

**SELECTION OF GEOGRAPHIC INFORMATION SYSTEM (GIS)
SOFTWARE FOR THE MAPPING OF LIVING PLANT COLLECTIONS**

By

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the requirements for the degree of Master of Science in Public Horticulture

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ABSTRACT

Botanical gardens, as stewards of living plant collections, are given the duty of managing the data concerning their collection. These data are both historical and geographical. Since the 1950s, people have been working to manage their geographic data using a system of computer modeling. This system has evolved into what is now commonly known as a Geographic Information System (GIS). This study looks at the database and mapping software system combinations currently in use at botanical institutions. A compiled list of forty-nine named institutions shows the reader what combinations are in current use.

This study is written for institutions that already have a computerized database in place, and are seeking information on choosing a computerized mapping system. A discussion of the history of Computer Aided Drafting (CAD), Geographic Information System (GIS) and computer mapping in general, educates and prepares the reader to become familiar with particular software packages. A literature and history review provides the reader with resources for more information on database systems if they do not currently have one implemented in their institution.

Plant mapping professionals rank a series of 20 questions on the importance of computerized mapping software to the institutional needs. The three most commonly utilized mapping software packages were then evaluated on a point-by-point basis to determine which software options most completely fulfill the garden users' stated desires. One software choice was found to be the most flexible for the garden users' stated desires.

Chapter 1

INTRODUCTION

Although we tend not to think about it much, it's a plain fact that everything human beings do takes place at a particular location on the earth: every activity, thing, trend, issue or phenomenon has a geographic component to it. In the routine activities listed above, the question of "where" is a crucial part of the larger issue....¹

Cartography, the art and science of making maps or charts, is among the most ancient and universal of sciences. Throughout recorded history, people have made maps and charts of the physical and cultural features of the world around them, whether on the vast geographic scale of the stars and the seas or the smaller scale of streets and houses within a small village. No matter the scale or the kind of feature, this question will eventually arise: "Where is it?" Since the 1950s, people have used computer modeling to address that question and to assist in drawing maps to show the answer. Combining the fields of cartography, computer science and the broad field of geography led to what is now commonly known as Geographic Information Systems (GIS). Through the development of GIS software in the 1950s and 1960s, to the large scale commercial availability in the 1980s, in 2000 there were believed to be about one-million regular users of GIS, with about five-million casual users worldwide.²

¹ David Davis, 2003, p. 1.

² Longley et al, 2001, pp 12-13.

For decades, botanical garden employees have drawn maps and worked to keep track of the location of plants. Accurate mapping enables the garden employees to answer promptly and accurately when someone asks, "Where is it?" and this in turn makes the visitor's experience more enjoyable and the researcher's work more efficient. Before GIS became available, gardens used paper, linen or Mylar®³ maps to keep track of the locations of their plants. However, a map displaying or illustrating a botanical garden must change frequently as the gardeners create new displays and replace dead plants. Historically, when plants died or were removed, many garden cartographers updated their maps merely by erasing those plants from the map, leaving no record of the plants' spatial location. Even if a voluminous archive of historical maps was held in a botanic garden, no efficient system existed to answer where a particular plant had been or which plants had occupied a specific space in the past. The question arises, "Is there a way to do this with computerized mapping software?"

GIS offers a two-part solution to these problems. First, a database keeps track of information about individual plants, including their present and past locations. Second, a mapping program presents that information to the user in a geographic perspective that answers spatial questions effectively. Many GIS software systems that allow these functions are on the market today.

This study is written for institutions that already have a computerized database in place, and are seeking information on choosing a computerized mapping system. The goals of this research are (1) to survey the software systems currently available for mapping a living plant collection, (2) to compare the three most

³ Mylar® is copyrighted by E. I. du Pont Nemours and Company. All rights reserved in the USA and/or other countries.

commonly used software system options based on their features and (3) to find the most flexible software option available for mapping living plant collections. These findings may assist botanical garden managers who wish to add a computerized mapping system to their existing computerized database system.

This study consists of three surveys to address these goals. Survey I, sent to member institutions of the American Association of Botanic Gardens and Arboreta (AABGA), sought to discover what, if any, computerized mapping systems member institutions currently use. Survey I also asked institutions what features they employed most often and what tools they utilized the least. This was followed by Survey II which asked the institutions that had responded to Survey I to rank specific software features based on their importance to their institutional needs. Survey III asked three leading mapping software companies to describe how their products fulfilled the functions that the respondents to Survey II had ranked. This enables a comparison of the three software packages from a botanical garden perspective.

This study begins with a discussion of the history of Computer Aided Drafting (CAD), Geographic Information System (GIS) and computer mapping in general, in order to familiarize the reader with particular software packages. A literature and history review provided the reader with resources for more detailed information on database systems if they do not currently have one implemented in their institution.

This thesis proceeds as follows: Chapter 2 provides an overview of the history of GIS and garden mapping procedures. Chapters 3, 4 and 5 describe Surveys

I, II and III respectively, and discuss the findings of each survey. Chapter 6 summarizes the results of this thesis and makes recommendations for future areas of research.

Chapter 2

HISTORY OF GIS AND GARDEN MAPPING

An investigation of garden mapping was conducted to confirm the need for this research, and by reviewing the literature. The scarcity of resources pertaining to mapping in garden settings confirmed the need for such a study. While a good deal of research exists on GIS and mapping in general circumstances, little information focused on the selection process for uses at botanical gardens. Moreover, the development of GIS is presented first to place mapping into a historical context and to provide an overview of GIS.

2.1 History of GIS

Before the 1950s, most drawings produced in the world were graphite on paper. In the 1950s, the US Air Force created the Semi Automatic Ground Environment (SAGE) which displayed computer-processed radar data in a graphic system.⁴ This was one of the beginning points of Computer Assisted Design (CAD). CAD, in its most basic sense, is a two-dimensional drawing software package.

CAD commonly refers to Computer Assisted Design or Computer Aided Drafting, while CADD commonly refers to Computer Aided Drafting and Design. Computer aided drafting systems usually allow for displaying, drawing and editing

⁴ Schoenherr, 2003.

multiple layers. CAD drawings can be two-dimensional digital representations of manually drafted drawings or three-dimensional models.⁵

The next generations of drawing packages were the forerunners of today's more simplistic GIS. These systems were initially referred to as Graphic Information Systems. That system stored, analyzed and displayed multiple geographic information layers as well as tabular data in a digital environment. In simplest terms, "a GIS can be thought of as a spatial database."⁶

The first GIS system is commonly believed to be the Canada Geographic Information System, or CGIS. It was designed in the mid 1960s as a computerized mapping system for land inventory. In 1964 the Harvard Laboratory for Computer Graphics and Spatial Analysis was established. In 1966, SYMAP, the first raster GIS, was created by Harvard researchers. In the late 1960s there was another era of development as the government readied for the 1970 census. This included the Dual Independent Map Encoding-Geographic Database Files (DIME-GBF) developed by the US Bureau of Census. In the very late 1960s and 1970s, the early development evolved into large GIS corporations. This included the formation of ESRI® Inc. and Intergraph Corporation, both in 1969. In the 1980s with the drop in price of computers, the era of commercially available GIS software exploded. This included the software Arcinfo in 1981 and MapInfo in 1986. In the year 1994, President Clinton signed Executive Order 12906 which leads to the creation of US National Spatial Data Infrastructure (NSDI) and the Federal Geographic Data Committee (FGDC). The year 1999 marked the first worldwide GIS day on November 16. By the

⁵ Montgomery and Schuch, 1993, pp 5-6.

⁶ Lang, 1998, p 4.

year 2000, there were believed to be one-million regular users of GIS, and about five-million casual users of GIS worldwide.⁷

While both CAD and modern GIS may contain layers of information defined as points, lines and polygons, they are distinctly different. In traditional CAD the layers are merely graphical. In a modern GIS, the layers relate to a special database that contains spatial information. A user can query the GIS for information from multiple layers simultaneously. It is this analytical power in GIS that separates it from traditional CAD.

For an overview of GIS applications used to manage natural resources, the book, *Managing Natural Resources with GIS* by Laura Lang, is recommended. Published by ESRI® Press in 1998, it focuses on sites using ESRI® products, but it also provides information of the variety of applications available. It offers a number of examples of how GIS is being used including settings in agriculture, clean water, coastal protection, and disaster planning and recovery. It also contains an Appendix with information on where to obtain GIS data for natural resources.

One large sector of the GIS industry is the utilities sector containing water, electric, gas and telephone lines. Utility companies fund much of the research and development of computerized mapping systems because accurate mapping of the locations of underground wires, gas lines and water mains permits more efficient construction, maintenance and daily operations. To the computer, a wooden telephone pole is simply a tree in a new form and use. When accessed in the database, both the telephone pole and the tree have an age, a date it was planted or put in that spot, a height, and a species or material data. With the utility companies providing

⁷ Longley et al, 2001, pp 10-13.

inspiration, encouragement, and financial sponsorship, upgrades to the utility database and mapping systems flow freely.

2.2 Mapping Features in a GIS

Both CAD and GIS maps show features using points, lines or polygons that represent real-world features or as grid cells defining areas. The two methods of representing geographic data in the digital computers are referred to as raster or vector views of reality. In a raster representation, geographic space is divided into an array of cells that are usually square, but can also be rectangular. All geographic variation is then represented by assigning properties to these cells. In a vector representation, all lines are captured as points connected by straight lines. Lines are captured in the same way with the term polyline used to describe a curved line represented by a series of straight segments between points. To capture an area object in vector form, one only needs to outline the shape of the area.⁸

For a garden, a mapped polygon may represent garden grounds, planting beds, perennial gardens, a cluster of multi-trunked trees, and the outline of a shrub hedge, building footprints or parking lots. A line may define a stream, an underground water main, the stripes on a parking lot or an overhead power line. Individual points mapped in the garden represent a tree, a shrub, or a singular herbaceous plant. Other objects mapped as points may include such items as a telephone pole, a fire hydrant, or the location of an in-ground mapping marker.

To create a geographic database, whether using CAD or GIS-based, there are three, not mutually exclusive, ways to create a digital geographical database. The

⁸ Longley et al, 2001, pp72-73.

first is to digitize existing analogue data using a digitizing tablet. The second is to carry out a digital survey by means of a total station system. The third is to obtain data in a digital form from a data supplier. In all cases the data must be geometrically registered to a defined coordinate system to allow different data layers to overlay together.⁹

One way to gather data in paper format is by converting current mapped information into digital information. This is accomplished in several ways, by digitizing, scanning and/or hand entry to create digital mapped data.

Digitizing a map involves manually tracing a paper map fastened on a digitizing tablet with a cursor or digitizing puck. The x, y location is recorded as the user traces features of interest to create points of data, strings of points (or lines) of data and/or closed lines (or polygons) of data. The digitizing process creates vector data that represent geographic features as points, lines and polygons.¹⁰

Scanning involves taking a paper map and making an image of the document which is used in the computer system. A scanned map for example, may contain the outlines of a garden. The scanned image is a raster (grid) layer of data in the software system with each subsequent scanned map as a separate layer. Scanned maps are special tiles covering a layer area. In some cases, numerous adjacent scanned maps will make up a garden where each scanned map represents a spatial tile covering the subsection of the larger area. These layers are pieced or “sewn” together to make a continuous layer covering the entire garden using GIS technique referred to as merge

⁹ Burrough and McDonnell, 1998, p 75.

¹⁰ Montgomery and Schuch, 1993.

or mosaic. This process creates one single raster layer of the entire garden represented as a grid pattern, with each cell holding one attribute value.

The process of transforming an image from an image coordinate system to a map coordinate system is called image rectification or ortho-rectification. To do this control points on an image are linked to ground control points whose coordinates are known. The more points on an image that is referenced, and the more spaced out they are, especially towards the edges, increase the accuracy of the rectification. This results in a map being georeferenced. Georeferenced historical scanned layers can then tell the garden user the location of specific classical plants or objects.

To survey, according to dictionary.com, is "To determine the boundaries, area, or elevations of (land or structures on the earth's surface) by means of measuring angles and distances, using the techniques of geometry and trigonometry."¹¹ This means to measure it. A varying array of equipment is available for purchase to assist an institution in surveying. Companies also exist that will survey your property for you, for a price.

With basic surveying, two people are needed. One to operate the total station, and one to hold the reflective prism (pole) at the point being measured. With some remote controlled systems, a single person can control both the station and the prism. The total station unit automatically records the data of point, line, distance, height, etc. Since all survey points are obtained from survey measurements their locations are always relative to other points. Measurement errors need to be apportioned between multiple points in a survey. For this reason, it is helpful to store

¹¹ As viewed on www.dictionary.com, February 11, 2005.

both the measurements and the point information inside a GIS database until the survey is complete.¹²

For an institution that wants to survey its own property, a book that discusses surveying in a thorough manner is *Elementary Surveying: an Introduction to Geomatics* by Paul R. Wolf and Charles D. Ghilanni, which is currently in its tenth edition. This textbook describes the equipment, calculations, mapping surveys and even astronomical observations. Wolf's text is good for people who are looking into surveying their grounds, and for those needing to convert paper maps into digital layers, requiring additional surveying for updates.

While a garden might be as small as a few square feet where measuring with a tape measure will suffice, land holdings can cover hundreds of square miles and still need a way of measuring. The use of the Global Positioning System (GPS) is a great advantage here. The Global Positioning System is a constellation of twenty-four active satellites (there are usually spares deployed as well) orbiting the earth at a height of 12,600 miles. By reading the radio signals from as few as three of these satellites simultaneously, a receiver on earth can pinpoint its exact location.¹³ The more satellites a receiver can "see" at any one time, the more accurate the location reading. Several sources of error, however, may reduce the accuracy of a reading. An out-of-the-box accuracy for GPS receivers can range from 10 to 15 meters for an average device. By utilizing GPS equipment, cartographers can map where equipment is in relation to the earth, and each other, over large distances. With the use of differential GPS (DGPS), the level of error can often be reduced to one to three meters with high

¹² Longley, 2001, pp.210-211.

¹³ Steede-Terry, 2000, p. 3.

end GPS units. DGPS uses two receivers, the user moving about the survey area has one receiver, and a stationary receiver at a known and accurately surveyed point, known as a base station. The further the roving GPS unit is from the stationary receiver, the less accurate the resulting positions. Most GPS users who live in coastal areas of the United States use the U.S. Coast Guard beacons as their method of differential correction which is freely available, while GPS users who live inland may have to acquire differential correction from a third party. Universities, government agencies and private companies who are already operating base stations frequently post data on the Internet. There are also companies who sell real-time correction as a service to GPS users.

Geographic Positioning System (GPS) is based on the principle of the length of time it takes a signal to travel from a satellite to a receiver on the ground. The GPS satellites constantly transmit a coded radio signal that indicates their exact position in space and time. The receiver measures how long it takes a the signal to travel from the satellites. By measuring the distance from three or more satellites, the location of the receiver can be determined by triangulation. With signals received from four satellites, the elevation of the receiver can also be determined.¹⁴

GPS may not be the best choice for mapping small areas where inches or centimeters of accuracy between items is important. In small spaces, a simple tape measure may still be more accurate, unless using a high end GPS with an accuracy of within centimeters with a base receiver. GPS also can have difficulty in the shadows of buildings. This is where a building is blocking out the signals from satellites in one (or more) direction(s). Moreover, the signals may bounce off a nearby building

¹⁴ Longley, 2001, p. 211.

causing the receiver to hear several signals, increasing error. Similar errors occur in narrow ravines or areas between mountains where limited sky is clearly visible. Tree canopies also interfere with the signal, causing lower levels of accuracy.

To obtain a short introduction to GPS, start with the book *Integrating GIS and the Global Positioning System* by Karen Steede-Terry. As a condensed book, it is a fast and easy way to learn the basics of GPS. After the introductory chapter, the following chapters discuss varying real-world uses of GPS such as tracking elephants in Africa which keeps the reading interesting and fast.

Digital data sets from data suppliers range from small geographic scale to continent wide and available for nothing, downloadable from the internet, to expensive personalized datasets. When combining datasets, attention must be paid to data compatibility. When data are combined, there may be differences in coordinate system, map projection, scale, base level and attributes for each individual dataset. For example, a geologic survey dataset could classify soils differently than a survey for agricultural resources. The part of the data that explains the way the survey was conducted and the information collected is called the metadata. Metadata can assist the user in understanding the dataset and processing the data in a GIS. Particularly where data crosses administrative, political and geographical boundaries, data compatibility and consistency must be checked.¹⁵

A garden cartographer may convert historical paper maps into computer-based digital information by digitizing and/or scanning the maps for archival, manipulation, and planning purposes. Inputting data into a GIS allows it to be spatially referenced, enabling the various data layers to overlay together. This enables

¹⁵ Burrough and McDonnell, 1998, p 81.

a GIS user to easily add features using a Geographic Positioning System (GPS) and permits all data layers to geographically align with one another. Following that, the user may then rotate or stretch the digital map as necessary to match known positions with specific GPS points. The act of assigning a location to an atom of information is to georeference a record. Without locations, data are said to be non-spatial or aspatial data.¹⁶ Although georeferencing has many different names (e.g. image rectification, vector name, address matching) the process is essentially to convert the layers' x, y spatial coordinates to a user-selected geographic coordinate system and projection.

One book that goes through the steps of data selection and data conversion is *GIS Data Conversion: Strategies, Techniques and Management* by Pat Hohl, editor. This book begins with a discussion of data definitions, types, sources and processing before moving on to converse on project management. The project management chapters discuss the topics of hardware considerations, various software systems available, as well as staffing and budgeting considerations. The data conversion chapters explain the differences of how to obtain data from airborne sensing, aerial photos, Global Position Systems (GPS) scanning and keyboard data entry to get data into the GIS. Data transfer and data quality are also addressed.

The *ESRI Map Book* by ESRI® Press shows a variety of maps created using GIS. While all these examples have been created using ESRI® products, it gives any prospective user a view of what is possible. This is published annually by ESRI® Press.

¹⁶ Longley et al, 2001, p80.

2.3 Garden Mapping

Historically, gardens used paper, linen or Mylar® maps to keep track of the locations of their plants. Institutions with larger land holdings or that have mapped their land areas in greater detail often created a grid system on their property. This system creates a series of spatial quadrants, often called spatial tiles, of an uniform size. Each mapped quadrant becomes one page in a larger book of mapped quadrants, often called a map book.

The problem with mapping in this fashion arises when a plant dies or is moved. This system erases it from the map, leaving behind no record of its original spatial location. Caretakers of gardens with an historical background often state a desire to return a garden to its configuration at a particular date in the past. The question arises then, "Is there a way to do this with computerized mapping software?" Consequently, the designers of computerized mapping software sought a means to keeping maps up to date while preserving historical data.

Computerized mapping may also assist in other areas of garden management. A computerized mapping system that allows multiple users to edit data may assist in staff time management by allowing landscape designers and area gardeners to keep datasets and maps up to date. The system may be used for resource management because plants and areas are easier to find using computerized query tools. It can assist in staff time management, because the landscape designers and area gardeners can be networked to make changes on the maps. This allows the plant curator more time to do non-mapping tasks.

Garden cartographers also have a desire to make current maps non-static in time. Having a computerized mapping system allows the cartographer to make new maps as features change within the garden. Also, the digital environment allows more

printing choices than paper maps. Previously, garden maps were copied by machine, or the person would only take one page of a map at a time out into the garden. Computer mapping systems allow the user to print at different scales and views. Also, the garden employee does not have to worry about dropping the only map copy in the mud since the data are stored in the computer. With the data stored electronically and new printing capabilities, a new map can be printed at will.

The *Canadian Journal of Botany* in 1964 published James H. Soper's article on "Mapping the Distribution of Plants by Machine." This study acknowledges the fact that prolonged production of maps by hand and study of these maps can produce eye-strain and visual fatigue. While the level of data available from one of these early "dot maps" is vastly different from the levels of data retrieval available from a current GIS system, this article showcases the early desire of cartographers and botanists to move map-making to a computerized format.

In 1988, David Murbach published a *Directory of Computer Use in Plant Record Keeping*. This study included a survey of 144 botanical institutions taken in 1984 of which forty-two (29%) were using computers to assist them with their plant records.¹⁷ Seventy-two institutions planned on computerizing by 1994. One-hundred three of the 144 respondents said they would like a listing of hardware and software available at other botanical gardens. Today, botanical institutions still desire a list of mapping software used at other botanical gardens.

This research focuses on the mapping needs of institutions that currently have a collections policy and computerized plant records database systems. For gardens that are researching the creation of a database system, the *Curatorial Practices*

¹⁷ Murbach, 1998, p7.

for Botanical Gardens by Timothy C. Hohn and *A Guide to the Computerization of Plant Records* by the American Association of Botanic Gardens and Arboreta (AABGA) Computer Information Services Committee are excellent resource guides. *Curatorial Practices for Botanical Gardens* has recently been updated and reprinted by the Edmonds Community College. Showcasing curatorial practices in use, *A Guide to the Computerization of Plant Records* explains how to create and use a database system. While these guides are very basic, many may find it necessary to reference the Appendix to fully understand the terminology used.

The American Association of Botanic Gardens and Arboreta has compiled a binder titled *Plant Records Policies* for organizations working on defining their plant records policies. This is a notebook available on loan from the organization. The notebook can be viewed at the AABGA offices, or they will mail it to a member of AABGA for their viewing. Inside the document are the plant record policies from the Scott Arboretum (1989), Longwood Gardens (1991), Bernheim Foundation (1992), Chicago Botanic Garden (1994) and the Morton Arboretum (undated).

2.4 Current Popular Database Software

In the 1960s, the Plant Sciences Data Center (PSCS) of the American Horticultural Society undertook work to computerize many separate database collections onto one mainframe computer. The Royal Botanic Gardens Kew computerized its database collections in 1969. In the early 1970s, the Royal Botanic Gardens Edinburgh and the Matthaei Botanical Gardens of the University of Michigan computerized their living plant collections data. These institutions were the forerunners of modern computerized plant database systems.¹⁸

¹⁸ Walter and O'Neal. 2001.

The purpose of this research is to compare computerized mapping programs for organizations that already have database programs. Some of the most frequently used database software systems are mentioned in the following paragraphs. While the researcher is not attempting to compare or recommend any particular database system, the discussion below will provide the reader with an overview of each database software including what it is and who makes it. Information on costs and purchasing is available in Appendix A: Database and Mapping Software Pricing and Purchasing Information starting on page 65.

BG-BASE ^{TM19} is a database application – a series of databases tables, windows reports and programs designed to manage collection information. It runs on the database management system of OpenInsight. BG-BASETM was created in 1985 at the request of the director of Arnold Arboretum of Harvard University. Originally it had twelve database tables to handle the information. It has evolved into a database application with literally dozens of tables that all cross-reference with each other to give the user complete information on plant collections. This database application is made specifically for botanic gardens collections. Currently there are modules for living collections, preserved collections, conservation, education, propagations, DELTA (Descriptors) and HTML output.²⁰

Microsoft ® Access²¹ is a database management program. Training is available on-line for free and at many continuing education locations. Microsoft®

¹⁹ BG-BASETM is trademarked by BG-BASE, Inc. in the USA and/or other countries.

²⁰ As viewed on www.rbge.org.uk/bg-base.

²¹ Microsoft®, Microsoft® Access, Microsoft® Excel and FoxPro® are either registered trademarks or trademarks of Microsoft Corporation in the USA and/or other countries.

Access comes packaged with some versions of Microsoft® Office. There is a discount for academic licensing.²²

Linda Plato interned at the Elizabeth C. Miller Botanical Garden in Seattle Washington in 1999. During her time as an intern, she developed an accession database for the garden in Microsoft® Access. This database is available free of charge to other botanical gardens. For more information, please contact Linda Plato or the Elizabeth C. Miller Botanical Garden.²³

Microsoft® Excel is a spreadsheet. Training is available on-line for free and is also available at many continuing education locations. Microsoft® bundles Excel in the Microsoft® Office packages that come with new personal computers. There are discounts available for academic licenses and volume licenses.²⁴

FileMaker²⁵ is a database management system. Training is available on-line as well as at many educational facilities. There are discounts available for volume purchases.²⁶

There is an application called CGI Virtual Collections^{TM27} which includes modules for acquisitions, collections, loans, and catalogues. It is designed to work as management software for archives, libraries and museums. This is an additional

²² As viewed on www.microsoft.com on March 1, 2005.

²³ As viewed on www.lindaplato.com and www.millergarden.org on March 1, 2005.

²⁴ As viewed on www.microsoft.com on March 1, 2005.

²⁵ FileMaker® is copyrighted by FileMaker, Inc. in the USA and/or other countries.

²⁶ As viewed on www.filemaker.com on March 1, 2005.

²⁷ Virtual CollectionsTM is trademarked by Gestion de Collections Informatisées, Inc. in Canada and other countries.

module and is designed to run on FileMaker™ (purchase of FileMaker™ is required).²⁸

2.5 Current Popular Mapping Software

The purpose of this research is to compare computerized mapping programs for organizations that already have database programs. Some of the most frequently used mapping software systems are mentioned in the following paragraphs with basic information. Information on costs and purchasing is available in Appendix A: Database and Mapping Software Pricing and Purchasing Information starting on page 65.

Autodesk, Inc.²⁹ manufactures the current product most commonly associated with the term “AutoCAD”. The initial demonstration of AutoCAD® Version 1.0 occurred in November 1982 at a COMDEX trade show.³⁰ As of 2005, AutoCAD® is on its nineteenth release, AutoCAD® 2005. The Autodesk company began in 1982 by a group of programmers who were currently working for different companies and looking to start their own venture. AutoCAD® is now sold worldwide supported worldwide.

AutoCAD® is primarily a drawing and drafting tool. It is used by architects, civil engineers and landscape designers. AutoCAD® classes are commonly taught in horticulture and engineering college courses. AutoCAD® was not created to

²⁸ As viewed on www.gci.ca on March 1, 2005.

²⁹ Autodesk, AutoCAD®, Autodesk Map®, and Autodesk MapGuide® are either registered trademarks or trademarks of Autodesk, Inc., in the USA and/or other countries.

³⁰ Walker, 1994.

be a GIS system. Educational institutions and government agencies can qualify for a reduced rate.³¹

A very specialized software system called BG-Map,³² is a product developed specifically for mapping botanical gardens. Designed by Mark Glicksman of Glicksman Associates, Inc., this product is based in AutoCAD® and works with BG-BASE™ as its database system. In the late 1980's, Mr. Glicksman was a consultant to the Morris Arboretum of the University of Pennsylvania in Philadelphia, and he used AutoCAD® for his engineering work while the Morris Arboretum was in the process of acquiring BG-BASE™ for its database management program. An idea developed to link these two programs for the benefit of plant management. The initial installment at Morris Arboretum occurred in November 1991, with continual developments since then. New features have been added each year, mostly spearheaded by user suggestions. BG-Map is designed to work with pre-existing plant records in BG-BASE™ and plant maps in AutoCAD®. BG-Map is not a drafting or design tool, but a tool to link plant records in BG-BASE™ with AutoCAD® maps. BG-Map adds features like plant lists, the ability to find plants in an area or by name, and printing features.³³

³¹ As viewed on www.autodesk.com on March 1, 2005.

³² BG-Map, GreVid™, Garden Notepad and Visitors QUICKFinder are either registered trademarks or trademarks of Glicksman Associates, Inc., in the USA and/or other countries.

³³ Mark Glicksman, personal communication, 2004.

Environmental Systems Research Institute, now commonly known as ESRI®³⁴, began in 1969 by Jack and Laura Dangermond as a private consulting group that specialized in land-use analysis projects. Jack Dangermond trained as a landscape architect at Harvard University, is the president of ESRI®. He has a strong belief in geography and the importance in applying its concepts to improving the lives of everyone. The business began with an initial investment of \$1100, and is still privately owned by Jack and Laura Dangermond who have no intention of going public or having a change in ownership. The early mission of ESRI® in the 1970's focused on the principles of organizing and analyzing geographic information. During the 1980's, ESRI® devoted its resources to developing and applying a core set of application tools that could be applied in a computer environment. The basic tools included analysis, edit and mapping tools. In 1982, ESRI® launched its first commercial GIS software called ARC/INFO. Today ESRI® employs more than 2800 employees with users in over 200 countries.³⁵

ESRI's most simple GIS package available is ArcView™. ArcView™ provides mapping, data use, analysis, editing and geoprocessing capabilities. ArcEditor™ is the GIS system for editing and managing GIS data. ArcEditor™ includes all of the functionality of ArcView™ in addition to comprehensive GIS editing tools. ArcEditor™ supports single user editing as well as a collaborative process between multiple editors. ArcInfo® is a full function GIS that extends the

³⁴ ESRI®, ArcInfo®, ArcGIS®, ArcIMS®, ArcPad®, ArcView™, ArcPublisher™, ArcReader™, Spatial Analyst™, 3D Analyst™ and ArcEditor™ are either registered trademarks or trademarks of Environmental Systems Research Institute, Inc. (ESRI), in the United States, the European Community, or certain other jurisdictions.

³⁵ Longley, p. 170.

capabilities of ArcView™ and ArcEditor™. Additional extensions are also available for purchase. These extensions includes ArcPublisher™, Spatial Analysis, ArcScan™, Trimble GPS Extension, and ArcPublisher™. ArcPublisher™ is the software to publish maps that can be downloaded and read over the internet via ArcReader™, a free software. Spatial Analysis gives the user advanced raster GIS spatial analysis capabilities. ArcScan™ gives the user raster to vector conversion. Trimble GPS Extension, enables users who collect their data with TrimbleTech equipment. ArcPad® allows the user to transfer data to a mobile or handheld device. Training is an additional cost for each additional GIS application. Additional training can also be found on-line, at local institutions of higher learning, and with user groups.

Free software, hardware and training bundles are available through ESRI® funded grants. There is also information on the ESRI® websites about non-ESRI® funded grants for assistance in obtaining geographic information systems acquisitions. Special rates for educational and not-for-profit institutions are available. A discount of is common for educational users and museums. Non-profits are provided on a case by case basis.³⁶

A GIS product that began with mapping utilities and migrated to mapping botanical gardens is the product Mélange™³⁷, developed by the Hilltop Consulting group of Boston, Massachusetts. Mélange™ started because of the perceived need for a true GIS product within several markets. Early research targeted the municipal and botanical garden markets, chosen because existing customers had custom solutions

³⁶ As found on www.esri.com as of March 1, 2005.

³⁷ Mélange™ is a trademark of Hilltop Consulting Group, Boston, Massachusetts, all rights reserved in the USA and/or other countries

written by Hilltop Consulting. Mélange™ is a tool that utilizes ESRI® software. With ESRI® products powering its GIS engine, Mélange™ can either enhance an existing GIS program or act as the basis for a new GIS. The basic guiding principle of the Mélange™ developers is the GIS should fully integrate all of the other systems within a garden, not merely associated with other systems through import/export functionality. Because end users have many different responsibilities, importing/exporting data files become a burden maintaining and using a mapping system. Mélange™ currently focuses on utilities and other general GIS applications with a package available for garden installments.³⁸

2.6 Associated Costs

There are many costs associated with implementing computerized mapping for an institution. Some of the other costs to consider include:

- Personnel hours
- Outside consulting
- Computer hardware – CPUs, keyboards, printers, etc.
- Database
- Mapping system software
- Mapping (data conversion from old maps)
- Mapping equipment (survey equipment, GPS, orthophotography)
- Long term map upkeep

Any facility that considers implementing a computerized mapping program should include these in calculations. A facility should also take into consideration that purchasing and maintaining a mapping system is more than a one

³⁸ Michael Doyle, personal communication, 2004.

time investment. New staff training, staff renewal training, software and hardware upgrades and the mapping of new areas, plants and items also will add to the costs.

Chapter 3

SURVEY I

This chapter presents the methods, results and conclusions of the compilation of research data from Survey I. To address the goals of this thesis, Survey I, sent to member institutions of the American Association of Botanic Gardens and Arboreta (AABGA), sought to discover what, if any, computerized mapping systems member institutions currently use. Survey I also asked institutions what features they employed most often and what tools they utilized the least. Additional insight from gardens without mapping systems was gained through survey comments and through personal communication with garden staff at such institutions.

3.1 Methods

An initial survey was created to determine which botanical gardens currently have mapping software coupled with a database system. Survey I was created and forwarded to the Office of Vice Provost for Research (OVPR) for approval. The approval letter can be found in Appendix B on page 71. A copy of Survey I appears in the Appendix C, on page 74.

Survey I contained four questions to determine whether the responding botanical garden has a computerized plant database and a computerized mapping system, and if so, what software the institution utilizes. Following these questions, the researcher asked five questions about the best features, the worst features, the most common and least common features, and what additional features the users desired.

Lastly, the researcher asked whether the respondent found the software easy to learn and use on a daily basis.

The User Survey (Survey I) was mailed to 459 institutions that were listed as American Association of Botanical Gardens and Arboreta (AABGA) Member Institutions as of March 2002. These gardens provided a representative sample of public gardens in the United States. These gardens were in variety of physical sizes, staff sizes and geographic locations. Additionally, some institutions participated in the survey after reading about the research through PlantNet, a United Kingdom (UK) plant group. Survey I allowed the respondents to reply by mail, fax or via the Internet through the website, www.studentresearcher.com.

3.2 Results

One hundred seventy-seven (177) individual institutions responded to Survey I out of 459 for a response rate of thirty-eight percent (38%). The organizations were asked if they currently use a database system, and if so, what system they use. Another question was if the respondents currently use a mapping system, and if it is a computerized system, what software is used. The responses are tabulated in Table 1: Cross Comparisons of the 177 Responses to Database Software Systems with Mapping Software Systems available on page 37. On pages 38 through 41, a reference list of institutions report on computerized mapping software. This list displays the names of institutions sorted first by the database system used, and then by the computerized mapping system. The list excluded any institutions that use a paper mapping system or do not have a mapping system. Institutions were given the option of not having their names publicly released. The institutions that preferred to not have their name published are included in the totals on Table 1, but are not listed by name

on page 38. These are represented by "Unnamed Site" references in the list beginning on page 38.

Table 1: Cross Comparisons of the 177 Responses to Database Software Systems with Mapping Software Systems.³⁹

		Database Systems																
		No Database System	Microsoft® Access	Microsoft® Access & Microsoft® Excel	BG-BASE™	BG-BASE™ & Microsoft® Access	BG-BASE™ & ArcGIS®	ArcView™40	BG-Recorder	Davey Tree Co Treekeeper	D Base	Microsoft® Excel	FileMaker Pro	Fox Pro	Mentor Pro	SYBase	Unnamed or Created in House	Total
Mapping Systems	No Computerized Mapping System	5741	17	2	23				1		2	3	11				3	119
	Microsoft® Access42		1															1
	Autodesk Products	1	7		3											1		12
	BG-Map				15													15
	ESRI® Products		7		1			1	1				2	1	1			14
	AutoCAD® Products & ESRI® Products		1			1	1											3
	Canvas												1					1
	Davey’s Tree Co									1								1
	Eagle Point LandCADD™		1	1														2
	Easy CAD		1															1
	Map Info®												1					1
	Microstation				2													2
	VectorWorks®												1					1
	Visual Cadd	1																1
	Unnamed or created in House	1	2															3
	Total		60	37	3	44	1	1	1	2	1	2	3	16	1	1	1	3

³⁹ Complete copyright information can be found in Appendix G: Trademark Information beginning on page 105.

⁴⁰ The ESRI® Products of ArcView™ and ArcGIS® use Access as their built in data base system.

⁴¹ Fifty-Seven out of a total of 177 respondents have no computerized database system and no computerized mapping system.

⁴² Microsoft® Access out of the box is not a computerized mapping system. This group stores X and Y data in a customized database.

Named Institutions Using Computerized Mapping Software

I. Microsoft® Access Database System

A Microsoft® Access as a Mapping System

- Mountain Top Arboretum

B. AutoCAD®/ Autodesk Products Mapping Systems

- Cedar Valley Arboretum and Botanic Garden
- Ganna Walska Lotusland
- Georgia Southern Botanical Garden
- Red Butte Garden and Arboretum
- The Dow Gardens
- The Friends of Vander Veer Gardens
- Unnamed site (1 site)

C. ESRI® Products Mapping Systems

- Bernheim Arboretum and Research Forest (ArcView)
- Forestry Commission, UK (ArcView)
- Missouri Botanical Garden (ArcView, ArcPad, ArcIMS)
- Santa Barbara Botanic Garden (ArcView)
- University of Tennessee Arboretum (ArcInfo)
- Winterthur Museum, Garden & Library (ArcMap)
- Unnamed site (ArcView) (1 site)

D. AutoCAD®/ Autodesk & ESRI® Products Mapping Systems

- Unnamed site (ArcInfo) (1 site)

E. Eagle Point LANDCADD™ Mapping Systems

- Illinois Central College

F. Easy Cadd Mapping Systems

- Amy B. H. Greenwell Ethnobotanical Garden

G. In-house created Mapping System

- Unnamed site (2 sites)

II. Microsoft® Access & Microsoft® Excel Database Systems

A. Eagle Point LANDCADD™ Mapping Systems

- State University of New York – Cobleskill College

III. BG-BASE™ Database System

A. AutoCAD®/ Autodesk Products Mapping Systems

- Lady Bird Johnson Wildflower Center
- W.J. Beal Botanical Garden
- Unnamed site (1 site)

B. BG-Map Mapping Systems

- Cornell Plantations
- Denver Botanic Gardens
- Descanso Gardens
- Dubuque Arboretum & Botanical Gardens
- Mendocino Coast Botanical Gardens
- Morris Arboretum at the University of Pennsylvania
- Mount Auburn Cemetery
- Mt. Cuba Center
- Queens Botanical Garden
- Rancho Santa Ana Botanic Garden
- Rio Grande Botanic Garden
- Scott Arboretum of Swarthmore College
- The Holden Arboretum
- The North Carolina Arboretum
- University of Delaware Botanic Gardens

C. ESRI® Products Mapping Systems

- Mounts Botanical Garden (ArcMap, ArcPad)

D. Microstation Mapping Systems

- Olbrich Gardens
- US Botanic Garden

IV. BG-BASE™ and Microsoft® Access Database System

A. AutoCAD®/ Autodesk Products & ESRI® Products Mapping Systems

- Unnamed site (ArcGIS) (1 site)

V. BG-BASE™ and ESRI Product ArcGIS as a Database System

A. AutoCAD®/ Autodesk Products & ESRI® Products Mapping Systems

- University of Massachusetts, Amherst (ArcGIS)

VI. ESRI Product ArcView as a Database System⁴³

A. ESRI® Products Mapping Systems

- David C. Shaw Arboretum at Holmdel Park (ArcView)

VII. BG Recorder

A. ESRI® Products Mapping Systems

- McKee Botanical Garden (ArcView, ArcGIS)

VIII. Davey Tree Co.'s Treekeeper Database System & Mapping System

- Hillwood Museum & Gardens

IX. FileMaker® Pro Database System

A. Canvas Mapping Systems

- Cincinnati Zoo & Botanical Garden

B. ESRI® Products Mapping Systems

- Oklahoma Botanical Garden & Arboretum (ArcView)
- Wellesley College Botanic Garden (ArcView)

C. Map Info® Mapping Systems

- JC Raulston Arboretum

D. Vector Works Mapping System

- Filoli, an Historical Estate

⁴³ ArcView uses Microsoft® Access as its database system.

X. FoxPro Database System

A. ESRI® Products Mapping Systems

- The Dawes Arboretum (ArcView, ArcGIS)

XI. MentorPro Database System

A. ESRI® Products Mapping Systems

- The Morton Arboretum (ArcMap)

XII. Sybase Database System

A. AutoCAD®/ Autodesk Products Mapping Systems

- University of California Botanical Garden at Berkeley

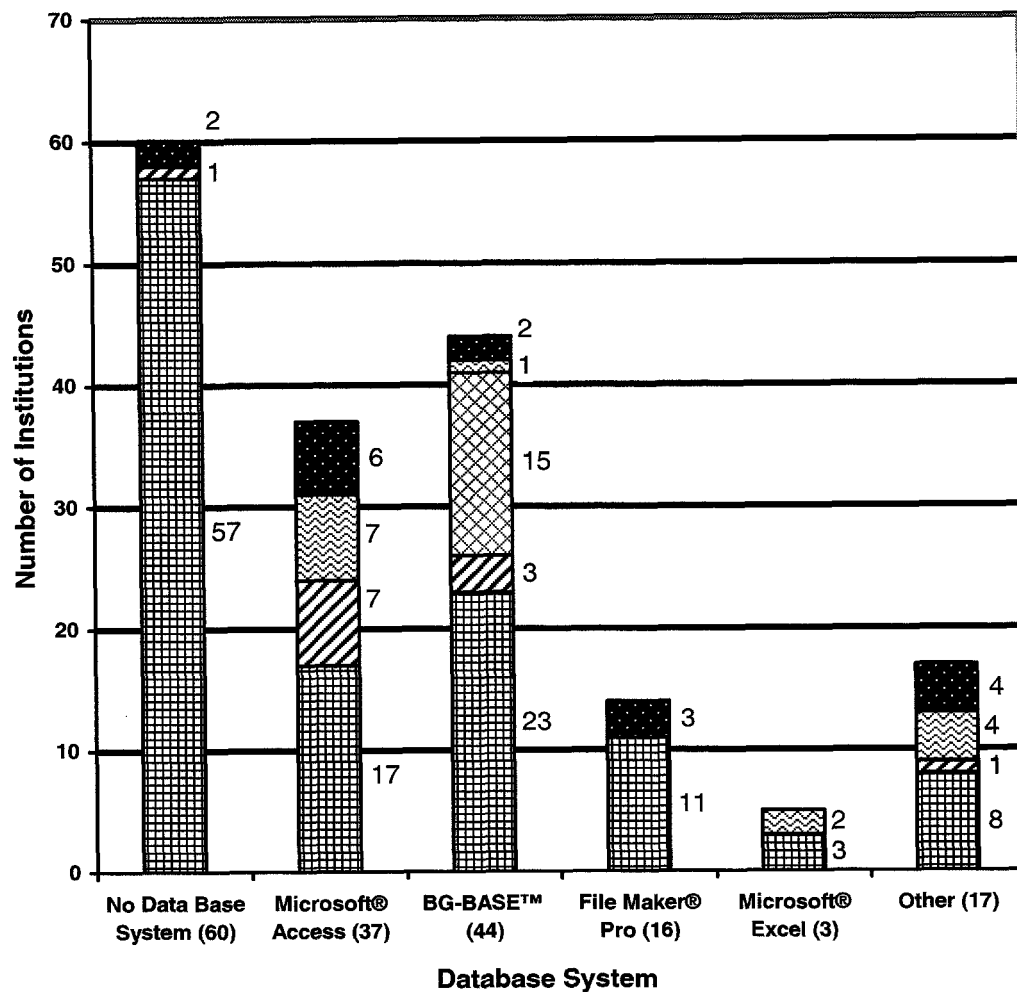
The four most commonly utilized computerized database systems for managing plant records data were BG-BASE™ installed in forty-six institutions, Microsoft® Access⁴⁴ installed in forty-three institutions, FileMaker® Pro⁴⁵ installed in sixteen institutions and Microsoft® Excel installed in six institutions. The current computerized mapping systems surveyed botanical gardens are using fall within five main groups. The first group does not have a computerized mapping system; they either have a paper system or currently no mapping system at all. The second group are members of the Autodesk/AutoCAD®⁴⁶ products. The third group uses BG-Map and its associated products. The fourth group uses the ESRI®⁴⁷ products of ArcGIS®, ArcPad®, ArcInfo® or ArcView™, listed in Figure 1 as ESRI® Product Users. The fifth and final group consists of institutions using a variety of other computerized mapping systems or a combination of the Autodesk and ESRI® Products. A visual representation is shown on page 43 in Figure 1: Summary of the 177 Survey I Respondents about Database and Mapping Systems.

⁴⁴ Microsoft®, Microsoft® Access, Microsoft® Excel and FoxPro® are either registered trademarks or trademarks of Microsoft Corporation in the USA and/or other countries.

⁴⁵ FileMaker® is copyrighted by FileMaker, Inc. in the USA and/or other countries.

⁴⁶ Autodesk, AutoCAD®, Autodesk Map ®, and Autodesk MapGuide® are either registered trademarks or trademarks of Autodesk, Inc., in the USA and/or other countries.

⁴⁷ ESRI®, ArcInfo®, ArcGIS®, ArcIMS®, ArcPad®, ArcView™, ArcPublisher™, ArcReader™, Spatial Analyst™, 3D Analyst™ and ArcEditor™ are either registered trademarks or trademarks of Environmental Systems Research Institute, Inc. (ESRI), in the United States, the European Community, or certain other jurisdictions.



Mapping System

- No Mapping System (119)
- BG-Map (15)
- Other computerized mapping system (17)
- Autodesk Product (12)
- ESRI® Product (14)

Figure 1: Summary of the 177 Survey I Respondents about Database and Mapping Systems Combinations.

In Survey I, the botanical gardens staffs were asked if they found their computer mapping software easy to learn. Of the three dominant software choices, AutoCAD®, ESRI® Products and BG-Map, the ease of use responses were as follows. Of the twelve AutoCAD® users, five found it easy to learn and seven did not. Of the fifteen BG-Map users, ten found it easy to learn and five did not. Of the fourteen ESRI® Product users who responded to the survey, eight found it easy to learn and six did not find it easy to learn. This is illustrated in Figure 2: Survey I Response as to the Ease of Learning the Software of the 41 Institutions with an AutoCAD®, BG-Map or ESRI® Software System

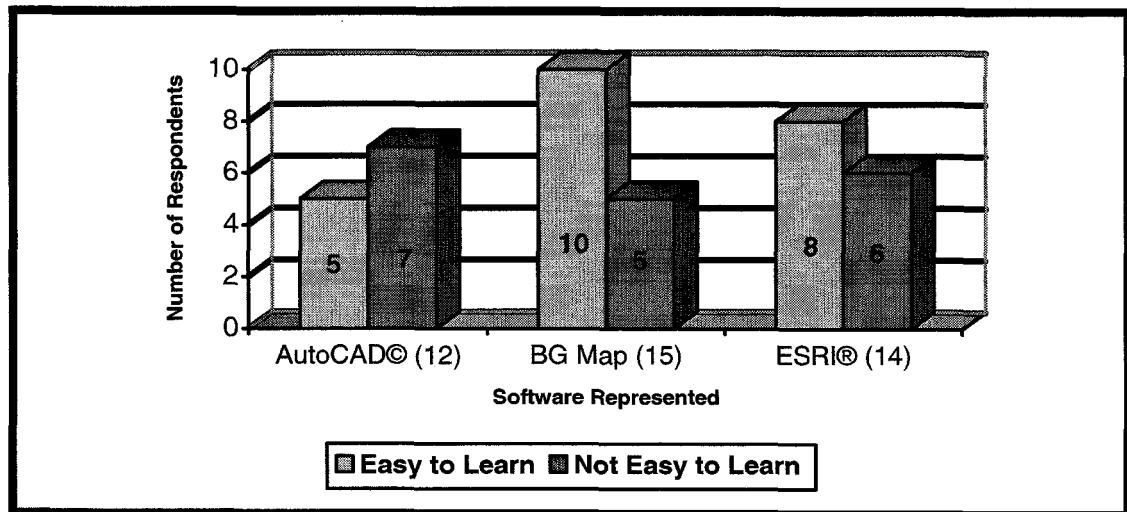


Figure 2: Survey I Response as to the Ease of Learning the Software of the 41 Institutions with an AutoCAD®, BG-Map or ESRI® Software System

In Survey I, users were asked five questions about their current computerized mapping systems. The questions were: (1) "What do you believe are the best features to your current mapping system?" (2) "What features do you use most frequently with your current mapping system?" (3) "What features do you like least in your mapping system?" (4) "What features do you use least frequently in your current mapping system?" and (5) "What additional features would you like to have in your mapping system?" There was also an open ended question of (6) "Additional comments?" The complete responses are available in Appendix D: on page 77. A summary of the most common responses were as follows.

(1) "What do you believe are the best features to your current mapping system?"

It links directly to the Database.

Printing.

Different levels can be used (with different colors) and the levels can be turned on and off, especially in printing.

Support.

Ability to share data with other industries.

Ability to link our survey equipment.

Simple-flexible.

(2) "What features do you use most frequently with your current mapping system?"

Printing.

Plant and object locator.

Adding and relocating plants.

Mapping non-plant features.

Simple drawing features.

Zoom in and out. Adding and subtracting layers.

(3) "What features do you like least in your mapping system?"

Incompatibility with our database.

Long learning curve to master.

It is not always intuitive/seems to be overly complicated.

Inability to change quad system.

Inability to make major changes in base map without paying for tech support.

How the software determines the information to be displayed in a defined view map. I would like to have more choice in the matter.

The ability to work with "non plant objects" is limited without a separate module.

(4) "What features do you use least frequently in your current mapping system?"

Many parts that I don't know what they do.

QuickFinder.

Images.

Many of the architectural features/CAD features are never used.

Geo analysis capabilities.

Streets/City Maps options.

We don't use our mapping system to generate plant lists. We use our database to do this.

3-D features.

All the special printing options.

(5) "What additional features would you like to have in your mapping system?"

Linked to database.

3-D modeling.

Aerial photo integration.

To have data available electronically in the field.

Direct link between plant profile and the map.

Ability to click on a plant and have the program take us directly to the plant record for modification to the record.

Greater flexibility in determining the information that is displayed in a defined view map.

Multiple users.

Maps accessible and retrievable by visitors/over internet.

More control over the printing scale/view/text size.

(5) "Additional comments?"

From Institutions with computerized mapping software:

I am very interested in seeing what's available for a small garden (at a low cost!)

We plan to purchase something else in the future.

We are in the midst of developing a complex GIS/database combo.

Are you looking into surveying and GPS devices that are used in the field?

Overall, [institution] is very excited to have acquired both BG-BASE™ and BG-Map.

We just need more resources (particularly staff) to use the systems more efficiently. We rely on mark Glicksman (BG-Map) for technical assistance.

We do not digitally map every plant, only long lived specimens. We draw in by hand the shorter lived species on the computer generated base maps, which will

include the long-lived specimens when we can get them entered into the system.

I think that GIS mapping is a great tool for public Gardens.

(5) "Additional comments?"

From institutions without computerized mapping software:

We are in the process of purchasing software.

About to start looking at mapping software. This survey should provide some use.

Any recommendations on software that work with our particular database?

May someday map, not necessary currently.

We are very small and don't have the funds to buy computer mapping software.

I feel the AABGA could do a great service for many small/medium sized gardens by providing customized-off-the-shelf software that is standardized for botanical gardens.

Can you send me a copy of the all available computerized database and mapping systems?

I'm looking for software for both right now. Please keep me posted on your results.

We are a display garden focused around events and there is no intention of doing any mapping.

Of the 119 out of 177 respondents (67%) who did not have a computerized mapping system, ninety-five requested to receive copies of this final document, and forty institutions stated that they were now or in the future planning on looking into or purchasing computerized mapping software. This shows an interest from institutions that do not currently have computerized mapping software to obtain software in the future.

Of the fifty-eight respondents (33%) who stated they do currently have computerized mapping software, fifty-three requested to receive copies of this final document, and seven stated that they were now or in the future planning on purchasing computerized mapping software. This shows that institutions that do currently have software can benefit from this research as well.

3.3 Conclusions

Survey I, sent to member institutions of the American Association of Botanic Gardens and Arboreta (AABGA), sought to discover what, if any, computerized mapping systems member institutions currently use. Survey I also asked institutions what features they employed most often and what tools they utilized the least. After reviewing the information responses of Survey I, the researcher concludes that 119 out of 177 (67%) of the respondents currently were not using computerized mapping systems and 58 out of 177 (33%) do already use computerized mapping systems. In addition the research concluded that many other gardens are considering adding computerized mapping systems that would interact with their current database systems.

The three software choices most commonly in use by botanic gardens are: AutoCAD®, ESRI® Products and BG-Map. The surveyed users of BG-Map and ESRI® Products found those products easy to learn, while the majority of AutoCAD® users found that the product not as easy to learn.

When asked what features were the best, worst, most frequently and least frequently used, along with what additional features the users would want to add to their system, the following features were mentioned most frequently included:

The ability of the mapping system to interact with the database.
Printing, including can the printing scale/view/symbols/text size be controlled by the user.

Layers.

Technical support.

Ability to access data in the field.

Ability to publish to the web.

Possibility of making personalized maps and information available to the visitor.

Having multiple users query, or outside sources (visitors) query information.

Ability of the mapping software to work with the survey equipment, especially survey equipment already in place at the facility.

3-D modeling, 3-D capabilities.

Finding plants.

Adding and relocating plants.

Aerial photo (ortho photo) integration.

Learning curve/is the software intuitive?

The ability to share data with other institutions.

Of the 119 out of 177 respondents who did not have computerized mapping system, ninety-five requested to receive copies of this final document, and forty institutions stated that they were now or in the future planning on looking into or purchasing computerized mapping software. This shows an interest from institutions that do not currently have computerized mapping software to obtain software in the future.

Of the fifty-eight respondents who stated they do currently have computerized mapping software, fifty-three requested to receive copies of this final document, and seven stated that they were now or in the future planning on purchasing computerized mapping software. This shows that institutions that do currently have software can benefit from this research as well.

Chapter 4

SURVEY II

This chapter presents the methods, results and conclusions of the compilation of research data from Survey II. Using the most frequently mentioned data of Survey I, a second survey was developed which is the focus of this chapter. With this survey, users of computerized mapping software rated the importance of twenty features and possible features of their software.

4.1 Methods

After analyzing the initial survey data, a second survey was created. Survey II was created and forwarded to the Office of Vice Provost for Research (OVPR) for approval. The approval letter can be found in Appendix B on page 71. A copy of Survey II appears in Appendix E beginning on page 87. This survey was sent to the fifty-six (56) respondents of Survey I who stated their organizations used computerized mapping systems and stated that they would be available for a second survey. The second survey was not sent to organizations that did not have a computerized mapping system. Survey II was distributed primarily via e-mail, or via the US Postal Service®⁴⁸ to respondents who did not provide an e-mail address. The respondents had the option to reply by mail, fax or through the Internet site at <http://www.studentresearcher.com>.

⁴⁸ United States Postal Service® and USPS® are copyrighted by the United States Postal Service, all rights reserved in the USA and/or other countries.

Survey II contained twenty questions asking the users how important they found various features of their computer mapping software. These questions were chosen based on the user responses from Survey I. Survey II also allowed users the opportunity to write in other factors they found important when utilizing their mapping system.

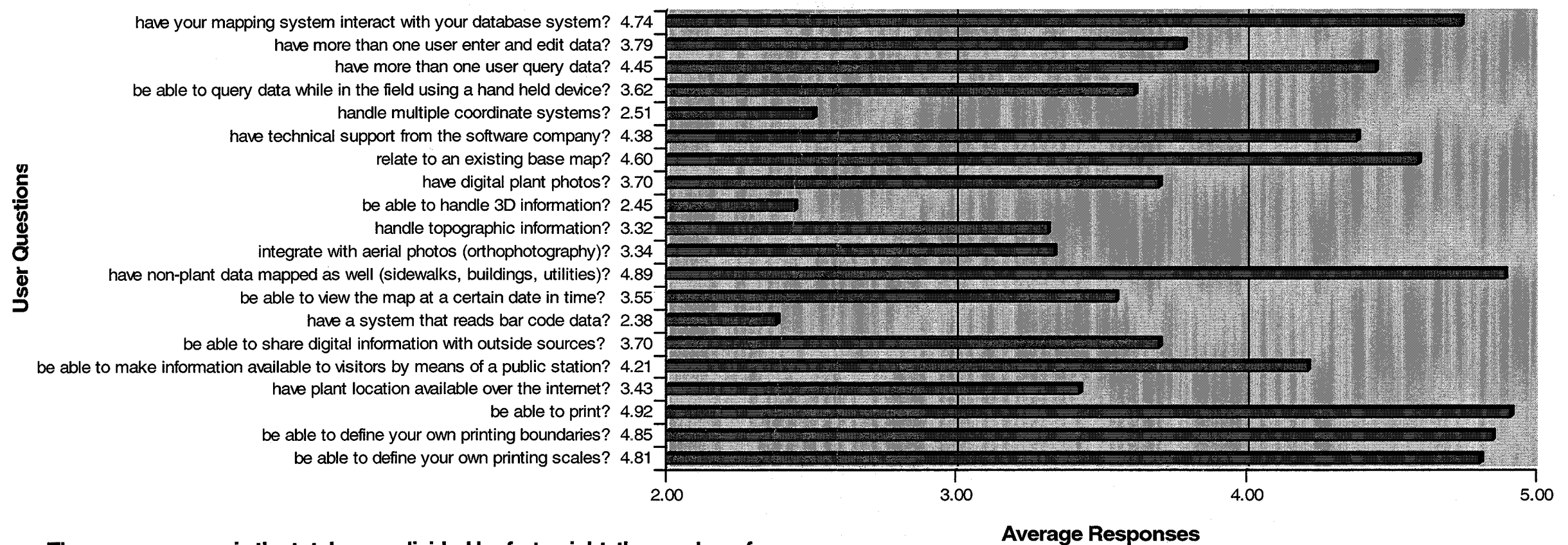
4.2 Results

There were 56 respondents to Survey I who stated that their organization used computerized mapping systems and that were willing to be contacted again. A second survey (Survey II) was sent to these organizations. The questions on this survey were developed from the topics most frequently mentioned by the respondents of Survey I. Of the fifty-six (56) surveys sent, forty-eight (48) individual institutions responded to Survey II with a response rate of 85.7 %. Respondents were asked to rate the importance of various features that pertain to their institution as well as write in additional important features.

The survey associated a point-ranking scale to the responses of institutions ranging from 5 points to 1 point with the following points assigned: Important (5 points), Relatively Important (4 points), Undecided (3 points), Relatively Unimportant (2 points), and Unimportant (1 point). The computed results obtained from the questionnaire as were derived by simply averaging the ranking scale. The averaging is the total score divided by the number of responses. Only simple percentage figures were computed. Although the institutions participating had a wide range in physical size, number of mapped materials, and length of experience with the software, no attempt was made to weight the results according to those factors. Rather, the intent was to obtain the frequency and type of requests desired from the users in varying

sized and staffed institutions. Figure 3 on page 53 shows the average scores for each question asked in Survey II.

How important is the ability to...



The average score is the total score divided by forty-eight, the number of responses.

0=unimportant

5=important

Figure 3: Survey II Average Question Scores

4.3 Conclusions

There were fifty-six out of 177 respondents to Survey I who stated that their organization used computerized mapping systems and that were willing to be contacted again. A second survey (Survey II) was sent to these organizations. The questions on this survey were developed from the topics most frequently mentioned by the respondents of Survey I.

The most important topic to the respondents was the ability to print. The ability to print, define the users' own printing boundaries and printing scales were three of the top five most important questions, according to the average scores of Survey II. The open ended questions in Survey I also showed a desire to have more control over printing ranges, sizes, scales and views. This could show that printing is one of the most used tasks of computerized mapping software. It could also show that printing is one of the more frustrating tasks to users who currently cannot control their printing ranges, sizes, scales and views.

The next most important factor in a mapping software system was the ability to map non-plant data, as well as plant data. This is showing that the users have a desire to know where other objects besides plants are. Buildings are used as reference points, some memorial items like benches and plaques have their own data, and utilities like gas and water are important in the garden setting.

The fifth most important feature on mapping software was the ability of the mapping system to interact with the database system. This shows the importance of having the mapping system and the database relate to each other. This also shows that to have a map without plant data is not useful to a cartographer in a botanic garden setting.

The abilities to have multiple users being able to query data or edit data and having a way of making information available to visitors all ranked highly. This shows a desire by the current users to be able to have more people access the information, and to make the information generally more accessible. This would allow the person in charge of mapping and the database more time to focus on other tasks, and less time spent on tasks that the other people could answer themselves if the data were more accessible.

The three questions which received the lowest average scores, averaging "Relatively Unimportant" were the topics of handling multiple coordinate systems, 3-D information, and bar code data. These results could be viewed as these features are not used on a regular basis, or that these features are not available on the computerized mapping software these institutions currently use.

Chapter 5

SURVEY III

With the results from survey II, the top three most commonly implemented computerized mapping packages are compared on the basis of the twenty features rated by Survey II respondents. This chapter presents the methods, results and conclusions of the compilation of research data and interviews from Survey III.

5.1 Methods

Survey III consisted of a series of questions designed to evaluate the three most common mapping choices as defined in Survey I. The three software systems are AutoCAD®, BG-Map and ESRI® products. These questions directly correlate to the questions the users were asked in Survey II about their software. Survey III appears in Appendix F beginning on page 90. Survey III was sent to a representative for Autodesk AutoCAD®, BG-Map and ESRI®. Personal interviews were then conducted with Mark Glicksman, representing BG-Map on August 26, 2003, with Jim Higgins and Greg Welc representing ESRI® on August 27, 2003, and with Cathy Pine representing Autodesk AutoCAD® on October 3, 2003. A question-by-question condensed dialogue is available in Appendix G beginning on page 93.

The top three software choices were evaluated and compared to each other based on employee interview responses to questions in Survey III and the researcher's personal experiences with the software. The software was compared on a point-by-point basis for each feature. Numerical values were assigned to the success of each

software package to each question. The scores were totaled for each of the three software choices to determine which software package is the most flexible.

5.2 Results

The three software systems were evaluated and compared to each other based on their company representatives' answers to the questions in Survey III and the researcher's personal experience. A system for creating a numerical value was created to weigh the usability of the software choices. If a software system was able to accomplish the task, one point was given, and if the system could not accomplish the task, no points were given. In an instance where BG-Map, for example, could not accomplish the task, but the task could be completed by leaving the BG-Map interface and going to AutoCAD® or BG-BASE™ interface, a half a point was given. If there were multiple ways to answer the question, a point was given for each. Deductions were not incurred if the user would have to purchase an additional extension to receive the benefit. Then the points for that question were weighted according to the average value assigned by the Users in Survey II.

Examine the following as a case in point:

“How available is the ability to handle topographic information?”
Autodesk® products can handle topographic information as a layer. BG-Map refers clients to use AutoCAD® and create topographic information as a separate layer in AutoCAD®. With ESRI®, the user has two options. First, they can obtain shaded relief information from the United States Geological Survey (USGS). Second, the user can purchase an additional extension like Spatial Analysis and 3D Analyst™ for additional capabilities.

AutoCAD® can complete the task, so it is awarded one point. BG-Map requires the user leave the BG-Map interface to complete the task in AutoCAD®, so BG-Map is awarded one-half a point. ESRI® has two options available for the user, so it is awarded two points.

In Survey II, the average user value of importance for this question was 3.32 points. Multiplying the average user value by the points received, Autodesk products are awarded 3.32 points, BG-Map is awarded 1.66 points, and ESRI® Products are awarded 6.64 points. A summary diagram of the points is found in Table 2: Top Three Software Packages Scored According to their Capabilities of Performing Twenty Tasks that the Users found Important in their Computerized Mapping Software available on page 59.

This process was completed for all twenty questions on Survey II. The points were totaled for each software option. ESRI® Products obtained the greatest number of points, with Autodesk products having the second largest tally of points and BG-Map having the smallest total points. It may therefore be concluded that ESRI® Products are the most accommodating, Autodesk products are the next most accommodating, and BG-Map is the least accommodating for the Survey II respondents stated desires.

Table 2: Top Three Software Packages Scored According to their Capabilities of Performing Twenty Tasks that the Users found Important in their Computerized Mapping Software

Question	Question Weight ⁴⁹	Autodesk Products		BG-Map		ESRI® Products	
		*50	*51				
How important is the ability to have your mapping system interact with your database system?	4.74	1	4.74	1	4.74	1	4.74
How important is the ability to have more than one user enter and edit data?	3.79	1	3.79	1	3.79	1	3.79
How important is the ability to have more than one user query data?	4.45	1	4.45	1	4.45	2	8.90
How important is the ability to be able to query data while in the field using a hand held device?	3.62	1	3.62	1	3.62	1	3.62
How important is the ability to handle multiple coordinate systems?	2.51	1	2.51	0	0	1	2.51
How important is the ability to have technical support from the software company?	4.38	1	4.38	1	4.38	1	4.38
How important is the ability to relate to an existing base map?	4.60	1	4.60	1	4.60	1	4.60
How important is the ability to have digital plant photos?	3.70	1	3.70	.5	1.85	1	3.70
How important is the ability to be able to handle 3D information?	2.45	1	2.45	.5	1.23	2	4.90
How important is the ability to handle topographic information?	3.32	1	3.32	.5	1.66	2	6.64
How important is the ability to integrate with aerial photos (orthophotography)?	3.34	1	3.34	1	3.34	1	3.34
How important is the ability to have non-plant data mapped as well (sidewalks, buildings, utilities)?	4.89	1	4.89	2	9.78	2	9.78
How important is the ability to be able to view the map at a certain date in time?	3.55	1	3.55	0	0	1	3.55
How important is the ability to have a system that reads bar code data?	2.38	1	2.38	2	4.76	1	2.38
How important is the ability to be able to share digital information with outside sources?	3.70	1	3.70	1	3.70	3	11.10
How important is the ability to be able to make information available to visitors by means of a public station?	4.21	1	4.21	1	4.21	1	4.21
How important is the ability to have plant location available over the Internet?	3.43	1	3.43	0	0	1	3.43
How important is the ability to be able to print?	4.92	1	4.92	1	4.92	1	4.92
How important is the ability to be able to define your own printing boundaries?	4.85	5	24.25	4	19.40	5	24.25
How important is the ability to be able to define your own printing scales?	4.81	2	9.62	2	9.62	2	9.62
	Total Points	25	101.85	21.5	90.05	31	124.36

⁴⁹ Question weight is the average response score the question received from the forty-eight respondents on a scale of 0 for Unimportant to 5 Important on Survey II.

⁵⁰ A product received 1 point for performing the mentioned task, 0 points if it could not perform the mentioned task, one-half a point if the product mentioned could not perform the task, but the user could leave the interface and perform the task with another piece of required software, and multiple points if there were multiple ways of performing the task.

⁵¹ A product score is obtained by multiplying the question weight by the points a product received for performing that function.