A COMPUTERIZED STREET TREE INVENTORY SYSTEM FOR THE CITY OF WINNIPEG FORESTRY BRANCH

by

David A. Domke

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ABSTRACT

Urban tree care deals with a dynamic product, and efficient management is difficult without accurate information. A Computerized Street Tree Inventory System (CSTIS) is a type of management information system designed to increase the efficiency and effectiveness of tree maintenance operations. The ultimate goal of the system is to enhance the structure of the urban forest.

A CSTIS needs assessment of the City of Winnipeg Forestry Branch resulted in the formulation of six specific CSTIS objectives. The general types of information to be retrieved from each objective were described in terms of required and desirable information. In essence this system should record information on each individual tree's physical and site characteristics, track all work required and completed for each tree, tabulate trees by specific geographical unit and other characteristics, and summarize information on all city trees.

A survey of thirteen CSTIS in North America gathered information on each system's development, status, scope, purpose, data variables, information retrieved, system use, costs, comments, and limitations. The types of information retrieved from each of the systems was then compared to the types of information required and desired of a system in the City of Winnipeg.

Four alternatives for implementation were presented that considered technical and economic issues as well as operational ones. These alternatives included software development in-house, purchase of custom developed software, purchase of a generalized CSTIS package, and a phased combination of alternatives. Advantages and disadvantages for each alternative were presented.

The City of Winnipeg requires a relatively complex tree information system. CSTIS software compatible with the needs of the Forestry Branch has been developed in other municipalities. This software has been custom developed for mainframe and minicomputers, and generalized software is available for microcomputers. A CSTIS in Winnipeg would have the greatest probability of success if it were developed in-house on a mainframe or minicomputer; however, more study on specific hardware requirements is needed.

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Chapter I

INTRODUCTION

1.1 PREAMBLE

The role of natural resource managers has changed dramatically within the last ten years. Managers now require more information to provide integrated solutions for increasingly complex problems. The development of information systems based on computer technology can meet many of these new requirements. Computer-based information systems can improve a manager's ability for assembling, storing, and analyzing large amounts of data in a framework designed to facilitate the resource management decision (Estes, 1983).

Effective management is based on the premise that the manager knows the current status of the natural resource in question. Computerized inventory systems supply the manager with information that enables more accurate and rational decisions to be made.

Recently, these computerized inventory systems have been adopted for use in urban forestry. Trees in the urban environment require specialized management techniques to ensure their perpetuation. Data collected from boulevard trees and compiled into a computerized information system permit the urban forester to coordinate the necessary labor and equipment to complete the activities of the urban forest agency (Kielbaso and Ottman, 1978). Overall labor and management costs may be reduced and as a direct result of system implementation.

1.2 PROBLEM STATEMENT

Winnipeg's past and present manual street tree information systems have not met the needs of the City of Winnipeg Forestry Branch. The information supplied from these systems has not been adequate nor accurate enough to manage an integrated forestry operation. Reliable and pertinent information would enhance the managers' decision-making abilities. Moreover, immediate and timely information on each tree is required so Forestry Branch staff can answer public and councillor inquiries.

The Forestry Branch requires an assessment of various inventory systems to improve the management of urban street trees. There are many computerized inventory systems throughout North America, and each has developed under unique circumstances. The use of such inventory systems is based on the needs of the user, and is limited by operational, technical, and economic constraints. An assessment of computerized inventory systems will enable the Forestry Branch to determine the applicability of these other systems to the City of Winnipeg.

1.3 OBJECTIVES

The primary purpose of this study was to evaluate and select a Computerized Street Tree Inventory System (CSTIS) for the City of Winnipeg Forestry Branch.

The specific objectives were:

1. to assess the CSTIS needs of the Forestry Branch;

2. to develop criteria for the evaluation of alternative CSTIS;

3. to assess selected CSTIS now being used in other jurisdictions in Canada and the United States; and

4. to recommend an effective CSTIS for Winnipeg.

1.4 STUDY ASSUMPTIONS AND LIMITATIONS

This study assumes that a complete and continual CSTIS is required in the City of Winnipeg. Each individual tree is uniquely identified, and information on each tree is continually updated.

An important limitation of this study is that only thirteen CSTIS were included in this study. As a result, comparison of these systems to the situation in the City of Winnipeg is somewhat limited. Other systems could be considered.

Chapter II

METHODS

2.1 INTRODUCTION

The primary methodological tools used in this study were a literature review, face-to-face and telephone interviews, and document analysis. The study has been broken down into five distinct segments each with specific research requirements.

2.2 PHASE 1: LITERATURE REVIEW

A literature review was undertaken to gain a better understanding of CSTIS, to suggest criteria to evaluate CSTIS (Phase 3), and to locate several systems for evaluation. Both manual and computerized searches of relevant literature were conducted to identify pertinent information on CSTIS.

2.3 PHASE 2: NEEDS ASSESSMENT

The first portion of this phase was designed to study the flow of information within the Forestry Branch. The specific purpose of this research was to assess the needs of a CSTIS for the Forestry Branch. This information was used to identify existing problems in information flow and to propose system objectives of a CSTIS. In turn, this defined the type of information to be retrieved from a CSTIS, and determined the type of information to be collected during the inventory.

The needs assessment took place in two steps. First, a number of documents were reviewed that concerned the operations of the Forestry Branch. Specifically, organizational charts, job descriptions, manuals, and reports were collected and analyzed. This was done to gain familiarity with the organization.

Secondly, Forestry Branch personnel were interviewed (Appendix A - condensed version). The questions were developed following a general framework suggested by Ostle (1985). In total twelve interviews were completed - three from administration, three from the technical staff, four from operations staff, and two from the clerical staff. This included all full-time administrative staff, technical staff, and foreman. Only two members of the clerical staff were interviewed since the other two were not directly involved with tree information. The staff members interviewed were identified from the document review as playing a key role in the development and implementation of a proposed CSTIS.

The specific number and type of questions for each interview varied depending on the interviewee's position in the organization and direct involvement with the problem (Ostle, 1985). For this reason, the questionnaire was split into three sections. The first section was designed to be answered by all respondents. It was concerned with the identification, functions and responsibilities, present information requirements, and future information requirements of each position. The second section of the questionnaire was administered to those respondents who had some knowledge of Winnipeg's past street tree inventory system and/or had an interest in a street tree inventory (Appen-

dix A). The third section of the questionnaire was designed for those respondents whose functions include direct planning and management of the urban forest (Appendix A).

A face-to-face interview method was used to enhance responsiveness, and an attempt was made for the interviews to remain casual and informal. For all individuals, the researcher asked the respondent the question, and wrote the response on the questionnaire form.

At the beginning of each interview, the respondent was told the purpose of the interview and that all information would be kept confidential. After the interview was completed, all answers were fully documented, and if there were any discrepancies in the responses the researcher contacted the respondent for clarification.

The information was analyzed descriptively to highlight problems and concerns of the staff and to identify problems of the present street tree information system. In addition, this phase enabled drafting of the general purpose, objectives, and information requirements for a CSTIS in the City of Winnipeg.

Once the needs assessment was completed, a number of informal meetings were held with the technical and administrative personnel of the Forestry Branch to ensure the validity of the needs assessment.

2.4 PHASE 3: CRITERIA TO EVALUATE ALTERNATIVE CSTIS

A series of criteria were developed to evaluate custom developed and generalized CSTIS. The criteria describe the operational, technical, and economic aspects of each system, and were developed through literature reviews of CSTIS and management information systems, and by consultation with CSTIS experts in the United States and Canada. These criteria were modified as more information was obtained, and eventually were developed into a focused, expanded, and combined version of frameworks suggested by Sacksteder and Gerhold (1979) and Smiley (1987).

The criteria were incorporated into a questionnaire format. The scope of the questionnaire included the system's background, characteristics, description of inputs/outputs, operational capabilities, cost, and recommendations. The questionnaire would be used in the next phase of the study.

2.5 PHASE 4: IDENTIFICATION AND ASSESSMENT OF CSTIS

Different CSTIS were identified through the literature review, by mail, and through telephone conversations with experts in the U.S. and Canada. Over 100 letters were mailed to professionals, municipalities in Canada and the U.S., and private and public forestry organizations. There were approximately 65 replies to these letters. In addition, 25 telephone calls were made to North American destinations. These people were largely university professors, public forestry information services, and private arboricultural firms. Each has made important con-

tributions to the development of CSTIS. Throughout this entire procedure, emphasis was placed on identifying Canadian cities using CSTIS, and generalized CSTIS available.

Each municipality or organization with a CSTIS was contacted by telephone and surveyed using Questionnaire 2 (Appendix B). When available, administrative or management personnel were interviewed, but if not available, staff closely associated with the CSTIS were interviewed.

A telephone interview was determined to be the most effective and economical means of collecting data on each of these systems. For the most part the questions were open-ended, and question wording and sequence was flexible.

At the beginning of each interview, a brief introductory statement was made, and in some critical instances, the respondent was asked if the conversation could be recorded. In other cases, the respondent answered the question and the information was recorded by hand. At the end of each interview each respondent was asked for any documentation on the system (ie. user's manual, data collection forms, and/or reports) and if they might be called back to clarify any discrepancies in information.

In addition, visits to CSTIS in Toronto, Ontario and Windsor, Ontario were undertaken to enhance understanding of CSTIS. In both cases, the researcher was shown how the system worked and any available documentation was obtained. Questionnaire 2 was used in a face-to-face interview format, and responses were recorded.

In retrospect, an important limitation of using telephone interviews was that much of the information was taken for granted. In addition, the system documentation received was not always clear and concise, and interpretation and deduction had to be used in some cases.

Of the twenty-two municipalities with CSTIS, thirteen were included in this study. Nine other CSTIS were not included because they did not meet these four basic criteria:

1. The inventory had to be continual and complete. Updating on a regular time interval and the inclusion of all street trees in the area are necessary for application in the City of Winnipeg.
2. The system had to be presently in use. Proposed or partially implemented systems have not proven their reliability in an operational situation, and thus did not warrant further consideration.
3. Each system must have at least 10,000 trees and/or spaces on the inventory. A few CSTIS are small scale projects and do not handle the complexity of information required for an integrated forestry operation.
4. System documentation (ie. user's manual, literature, or copies of reports) had to be available in order to further analyze the system.

The thirteen CSTIS surveyed in this study may or may not represent a statistical sample. Nonetheless, the researcher ended the identification of new systems when the time invested in the search yielded diminishing returns. An information summary on each of the surveyed CSTIS is contained in Appendix D.

2.6 PHASE 5: INFORMATION SYNTHESIS

Phase 2 identified system objectives and the types of information to be retrieved from a CSTIS in the City of Winnipeg. Required and desirable system characteristics were compared to the available characteristics of the surveyed systems. Recommendations were made according to the surveyed system's operational characteristics (ie. what the system could do); however, technical and economic issues were also defined. In addition, availability, capability, expandability, acceptability, and reliability were also important considerations for each system.

Chapter III

COMPONENTS AND USES OF CSTIS

3.1 INTRODUCTION

CSTIS are types of computer-based information systems designed to manage street trees more efficiently and effectively. These systems were first developed more than a decade ago, and were experimentally applied to university campuses and small communities in the United States.

A few progressive communities began to implement CSTIS as software database programs became available. The database programs were created for the specific purpose of managing street trees in each unique community. The majority of these systems were developed using a mainframe computer.

In other cities, urban forest managers were either unaware of or apprehensive about the new technology. There were three reasons for this:

1. a perception about the lack of tangible benefits of CSTIS;
2. a slow transfer of technology between urban centers; and
3. a lack of funding to develop CSTIS.

This latter point has been the most important limiting factor in the development of CSTIS.

Meanwhile, a number of the CSTIS developed on mainframe computers were discarded. Reasons cited were problems in accessing, understanding, and/or updating the data (Smiley and Baker, 1987) as well as lack of funding. The systems were ambitious projects that in retrospect were too complex for their purpose.

Today, the accessibility of microcomputers and the availability of inexpensive general application software database programs has revived interest in CSTIS. New techniques are being developed to computerize inventories for park trees and trees in greenbelts.

3.2 CHARACTERISTICS OF CSTIS

A computerized management information system is a comprehensive computer software system that organizes, stores, retrieves, and updates information in a database. It is a complete set of techniques designed and operated to assist decision making at various levels of management (Sumner, 1986).

CSTIS are forms of computer-based management information systems developed to meet the changing needs of the urban forest agency. Databases of street tree inventory information have become one of the most important and valuable decision making tools in urban forest agencies. Without an organized way of handling information on thousands of trees, effective tree management is difficult (Gerhold and Sacksteder, 1979).

The completion of an urban tree inventory is only one important step of the stages in the management planning process (Lobel, 1983).

After short term objectives and long term goals are defined, a thorough inventory of the urban forest is required. A management plan is then written that outlines the steps required to change the current urban forest to meet the plan's objectives. This is followed by a complete re-inventory of street trees on a continual or periodic basis to document changes that occur as a result of of the plan's implementation. The management plan is then re-evaluated and modified appropriately.

3.2.1 Objectives of Street Tree Inventory Systems

The specific objectives of a street tree inventory system state the type and purpose of information required by the organization (Sacksteder and Gerhold, 1979). As a result, the objectives of different systems vary greatly. Usually, simple inventory systems gather basic tree information such as species numbers and/or condition. At the other end of the spectrum, more comprehensive inventory systems record tree history, organize daily work assignments, and aid in long-term planning.

3.2.2 Types of Street Tree Inventory Systems

There are a number of ways to classify the different types of street tree inventory systems. The following classifications are by no means mutually exclusive; however, they represent categorizations of the essential elements of CSTIS.

3.2.2.1 Periodic vs. Continual

The first classification distinguishes whether collected data are gathered on a continual or periodic basis. In a continual inventory data are collected, updated, and may be retrieved on each individual tree. A card file or computer is used to continually update the database as tree maintenance work is completed. At the same time, other tree characteristic information is updated. New data are continually entered into the system and are accessible in a variety of formats. Furthermore, if data are collected on each tree in the street tree population, then the system is described as a complete (comprehensive) street tree inventory (Thurman, 1983).

On the other hand, a periodic inventory has no provision for updating or retrieval of information on an individual tree basis. Inventory data are collected once, and over time the information becomes outdated. Within five to ten years, the inventory would be conducted again.

In some cases, tree information is collected on a sample of the tree population. These types of inventories are often narrow in scope, and tree location information is not included (Gerhold and Sacksteder, 1979). Proper sampling procedures are suggested by Valentine et al. (1978).

The greatest advantage of the periodic and/or sample type of street tree inventory is low cost. Although the information produced from this type of inventory is not comprehensive, it is probably useful for communities with a shortage of funds, and/or for communities with specific and narrow inventory objectives. On the other hand, continual

and complete street tree inventory systems provide a wide variety of information on most any aspect of a forestry operation, but are very costly to develop and maintain.

3.2.2.2 Computerized Systems

Computerized systems for street tree management may be classified into one of two groups: custom developed or generalized CSTIS. Custom developed CSTIS are designed by individual cities for their own special use, and are not intended for use elsewhere. On the other hand, generalized CSTIS have been developed by private, university, or arboricultural companies. These systems are designed for use in any number of communities, and can be modified to meet the special needs of the forestry agency. In some cases, these programs are designed to be run with general database management software packages. The generalized CSTIS are commercially available.

3.2.3 Data Recording Methods

Various methods have been devised to obtain data on urban trees. Tree information can be gathered from aerial photographs, from moving vehicles, on foot, or by any combination of the three.

Aerial photographs provide many different types of information depending on the needs of the urban forest agency. Theobald et al. (1978) used foliage cover as a measure of the condition of an urban forest. In other cases, aerial photographs have been used to determine the location of trees for a CSTIS (personal communication Robert Maggio).

McQuestion (1979) suggests that tree information be recorded from moving vehicles. Slow moving automobiles with a driver, a recorder, and a tallier could be used to record basic tree data. This approach is most useful when a periodic or sample survey is undertaken.

The kind of detailed information required for a comprehensive management information system can best be obtained by observers on foot (Gerhold et al., 1986). Two to four person crews can measure, assess, and record information on individual trees accurately and efficiently.

3.2.3.1 Personnel and Completion of the Inventory

Although volunteer recording personnel have been used in some instances (Holmes, 1986), only well trained staff should collect data for a street tree inventory system. Limiting data collection errors is an integral part of a successful inventory, and experienced technical staff should collect data to ensure data integrity (Chan and Cartwright, 1979). In addition, the staff should be supervised, properly motivated, and adequately provided with written and illustrated guidelines (Bassett, 1978).

Once the inventory has begun, it should be completed as quickly as possible to maintain the integrity of the data (Chan and Cartwright, 1979). One season, usually mid-summer, is the best time to inventory street trees. Nonetheless, financial constraints often dictate an inventory period of several years.

3.2.3.2 Data Recording Media

Tree information for complete and continual CSTIS can be recorded by inventory personnel in three different ways: tally sheets, "op-scan", and portable data collectors. The choice of recording media should be determined by the efficiency of recording and the methods of processing (Gerhold and Sacksteder, 1979).

Tally sheets record tree information in a tabular format whereby symbols and codes are used to identify the particular phenomenon for each tree. The information is then key-punched into a computer.

In the past, "op-scan" or "mark sense" forms were used to eliminate key-punching. Data are entered by darkening the appropriate spots on the form and this is read by the machine (McQuestion, 1979).

Portable data collectors are a promising method of collecting data on a large number of trees (Cooney, 1985; Semmens, 1978). Data are entered directly onto pre-programmed hand-held computers, and at the end of the day data are transferred onto the main computer.

3.2.4 Data Variables

Data variables refer to the measurements and observations recorded in the inventory. The proper choice of data variables is important when planning an inventory because the kind of information that will be available for management purposes depends on what data are collected. In other words, the type, amount, and quality of information resulting from an inventory are dependent on the variables used (Sacksteder, 1978).

On the other hand, the number of data variables collected in the field should be the minimum number in order to achieve specific inventory objectives (Smiley et al., 1987). This reduces inventory cost, and ensures that all data collected will be used (Gerhold et al, 1986).

Two types of data variables exist: real and coded values. Real values refer to quantitative measurements such as trunk diameter and tree height. On the other hand, coded values refer to inventory information which is qualitative in nature. For example, overall tree condition may be rated on a scale between 1 (poor) and 5 (excellent). The major problems with this type of information is that anyone unfamiliar with the codes must refer to a key to interpret the information, and that it is a subjective method of evaluation. On the other hand, an advantage of coding is that it utilizes very little storage space. For these reasons, Sacksteder (1978) suggests that coded information is essential for some variables, but should be avoided where possible.

Data variables can be grouped into five categories (Gerhold et al., 1986): location of tree(s) or site(s), tree characteristics, site characteristics, actions recommended, and work completed.

3.2.4.1 Location of Tree(s)/Site(s)

There are a number of different techniques available for determining tree location. Location data are one of the most difficult and critical components of the inventory. Trees are planted in a wide variety of situations within the city, and determining an exact location

for a tree is sometimes difficult. Location information must be specific enough so that the tree in question can be located by maintenance personnel. Location gives a "place" for tree management work to be completed. Without individual tree locations, the effectiveness of the inventory would be severely restricted.

A number of different techniques for describing a tree's location have been developed. Sacksteder and Gerhold (1979) list a number of different methods to determine tree location.

area, division, or section number
street name
address, house number, or lot number
block number
distance from intersection
number of nearest utility pole
sequence number, within addresses or within blocks
map coordinates of various kinds
distance from street or curb
tree row number
side of street
tag number
map number
special codes

To ensure accurate tree locations, most CSTIS use a combination of location variables. Property addresses are useful for finding trees quickly, for summarizing trees by street blocks, and for responding to telephone inquires. There are two limitations to this method. First, if there are a number of trees at the same address, each tree would have to be uniquely identified. Secondly, other means of location identification would need to be found where no property address exists.

Various coordinate systems have been used to locate trees (Good, 1978). Usually, grids or co-ordinates are set up on street maps or on aerial photographs to determine distances from reference points.

One of the most promising methods of tree location is the use of computer mapping where location information is digitized. In some cases, maps may be printed as required and handed to maintenance crews. Although there are many benefits to computer mapping, high development and implementation costs are a deterrent to its use.

3.2.4.2 Tree Characteristics

Tree characteristic data describe the tree's physical and condition features. This information may be used to assess the scope and nature of maintenance, protective measures, and other work. Diameter, height, and crown spread may be recorded as absolute values or in classes. Codes for condition, health, and vigor need to be carefully planned before the inventory.

Some types of information collected as tree characteristic data include:

a) Physical Characteristics

- -species and/or cultivar
- -trunk diameter/caliper
- -height
- -crown spread/dimensions

b) Condition Data

- -overall tree condition
- -foliage condition (ex. scale from 0-100% unhealthy)
- -branch condition (ex. twig die-back, crotch split)
- -trunk condition (ex. scale from no injuries/decay to dead)
- -probable cause of injury

3.2.4.3 Site Characteristics

Site characteristics describe the immediate environment surrounding the tree. This description may be either brief or extensive. Information of this nature can aid in selecting suitable species or cultivars, and in planning work such as planting, trimming, or removal of trees.

The data collected on some of these systems include:

- -site class or land use
- -traffic amount
- -planting space dimensions - above/below ground
  - crown spread restriction
  - height restriction
  - length and width
- -presence of utilities (above/below ground)
- -condition of paved walkways
- -quality of landscaping

Other site variables not often used in inventories include (Sacksteder and Gerhold, 1979): street light influence, lot width, drainage, street width, and soil conditions. These are usually of limited use or are not economically feasible to gather.

3.2.4.4 Actions Recommended

Most CSTIS record information on the type of maintenance activity that is required for each tree. Although this may be recorded at the time of the inventory, actions recommended may also originate from citizen or councillor inquires about trees. The tree in question is investigated and a maintenance activity is suggested. Information may be required for planting, trimming, removal, fertilizing, watering, spraying, cabling, bracing, and so on.

3.2.4.5 Work Completed

Information that details specific work completed through a work order or contract can be added to the system which "updates" the actions recommended. Accumulated work completed provides a history of work done to each tree.

3.2.5 Data Processing, Storage, and Retrieval

In a comprehensive CSTIS, inventory data are continually updated and checked for accuracy. Maintenance crews fill out daily reports noting the maintenance activities completed on certain trees. Details of work completed, and tree characteristic data is entered into the computer as required.

Over longer periods of time, perhaps 5-10 years, a complete reinventory may be required (Thurman, 1983). The need for a reinventory, however, will depend on the frequency of change in the tree resource and the accuracy of the data.

Once the tree data is entered into the computer, three forms of information can be retrieved (Thurman, 1983):

1. Information on individual trees such as printouts (tree list) or visual displays of all information on each tree included in the inventory;
2. Summary information such as totals, averages, percentages, two-way contingency tables, cross tabulation of related data variables, and management needs by location; and
3. Graphically displayed information such as histograms, graphs, and maps can be either plotted or displayed on a monitor.

These types of output will be required by a Forestry agency over different time frames. In general, information on individual trees will be required daily by the operations section, specific summary information will be required by middle management, and general summary information will be required by top level management.

3.3 USES OF CSTIS

A database of street tree inventory information can be applied to an unlimited number of management problems. The database can be used for a spectrum of operational and managerial decisions depending upon the needs of the urban forest agency, and the creativity of the manager. From the forest agency's viewpoint, the information retrieved from the system is the essence of the inventory.

There are three important uses and a multitude of special uses of CSTIS (Bassett, 1978; Tate, 1985).

1. Resource Inventory

   An inventory of urban trees provides a record of the resource that the urban forester manages. CSTIS document the current status of the trees and monitor changes in the tree popu-

lation over time. Reports are generated on tree population composition, density, and distribution. The scope and locations of tree problems can be carefully monitored.

2. Budgeting

One of the most important and valuable use of CSTIS is to help develop, analyze, document, and justify budgets. The inventory system can be used to forecast the monetary needs of the department. Accurate predictions of capital and operating costs make it difficult for civic politicians to cut the forestry budget, and may justify an increase in funding.

3. Planning Work

The management of personnel such as scheduling assignments and setting job standards can vastly improve program efficiency. Maintenance crews can be more easily coordinated, and work can be performed on trees more quickly.

4. Special Uses

In addition to these general uses of CSTIS, there are a variety of special uses. A few examples of special uses are:

a) to control tree population density and to ensure species diversity;

b) to manage tree pests and diseases;

c) to evaluate different species or cultivars under different environmental conditions;

d) to monitor vandalism, car-tree collisions, and any other tree injuries;

e) to delineate specific areas of research;

f) to assist in legal matters - the inventory can establish the value of trees in damage claims, and healthy trees will reduce negligence suits;

g) to establish a public relations and education campaign; and

h) to determine the total value of city maintained trees.

Chapter IV

CSTIS NEEDS ASSESSMENT OF THE FORESTRY BRANCH

4.1 INTRODUCTION

A CSTIS needs assessment for the City of Winnipeg Forestry Branch requires an extensive knowledge of the agency's current street tree information system. Organizational charts, manuals, job descriptions, documentation, interviews with personnel, and analysis of past and present programs were used to diagnose the system's present deficiencies, and identify system requirements. Ultimately, the CSTIS needs of the Forestry Branch determine the applicability of the surveyed systems to the City of Winnipeg.

4.2 PAST TREE INVENTORY SYSTEMS

The Forestry Branch has been involved with a number of different types of tree inventory systems. The first survey was performed in the mid-1970's when an inventory of elm trees was undertaken. The objective of this survey was to establish the numbers, identify the relative location, and determine the total dollar value of the elm trees in Winnipeg. The purpose of this one-time survey was to justify the need for a Dutch Elm Disease program.

Another type of tree inventory system was implemented in 1977. The Master Street Tree Plan (M.S.T.P.) was an ambitious attempt to manual-

ly record and update information on Winnipeg's 150,000 street trees. The M.S.T.P. was to form the "heart" of the City's forestry operations. The data were collected on each tree in the succeeding five years.

The information collected on each street tree included tree location (street address, street side), species, condition, height, diameter (dbh), distance from curb, spacing, and a special comments section. Data were recorded for each tree on a separate tally sheet, and each sheet was stored in a filing cabinet according to a logical location sequence. To correspond with this manual filing system, maps of management units were prepared to detail the specific location of each tree.

In retrospect, this system was not used to any great extent. The reasons are clear. First, tree information was not rigorously updated and the data lost accuracy over time. As a result, staff lost confidence in the database. Secondly, information retrieval time was slow. When information on a specific tree was requested by a councillor or citizen, it was difficult for administrative and clerical staff to research a specific tree. Information is required immediately on each individual tree to solve this problem. Thirdly, information was easily lost or misplaced. Fourthly, the mapping system that was to work in tandem with the M.S.T.P. required too much time to complete. Finally, acquiring summary information on any aspect of the tree resource was impossible. In practice, information was cumbersome, inaccurate over time, not adequate for tree management, and not available quickly enough to respond to the public's inquires.

4.3 PRESENT USE OF COMPUTERS AT THE FORESTRY BRANCH

A number of existing information systems are now used by the Forestry Branch in its daily operations. They arose out of a need to have more accurate, accessible, and summary information. Some of these information systems have indirect and direct impacts on the development of a CSTIS. The computer-based information systems that indirectly affect the development of a CSTIS are the general ledger, equipment inventory, and stock inventory programs. The systems that have a direct impact on the development of a CSTIS are as follows.

The "Maintenance Management System" (MMS) is a program developed for the Parks and Recreation Department of which the Forestry Branch is a part. This system is designed to relate the cost of resources used to the amounts and kinds of work performed. An agency's budget and fund allocations can be directly related to work accomplished and not just to funds expended. Currently, the MMS is only used to record number of hours worked by Forestry Branch staff.

Clearly, the possibility of having a more complete MMS interact with the CSTIS would be advantageous. The two systems should be designed so there is no overlap or redundancy between the two systems.

A number of other tree information systems have been recently implemented at the Forestry Branch using dBase III on a microcomputer. Although a number of infrequently used databases exist, there are three large and frequently used databases:

1. The first system records detailed information on the Dutch Elm Disease program. Information is kept on tree location, size, disease symptoms, and maintenance requirements;

2. A second tree information system is designed to keep historical records on tree maintenance activities. The "Daily Worksheet" program keeps a record of pruning, planting, removal, chipping, and stump removal. As maintenance activities are completed, information on the activity, tree location, type, and size, and property type are entered into the database; and

3. A third database records tree planting information such as tree planting requests, location, and species.

To date, there are three problems with these systems. First, field staff do not always record information accurately. Secondly, there is a lack of clerical staff for data entry. Thirdly, tree information is not integrated between these systems. The intention was for these tree information systems to be linked, but the one drawback is the inability to identify specific tree location. As a result, only portions of these databases would be useful to include in a CSTIS for Winnipeg. Moreover, these databases are reactive in nature, recording information only after it has been completed.

Although a proposed CSTIS would not solve the aforementioned problems of data accuracy or lack of clerical staff for data entry, it would integrate these available databases, or portions thereof, into one central tree information system. In general, a CSTIS in Winnipeg should primarily revolve around the types of data variables included in the M.S.T.P. and the Daily Worksheet programs. The ability to record individual tree locations, track individual tree requests, and print individual tree work orders would enable a "live" CSTIS that could be used on a daily basis.

4.4 FUTURE USE OF COMPUTERS AT THE FORESTRY BRANCH

Presently, the City of Winnipeg is investigating a Geographic Information System (G.I.S.) which tracks information on all city roads, utilities, and lands into one system. It is a computerized mapping system that records a specific type of locational information on each "layer". One overlay has been allocated to the Forestry Branch for locating street trees; however, this project is in an experimental stage and is a long term project.

Clearly, the benefits of exact tree location would be advantageous for a CSTIS. Although the future of a G.I.S. is uncertain at this time, compatibility and integration with a CSTIS should be a priority. Depending on the G.I.S. chosen this will be more or less problematic.

4.5 ISSUES AND CONCERNS WITHIN THE ORGANIZATION

In addition to the past and present tree information systems, personnel within the Forestry Branch have indicated a number of concerns:

1. Summary information on trees necessary for making programmed tree maintenance decisions is not available. Little summary information is available for long-term planning (>5 years);
2. Background information on each individual street tree within the city is not available. This information could be used to answer questions from staff, city councillors, and the public; and
3. Information which is necessary to co-ordinate and priorize daily maintenance activities is lacking.

Better information on street trees would facilitate better communication, decrease response time to citizen inquiries, and enable deci-

sions to be made more quickly. At present, there is difficulty in keeping up with the tree maintenance demands requested by the public. In addition, technical staff spend a large amount of their time trying to get tree information organized. Many "snapshot" inventories of designated geographic areas are completed as the need arises.

Improved tree information capabilities would allow for better co-ordination of activities inside the Forestry Branch and with other external agencies (eg. Streets and Transportation or private contractors). Co-ordination would also be enhanced by the eventual integration with a G.I.S.

4.6 A CSTIS FOR THE CITY OF WINNIPEG

4.6.1 Purpose

The purpose of a CSTIS is to provide information for the effective and efficient management of trees within the care and jurisdiction of the City of Winnipeg Forestry Branch. The focus of this system is on the management of street or boulevard trees.

4.6.2 Specific Objectives

The specific objectives of a CSTIS in the City of Winnipeg are:

1. to provide a record of current tree requests, investigations, and outstanding work orders to organize and priorize daily work assignments;
2. to provide summary information on tree maintenance activities and/or on the physical structure of the urban forest for the purpose of short- and long-term planning and budgeting;
3. to provide baseline data and listings of boulevard trees sorted by different variables for compiling working plans, tender

work, and co-ordinating efforts between other related organizations;

4. to create an historical record of maintenance activities at each tree location in order to meet operational and legal requirements;

5. to provide immediate access to information on individual trees to answer public and councillor inquires; and

6. to determine the dollar value of street trees on an individual and collective basis.

4.6.3 Types of Information Retrieved by Objective

The specific CSTIS objectives describe what the system should do or the type of information to be retrieved from a CSTIS. Each CSTIS objective is followed by a general description of the types of information to be retrieved from a system in Winnipeg. This information is separated into required and desirable categories.

Objective 1: to provide a record of current tree requests, investigations, and outstanding work orders to organize and priorize daily work assignments.

Required: The system must be able to record information on individual tree work requests which are generated from within or outside the Forestry Branch. In addition, information on the action taken must be recorded. These reports should be generated for each management unit.

Desirable: A number of additional system features would be desirable. First, information on the requestor's name, address, and phone number would be helpful. Secondly, the ability to generate separate investigation orders for each tree request and record investigator's comments would be useful.

Objective 2: to provide summary information on tree maintenance activities and/or on the physical structure of the urban forest for the purpose of short- and long-term planning and budgeting.

Required: Three different types of summary information should be available by management unit and for the entire city: total amount of work completed for each maintenance activity; number of each species and planting spaces; tabulation by species and general condition, diameter class, and site characteristics.

Desirable: It would be desirable for a CSTIS to generate the following types of information (by management unit and for entire city unless otherwise noted): total amount of work completed by block or street; number of species on each block or street; tabulation by species and specific condition, height class, age class, size (diameter or height) and general or specific condition.

Objective 3: to provide baseline data, printouts, and listings on boulevard trees that can be sorted by different variables for compiling working plans, tender work, and coordinating efforts between other related organizations.

Required: A tree list should describe all trees, locations, and physical and site characteristics. This information should be available for each management unit, and for each block or street. In addition, the database should be able to generate lists that locate trees in a defined area with one or more specific condition, physical characteristic, and/or site characteristic variable.

Objective 4: to create an historical record of maintenance activities at each tree location in order to meet operational and legal requirements.

Required: Information on the history of work completed (ie. completed work orders) for each individual tree must be available.

Objective 5: to provide immediate access to information on individual trees to answer public and councillor inquires.

Required: On-line query ability to request information on a specific tree and provide information on its physical and site characteristics as well as to provide a tree history.

Objective 6: to determine the dollar value of street trees on an individual and collective basis.

Required: The ability to produce a monetary value based on the "Guide for Establishing Values or Trees and other Plants" (1983). determines the value of the tree resource.

4.6.4 Data Variables included for a Proposed CSTIS

The type of information retrieved from each objective suggests the type of data variables to be included in a CSTIS for the City of Winnipeg. The data variables collected for each tree relate directly to the objectives. The amount of information collected will be minimized if this approach is taken (Smiley and Baker, 1987).

Each proposed data variable must be carefully scrutinized to ensure it is useful and relevant to the inventory. This type of philosophy achieves four things.

First, the amount of data collected and entered into the computer will be minimized, thereby reducing project costs.

Secondly, this approach guarantees all data collected will be useful. Only data variables that are most frequently used or are important will be included in the system. Some types of information may have to be sacrificed, and provisions may be needed for special circumstances.

Thirdly, this approach ensures the system is not too complex or cumbersome. Many mainframe systems developed in the early 1970's have been discarded possibly for this reason. Simple and appropriate systems have a greater chance of success in an operational environment (personal communication Willem E. Morsink).

Finally, storage space on the computer and access time to the database will be reduced if the minimum amount of information is recorded. If a microcomputer-based system is under consideration, this is an important limitation (Gerhold et al, 1986).

The data variables collected for a street tree inventory are determined by the system objectives. Like the types of information to be retrieved from each system, the data variables are classified into two categories. Data variables which are <u>required</u> in the CSTIS indicate the minimum amount of information to be included in the database in

order to satisfy the basic needs of the Forestry Branch. The second group of variables contains information which is desirable, but not absolutely required.

This list describes the type of information to be included in a CSTIS. It does not suggest the specific variable designation in a database nor does it suggest file structure.

4.6.5 Required Variables

Location

- district number
- management unit (ward or community)
- street name/code
- house number
- tree sequence number
- side of boulevard or median
- block # or from what street to what street

Tree Characteristics

- species/variety
- diameter
- height
- general condition

Site Characteristics

- distance from curb
- boulevard width
- potential tree planting site

Maintenance Requirements

- date activity completed
- request or regular maintenance activity
- pruning
- planting
  - new or replacement
- removal
  - diseased or hazard
- agent and/or source who carried out activity

4.6.6 Desirable Variables

Location

map location (map number and/or coordinates)

Tree Characteristics
specific conditions
eg. broken branches, amt. of deadwood in crown, trunk damage, etc.

Site Characteristics
relationship to visible utilities:
ex. overhead wires, signs, traffic lights, etc.

Maintenance Requirements

requestor's name, address, and phone #
stump removal
relocation
chipping
other(s)
comment section for investigator's remarks

Others
survey year
survey crew

4.7 SYSTEM CONSTRAINTS

The objective of this study was limited to finding a computer-based tree information system to manage street trees. At this time, specific information from the Dutch Elm Disease program, the MMS, the Development Agreement Log, equipment inventories, stock inventory, and general ledger will not be included on a CSTIS. However, a CSTIS should be flexible enough and adaptable to interact with this type of information at some time in the future.

Moreover, the CSTIS suggested in this study is limited to a system for street trees. It may be desirable in the future to record information on all urban trees, most importantly park and residential trees.

Chapter V

EVALUATION OF SURVEYED CSTIS

5.1 INTRODUCTION

Previous chapters have dealt primarily with the operational requirements of a CSTIS in the City of Winnipeg. This chapter compares the CSTIS objectives (information retrieved) for Winnipeg to the information retrieved from the thirteen surveyed CSTIS, and discusses the general similarities and differences between custom developed and generalized CSTIS. Four alternative approaches to the development of a CSTIS are presented, and technical and operational issues are defined. Candidate systems are reviewed for the alternatives.

5.2 COMPARISON OF SURVEYED CSTIS TO WINNIPEG

Appendices C and D describe many of the operational, technical, and economic characteristics of different systems. The information retrieved from the surveyed CSTIS were compared to the information described in the needs assessment in Chapter 4. Each system was evaluated in terms of the type information required to achieve each specific CSTIS objective for Winnipeg (Table 1). A "dot" is used to denote

TABLE 1

CSTIS Requirements for the City of Winnipeg Forestry Branch

SYSTEM REQUIREMENTS	CUSTOM DEVELOPED SYSTEMS						GENERALIZED SYSTEMS						
	Etobicoke	Oshava	S. Maria	Toronto	Windsor	York	Computree	Iowa P.T.I.	Michigan	TIMS	Tree Manager	TREBASE	Utah
Objective 1: provide a record of tree requests and produce work orders.	●	●	●	●	●	●	●		●	●	●		●
Objective 2: provide summary information of work completed; tabulation of trees general tree and site characteristics.	●		?	●		●	●			●	●	●	●
Objective 3: produce a tree list of all trees (locations and characteristics); generate lists in specific areas by tree and site characteristics.	●	●	●	●	●	●	●	●	●	●	●	●	●
Objective 4: record information on completed tree maintenance activities for each individual tree.	●	●	●	●	●	●	●				●	●	●
Objective 5: on-line query capability to request information on each individual tree and history.	●	●	●	●	●	●	●		●	●	●	●	●
Objective 6: determine tree monetary value on an individual and collective basis.							●		●			●	

TABLE 2

Desirable CSTIS Characteristics

DESIRABLE CHARACTERISTICS	CUSTOM DEVELOPED SYSTEMS						GENERALIZED SYSTEMS						
	Etobicoke	Oshawa	S. Maria	Toronto	Windsor	York	Computree	Iowa P.T.I.	Michigan	TIMS	Tree Manager	TREBASE	Utah
Objective 1: provide information on requestor; generate requests for investigation.	●	●		●	●	●					●		
Objective 2: summary of work requests by block or street; detailed tabulations of tree and site characteristics.	●		●	●	●	●	●		●		●		?

those systems having system requirements similar to a CSTIS in Winnipeg. Similarly, Table 2 describes desirable system characteristics for Objectives 1 and 2. It describes features that are additional to the required features. Objectives 3, 4, 5, and 6 have no desirable system characteristics.

A limitation of Tables 1 and 2 is that some systems are better at fulfilling certain system requirements than others. While these tables show whether or not each system has a certain required or desirable system characteristic, it does not show the range of efficiency of fulfilling a specific system objective. Variability of this nature does exist, and should be qualified before a final decision is made on a CSTIS for Winnipeg.

5.2.1 Summary of CSTIS Evaluation

A number of the surveyed CSTIS have similar system requirements and desirable system characteristics as the City of Winnipeg. Based on the needs assessment completed in Chapter 4, five systems meet most of the needs of the Forestry Branch. Three are custom developed systems - Etobicoke, Toronto, and York, and two are generalized CSTIS - Compu-tree and Tree Manager. Other surveyed CSTIS have similar system characteristics, but are not as applicable as the aforementioned CSTIS.

Further analysis of these five candidate systems follow in Section 5.4. There are other undoubtedly many other CSTIS in North America, and these systems could be considered.

5.3 CUSTOM DEVELOPED VS. GENERALIZED CSTIS

Analysis of the surveyed CSTIS revealed some basic similarities and differences between custom developed and generalized CSTIS in this study. In essence, custom developed CSTIS were developed on mainframe or minicomputers while the generalized programs were developed for microcomputers. Therefore, the difference between custom developed and generalized systems is also a difference of hardware technology on which the systems were developed. There is a strong relationship between the type of computer the system was developed on, software development, and the structure of the system.

The basic principles of database management hold whether dealing with mainframe or microcomputer database systems (McFadden et al., 1985); however, the size of the database which can be supported will vary significantly. CSTIS are similar in a number of ways. Both have the ability to generate work orders, tree histories, and listings by location and maintenance requirements. Similarly, the type of information recorded in the data variables are comparable. In addition, both custom developed and generalized CSTIS have the ability for on-line query and updating.

Custom developed CSTIS differ from generalized CSTIS in the degree of completion of different tasks. First, custom developed systems tend to use a greater number of data variables in more complex systems. For example, a custom developed CSTIS is more likely to record the caller's name, address, and phone number for a tree request compared to a generalized CSTIS.

Secondly, the data variables from generalized CSTIS are more likely to be condensed or coded because storage capacity becomes an important issue on a microcomputer. On the other hand, mainframe systems usually do not code the data variables. This difference may be important when operating the system in a working environment.

Thirdly, custom developed CSTIS tend to be more procedure-oriented than the generalized systems. A tree request is initiated and recorded in the computer, an investigator is sent out and comments are recorded in the computer. Then action is recommended and a work order is prepared and sent to foreman. Finally, work is completed and recorded in the computer. The result is a full documentation of the tree maintenance procedure. In general, custom developed CSTIS keep track of this information better than generalized CSTIS. With generalized CSTIS more work is done manually "behind the scenes."

While the custom developed CSTIS are more able to deal with the tree request/maintenance procedure, there is considerable evidence that the reporting mechanism of generalized CSTIS are more detailed. Specifically, there are more types of reports available to the user especially on tree and site characteristic information. In addition, there is more flexibility with the on-line query capability of generalized CSTIS. Overall generalized CSTIS are more flexible when generating reports and with on-line queries.

Not surprisingly, a number of custom developed systems have special capabilities that generalized CSTIS do not. If a system is designed specifically for a city, then additional capabilities are usually ap-

propriate for their special needs. For example, the CSTIS in Toronto runs a sub-routine which keeps track of permit applications when activities outside the Forestry Branch occur that directly threaten street tree survival (eg. construction activities).

Finally, there is a tendency for mainframe systems to have more terminals available to Forestry staff. Although this capability exists for microcomputer systems, the generalized CSTIS are intended to be "one program - one machine" types of systems. It would be desirable for the City of Winnipeg Forestry Branch to have more than one terminal so that each level in the organization would have access to tree information.

In general, custom developed systems are similar to but not the same as generalized systems. The difference is that the custom developed CSTIS in this study are developed on mainframe or minicomputers while the generalized CSTIS are developed for microcomputers. Mainframe and minicomputer-based systems are more powerful than microcomputer-based systems, and therefore custom developed CSTIS can process, access, and sort information much faster than a microcomputer-based system. Nonetheless, the flexibility and low cost of microcomputers makes them attractive.

5.4 ALTERNATIVES FOR DEVELOPMENT

There are essentially four alternatives the Forestry Branch can pursue in the development of a CSTIS in the City of Winnipeg. These alternatives are based on more than the system's operational capability, and consider general technical and economic issues. Each of the four alternatives is based on either development of software in-house or purchase of system software. Since there are a number of technical issues related to the type of computer used in a CSTIS application, only the important technical concerns will be defined. Specific technical issues are beyond the scope of this study.

5.4.1 Alternative 1 - In-house Development

The first alternative is to develop CSTIS software using the City of Winnipeg Computer Services Department or a private consultant. In-house development on a micro-computer has not been considered because inexpensive generalized CSTIS packages are readily available (Alternative 3).

5.4.1.1 Development on Mainframe Computer

The Computer Services Department has the necessary technical expertise and database management software to develop CSTIS software for the mainframe computer. This alternative would require relatively several long and costly software development phases.

This entire procedure would require between two and four years. The cost of system development (software and hardware) would be ap-

proximately $400,000 although an exact figure is difficult to determine. The cost for system development and operation is provided by the Computer Services Department, and is not charged directly to the Forestry Branch.

There are two major difficulties with this alternative. First, obtaining the appropriate political approval to finance system development would be difficult and time consuming. The other disadvantage with this alternative is that it is the most expensive. On the other hand, the primary advantage is that the end product should exactly satisfy the requirements of the organization.

5.4.1.2 Development on Minicomputer

Another related approach is to develop system software in-house for a minicomputer. A private consultant would most likely be required to develop this type of system. The system could be developed in a much shorter time frame than with the mainframe system, and the cost of system hardware and software development would approximately be between $75,000-100,000.

5.4.2 Alternative 2 - Purchase of Custom Developed Software

The second viable alternative for development is to purchase an existing custom developed software from another municipality. Unfortunately this study did not determine if this software would be compatible with the hardware available in the City of Winnipeg. Similarly, the cost for the software is not known; however, it would probably be less expensive than those suggested in Alternative 1.

From an operational standpoint, Tables 1 and 2 suggest three candidate custom developed systems with similar system requirements and desirable characteristics as the City of Winnipeg. Two of these systems were developed on mainframe computers (Etobicoke and Toronto), and the third was developed on a minicomputer (York).

5.4.2.1 Etobicoke

The CSTIS implemented in Etobicoke meets most of the requirements for a CSTIS in Winnipeg. It also meets all of the desirable system characteristics largely because a "grid" location mechanism generates information by a specific block.

The system generates other information applicable to Winnipeg. These include specific reports on hydro line clearance, storm reports, and vandalism reports. The one apparent drawback of these reports is the lack of summary information on tree and site characteristics.

5.4.2.2 Toronto

The CSTIS in Toronto meets most of the system requirements and desirable characteristics that are required of a system in Winnipeg. The system is based on the Central Property Register (CPR) which determines individual tree location. The CPR is essentially the City's tax roll which is used by a number of departments.

One of the best characteristics of this system is that the entire tree maintenance procedure from initial request, to investigation, to work order is very thorough and complete. Appropriately, reports on tree maintenance activities and planting are detailed.

In addition this system carries out a special task that records and generates reports on permit applications. All activities that affect or threaten street trees are issued a permit by the Forestry Agency. The major weakness of this system is that summary reports on tree and site characteristic information is limited, and information is not available by the block. Since this system is highly integrated with Toronto's other municipal information systems, it is questionable if this software could be useful in the City of Winnipeg.

5.4.2.3 York

The system at York has been developed on a minicomputer and is used with four other major programs in the Parks Department. The reporting system has not been definitely established, and is still being programmed.

The system uses a relatively large number of actions recommended (45) which are very specific to the nature of the maintenance activity. Conversely, there are few data variables used to describe tree and site characteristics, and reports on this type of information would likely be limited in scope. Nonetheless, it meets most of the requirements for a CSTIS in Winnipeg.

5.4.3 Alternative 3 - Purchase a Generalized CSTIS Package

A third alternative for system development is to purchase a generalized CSTIS software package. All of the generalized packages included in this study are used with a microcomputer. If a commercially

available software and hardware were purchased, costs would probably not exceed $20,000.

Analysis of information in Tables 1 and 2 suggest two candidate generalized CSTIS packages included in this study would be applicable in the City of Winnipeg. Both cost approximately $3,000.

5.4.3.1 Computree

This package meets all of the required and most of the desired system features of a CSTIS in Winnipeg. There are two advantages to using this package. First, the system has a very flexible reporting mechanism. Information on most any aspect of the database is available. Secondly, this package is available in Canada.

One disadvantage of this package is that information on the tree requestor's name, address, and phone number is not recorded in the database. Another disadvantage is that information is recorded on the time and cost of each tree maintenance activity which is somewhat desirable but not required in Winnipeg. A user of this package is "locked into" using these variables although they are not required.

5.4.3.2 Tree Manager

This package also satisfies the information retrieval requirements of a CSTIS in Winnipeg except that is does not calculate tree value (Objective 6). On the other hand, this system records information on the requestor for a tree maintenance activity. It also generates an investigation sheet for each tree request complete with a comments

section. There are also a large number of reports that can be generated from the database.

Other than the inability to calculate tree value, a disadvantage of this system is that it records the time and cost of each maintenance activity.

5.4.3.3 Use of a Single Microcomputer

The difficulty with this approach is that at the present state of technology and considering the relatively complex system required in Winnipeg, it is questionable whether a single microcomputer can handle information on Winnipeg's 150,000 street trees. The CSTIS packages included in this study can handle 75,000-80,000 trees quite readily; however, larger databases would test the storage capacity and access time to the database (personal communication Thomas Smiley; Gerhold et al., 1986).

More technical information is required before one of these packages is purchased. Nonetheless, if this constraint is genuine, two options are still available.

5.4.3.4 Use of a Number of Microcomputers

Another option would be to adopt a system similar to that of Los Angeles County (personal communication Thomas Smiley). In this case, a number of microcomputers using generalized CSTIS software were used to manage 300,000 trees. Each microcomputer presided over a management unit comprised of approximately 50,000 trees. A similar type of situ-

ation could be considered in Winnipeg because there are three basic management districts with approximately the same number of trees in each district.

5.4.3.5 Use of a Microcomputer with Fewer Data Variables

This option suggests the number of data variables in the information system be reduced resulting in a more simplestic information system. The major problem with this type of development is that if fewer variables are collected then less managerial information will be available for reports and listings. In other words, the system would not meet all the system requirements.

For example, if information on tree history (ie. completed tree maintenance activities) were not collected, then the size and complexity of the information system would not increase over time.

Regardless, if these types of information were not collected or recorded, then system integrity would be partially lost.

5.4.3.6 Purchasing a Generalized CSTIS Package

If purchasing a commercially available CSTIS package is the only alternative available, then the following information is required:

1. letters of reference should be requested from other cities using the system to ensure no recent problems have arisen.
2. candidate CSTIS vendors should be contacted to discuss the possibility of a software trial or demonstration diskette for further evaluation.
3. software support arrangements and software improvement/enhancement should be determined.

5.4.4 Alternative 4 - Phased Combination

The final viable alternative involves a combination of the aforementioned alternatives. If a CSTIS is required immediately, a generalized CSTIS package might be purchased. This would be done with the intention in the long term of developing a program on the mainframe computer and uploading the information from one system to the other. Unfortunately, uploading information is difficult and software conversion is not always possible because of differences in compilers, operating systems, and hardware environments unless the software has been designed at the outset for both machines (personal communication David Forrest). The prospects to develop this alternative are better if microcomputer software was originally developed in-house with eventual software development on the mainframe already in mind; however, this can be an expensive undertaking.

This alternative is desirable for two reasons. First, it would determine if the microcomputer system is workable in the Forestry Branch environment. Secondly, the system could be implemented in the short term without having to wait for software development on the mainframe.

The major problems with this approach is that it involves some policy decisions on the part of the City of Winnipeg's Computer Services Department, and that in the long term this alternative would likely be the most expensive to develop.

5.4.5 Summary of Alternatives

These four alternatives outline a classic software issue to either "make" or "purchase" system software. Both the first and fourth alternative require in-house development by the City of Winnipeg Computer Services Department or by a private consultant. The second and third alternatives imply that a custom developed or generalized CSTIS package be purchased from another municipality or a vendor.

The in-house development required of Alternative 1 or Alternative 4 would result in several long and costly development phases. Specifically, needs analysis, specification of the system, programming, testing, documentation, training and implementation would be required. The benefit of this approach is that the end product would exactly satisfy the requirements of the organization.

In the case of Alternative 1, development on the mainframe is costly and requires political approval to finance development. On the other hand, the development of a CSTIS using a minicomputer would enable a system to be designed that has the power of a mainframe, but would require about 20% of the cost of a mainframe system. The implementation of Alternative 1 would have the highest probability of success.

In the case of Alternative 4, development may not be technically or economically feasible. It would be difficult and/or costly to upload information from a generalized CSTIS package to a mainframe system. In the long run this alternative would likely cost as much if not more than in-house development on the City's mainframe computer (ie. Alternative 1).

The other direction to follow is to purchase a custom developed or generalized CSTIS package (ie. Alternatives 2 and 3). In general, this approach is inexpensive and expedient. Nonetheless, purchase still implies needs analysis, evaluation of alternatives, selection and purchase, possible modifications, staff training, and implementation. Of special note is that modifications to software may or may not be possible. If modifications are possible then other questions arise such as the responsibility, extent, cost, and implementation time for the changes. Compromises in the system may be required if either Alternatives 2 or 3 is implemented.

It is difficult to make a specific recommendation about Alternative 2 because this study did not determine if the CSTIS software from Etobicoke, Toronto, or York is technically compatible with the computer environment in the City of Winnipeg. Moreover, these systems may not be commercially for sale to other municipalities. Therefore, it is assumed these systems are not readily available, and more information is required before any decision is made.

From a technical perspective the development of a CSTIS under Alternative 3 is not guaranteed success using a single microcomputer. Issues of capacity, expandability, and access time to the database should be addressed more specifically. Similarly, reducing the number of data variables in the computer system is not desirable because of the sacrifices in the managerial information retrieved from the system. On the other hand, a system that uses a number of microcomputers may have better prospects for development if a generalized CSTIS package is purchased.

Chapter VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 SUMMARY

Trees in our urban environment provide many direct and indirect benefits and their perpetuation requires specialized tree management. Efficient tree management requires detailed information on the street tree population.

A Computerized Street Tree Inventory System (CSTIS) implemented at the City of Winnipeg Forestry Branch can potentially accomplish two basic purposes. First, a CSTIS may increase efficiency by enhancing the ability to complete more tree maintenance work in the same amount of time compared to before the system was implemented. Secondly, the system can increase effectiveness by providing "instant" information on any street tree to answer citizen, councillor, and staff inquiries.

A CSTIS in Winnipeg requires two basic characteristics. First, it should be complete - each individual street tree within the jurisdiction of the Forestry Branch should be included. Secondly, the CSTIS should be continual - as work is completed on the trees, tree information should be continually updated ensuring database integrity. With this type of system, each individual tree would be accounted for.

A complete re-inventory of all street trees in the city would have to be conducted before such a system is successfully implemented.

A CSTIS in the City of Winnipeg requires a relatively complex system that generates information on individual and tabulations of tree and site characteristics as well as on required and completed tree maintenance activities.

6.2 CONCLUSIONS

1. Although customized CSTIS continue to be developed for specific cities, a growing number of generalized CSTIS software packages are commercially available for use in any municipality. In general, the custom developed CSTIS are designed in-house on mainframe or minicomputers, while generalized CSTIS packages are developed for use with microcomputers.

2. Custom developed and generalized CSTIS have the same basic purposes. CSTIS combine a tree inventory with tree maintenance operations to efficiently and effectively manage the tree resource. However, the custom developed CSTIS differ in scope with their generalized CSTIS counterparts. Custom developed (mainframe and minicomputer) systems are more powerful than microcomputer-based systems. Custom developed software is more complex, uses more data variables, codes less information, and usually have a number of special uses. In addition, custom developed systems are more formalized and detailed when it comes to the tree request/ investigation/actions recommended/work completed procedure. On the other hand, generalized CSTIS packages are inexpensive to purchase, and have more flexible reporting and query facilities.

3. The City of Winnipeg requires a relatively complex CSTIS that can generate information on individual trees, work orders, tree histories, and a variety of summaries and listings.

4. Five of the thirteen CSTIS included in this study meet most of the operational requirements of a CSTIS in the City of Winnipeg. These include the three custom developed systems in the municipalities of Etobicoke, Toronto, and York. The other two systems are generalized packages for the microcomputer - Computree and Tree Manager.

5. Although a number of mainframe CSTIS contain 150,000 trees, no microcomputer-based systems encountered have contained this number. Though the capability to store 150,000 trees may exist

for a microcomputer, continually expanding tree history information and processing time for such a large database may be prohibitive. Mainframe and minicomputer systems appear more appropriate to handle the large database required for Winnipeg's street trees.

6.3 RECOMMENDATIONS

Before any recommendation is made, it is important to remember advances in computer hardware are so frequent that any recommendation should be put in perspective. A system chosen in the short term will likely use different computer hardware than a system developed in the long term. As a result, the recommendation that follows assumes a system will be chosen in the short term.

Based on the information available, I would recommend that CSTIS software be developed in-house on a mainframe or minicomputer. This decision is based on my belief the probability for system success is greater compared to the other alternatives. Although the most expensive, the system would be powerful enough as well as specifically designed to meet the needs of the Forestry Branch.

Nonetheless, generalized CSTIS packages cannot be completely discounted because these systems are inexpensive, and meet the operational needs of a CSTIS in Winnipeg. The prospects appear to be much better if a number of microcomputers were to be used with a CSTIS package instead of just one microcomputer. Regardless, microcomputers will undoubtedly become more powerful and better able to cope with the large and relatively complex database suggested in this project. More research is required on system response time and performance issues of

the generalized CSTIS packages detailed in this study (ie. Computree and Tree Manager).

In addition, purchase of custom developed software from Etobicoke, Toronto, or York was not determined in this study and could be considered.

6.4 EPILOGUE AND AREAS OF FURTHER RESEARCH

This practicum is intended as a functional planning document for the implementation of a CSTIS for the City of Winnipeg Forestry Branch. While this document suggests general operational requirements of a CSTIS in Winnipeg, it does not detail the important technical and economic issues of each alternative. This study has only viewed thirteen CSTIS and other systems could be considered.

Before any system is developed or purchased, three areas need to be further researched. First, the specific needs of the Forestry Branch should be defined in terms of specific reports and computer screens. Secondly, more research is needed on the technical and economic aspects of system hardware and software requirements. Thirdly, an implementation study should be completed to ensure a rational and systematic approach to the tree inventory procedure.

It is very important to remember that system success is not solely determined by obtaining or developing the appropriate system software and hardware. A much greater commitment is required to achieve success. The initial inventory activity and database creation will determine the utility and acceptance of the system. Moreover,

rigorous updating of the database will be required throughout the operational life of the system to ensure data integrity and reliability.

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Forrest, David. Agassiz Systems Research and Technology Ltd., Toronto, Ontatio.

Maggio, Robert. Professor of Forestry, Texas A+M University, Texas.

Morsink, Willem E. Superintendent of Forestry, Toronto.

Smiley, E. Thomas. East Coast Regional Manager, ACRT Inc.

Appendix A

INTERVIEW SCHEDULE FOR NEEDS ASSESSMENT

A.1 ALL RESPONDENTS

A.1.1 Identification

1. Your name is _____
2. Your job title is _____
3. How long have you been at your present job? _____

A.1.2 Organization and Activities

1. What are your general functions and responsibilities at the Forestry Branch?
2. What contact do you have with other organizations, such as other City of Winnipeg branches and departments, with provincial or federal government departments, or with private firms?
3. What is the nature of these contacts? How often?
4. Do you rely on information from any of those organizations to perform your functions?
5. Do you provide any information to these organizations in the course of performing your functions? What use do they make of this information?
6. What are the most important objectives of the Forestry Branch, from your point of view?
7. Is the availability of information important in achieving these objectives?
8. In your view, how adequate is this information now?
9. What are the major issues facing the Branch today?

10. What activities do you perform on a periodic basis?

11. How many people do you supervise and what do they do?

A.1.3 Present Information Requirements

1. What reports, manual or computer-generated, do you generally receive from within the Forestry Branch and from other organizations? (Can you provide a copy?) How often do you receive these reports?

2. Do you generate any information or reports, who receives them, and how is that information used? (Can you provide a copy?) How often do you generate these reports?

3. Is there any other information that you use other than from the sources already mentioned?

4. Is the information you receive complete, timely, and accurate? If not, what changes would you suggest to make this information more useful?

5. What kind of information that you are not receiving now would help you to perform your job better?

A.1.4 Future Information Requirements

1. Do you foresee any changes in your functions at the Forestry Branch, e.g. new programs which may have associated information requirements?

2. Within the general confines of your job description, are there any additional activities you could usefully perform if you had appropriate information?

3. Are you familiar with the Master Street Tree Plan, the MSTP?
___yes ___no

   (if yes, then ask next question)

4. If you were a new employee at the Forestry Branch, do you think the existing street tree inventory could be easily accessed?
___yes ___no If no, why?

A.2 CONTINUE FOR SELECTED INDIVIDUALS (I)

1. Do you use the existing street tree inventory system? If so, can you briefly describe how you use it? How often?

2. In your opinion, is this information easy to access? Why or why not? ___yes ___no

3. What are the advantages of the current system?

4. What are its disadvantages?

5. Have you ever wanted information from this system that you were unable to obtain?

6. How could it be improved?

7. Ideally, what information would you keep on every tree?

A.3 CONTINUE FOR SELECTED INDIVIDUALS (II)

Please comment on the following scenarios. Have you ever considered using a CSTIS for:

1. historical information could be kept on individual trees, showing Branch activity (perhaps major activity) for that tree over time?

2. crew scheduling could perhaps be accomplished as part of a CSTIS?

3. persuasive accurate budgets could be better prepared with the help of a CSTIS?

4. assistance in legal matters?

5. monitor vandalism/car collisions?

6. evaluate different species/cultivars?

7. manage pests and diseases?

8. public relations/education?

9. assess total value of city's trees?

10. any other uses for a CSTIS that you can think of?

Appendix B

TELEPHONE QUESTIONNAIRE OF CSTIS

1. Name of municipality where CSTIS is located?
2. In what year was this system implemented?
3. What are the primary objectives (or purpose) of this inventory?
4. How many street trees and spaces are included on the inventory?
5. What type of computer does this system use?

   a) ___ mainframe computer

   b) ___ minicomputer

   c) ___ microcomputer

   d) ___ other (please describe)

B.1 BACKGROUND INFORMATION

1. What is the make (and model) of this computer?
2. The computer software used in this system was:

   a) ___ developed in-house (ie. by a municipally-connected agency).

   b) ___ developed by a private consultant.

   c) ___ an existing general applications program.
   If yes, name of program?

   d) ___ a general system purchased for the specific purpose of street tree management.

   e) ___ other (please describe)

B.2 SYSTEM OPERATIONAL INFORMATION

1. How frequently is this system used?
2. Does it use on-line and/or batch processing?
3. Is it accessible to all agency personnel (ie. multi-user)?

B.3 DATA VARIABLES AND INFORMATION RETRIEVAL

1. What are the data variables used in this system?
2. What information is retrieved from this system?

B.4 SYSTEM COST

1. What costs were involved in developing and implementing this system?

B.5 RECOMMENDATIONS

1. What are the greatest problems with this system?
2. In what ways might it be improved?
3. Do you know of any other cities using CSTIS?
4. Could you please send any system documentation (ie. user's manual, reports, inventory forms, and so on)?

Appendix C

SYSTEM REVIEW AND ASSESSMENT

C.1 IDENTIFICATION AND COMPARISON OF CSTIS

For ease of comparison, the CSTIS included in this study were separated into two main groups based on their origin of development (Table 3). Custom developed CSTIS were developed by the city for their own use, while generalized CSTIS refer to those systems which are developed for use in any municipality with the appropriate modifications.

The criteria developed to assess and compare each system were separated into two categories: background information (Tables 4 and 5) and information retrieval (Table 6).

C.2 BACKGROUND INFORMATION

C.2.1 Background Information on Custom Developed CSTIS

The purpose of describing the background information for each of the surveyed systems is to establish basic operational and technical requirements. Table 4 describes the basic system characteristics for each of the custom-developed CSTIS.

C.2.2 Background Information on Generalized CSTIS

The background information for generalized CSTIS was similar, but not the same as for the custom developed CSTIS (Table 5).

TABLE 3

CSTIS Surveyed

Custom Developed CSTIS

System Location	System Abbreviation
Etobicoke, Ontario	Etobicoke
Oshawa, Ontario	Oshawa
Santa Maria, California	S. Maria
Toronto, Ontario	Toronto
Windsor, Ontario	Windsor
York, Ontario	York

Generalized CSTIS

System Name	System Abbreviation
Computree	Computree
Iowa Public Tree Inventory	Iowa P.T.I.
Michigan Tree Inventory	Michigan
Tree Information Management System	TIMS
Tree Manager	Tree Manager
TREBASE	TREBASE
Utah Tree Inventory	Utah

TABLE 4

Background Information on Custom Developed CSTIS

system name	computer type[1]	make[2]	development[3]	yrs. in operation[4]	# of trees and/or spaces[5]	type of tree[6]
Etobicoke	mainfr.	Sperry	in-house	5	140,000	street
Oshawa	mainfr.	?	in-house	2	18,000	street, park
S. Maria	minico.	HP-3000	consultant	<1	16,000	street
Toronto	mainfr.	Amdahl	in-house	5	165,000	street, park
Windsor	mainfr.	Sperry	in-house	2.5	60,000	street
York	minico.	Mentor 3000	consultant	<1	30,000	street

[1] The hardware used for system development was a mainframe computer (mainfr.), minicomputer (minico.), or a microcomputer (micro.).

[2] The specific type of computer the system was developed on.

[3] The systems were developed in-house by the computer services division or by an independant consultant.

[4] The length of time the CSTIS has been in operation.

[5] The number of tree records (ie. trees and tree spaces) that the system contains.

[6] Many of the systems available handle park and greenbelt trees as well as street trees.

TABLE 5

Background Information on Generalized CSTIS

system name	computer type[1]	make[2]	# of cities[3]	tree type[4]	# of tree records[5]		other software required[6]	cost[7] ($ U.S.)
					hard	floppy		
Computree	micro.	IBM	>5	street, park	66,000	1800	File Pro 16	$2,950 (Cdn.)
Iowa P.T.I.	mainfr.	?	3	street,park, greenbelt	n/a	n/a	n/a	free
Michigan	micro.	IBM	1	street	75,000	2500	none	$300
TIMS	micro.	IBM	1	street,park, parkway	n/a	10,000	any data base pkg.	$3,000
Tree Manager	micro.	IBM	>6	street, park	50,000	1300	dBase III	$3,500
TREBASE	micro.	IBM	>11	street, park	?	4000	dBase III	$175
Utah	micro.	IBM	1	street, park	66,000	6800	none	$100

[1] The hardware used for system development was a mainframe (mainfr.), minicomputer (minico.), or a microcomputer (micro.).

[2] The type of microcomputer the system operates on.

[3] The number of cities or municipalities that are currently using the program.

[4] Many of the programs available are capable of handling park and greenbelt trees as well as street trees.

[5] The number of tree records that can be stored on a 10 megabyte hard disk and on one single floppy diskette.

[6] Not including the operating system, what additional software is required?

[7] Lists the cost of the software program (in U.S. dollars unless otherwise noted).

C.3 TYPES OF INFORMATION RETRIEVED

A critical component of CSTIS is the type of information output by the system. Comparison of the specific types of information retrieved from CSTIS is difficult because of the variability in output formats that are available. Appendix D lists as closely as possible the specific types of output available from each surveyed system.

To compare the information retrieved from the surveyed CSTIS, four categories of output were defined (Table 6):

1. Work orders refer to work requests for tree maintenance activities which are entered into the computer system at time of inquiry. These may be generated by the individual tree, by the block (street), and/or by the zone (management unit, district).

2. Tree history describes the record of past maintenance activities completed on a tree(s). This may be available by individual tree, by block (street), or by the zone (management unit, district).

3. Summary information or reports from the CSTIS may be available by:

   a) inventory - individual or combinations of tree and site characteristic variables.

   b) work orders - a summary of current work requests, by nature of activity.

   c) Tree history - a summary of the type of work completed on each street tree.

4. Tree listings may be available by:

   a) location and tree and/or site characteristic information.

   b) maintenance requirements - listed by location (and requirement).

TABLE 6

Types of Information Retrieved from Custom Developed and Generalized CSTIS

system name	work order generated by:			tree history record by:			summaries by:			tree listings by:	
	tree	block	zone	tree	block	zone	inventory	work order	tree history	location	maint. req.
Etobicoke	X	X	X	X		X	X	X	X	X	X
Oshawa	X	X	X	X	X	X		X	X	X	X
S. Maria	X	X	X	X	X	X	X	X	X	X	X
Toronto	X		X	X		X	X	X	X	X	X
Windsor	X		X	X		X	X	X		X	
York	X		X	X		X	X	X	X	X	X
Computree	X	X	X	X	X	X	X	X	X	X	X
Iowa							X			X	X
Michigan	X	X	X				X			X	X
TIMS	X	X	?		X	?	X			X	X
Tree Manager	X	X	X	X		X	X	X	X	X	X
TREBASE				X	X	X	X		X	X	X
Utah	X	X	?	X	X	?	X			X	X

Appendix D

SYSTEM PROFILES

D.1 KEY TO SYSTEM STUDY

After stating the location of the system, the following criteria were used to compare different CSTIS:

1. DEVELOPMENT: How was the system developed, and on what type of computer? The make of the computer is included if available.

2. STATUS: What is the current stage of system development?

3. SCOPE: What is the number of trees and/or tree spaces on the inventory? Is the inventory complete and/or partial? What types of trees are included?

4. PURPOSE: What is the system used for?

5. DATA VARIABLES: What are the data variables or information input into the system? For comparison, these variables are separated into the following categories: location, tree characteristics, site characteristics, action recommended, and work completed. Variables that do not fit into any one of these categories are referred to as "other". When available the variable will be followed by a discrete value (code) or quantitative value (class) in parenthesis. An "(unstructured)" data variable refers to information that is entered into the system in any desired manner.

6. INFORMATION RETRIEVAL: What type of information is obtained or output from the system, and may describe how is it used?

7. SYSTEM USE: What is the frequency of system use? Is it a multi-terminal environment? Does it use on-line or batch processing? What is the frequency of information updating?

8. COSTS: What are the costs of this system? Any available cost figures are included, however, they are generally not comparable because costs are calculated under different circumstances and over various time periods.

9. COMMENTS: This is a unstructured category that describes unique or noteworthy aspects of each of the systems. Notes on program routines, subroutines, and file structure are made, and the relative advantages of the system may be described.

10. LIMITATIONS: To date, what problems have been encountered with the system? What are the obvious limitations of each system?

D.2 PROFILES OF SPECIFIC SYSTEMS

D.2.1 Etobicoke, Ontario

1. DEVELOPMENT: In-house by computer services division on a mainframe (Sperry).

2. STATUS: The system was implemented in January 1982.

3. SCOPE: Information is stored on approximately 140,000 street trees and tree spaces.

4. PURPOSE: To provide an accurate up-to-date inventory of municipal trees at each address and to show relevant work for each tree that is either completed or outstanding.

5. DATA VARIABLES: resident's - name, home and business phone, owner or tenant, city, postal code.

   a) LOCATION: grid number, street name, house number, cross street, street leg, tree number, position of tree (unstructured), distance from curb.

   b) TREE CHARACTERISTICS: species or variety, height, diameter, general condition.

   c) SITE CHARACTERISTICS: ownership (ex. city or private), road allowance width.

   d) ACTIONS RECOMMENDED: work order number; all maintenance activities are coded and include pruning, planting, removals, lifting, spraying, stumping, storm damage, vandalism, rodding, drain instalation, and seeding.

   e) WORK COMPLETED: as "actions recommended" are completed, then the date and coded action for each maintenance activity is recorded.

6. INFORMATION RETRIEVAL:

   Besides providing instant information on any one or group of trees, eleven different reports are by this system.

   a) planting lists for street trees, subdivisions, and accidents.
   b) storm report to assess damage from a storm.
   c) daily work allotment - lists by date and grid for work outstanding.
   d) outstanding rodding, drain installation, and seeding.
   e) spray lists - either fungicide or dormant oil.
   f) hydro 3-wire - information sent to Hydro for special service.
   g) by-law report - addresses where by-laws have been contravened.

h) vandalism report - by area.
i) inclement weather work - addresses where work can be completed.
j) species report - listing by area of a specific species.
k) yearly summaries for pruning, lifting, and removals.

7. SYSTEM USE: The multi-terminal system is used daily within the Forestry agency, and uses on-line processing. Information is updated regularly.

8. COSTS: Information not known.

9. COMMENTS: This is a relatively complex information system that emphasises the tree maintenance procedure. When a tree problem arises, a maximum six step maintenance procedure is possible over time.

   The system's structure includes three main files - address information, tree listings, and work order information. Different combinations of this information provide the reports for the system.

10. LIMITATIONS: Errors arose from improper data collection and from key-punching errors.

D.2.2 Oshawa, Ontario

1. DEVELOPMENT: In-house by Information and Computer Services Division on a mainframe computer.

2. STATUS: Implemented in 1985.

3. SCOPE: Information is include on approximately 18,000 trees. It is a complete inventory of all city-owned trees on boulevards and parks.

4. PURPOSE: To co-ordinate the maintenance and planning of municipally-owned trees.

5. DATA VARIABLES: work order number, initiated by city or resident (if the latter then include name, phone number, and date of call).

   a) LOCATION: street or park, zone (district), street (park) name, house number, tree sequence number.

   b) TREE CHARACTERISTICS: species code, diameter, height, tree condition (18 codes).

c) SITE CHARACTERISTICS: site condition (7 codes).

d) ACTIONS RECOMMENDED: work order number, inspection required, inspection date, comments, planting, pruning, spraying, fertilizing, removal, stumping, replacement, other; expected date of action.

e) WORK COMPLETED: for each "action recommended," the action, date, and comments are entered into the system.

6. INFORMATION RETRIEVAL: Other than on-line query, six different types of reports can be generated by this program.

a) list of trees to be pruned or sprayed.
b) boulevard or park trees to be removed, planted, replaced, stumped.
c) tree inventory edit report - lists details of each transaction and indicates if update is successful.
d) tree history profile - gives history of a tree or a number of trees (dates, comments, work performed).
e) tree location list - alphabetically by street or park, all trees on street or park by species, and selected comments.
f) work order details report - individual work orders showing type of work performed and a list of trees worked on under the work order number.

7. SYSTEM USE: The system is used daily by Forestry agency personnel. It uses both on-line and batch processing, and information is updated daily.

8. COST: The program cost approximately $3,000 to develop, and the inventory cost $15,000 to complete.

9. COMMENTS: In general, this system appears simpler than similar systems. There are two main files in this database. First, the Tree Master File consists of the description, size, species, and dates of work done of to be done on each tree. Secondly, the Forestry Work Orders subfile, contains information on all work orders that initiate work or inspections of trees. Over time this results in a detailed work history for each tree. The two files are cross-referenced making it possible to access the files by tree identification or work order number.

10. LIMITATIONS: Initially, the inventory had to be done over again because of the number of errors in the information. Another problem was to motivate staff members to record their work on the input forms.

D.2.3 Santa Maria, California

1. DEVELOPMENT: By a private consultant on a minicomputer (HP-3000).

2. STATUS: Fully operational in 1987 although it has been working to a limited extent over the last three years. Historical data from the past 20 years is still being keypunched into the computer. A number of changes and additions are still occurring.

3. SCOPE: Information is provided on all 16,000 street trees.

4. PURPOSE: To provide information for street tree planning and maintenance.

5. DATA VARIABLES:

   a) LOCATION: street address; frontage or off-frontage, median, or empty lot; the street the tree is located on if it is off-frontage; tree sequence number.

   b) TREE CHARACTERISTICS: species or variety code, diameter, general condition (4 codes), planting date, hazards (5 codes), management information (6 codes).

   c) SITE CHARACTERISTICS: deep well, surface planting, or parkway; parkway width; property type (4 classes); wires present (3 codes); easement width; stumbling block; tree space; illegal planting.

   d) ACTIONS RECOMMENDED: scheduled or requested maintenance, request number, maintenance required (54 different codes including inspection requests and a variety of tree maintenance activities).

   e) WORK COMPLETED: date, amount of hours required for activity, remarks (unstructured).

6. INFORMATION RETRIEVAL: A number of different listings, reports, and summaries are available, and are still being developed. Information on tree histories and work requests is kept.

7. SYSTEM USE: The system is used on a daily basis, and information is available from a number of terminals. The system uses on-line processing and information is updated regularly.

8. COSTS: Information not available.

9. COMMENTS: The proposed changes and additions to this system will permit more information generation capacity requiring as little new information as possible. The changes ensure a more efficiently operating database.

Additional capabilities of this system include the ability to separate scheduled maintenance activities and requested maintenance, and a cost tracking ability for each maintenance activity.

The manager expects to save 15% of the operations budget by using this system.

10. LIMITATIONS: The proposed changes and additions to this system will solve many of the problems encountered thus far.

D.2.4 Toronto, Ontario

1. DEVELOPMENT: In-house by computer services division on mainframe computer (Amdahl).

2. STATUS: The inventory completed in 1978, and system was implemented in 1982. Revisions to the program are currently under way.

3. SCOPE: Information on approximately 90,000 trees and 75,000 tree spaces were recorded for the Metro-Toronto area. It is a complete inventory of all street and park trees.

4. PURPOSE: Information provided for the management and planning of all trees within the jurisdiction of the Forestry agency.

5. DATA VARIABLES: In addition to the variables found below, this system also keeps track of activities within the city that involve municipal trees. This information includes permit application number, file number, inspector's name and report, letter and attachment number, letter sent and received, and procedure completion date.

   Other information is kept on the requestor's name and phone number; inspector's name, date completed, and comments; foreman's name, truck number, and date completed.

   a) TREE LOCATION: All tree locations are tied into the Central Property Register (similar to tax roll); district, street code, street name, house number, tree sequence number.

   b) TREE CHARACTERISTICS: species/variety, diameter, general condition (3 codes - dead, hazard, or diseased).

   c) SITE CHARACTERISTICS: property type (5 classes), planting location, planting comments (unstructured).

   d) ACTIONS RECOMMENDED: general prune, spray, storm break, inspection required, general and specific comments on trees (unstructured), tree to be planted, tree to be removed, re-

location, work order number, action approved by council; Other information is kept on the requestor's name and phone number; inspector's name, date, and comments; foreman's name, truck number, and date.

e) WORK COMPLETED: each completed action is dated and stored - general prune, spray, storm break, tree planted, tree removed, tree relocation, paid, and general and specific comments for each tree (unstructured).

6. INFORMATION RETRIEVAL: Produces a listing of specific trees, work orders, and permit applications at request. A number of set reports is also available for a given time period. First, the total number of trees by address, by tree species, by property type, and by tree status is available. Secondly, lists of trees to be planted, removed, outstanding work orders, and outstanding permit applications can be determined. Thirdly, summary reports of service orders by action completed (removals, planting, pruning, and so on), tree removal notifications to alderman, and audit trails for various routines is accessible.

7. SYSTEM USE: This system is used and updated daily. A total of four terminals is available, and updating is on-line while reports are generated in batch.

8. COST: No information was available because the system was developed over a number of years, and the actual cost is difficult to determine.

9. COMMENTS: This system is relatively complex and procedural in nature, and is designed specifically to meet the needs of the Forestry agency. The tree inventory is only a small part of an overall system for municipal management.

   The tree inventory has four major subroutines. First, the planting data routine contains information on the trees - location, type, and status. Secondly, service order subroutine keeps track of all private and public tree inquires (four stages - initial request, inspection, work order, and action taken). Thirdly, the permit application subroutine keeps data on activities (ex. construction) where public tree survival is at risk. Fourthly, the reporting subroutine produces all summary information on the system.

   This system emphasizes public and private inquires about trees, and the procedure involved with inspections, actions recommended, and work completed. While simple tree and site characteristic data was collected, very specific information is collected on inspections, work orders, and actions completed.

10. LIMITATIONS: There were many data collection errors in the initial survey.

The director remarked (in retrospect) that if he knew a tree inventory system cost as much as it did, then the system would not have likely been developed.

D.2.5 Windsor, Ontario

1. DEVELOPMENT: In-house by municipal computer services division and the urban forest manager on mainframe computer (Sperry).

2. STATUS: Implemented in January 1985.

3. SCOPE: Information on approximately 60,000 trees and tree spaces was recorded; complete inventory of all trees on street rights-of-way within municipality.

4. PURPOSE: Information provided for the management and planning of street trees.

5. DATA VARIABLES: survey year, origin year (tree age).

   a) TREE LOCATION: tax roll number (map, sub, parcel, and tenant numbers), street number, street name, tree sequence number.

   b) TREE CHARACTERISTICS: species code, diameter, height, condition code (4).

   c) SITE CHARACTERISTICS: tree distance from curb.

   d) ACTIONS RECOMMENDED: date, work requested (unstructured), complainant's name, phone number.

   e) WORK COMPLETED: date, work performed (unstructured)

6. INFORMATION RETRIEVAL: Frequently generated reports include a tree list with information on each tree (address, species, diameter, height, condition, origin year and survey year), and a tree work order history for each tree. Other reports include summaries of planting sites, species and age class composition, a prediction of the number of trees in each age class in the future, and planting lists.

7. SYSTEM USE: The system is used daily by all Forestry Branch personnel, and information is accessible from two terminals within the Parks offices. It uses on-line processing, and information is updated daily.

8. COST: Some approximate costs include: design - $20,000; programmer - $12,000; survey personnel - $20,000; keying in data - $9,000; terminals - $2,000. The Branch is not directly charged for the use of the mainframe system.

9. COMMENTS: An interesting aspect of this system is its unique file structure. It uses a "split screen" approach whereby the basic tree inventory is kept in one file, while another relational file can be requested that gives the tree work history for each tree in the first file.

   When a tree complaint or request is initiated, a printed sheet with the tree inventory information, the tree work history file, and the request is handed to crew foreman for investigation and/or action.

   This system was an "opportunistic" development because the City's mainframe computer was not being fully utilized, and new applications were requested.

10. LIMITATIONS: While the unstructured work history file is simple, it does not allow for variables within the file to be accessed. For example, a report on all the trees pruned two years ago would not be easily available.

    Another problem is using the tax roll as a basis for determining tree location. Separate indexes had to be set up for trees on certain properties including row houses, churches, schools, rented addresses where tax is paid under municipal address, boulevard trees on the center median, and trees adjacent to public parks.

    There are some problems with data accuracy caused by improper data collection and entry.

D.2.6 City of York, Ontario

1. DEVELOPMENT: By private consultant on a minicomputer (Mentor 3000).

2. STATUS: Implemented in 1986 and modifications are now being made.

3. SCOPE: Information on 30,000 trees and tree spaces were recorded; complete inventory of all street trees.

4. PURPOSE: To provide information for the planning and management of the City trees.

5. DATA VARIABLES: survey date, requestor's name and phone number, request date, remarks.

   a) LOCATION: street name, street address, corner lot, setback, tree number.

b) TREE CHARACTERISTICS: species code, diameter, height (4 classes), condition code (7 classes).

c) SITE CHARACTERISTICS: publically- or privately-owned tree, hydro lines near tree, tree distance from curb.

d) ACTIONS RECOMMENDED: 45 different codes (ex. pruning, removal, stumping, supports, correspondence, and so on), date of investigation.

e) WORK COMPLETED: each recommended action that is completed is dated.

6. INFORMATION RETRIEVAL: Many different types of information can be generated from this system. Some of these include: co-ordinating daily pruning, planting, all the work for a certain street, a history of requests. Other reports include totals for each tree maintenance activity, by tree species, and so on.

7. SYSTEM USE: The system is used daily by clerical personnel, and the information is accessible from 16 terminals. The system uses on-line processing, and information is updated daily.

8. COST: The approximate costs for the system are: hardware - $40,000, software development - $20,000, and staff development - $10,000.

9. COMMENTS: The tree inventory program is only one of five programs used within the Parks Department. Initially, microcomputers were used in the offices, however, it became evident that a multi-user environment and faster information access was required so a minicomputer was purchased.

10. LIMITATIONS: The way information was recorded in the database posed a problem because tree maintenance operations was recorded for a property, and not for a specific tree. Thus, if there is a property with a number of different trees on it, the history of each tree could not be differentiated.

D.3 PROFILES OF GENERAL SYSTEMS

D.3.1 Computree

1. DEVELOPMENT: Arbo-Conseil Inc. (of Montreal) have the Canadian rights to the program. The program was created in U.S.A. by Systemics Inc.

2. STATUS: The system is currently being used in at least five municipalities in the U.S. and Canada.

3. SCOPE: A 10 megabyte hard disk can hold 66,000 tree records, and a 20 megabyte hard disk can hold 150,000 tree records.

4. PURPOSE: To provide information for tree management and planning.

5. DATA VARIABLES: notes (unstructured), dollar value, vigor.

   a) LOCATION: area, street name, number on street, serial number.

   b) TREE CHARACTERISTICS: species code, diameter, height, condition rating.

   c) SITE CHARACTERISTICS: location, wires present, traffic conditions, site class.

   d) ACTIONS RECOMMENDED: type of work needed, # of estimated minutes for activity.

   e) WORK COMPLETED: type of work completed, activity date, # of minutes used, name of equipment, type of equipment.

6. INFORMATION RETRIEVAL:

   a) complete or partial tree list by:
      i) civic addresses, streets, parks, sectors.
      ii) by species or dimensions.
      iii) by crown or trunk vigor class.
   b) work needed by type priority.
   c) estimated time to perform work on a specific tree or summary of trees.
   d) dollar value of each and every tree.
   e) list of routine/non-routine work orders.
   f) summaries of costs and crew productivity.
   g) various reports on age-class distribution, condition distribution, site conditions.

7. SYSTEM USE: The system is intended for daily use, and updating can occur at any desired frequency.

8. COSTS: The program and reference manual costs $2,950 (Cdn.). The estimated practical and theoretical training costs would be approximately $1,280 plus travel expenses.

9. COMMENTS: As far as this research has determined, this is the only system that is readily available in Canada. A complete English translation of the reference manual and program will soon be available.

   This program has the additional capability to use portable data collectors to input data into the system. The program for the portable computer costs an additional $300.

10. LIMITATIONS: Information not available.

D.3.2 Iowa Public Tree Inventory

1. DEVELOPMENT: By Iowa State University Forestry Department and Iowa Conservation Commission on the University's mainframe computer (initially an IBM, but has changed).

2. STATUS: The initiative to develop the program began in 1978, and was completed in 1982 for large towns (> 10,000 people) in Iowa State.

3. SCOPE: Intended as a complete inventory for street and park trees, and a partial inventory for greenbelt trees, however, it may be used as a partial inventory.

4. PURPOSE: To provide tree management and planning information and especially to respond to tree maintenance needs.

5. DATA VARIABLES:

   a) LOCATION: zone, block, street name, house number, tree number sequence.

   b) TREE CHARACTERISTICS: species code, diameter (5 classes), broad condition (3 codes), specific condition (19 codes).

   c) SITE CHARACTERISTICS: presence of underground utilities (6 codes), overhead wires, boulevard, and sidewalk; number of trees needed on each block and boulevard.

   d) ACTIONS RECOMMENDED: -no capability

   e) WORK COMPLETED: -no capability

6. INFORMATION RETRIEVAL: The following information is available from a particular zone or zones, a particular street, or to a street within a zone:

   a) data listing - prints back all data gathered in the field.

   b) species specific table - for each species, diameter class and broad or specific conditions can be compared (and total percent of each size and condition).

   c) combined table - size distribution and condition of all trees, and indicates additional planting space available.

   d) search for up to two condition variables whereby trees may require maintenance.

7. SYSTEM USE: Of the three or four municipalities using this system, only one uses it on a daily basis; others use it only part time. Access to the program is available through the University, or the program can be modified to a municipalities own computer. The program uses either on-line or batch processing, and information may be updated daily.

8. COST: The program is a public good, and therefore is free. Copies of the program written in Fortran are available or tapes may be mailed to the University and copied by them.

9. COMMENTS: A unique approach has been taken to differentiate between different types of trees in this program. Three different routines are designed for street, park, and greenbelt trees. While the street and park tree inventory is intended to be complete, the greenbelt inventory uses a statistical sample to collect information on trees. The only difference between the street tree and park tree routines is that the former uses a street address and house number while the latter uses a tree number for identification purposes. The street tree and park tree routine have contained within it a error checking, title page and code explanation, data analysis, and report writing subroutines. The greenbelt routine is very similar to the other routines, however, it also has a subroutine that estimates wood volume.

10. LIMITATIONS: Depending on the needs of the Forestry agency, this system may not be appropriate because it does not record tree/work histories, nor can it record information on actions recommended and/or work completed. Thus, the managerial information available from such a system is limited.

D.3.3 Michigan Tree Inventory

1. DEVELOPMENT: Michigan State University (Dr. James Kielbaso) for micro-computer (IBM).

2. STATUS: Currently used in one municipality.

3. SCOPE: Approximately 2,500 tree records fit on a floppy disk, and 75,000 records fit on a 10 megabyte hard disk; intended as a complete inventory.

4. PURPOSE: To provide information for management and planning of street trees.

5. DATA VARIABLES:

   a) LOCATION: district, street code, address, corner street, distance from corner street, street side, from what street to what street.

b) TREE CHARACTERISTICS: species code, tree diameter, tree height, amount of deadwood in crown, condition code.

c) SITE CHARACTERISTICS: street width, surface type, drainage, land use, building height, distance of building setback, distance to sidewalk, lawn width, site category, wire height, light height, corner, 3-way.

d) ACTIONS RECOMMENDED: 12 different codes, comment (unstructured).

e) WORK COMPLETED: no capability.

6. INFORMATION RETRIEVAL:

Most of the following types of information is available by district, primary street, block, and species:
a) on-line query and print
b) tree report - list of trees in a specified area.
c) summary report - total number of each tree species.
d) species report
e) work report - by action recommended variable.

7. SYSTEM USE: intended to be used daily; on-line processing; regular updating possible.

8. COST: $300 (U.S.) - additional installation and support costs.

9. COMMENTS: Information not available.

10. LIMITATIONS: The system does not record tree history information unless specifically entered in the system.

D.3.4 Tree Management Information System

1. DEVELOPMENT: By Dr. Robert Maggio (Texas) for a microcomputer (IBM).

2. STATUS: The program was developed in 1986, and has been used in Highland Park, Texas (tree population <10,000 trees).

3. SCOPE: Approximately 10,000 tree records can fit on one floppy disk. Street, park, and parkway trees can be included in this inventory.

4. PURPOSE: To inventory the location and characteristics of every tree on city rights-of-way, and to provide information for management.

5. DATA VARIABLES:

   a) LOCATION: trees are located on aerial photographs, assigned a number, and information recorded. The location information is then digitized; tree number, block number, street address.

   b) TREE CHARACTERISTICS: species code, diameter, condition (4 codes), crown diameter, potential removal difficulty (13 codes), hazard (ie. tree destroying street, curb, sidewalk concrete), visible injury (18 codes).

   c) SITE CHARACTERISTICS: street, park, or parkway tree.

   d) ACTIONS RECOMMENDED: management needs (8 codes), but can be expanded.

   e) WORK COMPLETED: unsure but appears to have no capability.

6. INFORMATION RETRIEVAL: In addition to the ability to produce computerized maps of the tree inventory, a number of lists and reports are available from this system that can be listed on the screen or printed. Trees can be selected by location (tree, block, or city), a tree characteristic variable, or a maintenance required variable. In addition, reports can be produced on data variables without reference to location variables.

7. SYSTEM USE: The system may be used and updated daily. Processing is both on-line and batch.

8. COST: The software costs approximately $3000 (U.S.), however, there are additional installation and support costs. This price increases to the amount of time the vendor spends with the client.

9. COMMENTS:

   This best aspect of this system is the tree location technique which involves digitizing information from aerial photographs. Field crews could be handed maps tree information and the locations of work to be completed. This would ensure that the tree location would be found, and that the appropriate maintenance is done.

10. LIMITATIONS: The system has not been tested with a large population of trees. Further, the expense of digitizing information may not be cost-effective for larger populations of trees.

D.3.5 TREBASE

1. DEVELOPMENT: At University of Wisconsin by Dr. Miller for the microcomputer (IBM).

2. STATUS: Developed in 1985. Approximately 11 municipalities are using the program.

3. SCOPE: Approximately 4,000 trees can fit on a floppy disk. The intention is that it should be used as a complete and continual inventory.

4. PURPOSE: To provide information for tree planning and maintenance.

5. DATA VARIABLES:

   a) LOCATION: district, street (code), house number, corner street (code), corner address, tree sequence number.

   b) TREE CHARACTERISTICS: species (code), diameter (2" class), general condition (6 classes).

   c) SITE CHARACTERISTICS: lawn width, wire height, tree present, planting priority.

   d) ACTIONS RECOMMENDED: work unit, crew name, action code, date.

   e) WORK COMPLETED: crew name, action code, date.

6. INFORMATION RETRIEVAL: Seven types of information can be formulated with this system:

   a) on-line query and print
   b) listings by location and maintenance requirements.
   c) listing of work history.
   d) species summary (including total tree value).
   e) diameter class summary (including tree value).
   f) frequency table by species and diameter class.
   g) planting sites by species and priority.
   h) work unit summaries

7. SYSTEM USE: intended to be used daily; uses on-line and batch processing; information is easily updated.

8. COSTS: $175 (U.S.) if already have Ashton-Tate's dBase III program.

9. COMMENTS:

TREBASE assumes the city is divided into work units. The programmer intended management to take place by the work unit. Each work unit should fit onto one floppy disk (about 4,000 trees).

Diskettes are used in three ways. First, the inventory disk records all new data. Secondly, this information is then moved to the data disk for more efficient storage. In turn, summary reports are generated for each of the work units, and then stored on the Report Disk which provides all summary information.

Additional capabilities of this program include the ability to determine tree value, and the ability to program in your city's street and corner codes, tree species, and action recommended codes.

10. LIMITATIONS:

One potential limitation of this program may be its inability to handle a large number of trees. The Forestry agency using this program would have to manage the trees by work units which is a definite operational constraint.

D.3.6 Tree Manager

1. DEVELOPMENT: by ACRT Consultants (Ken Joehlin) for the microcomputer (IBM).

2. STATUS: The system is currently being used by at least six different communities.

3. PURPOSE: This system is designed for giving a systematic approach to tree maintenance.

4. SCOPE: Approximately 1300 tree records can be stored on a floppy disk, and 50,000 records can be stored on a 10 megabyte hard disk. Intended as a complete inventory, and can be adapted for street or park trees.

5. DATA VARIABLES:

   a) TREE LOCATION: zone, management unit, street, address, tree sequence number, side of lot, serial number.

   b) TREE CHARACTERISTICS: species, diameter, amount of deadwood

   c) SITE CHARACTERISTICS: traffic sign or traffic light clearance, wires present, house damage, lawn width, uncurbed site, sidewalk.

d) ACTIONS RECOMMENDED: maintenance required, request number, requestor's name, address, phone, date received, received by, action taken, inspected by, date inspected, final results.

e) WORK COMPLETED: crew name, man hours, date of work, type of work, cost of work, comments (unstructured).

6. INFORMATION RETRIEVAL:

a) Listing of site/trees that meet a user specified condition (ie. location and any other variable).

b) Listings of inspections to be completed and space is included on this form for inspector's recommendation.

c) Routine and non-routine work orders and be generated. In the former case, any number of work orders can be generated. In the latter case, only work orders for individual trees can be generated.

d) Over 60 summary reports are available.

7. SYSTEM USE: intended to be used daily; uses on-line and batch processing; can be updated as required.

8. COST: The software for the program costs $3500 (U.S.). Installation and support costs are additional.

9. COMMENTS: Information in this program is broken down into four different files. The first file contains location and site information. The second file contains work history information, and the third file contains landowner request information. The fourth file contains tree maintenance work orders.

10. LIMITATIONS: Information not available.

D.3.7 Utah Tree Inventory

1. DEVELOPMENT: Utah State University (Baker and McCarter) for micro-computer (IBM).

2. STATUS: The program was developed in 1987, and one municipality is now using it.

3. SCOPE: Approximately 6,800 tree records can be stored on a floppy disk.

4. PURPOSE: To keep track of information about individual trees, to aid in the management of trees, to record tree histories, and to generate reports for management.

5. DATA VARIABLES: system user I.D.

   a) LOCATION: sector, block, building, street name.

   b) TREE CHARACTERISTICS: species code, species name, diameter, condition code.

   c) SITE CHARACTERISTICS: location code, vegetation type, utility, land use, planting space.

   d) ACTIONS RECOMMENDED: maintenance operation.

   e) WORK COMPLETED: maintenance operation, date.

6. INFORMATION RETRIEVAL: summary information from main, species, and operations databases.

7. SYSTEM USE: on-line processing; information can be updated regularly.

8. COST: $100 for software.

9. COMMENTS: Authors point out that dBase III was used initially, however, it is did not process information fast enough, thus they wrote their database software program.

10. LIMITATIONS: Reporting system is not completed yet, therefore the information retrieved from the system may or may not be accurate.