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# TREE INVENTORIES, PART 2: Strategic Decisions

*Part 1 of this article, which is an excerpt from ISA's* Best Management Practices: Tree Inventories, *appeared in the June issue of* Arborist News *and dealt with inventory objectives and tactics. Part 2 deals with strategies for conducting an inventory.*

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- understand the options for various types of inventories and the advantages and limitations of each.
- discuss the attributes that may or may not be included in tree inventories.
- explain how technology, tools, personnel training, and available resources affect the nature and quality of a tree inventory

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.

## 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—usually within about ten percent. The minimal sample size to achieve this level of accuracy is three to six percent, depending on how much variation there is from site to site. New GIS-based sampling tools are available on 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 sub-areas, such as by land use (for example, new subdivisions, historic district, and industrial areas).

### 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 which 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.

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

### Complete Tree Inventories

A complete, or 100 percent, tree inventory includes all the trees (and empty planting sites) in the urban forest. Typically, in a municipal environment, this 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

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

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). 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. 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. However, if the data are inaccurate, inconsistent, or incomplete, no manager or software application in the world can make up for it.

Although the exact list will depend on managerial objectives, complete tree inventories typically include the following attributes. 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 like to also indicate a sub-area such as ward, precinct, neighborhood, zone, management area, subdivision, or quadrant. Doing so 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 between associated sets of data within the software. Standard attributes include the following:

- 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 address
  - site location information, such as side, front, right, left, rear, or median—using a consistent method of locating trees' 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.)

**The location of each street tree should be clearly identified so that it can easily be found for future maintenance work.**

### 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 again finding a specific tree that cannot easily be linked to some permanent reference object.

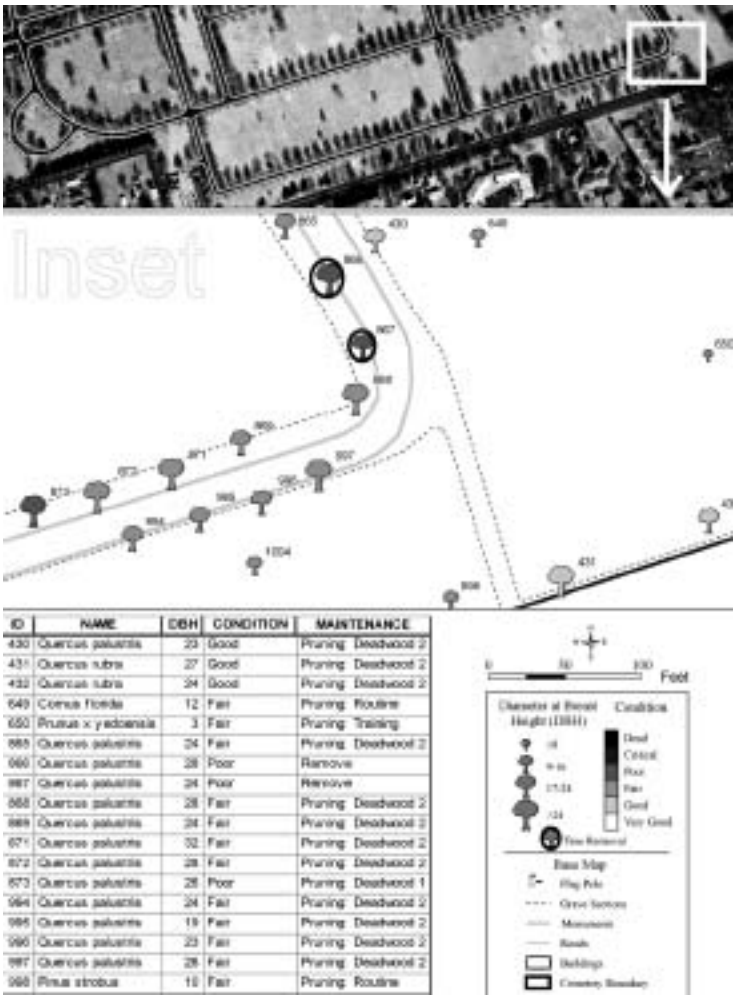
## Tree Information—Standard

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 (http://plants.usda.gov) database 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




| ID | NAME | DBH | CONDITION | MAINTENANCE |
|---|---|---|---|---|
| 430 | Quercus palustris | 20 | 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 |
| 665 | Quercus palustris | 24 | Fair | Pruning Deadwood 2 |
| 666 | Quercus palustris | 28 | Poor | Remove |
| 667 | Quercus palustris | 24 | Poor | Remove |
| 668 | Quercus palustris | 28 | Fair | Pruning Deadwood 2 |
| 669 | Quercus palustris | 24 | Fair | Pruning Deadwood 2 |
| 671 | Quercus palustris | 32 | Fair | Pruning Deadwood 2 |
| 672 | Quercus palustris | 28 | Fair | Pruning Deadwood 2 |
| 673 | Quercus palustris | 28 | Poor | Pruning Deadwood 1 |
| 984 | Quercus palustris | 24 | Fair | Pruning Deadwood 2 |
| 985 | Quercus palustris | 19 | Fair | Pruning Deadwood 2 |
| 986 | Quercus palustris | 23 | Fair | Pruning Deadwood 2 |
| 987 | Quercus palustris | 28 | Fair | Pruning Deadwood 2 |
| 988 | Pinus strobus | 18 | 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 photographs (top) or CAD drawings (middle), and are directly associated with an attribute data table (bottom).**

**Trees should be identified by genus and species using botanical names.**

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; therefore, 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 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, 7 to 12 inches). Because exact diameter can vary with a tree's water status, measurements might not remain accurate. Individual diameters also take more time 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 above grade on the uphill side of the trunk. Multi-stemmed trees are defined by the location of the pith union (for example, below ground) or the bottom of the stem union (for example, below 1 foot). The stems' diameters can be listed individually, averaged, or summed (which is the least preferred method).
- Diameter tapes with 0.1-inch 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 above the ground line if dbh is less than 4 inches, or at 12 inches from the ground if dbh is greater than 4 inches.

**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.

**Condition/DBH Class Frequency Matrix**

| Condition | 1 - 3 | 4 - 6 | 7 - 12 | 13 - 18 | 19 - 24 | 25 - 30 | 31 - 36 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Critical | 51 | 87 | 137 | 110 | 79 | 53 | 15 | 532 |
| Dead | 89 | 89 | 173 | 96 | 39 | 18 | 6 | 500 |
| Fair | 1670 | 1578 | 1791 | 1219 | 849 | 734 | 393 | 8234 |
| Good | 2403 | 1515 | 694 | 275 | 170 | 132 | 67 | 5256 |
| Poor | 347 | 570 | 1129 | 953 | 755 | 516 | 218 | 4488 |
| Very Good | 23 | 8 | 4 | 3 | 3 | | | 41 |
| Grand Total | 4583 | 3847 | 3928 | 2646 | 1895 | 1453 | 699 | 19051 |

**Example of inventory output. Tree condition is broken down by size class, providing an overview of future management needs.**

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.

A more analytic approach tries to separate tree stability from tree health, such as the U.S. Forest Service's STRATUM (Street Tree Resource and Analysis Tool for Urban forest Managers) tool at 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 in temperate climates, 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

- 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.
- Cleaning is the removal of dead, dying, broken, or diseased wood. It is important to specify a minimum size, such as 2 inches for such a maintenance determination.
- 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 over sidewalks and 14 feet over roads may be substituted. For grounds maintenance, a minimum clearance for riding mowers can be specified (typically 7 feet).

- 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.
- The selective removal of live branches to reduce density is an infrequent need, but it is a useful technique for managing watersprouts and suckers.
- 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.
- This category can be used for existing stumps above a set diameter; exceeding a minimum height above grade, such as 2 inches; or to be scheduled for removal.
- A tree with questionable health 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 accurately measure: 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) 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:

- 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).
- Managers of high-profile trees might wish to identify those that could benefit from soil treatment. Again, clear criteria need to be established.
- Large trees located in open, exposed areas have the greatest risk of lightning strikes, and lightning protection systems (following the ANSI A300 standard for lightning protection systems) might be indicated for some high-value trees.
- Significant and enduring pests sometimes are tracked during an inventory. Records often are limited to primary lethal agents (such as sudden oak death) or ones that cause structural failure (such as emerald ash borer).

**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

- Temporary or permanent watering of at-risk individual trees could be indicated if clear criteria exist for how much and how long to water.
- 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 used.
- Where applicable (ANSI A300 fertilization standard), trees that will benefit from a fertilization regimen can be identified.

**Images**
In some situations, a photo of the tree may be requested during an inventory. If images are to be included, rigorous definitions of image quality, dating, 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.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