LOCATING TREES USING A GEOGRAPHIC INFORMATION SYSTEM AND THE GLOBAL POSITIONING SYSTEM

by Brian Kane and H. Dennis P. Ryan III

Abstract. This paper reviews the basics of GPS and GIS technology and describes their application for locating trees in rural park and forest settings. During a hazard tree survey in a Massachusetts state park, project members investigated the feasibility of using GPS and GIS to create maps that highlighted individual trees and other landmarks. The project intended to show that GPS and GIS can accurately locate trees. This technology is especially useful for arborists and urban foresters who need to map trees in rural parks, along rural roads and trails, and on large estates and institutional land, where other location methods are impractical. Depending on a variety of circumstances, GPS and GIS can be used in combination with aerial photographs or standard line and symbol maps to create appropriate tree maps for a particular area. Although certain problems still hinder the mapping process, new technology developments will expedite using GPS and GIS to produce maps.

Many arborists and urban foresters need to locate trees precisely. During tree inventories for municipalities, institutions, large estates, and the like, knowing tree locations helps managers properly care for a property's plants. When surveying rural roads, nature parks, and hiking trails, managers need to identify and locate hazard trees. Before technology made new techniques available, arborists and urban foresters used several methods to locate trees during surveys, including simple diagrams, line and symbol maps, aerial photographs, and surveying. In certain scenarios, some location methods are impractical. Where it is not possible to use other methods, global positioning system (GPS) and geographic information system (GIS) technology can be used to locate trees. In many rural parks and trails, maps are inadequate to find specific trees, and surveying equipment can be too cumbersome to carry into remote hiking locations. GPS technology can be useful in such rural locations.

In a recent survey of hazard trees in a Massachusetts state park, project members used GPS, aerial photography, and GIS technology to locate the trees. The project intended to explore the feasibility of using GIS and GPS to locate trees, and it serves as a basis for further scrutiny of this technology. Based on the project, this paper provides a review of GPS and GIS and describes the project to give readers an overview of the techniques and equipment used and the options available for a similar undertaking. As GIS and GPS technology becomes more affordable, arborists and urban foresters will more readily utilize it for locating trees in areas where other methods are not viable.

Global Positioning System (GPS)

Sponsored by the U.S. Department of Defense (DoD), 25 GPS satellites currently orbit the earth. Each satellite transmits a particular code at a particular moment of time. GPS receivers track the satellites and note the time when they receive the signals transmitted from the satellites. Because the receiver knows what time the satellite sent its code and what time the receiver received it, the receiver can determine its distance from the satellite by calculating the time difference between transmission and reception. By calculating the distances to 3 satellites, the receiver can trilaterate its location. Because of the various errors that accompany calculating precise time differences, as well as signal interruption and obstruction, a fourth satellite is necessary to provide an accurate location (Figure 1) (Trimble Navigation 1994).

Factors affecting accuracy. Several factors hinder satellite signals and foster inaccuracy. First, the satellite arrangement determines accuracy. The best satellite constellation has 3 satellites evenly spaced around the horizon and one directly overhead (Figure 2). To reduce signal transmission errors caused by atmospheric disturbances, the satellites must be above the horizon by a pre-

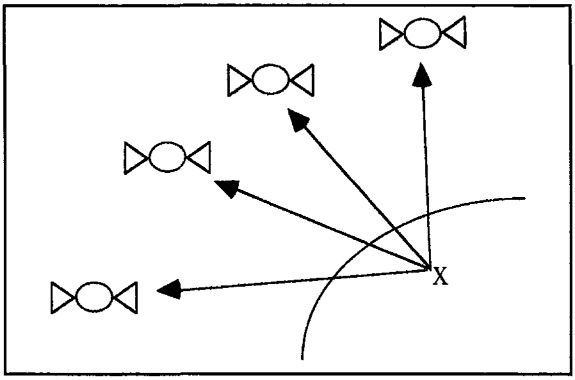

Figure 1. To find its coordinates, the GPS receiver needs to measure its distance from 4 GPS satellites (adapted from Trimble 1994).

determined elevation (usually 15 degrees). Impediments, such as a dense tree canopy, microwaves, and reflected signals (off of buildings, mountains, and water) weaken satellite signals, further reducing accuracy. GPS forecasting software can be used to plan data collection to coincide with periods of high accuracy (Trimble Navigation 1994; Zwick and Deleo 1996). Figure 3 shows a portion of a GPS satellite forecast produced by Trimble Geo-PC® software.

Interference from tree canopies is one of the most significant factors affecting accuracy. Dense tree canopies can sufficiently weaken GPS signals so the GPS receiver cannot take a position reading. Conducting surveys during winter will help reduce the problem of tree canopy interference; the bare twigs of deciduous trees do not block GPS signals as thoroughly as leaves do (Trimble Navigation 1994; Zwick and Deleo 1996). Obviously, with an evergreen canopy, winter surveys will not alleviate the canopy interference problem. High-grade GPS receivers can be programmed to compensate for the user moving away from a specific tree in order to avoid canopy interference. The user can stand where a clear GPS signal exists and the GPS receiver will automatically calculate the distance from the desired tree to the user's location (Zwick and Deleo 1996).

In addition to the above factors that cause inaccuracy, the DoD has programmed an intentional erroneous signal into the satellites to guard against illicit use of GPS receivers for locating strategic military targets. The signal causes the receiver to misrepresent actual coordinates by up to 100 m (328 ft). Postprocessing (or differential correction) of data can eliminate virtually all of this deliberate error. High-grade GPS receivers offer real-time differential correction, which eliminates the need to postprocess GPS positions in a separate computer after the position-gathering session. After differential correction, survey-grade GPS receivers produce coordinates within 1 cm (0.4 in.) of their actual position; mapping-grade receivers (similar to the one used in this project) produce coordinates with accuracy between 2 and 5 m (6.6 to 16.4 ft) (Trimble Navigation 1994; Zwick and Deleo 1996). Depending on the project, such accuracy can be acceptable for locating trees.

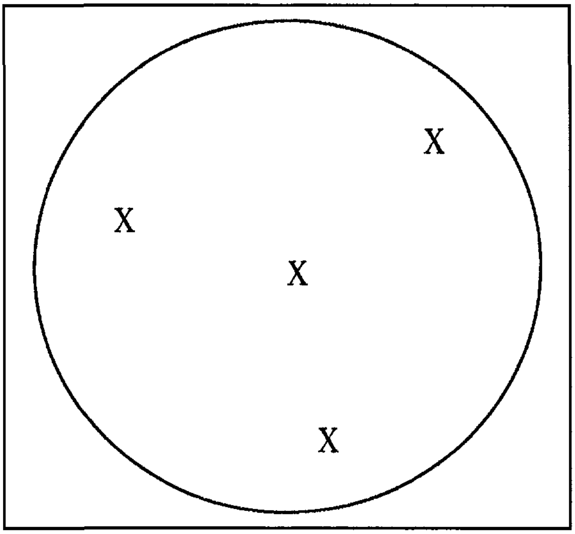

Figure 2. This view is looking up into the sky and shows the ideal GPS satellite constellation of 3 satellites spaced evenly around the horizon (above 15 degrees) and one directly overhead. Each "X" represents a satellite (adapted from Trimble 1994).

Postprocessing. Because DoD-introduced error is consistent to all GPS receivers within a certain radius at a given time, placing a receiver at a known location (called a base station), makes it possible to compare the skewed signals with the known location and determine the error introduced by DoD. Then, the receiver's skewed positions can be corrected by using the error determined by the base station (Trimble Navigation 1994; Zwick and Deleo 1996). Permanently established base sta-

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Trimble Navigation LTD PFPLAN
 ver. 1.08 - GPS Visibility Information

User location:
  42° 18' N, 72° 30' W  The Notch
Elevation mask" 15° 3D PDOP: 6 2D PDOP: 6   Interval: 30.0
Almanac: C:\GEO-PC\DATA\961210.SSF
25 Satellites Considered: 1-7 9 10 14-19 21-27 29-31
Best PDOPs from Wed Dec 11 00:00:00 1996 to Wed Dec 11 23:59:00 1996 LCL

LCL     3 Satellite PDOP  4 Satellite PDOP   Satellites Visible
09:30    17 21 261.82     1 17 23 262.73    1  9 17 21 23 26
10:00     1  9 171.99     1  5 17 233.53    1  5  9 17 21 23
10:30     1  9 171.88     1  9 17 233.59    1  5  9 17 21 23
11:00     1  9 301.94     9 21 25 302.93    1  5  9 21 23 25 30
11:30     5 15 251.72     1  9 15 252.58    1  5  9 15 21 23 25 30
12:00     5 15 231.81     1  5 15 232.73    1  5 15 21 23 25 30
12:30     5 15 211.72     1  5 15 212.98    1  5 15 21 25 30
13:00     5 15 211.62     5 15 21 252.43    1  5 15 21 25 30
13:30    22 29 301.68    21 25 29 302.48    1 14 21 22 25 29 30
14:00     6 22 291.70     6 22 25 292.62    1  6 14 22 25 29 30
14:30     1 14 301.81     1 14 25 302.89    1  6 14 22 25 29 30
15:00     1  6 141.86     1 16 22 252.47    1  6 14 16 12 25 29
15:30     6 16 222.31     6 14 16 293.61    6 14 16 22 25 29
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Figure 3. Planning report produced in Trimble Geo-PC software shows satellite availability and position dilution of precision (PDOP) for half hours of local time. A PDOP below 6 indicates high accuracy.

tions exist throughout the United States. Table 1 lists four base stations within range of most sites in Massachusetts. In this project, the GPS receiver and base station needed to be within 483 km (300 mi) of one another for differential correction to be accurate. For real-time differential correction, the GPS receiver used in this project would have required an additional receiver and would have received base station data from only a 48 km (30 mi) radius from the base station.

One last advantage of GPS technology is its compatibility with a GIS. Because GPS positions collected in the field readily download into a GIS computer program, GPS data can be easily translated into GIS format. The complete automation of GPS position collection, differential correction, and translation into GIS reduces errors of transcription (Trimble Navigation 1994; Zwick and Deleo 1996).

Geographic Information System (GIS)

A GIS is a computer mapping system that accepts, organizes, analyzes, and displays data in a spatial format. With an appropriate computer, the advantages of GIS include large data storage capacity, overlay analysis, statistical analysis, informative graphic outputs, and forecasting future consequences based on current actions. Currently, GIS's are used in a variety of ways. Advancing technology has made GIS available to more users, including those with fewer financial and personnel resources. During the early stages of GIS development, prohibitively expensive technology meant that users were exclusively large land-use management agencies such as the USDA Forest Service (McLean 1995; Miller 1995). With GIS, data are digitized, entered into the computer, and then referenced to a common coordinate system. A unique identifier (a number) links both locations and their attributes to the coordinate system. A GIS stores 2 types of data, spatial (or location data) and nonspatial (or attribute data). Spatial data refer to the geographic location of a point on a

Table 1. Sites to obtain GPS base station files for postprocessing.

Site	Latitude	Longitude	Access
DEP/Quabbin Reservoir	42°16′48.019″	72°20′52.427″	DEP network
University of Rhode Island	41°29′20.175″	71°31′39.763″	Internet
Vermont DOT	44°15′43.104″	72°34′56.556″	Telephone
Connecticut DOT	41°40′24.718″	72°42′52.25″	Telephone

map; a GIS can reference the point in various Cartesian coordinate systems. Nonspatial data refer to characteristics of a particular point or object (Robinson 1989; Avery and Berlin 1992; Rice 1993; Singletary 1993; Goodchild 1994; McLean 1995; Miller 1995). For example, a tree's latitude and longitude coordinates are spatial data; species, size, and vigor are nonspatial attributes of the tree.

The key to the expedience of GIS is its ability to link various layers of information to a specific map coordinate. In other words, a GIS can take a map coordinate and attach numerous characteristics to it. Each characteristic is stored in a separate layer or theme but is linked to all other layers and the coordinate by a unique identifier. By combining whichever layers are necessary, the user can create a map that illustrates the specific output desired to answer a question (Figure 4) (Robinson 1989; Avery and Berlin 1992; Singletary 1993; Goodchild 1994; McLean 1995; Miller 1995). In urban forestry, GIS has been used to plot individual street and park trees and their attributes in relation to urban infrastructure for street tree inventories (Figure 5) (Singletary 1993; McLean 1995; Miller 1995; Goodwin 1996). Each theme (e.g., trees, utilities, lampposts, house lots) can be overlaid onto the base map of the city being surveyed. A user can add different themes onto the map to show, for example, how many hazard trees occur next to bus stops. Many combinations are possible.

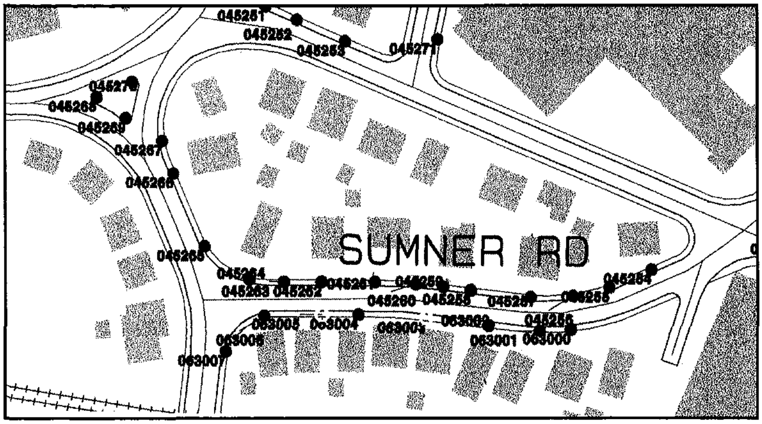

Figure 5. This GIS-created map of a street shows street tree locations and provides a reference number that links the location to attributes about that location (in this case a tree).

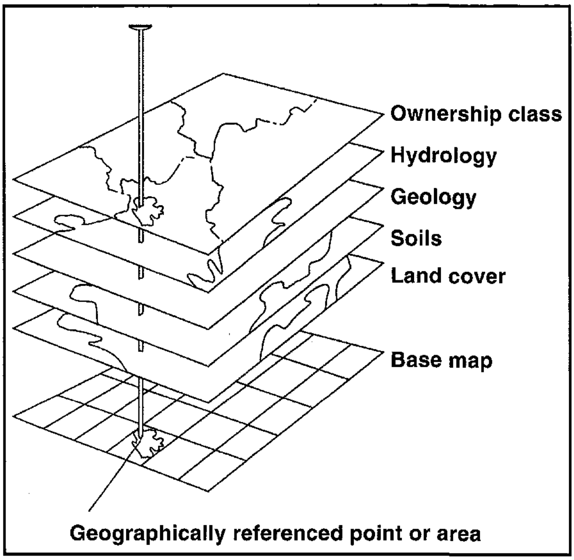

Figure 4. GIS expedites overlay analysis—the process of assembling various themes or layers on top of a base map to create a custom map suited for a specific situation. Each layer is geographically referenced; when combined, layers will fit onto the base map (courtesy of Avery 1992).

Overlay analysis, as the above process is known, is not new. Before computer technology, land-use mappers relied on acetate sheets placed over base maps and marked with grease pencils. GIS, however, reduces the messiness and inefficiency of that labor-intensive process. GIS can amend map layers each time newer information is available or whenever changes to a particular layer occur (McLean 1995).

Project Description

To determine whether GPS and GIS could be used to map trees, project members surveyed hazard trees in a Massachusetts state park (The Notch Visitors' Center, "The Notch," in Amherst, Massachusetts). The inspection team surveyed the park on 3 different occasions to encounter varying weather patterns and GPS satellite constellations. While the primary focus of this project was to determine the feasibility of using GPS to locate trees in areas where other methods were impractical, the inspection team also used aerial photographs where appropriate. Developing line and symbol maps, tagging trees, and surveying can also be used to locate trees. As described below, however, certain areas merit utilization of GPS technology. The project did not make statistical comparisons between methods because it sought only to determine the feasibility of using GPS to locate trees in areas where other methods were impractical. In some areas, the inspection team successfully used an aerial photograph to locate trees; the GPS receiver was not necessary.

Where landmarks abounded and tree density was low, an aerial photograph was more convenient and more accurate than the GPS receiver. Around the park's administration building and parking lot, the inspection team easily pinpointed individual trees on the photograph. Taking positions with the receiver, given its potential 5 m (16.4 ft) inaccuracy, would not increase the precision afforded by the aerial photograph. Where tree density was higher and landmarks were scarce, the Trimble Navigation Systems Geo-Explorer® GPS receiver proved helpful. Along trails especially, the receiver located trees more easily than using the aerial photograph because portions of the trail or identifying landmarks were difficult to discern on the photograph. With both methods, data were transferred to a GIS to create a map showing trees, infrastructure, and trails at The Notch.

Aerial photographs. After reviewing several combinations of various scales and prints, project members decided to use black-and-white, leaf-off aerial photographs (scale 1:1200). Acquired from Lockwood Resources, Rochester, New York, the photos were originally smaller scale (1:4800) 22.5 x 22.5 cm (9 x 9 in.) prints, flown in May. Lockwood enlarged the prints to 0.9 x 0.9 m (36 x 36 in.), thereby enlarging the scale to 1:1200. Enlargement did not diminish the photo's resolution; the image remained crisp and revealing. To avoid damaging the enlargement, and to ease note-taking, inspectors brought a 27.5 x 42.5 cm (11 x 17 in.) color photocopy of the enlargement into the field. Bringing out shades of gray, the color photocopy more clearly replicated the photograph than did a black-and-white photocopy. While the photocopy slightly degraded the enlargement's resolution, it was clear enough to locate trees. Pinning the photocopy to a (50 x 50 cm) 20 x 20 in.) plywood board eased marking trees and reference points on the photocopy. After determining a tree's location using landmarks, inspectors numbered it in pencil on the photocopy.

Global positioning system (GPS). In areas where the separation of individual trees on the photocopy was unreliable, inspectors used the GPS receiver to locate trees and other points. In addition to locating trees, inspectors collected points for signs, trails, roads, and a building. Creating a new computer file for each point taken, the GPS receiver can store up to 75 files. Depending on the scope of the survey, this could limit the efficiency of using GPS. Unlike a street tree inventory, where 75 points can be collected fairly quickly, this hazard tree survey required hiking long distances through rough country and collecting an average of only 10 positions per hour. After each data-collecting session, project members downloaded the files into a computer for postprocessing then deleted files from the receiver to restore memory for the next session.

Postprocessing. Before transfer to a GIS, the GPS positions must be downloaded into a computer and postprocessed (unless real-time differential correction is available on high-grade GPS receivers). Locations collected with the Geo-Explorer are stored as separate files in the receiver's memory. For each location, Trimble Navigation recommends collecting 120 positions. Under ideal conditions, the receiver collects 1 position each second, requiring a user to remain at each spot for at least 2 minutes. When obstructions disrupt satellite signals, the user sometimes must adjust the receiver's position to continue tracking satellites. At The Notch, inspectors usually collected the requisite 120 positions within 3 or 4 minutes. With a high-grade GPS receiver, a user could enter attribute data (for example the tree's size and hazard condition) into the receiver while it collects positions. This would increase the efficiency of using the GPS and further automate the data-collection process.

After the receiver's files have been downloaded to a computer, Trimble Navigation's Geo-PC® software differentially corrects them. Project members used base station data from the University of Rhode Island's GPS website (http://www.edc.uri.edu/gpsdata/). Internet access was the easiest way to acquire the base station files. After correcting the files, Geo-PC® averages all the positions for a particular location to create a more accurate coordinate. The software then translates the postprocessed files into GIS format, and they are downloaded into the GIS. This way, transfer of information is completely automated, leaving little room for transcription error. Figure 6 illustrates the 5 steps for collecting and processing GPS data.

GIS operations. Several GIS coverages or layers of information were developed from the GPS data, including a coverage showing trees, a coverage detailing infrastructure, and a coverage highlighting the trails. Each of these coverages became a layer of information in the GIS (Figure 4). The GIS can overlay any combination of these coverages on top of a base map, which in this project was the aerial photograph of The Notch.

Scanning the aerial photograph with a Sharp SX610 27.5 x 42.5 cm (11 x 17 in.) high-resolution scanner transferred the photo into the GIS. In conjunction with Adobe PhotoShop® software, the scanner produced a 300 dpi, 8-bit, grayscale computer image. Higher-resolution images (up to 600 dpi) require substantial computer memory (27.5 x 42.5 cm [11 x 17 in.], 600 dpi images can consume up to 50 Mb of memory), significantly slowing GIS operations.

UNIX-based ArcInfo® version 7.04 then registers (changes the image into a map and gives it known coordinates) the computer image to reduce displacement error. Displacement is the increasing inaccuracy of scale further from the center of the photo, due to topography; it is inherent in aerial photographs (Avery and Berlin 1992). To register the image, a GIS operator attaches GPS coordinates to their respective points on the image. Any known point, such as trees, utility poles, signs, and the like can serve as control points for registration. With more control points spread across the image, a higher degree of accuracy can be achieved during registration. Thus, when overlaying other GPS points on the registered image, a common frame of reference is provided.

Two prominent errors are inherent in the registration process. First, unless the user registers each individual pixel of the image using real-world coordinates (and this is extremely unreasonable), the registration is not perfectly accurate. The second source of error comes from the innate error of the GPS coordinates, which can be inaccurate from up to 5 m (16.4 ft).

After project members overlaid the GPS-collected locations of trails and trees on top of the registered image of The Notch, the computer image was enlarged to various scales (1:420 and 1:240). Maps were plotted of a single location within the park. Two problems arose in this process. First, at such large scales, resolution is lost during plotting—the plotted map is not nearly as lucid as the aerial photograph. Second, to print an enlarged image of the entire study

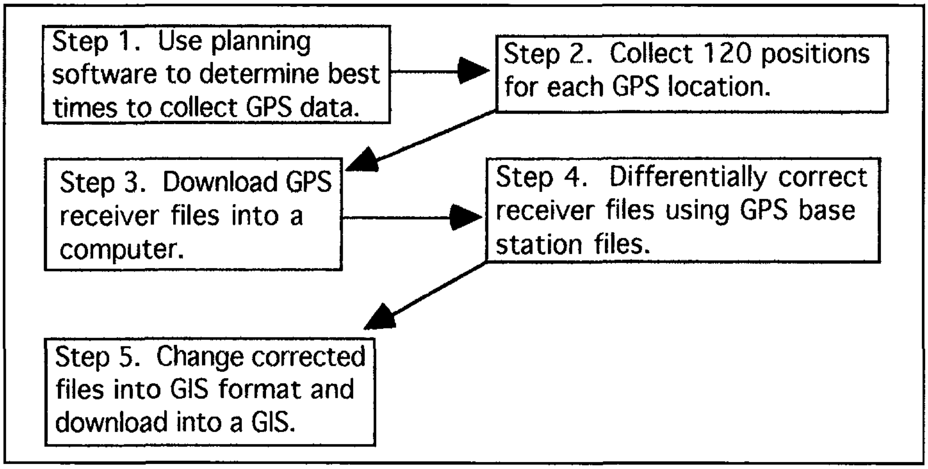

Figure 6. The 5 steps for collecting and processing GPS data.

area required a 0.9 x 0.9 cm (36 x 36 in.) plotter whose resolution was completely inadequate for the desired scale. High-quality plotters of appropriate size are available but are prohibitively expensive (US$20,000 and up). As an alternative, project members attempted to plot several 20 x 27.5 cm (8.5 x 11 in.) high-resolution maps of the same location within The Notch. These maps showed improved resolution at large scale but still did not present photograph quality.

Discussion

This project found 4 ways to utilize GIS and GPS technology for locating trees. Depending on the specific circumstances of a project and the tools available, GIS and GPS can be used in various combinations with aerial photographs or other base maps.

1. The GPS receiver can be used to collect points for an entire GIS map; this can be accomplished without any aerial photographs or other line and symbol maps to serve as a base map in the GIS. For example, someone collecting data can trace the outline of buildings and parking lots, walk any roads and trails, and take points for trees, signs, and other landmarks. Once the data are in the GIS, the lines and points can be tidied up to improve the visual quality, using different symbols for each landmark. A GIS can produce a simple line and symbol map from the GPS information sufficient for areas with adequate landmarks and where other maps are unavailable. Along rural roads or hiking trails, where maps do not exist and landmarks are scarce, it is possible to walk or drive with a GPS receiver and collect positions for hazard trees and the trails or roads to create a map showing trees that need to be removed.

2. If aerial photographs of appropriate scale are available, they usually provide better visual recognition of an area than do line and symbol maps. However, because of displacement, distances on the photo do not correspond to accurate distances on the ground (Avery and Berlin 1992). Furthermore, where landmarks are scarce and tree densities are high, locating individual trees can present a problem. When photos are available but insufficient for locating individual trees, the visual detail of the photo can be supplemented by registering the photo (as a computer image in a GIS) with GPS coordinates. After registration, GPS coordinates for trees and other landmarks that cannot be located on the photograph (such as trees along dense trails) can be overlaid on the image. In the GIS, it is easy to manipulate those points to highlight the trees and to draw colored lines for the trails, making it easier to find specific items on the photograph.

Alternatively, if the photograph presents a clear image—one that does not need supplemental lines for trails or points for trees—the photograph can be used for all the location data. The information can then be digitized into the GIS. This is a simple process of transferring information from the photograph into the computer by tracing over the photograph on a digitizing board. This way, points are manually linked from the photograph to the registered computer image, allowing the GIS to store and manage the spatial and nonspatial data.

A combination of the above 2 processes can also be used. For example, if trees and points are easily located around a building or landmark on the photograph, they can be digitized into the GIS. If other areas of the photograph do not lend themselves to easy resolution (such as trails and dense tree cover areas), a GPS receiver can be used to glean their locations and transfer them into the GIS.

3. Displacement can be removed from an aerial photo with photogrammetry. Cartographers use photogrammetry to create traditional line and symbol maps. Instead of registering the photo in the GIS with GPS coordinates, photogrammetry transforms the information on the photo into a map. All the information and topographical features from the photograph, including tree locations, trails, and other pertinent information, are transferred to a map. The map can then be scanned or digitized (traced) into a GIS. While photogrammetry accurately transfers information from a photograph to a map, it is labor intensive and takes longer than using GPS coordinates to register an image. Additionally, the map does not present the visual resolution of the photograph.

4. If available, an orthophoto can serve as a base map in the GIS. An orthophoto is a com-

puter image of a photo that has been registered and is therefore a map (Avery and Berlin 1992). MASSGIS is gradually developing black-and-white orthophoto coverage, at a scale of 1:5040, for Massachusetts. Because they are already registered, orthophotos are highly accurate and much more compatible with GPS coordinates, and the errors endemic to registering an image with GPS are not as severe. Orthophotos can be downloaded directly into a GIS; they do not have to be scanned. A GIS can enlarge the image to a scale as large as 1:480 without losing resolution. Obtaining orthophotos is difficult; presently, MASSGIS has only one staff member capable of producing hard copies of orthophotos. Complete orthophoto coverage of the state and ease of acquisition might be a few years in the future.

Conclusion

A GIS is useful because it can store and manage vast amounts of data. The primary drawback is that even though users can work with a photo-quality image in the computer (such as a scanned aerial photo or an orthophoto), producing a hard copy of similar quality requires a prohibitively expensive plotter. Realistically, such plotters are available only to government agencies and large companies that specialize in GIS mapping. New technology will make GIS and GPS increasingly compatible and user friendly. These methods will also become more affordable to arborists and urban foresters, allowing a greater automation of tree mapping in developed areas. Affordable GPS receivers will offer greater accuracy and allow data storage, so users can enter attribute data such as tree characteristics directly into the GPS receiver. Within a few years, the DoD intends to remove its intentional erroneous signal from the GPS satellites, eliminating the need for postprocessing GPS data (Zwick and Deleo 1996).

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Literature Cited

Avery, T.E., and G.L. Berlin. 1992. Fundamentals of Remote Sensing and Airphoto Onterpretation (5th Ed). McMillan, New York, NY. 472 pp.

Goodchild, M.F. 1994. Integrating GIS and Remote Sensing for Vegetation Analysis and Modeling: Methodological Issues. **In** Walsh, S.J. (Ed.). Applications of Remote Sensing and Geographic Information Systems in Vegetation Science. Opulus Press, Uppala, Sweden.

Goodwin, D.W. 1996. *A street tree inventory for Massachusetts using a geographic information system.* J. Arboric. 22:19–28.

McLean, H.E. 1995. *Smart maps: Forestry's newest frontier.* Am. For. 101(3&4):13–20.

Miller, L. 1995. *GIS branches into urban forest management.* Am. City & County 110(2):35–43.

Rice, D.S. 1993. *Tomorrow's urban forestry—today.* Urb. For. 13(4):8–16.

Robinson, V.B., et al. 1989. Expert Systems for Geographic Information Systems in Resource Management, pp 155–165. **In** Ripple, W.J. (Ed.). Fundamentals of Geographic Information Systems: A Compendium. American Society of Photogrammetry and Remote Sensing and American Congress on Surveying and Mapping, Falls Church, VA.

Singletary, L. 1993. Technology: GIS and Computer Assisted Planning, pp 89–99. **In** USDA Forest Service, Northeastern Area State & Private Forestry. An Ecosystem Approach to Urban and Community Forestry.

Trimble Navigation Ltd. 1994. Mapping Systems, General Reference (software manual). Sunnyvale, CA.

Zwick, R. and J. Deleo. 1996. GIS and GPS workshop. 28 October, 1996. Holdsworth Hall, University of Massachusetts, Amherst, MA.

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Résumé. La faisabilité d'utiliser les systèmes GPS et GIS pour produire des cartes d'inventaire d'arbres de rues qui mettent en relief les arbres sur une base individuelle ainsi que les autres éléments de repérage sur le terrain a été étudiée. Dépendant de la diversité de situations, le GPS et le GIS peuvent être utilisés en combinaison avec des photos aériennes ou des plans standards pour créer des plans de localisation d'arbres pour un secteur particulier. Cet article décrit les étapes opérationnelles et effectue un survol de différentes options pour produire des plans avec le GPS et le GIS.

Zusammenfassung. Es wurde die Eignung der Anwendung von GPS und GIS zur Erstellung von Baumkatastern untersucht, die einzelne Bäume und andere Landmarken hervorheben. In Abhängigkeit von verschiedenen Umständen, können GPS und GIS in Kombination mit Luftaufnahmen oder Standartkarten genutzt werden, um Baumkataster für bestimmte Regionen zu erstellen. Diese Studie beschreibt die praktische Ausführung und diskutiert verschiedene Möglichkeiten, mit GPS und GIS Baumkataster anzulegen.