Internet. 15 Mar. 2003. Available: www.esri.com/events/wssd/mycoe.html.

The program was deemed successful with submissions from 24 countries around the world. There were more than 200 individual students and student teams who had assistance from 500 volunteer mentors. The suggested project themes addressed sustainable development and are listed below (MyCOE, Suggested Project Themes, 2003):

- Biodiversity
- Climate Change
- Deforestation
- Environmental Pollution
- Food Production
- Freshwater Supply
- Health and Disease
- Mountain Development
- Poverty Reduction
- Rural Development
- Urbanization

A panel of authorities on geography and sustainability reviewed these projects, selecting the top 30. Ten projects were then selected by the MyCOE judges for display at the World Summit on Sustainable Development, which occurred in September 2002 in Johannesburg, South Africa (MyCOE, Students Change the Way We See Our World, 2003).

The Association of American Geographers, National Geographic Society, ESRI, and United Nations Environment Program (UNEP) organized the MyCOE program.

Projects like MyCOE is a good example of how GIS can be applied to help us understand how this tool can be applied to real world situations that deal with sustainable development.

Geographic Information Systems (GIS) Summary

In summary, GIS is a system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems (Korte 1997, 401).

GIS is referred to being a spatial informational system because it is used for processing and analyzing geographic data. Geographic data is a special form of spatial data that are characterized by two crucial properties, the reference to geographic space and the representation at a geographic scale (Lo 2002, 5).

The geographic data is represented as objects on an X-Y coordinate system that is stored in separate database (Korte 1997, 29). The graphical representations of the objects are: Point (non-dimensional), Line (one-dimensional) and Area (two-dimensional) (Bernhardsen 1999, 43).

GIS development has been linked to the relationship between society and technology. In the mid-twentieth century, government agencies and universities were

the primary developers and users of GIS. During this time, the Canadian and United States governments became increasingly interested in how to improve land use management (Foresman 1998, 10). This led to advancements in satellite imagery, remote sensing, photo interpretation and Global Positioning Systems (G.P.S.) (Hanna and Culpepper 1998, 17). Fundamental development of spatial and cartographic theories was further advanced by research conducted by universities (Foresman 1998, 13).

With GIS advancements in technology and theory, the users of GIS can be broken down into four general categories: GIS Managers, GIS Users, GIS Viewers and GIS Browsers (Korte 1997, 57-58).

In the field of land planning, one of the most important developments occurred in the mid-1960s with the work performed by Ian McHarg. Though his technique, referred to as *suitability mapping*, did not involve the use of computers, it did provide the basis for most computerized models used for land planning around the world (Hanna and Culpepper 1998, 14). This method was later quickly adapted and applied to computerized Geographic Information Systems.

In the early 1970s, landscape architects and planners were at the forefront of GIS development and its use. Unfortunately, over the last twenty-five years, there has been a steady decline in its use by landscape architects (Hanna and Culpepper 1998, 19).

This declining trend has begun to reverse. Today's landscape architectural firms are beginning to use GIS in a variety of applications, such as: site design, recreation master planning, visual analysis, comprehensive planning, resource management, and public advocacy (Hanna 1999, 3).

Landscape architects have encountered advantages, such as the ability to perform "what if?" scenarios, and disadvantages, such as being "data-rich and information poor" (Lo 2002, 443), in the application of GIS (Hanna et al. 1998, 107-108). Despite these advantages and disadvantages GIS, with its ability to integrate various

social, economic and environmental factors, is a tool that is suited to aid municipal governments, citizens, urban foresters and landscape architects in making decisions regarding policies and measurement of sustainable development (Wilken et al. 1992, 55 and 57).

GIS, with its ability to integrate various social, economic and environmental factors, is a tool that is well suited to aid municipal governments, citizens, urban foresters and landscape architects in making decisions regarding principles, policies, guidelines and measurement of sustainable development (Wilken et al. 1992, 55 and 57).

Urban Forestry

Definition of Urban Forestry

" The urban forest is the area in and around the places that we live that has or can have trees. Street trees, park trees, green spaces, residential land, public and private spaces with vegetation collectively make up an urban forest. This includes the urban fringe where subdivisions are under construction as well as the rural land that is being considered for development" (Moll 1995, 12).

A Brief Urban History

Prior to the Industrial Revolution, majority of Europe's populations were farmers. By the middle of the eighteenth century, technological advancements and discoveries began what is now referred to as the Industrial Revolution (Miller 1997, 7). This revolution caused a dramatic change to occur across the agricultural landscape. With the increase in mechanization of agricultural practices, there was less demand for farm labour. This resulted in migrations from the rural landscape to cities, where factories were in need of labour. The populations of these cities were increasing at such a rate that the infrastructure could not provide adequate services. European cities became over-populated and polluted (Miller 1997, 8).

In the middle of the nineteenth century the Industrial Revolution reached North America, including all of the urban issues that were occurring in Europe. At this time most of the North American population were working farmers and only 20 percent lived in cities (Miller 1997, 8). Over time, the 20 percent that lived in cities began to rise quickly due to the increase of mechanization in agriculture occurring in North America. It caused large migrations from the countryside into the cities where work was available in the factories. The cities' populations began to increase along with the pollution levels.

As a response to the terrible conditions that the city residents were experiencing, public urban parks were beginning to be commissioned in Europe and North America to provide green space and relief from the factories. The first of these public parks was

Birkenhead Park in Merseyside, England. The site for the park was designated in 1843, and was opened in April 5th 1847. The key figures in establishing the park were Sir William Jackson, Joseph Paxton and Edward Kemp. Birkenhead Park was surrounded by residential development and the designers were "determined that the park should not be, nor appear to be, the property of the houses which surrounded it" (Smith 1983, 51). This clearly shows that Birkenhead Park was intended to be a public park, which would provide relief from the existing working and living conditions.

Central Park was the first public park to be built in North America in 1856. It also initiated the "American Pastoral" landscape movement and the profession of landscape architecture. William Cullen Bryant and Andrew Jackson Downing supported the need for a park in New York and commissioned Calvert Bowyer Vaux and Frederick Law Olmsted to perform the design work. Vaux and Olmsted's plan

"conceived of the park as a place where the city dweller could find refreshment from the sights and sounds of urban life and enjoy scenery that would seem both limitless and natural" (Zaitzevsky, 1982 23).

Both Birkenhead and Central Park were designed for the residents of the city and to this day exist as parks for the public. These parks set a precedent for the creation of other public parks throughout Europe and North America.

By the 1920s, 50 percent of the North American population was living in cities and many of these people were farmers and immigrants. The response to the deplorable conditions that were present in the cities due to the increasing city populations was urban sprawl, which began to occur in the 1920s. This resulted in new suburban areas that were first located near railroad stations and trolley corridors. Located between these suburbs and the inner cities were areas of woodlands and farms. These landscapes were easily accessible by the residents of the suburbs due to their close proximity, but not by the urban residents (Miller 1997, 8-11).

By the end of World War II, the automobile was beginning to have a serious environmental and social impact on the growing urban centres. The social goal of many returning military servicemen played a future role. They wanted to marry, find a job, and live in a suburban home. New developments were occurring and spreading farther away from the urban core. The automobile provided people with even greater freedom of movement and led to decreased use of mass transit systems because the low-density developments were not well serviced by mass transit. By the mid-1950s, traffic congestion had reached a critical point (Miller 1997, 11).

To alleviate the problems of traffic congestion, Congress authorized the construction of the interstate highways to be built. These highways were primarily intended to approach the cities and not enter them. Urban governments were struggling with traffic congestion and did not have the funds to alleviate the problem. The Members of Congress from urban centres lobbied for federal assistance and Congress authorized the use of federal funds to extend the interstate highways into the urban centres (Miller 1997, 11).

With the extension of the interstate highways into the urban centres, the result was a more rapid movement of people from the urban areas to the suburbs (Miller 1997, 11). Open space was beginning to disappear in the suburbs and the residents had to be content with their yards. The suburban residents still could escape to the countryside, but the urban residents were effectively cut off from the countryside because mass transit to the suburbs was virtually nonexistent (Miller 1997, 12).

The mass migrations to the suburbs have caused many problems in urban centres, including a decrease in population, poor transportation, pollution, increased crime and bankrupt municipal governments (Miller 1997, 12). Today, with increasing congestion in suburbs, residents have begun to reconsider the cost of commuting. Old urban neighbourhoods are beginning to be renovated by people who want to live in the

city. Public and private investment is now slowly being redirected back into the urban centre (Miller 1997, 13).

This revitalization of the urban environment will most likely be accompanied by a greater demand for urban amenities that suburban residents have become accustomed to. Among these amenities will be the need for more open spaces, parks and attractive urban landscapes. Urban residents will begin to value urban vegetation and the management of this vegetation will no doubt become a higher priority for the urban government. Preservation of open space will receive higher priority as parcels of land are purchased or protected by easements and/or zoning (Miller 1997, 13).

Development of Urban Forestry in Canada

Erik Jorgensen initiated the development of urban forestry in Canada. In 1959, he taught forest pathology in the undergraduate and graduate level at the University of Toronto. In 1963, his teaching duties were expanded to include a plants material course for landscape architecture students at the then new School of Landscape Architecture also at the University of Toronto (Blouin et al. 1993, 16).

While he was teaching this course, he became aware of the importance of what he was doing. The course was to prepare graduates of forestry to take positions with responsibilities similar to those of an engineer, involved in building of architecturally designed structures, only that the forester would realize the landscape architectural design through his biological knowledge of the requirements of woody plants (Blouin et al. 1993, 16).

In 1965, his first graduate student talked to him about graduate work other than forest pathology. So Jorgensen developed a post-graduate course and was called "Urban Forestry" (Blouin et al. 1993, 16).

In August of 1966, he presented a paper titled "Urban Forestry: Some Problems and Proposals" at the International Shade Tree Conference in Cleveland. The U.S.D.A. Secretary of Agriculture met with him and discussed a highway beautification program and showed an interest in his idea of urban forestry (Blouin et al. 1993, 16).

When his paper was published, a copy was sent to the Minister who forwarded it to the presidential advisory committee that recommended the establishment of a community and urban forestry program. Jorgensen was invited to be an observer at a White House Conference to deal with the serious problems experienced in American cities in 1966 (Blouin et al. 1993, 17).

These events lead to the development of Urban Forestry in Canada. From 1967 – 1972 he continued to teach at the University of Toronto. In 1973, he retired from teaching to work for the Canadian Forestry Service in Ottawa. He was to prepare a report on the opportunities for the development of a National Urban Forestry Program. During his move, the Federal Government entered a policy of decentralization, which prevented the establishment of any new national programs or institutions. He was then placed into the Forest Management Institute as the Chief of the Urban Forestry Program. He wrote and presented another paper entitled "Towards an Urban Forestry Concept" which was presented in 1974 at the X Commonwealth Forestry Conference at Oxford England. This paper publicized the definition of Urban Forestry:

Urban Forestry is a specialized branch of forestry and has as its objective the cultivation and management of trees for their present and potential contribution to the physiological, sociological and economic well being of urban society. These contributions include the over-all ameliorating effect of trees on their environment, as well as their recreational and general amenity value (Blouin et al. 1993, 17).

The acceptance of this definition by several professional forestry associations and departments outside Ontario and Canada has led to the establishment of academic

positions at forestry schools at major universities and I trust will stand the scrutiny of future foresters (Blouin et al. 1993, 18).

The Density of the Urban Forest

The density of the urban forest varies with the land use patterns in urban areas as represented in Figure 13. Land use patterns can be divided into four zones, with urban being the centre, followed by suburban, exurban and rural, respectively. The urban zone contains commercial districts, old industrial sites, and high and medium density residential development. Although the trees in this zone are usually the most mature, it generally has the lowest density of trees and land dedicated to parks and open areas (Miller 1997, 29).

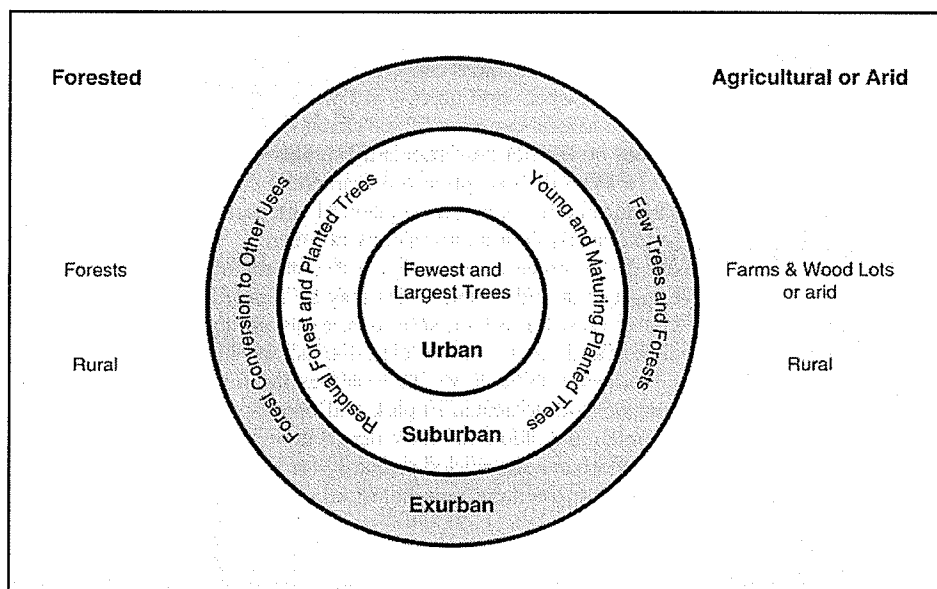


Figure 13. Tree density relationship from the city center to the rural areas.
Miller, Robert W. *Urban Forestry: Planning and Managing Urban Greenspaces*, 2nd ed.
Upper Saddle River: Prentice Hall, 1997, p.30.

The suburban zone contains low-density housing with shopping centres, industrial parks and transportation corridors. There is a higher density of trees and more land dedicated to parks and other open areas in this zone. The trees tend to be younger than those found in the urban zone and majority are located along boulevards and on

residential properties (Miller 1995, 30). Patches of trees do remain and usually occur along streams, creeks, and wetlands (Moll 1989, 14).

The exurban zone occurs in the transition between the suburbs and the hinterland. This zone contains hobby farms, residual agriculture land and forest, land held in speculation and commercial activities that are not permitted in the suburbs (Miller 1997, 30). The fourth zone is the rural area, which is composed of forested areas, agricultural lands and wood lots, or arid areas.

Direct and Indirect Effects of the Urban Forest

Urban trees can have both a direct and indirect affect on the urban climate and building energy (Figure 14). The direct affect would be the trees shading and lowering wind speeds, which alters the interaction between a building and its surroundings (Akbari et al. 1992, 28).

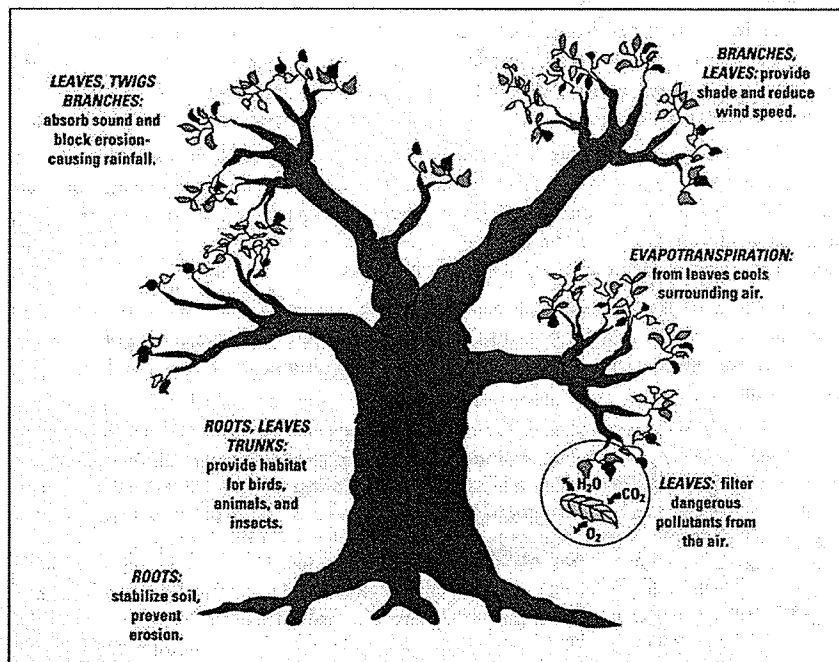


Figure 14. The ecological qualities of trees: almost every part of the tree provides a beneficial function. Only considering the leaves, they provide cooling from evapotranspiration, shelter from wind, sound absorption, and sequestering of carbon dioxide. Akbari, Hashem, Davis, Susan, Dorsano, Sofia, Huang, Joe, Winnett, Steven, eds. Cooling Our Communities: A Guidebook on Tree Planting and Light-Coloured Surfacing. Washington, DC: U.S. Environmental Protection Agency, 1992, p. 27.

Shading during the winter is not desirable in temperate and cold climates, because it will increase heating loads. Blocking the wind however is a benefit. During the summer, shading reduces the energy needs for cooling of buildings in three ways. Firstly, shading windows helps to prevent direct solar radiation from entering the structure. Secondly, shading walls, windows, and roofs keeps them from getting hot, thereby reducing the amount of heat reaching the interior. Lastly, shade keeps the soil around a structure cool, which can act as a "heat sink" for the structure (Akbari et al. 1992, 28).

Wind reduction by trees is another benefit. Within a single tree's crown or stand of trees, the wind can be very calm, while the wind is strong outside the tree crown. A possible disadvantage of too many trees in the summer will be the reduction of cool breezes, which would be welcome on hot days (Akbari et al., 1992, 30). If the trees are placed in strategic locations, this can be adverted (Akbari et al. 1992, 31).

The indirect effects, such as evapotranspiration, change the surrounding urban environmental conditions (Akbari et al. 1992, 28). Evapotranspiration is the process by which plants release moisture in the form of water vapour, which requires solar radiation or warm air. When the solar radiation is expended for evapotranspiration instead of heating the air, the temperature during the day will be lower (Akbari et al. 1992, 32).

Evapotranspiration and shading effects together can reduce air temperatures by 9°F (13°C), as Lawrence Berkeley Laboratory in Berkley, California have found. Higher levels of cooling have been measured in large urban parks, where evapotranspiration is increased by wind. In such parks, referred to as oases, the temperature can be 7°F (14°C) lower than the surrounding neighbourhoods (Akbari et al. 1992, 32).

Trees can also filter urban noise pollution. The leaves, twigs, and branches absorb sound, especially the high frequency sounds that bother people. For example, a belt of trees 98 feet wide and 49 feet tall has been shown to reduce highway noise by 6 – 10 decibels, which is a reduction of 50% (Akbari et al. 1992, 37).

De-icing Salts

The symptoms of salt damage differ for broadleaved deciduous and evergreen species. The damage can be attributed to salt in the soil environment or by salt spray.

Broadleaved Deciduous Species

Soil Salt: Leaf Symptoms. A large amount of salt accumulated in urban soils is attributed to de-icing salts for roads. Trees are often planted close to the roads and as a result are exposed to splashing, runoff, and ploughed snow containing considerable amounts of salt. The salt is absorbed by the trees roots and transported to the shoots. Chloride tends to accumulate in the dormant twigs and buds during late winter, with concentrations at their highest prior to bud bursting. Depending on the species sensitivity and Chloride concentration, the buds may fail to open causing whole branches to have no leaves, or the buds may open but as soon as the leaves begin to develop they wither and die, a symptom know as 'post flushing dieback' (Figure 15). Some trees have also been observed to re-leaf 5 – 6 times in a single growing season and in less severe cases the tree may be 3 – 4 weeks late in leafing out. On branches where the leaves have fully matured, they may begin to show marginal browning and necrosis, and may begin to wrinkle and curl (Dobson 1991, 4-5).

Soil Salt: Dieback and Death. Crown dieback, including leaf, shoot, and limb, is a common result of severe salt damage (Figure 16). The rate of death varies greatly: it may occur quickly leading to death of the tree in a few months, especially so in young or newly planted trees, or it may decline gradually. A gradual decline may show such symptoms as whole limbs being affected or only last years twig growth (Dobson 1991, 5).



Figure 15. Post flushing dieback. Dobson, M. C. De-icing salt damage to trees and shrubs. London, England: H.M.S.O., 1991, 7



Figure 16. Crown dieback of lime. A pile of de-icing salt was placed beneath the tree's crown and resulted in the eventual death of the tree and surrounding vegetation. Dobson, M. C. De-icing salt damage to trees and shrubs. London, England: H.M.S.O., 1991, 9.

Salt Spray. Damage of trees from salt spray may be found beside any salted road with fast moving traffic. Although deciduous trees have no leaves in winter they may still be affected by salt spray. This is because the dormant twigs catch the salt that may then reach living tissue by entering the twigs at leaf scars. Due to the death of the apical buds, lateral buds on wood that is more than one year old may open which can lead to a "witches



Figure 17. Salt spray damage to deciduous trees located near a busy street. Photo by Author

broom" appearance (Figure 17). In contrast to salt being absorbed by the trees roots, salt spray rarely causes death, but annual recurring damage tends to keep crowns narrow, stems thin and plants short (Dobson 1991, 5-6).

Evergreen Species (Pine and Spruce)

Soil Salt. The principal symptom, which indicates soil salt damage, is the failure of buds to open and the browning of needles that emerge from the bud. Another indication is when needles in the upper crown show greater damage than those lower down, and when needles sheltered from spray show as much damage as those exposed to it (Dobson 1991, 6).

Salt Spray. Damage from salt spray becomes apparent on one-year-old needles as "tip burn" (Figure 18). The needle tips first turn yellow, then bronze, and eventually turn brown and necrotic. Damage generally starts at the tips of the branches and progresses back into the crown. Buds on pines are rarely affected by salt spray and bud normally in the spring with

needles remaining green throughout their first year. This covers the older brown needles, but where shedding of older needles is considerable trees have a noticeably thinner crown (Dobson 1991, 6).

With the completion of Waterfront Drive, which runs parallel to the Stephen Juba Park, the effects of salt spray from the quick moving winter traffic and soil salt accumulations on existing and newly planted trees will become evident within few years.

Alternatives to Salt

The use of abrasives, such as sand, to improve traction in winter conditions is an alternative. The advantages of abrasives are that they are low in cost, readily available, and have little or no effect on roadside trees and plants. They are however relatively



Figure 18. Tip burn occurring on Spruce trees located near a busy street. Photo by Author.

ineffective in combating the effects of ice or snow when compared to salt (Dobson 1991, 47).

So salt-abrasive mixtures have been suggested instead of choosing to apply either salt or abrasives. The application of salt-abrasive mixtures tends to be applied more frequently than applications of only salt and this results in greater quantities of salt being used than just only salt. Further investigations need to be conducted to understand the potential of salt-abrasive mixtures (Dobson 1991, 48).

There are several other inorganic and organic alternatives to the application of salt, but the major factors limiting their use are cost and environmental effects. Costs for some alternatives can be 2 – 3 times, and in some cases 20 – 25 times, the cost of salt and can have the same environmental effects as salt. A reduction in the amount of soil salt accumulation can be achieved by designing raised planting beds, so that salt water does not collect in the tree's rooting area (Figure 19) (Dobson 1991, 54-55).



Figure 19. Example of a raised planting bed next to a busy street.
Photo by Author.

There is considerable reason for reducing salt usage due to its detrimental effects on trees. Salt usage could be reduced by 40% by more efficient storage and applications procedures. Even with the suggestion of reducing salt applications on our roads, there are still less damaging alternatives and one has to take into account the overall cost of salt, including environmental damage which can be 10-25 times the purchase price of some promising alternatives (Dobson 1991, 55).

Urban Heat Island Effect

Meteorologists were the first to notice this phenomenon and coined the term "urban heat island" (Akbari et al., 1992, 6). The cause of this effect is due to the bare surfaces, impermeable surfaces, large buildings, heat-generating cars and machinery, and pollutants that aid in making the urban areas hotter than the surrounding countryside (Akbari et al. 1992, 7).

By replacing vegetation and/or soil by concrete or asphalt, it reduces an urban landscape's ability to lower daytime temperature through evapotranspiration. In rural or irrigated landscapes, a large amount of the daytime solar energy is actually spent on evaporating water, not on raising air temperatures. The process of evapotranspiration occurs when the plant draws moisture from the ground, utilizes what it needs for growth and moderating its temperature, transpires the excess, and cools the surrounding air (Akbari et al. 1992, 7).

When vegetative cover is replaced by asphalt or concrete, it loses its ability to moderate temperatures. Instead, the solar energy raises the surface temperature (Akbari et al. 1992, 7).

Urban areas get hotter because their ability to cool by evaporation is reduced, but also they reflect less solar energy. This reflective ability is referred to as "albedo." Asphalt, has a low albedo; it absorbs almost all the solar energy falling on it. This then causes the surrounding air temperature increase (Akbari et al. 1992, 7).

Buildings will absorb and store the day's heat and release it at night. This can be felt by standing near a building in a summer evening (Akbari et al. 1992, 7).

Urban pollution also affects the heat island, depending on the time of day and season of the year. During the daytime, pollution lowers heat build up slightly by blocking the incoming solar energy. In the evening, the pollution prevents the heat

radiating from the city to escape by acting as a blanket (Akbari et al. 1992, 7). The pollution is composed of suspended particles of dust and gases.

In the evening the particles become nuclei on which moisture in the air condenses as fog. This fog gets thicker by the downward growth and eventually reaches the ground as smog. Smog inhibits cooling of the air and perpetuates the blanket of pollution by further preventing particles from moving out of the system. Without the presence of wind or heavy rain, the smog will continue to build up (Hough 1984, 32-33). This effect is graphically represented in Figure 20 below.

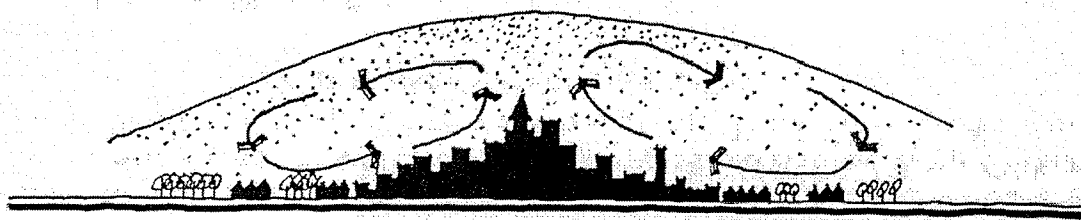


Figure 20. The Urban Heat Island. Smog dome over large cities occurs periodically due to urban activities. Air rises over warmer city centre and settles over cooler areas so that a circulatory system develops. The dome and its effect on the city may persist until wind or rain disperses it.
Hough, Michael. City Form and Natural Process: Towards A New Urban Vernacular. Australia: Croom Helm Ltd., 1984, p. 33.

With the exceptions of slight variations due to geographical or climatological features, the overall pattern of the heat island is consistent from city to city. Temperatures will begin to increase slowly as one approaches the downtown, with intermittent pockets of cooler air over parks and other wooded areas (Figure 21). The highest temperatures, or peaks, in the urban heat island occur in the downtown due to the high density of buildings (Akbari et al. 1992, 9).

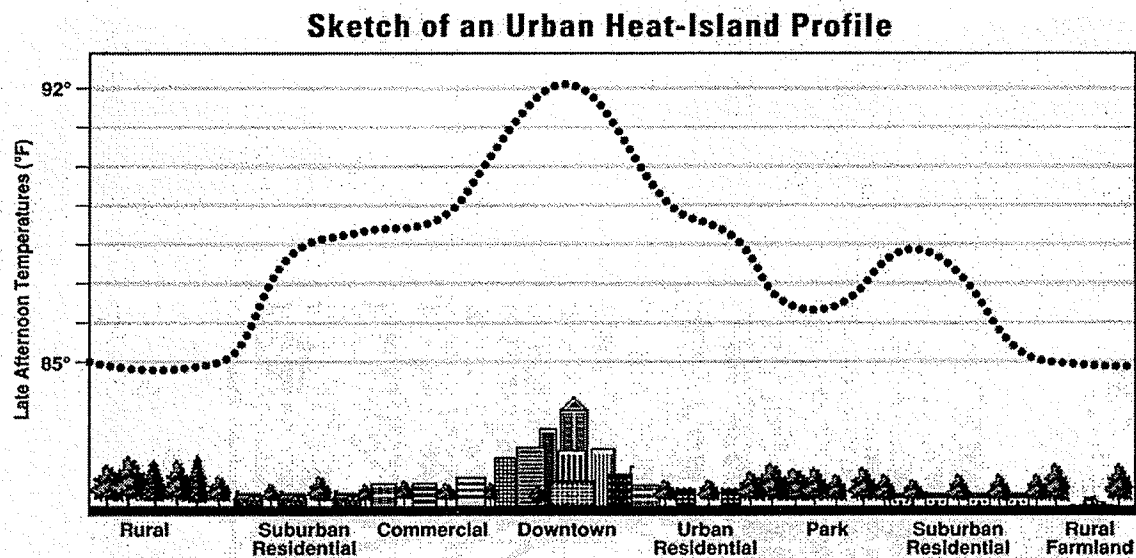


Figure 21. Urban Heat Island Profile. Profile of a heat island in a hypothetical city areas shows temperature changes (in degrees Fahrenheit) correlated to the density of development and trees. Akbari, Hashem, Davis, Susan, Dorsano, Sofia, Huang, Joe, Winnett, Steven, eds. *Cooling Our Communities: A Guidebook on Tree Planting and Light-Coloured Surfacing*. Washington, DC: U.S. Environmental Protection Agency, 1992, p. 9.

North America is separated into five general climate zones, according to the Köppen Climate Classification (Figure 22): Tropical, Drylands, Subtropical, Continental, and Polar. Cities located in the Continental zone, such as the City of Winnipeg, typically have long cold winters and mild short summers. The Continental zone is further subdivided into three categories, Winnipeg falls under Humid, Cool Summer (Dfb). Dfb classification has specific climatologic descriptions (Tarbuck 1994, 719):

- **D:** Average temperature of the coldest month is -3°C or below; average temperature of the warmest month is greater than 10°C ;
- **f:** Has adequate precipitation all year round;
- **b:** No month above 22°C ; at least 4 months over 10°C .

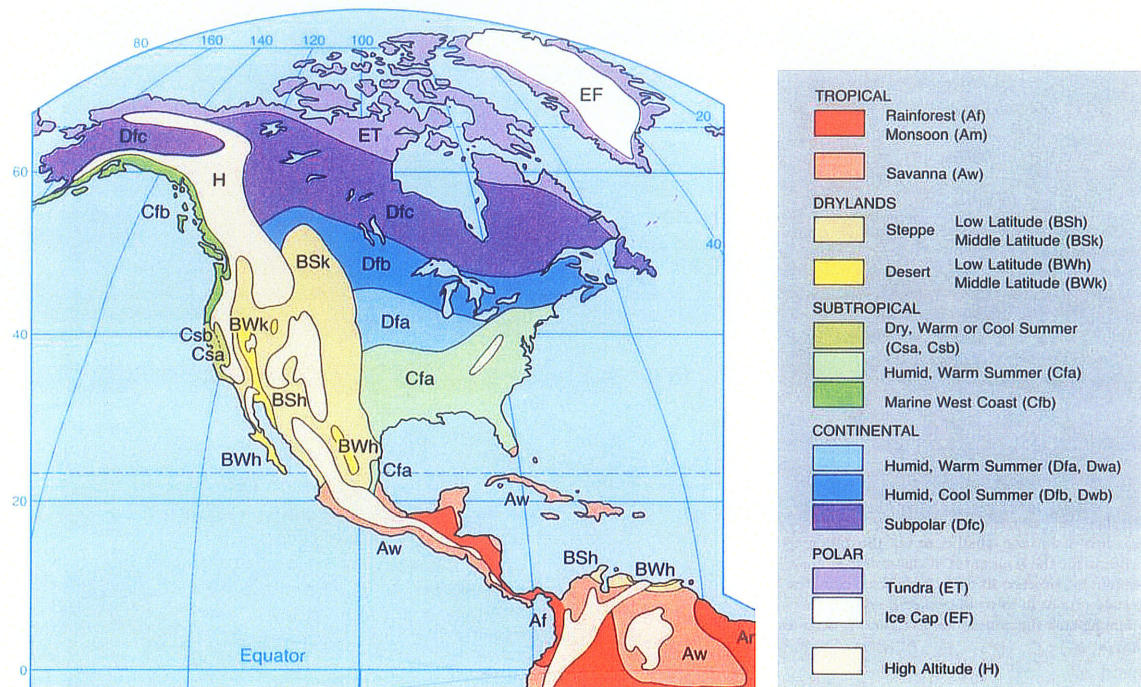


Figure 22. Köppen Climate Classification for North America.
 Tarbuck, Edward J. and Lutgens, Fredrick K. *Earth Science*, 7th ed. Ed. McConnin. U.S.A.: Macmillan College Publishing Company, Inc., 1994, p.716.

The effect of urban heat island on cities in the Continental zone is generally referred to as being positive, with some improvement of winter conditions and small increases in energy use during the short summer. Current thinking suggests the lightening surfaces, increasing albedo, and planting trees will probably have little effect on winter heat islands. Mitigation strategies for summer heat islands will still be a benefit (Akbari et al., 1992, 17).

Urban heat islands can also contribute to global warming because of warmer temperatures that result in greater demands for cooling. Coal-burning plants release 0.45 kilograms (1 pound) of carbon per kilowatt-hour of electricity they generate (McPherson 1994, 156). One way to mitigate the urban heat island is by planting trees, as shown in Figure 23. A tree can sequester CO₂, yet have indirect effects by shading and reducing air temperatures around buildings, reducing the high loads on air conditioning,

thus reducing the amount of CO₂ emitted into the atmosphere by coal burning power plants.

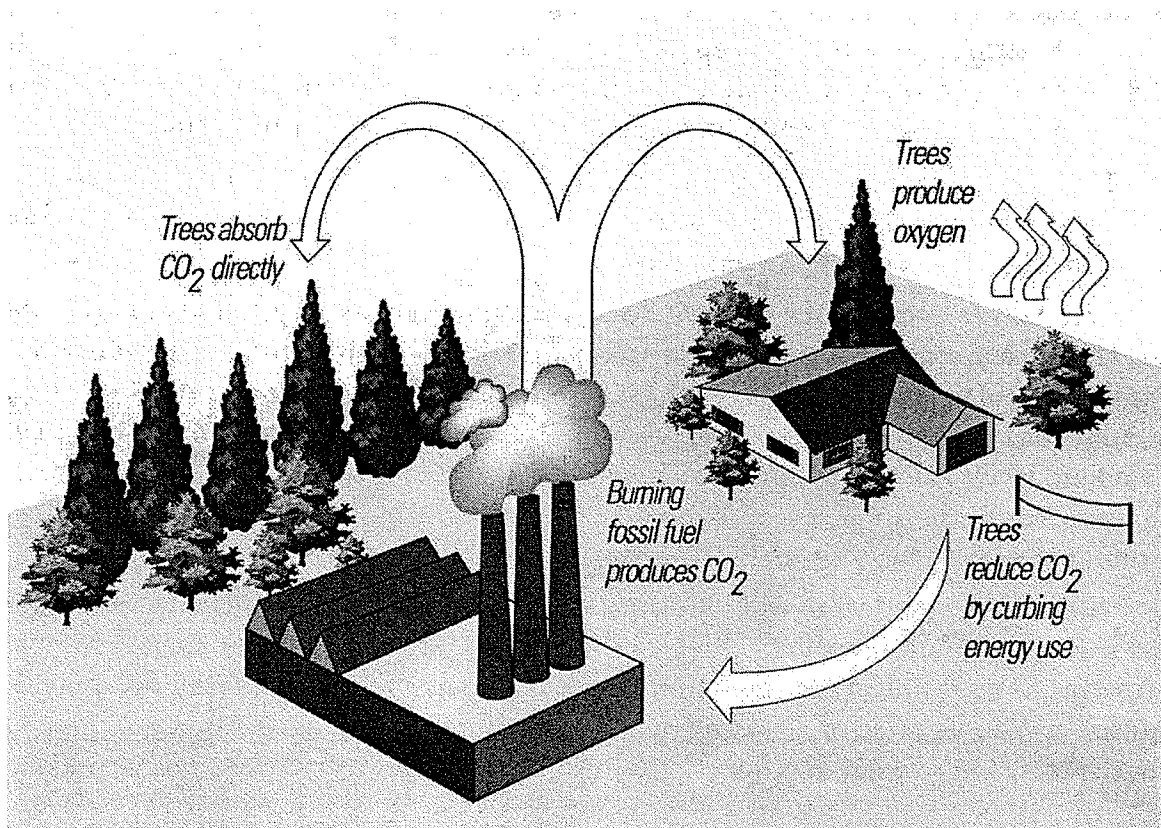


Figure 23. Trees can help to reduce the greenhouse effect in two ways. First, trees directly absorb CO₂ from the atmosphere during photosynthesis. Second, shade from trees can reduce air-conditioning loads, which reduces the amount of CO₂ by power plants.

Akbari, Hashem, Davis, Susan, Dorsano, Sofia, Huang, Joe, Winnett, Steven, eds. Cooling Our Communities: A Guidebook on Tree Planting and Light-Coloured Surfacing. Washington, DC: U.S. Environmental Protection Agency, 1992, p. 35.

Urban heat island also has several other adverse effects on the physical and psychological well being of urbanites. Heat aggravated illness and death are related to increased cardiovascular diseases that weaken resistance to heat. Unnaturally high temperatures can directly and indirectly reduce life expectancy (McPherson 1994, 156).

Plant Hardiness Zones

The Plant Hardiness Zones map outlines the different zones in Canada where various types of trees, shrubs and flowers will most likely survive (Figure 24). It is based on the average climatic conditions of each area. The first such map for North America, released by the United States Department of Agriculture in 1960, was based only on minimum winter temperatures. In 1967, Agriculture Canada scientists created a plant hardiness map using Canadian plant survival data and a wider range of climatic variables, including minimum winter temperatures, length of the frost-free period, summer rainfall, maximum temperatures, snow cover, January rainfall and maximum wind speed (Canada 2003).

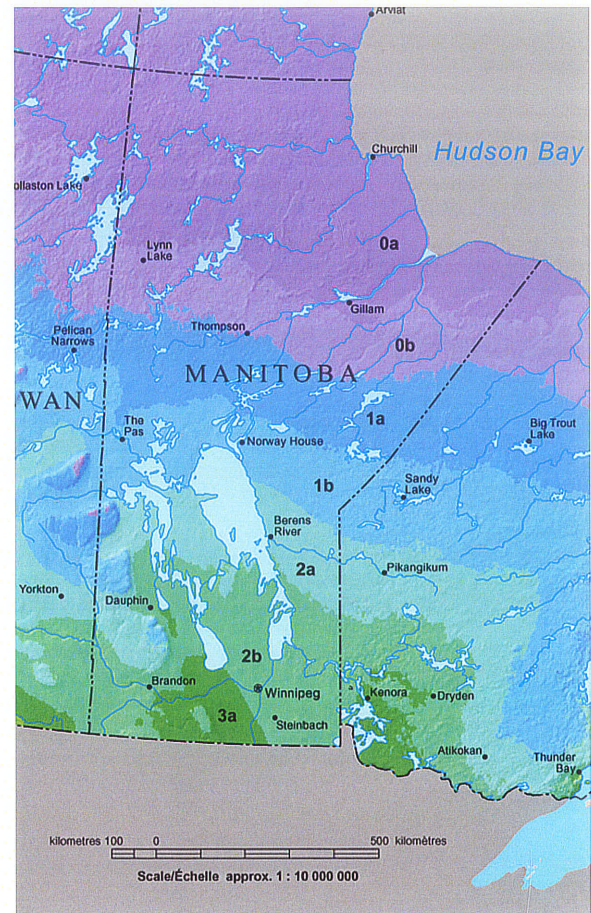


Figure 24. Plant Hardiness Zone Map for Manitoba. Plant Hardiness Zones. Map. On-Line. Agriculture and Agri-Foods Canada. Internet. 24 Mar. 2003. Available: sis.aar.ac.ca/cansis/nsdb/climate/hardiness/intro.html.

Natural Resources Canada, Canadian Forest Service scientists have now updated the plant hardiness zones using the same variables and more recent climate data (1961-90). They have used modern climate mapping techniques and incorporated the effect of elevation. The new map indicates that there have been changes in the hardiness zones that are generally consistent with what is known about climate change. These changes are most pronounced in western Canada (Canada 2003).

The Plant Hardiness Zone map is used to provide an interpretation of the hardiness of the trees in this list. The trees have a hardiness zone rating indicating the areas in which they can be expected to grow satisfactorily under normal landscape conditions. As Winnipeg is in Hardiness Zone 2b, plants listed for zones 2a and 1 are expected to perform well. Plants having a Hardiness Zone 3 rating, or higher, will be expected to have difficulties in performing to their full potential (Forestry Branch 2003). For a complete list of trees recommended for Winnipeg, refer to Appendix A.

Psychological Effects of the Urban Forest

It has been well documented that the inclusion and need for vegetation within the built urban environment of cities is of great importance for its citizen's mental well being and the perception they have of their living conditions.

Fredrick Law Olmstead stated in a report to congress of the State of California in 1852:

"it is a scientific fact that the occasional contemplation of natural scenes... is favourable to the health and vigour of men and especially to the health and vigour of their intellect beyond any other conditions which can be offered them" (Neal 1994, 37).

Stephan Kaplan, in studying the psychological affects of different environments, further supports the statement made by Olmstead. He asserts that

"an important component is nature's capacity to restore the mind and spirit – to allow one to recover from mental fatigue and to become once again comfortable, civil, and effective...untreated mental fatigue leads to risky and impulsive action, to irritability and distractibility... Urban forests have the great and not always realized potential to function as sorely needed restorative environments" (Kaplan 1995, 100).

What is mental fatigue?

Many people are familiar with the notion of mental fatigue. Stress is defined as a reaction to harm or threaten harm, where mental fatigue affects people who are doing what they like to do, but for too long without a break (Kaplan 1995, 101).

There are several consequences of a fatigued mind. Impatience and greater distractibility are common. There is also increased irritability. Co-workers, family and friends will easily recognize it, but not the fatigued individual. The person will become irritated by things that would not have done so before. Performing dull but necessary tasks becomes difficult. There is tendency to lose sight of the bigger picture, making it harder to remember that the various aspects of work fit together somehow and make some kind of sense (Kaplan 1995, 101).

Directed Attention and Fascination

William James, an American psychologist and philosopher, has made a distinction between two kinds of attention: directed attention and fascination. Directed attention is what it takes to get through a difficult or boring task. It is usually called upon when working in distracting surroundings or when trying to make a decision about a complex decision. It takes effort, and thus makes one susceptible to fatigue (Kaplan 1995, 102).

Fascination, by contrast, is effortless. Performing interesting tasks or experiencing exciting events exhibits this type of attention. Far from being hard work, it is often difficult to tear our attention away from something fascinating (Kaplan 1995, 102).

So directed attention is effortful, it is subject to voluntary control, and is susceptible to fatigue. Fascination is in direct contrast to each of these dimensions (Kaplan 1995, 102).

Restorative Environments: Relief from Directed Attention Fatigue

Fascination is the central component of a restorative environment. There are three other components to consider (Kaplan 1995, 103):

1. Being away is useful, but by itself does not guarantee a restorative environment. People use this term as shorthand for going to a restorative place. Nevertheless, there are many places that are "away" but would not permit the necessary relief from directed attention fatigue. A prison cell is one example.
2. The environment should have *extent* rich enough and coherent enough to constitute a whole other world. Restorative environments work best when one can settle into them and provide too much to see, experience, and think about.
3. There should be substantial compatibility of the environment to what one is trying to do and what one would like to do. When one is in a compatible environment, one can carry out their activity effortlessly.

Properties for Restorative Environments

There are four environmental properties that should be kept in mind in planning a restorative environment (Kaplan 1995, 104):

1. Proximity: people hesitate to go out of the way for restorative experiences, despite their importance. "If the greens are more than three minutes away, the distance overwhelms the need" (Alexander et al., 1977, 303);
2. Scale: a setting does not have to be large;
3. View: having an engaging view of nature is important, whether from a windows or a trail in a natural area.
4. Preference predictors: experiences such as mystery, legibility, complexity, and coherence.

Sensory Benefits

A sensory function that is often forgotten but which can be stimulated by urban vegetation is smell. Trees and other vegetation exude scents and odours that may be appealing and stimulating. An example is the sent of pine trees, especially after rain, can conjure up vivid memories of certain experiences and associations (Smardon 1988, 90).

Another sensory experience is sound which the rustling of leaves, creaking branches, and whistling of the wind, produces. Even the sounds from birds nesting in trees provide music (Smardon 1988, 90).

The gentle greens, yellows, and blues of trees with their softer-textured leaves that filter and reflect the light, making ever-changing patterns, provide a much needed contrast to the reds, whites, and grays, the often coarse and barren textures, the hard reflections and glare of the static, constructed environment. Trees absorb structures and in a larger scale have a visual absorption or dampening the impacts of urban development. At the same time, trees add visual diversity or complexity to the urban environment (Smardon 1988, 90).

Case Studies Supporting the Psychological Value of Urban Vegetation

In a psychological study performed by Stephen Kaplan, a large number of participants were asked to rate colour slides on a five-point reference scale. Results showed that the participants preferred scenes of natural elements when compared to totally urban scenes (Neal 1994, 37).

In Ulrich's findings from his psychological investigation, he determined that people benefit most from visual contact with nature, as opposed to urban environments lacking nature, when they are in states of high arousal and anxiety. Individuals experiencing stress or excessive arousal, nature views appear to reduce arousal more effectively than urban scenes, and hence are more beneficial in a psychophysiological sense. The effects of nature exposed to unstressed individuals can be significantly more positive than urban views. In addition to having more beneficial influences on affective states, views of vegetation and especially water appear to be more effective in maintaining attention and arousal (Ulrich 1981, 550-551).

Trees and foliage enhance preference, but the grounds texture and the configuration of the setting need to also be considered. "Naturalness," in the sense of least human influence, is not necessarily a characteristic of preferred settings. In fact, the smoothness of the ground texture is an important aspect of preference. In Gallagher's

study (1977), the least preferred nature scenes were characterized with coarse textures and by vegetation that obstructs one's visual access. The most preferred scenes had two attributes: facilitating comprehension of the immediately present situation enhances predictability, and enticing one to explore "beyond the bend" enhances involvement. These two processes are necessary for preference to be heightened (Kaplan 1983, 138). In Hull and Harvey's study in *Explaining the emotion people experience in suburban parks* assessed responses given to specific tree spacing, understorey density and presence of parks. It was discovered that pleasure heightens as tree density increases and understorey decreases. Ulrich added to these findings that respondents gave to his survey on residential parks. The park was viewed as an escape from other environmental stresses. The mere awareness of the park's presence induced feelings of control, and reduced frustration and irritation: 'I like having it there because I know I can use it if I want to' was a common response (Neal, 1994, 38). This statement is supported further by Burton who states that it is a mix of many characteristics and roles of open space that gives it its peculiar gift of generating satisfaction. Its actual use for recreation activity is often of relatively minor significance (Burton 1978, 77).

A study conducted by Sheets and Manzer found that the subjects exposed to urban pictures of vegetated versus non-vegetated scenes expressed "positive feelings when viewing tree-lined city streets; they felt friendlier, more cooperative, less sad and less depressed " (Sheets and Manzer 1991, 301). The study also found that the vegetated scenes were seen to be better, safer, and cleaner places to live in and also an easier place in which to settle down (Sheets and Manzer 1991, 301).

Urban residents desire urban trees, parks, and forests for a variety of reasons. We are a species that has evolved from the natural world and can find it difficult to live without some form of contact with nature. JD Balling has stated that this must be attractive to people because it resembles African savannas where the human species

evolved. Some say that people go to the forest "to get away from it all," while Rolston suggests that they "go there to get back to it all" (Dweyer 1994, 144).

As we become increasingly urban in our lifestyle, the desire for contact with nature will increase rather than decrease. This desire will manifest in an increased demand for urban tree and forest amenities as we seek to enhance the quality of life in our cities (Miller 1997, 25).

These claims provide additional evidence that the presence of vegetation in an urban setting can make people feel better psychologically and view the urban environment more positively. Urban planners and landscape architects must consider these types of studies when projects are being proposed and ask how they can enhance the publics' peace of mind and experience in the city through the use of vegetation (Sheets and Manzer 1991, 302).

Fear of Forests

Some researchers have come across instances where individuals have fears of trees and forested areas. These fears are not widespread, but many urbanites are afraid of entering forested areas. They may have a fear of being attacked by criminals hiding behind the vegetation, becoming lost, or being bitten by an insect. These types of fears may limit the density of trees planted around their homes and avoid heavily forested areas of a city. Other fears are that animals and insects will invade their home or that the tree or part of the tree will fall on the house or car (Dweyer 1994, 146).

In one study, individuals who grew up in suburban areas felt most comfortable in natural setting, while those who grew up in cities tended to feel most comfortable in developed settings (Dweyer 1994, 146).

The City of Winnipeg's Urban Forest Policy

The City Council of Winnipeg has developed a long-range policy plan, which is known to as PLAN WINNIPEG...2020 VISION. "Using Plan Winnipeg as a guide, Council can set priorities, make decisions, and manage the City with greater consistency, clarity, and predictability" (City of Winnipeg 2000, 1). In the "*Environment, Image, and Amenities: 5E-03 Protect and Enhance Urban Forest*" section of the Plan Winnipeg document, it outlines the City's policy regarding the urban forest. It states that the City shall protect and enhance its urban forest by (City of Winnipeg 2000, 55):

- i) Increasing the stock of trees through its tree planting programs and encouraging tree planting by others;
- ii) Adopting high standards of tree maintenance, replacement, and protection during construction and requiring developers to retain existing trees in new developments wherever possible;
- iii) Replacing trees affected by disease, in particular, Dutch Elm Disease, and diversifying the variety of new trees; and
- iv) Encouraging the participation of other levels of government in programs to protect and enhance the city's urban forest.

In 2001, the City of Winnipeg initiated the Civic Environmental Committee (C.E.C.) to develop a sustainability strategy for Winnipeg. The C.E.C. completed a comprehensive report titled: SUSTAINABLE WINNIPEG: A Comprehensive Environmental Strategy and was released to the public in 2004. This strategy is an extension of the PLAN WINNIPEG...2020 VISION.

The strategy addresses eight interconnected issues on the City of Winnipeg's current policies (Civic Environmental Committee 2004, iv):

- 1. Decision Making and Management
- 2. Climate Change and Air Quality
- 3. Urban Energy
- 4. Sustainable Land Use and Development
- 5. Sustainable Transportation
- 6. Solid Waste and Materials Management
- 7. Sustainable Water and Wastewater Management
- 8. Pesticides in the Urban Environment

In the chapter dealing with Sustainable Land Use and Development, the issue of Managing the Urban Forest is addressed. In addition to the policies stated in PLAN WINNIPEG, the key strategies identified are (Civic Environmental Committee 2004, 21):

1. Increasing the stock of trees through tree planting programs, diversifying the variety of new trees, and encouraging tree planting by others;
2. Adopting high standards of maintenance and replacement of trees affected by disease, in particular Dutch elm disease;
3. Preserving natural forests within the city and requiring developers to retain existing trees wherever possible;
4. Encouraging the participation of other levels of government in programs to protect and enhance the city's urban forest;
5. Quantifying the benefits of urban trees through canopy analysis;
6. Establishing and promoting Winnipeg as a Centre for Excellence in DED control and urban forest management.
7. Educating the public on the benefits of the urban forest;
8. Increasing public involvement and/or recruiting key organizations from the public, private and voluntary sectors;
9. Cooperating with other levels of government; and
10. Encouraging citizens to become involved in tree planting and the care of trees on private lands.

Of the above-mentioned strategies, strategy five states that the City needs to quantify the benefits of its urban forest. CITYgreen, if applied on a citywide scale, can quantify the benefits of the City of Winnipeg's Urban Forest. The implementation of CITYgreen at citywide scale would have to be initiated and managed by the Forestry Branch in the City of Winnipeg's Parks Division.

The Forestry Branch in the Parks Division of the City of Winnipeg carries out the above outlined policies. This branch was established in September 1976, representing the formal amalgamation and centralization of various district tree works operations, which had been active since 1905. This centralized Forestry operation coincided with the first identified case of Dutch Elm Disease (DED) in Winnipeg, which was reported in the summer of 1975. Organized control of the disease was imperative for the survival of the city's distinctive Elm Trees (Urban Forestry Plan 2001).

Presently, the Forestry Branch is responsible for all aspects of modern 'urban forestry'. This includes street tree inventories, tree planting, watering and fertilizing,

pruning, DED control, removal operations, public relations and education, extension services, group workshops, operation of a year round tree information phone-in line, on-site inspections and contract administration. Services extend to parks, public open space and other city lands (Urban Forestry Plan 2001).

The Forestry Branch has also established its own management objectives for Winnipeg's urban forest, in addition to the policies set in the PLAN WINNIPEG...2020 VISION. These objectives are (Urban Forestry Plan 2001):

- To complete the approved Master Street Tree Plan for the City of Winnipeg and to maintain it on a continuing basis.
- To maintain all public trees, for which the Forestry Branch is responsible, in a vigorous, safe, aesthetically pleasing and functional condition.
- To properly establish additional boulevard trees on a yearly basis ensuring that the collective and individual requirements of the five (5) City communities are met.
- To undertake and maintain an effective on-going Dutch elm disease (D.E.D.) control program within the City of Winnipeg.
- To provide technical support and associated input into all internal Forestry Branch activities and to other civic departments in matters including claims investigations, street reconstructions, sewer renewals, capital projects and development agreements.
- To provide the general public with professional information on care and maintenance of privately owned trees.
- To provide the Division with an annual report of Forestry Branch activities and associated costs.
- To represent the Department, as required, on all urban forestry related matters.
- To review annually all urban forestry programs to ensure that an acceptable, efficient and effective level of service is being provided.
- To foster and support citizen urban forester organizations.

A list of 10 factors that can be attributed to the loss of the trees in the City of Winnipeg has been created and are listed below (Allen 2000). The first four items are in order of significance with the others in no particular order. Also, the items in this list are probably either the same or similar factors in other cities around the world.

1. Accidents, Vandalism, Neglect and improper care;
2. Compacted, Disturbed, Filled or Containerized Soil;
3. Pests;
4. Too little or too much water;
5. Storage of essential elements;
6. Fertilizer and Chemical Abuse;

7. Changes in humidity and water balance;
8. Light changes and heat exchange problems;
9. Air pollution; and
10. Tree starvation.

City of Winnipeg's Forestry Branch has produced a fact sheet about Winnipeg's Urban Forest (Forest Branch 2003):

- Winnipeg's urban forest is comprised of a limited number of species due to its harsh climate.
- Some of the types of trees that do grow here are elm, ash, maple, oak, poplar, basswood, willow, birch, spruce, pine, cedar, some fruit trees and shrubs.
- Total number of public trees in Winnipeg's urban forest is estimated to be 6 million.
- Total number of boulevard trees in Winnipeg is 160,812.
- Number of boulevard trees damaged or destroyed by vandalism, vehicles or other circumstances is 365 annually.
- The City of Winnipeg, Forestry Branch removes 2600 trees per year for various reasons including; construction, danger, poor condition and private property concerns.
- The City of Winnipeg, Forestry Branch plants or supervises the planting of 1500 trees per year.
- Winnipeg trees could have a life span of 200 to 300 years.
- Tree cover in the area prior to settlement was much less extensive and primarily followed the rivers.

Within the fact sheet, there were some specific points related to Winnipeg's prestigious elm trees (Forestry Branch 2003):

- Total number of elms remaining in the urban forest is approximately 170,000.
- Total number of boulevard elm trees in Winnipeg is 62,085 or 40% of all boulevard trees.
- Average number of elms lost to D.E.D. over the last 10 years is 4,000 trees per year.
- The City of Winnipeg spends approximately \$2,000,000 annually to control Dutch elm disease.
- The value of Winnipeg's elms is estimated to be between 651 million to 1.2 billion dollars not including property values. They contribute in the order of \$160,000,000 to the properties they enhance.
- It would cost upwards of \$25,000,000 to remove Winnipeg's elms if they were allowed to die.
- Winnipeg has the distinction as a city of having the largest remaining mature urban elm forest in North America.

There is one interesting outcome from this fact sheet. If you add the 1500 trees planted each year to the 2600 trees that are lost every year, there is an 1100 tree per year deficit. So, if Winnipeg's 2.73 million trees were to be completely managed by the Forestry Branch at the current rate of loss, it would take 2,482 years before all the trees would be gone, if the growth of the City of Winnipeg was stagnant. Fortunately, this is not the case. The tree deficit is minimized by the fact that the City of Winnipeg's urban forest has many contributors to it, including residential areas, schools, parks, commercial development, landscape architecture, to name a few.

Landscape Architectures role in Urban Forestry

Landscape Architecture as a profession provides a broad range of services and activities that have a direct affect on the structure and development of the urban forest. In terms of the urban environment, these services can range from street-scaping to providing a management plan for an ecological corridor. The design solutions that are provided to the client, whether it is public and/or private, must take social, cultural, ecological, economical and political factors into consideration. These design solutions play a crucial role in how the urban forest will evolve and be managed over time. Individually, the resolutions may seem to contribute very little to the urban forest, but when observed as a whole, the benefits can be far greater.

An aspect of the urban forest that landscape architects are overlooking is the basic biology of the trees being planted in the urban environment (Urban 1996, 76). Many of the trees planted are in standard tree-pit details that do not provide sufficient room for root development and growth. The standard size of the tree-pits in urban conditions is the result of restrictions due to the competition for space from vehicles, pedestrians, and utilities (Urban 1996, 77). Landscape Architects are still working with outdated and unrealistic installation details, planting specifications and procedures that

were the result of less intense development (Goldstein *et al.* 1991, 68). The estimate life expectancy of a tree in the downtown area is seven years (Akbari *et al.* 1992, 96).

The solution for trees to survive the urban environment is to increase the amount of soil available for root development and growth. This can be achieved by designing interconnected tree-pits below the sidewalk or where space is limited by having raised beds to hold the sufficient amount of soil needed (Goldstein *et al.* 1991, 68).

Landscape Architects need to become more aware of trees basic biological requirements below the surface and address these problems with innovative design solutions. This can be partially achieved by implementing some biological design principles in the early stages of a project (Urban 1996, 97):

- **Volume:** Provide sufficient usable soil volumes and configurations to support the area of crown desired at maturity. Calculate usable soil that will exist at the site after construction together with imported planting soils.
- **Accessibility:** Design the soil volume to be accessible to air, water, nutrients, and periodic inspection. This is best achieved by separating the paving from the tree's rooting area.
- **Protection:** Develop designs and details that will protect the tree for the life of the project. Separate pedestrian traffic to reduce compaction. Where paving must cover the soil, structurally vault the paving over the soil.
- **Interconnection:** Design soil volumes to be interconnected from tree to tree and from tree areas to other planted areas.
- **Symmetry:** If even or symmetrical growth from tree to tree is desired, design for the symmetry of water, air, soil, light, nutrients, and drainage.
- **Growth:** Design paving, walls, and utilities to accommodate long-term growth of the roots and crown, trunk flare, and trunk enlargement.
- **Spacing:** Design trunk spacing and geometry to allow for long-term growth and management, including removal, thinning and replacements.

In addition to understanding the importance of the biological aspects of trees, diversification of species is another. The International Society of Arboriculture has developed a diversification formula. The formula is defined as a planting plan containing no more than 10% of one family and 5% of one species (Phillips 1993, 48). This means that for every 100 trees planted, no more than 10 trees are planted of any one

family, such as Ash, and no more than 5 trees of any one species, such as Green Ash (Phillips 1993, 48).

The diversification formula should also be applied to the existing urban forest so that dependence on a single species from previous or natural plantings is not carried forward into future plantings. The diversification formula was developed so that if disease or insect killed 3% of a city's single urban forest species population, such as Green Ash, then 97% of the city's urban forest trees would still remain. The diversification formula may prove difficult to use in zone 2 and 3 and other places where the number of trees is severely restricted due to soil or climatic conditions (Phillips 1993, 48).

For the last 25 years, Dutch Elm Disease (DED) has been the number one killer of Elm trees all across North American cities. One reason for the ease of proliferation of DED is due to the mass plantings of the single species of Elms in our cities. The same scenario could also be repeated with a different species, the Green Ash (*Fraxinus pennsylvanica*). Landscape architects are increasingly specifying the planting of Green Ash due to its hardy characteristics as both a shade and street tree (Knowles 1995, 77). If a devastating disease or insect were to spread and infect the Ash, their numbers would begin to decrease in every city across North America. Unfortunately, this has become a reality.

The Emerald Ash Borer was first discovered in the City of Detroit in Michigan in July 2002 (Figure 25). In August 2002, the Emerald Ash Borer was discovered in the City of Windsor and neighbouring municipalities of Amherstburg, Essex, LaSalle and Tecumseh



Figure 25. Adult Emerald Ash Borer. Canadian Food Inspection Agency, Science Branch. On-line. Internet. 23 Dec. 2003. Available: <http://www.inspection.gc.ca/english/sci/surv/data/a/grplae.shtml>.

(Canadian Food Inspection Agency 2003).

The Emerald Ash Borer is an introduced exotic beetle which native to China and eastern Asia. Emerald Ash Borer hosts are a variety of hardwoods species, including several varieties of Ash, Walnut, Wingnut and Elm (Chinese cork bark elm) (Canadian Food Inspection Agency, Science Branch 2003).

When a tree has become infected, the symptoms are (Canadian Food Inspection Agency, Science Branch 2003):

- Dying or dead trees, particularly with bark sloughing off and crown dieback, are indicative of buprestid beetle activity (Figure 26); and
- Profuse suckering and stem or basal sprouting may suggest physiological stress in trees that are suitable for infestation (Figure 27).



Figure 26. Ash tree in decline. Canadian Food Inspection Agency, Science Branch. On-line. Internet. 23 Dec. 2003. Available: <http://www.inspection.gc.ca/english/sci/surv/data/agrplae.shtml>.



Figure 27. Ash tree showing basal sprouting. Canadian Food Inspection Agency, Science Branch. On-line. Internet. 23 Dec. 2003. Available: <http://www.inspection.gc.ca/english/sci/surv/data/agrplae.shtml>.

The infestation first begins by the larvae boring through the bark and feed on the phloem and eventually on the outer sapwood as the larvae grows. As they feed, shaped tunnels are created (Figure 28). After 1 to 2 years of infestation, the bark falls off in pieces exposing the tunnels. After 2 to 3 years, the population builds up and

eventually the trees nutrient and water transport system is disrupted, thus causing wilting and eventually the tree dies (Canadian Food Inspection Agency, Science Branch 2003).

Currently, the Emerald Ash Borer has been successfully contained in the Windsor Ontario Region. If the Borer was to spread, the urban forest of North American Cities will begin to see drastic reduction in the number of Green Ash within 3 years of initial infestation.

The possible infestation of the Emerald Ash Borer is a relevant example of how important the Diversification Formula is. Those Landscape Architects and other agencies, trades and professions that contribute to or manage a city's urban forest must understand the importance of diversification and how it can lead to a Sustainable Developed urban forest.



Figure 28. Emerald Ash Borer tunnels. Canadian Food Inspection Agency, Science Branch. On-line. Internet. 23 Dec. 2003. Available: <http://www.inspection.gc.ca/english/sci/surv/data/agrplae.shtml>.

Urban Forestry and Sustainable Development

Clark et al. has identified 4 principles for Sustainable Developed urban forest:

1. **Sustainable Development is a broad, general goal.** While we may be able to describe the desired functions of an urban forest, we cannot yet design the forest to optimize them. For example, we know that urban forests can reduce atmospheric contaminants; we do not know how to design the forest to maximize this function. However, we accept that existing urban forests provide these functions to some degree. While there are costs involved in planting, maintaining and removing trees in cities, in a sustainable developed urban forest the net benefits provided by these functions are greater than the costs associated with maintaining the forest (Clarke et al. 1997, 20).
2. **Urban forests primarily provide services rather than goods.** Descriptions of sustainable developed systems usually focus on the goods that a system provides, such as sustainable yield. In contrast, urban forest comprises a limited number of goods. The most important outputs are services, such as reducing environmental contaminants, improving water quality,

reducing energy consumption, providing social and psychological well-being and providing for wildlife habitat (Clarke et al. 1997, 20).

In planting and maintaining a sustainable developed urban forest, we should strive for a balance among all benefits and not maximize the output of one service at the expense of all others. For example, maintaining a large wildlife habitat possible could conflict with other services, such as property development or conflicts with people (Clarke et al. 1997, 20).

- 3. Sustainable urban forests require human intervention.** Some urban forests are a mosaic of native forest remnants and planted trees. The native remnants may have some capacity for self-renewal and maintenance, particularly in greenbelts and other intact stands. However, the planted trees have essentially no ability to regenerate in place. Therefore, we must accept, acknowledge and act on the fact that urban forests may have a limited ability to retain or replace biological capital (Clarke et al. 1997, 20).

Sustainable developed urban forests cannot be separated from human activities. Such activity can be both positive and negative. A positive activity is the application of new technology, information and investment. This will not only will the ability to select and grow trees in cities be enhanced, but the ability to quantify the benefits of the urban forest (Clarke et al. 1997, 19). CITYgreen can calculate the quantification some of the urban forest benefits. In the latter case, creation and maintenance or urban infrastructure can be extremely destructive and disruptive. In essence, we superimpose cities atop forests. The greater imposition, the less natural the forests appear and function (Clarke et al. 1997, 20).

The adverse impacts of humans can be mitigated by positive actions such as planning, planting, and management; all occurring with common commitment and vision. We cannot separate sustainable developed urban forests from the people who live in and around them. In fact, we want to meld the two as much as possible (Clarke et al. 1997, 21).

- 4. Trees growing on private lands compose the majority of urban forests.** While publicly owned trees have been the longstanding focus of urban forestry, they comprise only a portion of the urban forest. An estimated 60 – 90% of the trees in urban forests are found on privately owned lands. Therefore, sustainable developed urban forests depend to a large degree on sustainable private forests (Clarke et al. 1997, 21).

If we consider further that trees probably are not evenly distributed among all private landowners, then we may also conclude that a small number of land owners and managers may be responsible for a large fraction of urban trees (Clarke et al. 1997, 21).

However, small private landholdings, particularly residential property, may also constitute a significant fraction of community trees. Their contribution to the urban forest must be considered in any effort towards a sustainable developed urban forest (Clarke et al. 1997, 21).

By applying these 4 principles leads the definition of a sustainable developed urban forest (Clarke et al. 1997, 21):

"The naturally occurring and planted trees in cities which are managed to provide the inhabitants with a continuing level of economic, social, environmental and ecological benefits today and into the future."

In applying this definition in urban areas requires accepting the following 3 ideas

(Clarke et al. 1997, 21):

1. Communities must acknowledge that city trees provide a wide range of net benefits.
2. Given the goal of maintaining net benefits over time, the regeneration of urban forests requires intervention and management by humans.
3. Sustainable urban forests exist within defined geographical and political boundaries of cities.

Urban Forestry Summary

In summary, prior to the Industrial Revolution in Europe and North America, majority of the populous were rural farmers. By the middle of the eighteenth century there was less demand for farm labour that resulted in migrations from the rural landscape to cities, where factories were in need of labour. European and North American cities became over-populated and polluted (Miller 1997, 8).

As a response, public urban parks were beginning to be commissioned in Europe and North America. The first of these public parks was Birkenhead Park in Merseyside, England in 1843 and Central Park in New York in 1856 (Miller 1997, 8).

In 1920s, another response to the deplorable conditions in the city was urban sprawl (Miller 1997, 8). Today, suburbanites have begun to reconsider the cost of commuting and investment is now being redirected back into urban centres and old urban neighbourhoods (Miller 1997, 13).

Revitalization of the urban environment will most likely be accompanied by a greater demand for urban amenities that suburban residents have become accustomed to such as open spaces, parks and attractive urban landscapes (Miller 1997, 13). To provide such amenities, an understanding of the various effects of the urban environment has on vegetation was needed.

In 1963, Erik Jorgensen taught a plants material course for landscape architecture students at the School of Landscape Architecture at the University of Toronto. The success of this course lead to the development of Urban Forestry studies and departments in other Canadian universities so as to better understand the form and function of the urban forest. These include:

- Urban forest density can be divided into four zones: urban being the centre, followed by suburban, exurban and rural, respectively outward (Miller 1997, 29).
- Urban trees provide a variety of direct and indirect affects on the urban climate and building energy (Akbari et al. 1992, 28).
- De-icing salts and salt spray are having a negative affect on urban forests located in winter cities that use salt in streets (Dobson 1991, 54-55).
- Urban forests have also been known to reduce the Urban Heat Island effect (Akbari et al. 1992, 7).

Psychologists, such as Stephen and Rachel Kaplan and William James, have conducted studies that state the inclusion and need for vegetation within the built urban environment of cities is of great importance for its citizen's mental well being and the perception they have of their living conditions.

The municipal governments are responsible for the care and maintenance of the urban forest for its citizens. The City of Winnipeg has outlined policies regarding the protection and enhancement of the urban forest in the PLAN WINNIPEG...2020 VISION and the SUSTAINABLE WINNIPEG: A Comprehensive Environmental Strategy by the Civic Environmental Committee.

Landscape architects have a direct affect on the structure and development of a city's urban forest. Currently, landscape architects are overlooking the basic biology of the trees being planted in the urban environment (Urban 1996, 76). Diversification of species in the urban forest also needs to be considered by landscape architects (Phillips 1993, 48).

Clark et al. has identified four principles of Sustainable Development and how it relates to Urban Forestry (Clarke et al. 1997, 21):

1. Sustainable Development is a broad, general goal;
2. Urban forests primarily provide services rather than goods;
3. Sustainable urban forests require human intervention; and
4. Trees growing on private lands compose the majority of urban forests.

Municipal governments, citizens, urban foresters and landscape architects all have a role to play in the sustainable development of a city's urban forest. With the increasing need for open space within cities and acknowledging the benefits it provides to people and the environment, sustainable development principles, policies and guidelines will aid in the enhancement and preservation of the urban forest for future generations.

Methodology

Overview

The purpose of the methodology section is to describe the materials and subjects that were used as sources of raw data as well as the procedures used to run the pre-design and post-design assessments. The methods section also describes how the goals and objectives presented in the Introduction were met and provides enough depth to allow other researchers to replicate the work. The goal of this research was achieved through the realization of the objectives that occurred in seven discrete steps:

1. Literature Review;
2. Stage 1 - Site Inventory and Analysis;
3. Stage 2 - UEA Pre-Design Assessment;
4. Stage 3 - UEA Post-Design Assessment;
5. UEA Pre-Design and Post-Design Assessment Results;
6. Discussion of Assessment Results;
7. Conclusion

Literature Review

Identifying key issues, words and phrases that pertained to the research goal and objectives developed a literature review. These terms were used to perform a computer-based literature search of books and periodicals. Electronic databases were accessed at the University of Manitoba included *Avery Index to Architectural Periodicals* and *Bison*. Other electronic databases that were accessed were at the *University of Winnipeg* and *University of Minnesota Forest Library*. The Internet search engine *Yahoo!* was also utilized. A variety of functions and operators were used to access the pertinent information including "and/or" functions to concatenate search terms and quotation marks to define phrases. A sample of search terms included: "Sustainable Development"; "Global Information Systems"; "Urban Forestry"; "Urban Forestry" and "Global Information Systems."

Urban Ecological Analysis Methodology

The methodology for this practicum is based, in part, on a model developed by American Forests referred to as the Urban Ecological Analysis (UEA). The Urban Ecological Analysis provides a quantitative analysis of a city's urban forest by calculating energy savings, carbon storage, storm water retention, pollution removal and wildlife benefits. These are calculated by the use of specific formulas and methods. The UEA will be modified by not calculating the energy savings due to there not being any habitable buildings on the site. This methodology has been outlined below in the following stages and illustrated in the following flowchart (Figure 29):

- Stage 1** – Site Inventory and Analysis
- Stage 2** – UEA Pre-Design Assessment
- Stage 3** – UEA Post-Design Assessment

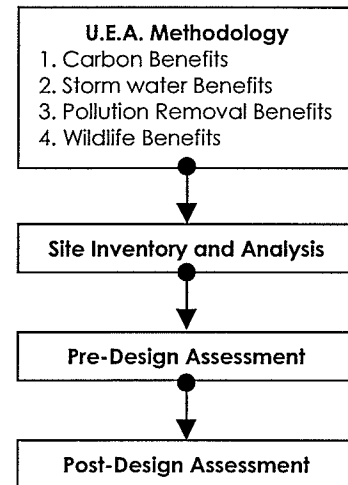


Figure 29. Flow chart representing the methodology. Figure by Author.

Stage 1 - Site Analysis and Inventory Boundary of Stephen Juba Park

The boundaries for the pre-design and post-design assessments of Stephen Juba Park are outlined in Figure 30 below. The site is bordered to the north by the Water Intake Structure; east by the Red River; south by the CN Rail Bridge; and to the west by the existing Waterfront Drive. Refer to appendix F for an illustrated site history of the site beginning from 1816 to 2001.

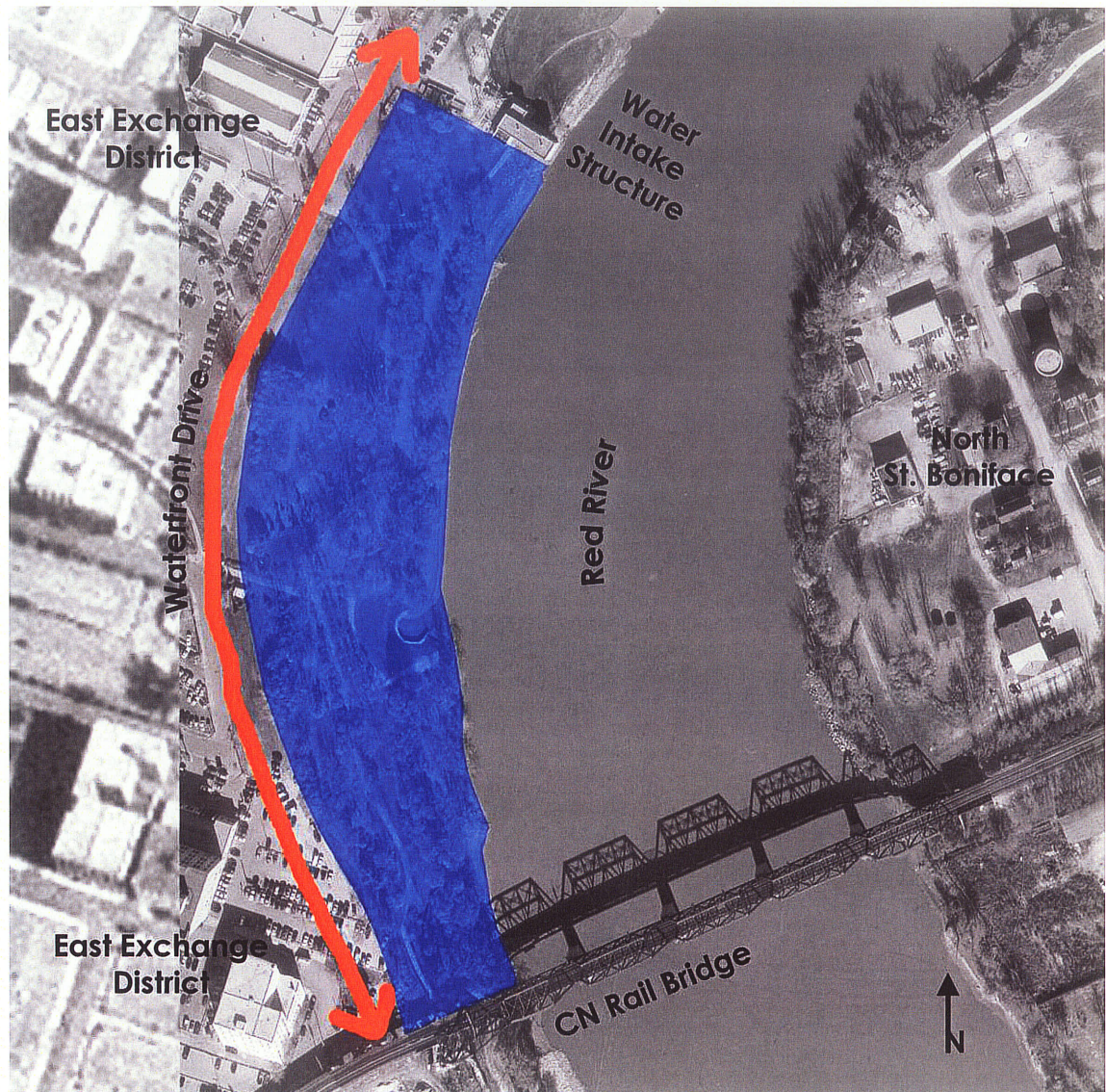


Figure 30. Site boundary for Stephen Juba Park. Scale: NTS.
Map by Author.

CITYGreen Soil Categorization

CITYgreen asks for basic information about the soil properties of the study area and there are four hydrologic soil groups to select from (United States Department of Agriculture, 1994, 72-73):

- **Class A:** High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.

- **Class B:** Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
- **Class C:** Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
- **Class D:** Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.

For Stephen Juba Park, the description of the Fort Garry Clay soil classification falls under the USDA Class C. The Geological Sciences at the University of Manitoba aided in the determination of this classification. A full description of the characteristics for Fort Garry Clay is in Appendix I.

Stephen Juba Park Tree Inventory

The tree inventory for Stephen Juba Park was collected and compiled in several steps. The first step was to acquire an AutoCAD drawing file that had base information about the site that would be required to conduct the Urban Ecological Analysis. The file became available during the "Ideas Competition: City Re-emerging" that was held in 2002 by the City of Winnipeg. The AutoCAD drawing file had all the base layers of information required. The original hand-drawn planting



Figure 31. Referring to Pre-Design Field Map.
Photo by Author.

plans from Lombard North Group, the original landscape architectural firm that designed and managed the construction of the park, were also acquired. By utilizing both forms of media, the AutoCAD and hand-drawn, a field map of the trees located within the park was created and used in the field (Figure 31). The field map can be referred to in Appendix D.

With the field map in hand, the next step was to perform a preliminary ground truthing of the park. Not surprisingly, there were several inconsistencies that were to be

expected since the park was completed in 1983. Such inconsistencies included: trees that were removed, trees that were added, different species planted other than what was indicated on the original planting plan, and varying quantities. With these inconsistencies occurring, smaller field maps were created to aid in mapping the actual tree locations. Along with the mapping of the tree locations, other specific attributes about each tree had to be collected to perform the Urban Ecological Analysis.

This information was collected by the use of a tree inventory worksheet that was provided by the CITYgreen software and can be referred to in Appendix C. The data collected from each tree was:

1. Identify a unique tree ID number
2. Determine if tree is on public or private property
3. Identify and record the tree species
4. Measure and record the diameter (DBH) and its diameter class
5. Measure and record the height by use of a clinometer and its height class
6. Record if the tree has been topped
7. Identify any existing or potential conflicts
8. Identify and record the existing ground cover

This data was collected for the trees located in the park portion of the site. The heights of the trees were determined by utilizing a clinometer (Figure 32).

A clinometer is a tool that can be used to measure the angle of elevation of an object. The opportunity to construct a clinometer came about and was constructed by using a protractor, a straw to look through, tape, some string and a small weight. Instructions on how to construct one of your own are included in Appendix E.

For the riverbottom forested patches of the site, the recommended procedure by CITYgreen for collecting tree data was to use the line

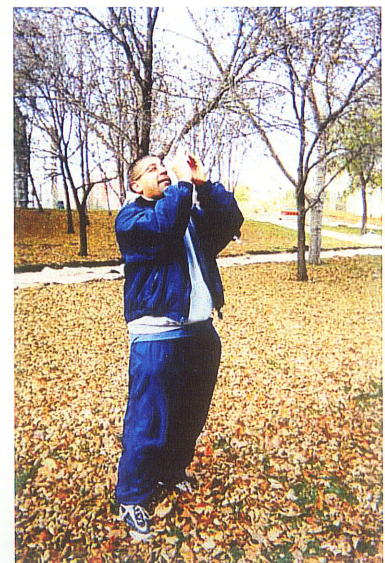


Figure 32. Measuring tree heights by using a clinometer.
Photo by Author.

transect segments method. Instead of using the line transect segment method, another widely acceptable method referred to as the quadrat method to determine the riverbottom forests' composition was utilized. The size of the quadrat used was a 10m x 10m square.

Before implementing the quadrat method in the park, the number of quadrats required had to be determined in the park. To achieve this, the first task was to determine the overall baseline length of the park from the CN bridge to the Pump House and that was approximately 340m. The next step was to refer to the table in the CITYgreen manual to determine the number of sample sites required based on the overall length of the baseline. In the table below (Table 2), the number of transect segments recommended was substituted for the number of quadrats required and it was 5.

Table 2. Baseline length determines the number of Transect Segments

Overall Baseline Length (M)	Number of Transect Segments
<305	3
>305 – 1,525	5
>1,525 - 3,048	7
>3,048	variable

American Forests. CITYgreen calculating the values of Nature 4.0 user manual. U.S.A.: American Forests, 2000, p. 39.

So, the overall baseline length of 340m was divided by the number of quadrats required, 5, and equalled 68m. The number 68 was entered into a calculator with a random number generator to determine the beginning point of each of the 5 quadrats. The number that was randomly generated each time was recorded and mapped onto the tree inventory plan. For example, the first number generated was 20, so a distance of 20m was measured from the beginning of the baseline, which was the CN bridge. The next number generated was 40, so 40m was measured from the beginning of the first

location of the quadrat, and so on until all 5 quadrat locations were determined and mapped on the tree inventory plan.

Once all 5 quadrat locations were located on the field map, a site visit was carried out and located each of the quadrat sites in the riverbottom portion of the Park. The next step was to hammer in a stake to mark the first corner of the quadrat (Figure 33). Then by using a 10m long piece of rope, measured off



Figure 33. Hammering the first stake for 10m x 10m quadrat.

Photo by Author.

another 10m section and hammered in the second stake and so on until a 10m x 10m square, or quadrat, was created.

Once the quadrat was established, measurement of the dbh, or diameter at breast height, of each tree located within the quadrat, along with other specific information, such as species, height, potential conflicts, and ground cover were recorded (Figure 34 and 35). The worksheet used was supplied by American Forests and can be found in Appendix C. The completed tree inventory worksheets can be referred to in Appendix D.



Figure 34. Measuring dbh, trunk diameter.

Photo by Author.



Figure 35. Recording Tree Data.

Photo by Author.

Stage 2 – Pre-Design Assessment

Once the tree inventory for Stephen Juba Park has been completed, the next step is to enter the data into CITYgreen. Before this was initiated, a raster image of the Stephen Juba Park Field Map was imported and scaled into the program. When the raster image was scaled, specific attributes were then traced on specific layers created in CITYgreen. The layers created were: SJP Trees, SJP Site Boundary, SJP River Bottom Forest, SJP Impervious Surfaces and SJP Planting Beds (Figure 36).

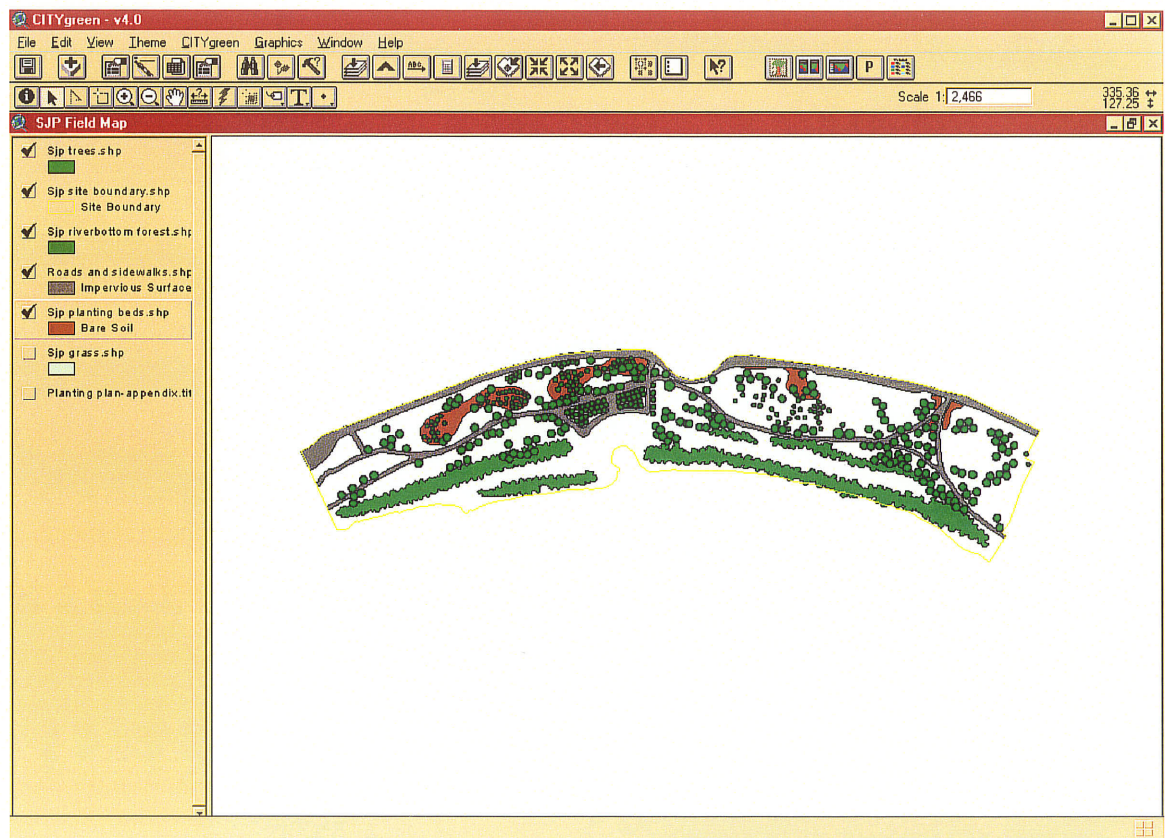


Figure 36. Screen shot of the CITYgreen program showing the different layers created for the Pre-Design Assessment.
Figure by Author.

Along with creating of each layer, information from tree inventory worksheets were entered and linked to each of the objects on their respective layers. An

explanation of the methods and formulas used by CITYgreen for performing the calculations can be found in Appendix J.

Once all the objects have been created on each layer and the associated data linked, the Pre-Design Assessment was executed. The assessment results can be viewed in Stage 4 – Pre-Design and Post-Design Assessment Results.

Stage 3 – Post-Design Assessment

The landscape development for Waterfront Drive was initiated in the summer of 2003. When the trees were all planted, a Post-Design tree inventory was conducted which recorded the characteristics of each newly planted tree. Refer to Appendix L for the Post-Design tree inventory data and field map.

The same method of entering the data into CITYgreen that was used as for the Pre-Design Assessment was applied. The raster image of the landscape development plan was imported and scaled. Then the same layers were recreated: SJP Trees, SJP Site Boundary, SJP River Bottom Forest, SJP Impervious Surfaces and SJP Planting Beds (Figure 37). Along with each layer, information from tree inventory worksheet were entered into the program and linked to each of the layers. An explanation of the methods and

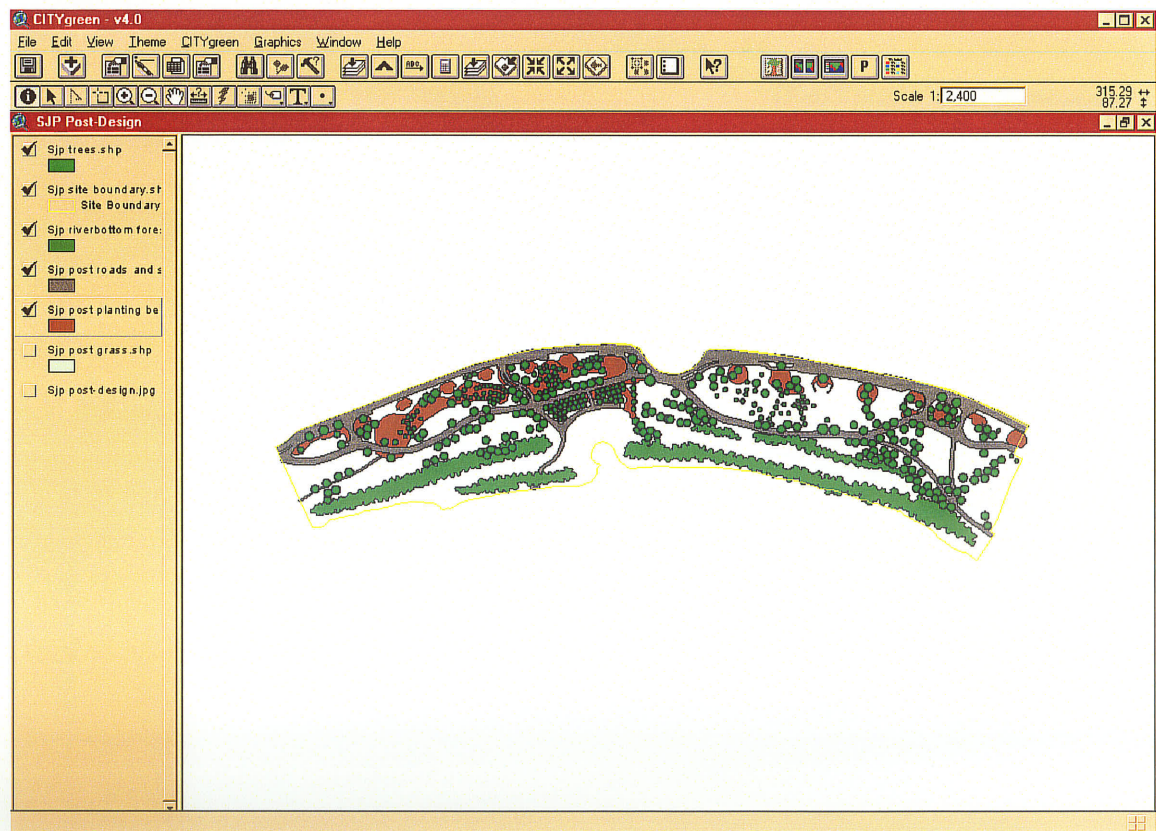


Figure 37. Screen shot of the CITYgreen program showing the different layers created for the Post-Design Assessment.

Figure by Author.

formulas used by CITYgreen software for the calculations can be found in Appendix J.

Once all the objects have been updated and created on each layer and the associated data linked, the Post-Design Assessment was executed. The assessment results can be viewed in Stage 4 – Pre-Design and Post-Design Assessment Results.

Pre-Design and Post-Design Assessment Results

Once CITYgreen has completed the Pre-Design and Post-Design Assessments, the data generated were formatted in a tabular form for ease of reference. In this section, the data and maps are presented for the Pre-Design and Post-Design Assessments, also with their corresponding Wildlife Assessments.

Pre-Design Assessment Results

The results of the Pre-Design Assessment are illustrated in Table 3 below and can be referenced to the Pre-Design Assessment Map (Figure 38). The complete Pre-Design Assessment site statistics are also located in Appendix K.

Table 3. Pre-Design Assessment

Study Site		Tree Statistics		Stormwater Benefits	
Total Area	7.08	Tree Count	393.00	Precipitation	2.00 in
Canopy Area	1.08	Avg. dbh	10.30	Runoff Volume	2.45 in
Grass Area	5.77	Dom dbh Class	1.40	Time of Concentration	0.00 hrs.
Impervious Area	0.93	Dom Ht. Class	1.80	Peak Flow	34.2 cfs
Building Area	0.00	Dom Health Class	0.00		
Bare Area	0.42	Number of Species	13.00	Pollution Removal Benefits	
Shrub Area	0.00	Dominant Species	GA (40%)	Ozone	\$198.85 (64.8lbs.)
Cover 1 Area	0.00	Ownership (V B Unk)	0% 100% 0%	SO ₂	\$16.30 (21.7lbs.)
Cover 2 Area	0.00			NO ₂	\$103.00 (33.5lbs.)
Water Area	0.00	Carbon Benefits		PM 10	\$123.16 (60.1lbs.)
Number of Homes	0.00	Carbon Storage	65.07 tons	CO	\$3.07 (7.2lbs.)
Hydrologic Soil	C	Carbon Sequestration	1.47 tons/yr		
Percent Slope	12.00				
Rainfall Type	II				

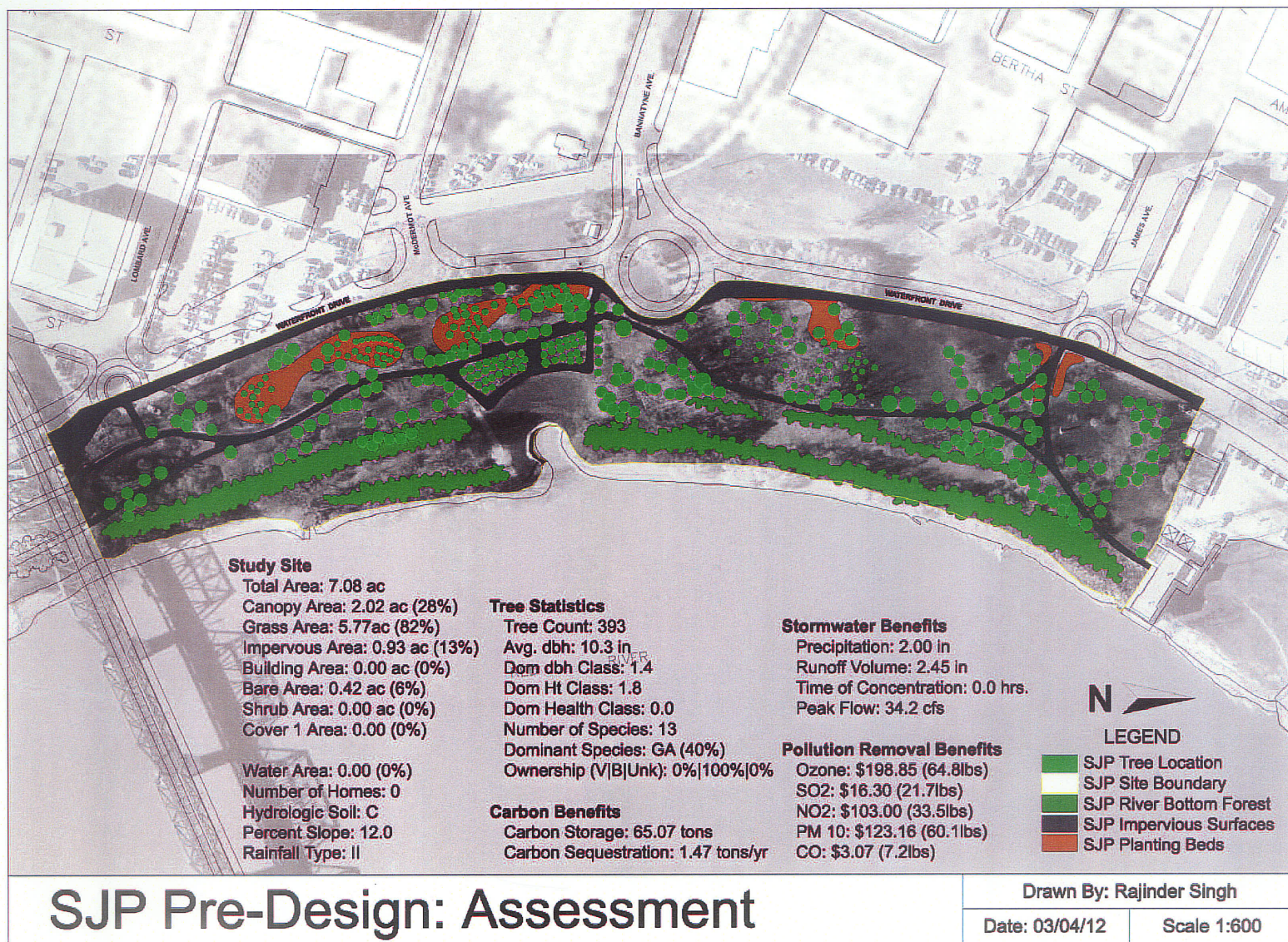


Figure 38. SJP Pre-Design: Assessment.
Map by Author.

In conjunction with the Pre-Design Assessment, the Wildlife Benefits of Stephen Juba Park was also determined (Table 4). The analysis dealt with three criteria: food, cover and nesting. The CITYgreen program created maps (Figure 39, 40 and 41) for each criterion, identifying trees that were either Poor, Fair, Good, Very Good or Unknown.

Table 4. Pre-Design Wildlife Benefits Analysis

Wildlife Food		Wildlife Cover		Wildlife Nesting	
Suitability	Trees	Suitability	Trees	Suitability	Trees
Poor	0	Poor	88	Poor	83
Fair	198	Fair	14	Fair	19
Good	58	Good	17	Good	17
Very Good	77	Very Good	0	Very Good	0
Unknown	58	Unknown	272	Unknown	272
The Trees and Wildlife analysis program identifies trees that are very good, good, fair, or poor for food, cover, or nesting habitats for urban wildlife.					
American Forests has assigned wildlife ratings to tree species according to their ability to provide food, cover, and nesting to urban wildlife. The wildlife rating definitions are as follows:					
Moderate	1 (Fair)		Very High	3 (Very Good)	
High	2 (Good)		Unknown	9	

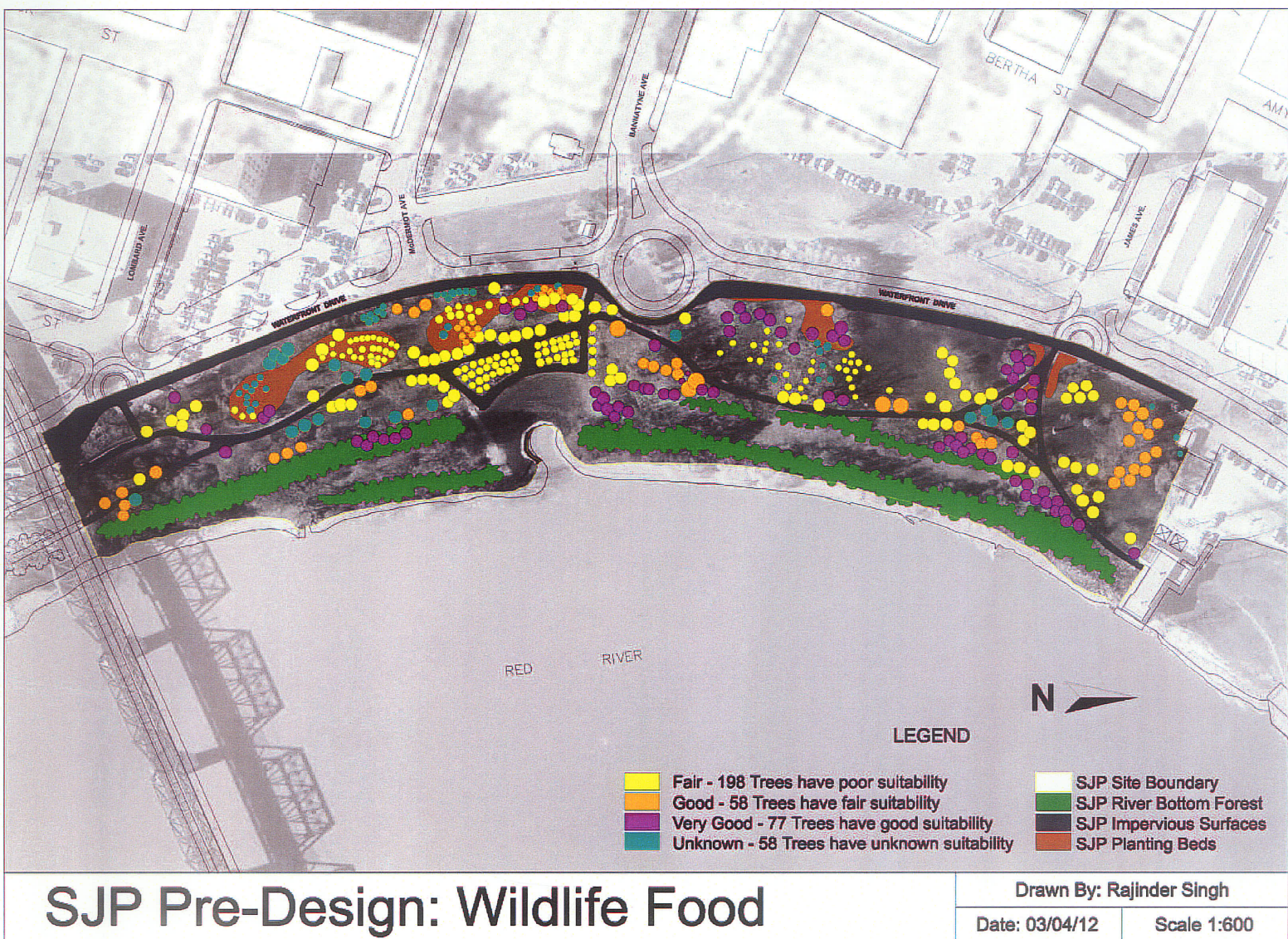


Figure 39. SJP Pre-Design: Wildlife Food.
Map by Author.



Figure 40. SJP Pre-Design: Wildlife Cover.
Map by Author.

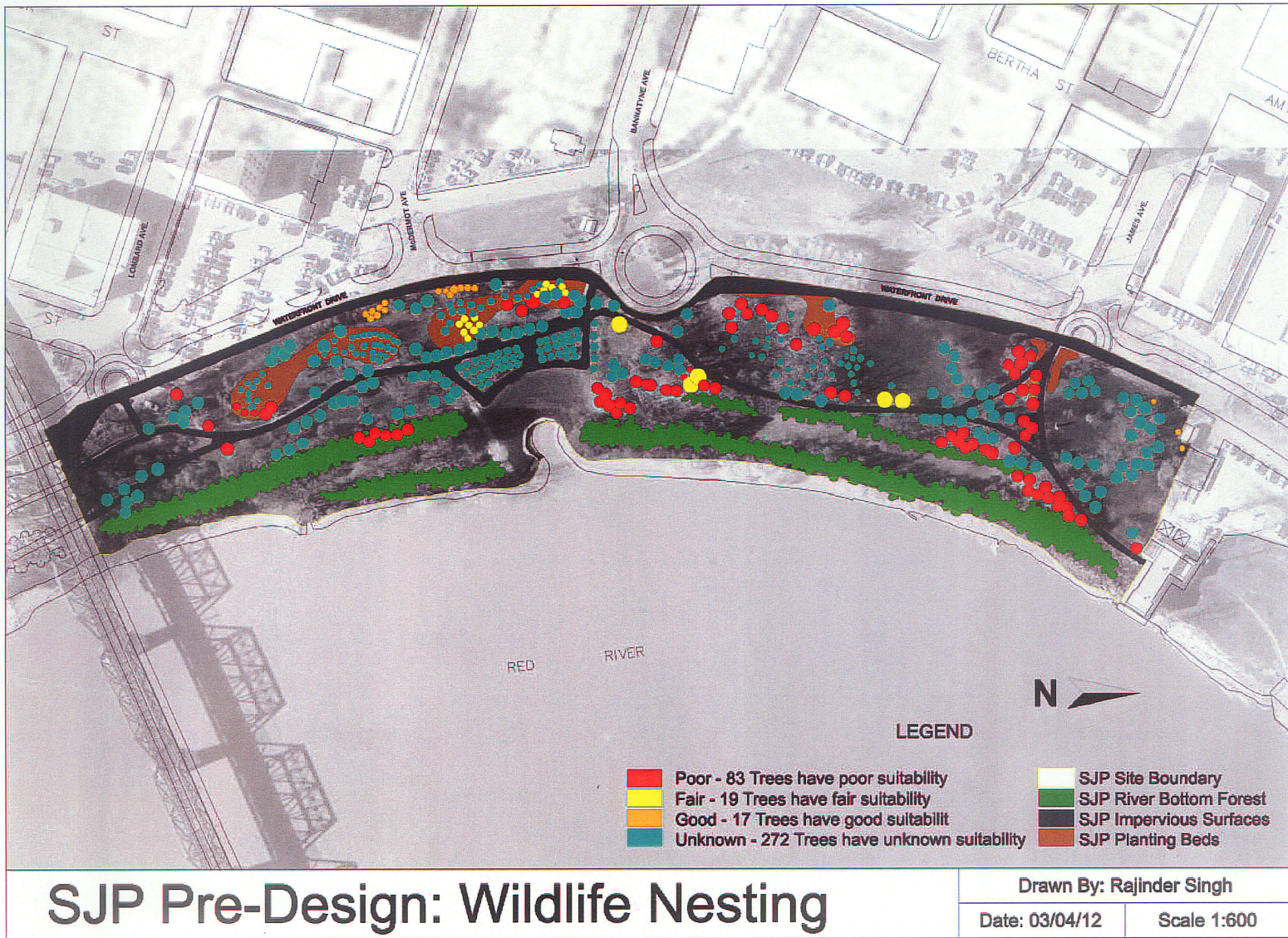


Figure 41. SJP Pre-Design: Wildlife Nesting.
Map by Author.

Post-Design Assessment Results

The results of the Post-Design Assessment are illustrated in Table 5 below and can be referenced to the Post-Design Assessment Map (Figure 42). The complete Post-Design Assessment site statistics are located in Appendix K.

Table 5. Post-Design Assessment

Study Site		Tree Statistics		Stormwater Benefits	
Total Area	7.08	Tree Count	384.00	Precipitation	2.00 in
Canopy Area	1.09	Avg. dbh	9.80	Runoff Volume	2.52 in
Grass Area	5.07	Dom dbh Class	1.40	Time of Concentration	0.03 hrs.
Impervious Area	1.24	Dom Ht. Class	1.70	Peak Flow	35.46 cfs
Building Area	0.00	Dom Health Class	0.00		
Bare Area	0.74	Number of Species	15.00	Pollution Removal Benefits	
Shrub Area	0.00	Dominant Species	GA (39.6%)	Ozone	\$199.83 (64.8lbs.)
Cover 1 Area	0.00	Ownership (V B Unk)	0% 100% 0%	SO ₂	\$16.30 (21.7lbs.)
Cover 2 Area	0.00			NO ₂	\$103.00 (33.5lbs.)
Water Area	0.00	Carbon Benefits		PM 10	\$123.77 (60.1lbs.)
Number of Homes	0.00	Carbon Storage	65.37 tons	CO	\$3.09 (7.2lbs.)
Hydrologic Soil	C	Carbon Sequestration	1.47 tons/yr		
Percent Slope	12.00				
Rainfall Type	II				

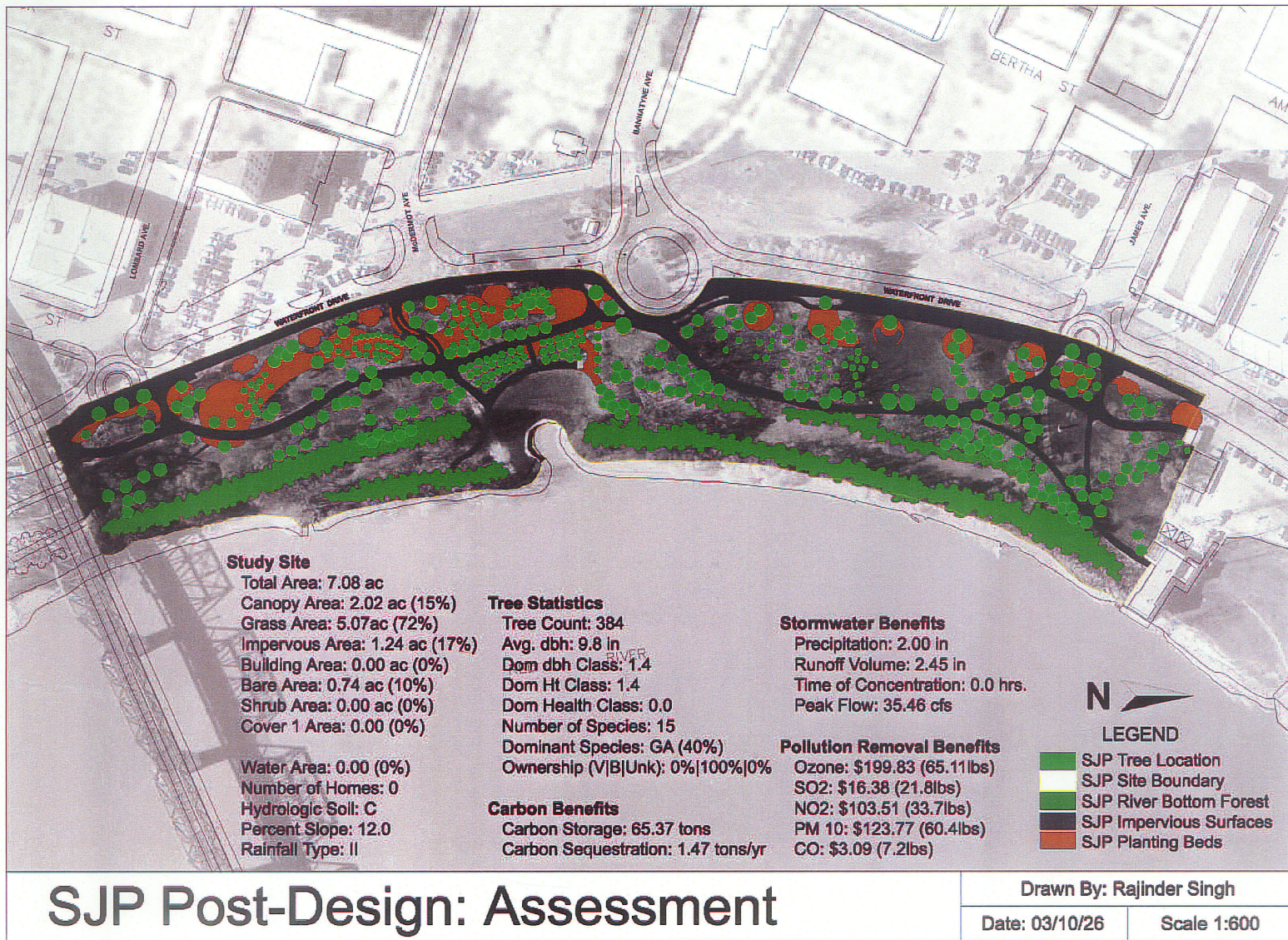


Figure 42. SJP Post-Design: Assessment.
Map by Author.

Also, as with the Pre-Design Assessment, the Wildlife Benefits of Stephen Juba Park was also determined for the Post-Design (Table 6). The analysis dealt with same three criteria: food, cover and nesting. The CITYgreen program created maps (Figure 43, 44 and 45) for each criterion, identifying trees that were Poor, Fair, Good, Very Good or Unknown.

Table 6. Post-Design Wildlife Benefits Analysis

Wildlife Food		Wildlife Cover		Wildlife Nesting	
Suitability	Trees	Suitability	Trees	Suitability	Trees
Poor	0	Poor	87	Poor	82
Fair	206	Fair	11	Fair	16
Good	51	Good	6	Good	6
Very Good	74	Very Good	0	Very Good	0
Unknown	51	Unknown	278	Unknown	278
The Trees and Wildlife analysis program identifies trees that are very good, good, fair or poor for food, cover, or nesting habitats for urban wildlife.					
American Forests has assigned wildlife ratings to tree species according to their ability to provide food, cover, and nesting to urban wildlife. The wildlife rating definitions are as follows:					
Moderate	1 (Fair)		Very High	3 (Very Good)	
High	2 (Good)		Unknown	9	

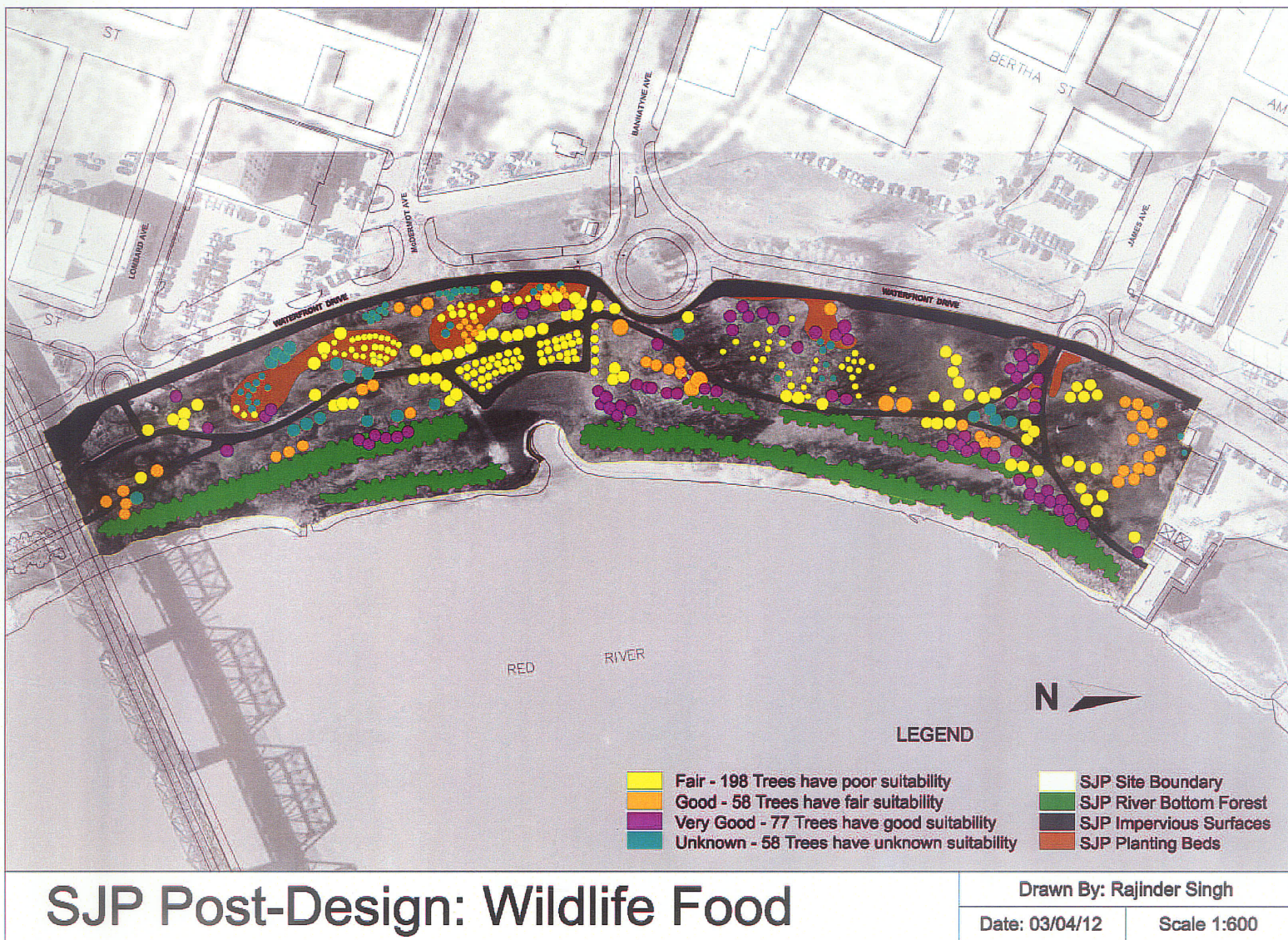


Figure 43. SJP Post-Design: Wildlife Food.
Map by Author.



Figure 44. SJP Post-Design: Wildlife Cover.
Map by Author.

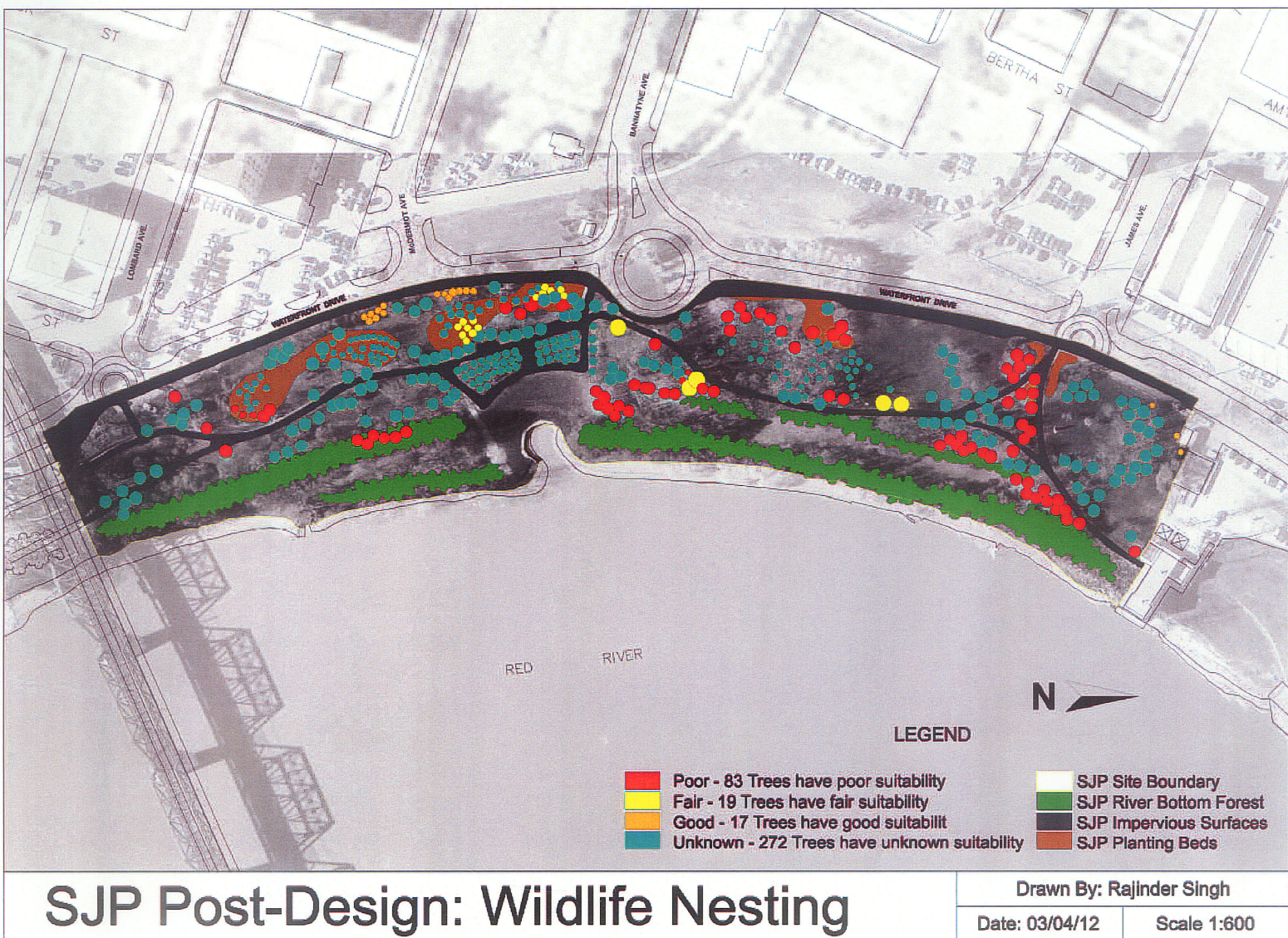


Figure 45. SJP Pre-Design: Wildlife Nesting.
Map by Author.

Pre-Design and Post-Design Assessment Comparison Discussion

Once the Pre-Design and Post-Design Assessments were completed, a relative comparison of the assessment results can be conducted. The following discussion will compare the results under each the headings listed in Table 3 Pre-Design Assessment and Table 5 Post-Design Assessment: Study Site, Tree Statistics, Carbon Benefits, Storm water Benefits and Pollution Removal Benefits. For reference, under each heading discussion the associated table has been included.

Study Site

The Study Site heading describes the amount of acres that each specific area of each assessment occupied within the site boundary of Stephen Juba Park (Table 7). The bar graph below (Figure 46) illustrates the comparison of the different areas located within the Study Site.

In the above table, categories that have a zero value, data was not collected due to there being no buildings on site. No inventory was conducted regarding the Shrub Areas, any other types of Cover Areas, Water Areas and the Number of Homes.

Table 7. Pre-Design and Post-Design Study Sites

Pre-Design Study Site		Post-Design Study Site	
Total Area	7.08	Total Area	7.08
Canopy Area	1.08	Canopy Area	1.09
Grass Area	5.77	Grass Area	5.07
Impervious Area	0.93	Impervious Area	1.24
Building Area	0.00	Building Area	0.00
Bare Area	0.42	Bare Area	0.74
Shrub Area	0.00	Shrub Area	0.00
Cover 1 Area	0.00	Cover 1 Area	0.00
Cover 2 Area	0.00	Cover 2 Area	0.00
Water Area	0.00	Water Area	0.00
Number of Homes	0.00	Number of Homes	0.00
Hydrologic Soil	C	Hydrologic Soil	C
Percent Slope	12.00	Percent Slope	12.00
Rainfall Type	II	Rainfall Type	II

Pre-Design and Post-Design Assessment Comparison Discussion

The Total Area remained constant for the Pre-Design and Post-Design assessments because the boundaries for both assessments remained constant.

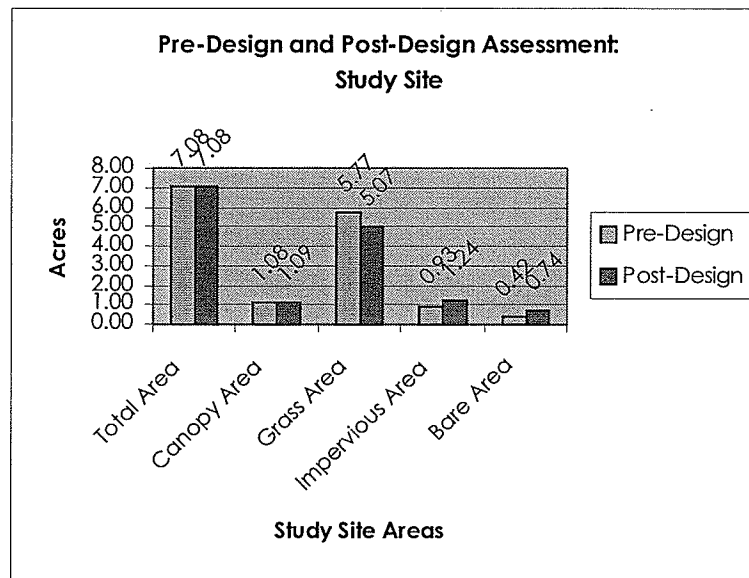


Figure 46. Pre-Design and Post-Design Assessment: Study Site.
Figure by Author.

Canopy Area for the Post-Design increased slightly. Although there were some mature trees removed from the site, the number of newly planted trees with smaller canopies made up for the decrease and also slightly surpassed it.

Changes were noticed in the total acres for Grass, Impervious, and Bare Areas. The decrease in the Grass Area for the Post-Design can be attributed to increase in the Impervious and Bare Areas. The increase in the Impervious Area is due to the widening of the pathway's and by the addition of new pathways in Stephen Juba Park. The increase in the Bare Area can be attributed to the installation of several large planters located along Waterfront Drive that have bare soil or some mulch.

The Hydrologic Soil classification remains the same for both Assessments. The Soil Classification C is defined as:

Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.

The Percentage Slope of 12.00, which is an average of the site, for the Pre-Design Assessment site was determined by referring to the original grading plan by Lombard North Group. The slope also remained the same for the Post-Design Assessment, even though some grade changes were done for the planters along Waterfront Drive and the pathways in Stephen Juba Park.

The Rainfall Type for both Assessments is II. This was determined by referring to the reference map supplied by CITYgreen (Figure 47). Although Canada is not included in this map, the assumption was made that Winnipeg, Manitoba would fall under the Rainfall Distribution Type II.

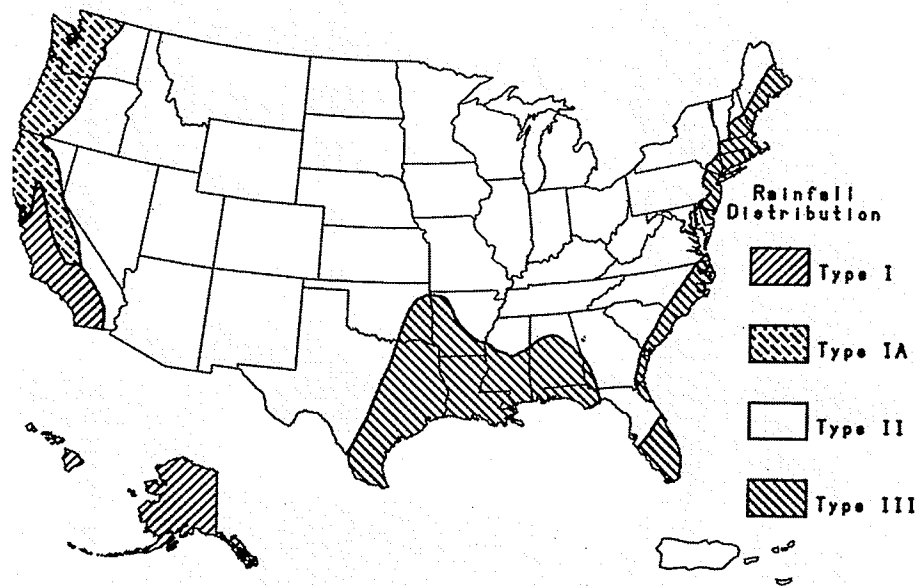


Figure 47. Rainfall Distribution for USA.
Rainfall Type. Map. American Forests, 1995.

Tree Statistics

The total number of trees in the Pre-Design Assessment was 393 and when compared to the Post-Design Assessment of 384, there is a decrease of 9 trees within the park alone (Table 8). It is important to note here that although there was a decrease within the park, the total number of trees planted with regard to the entire Waterfront

Drive project is 180 trees. The bar graph below (Figure 48) illustrates the comparison of the Tree Statistics.

Table 8. Pre-Design and Post-Design Tree Statistics

Pre-Design Tree Statistics		Post-Design Tree Statistics	
Tree Count	393.00	Tree Count	384.00
Avg. dbh	10.30"	Avg. dbh	9.80"
Dom dbh Class	1.40	Dom dbh Class	1.40
Dom Ht. Class	1.80	Dom Ht. Class	1.70
Dom Health Class	0.00	Dom Health Class	0.00
Number of Species	13.00	Number of Species	15.00
Dominant Species	GA (40%)	Dominant Species	GA (39.6%)
Ownership (V B Unk)	0% 100% 0%	Ownership (V B Unk)	0% 100% 0%

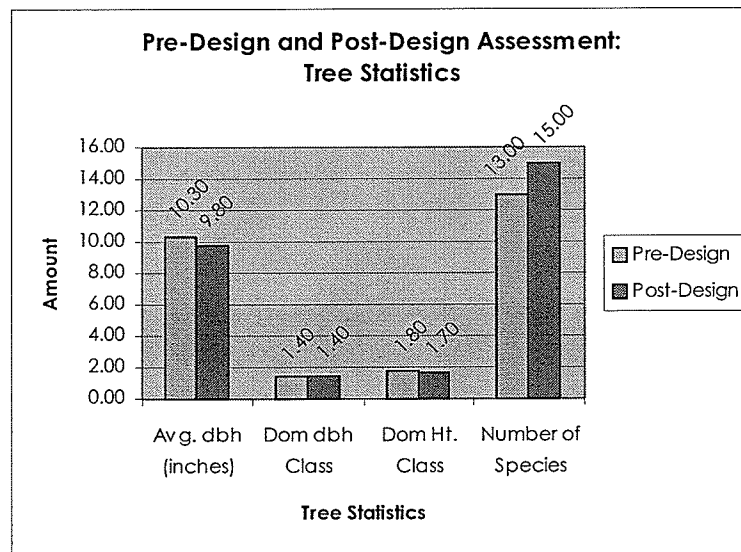


Figure 48. Pre-Design and Post-Design Assessment: Tree Statistics.
Figure by Author.

The average diameter of the trees has been reduced by 3/8". This decrease can be attributed to the decrease of mature trees and increase of newly planted younger trees with smaller trunk diameters (dbh).

The dominant diameter class showed no change.

The height class has decreased slightly. This is due to the removal of some mature trees and increasing the amount of shorter, younger trees.

The dominant health class was not determined due to the amount of time that would have been required to complete the tree health worksheets supplied by CITYgreen.

The number species in the Park has increased by two. This increase is a positive characteristic in that by increasing the species diversity can lead to heterogeneous urban forest. One benefit of a heterogeneous urban forest is the decrease in the negative effects of disease and insects that can have a damaging effect to homogenous urban forests. For example, the effect of Dutch Elm Disease (DED), which is currently affecting the Elms here in Winnipeg and other cities across North America.

The dominant species for both Assessments is the Green Ash, *Fraxinus pennsylvanica*, at about 40%. The hardy characteristics of the Green Ash make it a tree that is commonly planted as a shade and/or street tree in urban areas. The Green Ash is still susceptible to insect infestations, such as canker worms, which are a serious problem here in Manitoba. Another is the heavy infestation of ash flower gall mite (*Aceria fraxiniflora*) that can cause an unsightly appearance on the branches in the spring (Knowles 1995, 77). The arrival of the Emerald Ash Borer and possible infestation, the diversification of species is very important.

With the frequent planting of Green Ash becoming the common street tree, we may be setting the stage for a similar problem in the future with the Emerald Ash Borer that some North American cities are currently facing with Dutch Elm Disease. One way to counter this possible effect is to plant several different species so as to create a heterogeneous urban forest. To aid Urban Foresters in determining the species diversification for a heterogeneous urban forest, a formula has been developed by the International Society of Arboriculture and is now the accepted standard. The formula is defined as a planting plan containing no more than 10% of any one family and 5% of one species (Phillips 1993, 48).

This means that for every 100 trees planted, no more than 10 trees are planted of any one family, such as Ash, and no more than 5 trees of any one species, such as Green Ash. The diversification formula is difficult to use in zones 2 and 3 and in other places where the number of trees is restricted due to soil or climatic conditions (Phillips 1993, 48).

CITYgreen also allows for the recording and storing of a tree's Ownership characteristic on whether it is located on Public, Private or Unknown property. One benefit of knowing this type of information about a tree is that if a tree requires maintenance, the City's maintenance crew can refer to CITYgreen to determine tree's location and see if it is located on Public or Private property. If the tree is located on Public property, then the City's maintenance crew can go ahead with the maintenance, but if the tree is located on private property, then the owner of property will have to be contacted and proper arrangements would have to be made for the maintenance of the tree. Also, the City can begin to know how much of its urban forest is located on public and/or private property.

Carbon Benefits

The Carbon Benefits are calculated by formulas adapted from the US Forest Service research. For more information regarding the formulas and multipliers used to calculate these results, refer to Appendix J, section J2 Carbon Storage and Sequestration. CITYgreen references the feature data about the tree canopy cover to make its estimates. CITYgreen also refers to the trunk diameter of each tree and calculates an average diameter for the whole site (American Forests, 2000, 62).

There was a slight increase in the amount of carbon being stored in the Park (Table 9). In the Pre-Design Assessment, the amount of carbon storage is 65.07 tons and in the Post-Design Assessment, the amount is 65.37 tons. When CITYgreen performs this calculation, there are two constants, the total acres of the site and the multiplier. Only

Pre-Design and Post-Design Assessment Comparison Discussion

the percentage of tree cover varies. Due to the slight variation in the percentage tree cover, there was a .3 ton carbon storage increase in the Post-Design Assessment.

The carbon sequestration remained the same at rate of 1.47 tons/yr.

Table 9. Pre-Design and Post-Design Carbon Benefits

Pre-Design Carbon Benefits		Post-Design Carbon Benefits	
Carbon Storage	65.07 tons	Carbon Storage	65.37 tons
Carbon Sequestration	1.47 tons/yr	Carbon Sequestration	1.47 tons/yr

Storm Water Benefits

CITYgreen also calculate effects the tree canopy and other vegetation can have on storm water runoff volume, time of concentration and peak flow for the study area (Table 10). The runoff volume in the Pre-Design Assessment is 2.45" and in the Post-Design Assessment it is 2.52", an increase of 0.07". In the Post-Design Assessment, a time of concentration of 0.03 hours, or 18 minutes, was calculated. This means that now the flow of water after a rainfall will concentrate in 18 minutes, where in the Pre-Design Assessment there was none. The peak flow in Pre-Design Assessment is 34.2 cfs (cubic feet/sec) and in the Post-Design Assessment it is 35.46 cfs, an increase of 1.26 cfs.

Table 10. Pre-Design and Post-Design Storm Water Benefits

Pre-Design Storm Water Benefits		Post-Design Storm water Benefits	
Precipitation	2.00"	Precipitation	2.00"
Runoff Volume	2.45"	Runoff Volume	2.52"
Time of Concentration	0.00 hrs.	Time of Concentration	0.03 hrs.
Peak Flow	34.2 cfs	Peak Flow	35.46 cfs

The increase in the Post-Design Assessment Storm Water Benefits can be attributed to the decrease in the number of trees in Stephen Juba Park and in the increase in the amount of impervious surface area in the Post-Design Assessment. As a result, a higher concentration of rainfall will now reach the grassed and impervious areas, collect and then drain towards the Red River.

Pollution Removal Benefits

David Nowak, PhD, of the United States Department of Agriculture (USDA) Forest Service developed a methodology to assess the air pollution removal capacity of urban forests with respect to pollutants such as Ozone (O₃), Sulfur Dioxide (SO₂), Nitrogen Dioxide (NO₂), particulate matter less than 10 microns (PM₁₀) and Carbon Monoxide (CO). The numbers generated by CITYgreen are reported in pounds, on an annual basis (American Forests, 2000, 105). The dollar benefits estimates produced by CITYgreen are based on direct and indirect costs associated with a pollutant once it enters the atmosphere. CITYgreen references feature data about tree and/or forest canopy cover to make its estimates (American Forests, 2000, 63).

The pollution removal benefits can be based upon one of ten US cities, or an average of the ten, where the US Forest Service has conducted its research: Atlanta, Austin, Baltimore, Boston, Chicago, Denver, Milwaukee, New York, Philadelphia, Seattle, and St. Louis. For the Pre-Design and Post-Design Assessments, the average of the ten US cities was used. The Pollution Removal Benefits are displayed below (Table 11).

**Table 11. Pre-Design and Post-Design
Pollution Removal Benefits**

Pre-Design Pollution Removal Benefits		Post-Design Pollution Removal Benefits	
Ozone	\$198.85 (64.8lbs.)	Ozone	\$199.83 (64.8lbs.)
SO ₂	\$16.30 (21.7lbs.)	SO ₂	\$16.30 (21.7lbs.)
NO ₂	\$103.00 (33.5lbs.)	NO ₂	\$103.00 (33.5lbs.)
PM 10	\$123.16 (60.1lbs.)	PM 10	\$123.77 (60.1lbs.)
CO	\$3.07 (7.2lbs.)	CO	\$3.09 (7.2lbs.)

In Figure 49, there was very little difference in the total dollar amount of pollution removed between the Pre-Design and Post-Design Assessments. One benefit of this assessment is that CITYgreen was able to provide the amount, in pounds/year, of pollutants that will be removed from Winnipeg's atmosphere by the trees located within Stephen Juba Park, which was not known prior to this assessment.

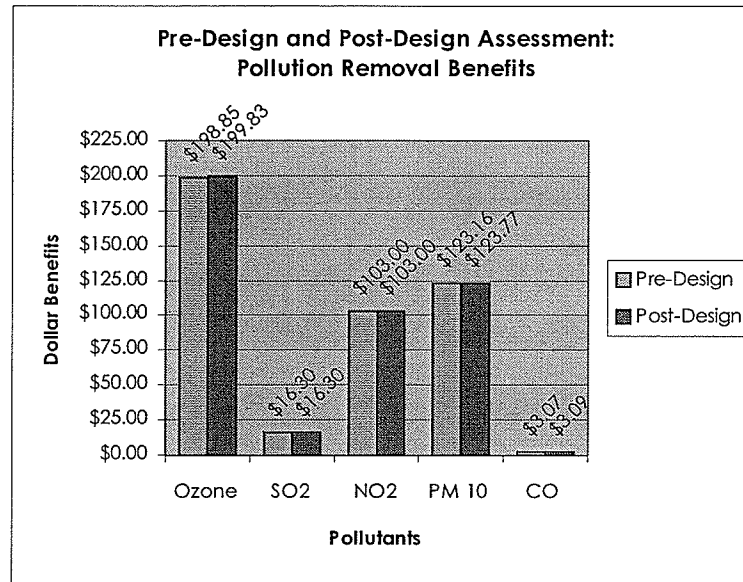


Figure 49. Pre-Design and Post-Design Assessment: Pollution Removal Benefits.
Figure by Author.

Pre-Design and Post-Design Wildlife Analysis Comparison Discussion

In addition to the above Pre-Design and Post-Design Assessment, CITYgreen also conducted a Wildlife Analysis for the Pre-design and Post-Design Assessments. The following discussions will compare the Wildlife Analysis for both assessments under each of the following major headings: Food, Cover, and Nesting.

CITYgreen rates each tree species for their value in providing food, cover and nesting habitats for small mammals and birds within the specified study area. CITYgreen determines the individual values by combining the master species database to the tree theme attribute table. This process will therefore create a complete list that includes wildlife variables for each tree present in the study area. Currently, the masters' species database contains wildlife ratings for approximately 100 trees (American Forest, 2000, 74). The wildlife ratings are assigned in accordance with research compiled in *American Wildlife and Plants* and the *Forestry Handbook*.

The wildlife benefits analysis assigns a value to each tree individually, based on its species, size and wildlife rating. Results are on a per tree basis and do not assess the

wildlife value of the study area overall. For example, five closely grouped trees in a half-acre grass field will yield the same wildlife results as five trees spread out over a five-acre impervious site (American Forest, 2000, 74).

The number of species in the Post-Design Assessment when compared to the Pre-Design Assessment is 15, an increase of two species: American Elm and Japanese Tree Lilac. The additional two species is a positive step towards increasing the diversification of Stephen Juba Park. The summary table below (Table 12) lists the percentage of each species within each Assessment.

Table 12. Pre-Design and Post-Design Species Diversity

Pre-Design Species Diversity		Post-Design Species Diversity	
POP (Poplar, White)	9.9%	POP (Poplar, White)	9.1%
LIN (Linden, American)	10.2%	LIN (Linden, American)	10.2%
GA (Green Ash)	40.2%	GA (Green Ash)	39.6%
BM (Boxelder Maple)	12.5%	BM (Boxelder Maple)	12.5%
SM (Silver Maple)	7.1%	SM (Silver Maple)	6.8%
SE (Siberian Elm)	2.3%	SE (Siberian Elm)	1.8%
CHY (Ornamental Cherry)	0.3%	CHY (Ornamental Cherry)	0.3%
WIL (Willow)	4.3%	WIL (Willow)	1.6%
CR (Cottonwood)	1.3%	CR (Cottonwood)	1.3%
ASH (Ash)	6.4%	ASH (Ash)	7.8%
CRB (Crabapple)	1.5%	CRB (Crabapple)	2.1%
CP (Scotch Pine)	0.5%	CP (Scotch Pine)	0.5%
SPR (Spruce)	3.6%	SPR (Spruce)	3.6%
		AE (American Elm)	2.3%
		ORN (Ornamental)	1.3%

Wildlife Analysis - Food

The results from the Wildlife Food Analysis are located below (Table 13) that displays the number of the trees that fall under each suitability rating.

Table 13. Pre-Design and Post-Design Wildlife Food

Pre-Design Wildlife Food		Post-Design Wildlife Food	
Suitability	Trees	Suitability	Trees
Poor	0	Poor	0
Fair	198	Fair	206
Good	58	Good	51
Very Good	77	Very Good	74
Unknown	58	Unknown	51

Pre-Design and Post-Design Assessment Comparison Discussion

With the removal of trees and planting of new, younger ones, the number of trees under each suitability rating changed as expected. The Pre-Design numbers set the benchmark because there was no Wildlife Analysis conducted prior to this one in utilizing CITYgreen. When the Post-Design Assessment is relatively compared to the Pre-Design Assessment, the data shows increases and decreases in each suitability rating.

In both Assessments, the trees that have a Fair suitability are Green Ash, Crabapple, Ash, Siberian and American Elm. The Post-Design shows an increase in the amount of trees in the Fair rating when compared to the Pre-Design. This increase can be attributed to the removal of some Green Ash, Ash and Siberian Elm trees in the Post-Design and the additional planting of American Elm, Crabapple and Ash in the Post-Design.

The trees that have a suitability rating of Good are the White Poplar, Cottonwood, Scotch Pine and Spruce. CITYgreen identified these tree species for both Assessments. The decrease of trees with a suitability rating of Good in the Post-Design assessment can be attributed to the removal of White Poplars and Spruce trees.

The trees that have a suitability rating of Very Good are the Boxelder Maple and Silver Maple, which have been identified for both Assessments. The decrease in the Post-Design can be attributed to the removal of Silver Maples.

Under the Unknown suitability rating, American Linden and Willow were identified in the Pre-Design and Post-Design Assessment. The decrease in the Post-Design can be attributed to the removal of several Willows, but has been offset due to the additional planting of Ornamentals, which are the Japanese Tree Lilacs. The reason why the above tree species have an Unknown suitability rating is that the wildlife rating database referred to by CITYgreen has no data associated to them.

Wildlife Analysis - Cover

The results from the Wildlife Cover Analysis are located below (Table 14) that display the number of the trees that fall under each suitability rating.

Table 14. Pre-Design and Post-Design Wildlife Cover

Pre-Design Wildlife Cover		Post-Design Wildlife Cover	
Suitability	Trees	Suitability	Trees
Poor	88	Poor	87
Fair	14	Fair	11
Good	17	Good	6
Very Good	0	Very Good	0
Unknown	272	Unknown	278

For both Assessments, the trees that have a Poor suitability rating for providing cover are the Cottonwoods, Silver Maples, Boxelder Maples and Crabapples. The reason for the decrease of trees that have a Poor suitability rating in the Post-Design is due to the removal of a Silver Maple.

The trees that fall under the Fair suitability rating were the coniferous, Spruces and Scotch Pines. These two trees were the only ones that were determined Fair by CITYgreen for both Assessments. The reason for the decrease was the removal of some Spruce trees in the Post-Design.

Only one tree species fell under the rating of Good for both assessments and that is the Willow. The difference between the Pre-Design and Post-Design is due to the high number of Willows removed and none being replanted in the Post-Design.

The trees that fall under the Unknown suitability rating in the Pre-Design are the White Poplar, Green Ash, Siberian Elm, Ash and American Linden. In the Post-Design, the Ornamental and American Elm were added to the list of Unknown. Also, these two tree species can be attributed to the increase in the total number of Unknowns. The reason why the above tree species have an Unknown suitability rating is that the wildlife rating database referred to by CITYgreen has no data associated to them.

Wildlife Analysis - Nesting

The results from the Wildlife Nesting Analysis are located below (Table 15) that display the number of the trees that fall under each suitability rating.

Table 15. Pre-Design and Post-Design Wildlife Nesting

Pre-Design Wildlife Nesting		Post-Design Wildlife Nesting	
Suitability	Trees	Suitability	Trees
Poor	83	Poor	82
Fair	19	Fair	16
Good	17	Good	6
Very Good	0	Very Good	0
Unknown	272	Unknown	278

For both Assessments, the trees that have a Poor rating for providing Nesting are Boxelder Maple, Silver Maple and Crabapples. The slight decrease in the Post-Design can be attributed to the removal of a Silver Maple.

The trees that have a Fair rating are the Spruce, Scotch Pine and Cottonwood. These trees also have the same rating in the Post-Design. The reason for the decrease in the Post-Design is due to the removal of some Spruce trees.

Only one tree was categorized under the Good rating and that is the Willow for both Assessments. The decrease is due to the removal of several Willows from the site in the Post-Design.

The trees that fall under the Unknown rating are Green Ash, White Poplar, Siberian Elm, Ash and American Linden. These same trees were also identified in the Post-Design with the addition of Ornamentals and American Elms to the list and thus increased the number of trees with the Unknown rating. The reason why the above tree species have an Unknown suitability rating is that the wildlife rating database referred to by CITYgreen has no data associated to them.

Conclusions

In the introduction, four practicum objectives were outlined. First is to provide an understanding why the definition of sustainable development is a vague term. This vagueness is attributed to its complex overarching concept that encompasses the economy, environment, health and social well-being of people. The concept of sustainable development allows for the development of various methods and techniques to be utilized in order to calculate sustainable development and to determine how close we are from achieving set goals. Secondly, to demonstrate how GIS technology is a flexible and beneficial tool that can continue to be applied in the realm of landscape architecture. Thirdly, to provide an increased awareness to the political decision makers and the public of what the urban forest is, the benefits it provides and how CITYgreen can be used to determine some of these benefits towards the sustainable development of a city and its citizens. Lastly, to provide a methodology that can be applied to assess the benefits of a proposed design solution for a site. The significance of the research will also be discussed.

Objective #1

To provide an understanding why the definition of sustainable development is a vague term. This vagueness is attributed to its complex overarching concept that encompasses the economy, environment, health and social well-being of people. The concept of sustainable development allows for the development of various methods and techniques to be utilized in order to calculate sustainable development and to determine how close we are from achieving set goals.

Critics of the definition of sustainable development claim that it is simple and does not specify what should be sustained (Redcliff 1999, 60). Reid has taken a different approach to explain the definition. He states that it "is not something to be defined, but declared. It is an ethical guiding principle" (Reid 1995, xvi). In both arguments, people are in favour of sustainable development but will retain their individual definitions of what

sustainable development actually means and conceding that they might be hard pressed to agree with others on how we may achieve it (Reid 1995, xvi). The agreement of different cities and societies on what should be sustained and what should not be sustained will continue to be a difficult hurdle to overcome. Even though, cities and societies around the world are attempting to implement sustainable development principles, policies and guidelines at various levels of international, national and local governments to determine goals and targets in achieving them, such as Agenda 21.

Agenda 21 is an action plan and strategy for the world's governments and citizens to consider environmental and economic problems and to propose solutions to these problems (Carrol-Foster 1993, 7). Agenda 21 states that methods and techniques should be utilized to calculate sustainable development, to determine goals and targets, and how close we are from achieving them. The application of CITYgreen in this practicum is one such method. This focus of the practicum is on how trees can become part of a sustainable urban design strategy. With the utilization of CITYgreen, a city can determine the carbon, storm water, pollution removal and wildlife benefits of its urban forest. CITYgreen can also be utilized to assist in establishing sustainable goals and targets for its urban forest.

Although sustainable development is still considered a vague term, it does provide cities and societies with a concept, although complex and overarching, that can be utilized to develop principles, policies and guidelines to determine goals and targets. By focusing on how trees can be one way to achieve sustainable development of an urban forest, CITYgreen can be utilized as a tool to determine, measure and calculate how close we are to achieving these goals and targets. At the same time, urban foresters and landscape architects can begin to illustrate the principles of sustainable development with the common goal of informing and persuading society to declare its position on the issue.

Objective #2

To demonstrate how GIS technology is a flexible and beneficial tool that can continue to be applied in the realm of landscape architecture.

GIS usage in landscape architectural firms varies in application. GIS is used for site design, recreation master planning, visual analysis, comprehensive planning, resource management and public advocacy (Hanna 1999, 3). This practicum has demonstrated the flexibility and benefits that are possible by adapting the application of CITYgreen.

The original intended use for CITYgreen by American Forests was to be utilized as a tool to determine the benefits of a city's urban forest on a citywide scale. The benefits on a citywide scale would be determined by selecting sample sites that would contain various development densities and tree cover. This practicum has adapted CITYgreen to be utilized as a tool to perform a comparative assessment of a pre-design and post-design solution of a single site, Stephen Juba Park.

In the application of GIS, landscape architects have encountered disadvantages, such as being "data-rich and information poor" (Lo 2002, 443) and advantages, such as the ability to perform "what if?" scenarios (Hanna et al. 1998, 107-108). With the application of CITYgreen, disadvantages and advantages were also encountered.

Disadvantages included that a novice user would have a difficult time in applying CITYgreen. A CITYgreen user would likely require previous experience with a GIS, particularly ArcView. American Forests does provide training courses for the application of CITYgreen for a fee. Which brings cost to be another disadvantage. CITYgreen is an extension for ArcView. The cost for acquiring both pieces of software would be approximately \$3000.00CDN. Combining the cost of the software and possible training, CITYgreen can become expensive for a small private landscape architectural

firm to implement and utilize. Another cost issue is the data collection process. This process can prove to be time consuming and possibly be cost prohibitive.

An advantage encountered in the application of CITYgreen was that the data utilized in the assessments came from a reliable source. The data utilized was personally collected and recorded from conducting the site analysis and ground truthing of Stephen Juba Park. So, as the adage goes, "Garbage In – Garbage Out," did not apply. Another advantage was the successful demonstration and application of CITYgreen in determining the benefits with applied methodology of this practicum. Although there were slight increases and decreases in the pre-design and post-design assessments results based on this one site, a citywide application of determining the benefits could be used as one reason to legitimize the amount of time and cost that would be required in acquiring and implementing CITYgreen.

GIS has proven to be a flexible tool that has been used to capture, manage, manipulate, analyze, model and display data for solving complex planning and management problems. GIS has been utilized by cities as a tool to aid in management of their infrastructure. By viewing the urban forest as another layer of the city's infrastructure, CITYgreen, in addition to calculating the benefits, can also aid in the management and to increase awareness to the political decision makers and the public regarding the benefits the urban forest provides to the city.

Objective #3

To provide an increased awareness to the political decision makers and the public of what the urban forest is, the benefits it provides and how CITYgreen can be used to determine some of these benefits towards the sustainable development of a city and its citizens.

In order to provide increased awareness to the political decision makers and the public, they should have a greater awareness of the urban forest and the benefits it provides. In the context of Winnipeg, this would include the:

- Definition of a sustainable developed urban forest that takes into consideration the evolution of the urban forest from current to future generations;
- Description of the various densities of the urban forest and how CITYgreen can be used to develop a grading scale based on them;
- Direct and indirect effects, costs and benefits provided by the urban forest and how CITYgreen can be used to determine the benefits for individual tree species;
- Importance of species diversification and how CITYgreen can be used to help determine the potential loss of benefits from trees affected by insect and/or disease; and
- Reduction of the Urban Heat Island Effect and how CITYgreen can measure the energy savings and avoided carbon emission benefits;

The first step is to provide the political decision makers and the public with a definition of a sustainable developed urban forest. Since this practicum is focusing on sustainable development, the perception and benefits of the urban forest will continue to evolve from current and future generations. The definition provided by Clark et al. for a sustainable developed urban forest, that only considers trees, should be provided which is (Clark et al. 1997, 21):

"The naturally occurring and planted trees in cities which are managed to provide the inhabitants with a continuing level of economic, social, environmental and ecological benefits today and into the future."

Once the definition of the urban forest has been presented, next is to illustrate and describe the density of the urban forest. According to Miller, the density of the urban forest varies with land use patterns of a city (Figure 13). The land use patterns have been divided into four zones, with urban being the centre, followed by suburban, exurban and rural, respectively. The illustration provided by Miller should be regarded as a general description for North American cities and is not an accurate representation of

all cities. By identifying these four land use patterns, a type of grading scale for the entire city can be developed.

From each land use patterns, sample sites with various development densities and tree cover can be identified. CITYgreen can then determine the carbon, storm water, pollution removal and wildlife benefits for each of the sample sites. The results determined will be regarded as the base data for the entire city and can therefore be used to develop a grading scale. This scale could be referred to as City of Winnipeg Urban Ecological Assessment Scale (CWUEAS). When a proposed design solution(s) is to be implemented on a site, the CWUEAS will be determined for the proposed design and compared to the corresponding development density base data. If the design meets or exceeds the base data, it passes. If it does not, then it will either have to be redesigned, or that concessions must be made in another area of the city, or the payment of penalties.

The political decision makers and the public also need to be made aware that the benefits provided by the urban forest are greater than the maintenance costs (Clarke et al. 1997, 20). The urban forest provides a variety of direct and indirect effects. Figure 14 illustrates the various benefits a single tree provides. Not included is the indirect psychological benefit the urban forest provides. The psychological benefits identified by psychologists, such as Stephen and Rachel Kaplan and William James, have concluded that the inclusion and need for vegetation within the built urban environment of cities is of great importance for its citizen's mental well-being and the perception they have of their living conditions. Urban planners and landscape architects must consider these types of studies when projects are being proposed and ask how they can enhance the publics' peace of mind and experience in the city through the use of vegetation (Sheets and Manzer 1991, 302).

Identifying the various direct and indirect effects that a single tree can provide, awareness of the accumulated benefits from the city's urban forest will also be realized. In addition to the variety of direct and indirect effects, the development of base data for individual tree species may be beneficial and useful for urban foresters and landscape architects. The base data will be comprised of carbon, storm water, pollution removal, and wildlife benefits determined by CTYgreen.

The generation of this base data for individual tree species can be referred to the trees recommended by the City of Winnipeg Forestry Branch plant list in Appendix A. The base data can be determined by establishing standards on various dimensions and types of permeable and impermeable surfaces and tree species characteristics. For example, the dimension of a permeable surface could be a 5m x 5m square plot with grass as the ground cover. Then place a single tree species in the middle of the grassed plot, enter its associated characteristics and initialize CITYgreen to calculate the benefits. This process will therefore provide the base data for the particular tree species. CITYgreen also has the capability of running modeling scenarios that can model the growth of trees based on 10, 20, 30 or 50 years. This modeling capability can therefore be applied to the base data to determine the potential future benefits of each tree species. Once completed, the base data can then be compiled into a tabular format. This table can then be referred to by a landscape architect to aid in preparing the landscape development plans for a site so as to maximize the overall benefits.

Awareness regarding the importance of species diversification of the urban forest is another important aspect. For example, for the last 25 years Dutch Elm Disease (D.E.D.) has been the number one killer of Elm trees all across North American cities. This same scenario may be repeated, but with the Ash species (*Fraxinus sp.*) because this species is increasingly being planted due to its hardy characteristics as both a shade and street tree (Knowles 1995, 77). An insect has been identified in North America called the

Emerald Ash Borer from China and eastern Asia and attacks Ash species. It has currently been contained in Windsor, Ontario. Inevitably, the Emerald Ash Borer will spread and the effects on the urban forest in cities across North America may be similar to those affected by Dutch Elm Disease. The diversification of tree species is therefore an important concept for the sustainable development of the City of Winnipeg's urban forest. The importance of the diversification of tree species also has to be explained and emphasised to the political decision makers and public so as aid preventing future insect infestations and/or diseases from destroying the City of Winnipeg's urban forest.

The Forestry Branch, with perhaps cooperation from the Coalition to Save the Elms, could utilize CITYgreen to determine the current carbon, storm water, pollution removal and wildlife benefits for neighbourhoods that are currently "hot spots" for D.E.D. CITYgreen could be used to model scenarios to identify the potential loss of benefits as the infected Elms slowly die. CITYgreen could also be used as a tool establishing a reforestation program for replacing the dying Elm trees. Therefore, the modeled scenario results can be used to provide additional awareness of D.E.D. and the potential loss of benefits, aid in the management of D.E.D., and to also provide additional support of the importance of species diversification in a city's urban forest.

The Urban Heat Island Effect can be reduced by the urban forest. By replacing vegetation by concrete or asphalt, it reduces an urban landscapes ability to lower daytime temperature through evapotranspiration. Instead, the solar energy raises the surface temperature (Akbari et al. 1992, 7). By increasing the amount of vegetation in cities, the air temperature will decrease thus reducing energy loads from power plants that burn fossil fuels for cooling buildings.

CITYgreen has the capability to calculate the amount of energy savings and avoided carbon emission benefits that trees provide by shading of buildings. This benefit was not determined for Stephen Juba Park because the site did not have any buildings

within the specified site boundary. These benefits can be determined for the same sample sites based on the various development densities and tree cover. By using CITYgreen's modeling scenario capability, political decision makers, urban foresters and landscape architects it can illustrate to the public the potential future savings in energy and reduction in carbon emissions by the simple act of planting additional trees in strategic locations around their buildings and homes.

Urban foresters and landscape architects can begin to increase awareness to the political decision makers and the public regarding what the urban forest is and the various benefits it provides by presenting them the discussed topics. The political decision makers and the public also need to be made aware of CITYgreen's flexibility and capability of determining these various benefits. Urban foresters and landscape architects have to emphasize that for the continued sustainable development of the City of Winnipeg's urban forest will greatly depend on the current and future generations.

Objective #4

To provide a methodology that can be applied to assess the benefits of a proposed design solution for a site.

The methodology applied in this practicum is a relative comparison of a pre-design and post-design assessment, which was built upon from the initial proposed application of CITYgreen by American Forests. American Forests recommended that by using several sample sites that varied in development and tree cover densities CITYgreen could be used to determine the overall benefits of the urban forest on a citywide scale. Instead of determining the benefits on a citywide scale, personnel interest was directed towards the application of CITYgreen as a tool in conducting a pre-design and post-design relative comparison assessment of Stephen Juba Park, a single site.

The development of the relative comparison methodology that was implemented in this practicum can therefore be applied to a situation that will require the determination of what benefits will be gained and/or lost of an intended design solution or development verses the existing site conditions. CITYgreen provides this opportunity by being able to model design alternatives so as to determine each designs benefits towards the continued sustainable development of the city.

Significance of this Research

The significance of this research was developing an in depth understanding of the relationship between Geographic Information Systems (GIS) and Urban Forestry and that the concept of Sustainable Development further strengthened this relationship. That CITYgreen is a tool that can be utilized by the political decision makers and urban foresters to make informed management decisions based on the current and potential benefits the urban forest provides. Also, CITYgreen can be used as a tool to evaluate, compare and possibly aid in developing design solutions by landscape architects. Although the benefits determined by CITYgreen for Stephen Juba Park showed slight increases and decreases of the benefits at the site scale, that if CITYgreen were applied on a citywide scale the accumulated benefits would be realized.

Since the introduction of Sustainable Development in 1984, a variety of disciplines, such as GIS and urban forestry, have begun to adapt and adopt the concept of sustainable development. GIS, as a sustainable development tool, has been recognised for (Wiken et al. 1992, 55):

"its ability to integrate various social, economic, and environmental factors for decision-making use, makes it a practical tool for achieving the transition to sustainable development."

This is made possible due to the flexibility of GIS and the development of various GIS software extensions, such as CITYgreen that can be used to develop and measure indicators of the sustainable developed urban forest. The sustainable development of the urban forest has been defined as (Clarke et al. 1997, 21):

"The naturally occurring and planted trees in cities which are managed to provide the inhabitants with a continuing level of economic, social, environmental and ecological benefits today and into the future."

The above definitions of GIS and urban forestry have been redefined in accordance to the concepts behind sustainable development. The benefits determined by CITYgreen may be useful in specific disciplinary fields, such as urban forestry and landscape architecture, but it may have limited use for interdisciplinary decision making. Since we can use CITYgreen to measure the benefits of the urban forest does not mean that it should be the most important element in the design and decision making process. We have to be critical of the results and not accept them at face value.

As with the introduction of any new methodology that generates numerical data, there will be some scepticism. As described in Objective #3, establishing a type of grading scale and/or the generation of base data for individual tree species can help diminish some of the scepticism behind the results. This will therefore allow the city's political decision makers, urban foresters and landscape architects to establish goals for the sustainable development of its urban forest and to determine how close they are to achieving them.

Landscape architects can use CITYgreen to determine the benefits of their various design solutions and also model scenarios for potential future benefits. In applying CITYgreen, landscape architects must view it as a tool to not inform design, but to aid in design. Design is primarily based on qualitative aspects and CITYgreen is a tool that primarily based on quantitative aspects. Landscape architects are known to be

skilled in the art of analysing and balancing diverse and often conflicting interests. By successfully utilizing this skill, landscape architects may begin to use CITYgreen to aid in design and to continue incorporating sustainable development principles, policies and guidelines into day-to-day practice (Herrmann 2000, 233).

Establishing a type of grading scale system and/or base data for each tree species, it may mean that at a city scale, future development possibilities may not only be based on sustaining the economic benefits, but also measuring and sustaining the ecological benefits as well.

The data generated from performing the relative comparison of the pre-design and post-design assessment is also significant. It is the first time, to my knowledge, that by utilizing CITYgreen to determine the carbon, storm water, pollution removal, and wildlife benefits of a Stephen Juba Park was determined or for the City for that matter.

Upon quick glance of the determined benefits, there is slight increases and decrease in the carbon, storm water, pollution removal, and wildlife benefits. The reason can be reviewed in the Pre-Design and Post-Design Assessment Comparison Discussion section. The underlying reason for the slight increases and decreases can be attributed to land use of the site remaining as an urban park and the applied methodology was for a single site. Consider if all the urban parks in the City of Winnipeg were to be upgraded to the same level as Stephen Juba Park, the accumulated benefits would be significantly higher. Thus, the benefits the urban forest provides to the city and its citizens would be determined and realized.

Appendix A
Plant List Recommended by City of Winnipeg Public Works Department
Parks and Open Space Division Forestry Branch

DECIDUOUS TREES

COMMON NAME	TAXONOMICAL NAME	HARDINESS ZONE
ASH	Fraxinus	
Black	<i>F. nigra</i>	2
Fallgold	<i>F. nigra</i> 'Fallgold'	2
Green	<i>F. Pennsylvanica subintegerrima</i>	1b
Manchurian	<i>F. Mandshurica</i>	3
Patmore	<i>F. Pennsylvanica subintegerrima</i> 'Patmore'	1b
BASSWOOD (Linden)	Tilia	
American	<i>T. americana</i>	2b
Little Leaf	<i>T. cordata</i>	3
BIRCH	Betula	
Paper	<i>B. papyrifera</i>	1
Weeping	<i>B. verrucosa</i> 'Gracilis'	2b
HACKBERRY	Celtis	
Hackberry	<i>C. occidentalis</i> 'Delta'	2b
LARCH	Larix	
Siberian	<i>L. sibirica</i>	2
Tamarack	<i>L. laricina</i>	2
MAPLE	Acer	
Manitoba	<i>A. negundo</i>	2
Silver	<i>A. saccharinum</i>	3
OAK	Quercus	
Bur	<i>Q. macrocarpa</i>	2
POPLAR	Populus	
Columnar European Aspen	<i>P. tremula</i> 'Erecta'	1b
Manchurian	<i>P. songarica</i>	2
Northwest	<i>P. X jacki</i> 'Northwest'	1b
Plains Cottonwood	<i>P. deltoides occidentalis</i>	2b
WALNUT/BUTTERNUT	Juglans	
Black	<i>J. nigra</i>	3
Butternut	<i>J. cinerea</i>	3b

Manchurian	<i>J. mandshurica</i>	3b
WILLOW	<i>Salix</i>	
Golden	<i>S. alba</i> 'Vitellina'	2b
Laurel	<i>S. pentandra</i>	2b
Redstem	<i>S. alba</i> 'Chermisina'	2b
Sharpleaf	<i>S. acutifolia</i>	2
Silky White	<i>S. alba</i> 'Sericea'	2
BIRCH	<i>Betula</i>	
Water	<i>B. fontinalis</i>	2
Young's Weeping	<i>B. verrucosa</i> 'Youngi'	2b
BUCKEYE	<i>Aesculus</i>	
Ohio	<i>A. glabra</i>	3
CHOKECHERRY	<i>Prunus</i>	
Amur	<i>P. maacki</i>	2
Shubert	<i>P. virginiana</i> melanocarpa 'Shubert'	2
CRABAPPLES	<i>Malus</i>	
Hybrids (pink flowered)	'Almey', 'Kelsey', 'Radiant'	3
Hybrids	'Garry', Red Splendor', 'Rudolph', 'Selkirk', 'Thunderchild'	2
Hybrids (white flowered)	'Dolgo', 'Rosthern', 'Tanner'	2
Manchurian	<i>M. baccata</i> mandshurica	2
Siberian	<i>M. baccata</i>	1b
HOPHORNBEAM	<i>Ostrya</i>	
American	<i>O. virginiana</i>	3
LILAC	<i>Syringa</i>	
Japanese Tree	<i>S. reticulata</i>	2
LINDEN (Basswood)	<i>Tilia</i>	
Dropmore	<i>T. X flavescens</i> 'Dropmore'	3
Littleleaf	<i>T. cordata</i> (hardy strain)	2b
Mongolian	<i>T. mongolica</i>	2b
MOUNTAIN ASH	<i>Sorbus</i>	
American	<i>S. americana</i>	1b
Russian	<i>S. aucuparia</i> 'Rossica'	2b

Showy	<i>S. decora</i>	1b
PEAR	Pyrus	
Ussurian	<i>P. ussuriensis</i>	2
PINCHERRY	Prunus	
Common	<i>P. pennsylvanica</i>	1b

CONIFEROUS TREES

COMMON NAME	TAXONOMICAL NAME	HARDINESS ZONE
ARBORVITAE	Thuja (white cedar)	
Eastern	<i>T. occidentalis</i>	2
FIR	Abies	
Balsam	<i>A. balsamea</i>	1
Siberian	<i>A. sibirica</i>	2
PINE	Pinus	
Ponderosa	<i>P. ponderosa</i>	2b
Red	<i>P. resinosa</i>	2b
Scots	<i>P. sylvestris</i>	2
Swisstone	<i>P. cembra</i>	2
SPRUCE	Picea	
Blackhills	<i>P. glauca densata</i>	2
Colorado	<i>P. pungens</i> cvs 'Hoopsi', 'Koster', 'Moerheim', 'Morden'	2
Norway	<i>P. abies</i>	2
White	<i>P. glauca</i>	1

Plants commonly advertised nationally which are not recommended for Manitoba:

- Austrian pine, *Pinus nigra*
- Babylon weeping willow, *Salix babylonica*
- Catalpa, *Catalpa* sp.
- Crimson King maple, *Acer platanooides* 'Crimson King'
- Flowering dogwood, *Cornus florida*
- Ginko (Maidenhair tree), *Ginko biloba*
- Goldenchaintree, *Laburnum* sp.
- Goldenraintree, *Koelreuteria paniculata*
- Honeylocust, *Gleditsia triacanthos*
- Japanese maple, *Acer palmatum*

- Japanese rose (living fence), *Rosa multiflora*
- Kentucky coffeetree, *Gymnocladus dioica*
- Lombardy poplar, *Populus nigra* 'Italica'
- Privets, *Ligustrum* sp.
- Redbud, *Cercis canadensis*
- Rose of Sharon, *Hybiscus syriacus*
- Silver fir, *Abies concolor*
- Tree of Heaven, *Ailanthus altissima*

Reference:

Forestry Branch. Recommended Trees. 2003. On-Line. Internet. 24 Mar. 2003.
Available: www.city.winnipeg.mb.ca/PWDForestry/hardy_z.html.

Appendix B

Species List for Riverbottom Forest

A species list was also compiled of only the river bottom forest portion of Stephen Juba Park.

Trees

Species	Common Name
<i>Acer negundo</i> var. <i>interius</i>	Manitoba Maple
<i>Fraxinus pennsylvanica</i>	Green Ash
<i>Salix</i> sp.	Willow
<i>Populus deltoides</i> var. <i>occidentalis</i>	Plains Cottonwood
<i>Ulmus americana</i>	American elm

Shrub

Species	Common Name
<i>Cornus stolonifera</i>	Red-osier dogwood
<i>Lonicera</i> sp.	Honeysuckle

Herbs

Species	Common Name
<i>Arctium lappa</i>	Common burdock
<i>Artemisia absinthium</i>	Absinthe
<i>Astragalus danicus</i>	Purple Milk-Vetch
<i>Brassica kaber</i>	Wild Mustard
<i>Campanula rapunculoides</i>	Creeping Bluebell
<i>Capsella bursa-pastoris</i>	Shepherds-purse
<i>Chenopodium album</i>	Lambs-Quarters
<i>Cirsium arvense</i>	Canada thistle
<i>Convolvulus sepium</i>	Hedge bindweed
<i>Echinocystis lobata</i>	Wild cucumber
<i>Helianthus</i> sp.	Sunflower
<i>Lactuca serriola</i>	Lobed Prickly Lettuce
<i>Lappula echinata</i>	Bluebur
<i>Lepidium densiflorum</i>	Common Pepper-Grass
<i>Lythrum salicaria</i>	Purple loosestrife
<i>Malva neglecta</i>	Common Mallow
<i>Melilotus indica</i>	Yellow Sweet-clover
<i>Mentha arvensis</i>	Field mint
<i>Oxalis stricta</i>	Yellow wood-sorrel
<i>Parthenocissus quinquefolia</i>	Virginia creeper
<i>Plantago major</i>	Common plantain
<i>Polygonum amphibium</i>	Water Smartweed
<i>Polygonum aviculare</i>	Doorweed
<i>Potentilla anserina</i>	Silverweed
<i>Ranunculus macounii</i>	Macoun
<i>Raphanus sativus</i>	Wild Radish
<i>Rumex crispus</i>	Curled dock
<i>Rumex</i> sp.	Wild Rhubarb

<i>Scutellaria galericulata</i>	Common skullcap
<i>Solanum dulcamara</i>	Bittersweet
<i>Sonchus arvensis</i>	Perennial sow-thistle
<i>Stachys palustris</i>	Marsh hedge-nettle
<i>Tanacetum vulgare</i>	Tansy
<i>Taraxacum officinale</i>	Dandelion
<i>Thalictrum dasycarpum</i>	Tall meadow-rue
<i>Thlaspi arvense</i>	Stinkweed
<i>Trifolium repens</i>	White clover
<i>Urtica dioica</i> var. <i>procera</i>	Stinging nettle

Grass

Species	Common Name
<i>Agropyron repens</i>	Quack- grass, Couch-grass
<i>Ambrosia psilostachya</i>	Perennial Ragweed
<i>Bromus inermis</i>	Smooth brome
<i>Phalaris minor</i>	little seed canary grass
<i>Setaria viridis</i>	Green Foxtail

Sedge

Species	Common Name
<i>Carex</i> sp.	Sedge

Allies

Species	Common Name
<i>Equisetum arvense</i>	Common horsetail

Reference:

Naturalist Services Branch, City of Winnipeg Community Services Department. Stephen Juba Park – River View North 27. Winnipeg: City of Winnipeg, 1996.

Appendix C
Tree Inventory Work Sheets

TREE INVENTORY SHEET

Study Site: _____

Cruiser: _____

Date: _____

Page _____ of _____

	Tree ID #	Pub Priv	Species	Trunk Diameter		Ht. Class	Red. Ht.	Health	Conflict Cover	Ground
				Inches	Class					
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

DBH Class:

1 = <10 inches
 2 = 10-20 inches
 3 = >20 inches

Ht. Class:

1 = <15 feet
 2 = 15-35 feet
 3 = >35 feet

Health Class:

1 = Dead/Dying
 2 = Poor
 3 = Fair
 4 = Good
 5 = Excellent

Conflicts:

1 = Pot. overhead wires
 2 = Ex. overhead wires
 3 = Structure(specify)
 4 = Sidewalk
 5 = Other tree

Grd Cover:

1= Shrub
 2= Grass
 3= Pavement
 4= Exp Soil
 5= Mulch

FOREST PATCH INVENTORY SHEET

Forest Patch ID: _____

Cruiser: _____

Supervisor: _____

Date: _____

Page of _____

Map #: _____

Plot #: _____

Plot Method: _____

Plot Coords: _____

Sub-Plot Features (within a 5.3 foot radius from plot center)

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover%

Plot Features (uses the ocular tube to count hits within a radius of 26.3 feet from plot center)

Overstory Cover % (>25 feet tall)	Understory Cover % (3-25 feet tall)

Downed tree count on the ground (>3" diameter and >10' long):

Landscape Position (circle one): Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features (within a radius of 26.3 feet)

#	Species	Trunk Diameter"	Crown Dominance	Health	Cavities	Height of Dominant	Comments

Crown Dominance:

D = dominant

C = co-dominant

Cavities:

Y = yes

N = no

Bio - Features Observed within the Plot (check box if yes)☐ Burrows☐ Fence Rows☐ Streams:☐ Rock Crevices☐ Seeps/Spring☐ Nests☐ Caves☐ Trails☐ Rock Piles**Health Class:**

1 = Dead/Dying

2 = Live

Notes: Do not measure trees < 1" DBH

Appendix D

Pre-Design Tree Inventory Data and Field Map

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: September 22, 2002

Sheet No. : SJP #1

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter Inches	Class	Height Feet	Class	Red. Hf.	Health	Conflict Cover	Ground Cover
1	1	Pub.	Northwest Poplar	12	2	59	3	no			2
2	2	Pub.	Northwest Poplar	3	1	23	2	no			2
3	3	Pub.	Northwest Poplar	12	2	58	3	no			2
4	4	Pub.	Northwest Poplar	13	2	59	3	no			2
5	5	Pub.	Basswood	13	2	23	2	no			2
6	6	Pub.	Green Ash	8	1	35	2	no			2
7	7	Pub.	Northwest Poplar	4	1	48	2	no			2
8	8	Pub.	Green Ash	4	1	19	2	no			4
9	9	Pub.	Manitoba Maple	21	3	35	2	no		4	4
10	10	Pub.	Green Ash	5	1	30	2	no			2
11	11	Pub.	Green Ash	5	1	30	2	no			2
12	12	Pub.	Green Ash	8	1	30	2	no			2
13	13	Pub.	Green Ash	10	2	30	2	no			2
14	14	Pub.	Silver Maple	21	3	35	2	no		1	4
15	15	Pub.	Silver Maple	32	3	48	3	no		1, 4	4
16	16	Pub.	Manitoba Maple	9	1	35	2	no			4
17	17	Pub.	Manitoba Maple	12	2	35	2	no			4
18	18		MAPPING ERROR								
19	19	Pub.	Basswood	6	1	23	2	no			2
20	20	Pub.	Basswood	14	2	23	2	no			2
21	21	Pub.	Basswood	8	1	23	2	no			2
22	22	Pub.	Basswood	9	1	23	2	no			2
23	23	Pub.	Northwest Poplar	14	2	58	3	no		1	2
24	24	Pub.	Northwest Poplar	13	2	74	2	no		1	2
25	25	Pub.	Northwest Poplar	14	2	74	2	no		1	2

DBH Class:

1=<10 inches
 2=10-20 inches
 3=>20 inches

Height Class:

1=<15 feet
 2=15-35 feet
 3=>35 feet

Health Class:

1=Dead/Dying
 2=Poor
 3=Fair
 4=Good
 5=Excellent

Conflicts:

1=Pot. Overhead wires
 2=Ex. Overhead wires
 3=Structure (specify)
 4=Sidewalk
 5=Other tree

Grd. Cover:

1=Shrub
 2=Grass
 3=Pavement
 4=Exp. Soil
 5=Mulch

File: Tree Inventory.xls
 Tab: SJP #1

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: September 22, 2002

Sheet No.: SJP#2 - PLANTING BED #1

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	p1	Pub.	Basswood	9	1	23	2	no			5
2	p2	Pub.	Basswood	10	2	23	2	no			5
3	p3	Pub.	Basswood	8	1	23	2	no			5
4	p4	Pub.	Basswood	3	1	11	1	no	1		5
5	p5	Pub.	Basswood	8	1	23	2	no			5
6	p6	Pub.	Basswood	9	1	23	2	no			5
7	p7	Pub.	Basswood	8	1	23	2	no			5
8	p8	Pub.	Manitoba Maple	8	1	23	2	no			5
9	p9	Pub.	Manitoba Maple	4	1	23	2	no			5
10	p10	Pub.	Manitoba Maple	2	1	23	1	no			5
11	p11	Pub.	Rosybloom	12	2	26	2	no			5
12	p12	Pub.	Rosybloom	17	2	26	2	no			5
13	p13	Pub.	Rosybloom	14	2	26	2	no			5
14	p14	Pub.	Patmore Ash	9	1	30	2	no			5
15	p15	Pub.	Siberian Elm	16	2	30	2	no			5
16	p16	Pub.	Siberian Elm	18	2	30	2	no			5
17	p17 - p29	Pub.	Green Ash	7	1	35	2	no			5
18	p30 - p42	Pub.	Patmore Ash	6	1	35	2	no			5
19											
20											
21											
22											
23											
24											
25											

DBH Class:

1=<10 Inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure (specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls

Tab: SJP#2 PB#1

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: September 28, 2002

Sheet No. : SJP#3

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	26	Pub.	Basswood	8	1	23	2	no		1	2
2	27	Pub.	Basswood	14	2	23	2	no		1	2
3	28	Pub.	Basswood	10	1	23	2	no			2
4	29		MAPPING ERROR								
5	30	Pub.	Green Ash	9	1	23	2	no			2
6	31	Pub.	Basswood	36	3	23	2	no			2
7	32	Pub.	Basswood	8	1	23	2	no			2
8	33	Pub.	Basswood	7	1	23	2	no			2
9	34	Pub.	Green Ash	9	1	21	2	no			2
10	35	Pub.	Green Ash	9	1	21	2	no			2
11	36	Pub.	Green Ash	7	1	21	2	no			2
12	37	Pub.	Poplar	15	2	60	3	no			4
13	38	Pub.	Poplar	16	2	59	3	no			4
14	39		MAPPING ERROR								
15	40		MAPPING ERROR								
16	41	Pub.	Manitoba Maple	26	3	25	2	no		1	4
17	42	Pub.	Manitoba Maple	12	2	25	2	no		1	4
18	43	Pub.	Basswood	8	1	23	2	no		1	4
19	44	Pub.	Manitoba Maple	12	2	25	2	no		1	4
20	45	Pub.	Manitoba Maple	12	2	22	2	no		1	4
21	46	Pub.	Manitoba Maple	12	2	22	2	no			4
22	47	Pub.	Manitoba Maple	11	2	19	2	no			4
23	48	Pub.	MAPPING ERROR								
24	49	Pub.	MAPPING ERROR								
25	50	Pub.	Basswood	7	1	22	2	no		1	4
26	51	Pub.	Poplar	15	2	48	3	no		2	2

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure(specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls
Tab: SJP#3

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: September 28, 2002

Sheet No. : SJP#4

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	52	Pub.	Siberian Elm	9	1	32	2	no			2
2	53	Pub.	Siberian Elm	10	2	32	2	no			2
3	54	Pub.	Green Ash	8	1	26	2	no			2
4	55	Pub.	Amur Cherry	8	1	26	2	no		1	2
5	56	Pub.	Green Ash	7	1	26	2	no			2
6	57	Pub.	Green Ash	7	1	26	2	no		1	2
7	58	Pub.	Green Ash	7	1	26	2	no			2
8	59	Pub.	Siberian Elm	8	1	32	2	no			2
9	59A	Pub.	Siberian Elm	8	1	32	2	no			2
10	60	Pub.	Siberian Elm	10	2	32	2	no		4	2
11	61	Pub.	Willows	41	3	35	2	no			4
12	62	Pub.	Willows	25	2	35	2	no			4
13	63	Pub.	Willows	46	3	35	2	no			4
14	64	Pub.	Willows	40	3	35	2	no			4
15	65	Pub.	Willows	30	2	35	2	no			4
16	66	Pub.	Willows	45	3	35	2	no			4
17	67	Pub.	Willows	26	2	35	2	no			4
18	68	Pub.	Poplar	11	2	48	3	no			4
19	69	Pub.	Poplar	10	2	48	3	no		4	4
20	70	Pub.	Poplar	10	2	46	3	no			4
21	71	Pub.	Green Ash	5	1	30	2	no			2
22	72	Pub.	Green Ash	7	1	35	2	no			2
23	73	Pub.	Green Ash	7	1	35	2	no			2
24	74	Pub.	Green Ash	7	1	35	2	no			2
25	75	Pub.	Green Ash	7	1	30	2	no			2

DBH Class:

1=<10 inches
2=10-20 inches
3=>20 inches

Height Class:

1=<15 feet
2=15-35 feet
3=>35 feet

Health Class:

1=Dead/Dying
2=Poor
3=Fair
4=Good
5=Excellent

Conflicts:

1=Pot. Overhead wires
2=Ex. Overhead wires
3=Structure(specify)
4=Sidewalk
5=Other tree

Grd. Cover:

1=Shrub
2=Grass
3=Pavement
4=Exp. Soil
5=Mulch

File: Tree Inventory.xls
Tab: SJP#4

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: September 28, 2002

Sheet No. : SJP#5

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	1b-44b	Pub.	Green Ash	6	1	30	2	no			2
2	76	Pub.	Silver Maple	11	2	25	2	no			2
3	77	Pub.	Green Ash	9	1	25	2	no			2
4	78	Pub.	Green Ash	8	1	20	2	no			2
5	79	Pub.	Green Ash	6	1	22	2	no			2
6	80	Pub.	Green Ash	8	1	25	2	no			2
7	81	Pub.	Green Ash	7	1	22.5	2	no			2
8	82	Pub.	Green Ash	7	1	22.5	2	no			2
9	83	Pub.	Green Ash	7	1	22.5	2	no			2
10	84	Pub.	Siberian Elm	7	1	27	2	no			2
11	85	Pub.	Willow	4	1	27	2	no			2
12	86	Pub.	Willow	5	1	27	2	no			2
13	87	Pub.	Willow	4.5	1	27	2	no			2
14	88	Pub.	Willow	4.5	1	27	2	no			2
15	89	Pub.	Willow	4.5	1	27	2	no			2
16	90	Pub.	Willow	4.5	1	27	2	no			2
17	91	Pub.	Willow	4	1	27	2	no			2
18	92	Pub.	Green Ash	8.5	1	22.5	2	no			2
19	93	Pub.	Green Ash	8.5	1	22.5	2	no			2
20	94	Pub.	Green Ash	7	1	35	2	no			2
21	95	Pub.	Green Ash	5	1	35	2	no			2
22	96	Pub.	Green Ash	5	1	35	2	no			2
23	97	Pub.	Green Ash	5	1	35	2	no			2
24	98	Pub.	Green Ash	9	1	35	2	no			2
25											

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure(specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls

Tab: SJP#5

TREE INVENTORY SHEET

Stephen Juba Park

Study site: Stephen Juba Park

Date: OCTOBER 6, 2002

Sheet No. : SJP#6- PLANTING BED #2

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	p43a	Pub.	Scott's Pine	5	1	20	2	no			4
2	p43b	Pub.	Scott's Pine	5	1	16	2	no			4
3	p43	Pub.	Spruce	2	1	7	1	no			4
4	p44	Pub.	Spruce	4	1	12	1	no			4
5	p45	Pub.	Spruce	2	1	7	1	no			4
6	p46a	Pub.	Spruce	3	1	7	1	no			4
7	p46	Pub.	Spruce	2	1	7	1	no			4
8	p47	Pub.	Spruce	5	1	15	1	no			4
9	p48	Pub.	Spruce	1	1	12	1	no			4
10	p49	Pub.	Spruce	3	1	7	1	no			4
11	p50	Pub.	Silver Maple	7	1	34	2	no			4
12	p51	Pub.	Silver Maple	7	1	34	2	no			4
13	p52	Pub.	Spruce	2	1	10	1	no			4
14	p52a	Pub.	Basswood	7	1	35	2	no			4
15	p52b	Pub.	Basswood	7	1	35	2	no			4
16	p53	Pub.	Spruce	2	1	12	1	no			4
17	p54	Pub.	Spruce					no			4
18	p55	Pub.	Spruce	5	1	35	2	no			4
19	p56	Pub.	Basswood	7	1	24	2	no			4
20	p57	Pub.	Spruce					no			4
21	p58	Pub.	Spruce					no			4
22	p59	Pub.	Green Ash	8	1	33	2	no			4
23	p60	Pub.	Manitoba Maple	8	1	35	2	no			4
24	p61	Pub.	Green Ash	7	1	33	2	no			4
25	p62	Pub.	Green Ash	9	1	34	2	no			4

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure (specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls

Tab: SJP #6 PB#2

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: OCTOBER 12, 2002

Sheet No. : SJP#7

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	99	Pub.	Manitoba Maple	20	2	34	2	no			2
2	100	Pub.	Manitoba Maple	18	2	33	2	no			2
3	101	Pub.	Manitoba Maple	15	2	35	2	no		2	2
4	102	Pub.	Manitoba Maple	12	2	34	2	no		2	2
5	103	Pub.	Manitoba Maple	17	2	34	2	no		2	2
6	104	Pub.	Manitoba Maple	18	2	33	2	no		2	2
7	105	Pub.	Manitoba Maple	12	2	35	2	no		2	2
8	106	Pub.	Green Ash	5	1	33	2	no			2
9	107	Pub.	Green Ash	8	1	33	2	no			2
10	108	Pub.	Green Ash	7	1	33	2	no			2
11	109	Pub.	Manitoba Maple	17	2	34	2	no			2
12	110	Pub.	Manitoba Maple	30	3	33	2	no			2
13	111	Pub.	Manitoba Maple	38	3	35	2	no			2
14	112	Pub.	Manitoba Maple	20	2	34	2	no			2
15	113	Pub.	Manitoba Maple	16	2	33	2	no			2
16	114	Pub.	Cottonwood	27	2	50	3	no			2
17	115	Pub.	Poplar	11	2	48	3	no			2
18	116	Pub.	Poplar	9	1	48	3	no			2
19	117	Pub.	Poplar	6	1	48	3	no			2
20	118	Pub.	Poplar	12	2	48	3	no			2
21	119	Pub.	Poplar	13	2	48	3	no			2
22	120	Pub.	Manitoba Maple	11	2	24	2	no			2
23	121	Pub.	Manitoba Maple	10	2	25	2	no			2
24	122	Pub.	Manitoba Maple	11	2	24	2	no			2
25	123	Pub.	Basswood	11	2	24	2	no			2

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure (specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls
Tab: SJP#7

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: OCTOBER 12, 2002

Sheet No. : SJP#8

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter Inches	Class	Height Feet	Class	Red. Ht.	Health	Conflict Cover	Ground Cover
1	124	Pub.	Green Ash	3	1	26	2	no			2
2	125	Pub.	Cottonwood	14	2	50	3	no			2
3	126	Pub.	Cottonwood	16	2	50	3	no			2
4	127	Pub.	Manitoba Maple	12	2	34	2	no			2
5	128	Pub.	Manitoba Maple	19	2	30	2	no			2
6	129	Pub.	Silver Maple	17	2	25	2	no			2
7	130	Pub.	Silver Maple	18	2	25	2	no			2
8	131	Pub.	Silver Maple	20	2	25	2	no			2
9	132	Pub.	Silver Maple	18	2	25	2	no			2
10	133	Pub.	Silver Maple	22	3	25	2	no			2
11	134	Pub.	Silver Maple	14	2	25	2	no			2
12	135	Pub.	Silver Maple	11	2	25	2	no			2
13	136	Pub.	Silver Maple	17	2	25	2	no			2
14	137	Pub.	Green Ash	8	1	25	2	no			2
15	138	Pub.	Green Ash	8	1	25	2	no			2
16	139	Pub.	Siberian Elm	10	2	25	2	no			2
17	140	Pub.	Manitoba Maple	8	1	25	2	no			2
18	141	Pub.	Manitoba Maple	8	1	25	2	no			2
19	gal - gal18	Pub.	Green Ash	8	1	14	1	no			2
20	142	Pub.	Basswood	3	1	10	1	no			2
21	143	Pub.	Basswood	4	1	14	1	no			2
22	143a	Pub.	Basswood	4	1	14	1	no			2
23	143b	Pub.	Basswood	4	1	14	1	no			2
24	144	Pub.	Cottonwood	27	3	55	3	no			2
25	144a	Pub.	Cottonwood	54	3	55	3	no			2

DBH Class:

1=<10 inches
2=10-20 inches
3=>20 inches

Height Class:

1=<15 feet
2=15-35 feet
3=>35 feet

Health Class:

1=Dead/Dying
2=Poor
3=Fair
4=Good
5=Excellent

Conflicts:

1=Pot. Overhead wires
2=Ex. Overhead wires
3=Structure(specify)
4=Sidewalk
5=Other tree

Grd. Cover:

1=Shrub
2=Grass
3=Pavement
4=Exp. Soil
5=Mulch

File: Tree Inventory.xls
Tab: SJP#8

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: OCTOBER 12, 2002

Sheet No. : SJP#9 - PLANTING BED #3

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	p63	Pub.	Poplar	16	2	55	3	no			4
2	p64	Pub.	Silver Maple	18	2	40	3	no			4
3	p65	Pub.	Basswood	5	2	15	2	no			4
4	p66	Pub.	Basswood	7	2	15	2	no			4
5	p67	Pub.	Silver Maple	13	2	26	2	no			4
6	p68	Pub.	Silver Maple	18	2	26	2	no			4
7	p69	Pub.	Silver Maple	14	2	26	2	no			4
8	p70	Pub.	Basswood	6	2	15	2	no			4
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure(specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls

Tab: SJP#9 PB#3

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: OCTOBER 13, 2002

Sheet No. : SJP#10

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	145	Pub.	Green Ash	5	1	19	2	no			2
2	146	Pub.	Green Ash	6	1	19	2	no			2
3	147	Pub.	Green Ash	5	1	19	2	no			2
4	148	Pub.	Green Ash	7	1	19	2	no			2
5	149	Pub.	Green Ash	7	1	19	2	no			2
6	150	Pub.	Green Ash	5	1	19	2	no			2
7	151	Pub.	Green Ash	7	1	19	2	no			2
8	152	Pub.	Palmore Ash	15	2	19	2	no			2
9	153	Pub.	Green Ash	5	1	19	2	no			2
10	154	Pub.	Silver Maple	25	3	30	2	no			2
11	155	Pub.	Silver Maple	12	2	21	2	no			2
12	156	Pub.	Silver Maple	15	2	21	2	no			2
13	157	Pub.	Silver Maple	21	3	21	2	no			2
14	158	Pub.	Silver Maple	20	2	21	2	no			2
15	159	Pub.	Basswood	13	2	20	2	no			2
16	160	Pub.	Basswood	14	2	20	2	no			2
17	161	Pub.	Basswood	13	2	20	2	no			2
18	162	Pub.	Basswood	13	2	20	2	no			2
19	163	Pub.	Rosybloom	12	2	15	1	no			2
20	164	Pub.	Rosybloom	9	1	15	1	no			2
21	165	Pub.	Rosybloom	22	3	15	1	no			2
22	166	Pub.	Silver Maple	13	2	18	2	no			2
23	167	Pub.	Silver Maple	15	2	15	2	no			2
24	168	Pub.	Silver Maple	24	3	25	2	no			2
25	169	Pub.	Silver Maple	10	2	25	2	no			2

DBH Class:

1=<10 inches
2=10-20 inches
3=>20 inches

Height Class:

1=<15 feet
2=15-35 feet
3=>35 feet

Health Class:

1=Dead/Dying
2=Poor
3=Fair
4=Good
5=Excellent

Conflicts:

1=Pot. Overhead wires
2=Ex. Overhead wires
3=Structure(specify)
4=Sidewalk
5=Other tree

Grd. Cover:

1=Shrub
2=Grass
3=Pavement
4=Exp. Soil
5=Mulch

File: Tree Inventory.xls
Tab: SJP#10

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: OCTOBER 13, 2002

Sheet No. : SJP#11

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	170	Pub.	Silver Maple	39	3	26	2	no			2
2	171	Pub.	Green Ash	8	1	26	2	no			2
3	172	Pub.	Green Ash	7	1	26	2	no			2
4	173	Pub.	Green Ash	7	1	26	2	no			2
5	174	Pub.	Green Ash	8	1	26	2	no			2
6	175	Pub.	Green Ash	6	1	26	2	no			2
7	176	Pub.	Green Ash	8	1	26	2	no			2
8	177	Pub.	Green Ash	6	1	26	2	no			2
9	178	Pub.	Green Ash	6	1	26	2	no			2
10	179	Pub.	Green Ash	6	1	26	2	no			2
11	180	Pub.	Green Ash	8	1	26	2	no			2
12	181	Pub.	Green Ash	6	1	26	2	no			2
13	182		Green Ash								
14	183 - 197	Pub.	Poplar	11	2	41	3	no			2
15	198	Pub.	Willow	20	1	26	2	no			2
16	199	Pub.	Willow	23	3	28	2	no			2
17	200	Pub.	Willow	56	3	28	2	no			2
18	201	Pub.	Silver Maple	15	2	25	2	no			2
19	202	Pub.	Green Ash	4	1	19	2	no			2
20	203	Pub.	Green Ash	6	1	19	2	no			2
21	204	Pub.	Green Ash	9	1	19	2	no			2
22	205	Pub.	Green Ash	5	1	19	2	no			2
23	206	Pub.	Poplar	15	2	53	3	no			2
24	207	Pub.	Poplar	12	2	53	3	no			2
25	208	Pub.	Poplar	7	1	53	3	no			2

DBH Class:

1=<10 inches
2=10-20 inches
3=>20 inches

Height Class:

1=<15 feet
2=15-35 feet
3=>35 feet

Health Class:

1=Dead/Dying
2=Poor
3=Fair
4=Good
5=Excellent

Conflicts:

1=Pot. Overhead wires
2=Ex. Overhead wires
3=Structure(specify)
4=Sidewalk
5=Other tree

Grd. Cover:

1=Shrub
2=Grass
3=Pavement
4=Exp. Soil
5=Mulch

File: Tree Inventory.xls
Tab: SJP#11

TREE INVENTORY SHEET

Stephen Juba Park

Study site: Stephen Juba Park

Date: OCTOBER 13, 2002

Sheet No. : SJP#12

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter:		Height:		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	209	Pub.	Poplar	11	2	53	3	no			2
2	210	Pub.	Manitoba Maple	12	2	33	2	no			2
3	211	Pub.	Manitoba Maple	40	3	33	2	no			2
4	212	Pub.	Manitoba Maple	17	2	33	2	no			2
5	213	Pub.	Manitoba Maple	14	2	33	2	no			2
6	214	Pub.	Manitoba Maple	8	1	33	2	no			2
7	215	Pub.	Manitoba Maple	18	2	33	2	no			2
8	216	Pub.	Manitoba Maple	12	2	33	2	no			2
9	217	Pub.	Manitoba Maple	16	2	33	2	no			2
10	218	Pub.	Manitoba Maple	21	3	33	2	no			2
11	219	Pub.	Green Ash	5	1	19	2	no			2
12	220	Pub.	Green Ash	5	1	19	2	no			2
13	221	Pub.	Green Ash	5	1	25	2	no			2
14	222	Pub.	Manitoba Maple	10	2	25	2	no			2
15	223	Pub.	Manitoba Maple	11	2	25	2	no			2
16	224	Pub.	Manitoba Maple	11	2	25	2	no			2
17	225	Pub.	Manitoba Maple	16	2	25	2	no			2
18	226	Pub.	Manitoba Maple	32	3	25	2	no			2
19	227	Pub.	Manitoba Maple	16	2	25	2	no			2
20	228	Pub.	Manitoba Maple	12	2	25	2	no			2
21	229	Pub.	Manitoba Maple	12	2	25	2	no			2
22	230	Pub.	Manitoba Maple	14	2	25	2	no			2
23	231	Pub.	Manitoba Maple	13	2	25	2	no			2
24	232	Pub.	Manitoba Maple	7	1	25	2	no			2
25											

DBH Class:

1=<10 inches

2=10-20 inches

3=>20 inches

Height Class:

1=<15 feet

2=15-35 feet

3=>35 feet

Health Class:

1=Dead/Dying

2=Poor

3=Fair

4=Good

5=Excellent

Conflicts:

1=Pot. Overhead wires

2=Ex. Overhead wires

3=Structure(specify)

4=Sidewalk

5=Other tree

Grd. Cover:

1=Shrub

2=Grass

3=Pavement

4=Exp. Soil

5=Mulch

File: Tree Inventory.xls
Tab: SJP#12

TREE INVENTORY SHEET

Stephen Juba Park

Forest Patch ID: Stephen Juba Park Forest Patch #1

Supervisor: Rajinder Singh

Date: OCTOBER 19, 2002

Page: 1 of 5

Plot Method: Quadrat

Plot #: 1

Sub-Plot Features

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover %
10	50	0	40

Plot Features

Overstory Cover % (> 25 feet tall)	Understory Cover % (3 - 25 feet tall)
90	10

Landscape Position: Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features

#	Species	Trunk Diameter*	Crown Dominance	Health	Cavities	Height of Dominant
1	Manitoba Maple	10	C	2	N	30
2	Willow	17	D	2	N	50
3	Willow	16	D	2	N	50
4	Manitoba Maple	7	C	2	N	30
5	Manitoba Maple	10	C	2	N	30
6	Willow	14	D	1	N	17

Crown Dominance:

D = dominant

C = co-dominant

Cavities

Y = yes

N = no

Bio - Features Observed within the Plot

Burrows

Rock Crevices

Caves

Fence Rows

Seeps/Springs

Trails

Streams

Nests

Rock Piles

Health Class

1 = Dead/Dying

2 = Live

File: Tree Inventory.xls

Tab: SJP FP#1

TREE INVENTORY SHEET

Stephen Juba Park

Forest Patch ID: Stephen Juba Park Forest Patch #2

Supervisor: Rajinder Singh

Date: OCTOBER 19, 2002

Page: 2 of 5

Plot Method: Quadrat

Plot #: 2

Sub-Plot Features

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover %
5	60	0	35

Plot Features

Overstory Cover % (> 25 feet tall)	Understory Cover % (3-25 feet tall)
90	10

Landscape Position: Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features

#	Species	Trunk Diameter*	Crown Dominance	Health	Cavities	Height of Dominant
1	Willow	24	D	2	N	55
2	Green Ash	4	C	2	N	30
3	Willow	15	D	2	N	55
4	Willow	10	D	2	N	55

Crown Dominance:

D = dominant

C = co-dominant

Cavities

Y = yes

N = no

Bio - Features Observed within the Plot

Burrows

Rock Crevices

Caves

Fence Rows

Seeps/Springs

Trails

Streams

Nests

Rock Piles

Health Class

1 = Dead/Dying

2 = Live

File: Tree Inventory.xls

Tab: SJP FP#2

TREE INVENTORY SHEET

Stephen Juba Park

Forest Patch ID: Stephen Juba Park Forest Patch #3

Supervisor: Rajinder Singh

Date: OCTOBER 19, 2002

Page: 3 of 5

Plot Method: Quadrat

Plot #: 3

Sub-Plot Features

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover %
5	50	0	45

Plot Features

Overstory Cover % (> 25 feet tall)	Understory Cover % (3-25 feet tall)
90	10

Landscape Position: Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features

#	Species	Trunk Diameter*	Crown Dominance	Health	Cavities	Height of Dominant
1	Manitoba Maple	14	D	2	Y	40
2	Manitoba Maple	11	D	2	N	40

Crown Dominance:

D = dominant

C = co-dominant

Cavities

Y = yes

N = no

Bio - Features Observed within the Plot

Burrows

Rock Crèches

Caves

Fence Rows

Seeps/Springs

Trails

Streams

Nests

Rock Piles

Health Class

1 = Dead/Dying

2 = Live

File: Tree Inventory.xls

Tab: SJP FP#3

TREE INVENTORY SHEET

Stephen Juba Park

Forest Patch ID: Stephen Juba Park Forest Patch #4

Supervisor: Rajinder Singh

Date: OCTOBER 19, 2002

Page: 4 of 5

Plot Method: Quadrat

Plot #: 4

Sub-Plot Features

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover %
5	50	0	45

Plot Features

Overstory Cover % (> 25 feet tall)	Understory Cover % (3 - 25 feet tall)
90	10

Landscape Position: Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features

#	Species	Trunk Diameter*	Crown Dominance	Health	Cavities	Height of Dominant
1	Manitoba Maple	11	D	2	N	40
2	Manitoba Maple	12	D	2	N	40
3	Manitoba Maple	13	D	2	N	40
4	Manitoba Maple	14	D	2	N	40

Crown Dominance:

D = dominant

C = co-dominant

Cavities

Y = yes

N = no

Bio - Features Observed within the Plot

Burrows

Rock Crevices

Caves

Fence Rows

Seeps/Springs

Trails

Streams

Nests

Rock Piles

Health Class

1 = Dead/Dying

2 = Live

File: Tree Inventory.xls

Tab: SJP FP #4

TREE INVENTORY SHEET

Stephen Juba Park

Forest Patch ID: Stephen Juba Park Forest Patch #4

Supervisor: Rajinder Singh

Date: OCTOBER 19, 2002

Page: 5 of 5

Plot Method: Quadrat

Plot #: 5

Sub-Plot Features

Bare Soil %	Forest Litter %	Rock Cover %	Ground Cover %
5	50	0	45

Plot Features

Overstory Cover % (> 25 feet tall)	Understory Cover % (3 - 25 feet tall)
90	10

Landscape Position: Upland Midslope Bottom

Landscape Aspect or direction slope is facing (circle one): N S E W NW NE SW SE

Tree Species Features

#	Species	Trunk Diameter"	Crown Dominance	Health	Cavities	Height of Dominant
1	Manitoba Maple	48	D	2	N	40
2	Manitoba Maple	13	D	2	N	40

Crown Dominance:

D = dominant

C = co-dominant

Cavities

Y = yes

N = no

Bio - Features Observed within the Plot

Burrows

Fence Rows

Streams

Rock Crevices

Seeps/Springs

Nests

Caves

Trails

Rock Piles

Health Class

1 = Dead/Dying

2 = Live

File: Tree Inventory.xls

Tab: SJP FP#5

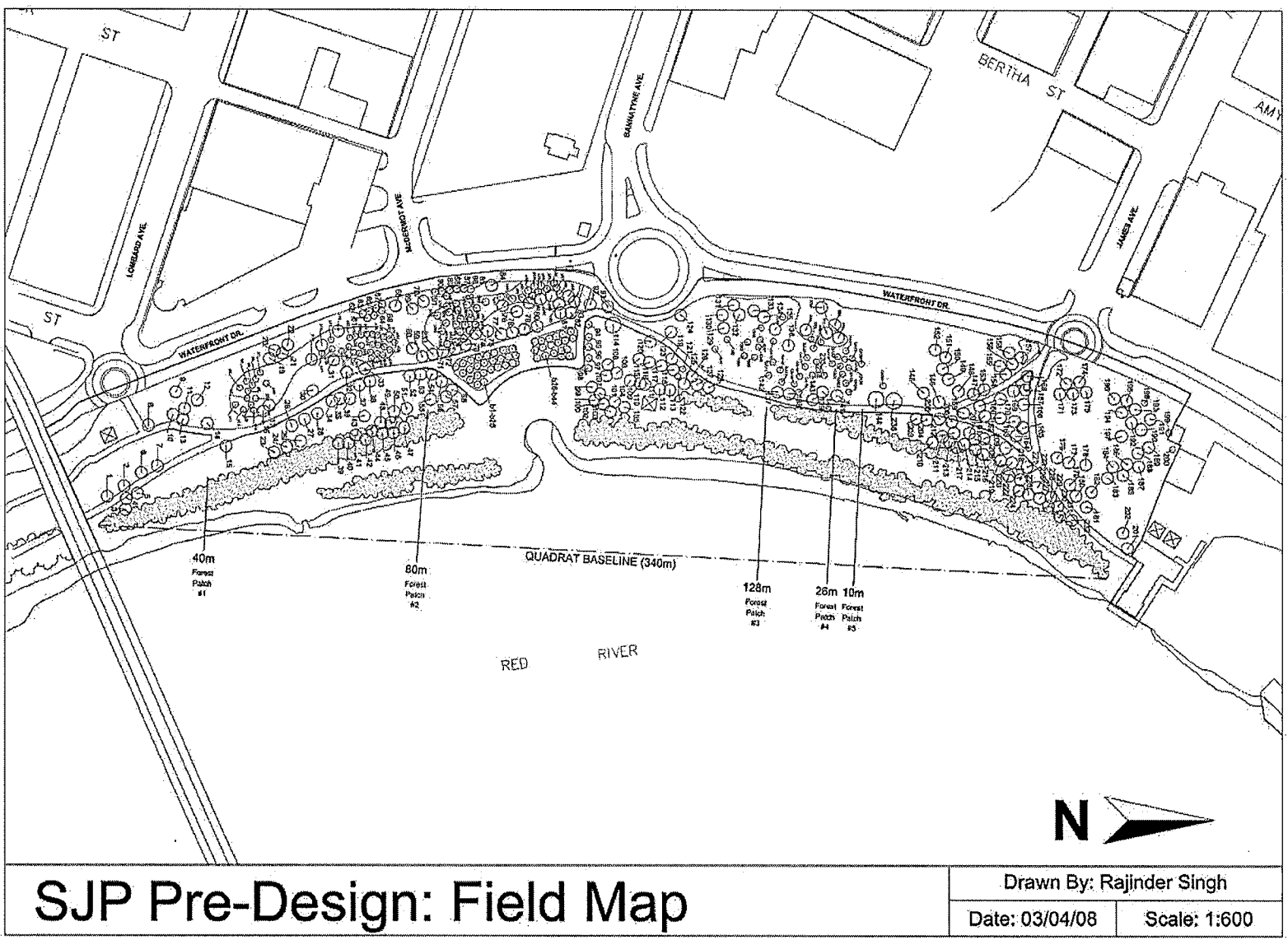


Figure 50. SJP Pre-Design: Field Map.
Map by Author.

Appendix E

How to Make and Use a Clinometer

How to Make a Clinometer

The materials needed:

- Soda Straw
- Protractor
- String or Thread
- Weight (a metal washer works well)
- Masking or Scotch Tape

How to assemble:

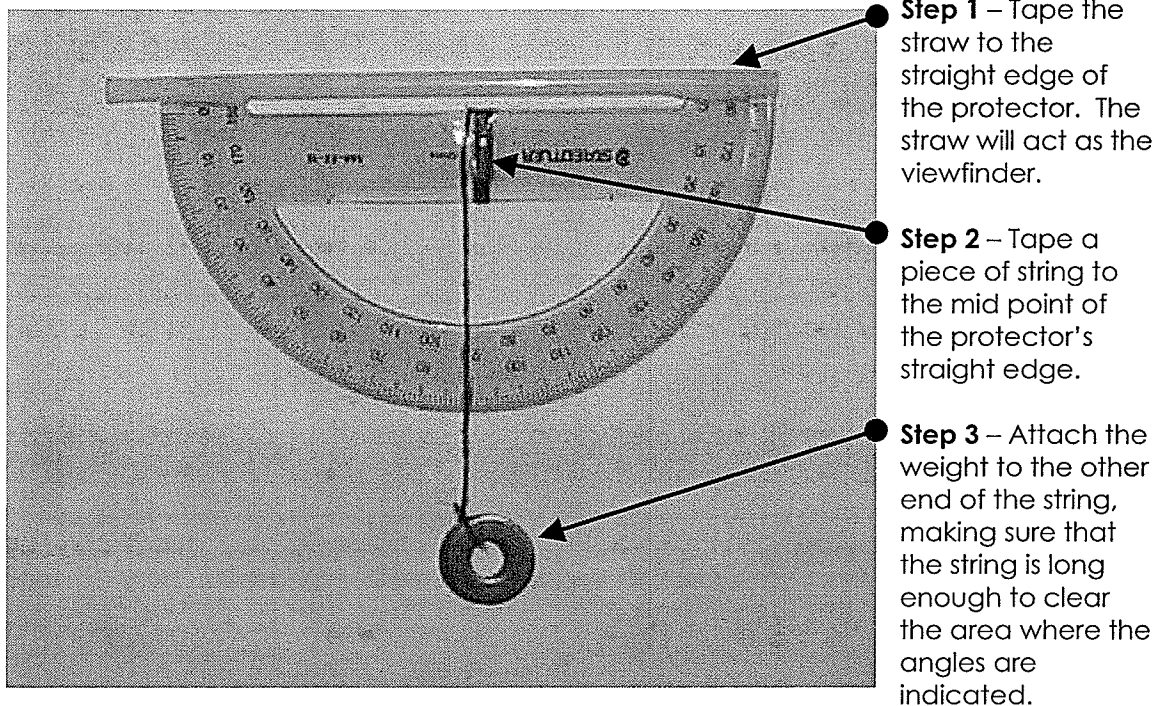


Figure 51. How to assemble a Clinometer.
Photo by Author.

How to Use a Clinometer

How to use a Clinometer:

Step 1 – To determine the angle of elevation, look through the straw to the top of object (**A – B**).

Step 2 – Then have another person record the angle where the string lies against the protractor.

Step 3 – Subtract the number from 90 to obtain the angle of elevation.

Step 4 – Measure the horizontal distance between the object being sighted and the place where you were standing (**A – C**).

Step 5 – Measure the vertical distance from your eye to the ground, (**A – D**).

Step 6 – Then by using trigonometric function: $\tan \square = (B - C) / (A - C)$, transpose the equation to solve for the height, $(B - C) = (\tan \square)(A - C)$. When the height of the tree is determined from the transposed formula, $(B - C)$, add your vertical height (**A – D**) to number calculated and you have the total height of the tree.



Figure 52. How to use a Clinometer.
Photo by Author.

Appendix F

An Illustrated Site History

An Illustrated Site History

The early maps of Winnipeg show where structures were located, but also the presence of vegetation, especially trees. The species of trees that may have grown long the banks of the rivers where probably the same species that exist there today: Manitoba Maple, Ash, Willows, Cottonwoods and Elms. Whether the maps accounts are accurate, the location of the trees was mapped and probably used as an incentive to attract pioneers travelling west.

1816 - Red River Settlement

This early map of the future site of the City of Winnipeg clearly shows how each generation leaves its characteristics on the final appearance of a city (Figure 53). For although more than sixty years would pass before Winnipeg would become a city, several of its basic features were firmly set during the development of the narrow strip of land along the west bank of the Red River, north from the junction of the Red and Assiniboine (shown as "Ossiniboyne" on this map) to Point Douglas and the Scotch settlements beyond (Artibise, 1975, 5).

The junction of the Red and Assiniboine Rivers had been known throughout the fur-trading community as "The Forks" long before the North West Company built Fort Gibraltar and the Hudson's Bay Company their small stores depot. But Point Douglas was occupied only after the arrival of the Selkirk Settlers, marking as it did the first white settlement in Western Canada (Artibise, 1975, 5).

Some years prior to their coming, the Hudson's Bay Company had built a stores depot on the east side of the river in the neighbourhood of the present day St. Boniface Hospital and it was here that Governor Miles Macdonell and his advance party arrived in August 1812. As a consequence of their late arrival at York Factory the previous fall, the party had been forced to winter there and reached "The Forks" only a few weeks ahead

of the of the first party of actual settlers. The governor chose land for the settlement on the west side of the Red River immediately north of the long narrow point known as Point Douglas, a mile below the North West Company post of Fort Gibraltar which was built in 1810.

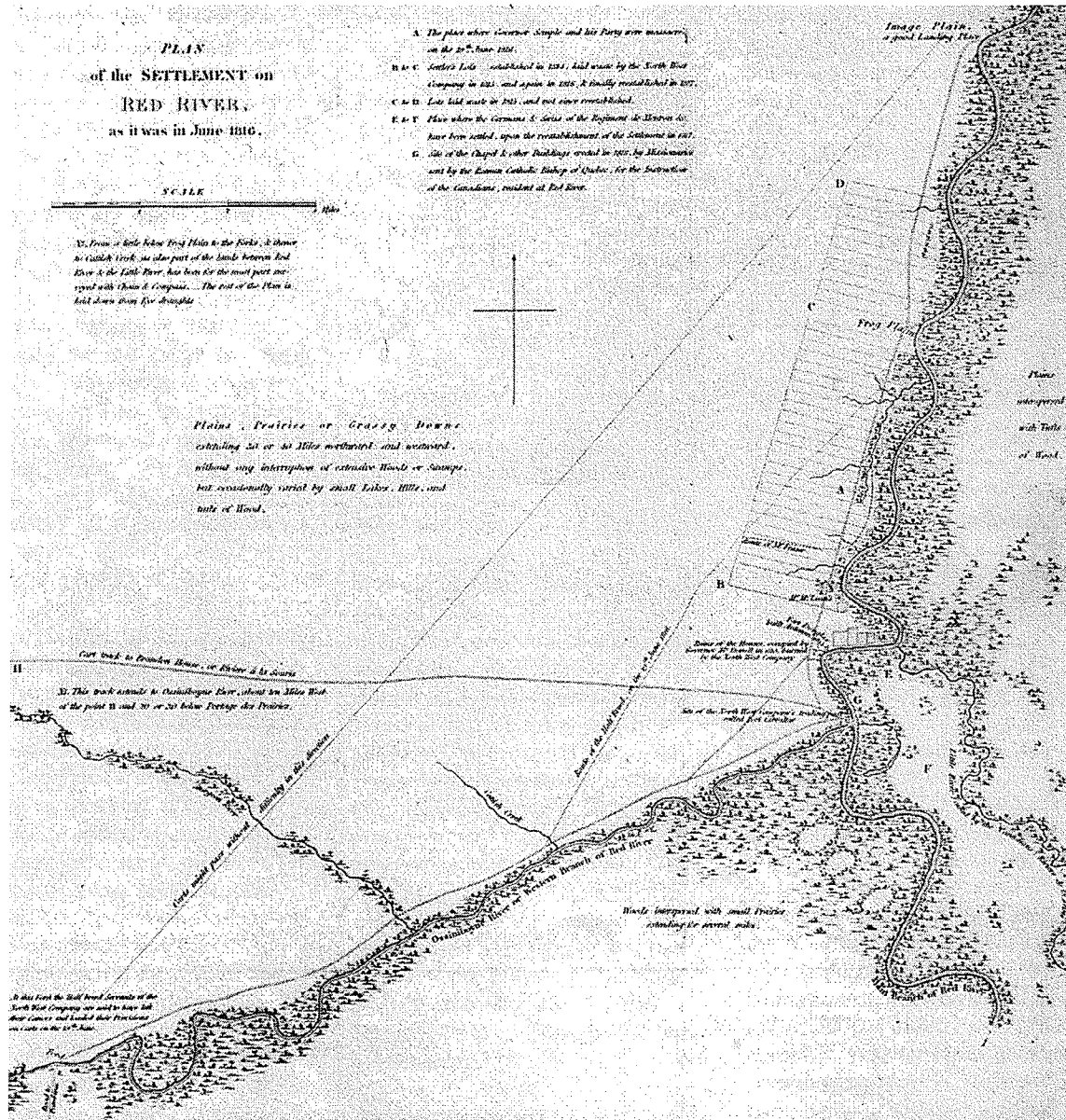


Figure 53. Plan of the settlement on the Red River, as it was in June 1816. London. Engraved & printed by A. Arrowsmith, 10, Soho Square, Decr. 1819.
 Artibise, Alan F.J. Winnipeg in maps, 1816 – 1972. Ottawa: National Map Collection, Public Archives of Canada, 1975. p.6.

The settlers' farms, commencing some distance north of the main buildings on the Point, were long narrow lots of approximately one hundred acres, facing on the river, running back two miles, with another two miles beyond to be used as a "hay privilege." On the opposite side of the river each settler was given a "wood lot" for his own use. The west side of the Red River at this time was nearly all treeless plain and it was for this reason that the Governor chose this particular location (Artibise, 1975, 5).

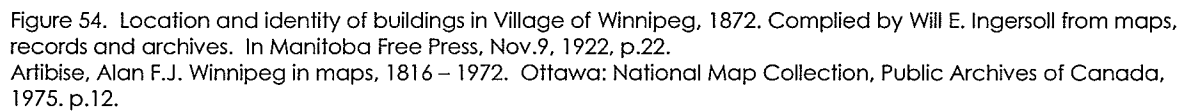
As later maps will indicate, the city's basic street pattern closely followed the boundary lines of these early river lots. Both Portage Avenue and Main Street (Artibise, 1975, 5):

- Are Winnipeg's main thoroughfares; and
- Followed the "Cart track to Brandon House" and the trail that ran northward along the Red River.

1872 - Village of Winnipeg

In 1872, Winnipeg had more than seventy houses and buildings (Figure 54). The streets and roads - if one can speak of streets at all - had developed from former trails and tracks, or followed the survey lines of the early river lots. Most of the streets, however, were not surveyed prior to incorporation in November 1873. The community's main avenue was the old trail between the Selkirk Settlement along the Red River and the Hudson's Bay Company post of Upper Fort Garry. Also, during this early period property-owners often planned streets or paths according to their own wishes (Artibise, 1975, 11).

The part of the "Main Road" north of "Portage Road" attracted most of the newly arrived traders. The buildings in this area often served a dual purpose, having a store or office on the main floor and living quarters above. Except for the Main Road and some streets leading to the river only a very small area was built-up. Notre Dame Street, for example, had over ten dwellings located on it and Post Office Street also had several residential and commercial structures.



1880 - Bird's Eye View of Winnipeg

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Street in the section bordered by Notre Dame to the south and Alexander to the north. Many of the lots close to and along Main Street were also put into use (Artibise, 1975, 19).

Main Street, between Portage Avenue and Point Douglas, was the centre of the city's commercial life even though the street was still muddy, its road surface having changed little since the time it was a trail (Artibise, 1975, 19).

The main industries at this time were saw and flour mills, which because of easy access to water transportation was located along the Red River. Winnipeg also had two breweries that occupied sites at considerable distances from the built-up area, and a distillery and a soda water factory situated in the centre of the city. With the absence of a suitable supply of drinking water, these business enterprises flourished. Also located in the city's centre were two foundries and three carriage and wagon manufacturers. The combined railway-highway bridge in Figure 55 was not completed until 1881. Its inclusion

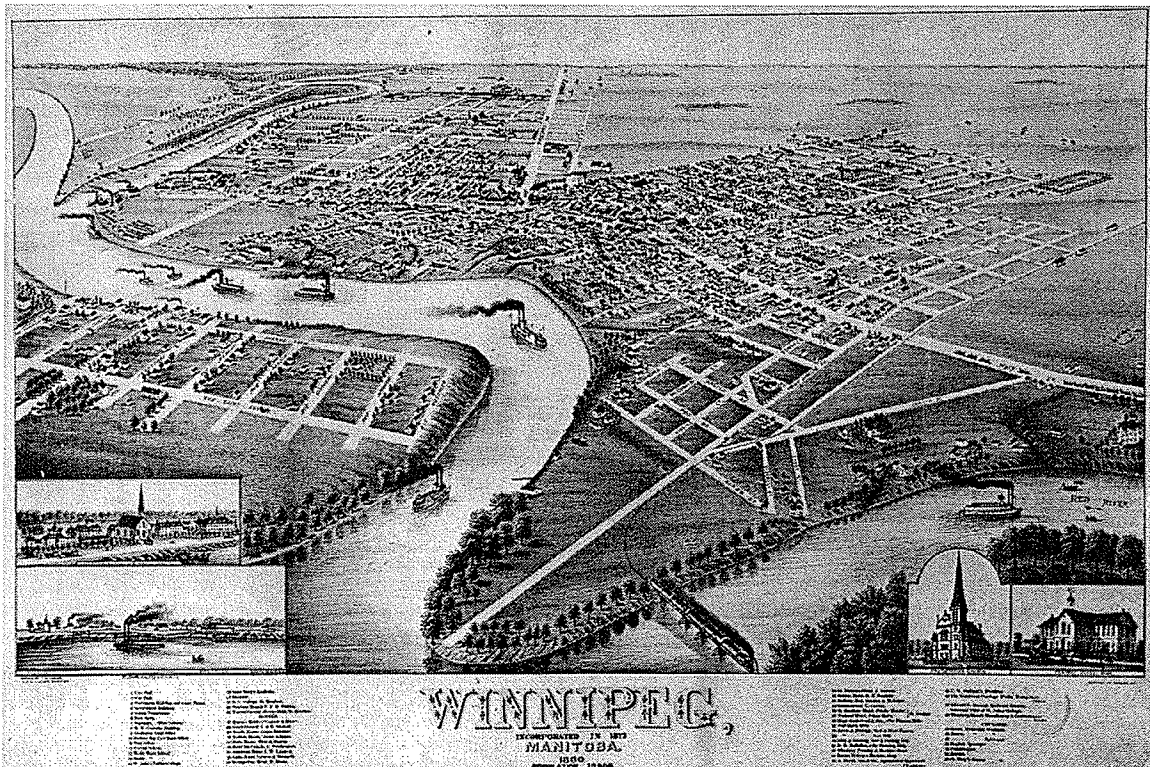


Figure 55. Winnipeg, Manitoba. 1880. Drawn by T.M. Fowler. Pub. By J.J. Stoner, Madison, Wis. Beck & Pauli Lith., Milwaukee, Wis.

Artibise, Alan F.J. Winnipeg in maps, 1816 – 1972. Ottawa: National Map Collection, Public Archives of Canada, 1975. p.20.

on this map, along with the 10,000-population figure, indicates the “boosterism” of the cartographer or his employer (Artibise, 1975, 19).

1900 – Point Douglas

In 1900, a photo taken from Point Douglas looking south along the Red River showed that all the trees, probably Manitoba Maple, Ash, Willows, Cottonwoods and Elms, were removed from its bank (Figure 56). There were trees that existed within the urban fabric of Winnipeg at that time.



Figure 56. Photograph circa 1900 looking south along the Red River from Point Douglas. Manitoba, Provincial Archives of Manitoba. South from Point Douglas. Negative Number N4551.

Air Photo 1950

The air photo in Figure 57 indicates how the site has become an industrial area with spur rail lines extending into the East Exchange. There is also the presence of vegetation, which may have been predominantly Manitoba Maple, along the Red River that was not present in photo from the 1900 from Point Douglas looking south along the Red River.

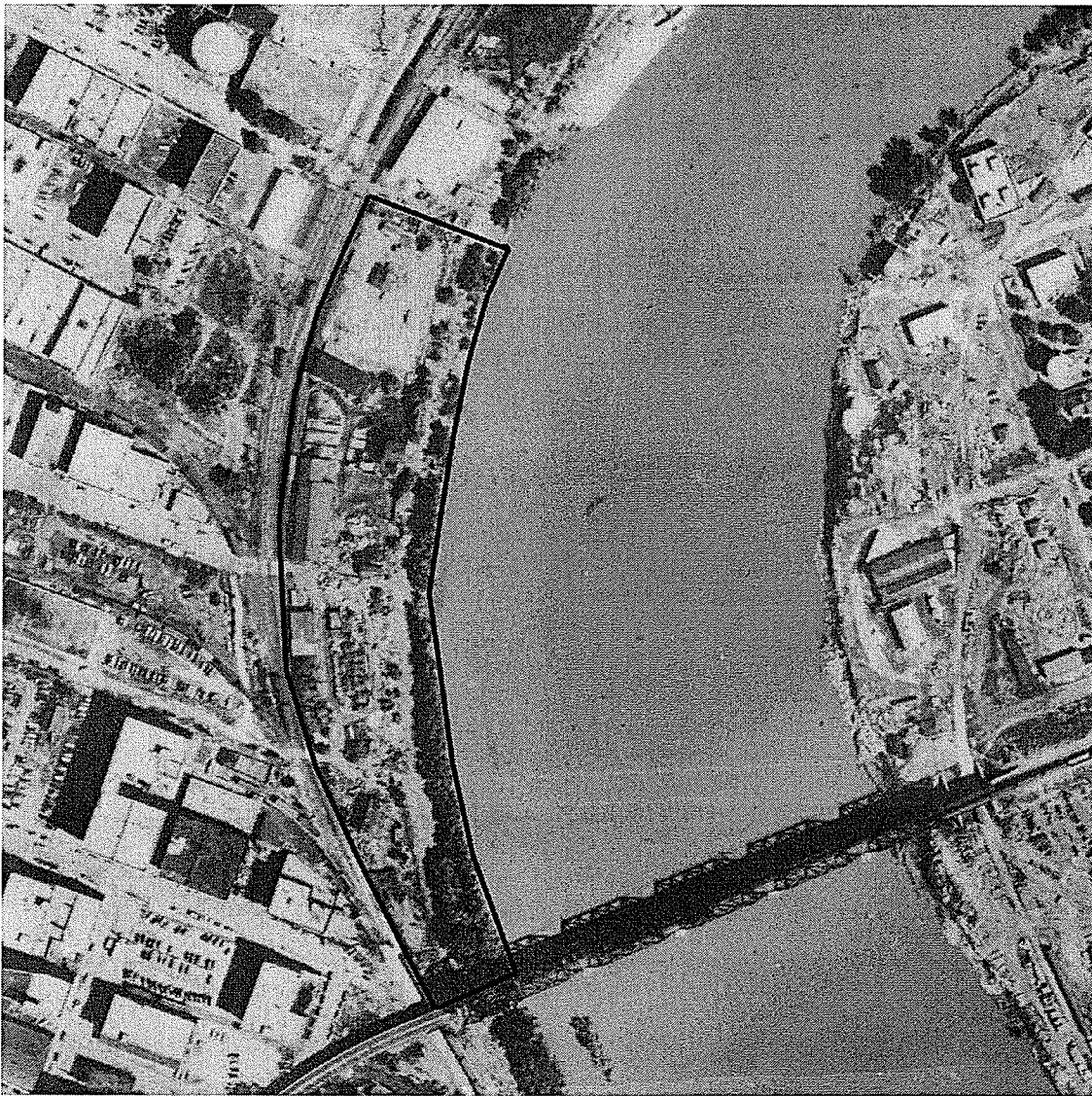


Figure 57. Air Photo from 1950. Site boundary in black outline. Scale: Nts. Manitoba. Manitoba Conservation: Land Information Centre, Canada Map Sales. Air photo taken June 27, 1950.

Air Photo 1983

Thirty-Three years later, large white patches are clearly visible in Figure 58 and were probably the remnant of building footprints that existed in the 1950 air photo. Site inventory pictures taken in 1982 by Lombard North Group indicate that these white patches were at the time probably used as parking lots (Figure 59 – 61).



Figure 58. Air Photo from 1983. Site boundary in black outline. Scale: Nts.
Manitoba. Manitoba Conservation: Land Information Centre, Canada Map Sales. Air photo taken April 23, 1983.



Figure 59. Section through bank looking south towards Bannatyne Ave.
Lombard North Group. Downtown Riverbank Park. Winnipeg: Lombard North Group, 1992.



Figure 60. Section through bank at Bannatyne Ave.
Lombard North Group. Downtown Riverbank Park. Winnipeg: Lombard North Group, 1992.



Figure 61. Parking on middle terrace and concrete pylons of CNR Bridge.
Lombard North Group. Downtown Riverbank Park. Winnipeg: Lombard North Group, 1992.

Air Photo 1988

The official opening of Stephen Juba Park was on October 14, 1983. To know who Stephen Juba was, please refer to Appendix M. Figure 60 below shows how the site has evolved from an industrial area (Figure 62) to parking lots (Figure 58) to finally a public park based on the design concept by Lombard North Group (Figure 63 – 66). The pathways and trees are visible.

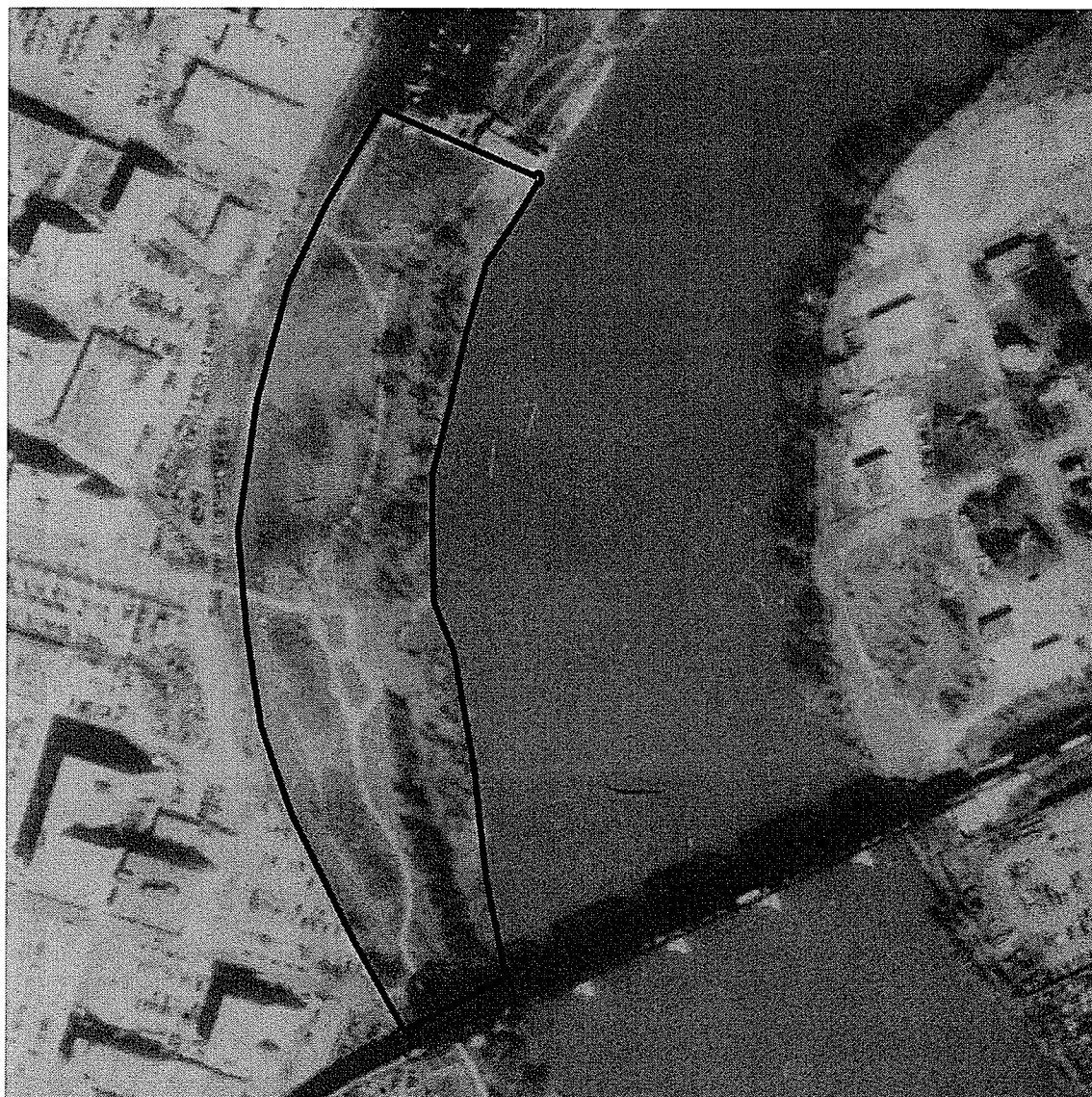


Figure 62. Air Photo from 1988. Site boundary in black outline. Scale: Nts.
Manitoba. Manitoba Conservation: Land Information Centre, Canada Map Sales. Air photo taken April 14, 1988.

Concept for Stephen Juba Park

Stephen Juba Park

Winnipeg, Manitoba

Steven Juba Park is the first phase of the development of a linear riverbank park system in Downtown Winnipeg. The project was initiated by the Manitoba A.R.C. Authority as one component of its program to preserve, protect, interpret and develop the natural, recreational and heritage resources of the Red River Corridor.

The major components of Steven Juba Park are a southern entry area at the Provencher Bridge, a large open park space and amphitheatre, serving as the terminus to the formal streetscape atmosphere of Bannatyne Avenue, and a multi-use waterfront area at Alexander Dock, anchoring the north end of the park. Street furniture, bollards, banners and elevated boardwalks are used to provide continuity and to enhance the visual and functional qualities of this urban riverbank park.

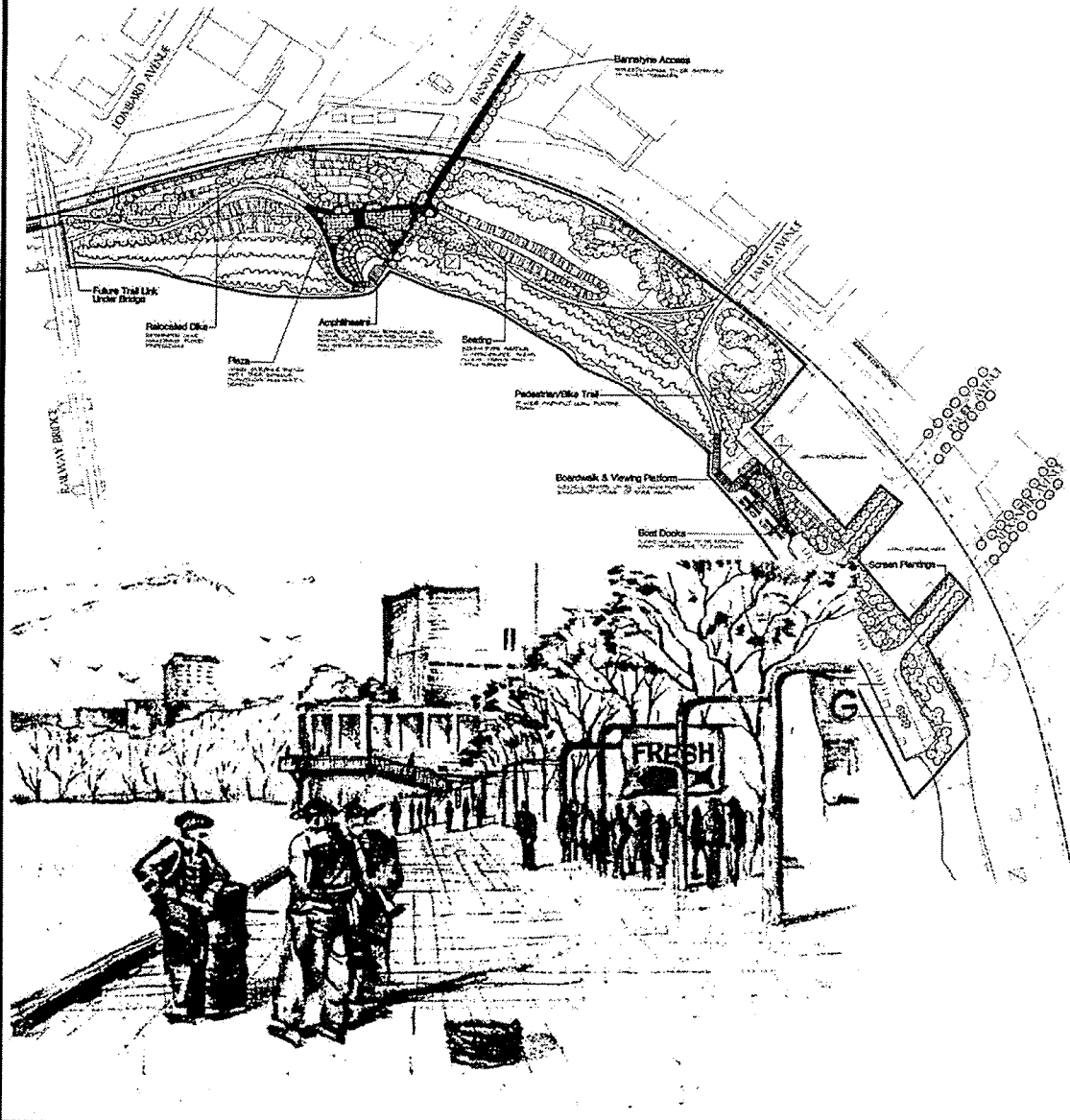


Figure 63. Concept statement for Stephen Juba Park by Lombard North Group.
Lombard North Group. Downtown Riverbank Park. Winnipeg: Lombard North Group, 1992.

Concept Sketches for Stephen Juba Park

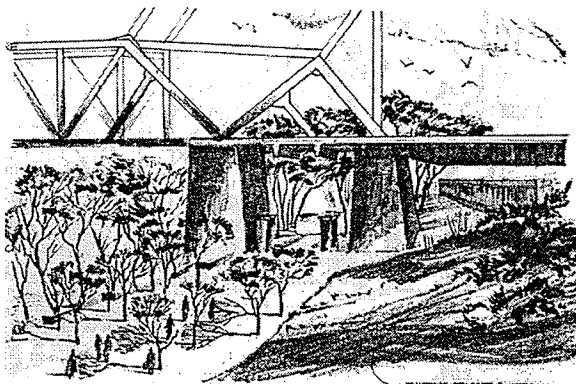


Figure 64. Looking south to the CNR Bridge.
Lombard North Group. Downtown Riverbank Park.
Winnipeg: Lombard North Group, 1992.



Figure 65. Looking north along the river terraces.
Lombard North Group. Downtown Riverbank Park.
Winnipeg: Lombard North Group, 1992.

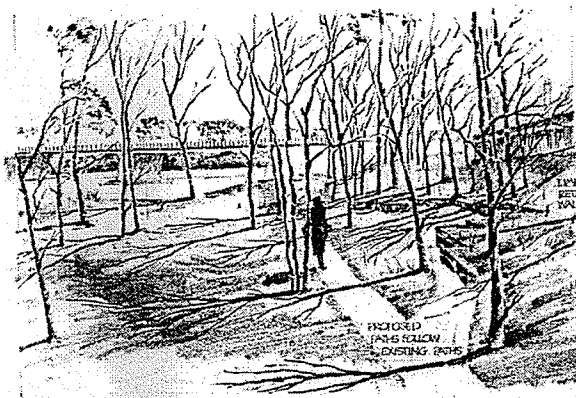


Figure 66. Looking south towards Provencher Bridge.
Lombard North Group. Downtown Riverbank Park.
Winnipeg: Lombard North Group, 1992.

Air Photo 1998

10 years later the park has changed very little from its opening day, except for the trees maturing (Figure 67). The CN Rail Line has been completely removed and has provided the opportunity for the City of Winnipeg's next major landscape architectural project: Waterfront Drive.

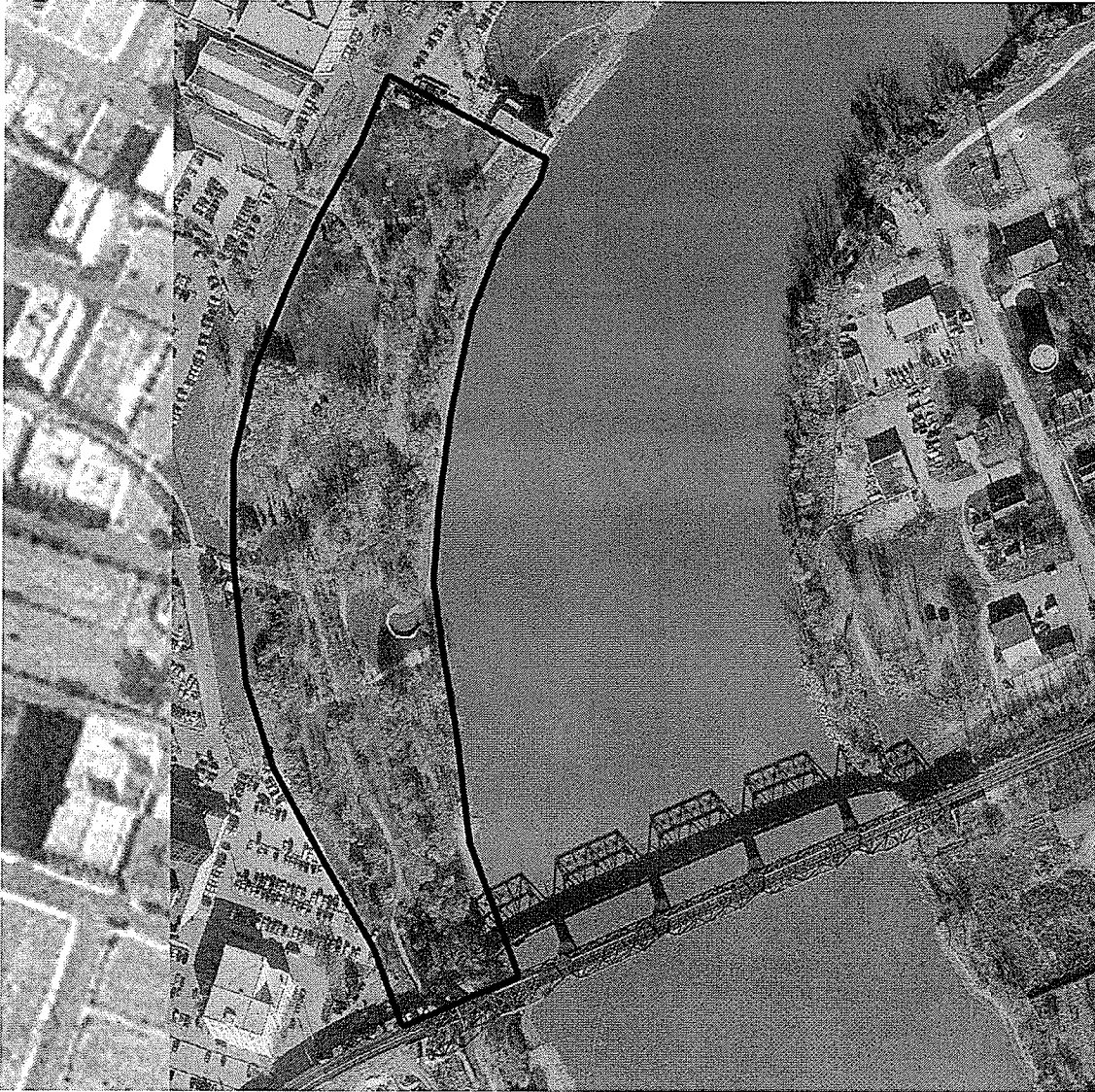


Figure 67. Air Photo from 1998. Site boundary in black outline. Scale: Nts. Winnipeg. City of Winnipeg Land Information Systems. Air photo taken spring 1988.

Air Photo 2001

In this air photo (Figure 68), the construction of Waterfront Drive has begun with the foundation work almost complete. The Bannatyne Ave. roundabout can also be clearly seen. The landscape development was scheduled to begin for Stephen Juba Park in Spring 2002.



Figure 68. Air Photo from 2001. Site boundary in black outline. Scale: Nts. Manitoba. Manitoba Conservation: Land Information Centre, Canada Map Sales. Air photo taken spring 2001.

Site Photos of Stephen Juba Park

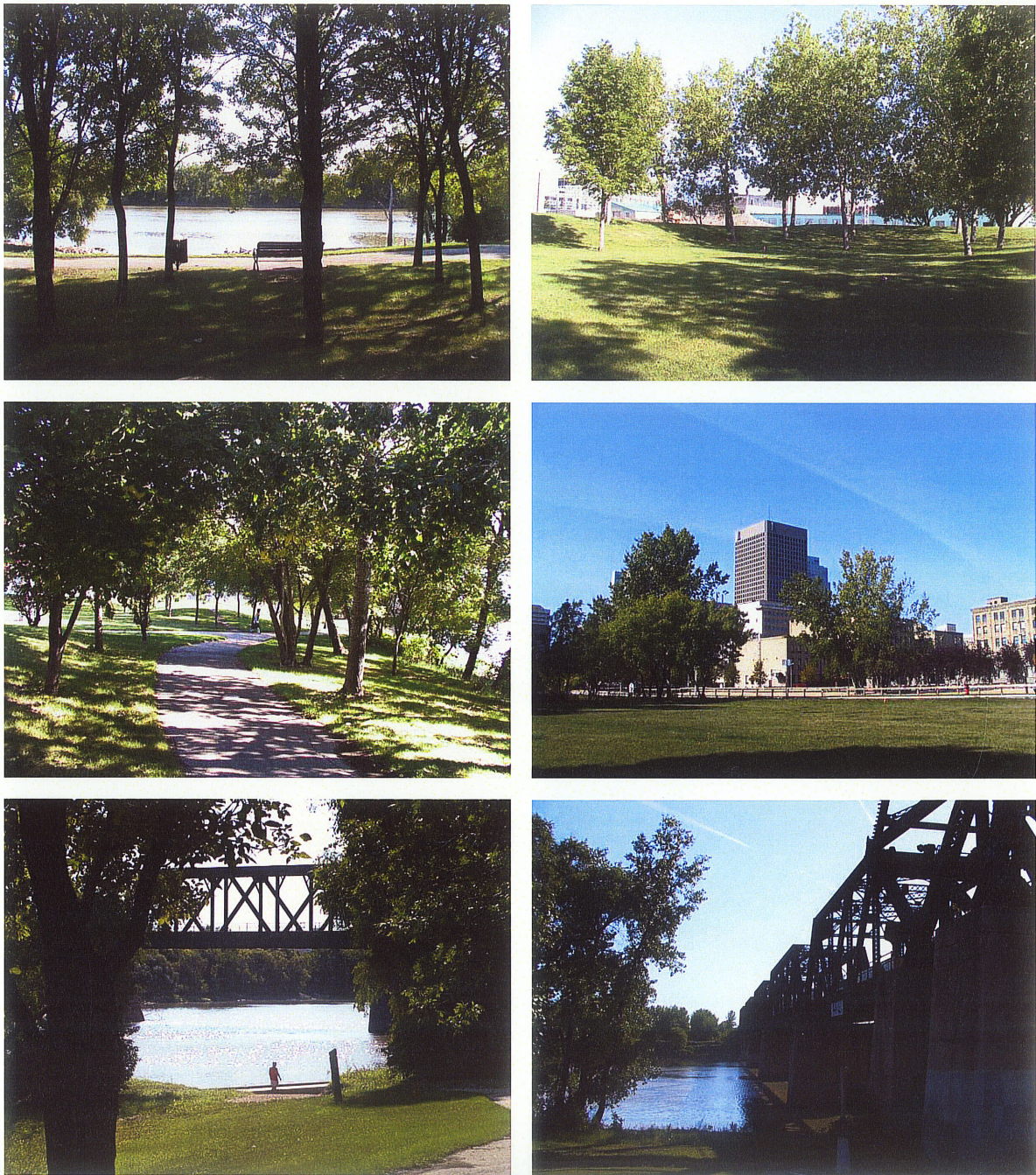


Figure 69. Various site photos of Stephen Juba Park.
Photos by Author.

Appendix G

Stephen Juba Park Quality Assessment

In Stephen Juba Park, there is a distinct visual separation between the park area and the river bottom forest. This distinct visual separation is created by having the grass mown on the park side and by allowing grasses to be left uncut in the river bottom forest portion. An assessment of quality of habitat was completed for Stephen Juba Park on July 31, 1996. According to the Seine River Gateway Study, there are four categories that a site may fall under, or a combination of, when performing a quality of habitat assessment:

"A" Quality Habitat (Maximum Sensitivity to disturbance): Virtually undisturbed by man or recovered to an extent where community structure and composition is intact and reflects historical natural vegetation and wildlife habitat. Other factors examined included soil disturbance, a high degree of native vegetation present and conversely, a lack of weedy or non-native species.

"B" Quality Habitat (High Sensitivity to disturbance): Light to moderate disturbance, for example, flood suppression (resulting in the encroachment of non-native species), may have a minimal amount of weeds but maintains a more natural condition where native species are still the major vegetative community.

"C" Quality Habitat (Low Sensitivity to disturbance): Moderate disturbance, a significant number of weed species, which have replaced native species, few native species present. For example, an old agricultural clearing that has not been used in recent times and native plant species are slowly returning, or an area that is regularly mowed.

"D" Quality Habitat (Minimum Sensitivity to disturbance): Heavily disturbed site, the vegetation is dominated by weed species or absent all together. None or very few native species present.

For Stephen Juba Park, the following description was given, including which category the park fell under in the quality of habitat assessment:

This small narrow park is classified as river bottom forest. The riverbank, at the time of inventory, had some monkey trails running along to the harbour area. There is a long high gravel path suitable for cycling. The first 100 feet from Provencher North were in poor condition and designated as B/C- quality habitat. There are some large heritage cottonwoods in the park. There was also a lot of purple loosestrife noted at the time of the inventory. The floodplain region is overgrown with weed species.

In addition to the description of Stephen Juba Park given above, a table was compiled which gave a subjective description of the site (Table 1). A scale of 1 to 10 was used in which the higher the score, the higher value that characteristic has. A plant list was also compiled and can be referred to in Appendix B.

Table 1. Habitat Quality Assessment

Community Type	Riverbottom Forest
Rank:	C-B
Size:	4
Faunal Diversity:	3
Floral Diversity:	7
Exotics:	5
Habitat Quality:	5.5
Special Features:	Nil.
Isolation/Access:	9
Aesthetics:	4
Disturbance:	5
Potential Risks:	6
Public Usage:	8
Historic Value:	7

Habitat quality assessment conducted July 31, 1996.
 Winnipeg. Naturalist Services Branch, City of Winnipeg
 Community Services Department. Stephen Juba Park –
River View North 27. Winnipeg: City of Winnipeg, 1996.

Appendix H

Riverbank Classification

The City of Winnipeg's Planning, Property and Development Department produced a "Riverbank Stability Characterization Study for City Owned Riverbanks" report for the Riverbank Management Committee in 2000. The report developed five basic classification areas for categorizing the City's riverbanks: Failure Controlled Banks, Erosion controlled banks, Transition Banks, Flood Plain Banks, and Altered Banks (Winnipeg 2000, 15).

According to this report, Stephen Juba Park riverbanks fall under two categories: Failure Controlled and Altered Banks, which are described below and is indicated on the map on Figure 70 below (Winnipeg 2000, 15 and 21):

1. Failure Controlled Banks: Failure controlled banks are associated with concave sections or outside bends of the river where massive sections of the bank fail and slide into the river channel. These bank failures incorporate the cohesive clay rich or glaciolacustrine soil deposits. Riverbank failures are deep-seated extending 12 to 15 meters below the ground surface and in some cases over 80 meters from the river's edge. The principle factors controlling riverbank failure include groundwater, river hydraulics and progressive soil weakening.
2. Altered Banks: These consist of any of the mentioned riverbank classification categories where remedial works have been done to improve bank stability. Remedial works performed to alter the condition of the bank may include slope regading, river edge erosion protection, installation of deep-seated stabilization techniques such as shear keys, granular ribs, rock fill caissons or retaining wall. Altered banks are not necessarily stable banks. In some cases, additional works may be necessary to realize long-term stabilization.

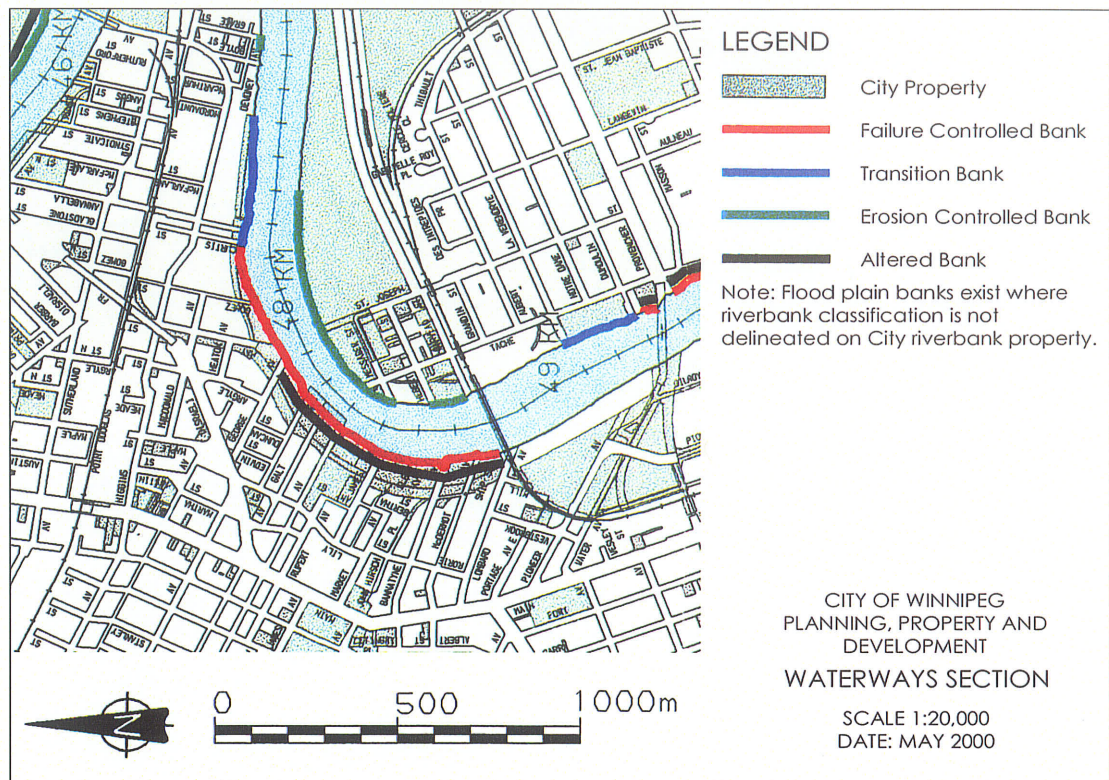


Figure 70. Stephen Juba Park Waterways Section by the City of Winnipeg Planning, Property and Development. Winnipeg, Planning, Property and Development Department. Riverbank Stability Characterization Study for City Owned Riverbanks. Winnipeg: City of Winnipeg, 2000, Figure A1 sheet 2 of 4.

Appendix I

Soil Survey of Winnipeg and Morris and Fort Garry Clay

Soil Survey of Winnipeg and Morris

The soil survey of Winnipeg and Morris was a joint project by the Canadian Department of Agriculture, Manitoba Department of Agriculture and Soils Department of the University of Manitoba. This survey was first published in 1953 and was conducted by W.A. Ehrlich, E.A. Poyser, L. E. Pratt, and J. H. Ellis. According to the soil map that resulted from the survey, Stephen Juba Park soil is composed of the Fort Garry Clay (Figure 71).

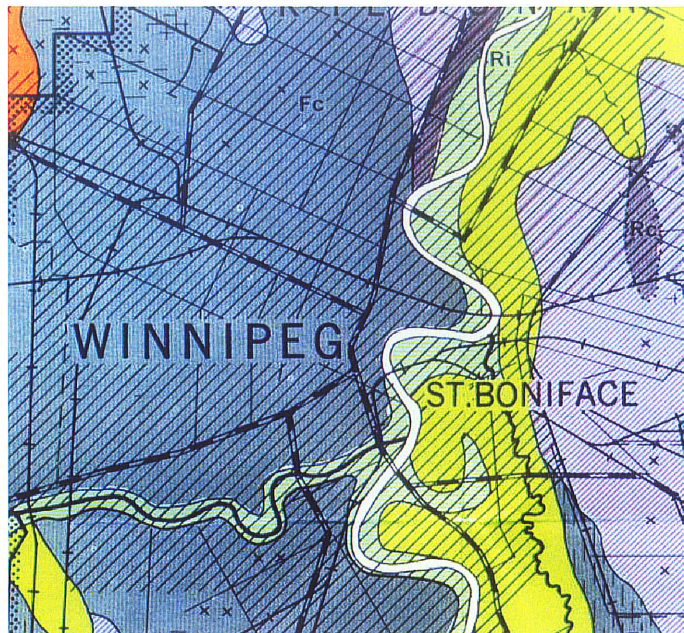


Figure 71. Fort Garry Clay (Fc) distribution in Winnipeg.
Soil Map: Reconnaissance Survey Of Winnipeg Area In Manitoba.
Map. Winnipeg: Province of Manitoba, Dept. of Municipal Affairs
and Municipal Planning Branch, 1975.

Fort Garry Clay

Fort Garry soils are developed on a clay and silty clay mantle, which lies over strongly calcareous silty and fine sandy clay dolomite sediments. The clay mantle may be 6 to 20 inches or more in thickness and it is invariably tongued into the underlying pale yellow material on which it rests. In some areas the calcareous silty materials are confined to low ridges with clay soils of the Red River soil association occupying the intervening positions, whereas other areas are covered completely by silty deltaic and

lacustrine deposits. These deposits, which are up to six or more feet thick, consist of laminated deposits varying in texture from very fine sandy loam to sandy clay and silty clay. Lacustrine clay, generally varied, occurs beneath these silty sediments (Ehrlich et al. 1976, 25). A complete description of Fort Garry Clay is listed in Figure 72.

A chlorotic condition of certain root and garden crops, and also trees and shrubs, is commonly observed due to the highly calcareous nature of the subsoil. The cause of the chlorotic condition is a nutrient deficiency of mainly iron. The chief problems in the management of the Fort Garry soil consist of the physical problems connected with surface drainage and with amelioration of the clay surface soil, and the fertility problems of phosphorus deficiency and lime-induced chlorosis that result from the excessive amounts of lime in the subsoil. Nevertheless, with good soil management practices these soils can be made productive; especially if suitable lime-tolerant trees are selected (Ehrlich et al. 1976, 26).

The topography is very gently to gently sloping; runoff is moderate and permeability is variable in the upper clay and silty layers being dependent on the texture and thickness of the stratified silty sediments (Michalyna 1975, 38).

Located below is the soil texture composition for the Fort Garry soil type (Michalyna 1975, 213):

1. Ah (top layer)
 - a. Depth range: 0 to 18 cm
 - b. Composition: sand = 8 %, silt = 44 %, clay = 48 %
 - c. Texture = silty clay
2. Bm (middle layer)
 - b. Depth range: 18 to 46 cm
 - c. Composition: sand = 11 %, silt = 36 %, clay = 53 %
 - d. Texture = clay
3. Ck (bottom layer)
 11. Depth range: 46 to 80 cm
 12. Composition: sand = 9 %, silt = 39 %, clay = 52 %
 13. Texture = clay
4. Ck (deeper layer)
 - a. Depth range: 80 to 135 cm
 - b. Composition: sand = 9 %, silt = 50 %, clay = 41%
 - c. Texture = silty clay

Soil Zone	Association	Profile Characteristics of Typical or Dominant Soil	Geological Parent Material and Prevailing Texture	Native Vegetation	Topography and Drainage	Natural Fertility	Suitability for Agricultural Use Indicated	Soil Problems
Black-earth Zone	Fort Garry	Dominant Soil Associate (P-PH) Well to Intermediately drained. "A" Horizon: Very dark grey clay, 7 to 10 inches thick in normal position, (tongues may intrude 20 inches downward); prismatic; very hard when dry, moderately plastic and sticky when moist; neutral to slightly alkaline. "Ca" Horizon: Light grey, rarely, very fine sandy clay loam to silty clay, 5 to 8 inches thick; weakly granular; friable;; very calcareous. "C" Horizon: Light grey to pale yellow, very fine sandy clay loam to silty clay; more or less stratified; friable; very calcareous. (this horizon may be up to 5 feet thick). "D" Horizon: Lacustrine clay.	Deltaic and lacustrine deposits. Dominantly clay surfaced textures (but may range from silty clay loam to clay) over more or less stratified pale yellow very fine sand and silty clay which rests on lacustrine clay.	Prairie and meadow prairie grasses and herbs. Some alkali-tolerant plants in local saline areas. Unthrifty, scrubby aspen and oak have invaded much of this association	Level with micro-relief. Drainage imperfect, some localized ponding occurs in wet seasons.	Moderately high, but many plants show chlorosis due to high lime subsoil.	Suitable for regional grain crops in well-drained sites. Limited use for garden and infertile crops.	Thin surface soil. Generally too high in lime for certain trees, shrubs and flowers. Salinity is common in low sites. Limitation of good well water. In some areas artificial drainage is required.

Figure 72. Soil characteristics for Fort Garry Clay. Ehrlich, W.A., Poyser, E.A., Proft, L.E., and Ellis, J.H. Report of Reconnaissance Soil Survey of Winnipeg and Morris Map Sheet Areas. Manitoba: Manitoba Department of Agriculture, 1976, p. 56A-2.

Appendix J

Assessment References

J.1 Air Pollution Removal

Summary

The Air Pollution Removal program is based on research conducted by David Nowak, PhD, of the USDA Forest Service. Dr. Nowak developed a methodology to assess the air pollution removal capacity of urban forests with respect to pollutants such as Nitrogen Dioxide (NO₂), Sulfur Dioxide (SO₂), Ozone (O₃), Carbon Monoxide (CO), and particulate matter less than 10 microns (PM₁₀). Pollution removal is reported in pounds, on an annual basis.

Removal rates were estimated for ten cities: Atlanta, Georgia; Austin, Texas; Baltimore, Maryland; Boston, MA; Denver, CO; Milwaukee, WI; New York, NY; Philadelphia, PA; Seattle, WA and St. Louis, MO. The user is asked to identify the city nearest the area being analyzed, and results from that city is used. Or, the user can use an average of results from all ten cities.

The program estimates the amount of pollution being deposited within a certain given study site based on pollution data from the nearest city, and then estimates the removal rate based on the area of tree and/or forest canopy coverage on the site.

Technical Methodology

The methodology determines a pollutant removal rate or flux (F) by multiplying the deposition velocity (V_d) by the pollution concentration (C).

$$F(\text{g/cm}^2/\text{sec}) = V_d(\text{cm/sec}) \times C(\text{g/cm}^3)$$

The pollutant flux is then multiplied by the area of the surface over periods in which the pollutant is known to exist over that surface in order to estimate total pollutant flux by hour for that surface. Hourly fluxes can be summed to estimate daily, monthly, or yearly fluxes.

Currently, air pollution estimates generated from CITYgreen are designed for urban and suburban forests. Therefore, estimates made using CITYgreen Watershed Analysis may over estimate conditions for rural watersheds.

References:

- | | |
|-------------------|--|
| Atlanta, Georgia: | Nowak and Crane (in review) |
| Austin, Texas: | Unpublished USDA Forest Service Data, Northeastern Research Station, Syracuse, NY |
| Baltimore, MD: | Nowak and Dwyer (in press); Nowak and Crane (in review) |
| Boston, MA: | Nowak and Dwyer (in press) |
| Denver, CO: | Nowak, personal Communication |
| Milwaukee, WI: | Unpublished USDA Forest Service Data, Northeastern Research Station, Syracuse, NY |
| New York, NY: | Nowak and Dwyer (in press); Nowak and Crane (in review) |
| Philadelphia, PA: | Nowak and Dwyer (in press) |
| Seattle, WA: | Unpublished USDA Forest Service Data, Northeastern Research Station, Syracuse, NY. Nowak, D.J. and J.F. Dwyer (in press) |
| | Understanding the benefits and costs of urban forest ecosystems. |

In: Kuser J. (ed.) Urban and Community Forestry in the Northeast. Plenum Publ. Co. New York. Nowak, D.J. and D.E. Crane. (in review) The Urban Forests Effect (UFORE) Model: quantifying urban forest structure and functions. To be published in Proceedings of Second International Symposium on Integrated Tools for Natural Resource Inventories in the 12th Century.

St. Louis, MO: Nowak, Personal Communication.

Notes

- Austin SO₂ and NO₂ data were taken from Houston and may not represent actual conditions in Austin.
- Austin was missing O₃ concentration data for Jan., Feb., and December. Concentration data for these missing months were estimated based on average national O₃ concentration trend data.

J.2 Carbon Storage and Sequestration

Summary

CITYgreen's carbon module quantifies the role of urban forests in removing atmospheric carbon dioxide and storing carbon. Based on tree attribute data on trunk diameter, CITYgreen estimates the age distribution of trees within a given site and assigns one of three Age Distribution Types. Type 1 represents a distribution of comparatively young trees. Type 2 represents a distribution of older trees. Type 3 describes a site with a balanced distribution of age. Sites with older trees (with more biomass) are assumed to remove more carbon than those with younger trees (less biomass) and other species. For forest patches, CITYgreen relies on attribute data on the dominant diameter class to calculate carbon benefits.

Each distribution type is associated with a multiplier, which is combined with the overall size of the site and the site's canopy coverage to estimate how much carbon is removed on a given site. The program estimates annual sequestration, or the rate at which carbon is removed, and the current storage in existing trees. Both are reported in tons. Economic benefits can also be associated with carbon sequestration rates using whatever valuation method the user feels appropriate. Some studies have used the cost of preventing the emission of a unit of carbon—through emission control systems or "scrubbers" for instance—as the value associated with trees' carbon removal services.

Technical Methodology

In estimating urban carbon storage and sequestration, the study area (in acres), the percentage of crown cover, and the tree diameter distribution are required.

Multipliers are assigned to three predominant street tree diameter distribution types:

Distribution Types	Carbon Storage Multipliers
Type 1 (Young population)	0.3226
Type 2 (Moderate age population 10-20 years old)	0.4423
Type 3 (Even distribution of all classes)	0.5393
Average (Average Distribution)	0.4303

Distribution Types	Carbon Storage Multipliers
Type 1 (Young population)	0.00727
Type 2 (Moderate age population 10-20 years old)	0.00077
Type 3 (Even distribution of all classes)	0.00153
Average (Average Distribution)	0.00335

CITYgreen uses these multipliers to estimate carbon storage capacity and carbon sequestration rates. For example, to estimate carbon storage in a study area:

Study area (acres) x Percent tree cover x Carbon Storage Multiplier = Carbon Storage Capacity

To estimate carbon sequestration:

Study area (acres) x Percent tree cover x Carbon Sequestration Multiplier = Carbon Sequestration Annual Rate

In recent studies conducted by Dr. David Nowak and Dr. Greg McPherson of the USDA Forest Service (USFS), it has been suggested that if urban trees are properly maintained over their lifespan, the carbon costs outweigh the benefits. Tree maintenance equipment such as chain saws, chippers and backhoes emit carbon into the atmosphere. Carbon released from maintenance equipment and from decaying or dying trees could conceivably cause a carbon benefit deficit if it exceeds in volume the amount sequestered by trees.

In order to maximize the carbon storage/sequestration benefits of urban trees, the USFS suggests that we should plant larger and longer living species in urban areas, so that more carbon can be stored, mortality rates can be decreased, and maintenance methods can be revised over time as technology improves. For more information on how to estimate urban carbon storage and sequestration, please contact the US Forest Service (Northeastern Forest Experiment Station - Syracuse, NY).

CITYgreen's carbon estimates are designed for urban forests. Therefore, carbon storage and sequestration estimates will be coarse when used on 1992 NRI Watershed data, and may not be as accurate when applied to rural conditions.

References

1. Nowak, David; Rowntree, Rowan A., "Quantifying the Role of Urban Forests in Removing Atmospheric Carbon Dioxide", *Journal of Arboriculture*, 17 (10). October 1, 1991. p.269.

2. McPherson, E. Gregory; Nowak, David J.; Rowntree, Rowan A. eds. 1994. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. department of Agriculture, Forest Service, Northeastern Forest Experiment Station; p. 201.

J.3 Stormwater Runoff Reduction

Summary

The CITYgreen stormwater runoff analysis estimates the amount of stormwater that runs off a land area during a major storm, as well as the time of concentration and peak. The program determines runoff volume based on the percentage of tree canopy, percentage of shrubs or grass, and percentage of impervious surfaces, as digitized by the user in the CITYgreen Local View.

The analysis also considers a variety of localized information entered by the user, such as local rainfall patterns, soil type, and other site characteristics.

The Stormwater Runoff program incorporates procedures and formulas developed by the US Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), to estimate runoff volume as well as percent changes in time of concentration and peak flow. The Urban Hydrology for Small Watersheds model, commonly referred to as Technical Release 55 or TR-55, was incorporated into CITYgreen and customized, with the help of Don Woodward, PE, a hydraulic engineer with NRCS, to determine the benefits of trees and other urban vegetation with respect to stormwater management.

Technical Methodology

CITYgreen's stormwater runoff analysis enables a user to map urban land cover features (grassland/shrub, trees, buildings and impervious surfaces) and determine percentages of each land cover feature.

Land cover percentages are then combined with average precipitation data, rainfall distribution information, percent slope, and hydrologic soil group to estimate how trees affect runoff volume, time of concentration, and peak flow. In addition, the program estimates the additional volume of water, in cubic feet, that would have to be managed if trees were removed when comparing two scenarios. This volume estimate can be associated with an economic value since planners generally know the costs per cubic foot to build a retention pond in their municipality. CITYgreen also enables the user to model different land cover and precipitation scenarios to determine acceptable development or conservation practices.

The TR-55 model was designed to analyze runoff patterns during a 24-hour single storm-event. Engineers and non-engineers typically design stormwater management facilities for average storm events, usually 24 hours in duration, according to NRCS. CITYgreen allows the user to input values for the amount of rain that would typically fall during a typical 24-hour event observed within a 2-year span, 5-year span, 10-year span, or 25-year span. These different values are based on NRCS estimates of rainfall distributions for different regions of the country. Their values differ in part because a higher maximum rainfall is observed in a ten-year period than in a two-year period, for instance.

The choice depends on how conservative the user wants estimates to be (clearly a 10-year span will produce a larger value than a 2-year period), the time frame under consideration in the analysis, and other factors.

The user is also asked to input a slope, which can be best thought of as the estimated average slope of the site.

The following formulas are used to estimate curve numbers, stormwater runoff, time of concentration and peak flows.

Formulas used in Calculations

Curve Numbers: $CN \text{ (weighted)} = \frac{\text{Total Product of (CN x Percent land cover area)}}{\text{Total Percent Area or 100}}$
Potential Maximum Retention after Runoff begins: $S = (1000 / CN) - 10$
Runoff Equation: $Q = [P - 0.2 ((1000 / CN) - 10)]^2 / P + 0.8 ((1000 / CN) - 10)$
Flow Length: $F = (\text{total study area acres} / 0.6) * 209.0$
Lag Time: $L = ((F / 0.8) * ((S + 1.0) / 0.7)) / (1900 * ((\text{slope}) / 0.5))$
Time of Concentration: $T_c = 1.67 * L$
Unit Peak Discharge: $\log(q_u) = C_0 + C_1 \log(T_c) + C_2 [\log(T_c)]^2$
Peak Flow: $\text{Peak} = (q_u * A_m * Q * F_p)$
Storage Volume: $V_s = V_r * (C_0 + (C_1(q_o/q_i)) + (C_2((q_o/q_i) * (q_o/q_i))) + (C_3(q_o/q_i) * (q_o/q_i) * (q_o/q_i))) * \text{study area acres} * 43560.17 / 12$

Variable Definitions

P = Average Rainfall for a 24 hour period (inches)
 A_m = study area acres / 640 to determine square miles
 q_o = Existing peak flow condition with trees
 q_i = Peak flow without trees
 C₀..... = TR-55 Coefficients in accordance with raintype

Output Values

Peak = Peak Flow (cfs)
 V_s = Storage volume (cubic feet)
 V_r = Runoff Volume (in)
 CN = Runoff Curve Number (weighted)
 Q = Runoff (inches)
 F = Flow length (feet)
 S = Potential Maximum Retention after Runoff begins (in)
 L = Lag Time (hours)
 T_c = Time of Concentration (hours)
 q_u = Unit Peak Discharge (csm / in)

TR-55 formulas are used in most engineering firms, soil conservation districts, and municipalities around the country. Over 300,000 copies of the TR-55 manual have been sold by the US National Technical Information Service as of 1994. The NRCS methods used in TR-55 are very effective in evaluating the effects of land cover/land use changes and conservation practices on direct runoff. For more information about TR-55, see the following website: www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.html

The CITYgreen stormwater runoff analysis is not intended to be used to design stormwater management facilities, culverts, or ditches. The program is used to estimate the effects of vegetation, especially trees, on runoff volume and peak flow. Percent changes in runoff volume and peak flow are determined automatically by comparing two different scenarios of the same site.

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Appendix K

Pre-Design and Post-Design Assessment Site Statistics

Pre-Design Assessment Statistics

Trees		Forest Patches	
Tree Count	393	Forest Patch Count	5
Tree Canopy Percent	15.23%	Forest Patch Canopy Percent	13.26%
Canopy Acres	1.08	Forest Patch Canopy Acres	0.94
Area of Study Site (acres)	7.08	Area of Study Site (acres)	7.08
Canopy Area per Tree (sq ft)	119.51	Canopy Area per Forest Patch (sq ft)	8177.79
Dominant Diameter Class	1.4	Dominant FP Diameter Class	1.8
Diameter Class Distribution	Young	Diameter FP Class Distribution	Mature
(1 2 3)	64.1% 28.8% 7.1%	(1 2 3)	40.0% 40.0% 20.0%
Average dbh	10.3"	Average dbh	16.1"
Dominant Height Class	1.8	Dominant FP Height Class	1.8
Dominant Health Class	0	Dominant FP Health Class	0
Ownership (Prv Pub Unk)	0% 100% 0%	Bare Areas	
Number of Species	13	Bare Percent	5.92%
Dominant Species	GA (40.2%)	Bare Area (acres)	0.42
Species Diversity		Area of Study Site (acres)	7.08
POP (Poplar, White)	9.9%	Grass	
LIN (Linden, American)	10.2%	Grass Percent	81.53%
GA (Green Ash)	40.2%	Grass Area (acres)	5.77
BM (Boxelder Maple)	12.5%	Area of Study Site (acres)	7.08
SM (Silver Maple)	7.1%	Dominant Grass Type	Poa sp. (100%)
SE (Siberian Elm)	2.3%	Impervious Surfaces	
CHY (Ornamental Cherry)	0.3%	Impervious Surfaces Percent	13.81%
WIL (Willow)	4.3%	Impervious Surfaces Area (acres)	0.93
CR (Cottonwood)	1.3%	Area of Study Site (acres)	7.08
ASH (Ash)	6.4%	Dominant Impervious Surface Color	Black (100%)
CRB (Crabapple)	1.5%		
CP (Scotch Pine)	0.5%		
SPR (Spruce)	3.6%		

Post-Design Assessment Statistics

Trees		Forest Patches	
Tree Count	384	Forest Patch Count	5
Tree Canopy Percent	15.34%	Forest Patch Canopy Percent	13.26%
Canopy Acres	1.09	Forest Patch Canopy Acres	0.94
Area of Study Site (acres)	7.08	Area of Study Site (acres)	7.08
Canopy Area per Tree (sq ft)	123.39	Canopy Area per Forest Patch (sq ft)	8177.79
Dominant Diameter Class	1.4	Dominant FP Diameter Class	1.8
Diameter Class Distribution	Young	Diameter FP Class Distribution	Mature
(1 2 3)	65.9% 28.1% 6.0%	(1 2 3)	40.0% 40.0% 20.0%
Average dbh	9.8"	Average dbh	16.1"
Dominant Height Class	1.7	Dominant FP Height Class	1.8
Dominant Health Class	0	Dominant FP Health Class	0
Ownership (Prv Pub Unk)	0% 100% 0%	Bare Areas	
Number of Species	15	Bare Percent	10.43%
Dominant Species	GA (39.6%)	Bare Area (acres)	0.74
Species Diversity		Area of Study Site (acres)	7.08
POP (Poplar, White)	9.1%	Grass	
LIN (Linden, American)	10.2%	Grass Percent	71.54%
GA (Green Ash)	39.6%	Grass Area (acres)	5.07
BM (Boxelder Maple)	12.5%	Area of Study Site (acres)	7.08
SM (Silver Maple)	6.8%	Dominant Grass Type	Poa sp. (100%)
SE (Siberian Elm)	1.8%	Impervious Surfaces	
CHY (Ornamental Cherry)	0.3%	Impervious Surfaces Percent	17.47%
WIL (Willow)	1.6%	Impervious Surfaces Area (acres)	1.24
CR (Cottonwood)	1.3%	Area of Study Site (acres)	7.08
ASH (Ash)	7.8%	Dominant Impervious Surface Color	Black (100%)
CRB (Crabapple)	2.1%		
CP (Scotch Pine)	0.5%		
SPR (Spruce)	3.6%		
AE (American Elm)	2.3%		
ORN (Ornamental)	1.3%		

Appendix L

Post-Design Tree Inventory Data and Field Map

TREE INVENTORY SHEET

Stephen Juba Park

Study Site: Stephen Juba Park

Date: October 5, 2003

Sheet No.: SJP#13

	Tree ID#	Pub./ Priv.	Species	Trunk Diameter		Height		Red. Ht.	Health	Conflict Cover	Ground Cover
				Inches	Class	Feet	Class				
1	B	Pub.	American Elm	2.5	1	12	1	no		4	5
2	C	Pub.	American Elm	2.5	1	12	1	no		4	5
3	D	Pub.	American Elm	2.5	1	12	1	no		4	5
4	A	Pub.	Selkirk Rosybloom	3.5	1	11	1	no			5
5	E	Pub.	Selkirk Rosybloom	3.5	1	11	1	no			5
6	F	Pub.	Patmore Ash	3.5	1	15	1	no			5
7	G	Pub.	Japanese Tree Lilac	3	1	8	1	no			5
8	H	Pub.	Patmore Ash	4	1	18	2	no			5
9	I	Pub.	Patmore Ash	4	1	18	2	no			5
10	J	Pub.	Patmore Ash	4	1	18	2	no			5
11	K	Pub.	Patmore Ash	4	1	18	2	no			5
12	L	Pub.	American Elm	2	1	16	2	no			5
13	M	Pub.	American Elm	2	1	17	2	no			5
14	P	Pub.	Japanese Tree Lilac	4	1	6	1	no			5
15	Q	Pub.	Japanese Tree Lilac	4	1	6	1	no			5
16	R	Pub.	Japanese Tree Lilac	2	1	6	1	no			5
17	S	Pub.	Japanese Tree Lilac	3	1	6	1	no			5
18	N	Pub.	American Elm	2.5	1	13	1	no		4	5
19	O	Pub.	American Elm	2.5	1	12	1	no		4	5
20	T	Pub.	American Elm	3	1	15	1	no			4
21	U	Pub.	American Elm	3	1	14	1	no			4
22											
23											
24											
25											

DBH Class:

1=<10 inches
2=10-20 inches
3=>20 inches

Height Class:

1=<15 feet
2=15-35 feet
3=>35 feet

Health Class:

1=Dead/Dying
2=Poor
3=Fair
4=Good
5=Excellent

Conflicts:

1=Pot, Overhead wires
2=Ex. Overhead wires
3=Structure(specify)
4=Sidewalk
5=Other tree.

Grd. Cover:

1=Shrub
2=Grass
3=Pavement
4=Exp. Soil
5=Mulch

Post-Design Assessment Tree Inventory.xls
Post-Design #1

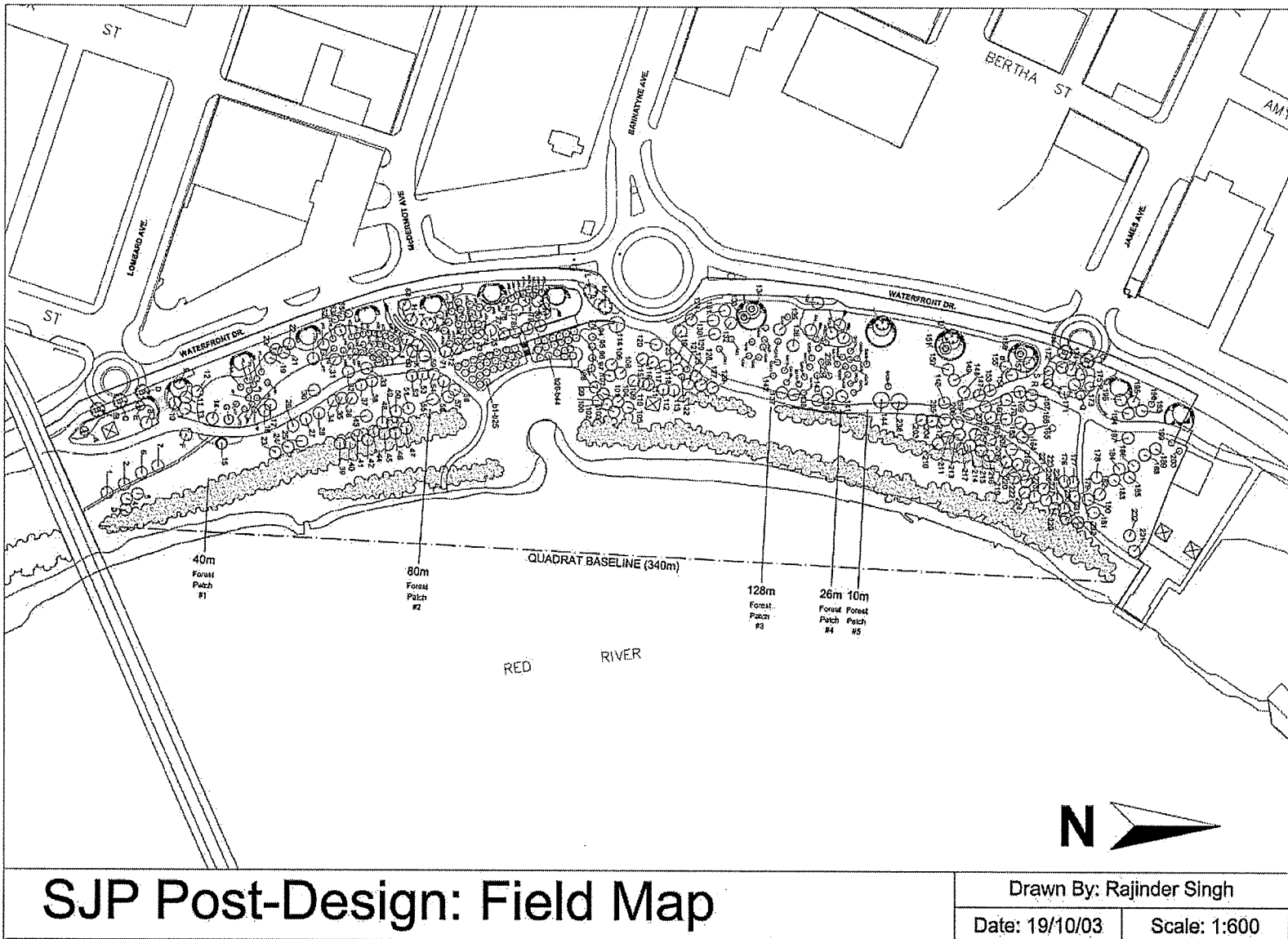


Figure 73. SJP Post-Design: Field Map.
Map by Author.

Appendix M

Who was Stephen Juba?

As mayor of Winnipeg, Stephen Juba governed for 20 years from 1957 to 1977 (Figure 74). He was born on Dominion Day, July 1, 1914 the second son of Gregory Juba and Sophia Mosata who immigrated to Canada from the Ukraine (Czuboka 1986, 25). Stephen Juba had grown up in the 1930's and 1940's, which had made him aware that money was important (Czuboka 1986, 25). He was forced to leave school because his father could not afford it (Czuboka 1986, 37). He attempted to make his fortunes in several ways, but failed at most of them except salesmanship. He had worked for many



Steve Juba in the late 1950s.

Figure 74. Stephen Juba in the late 1950s.
Czuboka, Michael. Juba, Winnipeg:
Communigraphics/printers aid group, 1986, p.46.

firms and individuals and tried to be a contractor, but realized that he would not become wealthy by working for other people. That was when he discovered that his greatest strength was as an 'idea man,' which he defined as someone who comes up with a lot of schemes for improving the world and making money besides (Czuboka 1986, 31). From this, he had developed a successful business called Keystone Supply.

With several years of running a successful business, his goals were set on something higher, to become mayor of Winnipeg (Czuboka 1986, 37). He was elected into the Manitoba legislature in 1953. With several political parties to join their party approached him, but his passion was to become mayor of Winnipeg (Czuboka 1986, 37). In 1957, Stephen Juba ran for mayor and won. When he won, he reminded himself that he had

been elected by the citizens of Winnipeg and not the community leaders (Czuboka 1986, 45).

Stephen Juba ran Winnipeg much that same way he ran his business. He expected his employees to be competent, hardworking and loyal. He was not afraid to delegate duties to his trusted aides. He would listen carefully to what others had to say and made up his mind accordingly. To a large degree he operated on the basis of common sense and natural instinct (Czuboka 1986, 53). During his years in office, several projects were accredited to him. The Desraeli Freeway, Pan-AM Games, city hall, overhead sidewalks, Sunday professional sports, legalized sweepstakes, and liberalized liquor laws (Czuboka 1986, 65). Stephen Juba was responsible in the amalgamation of 12 Cities, Towns, and Rural Municipalities into the unified City of Winnipeg by the passing of Bill 36 on July 21, 1971. The Cities, Towns and Rural Municipalities were: City of Kildonan, St. Boniface, St. James-Assiniboia, St. Vital, Transcona, West Kildonan, Winnipeg, the R.M.'s of Charleswood, Fort Garry, North Kildonan, Old Kildonan, and Town of Tuxedo (Czuboka 1986, 117).

He also had some projects that were unsuccessful, such as gambling casinos, a covered stadium, parking lots on top of service stations, and a weather proof cover for downtown Winnipeg (Czuboka 1986, 66). His greatest disappointment was the rejection of a monorail system from the citizens of Winnipeg, but still promoted when he retired from office (Czuboka 1986, 66).

In 1977, Stephen Juba retired as mayor of Winnipeg. The main reason was due to the lack of support of the monorail system by the public, but more so by a single administrator that had a lot of influence. It was rumoured that the administration developed a report that was going to support the monorail idea if he ran for mayor again. Stephen Juba saw this report accidentally and the opposite was true. The

administration was firmly against the monorail system for Winnipeg. He realized that if he ran for mayor again, he would be confronted with it (Czuboka 1986, 185).

"This time, though, a bureaucrat got the best of me, and realized I was just banging my head against a brick wall. I just couldn't take it any more of that, and that's why I quit" (Czuboka 1986, 186).

So, Stephen Juba retired in 1977 ending his 20-year reign as mayor of Winnipeg. Named for Winnipeg's longest serving mayor, Stephen Juba Park on the Red River was opened in 1984. This park occupies a site, which, prior to the arrival of the transcontinental railway in 1881, served as the commercial centre of Winnipeg. Ship Street suggests the early history of this area when most settlers and goods coming to the new city were transported by boat from St. Paul, Minnesota where the closest rail line passes. Alexander Dock still stands at the northern end of the park. More recently, a railway spur line that had serviced the many warehouses, which were built in the District, has been removed and the land has been redeveloped as a landscaped walk called Theatre Way. Freight trains continue to pass over the bridge at the southern end of the park (Heritage Winnipeg, 2001).

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