COMPUTER ASSISTED MANAGEMENT OF URBAN TREES

by J. Alan Wagar and E. Thomas Smiley[1]

Abstract. Commercial programs for computerized management of urban trees now offer the ability not only to retrieve, display, and summarize inventory and work records but also to compute tree values, map tree locations, track costs, develop profiles showing species performance, and to forecast future workloads. Computers are suited to such tasks as analyzing cost effectiveness, matching trees to sites, and guiding pest control. Computerizing is a commitment in management philosophy more than in time and funds and will normally save money. Before computerizing, however, you need to know your management objectives, how available software will meet them, the time until benefits are realized, and how to code data for greatest effectiveness in organizing and extracting information.

Résumé. Les programmes commerciaux pour la gestion informatisée des arbres urbains offrent maintenant la capacité de non seulement retrouver, exposer et compiler les données d'inventaire et sur les travaux, mais aussi de calculer les valeurs d'arbres, d'informatiser les cartes de localisation d'arbres, de relever des coûts, de développer des profils présentant les performances des espèces et de prévoir les charges futures de travail. L'informatisation est un engagement en philosophie de gestion plus que jamais et la mise de fonds et la volonté économisent normalement de l'argent. Avant l'informatisation, toutefois, vous avez besoin de connaître vos objectifs d'aménagement, comment un logiciel disponsible les rencontrera, le temps jusqu'à ce que les bénéfices seront réalisés et comment coder les données pour une efficacité maximum dans l'organisation et l'extraction de l'information.

Municipal arborists and urban foresters who coordinate the management of thousands of trees have much to gain from microcomputers, which now offer enormous power and capability at very reasonable cost. In fact, you can buy a first-rate computer suitable for the records of 40 or 50 thousand trees for less than a month's salary for a tree climber.

Organized records are important for efficient management, and Smiley and Baker have summarized reasons for inventory, kinds of inventories, and ways to conduct them (6). However, increasingly powerful programs now go beyond the simple listings and summaries originally implied by the term "inventory," and the broader term "computer assisted management" may convey a greater sense of this capability.

This paper examines some of the urban tree management assistance which can be expected from computers and also suggests matters to consider before embracing computer assisted management.

Data Selection and Entry

Selection. The information collected and entered into a computer should be the minimum needed to achieve management goals. Appropriate data categories are a major consideration in selecting tree management software, and Smiley and Baker have developed a list of commonly used categories (6). In many "off-the-shelf" systems, programmers have selected the data entry fields. In more advanced systems, however, users can select the data categories to be included.

Entry. Data are entered either by typing information into an office computer from field data forms or by field entry into portable computers or data recorders. The cost of portable computers and recorders varies widely, but the time saved and reduced chance of errors may make even the more expensive units cost-effective, especially when large numbers of trees must be inventoried.

As discussed below, data entry should be simple and should screen out as many potential errors as possible. Also, the coding of data greatly affects the ways that information can be retrieved and summarized.

All systems must have the capability to copy data files to diskettes or tape. Such backup copies are important because hard disks (which are almost essential for handling large numbers of records) can fail, with partial or total loss of stored information. Although such failure is rare, data files need to be backed up whenever significant changes or additions have been made. Otherwise, you could lose data that are costly or even im-

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possible to replace.

Growing Capability

Some of the computer assisted management capabilities now commercially available for urban trees are as follows, in approximately ascending order of power.

Retrieving, displaying, and reviewing records. To respond to calls from homeowners or others, you should be able to retrieve inventory and work information instantly by address or location code. Street tree records need to be retrievable by address, even if the tree under consideration is around a corner on a different street than the property address. Records for trees in parks and greenbelts need to be retrievable by grid coordinates or map areas. For other management needs, it is important to record and recall work records by date, species, crew, or work codes. An option to list selected records on the screen or to print them out is desirable.

Creating work orders. Work orders are simply a listing of selected work needs for a given area. Space is usually provided for writing when the work was completed and who did it. Work orders generated in response to resident complaints may be handled differently, with each complaint given a priority and printed on a card or individual sheet. Again, space should be provided to record information upon completion of the work.

Computing tree values. If inventory data include species, diameters, and ratings for tree condition and location, then a computer can quickly apply the ISA/CTLA valuation formula (3) to determine the dollar value for any tree or for various groupings of trees, including all trees in inventory. The value of a city's trees is often an impressive number and may be even more impressive if it shows that values are increasing (2) and that maintenance costs, as a percentage of value, are lower than for most other city property.

In determining values, the computer not only searches through selected records, but also uses preassigned species values and the current value per square inch of basal area for a calculation within each record.

Summarizing records. Summaries go a step beyond the recall and listing of individual records or computation of values and count or combine entries in selected categories. Managers and administrators often need information such as numbers of trees in specific areas; their species, size, value, and condition; amounts spent on various tasks or during selected periods; and summaries of needed work.

Summaries of crew work hours or contractor costs can assist in comparing crew productivity and can be used in pay-for-performance programs.

Mapping tree locations. Mapping of trees may help in identifying their locations for planting, maintenance, and for planning the construction of such infrastructure as streets, buildings, and utilities. Maps or grid coordinates are especially important for trees without adjacent houses as in parks, zoos, golf courses and industrial areas. Maps are useful for routing work crews, planning

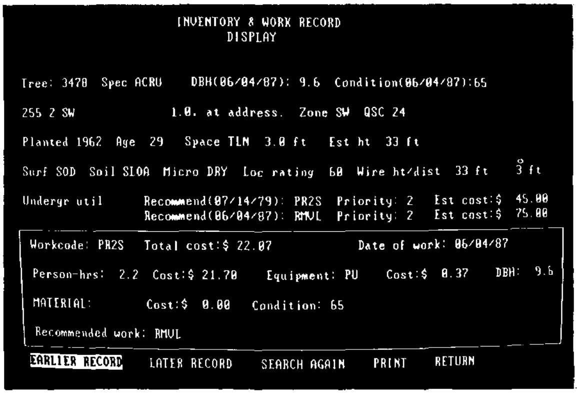

Figure 1. Computerized inventory records (upper portion of photo) and work records (in box) can be retrieved and displayed almost instantaneously, permitting immediate response to calls from homeowners or others. UTMS lets user scan through both inventory and work records and print them out.

UTMS TINYTOWN, 03/19/89
Value is $13,474 for 48 trees , Species = LIST, age 15 to 25
100 to 200 blocks of SE CHERRY

UTMS TINYTOWN, 03/19/89
Value is $300,489 for 936 trees
in work zone NE

UTMS TINYTOWN, 03/19/89
Value is $108,748 for 384 trees
in species code QURO

Figure 2. Dollar values for individual trees or groups of trees are readily determined by computer assisted management systems.

for planting, and analyzing geographic trends.

The value of maps for street trees in residential areas is questionable. Few properties have more than four trees, and these may be separated with location coding or a number system. Or, they may be separated by species, size or work requirements. If a citywide Geographic Information System (GIS) is available, locating trees on the maps used by city engineers and others may reduce construction damage from building or repairing utilities, streets, and buildings.

Mapping systems for microcomputers may be either an integrated part of the tree management software or separate but interrelated programs. The majority of such mapping systems are separate programs such as Map Info or AutoCAD. A three dimensional mapping system using Auto Shade has been demonstrated for city center visualization (1).

Creating graphs. Graphic presentation of urban forestry data can make the information easier to assimulate and understand. Commonly used graphics are pie charts and bar graphs showing species, conditions, diameter distributions, or work requirements. It is most convenient if the tree management program generates these graphics directly. However, virtually all systems can provide the summary data for graphics made by a separate program or by hand.

Tracking costs and profiling species performance. If work records are maintained for each tree, and if work codes, costs, and labor are identified in each record, then these records can be summarized to show what various kinds of work are costing, what species or cultivars are the most and least costly to maintain, at what sizes or ages of trees in a species require various kinds of work, and perhaps when costs of maintenance exceed benefits enough to justify replacement. Because costs from different years are not comparable, they need to be adjusted to a common year, using the consumer price index. Although considerably more complex than making most other summaries, profiling performance is quite suited to a computer's ability to track many pieces of information and do thousands of repetitive calculations very quickly.

Ability to document and profile the actual performance of each species or cultivar opens opportunities for greatly improved matching of trees to sites. Currently, much of the performance information being used is based on personal experience and impressions, with different people using different criteria and with both good and bad information repeated from one tree list to another. One expert may judge a tree as excellent because it grows well in his or her region, has few insect and disease problems, and is especially attractive. Yet the same tree may require frequent pruning, do poorly in an apparently similar region, or have roots that devastate sidewalks. Diversity or selections within a species may also be evaluated: trees of a species are too often rated as if uniform, even though individuals from seedling origin may differ enormously from each other. As actual records of performance accumulate, both managers and researchers will be better able to match trees and sites.

Forecasting future workloads. Performance data provide a basis for forecasting future

1975 TO 1987 COST PROFILE FOR 384 LIST TREES

UTMS TINYTOWN, 03/20/89

Age Class:	1- 5	6-10	11-20	21-30	31-40	41-50	51-60	61-80	80-100	100+
$/Tr-Yr:	14.10	2.90	4.80	6.20	0.00	0.00	0.00	0.00	0.00	0.00
Tree-Yrs:	684	1296	2412	528	0	0	0	0	0	0
Cost 1:	ESTB	PR1S	SWLM	SWLR	--	--	--	--	--	--
Hr/Tr-Yr:	0.21	0.12	0.26	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Cost 2:	PR1S	SPRA	PR2S	PR2S	--	--	--	--	--	--
Hr/Tr-Yr:	0.17	0.09	0.11	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Cost 3:	SPRA	SWLM	PR2E	PR2E	--	--	--	--	--	--
Hr/Tr-Yr:	0.03	0.03	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00
All other work codes:										
Hr/Tr-Yr:	0.03	0.02	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00

(All costs expressed in 1988 dollars.)

Figure 3. A performance profile (with hypothetical data) for sweetgum (*Liquidamber styraciflua*). Because a tree may be in an age class for only part of the period for which a profile is generated, data are summarized by tree-years (rather than trees). In general, the more tree-years the stronger the data.

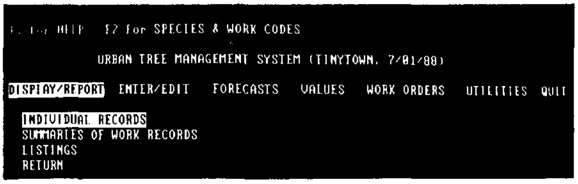

Figure 4. User-friendly software permits powerful routines to be selected and used with few keystrokes. The "light-bar" menus of UTMS let users choose by typing the first letter of an item's name. For example, typing d at the main menu displays the submenu for DISPLAY/REPORT. Typing i at the submenu starts the routine for displaying INDIVIDUAL RECORDS. Users can press F1 at any time for HELP or F2 for the definitions of species codes and work codes.

workloads, capability that begins to exploit the full power of computers. By forecasting workloads, you can plan ahead for personnel and equipment, prepare and justify budgets, and decide on replacement schedules and species.

If local records are still too limited to provide sound profiles on which to base forecasts, performance data can be entered from other sources, such as other cities that have already profiled the performance of the species and cultivars of interest.

Other Desirable Features

Computerized management systems may offer other specific features and should also be easy to use and have good documentation and support.

Ease of use. Computers can now be made so "userfriendly" that users can select self-evident menu options and harness powerful routines without knowing how a system works and with very few keystrokes. As mentioned, data entry should be simple and should screen out as many potential errors as possible. Typically, a well-designed system will refuse an inappropriate entry and ask that it be corrected. For example, invalid dates (such as 02/31/89) can be rejected, as can incorrect work codes or species codes. Entries can also be rejected if not within prescribed ranges. Where numbers are required, other characters can be rejected and vice versa.

If entry routines offer the option of automatically duplicating information from one record to the next, they save a great deal of time when many similar records are entered, as when all trees on a block are pruned at the same time. The ultimate test, however, is what you can do with the data entered. Record keeping is a means to better management, not an end in itself.

Documentation and support. Initially, well-written documentation is needed for installing and understanding a computerized management system. Thereafter, documentation is most useful if available on the computer screen. HELP menus instantly called to the screen with a single key and applying to what you are doing are very convenient.

If well designed and documented, a computerized system may need very little support. Users, however, are reassured to know someone will see them through any difficulties. Some software suppliers provide toll-free 800 numbers their users can call for assistance. Assistance may be free or may involve a yearly subscription charge which usually includes program updates. Cost for software support and updates is usually less than $150 per year.

Programs now available permit one computer to control another distant one by way of modems and telephone lines, allowing a software provider to diagnose problems and provide training without the expense of personnally traveling to user locations.

Password/security systems. Like other software, tree management systems can be programmed to require users to enter a password before they can proceed, reducing the risk of someone accidentally or willfully entering and damaging files. Many computers now give similar protection mechanically, by providing a key that turns off the keyboard.

Networked systems for multiple users. If a number of people need access to tree records, as in large cities or when several municipal departments have responsibility for trees, then networked systems are desirable. These systems may limit most users to "read only" access so they can not add to or change files.

Other Computer Assistance

Almost any management operation is a candidate for computer assistance if it requires complex or repetitive computations or would benefit from tapping into or manipulating large amounts of

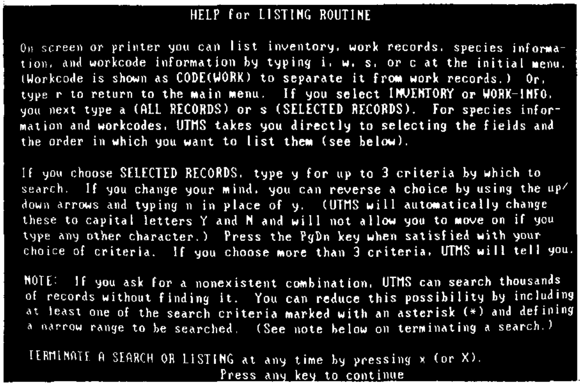

Figure 5. Once a system is installed, documentation is most useful if available as HELP for whatever routine is being used.

information. Because trees live for many years and may need repeated attention, analyses of cost effectiveness that incorporate the effects of compound interest rates are needed and are readily handled by computer (4). Summaries of performance data have already been mentioned, and, once such data are available, computers can be programmed so you can select trees with the best performance for a site by answering questions about climate, available space, soil conditions, overhead wires, preferred form, etc. The computer would respond with one or more species or cultivars suited to the site described. Diagnosing insect and disease problems and determining the most effective treatments and times for treatment would also be suited to computer assistance. Such assistance will increase the effectiveness and professionalism of arborists and urban foresters.

Matters to Consider Before Computerizing

Using computers for improved street tree management is more a commitment to a management philosophy than of dollars and time. In fact, savings can be expected. In California, developing monthly and annual reports by computer costs the City of Santa Maria $1,500 less per year than developing such reports manually. Another $300 to $500 is saved in retrieving other information.[1] Some of the matters to consider before computerizing are management needs, choice of both software and computer equipment, costs, time until the commitment pays off, and data coding conventions.

Management needs. Unless you have clear management objectives and see how specific software would help you reach these objectives, you are not ready to computerize. However, once a system has been acquired, you may find yourself expanding your concepts of effective management and using features you had not considered. It is better to buy a system you can "grow into" rather than one that confines you.

Choosing software. You should choose software only after thorough analysis of current and likely management needs and after exploring what features you could effectively use. The tree inventory and management software packages now available perform from some to most of the tasks listed above and cost from a few hundred to several thousand dollars each (5). Demonstration disks are available for most packages, permitting you to try them out before investing.

If you already have a substantial investment in tree records, and if they will meet foreseeable management needs if computerized, then software that is compatible with your existing records may be especially desirable. However, once you adopt software with limited capability, upgrading to obtain additional features may require new software, additional data for each tree, and perhaps a major reorganization of records.

Increasingly, inventory and management packages are written in machine language. Machine language programs run several times faster than equivalent programs written in database languages and do not require you to own a database which may cost an additional $500 or more. However, local programmers usually can not modify or customize machine language packages, making you dependent on the original supplier if changes are needed.

Choosing a computer. The primary rule for selecting a computer is to find the best software for your needs and then get a computer that runs the software. Other considerations are computer availability and compatibility with other uses such as word processing and accounting. Many people consider developing their own custom program for an existing computer. But custom development and debugging will probably cost more than a new computer and commercial software to run it.

Because speed, memory, and hard disk space are increasingly economical, you should probably error on the side of too much rather than too little. For an inventory of more than a thousand trees, a hard disk is considerably faster and more convenient that "floppy" diskettes. At least a megabyte of hard disk space should be planned for each thousand trees in inventory, plus additional space if work records are to be maintained or if the same machine will be used for word processing or other purposes.

Computers are changing so rapidly that today's

[1]Personal communication with Bailey Hudson, Park Superintendent, City of Santa Maria, California, December 28, 1988.

systems may soon seem slow or even primitive. Current systems nevertheless will serve effectively for years, especially as "stand-alone" units that do not inconvenience other people if temporarily tied up. (If a major summary will take 10 or 15 minutes, run it when leaving for lunch or starting some other task.)

Continuing costs for data entry are also likely to be modest. In California, for example, the City of Oakland needs about two hours per week to keep computerized records current for approximately 30,000 trees.[2]

Time until payoff. Computerizing will provide some benefits almost immediately, with others taking longer. Records can be retrieved, displayed, and summarized as soon as they are entered into the system, and summaries of quarterly, annual, or other accomplishments can also be made as soon as data are entered.

Generating performance profiles by computer requires cost and work data for the various tasks performed in the various age classes of a species or cultivar. If most age classes are well represented among a city's trees, solid performance data may accumulate in just a few years. If only a few age classes are present, local performance data will accumulate more slowly.

Forecasts of workloads can be made as soon as performance data are available, whether they result from computer summaries of local work records, are imported from other cities, or are based on professional judgment and experience. Although forecasts will be only as good as the performance profiles on which they are based, experienced managers should be able to create realistic profiles for many species, especially if they share their data and experience with each other.

At least three strategies for creating a computerized data base are available. Existing records on cards or other written forms can be entered into computer files for immediate access. Second, you can incur the initial cost of an inventory, again providing immediate access. Third, you can enter records only as trees are visited and maintained, requiring a full maintenance cycle of perhaps 5 or more years before every tree is recorded but avoiding the initial cost of inventory. If your objective is primarily to track costs, this third option might provide desired information as fast as taking a complete inventory all at once. A combined strategy is also possible, with some trees inventoried immediately and others left to the next year or two when they will be visited and maintained.

Data coding conventions control how data may be retrieved and organized, and codes ideally should suggest what they stand for. For example, in a four-character work code you could use an initial letter "P" to indicate pruning, followed by another letter to indicate Shaping, Lifting, Deadwood removal, Hazard removal, etc. A number indicating intensity of pruning might follow, followed in turn by a final letter to indicate whether work was Scheduled, Requested, or in response to an Emergency. Then, codes like PD3S, PL2R, and PH4E would define a heavy but scheduled pruning to remove deadwood, a somewhat lighter and homeowner-requested pruning to lift the lower canopy, and a very heavy emergency pruning to remove a hazard. Such coding permits costs per tree and total expenditures to be summarized and compared for scheduled and unscheduled maintenance and may help justify the resources needed to convert most of your workload to scheduled maintenance. Most systems code only for work category and priority.

In addition to controlling how data can be retrieved and organized, coding conventions insure consistency, fit information into available storage, and reduce the number of keystrokes needed to use a system. Codes of three to six characters are often used, as illustrated above with codes. Work zones might be defined as existing sections of a city (NE, SW, etc.). Alternatively, you may want to designate zones that correspond with your management needs. For example, the city can be divided into zones of such size that the trees within each zone can be inspected and maintained within a single year.

Species are often coded with the first two letters of the genus name followed by the first two letters of the species name, with one or two additional characters added to indicate varieties and avoid duplication. For example, silver maple *(Acer*

[2]Personal communication with Antonio E. Acosta, Administrative Assistant, City of Oakland, California, January 23, 1989.

saccharinum) could be coded as ACSA1 and sugar maple *(Acer saccharum)* as ACSA2.

Street names are handled differently by different systems, as are grid coordinates. The abbreviations ST, AV, PL, TR, BL, RD, etc. may be needed to distinguish street, avenue, place, terrace, boulevard, road, etc. Using a single space between name and abbreviation and avoiding punctuation saves space and keystrokes without losing information. Direction or section indicators can be handled the same way (as NW JEFFERSON BL or 102 ST SE). Numbered streets can be given either a number or number with suffix (23 or 23RD) as long as you are consistent. Very long names (as REDMOND-SNOHOMISH HIGHWAY NORTHEAST) usually must be abbreviated and, once adopted, the same abbreviations should always be used.

Conclusion

The microcomputers and software currently available can move street tree management dramatically ahead by letting municipal arborists and urban foresters summarize records and current work needs, project future workloads, and track costs and opportunities for savings. For the longer term, computerized records can provide a greatly improved basis for evaluating the performance of different species and cultivars in a variety of environments. By increasing the effectiveness and efficiency of management, computerized records can contribute not only to growing professionalism but to coping with ever present budget constraints.

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ABSTRACT

FLEMER, WILLIAM III. 1989. **Successful tree planting.** Grounds Maintenance 24(9):48, 50-52, 54, 109.

For various reasons, planting schedules do not always run smoothly. Unexpected events delay planting, and sometimes trees and other plants must be stored on the job site for long periods. If prompt planting is impossible, mass the trees together closely and set up temporary sprinklers to irrigate the soil balls. Traditionally, spring was the preferred planting time—particularly in the era when all trees and shrubs were planted bare root. Generally, shade trees 2½ to 4 inches in diameter, measured 6 inches above ground level, are an ideal size for transplanting. Don't plant when the soil is too wet. The *size* of the planting hole is most important. Dig the hole 1½ to 2 times wider than the diameter of the root ball and the same depth. Partially fill the hole with well-aerated existing soil. Fill the hole with soil, building a 2-3 in. berm around the outside edge to hold moisture. Don't mix fertilizer with the backfill. The majority believe that wrapping is worth the time and expense.