Best Management Practices

TREE INVENTORIES

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Introduction

Purpose

This booklet is written as a consensus document for professionals who manage a large number of trees considered primarily as individuals rather than as groups or stands. It is relevant for trees within public jurisdictions—such as municipalities, villages, towns, water districts, or counties—as well as other collections of managed private trees such as those found on university campuses, cemeteries, military bases, utility corridors, corporate or institutional grounds, arboreta, and private grounds. For simplicity, all such populations will be included here under the term "urban forest," all persons responsible for them called "urban forest managers," and all groups served by urban forest managers labeled "communities."

The primary purpose of this publication is to describe the standards to which tree inventories should be compared. It also strives to serve as a guide for making informed choices that will match inventory goals with needs and resources. Because all urban forests are unique, a single inventory format cannot be applied universally. In addition, funding levels and other resources vary significantly from program to program. It is thus important to choose carefully to maximize resources to achieve the desired goals.

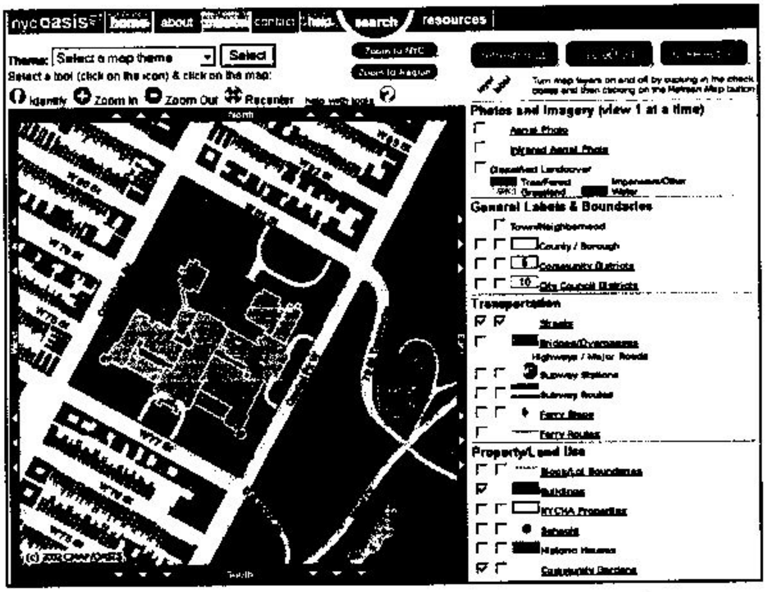
Definition

A tree inventory is a record of the location, characteristics, and assessment of individual trees within a well-defined group. However, inventory scale and complexity vary by the specific needs, goals, and resources of the local context.

Inventories are typically accompanied by an analysis of the population—an *inventory report*. The urban forest can be separated into categories such as species or size classes, and assessments are made of their quantity and quality. In its simplest form, such analysis comprises a series of charts, tables, or maps from which the user can retrieve information. A more sophisticated form or inventory report is a *management plan* in which the implications of the data analysis are laid out in detail.

A data collector using a pen-based unit to record tree location on a georectified map. The collector also gathers information about species, diameter, and other attributes.

Historically, inventory media included index cards, ledger books, and paper maps, which made searching, manipulation, and analysis difficult. Most inventories now are electronic, greatly facilitating these tasks. Similarly, field data collection is now commonly carried out on handheld electronic devices.



The map page OASIS (Open Accessible Space Information System, www.oasisnyc.net), a Web-based GIS mapping resource of open space. This system was developed by a coalition of public agencies and private companies and institutions to catalog New York City's open spaces for use by greening and planning groups.

Preparation

Goals and Objectives

The first step in the inventory process is establishing its goals and objectives. Managers need to carefully consider their needs and priorities, because data collection and inventory software can entail a significant investment of time and financial resources.

Safety

The number one concern for most urban forest managers is risk management. This concern follows from the obligation for prudent care that lies at the heart of liability. Tree inventories need to identify trees requiring pruning and removal for safety concerns. When this information is prioritized, long-term policies can be implemented, resources for remediation allocated, and future periodic monitoring scheduled.

Population Identification and Characteristics

Inventories count the tree population and, in many cases, the sites available for tree planting. This enumeration process is a key objective in most inventories. Tree characteristics such as species, size, and health rating are normally included, as well. These factors will enter into work planning, budget preparation, policy development, and program review.

Maintenance Assessment

Planning for maintenance is much more efficient when suitable data are available. Maps of geographic areas or lists of sites can be combined with work needs to develop budgets for work and assign work to crews. Long-term management issues such as prioritizing maintenance, preserving species diversity, and training young trees can also be readily addressed.

Work History

Inventories can be used as the basis for tracking the work history of each tree. This information helps in addressing service requests, determining when an individual tree is near the end of its useful life, and supplying critical data to evaluate species performance.

Longevity and Utility

The longevity of the inventory is another factor that must be determined in advance and incorporated as an objective. Inventories can be one-time events that provide a snapshot of the urban forest, or they can be used as an ongoing basis for management. If an inventory is to be ongoing, a data management system that achieves this goal is essential.

Report by Priority 1 Removal

Tree ID	Site	Species	DBH	Cond	Maintenance	Utilities	Inspect	Growspace	Space Size	Hardscape	Clear-ance	Inv_Date
[illegible]						*Ward:*	17		*Location Type:*		Street	
SIDE: Front		*ON:* 18th St		*FROM:*	Rugraff St		*TO:*	Amanda St				
25178	1	Planetree, London	32	Poor	Priority 1 Removal	No	No	Open	99	No	None needed	5/20/2005
[illegible]						*Ward:*	17		*Location Type:*		Street	
SIDE: Front		*ON:* 18th St		*FROM:*	Rugraff St		*TO:*	Amanda St				
25181	1	Planetree, London	33	Critical	Priority 1 Removal	Yes	No	Well or Pit	4	Yes	Vehicle	5/20/2005
[illegible]						*Ward:*	9		*Location Type:*		Street	
SIDE: Side A		*ON:* Foster St		*FROM:*	44th St		*TO:*	43rd 1/2 St				
2048	1	Maple, Red	17	Dead	Priority 1 Removal	Yes	No	Well or Pit	2	No	None needed	2/16/2005
[illegible]						*Ward:*	18		*Location Type:*		Street	
SIDE: Side A		*ON:* Tarragona St		*FROM:*	Abner Ave		*TO:*	Schubert St				
26884	3	Locust, Black	11	Poor	Priority 1 Removal	Yes	No	Open	99	No	None needed	5/26/2005
[illegible]						*Ward:*	27		*Location Type:*		Street	
SIDE: Front		*ON:* Acacia Ln		*FROM:*	Diploma St		*TO:*	Brighton Rd				
19725	1	Elm, American	13	Critical	Priority 1 Removal	No	No	Open	99	No	None needed	5/3/2005
[illegible]						*Ward:*	5		*Location Type:*		Street	
SIDE: Rear		*ON:* Rampart St		*FROM:*	Camp St		*TO:*	Iowa St				
17142	1	Maple, Norway	16	Critical	Priority 1 Removal	Yes	No	Open	99	No	None needed	4/21/2005

Example of inventory output. Information about trees needing removal is organized in a table that facilitates oversight and review.

Benefits of Using an Inventory

The overarching benefit of a tree inventory is that it allows the manager to change the operation from a predominantly *reactive* position—always "putting out a fire"—to a *proactive* position, where a significant portion of daily work occurs within the framework of information, planning, and policy.

Increased Efficiency

Once an inventory has identified the work to be done, a manager can use it to execute that work in a much more efficient manner than before. Scheduling all work in a given area to be done at the same time, for instance, has been shown to result routinely in substantial savings in travel and setup time. There is also increased efficiency in the office created by the ability to quickly locate and manipulate records, select and schedule work, and write summary reports.

Improved Community Relations

Tree inventories can usually be used to record service requests, link them with individual tree records, and prepare inspection lists. Tree inventories are also useful educational tools. Data, maps, significant individual trees, and summary reports can be distributed in print or on a Web site. In this way, the community can gain a better understanding of the urban forest and its management—and become more willing to provide support.

Emergency Preparedness

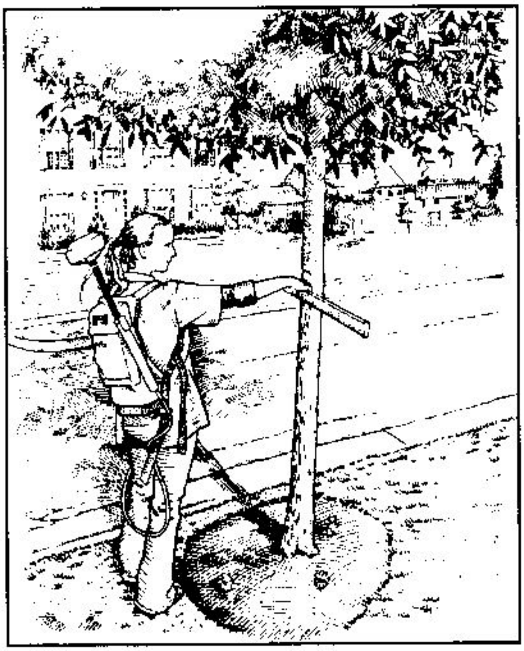
Tree inventories provide a powerful management tool when a disaster strikes. Knowing the forest's size-class distribution, for instance, allows appropriate allocation of resources without waiting for a complete assessment to be made. Furthermore, good information about the forest *before* the disaster puts application for restoration funds on a sound footing.

Justified Budgets

Up-to-date tree inventories provide the data needed to project specific levels of funding that will be necessary for tree maintenance and planting over a multi-year period. With accurate data, the tasks and associated costs can be clearly spelled out and supported by detailed lists. An inventory may report a dollar value for the urban forest following methodologies developed by the Council of Tree and Landscape Appraisers or the USDA Forest Service (STRATUM—Street Tree Analysis Tool for Urban Forest Managers; and UFORE—Urban Forests Effects Model; see www.itreetools.org). Finally, a good inventory can compare the cost of implementing different future strategies, as well as provide a solid basis for grant applications.

Documented Actions

Tree managers are frequently asked to provide documentation of their actions. This documentation can range from work accomplished to a contractor's costs per tree, from a removal list to a particular service request. In the rare instance of litigation involving a tree, an inventory documents that policy has been implemented. Much time and frustration can be spared through the use of a good inventory and data management package for documentation.



A data collector carrying a GPS unit on her back for establishing tree location and using a Biltmore stick to measure tree diameter.

Resources Required for Inventories

Office Personnel

The urban forest manager and staff must, of course, understand and support the tree inventory process and outcome. But, in addition, an office member must be designated to take responsibility for maintaining the data. That person should be involved in program choice and office setup. Also, the ongoing work of data entry required to maintain an inventory must be acknowledged and budgeted.

Data Collection Personnel

The cost, accuracy, and efficiency of data collection vary with the nature of the personnel. Table 1 summarizes the general experience of the authors and the review committee of this guide.

Table 1. Options for data collection personnel.

Personnel	Labor cost	Accuracy	Comments
Volunteers	Low	Poor–Good	Need high level of training and supervision to obtain good data
Temporary or part-time staff	Low–Medium	Fair–Good	Need medium amount of supervision and training
Full-time staff	Medium–High	Good–Excellent	Need low amount of supervision and minimal training
Contractors	Medium–High	Good–Excellent	Need low amount of supervision and no training; have own equipment

Data Collection Equipment

Data collection equipment ranges from paper and pencil to various handheld devices such as personal digital assistants (PDAs) or pen tablets displaying a geographic information system (GIS). The choice depends primarily on local resources and personnel. Electronic equipment is useful because it is fast, accurate, and does not require office data entry. But it does require acceptance, investment, training, and maintenance—so it would be time-consuming and risky to go that route without technical support.

A data collector using a small, personalized digital assistant (PDA) to record data about each tree quickly and reliably.

Computing Needs

What hardware is required and where will it reside? Most of the time, it will be on a local computer, although some software vendors offer the option of hosting the data on a remote computer accessed with a browser. If a local host will be used, it is important to identify the exact computer that will be used and determine whether its configuration is equal to the task. Some networking will typically be required.

Software Compatibility

Are the data and software flexible enough to work with other systems? If older inventory data exist, for instance, then it is critical that data categories, structures, and definitions can be correlated if comparisons are to be made. Software options range from adapting off-the-shelf spreadsheets or databases to purchasing one of the many different commercial products available. Dialogue between the urban forest manager and the local IT department is imperative for a good choice.

GIS Compatibility

Traditional paper maps are increasingly being replaced by the use of a geographic information system (GIS), especially for trees that are not nicely lined up in front of buildings. If suitable, universal location data can be collected along with other tree information through the use of global positioning system (GPS) units or pen tablet computers. This allows trees to be represented in a GIS, enabling easy production of accurate, up-to-date maps and reports, as well as advanced analyses. GIS systems are often already at work elsewhere in the community, offering potential data-sharing and cost-reducing opportunities.

Budget

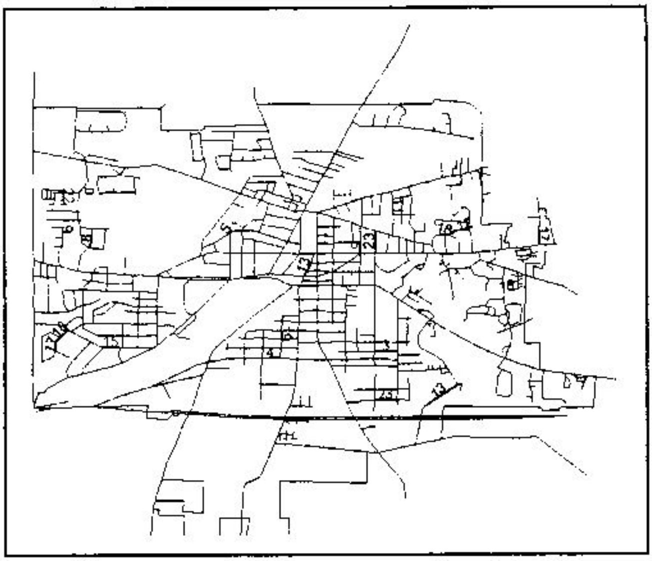
The costs of an inventory can be broken into three main areas: data collection, software, and maintenance. An inventory (data collection using software) can be carried out within almost any budget, but higher-quality inventories generally cost more. It is worth keeping in mind that *cost* is not the same as *value*. The optimal strategy is to weigh data and software features and quality against actual needs and budget.

Inventory Types

Sample Tree Inventories

Random sampling is a cost-effective way of obtaining a large-scale picture of the urban forest and its needs, from which a strategic plan can be developed. A small percentage of street blocksides or a specified mileage or area is randomly drawn and used to provide estimates that are accurate to within about 10 percent. The minimal sample size to achieve this level of accuracy is 3 to 6 percent, depending on how much variation there is from site to site. New GIS-based sampling tools are available from the i-Tree Web site (www.itreetools.org).

For greater accuracy, the sampling process can further involve "stratification" that divides the inventory area into meaningful subareas, such as by land use (for example, new subdivisions, historic district, and industrial areas).



A community map showing the locations and ID numbers of a random two percent of blocksides that can be used to create a sample inventory.

Partial Tree Inventories

Partial tree inventories allow the acquisition of information about a portion of the population or area that is perceived as critical. It may be desirable, for instance, to inventory a single area where trees are older and population density is greater. When budgets are limited, such an approach can provide an effective and affordable management tool. This same procedure can be used to spread the work out over multiple years by moving sequentially through divisions of the area (wards, districts, neighborhoods, etc.).

Surveys can focus on one or a small number of factors over the entire urban forest. One common example is a hazard tree survey. In this survey, all streets are driven, but the survey team stops to record data only for trees that appear to present a hazard as defined within the specifications.

Complete Tree Inventories

A complete, or 100 percent, tree inventory includes all the trees (and empty planting sites) in an urban forest. Typically, in a municipal environment, that means all the street trees in the public right-of-way and, in many cases, the municipal parks and other municipally owned land. For other managed private tree populations, this type of inventory includes all trees within the defined geographic limits.

Technical Details

Inventory Concept

Conceptually, every inventory involves features, attributes, and values:

Features are the items that are inventoried—in the case of tree inventories, trees or sites. Examples of other features that can be inventoried include utility poles, shrubs, putting greens, irrigation systems, and hardscape (fountains, walks, etc).

Attributes are the characteristics of a feature that will be recorded during the inventory process. Attributes can be broadly divided into two types of data: (1) location information and (2) tree (or other feature) information.

Values are the quantitative or qualitative measures of an attribute. Quantitative values are usually direct measurements with an instrument, such as when a diameter tape is used for the attribute "diameter at breast height." Qualitative measurements, by contrast, involve somewhat arbitrary categories and individual judgment, such as for the attribute "tree condition."

Attributes, Values, and Definitions

The most important aspect of any inventory is the data it contains. A manager with limited, flawed, or even no software can still make excellent use of an inventory as long as the data are sufficient and of good quality. But if the data are inaccurate, inconsistent, or incomplete, no manager or software application in the world can make up for it.

Complete tree inventories typically include the following attributes, although the exact list will depend on managerial objectives. This list may also be reduced or altered for sample and partial inventories.

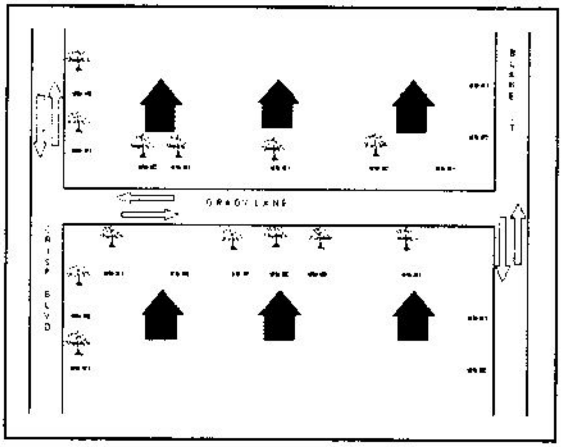
Location Information

General Location

In addition to the name of the whole urban forest, many managers also like to indicate a sub-area such as ward, precinct, neighborhood, zone, management area, subdivision, or quadrant. Doing so is often a good idea because it allows the data to be analyzed and applied within local managerial structures that form the basis of maintenance routines. Such areas need to be clearly defined, delineated on the map for data collection, and included as a field in the inventory database.

Detailed Location—Street Trees

The location of each street tree or planting site should be clearly identified so that it can easily be found for future maintenance work. At a minimum, each site (or other feature) needs a unique identifier in the database. If historical information about individual trees will be included, then each tree needs a unique number in addition to the one assigned to the site it occupies. These unique identifiers form the link among associated sets of data within the software. Standard attributes include the following:



One method of treating blocksides and corners. Note: With this method, the planting sites are numbered in the direction of traffic flow. Also, not all planting sites have a tree.

- street name
- blockside information (if a GIS is not going to be used)
  - → include fields that identify the tree's frontage or street section
  - → the unique TIGER/Line ID numbers (TLID) provided by the U.S. Census Bureau's dataset for blocksides could also be used
- X and Y coordinates, or northing and easting if that system is used
- site information
  - → address, using a consistent method for buildings without numbers posted
  - → site number at street address
  - → site location information, such as side, front, right, left, rear, or median—using a consistent method of locating trees on corners
  - → type (tree lawn, median, pit, etc.)
  - → size (shortest dimension of growing space, or size class: S, M, L)
  - → overhead utilities (service, 3-phase, all, etc.)

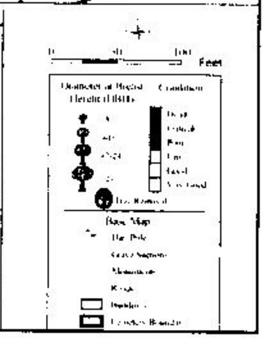
Detailed Location—Randomly Distributed Trees

Each feature needs a unique identifier in the database; planting sites usually are not inventoried. Standard detailed location attributes for randomly distributed trees include a spatial reference such as

- local map marker
- X and Y coordinates, or northing and easting if that system is used
- distance and direction from fixed reference points

A physical marker of some kind is the surest method of finding a specific tree again that cannot easily be linked to some permanent reference object.

ID	NAME	DBH	CONDITION	MAINTENANCE
430	Quercus palustris	23	Good	Pruning Deadwood 2
431	Quercus rubra	27	Good	Pruning Deadwood 2
432	Quercus rubra	24	Good	Pruning Deadwood 2
649	Cornus florida	12	Fair	Pruning Routine
650	Prunus x yedoensis	3	Fair	Pruning Training
865	Quercus palustris	24	Fair	Pruning Deadwood 2
866	Quercus palustris	28	Poor	Remove
867	Quercus palustris	24	Poor	Remove
868	Quercus palustris	28	Fair	Pruning Deadwood 2
869	Quercus palustris	24	Fair	Pruning Deadwood 2
871	Quercus palustris	32	Fair	Pruning Deadwood 2
872	Quercus palustris	28	Fair	Pruning Deadwood 2
873	Quercus palustris	26	Poor	Pruning Deadwood 1
994	Quercus palustris	24	Fair	Pruning Deadwood 2
995	Quercus palustris	19	Fair	Pruning Deadwood 2
996	Quercus palustris	23	Fair	Pruning Deadwood 2
997	Quercus palustris	26	Fair	Pruning Deadwood 2
998	Pinus strobus	10	Fair	Pruning Routine



Example of a GIS-based inventory. Tree locations can be overlaid on a wide variety of base map data, such as aerial photography (top) or CAD drawings (middle), and are directly associated with an attribute data table (bottom).

Tree Information—Standard

The following tree attributes are recommended for complete inventories that will be used on a day-to-day basis for urban forestry management.

Species

Trees should be identified by genus and species using botanical names as found in the USDA's PLANTS database (http://plants.usda.gov) or standard published reference works. Common names often are included for the sake of nonprofessionals, but they can be ambiguous or misleading if not referenced to botanical names. A species profile can be created for the entire forest from these data to help managers analyze such issues as planting for species diversity, determining susceptibility to pests, and projecting maintenance needs.

- Some exception must be made for trees that are routinely identified only to the genus level because of hybridization or other biological mechanisms that make species identification difficult or pointless (for example, *Malus* or *Crataegus*).
- Cultivar information is rarely collected for existing trees because field identification is difficult. For certain management goals (for example, to test survival and performance of recently released elms), it might be desirable to enter cultivar information from the vendor at planting time; the database will need a field for such cases.
- For greater economy, empty planting sites can be recorded as an entry in the "species" field that indicates the largest acceptable mature tree size (for example, "planting site small").
- Sufficient values for unidentified species (for example, "Unknown 1," "Unknown 2") must be available to accommodate all data collectors (say, five per person).

Diameter

Tree trunk diameter should be recorded. It provides an estimate of tree age from which the forest's overall age structure can be derived to aid long-range management decisions and to enable value to be estimated.

- Diameter is measured at a standard height. In most areas, the standard height is 4.5 feet (1.4 meters) above grade (referred to as diameter at breast height, dbh). It may be sufficient for many purposes to use size-class [for example, 1 to 6 inches (1 to 15 centimeters), 7 to 12 inches (16 to 30 centimeters)] because exact diameters can vary with a tree's water status, will quickly lose their accuracy, and are slower to collect.
- Standard criteria should be adopted for measuring the diameter of common exceptions such as trees on slopes and multi-stemmed trees. Trees on slopes typically are measured at 4.5 feet (1.4 meters) above grade on the uphill side of the trunk. Multi-stemmed trees are defined by the location of the pith union (e.g., below ground) or the bottom of the stem union [e.g., below 1 foot (0.3 meter)]. The stems' diameters can be listed individually, averaged, or summed (which is the least preferred method).
- Diameter tapes with 0.1-inch (2-millimeter) increments can be specified for the highest level of precision, although a Biltmore stick is faster and still provides a useful measurement. Rounding to the nearest inch or centimeter is standard practice.

- The use of calipers is sometimes specified for measurement on smaller trees, following the American Standard for Nursery Stock: at 6 inches (15 centimeters) above the ground line if dbh is less than 4 inches (10 centimeters) or at 12 inches (30 centimeters) from the ground if dbh is greater than 4 inches (10 centimeters).

Condition

There is no single system used to rate tree condition. Some inventories use a system set up by the Council of Tree and Landscape Appraisers, although that system was designed for individual tree appraisal rather than forest management.

Two examples can serve as a guide for the manager considering an inventory. The simplest system applies a number to a qualitative scheme, for example,

Code 1: good (with or without a higher category of "excellent")
Code 2: fair
Code 3: poor (with or without a lower category such as "critical")
Code 4: dead

The definitions in such a simple system must be as precise as possible (for example, fair = at least one major defect) and applied consistently across the entire inventory process. Many variations of this scheme exist.

Condition/DBH Class Frequency Matrix

Condition	*1 - 3*	*4 - 6*	*7 - 12*	*13 - 18*	*19 - 24*	*25 - 30*	*31 - 36*	*37 - 42*	*43 +*	*TOTAL*
Critical	51	87	137	110	79	53	15	8	2	543
Dead	89	89	173	86	39	18	6	1	1	502
Fair	1670	1578	1791	1219	849	734	393	113	28	8375
Good	2403	1515	694	275	170	132	67	16	2	5274
Poor	347	570	1129	953	755	516	218	73	16	4577
Very Good	23	8	4	3	3					41
Grand Total	*4583*	*3847*	*3928*	*2646*	*1895*	*1453*	*699*	*212*	*49*	*19312*

Example of inventory output. Tree condition is broken down in this table by size classes, providing an overview of future management needs.

A somewhat more analytic approach tries to separate tree stability from tree health, such as the U.S. Forest Service's STRATUM tool (www.itreetools.org):

Wood Condition

Code 1 = extreme problems = unstable
Code 2 = major problems = poor
Code 3 = minor problems = fair
Code 4 = no apparent problems = good

Foliage Condition

Code 1 = extreme problems = dead/dying
Code 2 = major problems = poor
Code 3 = minor problems = fair
Code 4 = no apparent problems = good

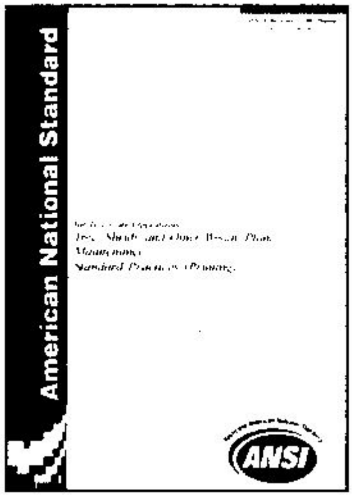
Once again, it is critical that the terms (in this case, "extreme," "major," "minor," and "problems") be clearly defined and consistently applied for the scale to provide useful information. The total can be equated to a condition class ("good," "fair," etc.) for easier understanding by nonprofessionals.

For deciduous trees, tree stability is easiest to evaluate after leaf fall, but tree health is best judged late in the dry season, when the tree's stress is reflected by foliage condition.

Maintenance

Primary maintenance needs should be included in every complete inventory. The preferred system is based on the ANSI A300 pruning standard. That document is designed to provide universal terms to ensure clarity and consistency in arboriculture.

Also, some system of priority usually is implemented. Priority can be a stand-alone attribute or integrated with the work class (for example, Remove 1, Remove 2, Prune 1, Prune 2). The basic maintenance values are



National pruning standard—*American National Standard for Tree Care Operations—Pruning* (A300, Part 1-2001).

- **Remove.** The reasons for removal range widely from mandatory removal of high-risk trees to optional removal as the best long-term management strategy for lower-risk trees.

- **Clean.** Cleaning is the removal of dead, dying, broken, or diseased wood. It is important to specify a minimum size, such as 2 inches (5 centimeters) for such a maintenance determination.

- **Raise.** Trees with this maintenance value require pruning to remove low branches that interfere with sight or traffic, as required by code or common sense. The forest manager should provide the clearances required by local code; lacking this information, 8 feet (2.4 meters) over sidewalks and 14 feet (4.3 meters) over roads may be substituted. For grounds maintenance, a minimum clearance for riding mowers can be specified [typically 7 feet (2.1 meters)].

- **Structural prune.** Young trees needing this procedure should be identified so that the all-important pruning for structure and health is carried out in a methodical manner throughout the urban forest.
- **Thin.** The selective removal of live branches to reduce density is an infrequent need, but it is a useful technique for managing watersprouts and suckers.
- **Reduce.** Selective pruning to decrease height and/or spread of the crown has many applications in the urban forest, including providing clearance for electric utilities and lighting.
- **Stump/grind.** This category can be used for existing stumps above a set diameter; exceeding a minimum height above grade, such as 2 inches (5 centimeters); or to be scheduled for removal.
- **Inspect.** A tree with questionable health but that cannot be sufficiently evaluated during data collection can be marked for further attention.

Comments

This field is for other information pertinent to a particular tree. Because the information in this field cannot be easily analyzed, the use of comments should be restricted to critical information such as the location of a limb to be removed or the presence of a bees' nest.

Extra Fields

It often is a good idea to include at least one undefined field so that an attribute can be added later without additional cost.

Tree Information—Supplemental

The more data collected, the more the inventory will cost, so urban forest managers should be careful that they will use whatever supplemental attributes they select.

Other Site Information

Some managers take advantage of field data collection to add other site attributes (hardscape damage, underground utilities, etc.).

Height

The height of the entire tree or the crown alone is relatively expensive to measure accurately because it requires a dedicated instrument, is subject to error on trees that lack a central leader, and takes quite a bit of time. Also, such information rarely is useful in urban forestry. It has been shown that trained data collectors can make reliable visual estimates if they occasionally check themselves against actual measured height. Estimates of height class [for example, 10 feet (3 meters)] are also useful, because height constantly changes.

Crown Width/Spread

As with tree height, crown width takes time to measure correctly and serves no common managerial purpose—although it may be needed for environmental assessment programs. Measurement of crown width requires that readings or estimates be made from two positions at right angles to each other so that an average can be obtained.

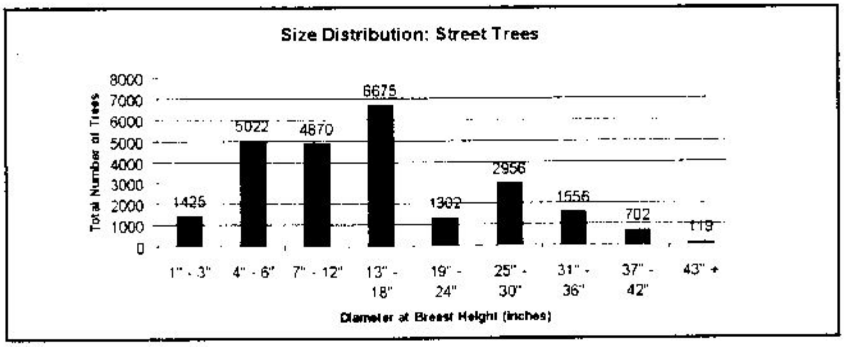
Community Status

In some urban forests, it is important to record trees that have a special status (historic, memorial, etc.).

Secondary Maintenance

A variety of maintenance categories could be added for specific purposes and specific urban forests. Some examples include the following:

- **Structural support.** In some urban forests, trees with weaknesses such as included bark or poor limb attachment may be recommended for structural support (following the ANSI A300 standard for tree support systems).
- **Soil.** Managers of high-profile trees might wish to identify those that could benefit from soil treatment. As always, clear criteria need to be established.
- **Lightning protection.** Large trees located in open, exposed areas have the greatest risk of lightning strikes, and lightning protection systems (following ANSI A300 standard for lightning protection systems) might be indicated for some high-value trees.
- **Pests.** Significant and enduring pests sometimes are tracked during an inventory. Records often are limited to primary lethal agents (such as the pathogen that causes sudden oak death) or ones that cause structural failure (such as emerald ash borer).



Example of inventory output. The number of trees in each size class is shown in a bar graph that helps the tree manager project future needs.

Risk Assessment

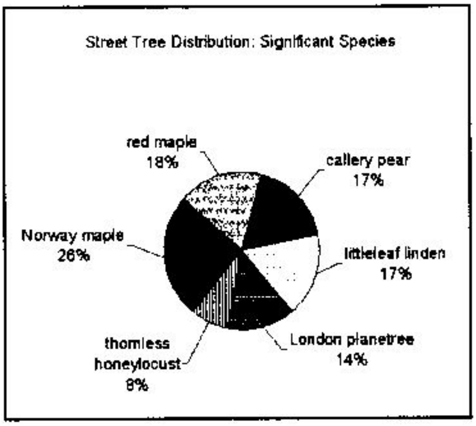
Each tree can be rated for potential risks to people or property, and the results can be helpful in prioritizing work when budgets are limited.

- A simple numeric method has been defined and adopted by ISA that rates each of three categories (probability of failure, size class of the tree part, significance of target). Applied to the entire forest, this scheme enables work to be prioritized by starting from the highest totals and working down as far as time and budget allow.
- Other methods are also available. What matters most is that a well-defined method for identifying high-risk trees be applied consistently.
- Good risk assessment requires knowledge, training, and experience. Volunteers usually are not assigned this responsibility.
- A field should exist for flagging a large tree or tree part identified to be in the process of failing (for example, newly opened crack below leader junction) on a significant target so that immediate notification can be made.

Plant Health Care

For urban forests that are managed with sufficient resources, it can be worthwhile to record required treatments for plant health care. Examples of attributes under this heading include

- **Irrigation.** Temporary or permanent watering of at-risk individual trees could be indicated if clear criteria exist for how much and how long to water.
- **Mulch.** It can be important in some contexts to know which trees need mulching. Clear criteria about mulch depth and width should be defined if this attribute is to be used.
- **Fertilization.** Where applicable (based on the ANSI A300 fertilization standard), trees that will benefit from a fertilization regimen can be identified.



Example of inventory output. The dominant species are displayed in a pie chart, helping urban forest managers attain diversity in future planting decisions.

Images

In some situations, a photo of the tree may be requested during an inventory. If the images are to be included, rigorous criteria for image quality, dating, the tree-photo reference system, and storage method are required.

Quality

The final, and possibly most neglected, inventory topic is quality. Urban forest managers should take all steps possible to ensure they have a reliable and useful product. If practical, the manager should ask for a dry run to make sure that he or she gets data and software that meet inventory needs.

Contracting out a tree inventory is no different from that of any other service, and standard consumer cautions should be used:

- Match local needs to service.
- Evaluate equivalent vendors and products.
- Ask for and consult references.
- Do a hands-on test of the software that will be used.
- Write detailed requirements and specifications for bidding.
- Solicit recommendations and reviews from other urban forest managers.
- Check product specifications, history, and usage.

These standard procedures provide a good base for evaluating the quality of tree inventory services.

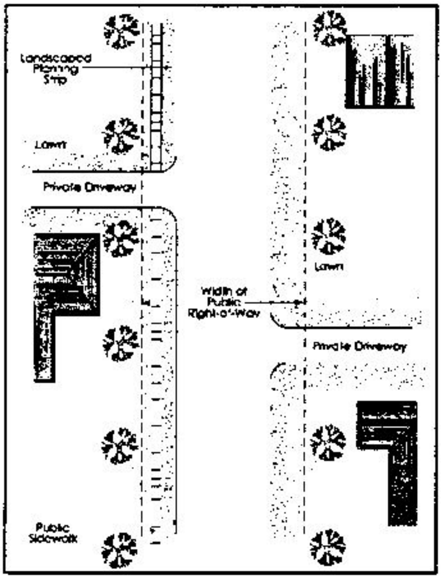
In addition, steps can be taken to maximize quality, no matter which method or vendor is chosen. These steps can be divided into questions of data quality and data integrity.

Data Quality

Features

- Provide all information required so that the crew will include all managed trees. Doing so may require maps, right-of-way information, and other indications of inclusion.
- If no existing criteria exist, give the data collectors clear written directions on how to proceed.
- Spell out the criteria (check local code, if relevant) for determining when a marginal or boundary line tree will be included (for example, any part in, mid-point in, entire tree in).
- Ask for details on options with regard to tree location equipment and available map data.

- Make sure that an explicit method exists for dealing with unrecognized species. The method should include sampling, labeling, and subsequent identification efforts.



Credit: City of Milford, Connecticut. Used with permission.

Example of the importance of right-of-way information. In this case, public trees have been planted on private property through the use of easements. Without this information, data collectors would not include these trees in the inventory.

Attributes

- Examine attributes carefully to make sure that all necessary data are collected, that nothing is included that will not be used, and that the attributes make sense in the local context.
- Specify in writing a maximum percentage of unknowns (for example, 1 percent).

Values

- Specify the level of accuracy required for tree diameter, and verify how unusual cases will be handled.
- Examine the condition system (categories, definitions, and codes) carefully, and make sure it can be understood and used.

- Where feasible, require a list to be submitted showing that data collectors doing risk assessment are ISA Certified Arborists or the equivalent.
- Make sure that the fields and the values within them are (1) clear and (2) mutually exclusive so that data analysis will be effective and reliable.
- Require an explicit statement of field data quality control from the vendor. The statement should include level and timing of review by the project manager.
- Where feasible, select a random segment of data early in the process and have it reviewed by a qualified member of the manager's own staff for accuracy and consistency.

Data Integrity

Data Entry Errors

- If electronic media are not being used for data collection, require a written procedure for quality control of data entry (such as double keypunch).
- If electronic media are being used, ask how field data are being backed up during collection.
- Check that drop-down lists are used throughout the system so that the data will be recorded in a consistent format and without spelling errors.
- Inquire about error-checking methods that will be applied to field data.
- Make sure that permission to alter the actual database is appropriately limited.

Software

- If using an off-the-shelf spreadsheet or database, be sure that sufficient professional help is available locally for support.
- Obtain an explicit statement of level and duration of support for commercial packages, including response to software bugs.
- Try to get free maintenance releases (for example, version 1.0 to 1.2) of commercial packages and ask for the update policy, frequency, and costs.

Storage

- Adopt an explicit policy of regular scheduled backups, as well as mandatory local backup after data entry.
- Establish a method and schedule for regular off-site storage.
- Establish backup policies in cooperation with local IT people.

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