A MICROCOMPUTER-BASED TREE MANAGEMENT SYSTEM[1]

by Mark Lindhult

Abstract. A problem with many tree inventories is locating trees for future reference. This paper outlines the creation of a microcomputer-based tree management system which links two popular software packages, dBASE III and AutoCAD, to create an affordable and easy-to-use system for managing tree information. The major benefit of this approach is the ability to link tabular data collected about trees through an inventory (name, condition, dbh) with graphic data detailing the locations of trees possessing specific characteristics or maintenance needs. The paper describes the various components of the system, the methods used in setting up a graphic and tabular database, and the application of the system to downtown Amherst, Massachusetts.

Résumé. Un problème relié à plusieurs inventaires d'arbres est de localiser les arbres pour s'y référer dans le futur. Cet article décrit un système informatisé de gestion des arbres qui associe deux logiciels, dBase III et AutoCAD, pour créer un système de gestion de l'information sur les arbres économique et facile d'utilisation. Le principal bénéfice de cette approche est la capacité de relier des données tabulaires recueillies lors de l'inventaire (nom, état de santé, DHP) avec des données graphiques détaillant la localisation des arbres présentant des caractéristiques ou des besoins d'entretien spécifiques. Cet article décrit les diverses composantes du système, les méthodes utilisées pour établir la banque de données graphiques et tabulaires, et les applications du système au centreville d'Amherst, Massachusetts.

There is a need for urban foresters to have current information about the status of their trees so that they can make informed management decisions. Tree inventory systems are the best way of gathering information about the condition of trees and their maintenance needs (1), and the computer is an invaluable tool for implementing these systems (2). Computerized tree inventory systems have been available for many years, typically residing on mini- or mainframe computers. In recent years they have migrated down to the microcomputer level (3).

To date, each level of computerization has used the same basic approach for the generation and management of tree information. A tree inventory is performed to establish a database of information which is entered into a computer. This database (tabular data) is basically a list of plants and their relevant factors, such as name, condition, and diameter at breast height (dbh). A database management system is then used to allow users to query the database to identify trees that have specific characteristics. The query's results may be printed out in a report form which lists the trees that meet the specified criteria and data relevant to the query.

A problem which has hampered all tree inventories is locating the trees for future reference (4). There are various approaches to this which range from a block number or coordinate reference to a street address. However, each of these techniques requires the urban forester to reference a map and locate each individual tree, a long and tedious process. After using the computer to quickly search for all trees meeting specific characteristics, it is time consuming to then perform the task of locating the trees by hand.

The logical extension to these systems is to integrate spatial data (the trees' location) with tabular data (information about the trees) to provide users with a graphic display of database reports. Recent developments in microcomputer hardware, improved graphics and increased memory capabilities, and advances in software have provided the opportunity for this integration to occur. This paper will illustrate the development of a tree management system that uses a microcomputer to integrate graphic information with the tree database.

Tree Management Systems

The term management is used to describe the system rather than inventory for a very basic reason. An inventory is simply a list of trees and their characteristics. The system described in this paper allows the urban forester to manage tree information and, as a result, to better manage the

[1] Presented at the Annual Tree Wardens, Arborists, and Utilities Conference in Chicopee, Massachusetts, March 1987.

trees. Once information is entered into the computer, it can be manipulated in a large variety of ways.

To develop a useful tree management system, it is first necessary to explore and understand the urban forester's needs. The urban forester is responsible for a multitude of tasks, which include: locating trees that need replacement; identifying trees that have particular management need; preparing budgets, reports, and work orders; and answering queries by the general public.

Performing these tasks requires a great deal of information. To manipulate this information in a timely fashion requires the use of the computer. Based upon the above tasks, the general criteria for the development of a microcomputer-based system are as follows:

1. *Tabular database* - all tree information (attributes) necessary for management decisions, such as name, condition, management needs, and work priority.
2. *Graphic (spatial) data* - map information indicating the exact location of each tree in relationship to streets, buildings, and other major features which is linked to the tabular data.
3. *Database management capabilities* - the ability to query the database to find out what trees have specific characteristics.
4. *Report and map generation* - a mechanism for outputting written reports, work orders, and location maps.

In addition, the system must be *easy to use* and *affordable.* A major consideration for urban foresters, whose municipal budgets are often limited, was to develop a system with the most power for the least cost.

To achieve all of the above specifications, many separate components are necessary. To reduce the development time and expense, existing general purpose software packages were used: AutoCAD for creating the graphic database of streets, buildings, and trees; and dBase III for entering and manipulating the tree's tabular data. Some custom programming was also required to link these two programs together.

The hardware and software components of the prototype system cost approximately $12,000. This includes AutoCAD, dBASE III, a customized translation program, MS-DOS computer (80286 based machine), enhanced graphics adapter (EGA) graphics board, high resolution color monitor, 24"x36" digitizer, D size plotter, and dot matrix printer.

Work Procedure

The whole procedure for the development of this tree management system can be outlined as follows:

1. Inventory trees.
2. Create digital database of streets and buildings in inventory area.
3. Enter each tree's location from the map and all attributes from the inventory into AutoCAD.
4. Move attribute data from AutoCAD into dBASE III.
5. Query data for trees meeting specific criteria using dBASE. eg. Show all trees that must be worked on in the next 6 months and have a DBH greater than 24".
6. Print out the results of the query in report form.
7. Convert results of query into AutoCAD format (this is the custom program).
8. Display the trees that meet the criteria queried in dBASE using AutoCAD.
9. Plot the map using AutoCAD.
10. Hand the map and report with a description of the trees, their location, and the work to be done to the crew foreman.

The following diagram illustrates this procedure (Fig. 1).

Tree inventory. The first task in creating a tree management system is to inventory all trees to form the database. Because trees are dynamic and their condition may change, a good tree management system must be constantly updated. A major problem with many tree inventory systems is that they are too complicated and as a result are difficult for the urban forester to maintain. Thus, the inventory used for this system collected just the data necessary to make everyday decisions. The information collected, hereafter referred to as attributes, is listed below:

Graphic database. As with any inventory, a base map is necessary in order to put trees into their proper context. The computer is no different, as a digital base map consisting of streets,

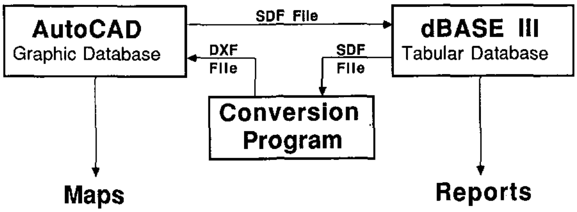

Fig. 1. The flow of data in the tree management system.

sidewalks and buildings must be created. In some cases, digital data is available from department of public works or other source. If digital data are not available, the graphic data are entered into the computer through the process of digitizing. The map (an assessor's map or aerial photograph) is placed on a digitizing tablet and the map is traced with a stylus (a pen-like instrument connected to the digitizer) which sends the x,y coordinates of all points touched to the computer. This digital map is displayed on the screen (Fig. 2) as the digitizing is performed so that any errors can be detected and corrected.

Tree symbols. To graphically represent trees in AutoCAD, a set of tree symbols are created for each tree species in the inventory. A symbol consists of a circle with the species' initials (eg. AS -for *Acer saccharum)* and a list of attributes that form the database (see Table 1). Two of these attributes, the botanical and common names are permanently attached to the symbol. The other information, which will vary from tree to tree, is entered for each individual tree location (Figure 3).

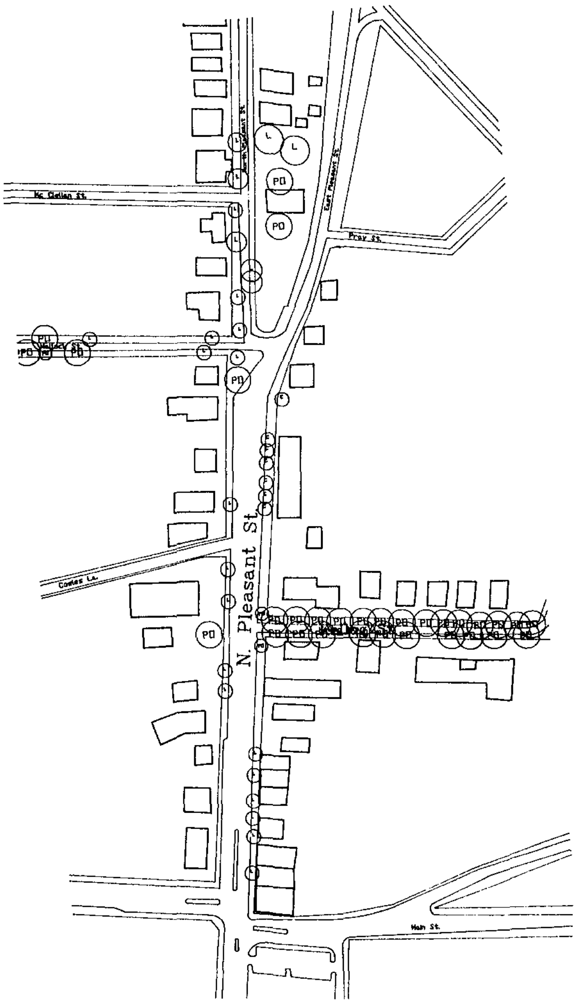

Fig. 2. Map of trees in downtown Amherst.

Locating the trees. The next task is to digitize from a base map or aerial photograph the location of each tree and to enter the corresponding attribute information from the tree inventory. The user selects the desired tree symbol from a menu and then, with the base map taped to the digitizer, touches the tree's location with the stylus. The symbol appears on the screen and the computer then prompts the user to enter the tree's specific attributes.

Using the tree inventory, the user types in the corresponding data to each question. To speed up the input process, each question has a default value which can be predefined as the most common response for that particular species of tree. Thus, the response to most questions is simply the RETURN key. After the attributes have been entered, they are displayed adjacent to the tree symbol (see Fig. 3).

Table 1. List of attributes used in the tree management system

Common Name	
Botanical Name	
Street Number	for more than one tree per address, the trees are labeled A, B, C, etc..
Street Name	
DBH	to the nearest 1 inch
Present condition	three classes
Date recorded	changed when information is updated
Landscape value	three classes
Comments	general comments that add information proximity to power lines, weak crotch, dead wood, damaging cavity, root cover (lawn, mulch, compacted soil), pests found.
Management need	description of work needed to bring the tree up to good condition: pruning, fertilization, cabling, removal, watering, aeration, disease management, and/or insect control.
Work priority	three priority classes (immediate to within 3 years)

The Tree Management System

The Tree Management System is an integrated graphics and database management system designed for street and park trees. The three major components of the system, database manager, graphics, and conversion utility, were all customized for this particular application. The database for Amherst, Massachusetts serves to highlight the utility of the system.

Database management functions. The database management system is the heart of this system. Once data are entered into the computer, it can be manipulated in a large variety of ways. For example, a standard feature of a database management system is the sort function. This allows the urban forester to sort all trees according to any attribute, such as street name to see the mix of trees on certain streets or tree name to see how many trees of each species there are. Another feature of the database management system is the ability to extract data with certain characteristics. To find out what large trees need immediate care, the urban forester can query the system for all trees with a work priority of 1 and a dbh of greater than 24". The database management system will extract all trees that meet these two criteria. The list may be narrowed further by adding more criteria.

Further capabilities of the database management system can be utilized to meet some of the urban forester's other needs outlined earlier in this paper. A major task is the generation of reports listing all pertinent information sorted or extracted from the database. After determining trees with specific management needs, a report may be generated outlining work to be performed and performance specifications. This type of report is most useful in preparing work orders for in-house personnel or be sent out to bid.

Urban foresters are constantly fighting for and justifying budgets. The preparation of budgets can be simplified using the computer by extracting all work that needs to be performed in the next year from the database. These data can be loaded into a cost estimating program and matched with standard costs for each operation resulting in a total for all work. A variety of different scenarios can then be performed given various budget figures. If a budget figure has already been set, it is possible to outline to other administrators exactly what work can be completed and what work that should be done will remain unfinished.

Graphic capabilities. The most unique facet of this system is its ability to display tree information graphically. AutoCAD provides the ability to zoom in on specific streets or areas that need to be reviewed in detail. This can be used to check and edit data or to answer questions from the general public about specific trees in their neighborhood.

The ability to view the spatial distribution of trees with specific characteristics is a very powerful tool. By graphically displaying the results of database queries, the urban forester can visually identify trends or patterns in tree conditions, map out various strategies for scheduling work, view the spatial distribution of specific tree species, and quickly view tree data in ways that were not previously feasible. Any information contained within the database can be viewed spatially.

Conversion program. The conversion program converts data from dBASE III into AutoCAD format so that the data extracted may be viewed graphically. The program is menu driven so the user merely responds to questions posed by the computer. When data are extracted from dBASE III, the conversion program matches the botanical name with a corresponding tree symbol. The tree's coordinates, which are part of the database, are used to place the symbol in relation to the other objects in the graphic database and to determine the location of each attribute.

A feature of AutoCAD which is utilized by the conversion utility is the ability to place different types of information on a different layer; imagine a separate piece of tracing paper overlayed on a map. This maintains the integrity of the new information, allowing the urban forester to select a uni-

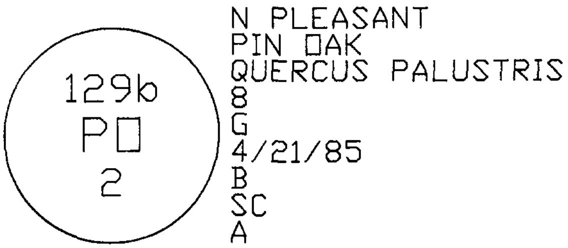

Fig. 3. Typical tree symbol with all attributes displayed.

que color for these trees so that they stand out from other data or can be viewed separately.

Application. To demonstrate the utility of the system, a sample data set was developed for downtown Amherst, Massachusetts. All streets, sidewalks, buildings, and tree locations were digitized (Figure 2) and all tabular data were entered into the computer. The database was queried for all trees with a work priority of 1 and DBH greater than 24". After the database extracted all trees meeting these criteria, the list of trees was converted to AutoCAD format and merged with the existing base information.

The urban forester can have a map plotted to any scale. Thus, maps can be produced to show a large area (Fig. 2) or a detailed area such as a single street showing tree locations (Fig. 4). The map can be provided, along with the report generated from dBASE III detailing all work to be done, to the work crew.

Updating. After work is completed, the user goes back into either dBASE or AutoCAD and edits the attributes that have changed. Additional information is added to the database to identify when and what work was performed. These new data are then saved.

To update the database with new trees, it is possible to speed up the process of collecting data by performing the tree inventory with a portable computer running dBASE III (or any program that can put the file into the proper format). For each tree, the required tree information is entered into the computer by field personnel and the location of the tree is noted on a map. Back in the office, the file containing the tree information is transferred into AutoCAD. During the conversion process, the tree data are matched with corresponding tree symbols. The user then works in AutoCAD to move the new symbols to their proper location as described previously. The task of manually transferring the inventory data as attributes into the computer is eliminated.

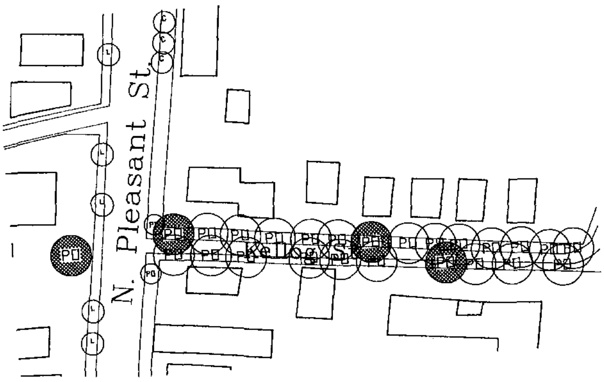

Fig. 4. Map showing the locations of trees that satisfy the database query.

Other applications. The ability to see the tree data in plan view to identify the spatial distribution of trees is an important function of the system. However, trees are not two dimensional. They are three dimensional living organisms that change over time. AutoCAD has the ability to view a street scene as an isometric, giving a sense of the three dimensional characteristics.

It is also possible to move the graphic database to another program, such as the Perspective Graphics Package, and view the whole scene in perspective. Each tree location from AutoCAD is replaced by a three dimensional tree symbol, so that an accurate wire-frame representation of the street scene is created. This has great potential for determining what size or type of tree should be planted in particular situations. With graphic imaging techniques improving rapidly, it will be possible to view these scenes in great detail.

Conclusion

This tree management system provides a complete operating environment for entering, editing, manipulating, and outputting information about a municipality's street tree resources. The system's purpose is to reduce the tedium involved with manual systems, speed up operations, and allow the urban forester to focus attention on the management of trees rather than the collection and management of data. Systems such as the one described in this paper will soon play an important role in managing trees in our cities and towns.

Acknowledgments: The author wishes to thank H. Dennis Ryan III for his professional expertise and encouragement and Albert Rau for his assistance in writing portions of this system.

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dBASE III is a registered trademark of Ashton-Tate.

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ABSTRACTS

WICK, ROBERT L. 1986. **Careful specimen selection helps plant disease diagnosis.** Am. Nurseryman 164(4): 79-80, 82-85.

Of paramount importance for accurate diagnosis of plant disease is a fresh and adequate specimen and a complete case history of the plant's problem. Remember the following points when collecting specimens and information for plant-disease diagnosis. The part of a plant showing symptoms may or may not be the primary site where disease began. When this is the case, foliage or branch samples are of no diagnostic value because the primary problem occurs in the root system. Soil type, environmental conditions, cultural practices, parasitic organisms and the plant itself all interact to influence the health of the plant. For cooperative extension or private consultants to accurately assess the importance of the factors and give meaningful recommendations, a carefully selected specimen accompanied by a case history is necessary. Guidelines for collecting specimens and information are given.

CERVELLI, JANICE A. 1986. **Raised containers undermine urban trees and urban design.** Am. Nurseryman 164(9): 50-52.

Numerous product advertisements still praise the values of raised tree containers measuring 4 feet by 4 feet. Due to the barren city environments and the many difficulties of planting trees in cities, containers are the only alternative in many cases. However, a re-evaluation of such tree containers is necessary to determine their effectiveness in meeting not only the physiological needs of trees but also the functional and aesthetic requirements of cities. Continued use of surface planters has shown them to be notorious tree killers. Winter root damage is the major limiting factor of containers in the Midwest and Northwest. One researcher has found the cold tolerance of root systems of many woody ornamentals to be less than that of the aerial parts. Trees in containers must also contend with restricted root growth and nutrient availability. Since most feeder roots are in the upper 30 inches of soil, an increase in container depth does not compensate for winter root damage and horizontal root spread. Container trees receive minimal moisture from rainfall and can suffer from leaf scorch, winter dessication and partial defoliation. Lastly, soil mixes with high humus content can subside--compacting to half or less of the original level and significantly reducing soil aeration. This myriad of cultural problems reduces the natural resistance of a container plant to disease and insect infestation as well as its life-span and ultimate size. Large container trees rarely live over 10 years.