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**Development of the Arboretum /
Longenecker Gardens Information System**

by

Eric W. Kolstad

A thesis submitted in partial fulfillment of
the requirements for the degree of

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ABSTRACT

The University of Wisconsin-Madison Arboretum was founded in 1934 as a form of outdoor teaching and research laboratory. The Arboretum contains a unique collection of restored biological communities, including forests, prairies and wetlands. Detailed background information such as maps, photographs and text concerning these areas are available. In an effort to provide visitors easy access to this broad base of related data, a computerized information system has been created which allows visitors to rapidly and independently obtain information according to their interests and concerns.

The initial version of this system concentrates on the Longenecker Garden section of the Arboretum, which displays a wide variety of trees, shrubs and other species indigenous to the Midwestern region of the United States. The system features a zoomable map, which can be used to locate specific varieties of plants within the Gardens; several alternate map layers containing vegetation and landscape features may be displayed at the user's option. By selecting an individual plant on the map, species information on identifying features, growth requirements and landscape characteristics can be obtained. Map layers are linked to a database containing this information and corresponding plant locations, as well as scanned images representative of species and pictures detailing leaves, bark, flowers etc. A query feature allows the user to check the database for information on a particular plant, or to search for species having a specified set of characteristics. This is one of several functional areas visitors can use to assist in selecting trees and shrubs for their own homes.

The effective design of such a system involves consideration of many factors. One of the main concerns is construction of the graphical user interface; aesthetic and practical issues are involved. The system is constructed such that both novice or more experienced users can work well within the set of related program modules. System navigation is visually oriented; it is designed with an uncomplicated graphical point-and-click interface, with icons and command buttons used to navigate the system and retrieve graphical/text information. Information from different sources may be examined without dismissing current queries. Also available are scenic view screens which automatically identify plants and other features as the user moves the mouse (clicking to obtain further text, audio or video sequences and so forth).

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Chapter 1: Introduction

1.1 Overview

The project application discussed in this thesis is the Arboretum/Longenecker Gardens Information System (ALGIS), an interactive exhibit system developed for the University of Wisconsin-Madison Arboretum. Its objective is to allow visitors to interactively examine information concerning plant species and related topics in the Longenecker Gardens area. ALGIS allows the general public to make easy but effective use of spatially referenced data (vector map layers showing pathways, structures, etc., along with planting locations) and access various connected information. Digitized photographs, text and attribute information, sounds and video are incorporated within a multimedia PC environment. Through the use of this system, the user is able to answer various questions they might have considered, such as, "Where is this particular type of plant located in the Gardens? What of its appearance, and its characteristic features? Would it function well in my backyard conditions, and how might it look there? What are the differences and similarities between related species?" Also included are online help facilities, and hardcopy generation of maps and information forms.

1.2 Multimedia background

Discovery and exploration of information should be a positive experience, but with the increasing amounts of information now available, user anxiety and information overload may result. A single page of information is usually relatively easy to interpret. However, when the volume reaches the size of a book, a library or an even larger collection, browsing through and locating particular information can be problematic (Shneiderman, 1992). An advantage of hypertext and hypermedia, discussed shortly, lies in their ability to provide access to large amounts of information, yet show users only the particular parts which are of interest to them (Nielsen, 1990).

'Multimedia' is generally understood to mean the combination of two or more different media (carriers of information). To an artist, this might bring to mind a work created with different methods such as oil painting, collage work, watercolors, sculpture, etc. In years past, multimedia would often have brought to mind images of two or more slide projectors with sound, in a synchronized presentation. As technology has evolved, however, multimedia computer systems have become more prevalent. Although computer systems support input or output via multiple formats, the term multimedia is usually applied where physical output media such as a computer display terminal, video, and audio are used (Dannenberg and Blattner, 1992; Shneiderman, 1992).

Varied related systems of access have been developed to work with these different

media forms, which are often made more accessible when stored in a structured manner. Many traditional types of information structuring, such as books, are sequential in nature. Hypertext is essentially a nonsequential connected association of nodes of text information stored in a network structure. If one were to take a book and set up various cross-referenced connections between words, pages or sections thereof, the traceable paths through the resulting links would constitute hypertext. Hypermedia expands upon the notion of hypertext to include linkage of information nodes to and from one or more other media such as sound and graphics, in addition to text (Dannenbergh and Blattner, 1992). The power and flexibility of these systems in handling text, graphics, animation and sound provide an opportunity for representing a broad range of possible applications.

Although hypertext and hypermedia have become familiar terms only recently, many of the ideas which form their foundation were conceived over a longer period of time. Vannevar Bush, President Franklin Roosevelt's Science Advisor, is generally regarded as the "grandfather" of hypertext. His proposed Memex ('memory extender') system appeared in the July 1945 article in Atlantic Monthly titled "As We May Think." His primary objective in developing the system was to deal with the increasing amounts of information that made it difficult to keep pace with scientific developments. This information-exploration tool was intended to enhance human memory and thinking by providing an automated means of information retrieval, which included links and cross-referencing to allow association of ideas to be seen, and related materials browsed through (Nielsen, 1990; Hooper, 1991).

The Memex was described as a mechanized storage device which would function as a sort of personal library, where the user would have flexible high-speed access to files stored on microfilm, which could be shown on several different screens in a manner similar to the computerized "windows" of today. Eye-tracking technology would allow readers to follow cross-references simply by staring at them. Bush made provision for a scanner to allow the user to input new material, as well as make annotations and comments; he thought that most of the Memex information ("books of all sorts, pictures, current periodicals, newspapers") would be readily available for purchase and insertion into the system (Nielsen, 1990; Shneiderman, 1993).

Bush envisioned not only the building of singular links, but construction of connected information pathways to relate material of importance on any given topic, focusing on particular points on view. Professionals working as "trail blazers" would set up a "web of hypertext links to supplement the basic information." (Nielsen, 1990) Ordinary users could likewise create their own trails.

Although the original publication drew much interest, the Memex system was never constructed. While we have not yet fully achieved Bush's designs, most of the functional components are now incorporated within current computerized systems.

1.3 Statement of problem

The Arboretum now possesses or is in the process of obtaining the following information. Several Arc/Info map layers contain features such as planting regions, physical structures, and annotated text. Geographic point locations of specific plants have been surveyed and recorded. Photographic resources include a large collection of 35mm slides showing varied plant species, along with respective components (leaves, flowers, bark, fruit, and/or buds). Additional pictures show seasonal variation, growth stages, and so on. Each plant has associated text information, including scientific/common names, dates planted, memorial dedications, etc., marked on notecards. Characteristic attribute data on each species exists; this consists of inventory background, identifying features, cultural requirements, and landscape characteristics. Along with other pertinent information, the above will form the initial base for approximately 500 species of plants.

The lack of interpretative features on plants, along with limited staff availability, has meant that users of this planting collection have encountered difficulty obtaining requested information. While brief tags identify individual plants within the collection, and several general gardens maps exist, acquiring more detailed information is difficult. Appropriate staff members to aid in this function are not always available; their assistance is often necessary to locate specific plants and access visitor center files (Armstrong, 1992). Many user queries would be time-consuming and tedious to attempt via manual means, due to the large amounts and different forms of information involved.

Through use of the base of available information, in combination with means currently available, it should be possible to construct an interactive computerized system whereby an effective solution to these problems is offered. In examination of this problem, qualitative and quantitative testing will be used to evaluate the validity of this statement. The basic premise is that a system can be designed, through the use of commercially available hardware/software, that will:

- Answer the types of questions and present information which users frequently request
- Give responses in a timely manner
- Fulfill functional requirements set forth by the Arboretum
- Satisfy subjective measures (as perceived by system users)

Various questions arise, such as: "For a given topic area where both computer system and staff possess the necessary information, how effectively can this be conveyed to the visitor? Does the system present information in a clear and useful format, allowing interaction in such a way that users can obtain desired results quickly? In some cases, certain lines of query (which may involve intense search and computation) necessitate an automated method to accomplish. (Then, what types of questions are better left for human-to-human interaction?)"

Through study and actual implementation, this thesis will explore methods through which a system can be constructed to provide users with a fully interactive computerized guide to the Longenecker Gardens. Such a system can allow for alternate approaches in examining information, and present a user-friendly environment through the use of graphical

user interface concepts; also, that it can be shown effective in maintaining user interest and enhancing the learning process. Further, it will demonstrate a functional, cost-effective solution for multimedia applications.

In the remainder of this chapter, project background and brief history of preliminary efforts (the ARBIS package) are related, followed by a description of current project description. Thereafter, elements which concern current system development are discussed in detail. Chapter 2 concerns the base components and structural design ideas inherent in graphical user interface, perceptual concepts, etc. Chapter 3 provides a functional overview of ALGIS system operation, discussing individual modules. Chapter 4 discusses current system development, software and hardware specifics, problems and pitfalls encountered to that point. Thereafter, in Chapter 5, a preliminary evaluation of system function and effectiveness is demonstrated through results of a user rating survey; final interpretations and conclusions are presented there.

1.4 Initial funding

In 1985, the University of Wisconsin-Madison Arboretum began development of ArborLIS, a geographic information system which would integrate spatial information, such as planting locations, with various plant species data that included information collected through research and management activities. Initial grants provided by the Brittingham Fund in 1986-1987 supported establishment of survey monuments, as well as preliminary database

and GIS design. Further development of the basic system was then made possible through funding from the Institute of Museum Services, and start-up hardware and software were acquired through University system grants. UW-Madison faculty and graduate students in the Civil and Environmental Engineering department, as well as those with the Institute for Environmental Studies, have performed surveying and environmental monitoring work with the UW Arboretum since 1986 (Armstrong, 1992).

Three years ago, the IES Environmental Monitoring Practicum class assembled a simple hypertext-like demonstration program concerning the Arboretum. Through this program users were able to view several maps, examine digitized pictures and information on types of plants present at various locations and times of year. Also included were a photo/text section on Arboretum history and a planned events calendar. This precursor is reviewed below, followed by an overview of the project presently being undertaken.

1.5 ARBIS

The ARBoretum Information System (ARBIS) was developed by several members of the IES Environmental Monitoring Practicum class in Fall 1990 and Spring of 1991, as part of a more encompassing pilot project designed to explore the use of GIS in various applications with the UW-Madison Arboretum. Preliminary planning established the following major objectives: 1) to illustrate how a GIS may be used in an educational capacity by employing a graphical user interface; 2) to enhance public interest in the mission and role

of the Arboretum; and 3) to provide visitors with an interesting and functional computerized guide to the Arboretum itself.

System development began with a public needs assessment. It was determined that Arboretum visitors would be primarily interested in what they could see, where it could be seen, and how to get there. Other potential topics included information on current tours, and nature programs available at the time. Following this evaluation, system hardware and software were selected. Version 1.0 of ToolBook for the IBM PC was chosen, as it provided capabilities to combine pictures, graphics, and text in a "hypermedia" format, similar in function to flipping through different pages of a electronic book. This software was placed on a computer system at ERSC, a CompuAdd 325 (80386, 25Mhz machine with a VGA graphics board) which would function as the prototype/development platform.

Conceptual design for ARBIS was constructed conceptually through a flowchart of menu options available to the user. The system focused on flora within Curtis Prairie, with a starting content of fifty pages of combined graphics and text screens. Arboretum visitors were to use command buttons to navigate throughout different graphic screens, or "pages" within the graphic "book" which had been prepared (see Figure 1.1, next page).

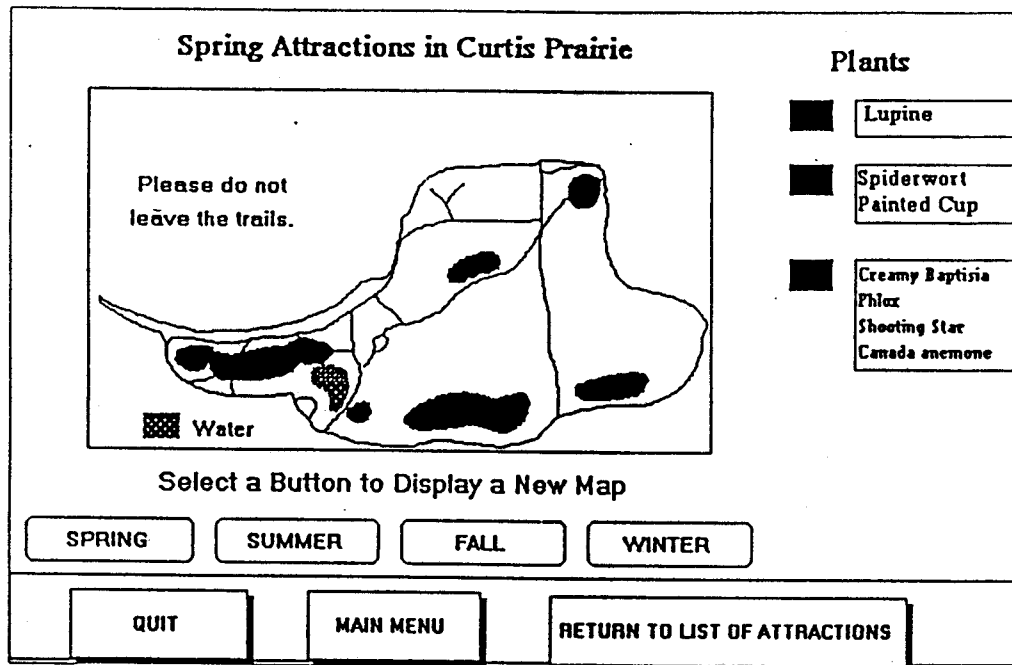


Figure 1.1 - Sample screen from ARBIS

Four major areas demonstrating basic GIS capabilities (with buttons behaving as querying tools, and maps displaying spatial information brought up in response) were implemented. The first area covered Arboretum history, its mission, ecological restoration projects, and related information. This was drawn mainly from archival photographs from the Arboretum's collection, along with associated textual data.

A general map of ecological communities within the Curtis Prairie region was created with the PC version of Arc/Info, and integrated into the system. Here, digitized images and text concerning natural areas, plants encountered, and spatial locations were available. Also included were several screens of text detailing current attractions at the Arboretum, upcoming events, and information to be communicated to the general public (refer to Figure 1.2, next page).

General Layout of ARBIS

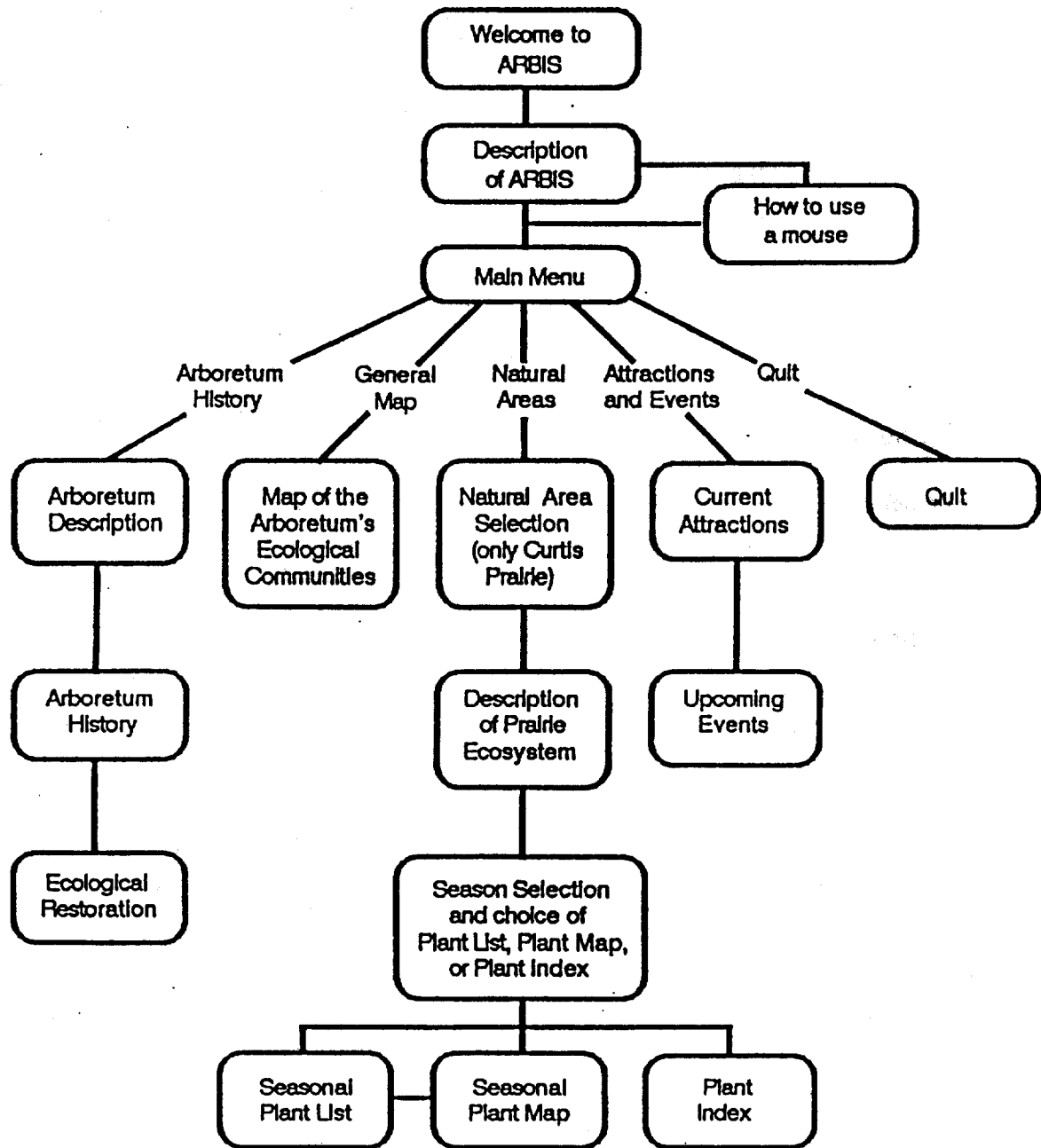


Figure 1.2 - ARBIS System Organization

At the end of the project, a two-week trial/review period was arranged, where the system would reside in the Arboretum main lobby for evaluation by Arboretum staff and the general public. Feedback was obtained concerning useful changes in screen appearance and command button layout. Additionally, functional modifications were suggested, such as implementing of a direct index reference to all plants within the system (instead of having to move through various seasonal plant lists), and expanding upon the number of available screen pages to allow for further detail.

Finally, several considerations for future upgrades were thought out. These included a larger history section, and expansion of ARBIS' scope to include major plant species in all natural areas of the Arboretum, birds and other animals, as well as cultural features. Other suggestions were use of higher resolution images (at that time, the current version of Toolbook allowed only 16 colors), and a possible link between ARBIS and other programs (possibly Arc/Info, or DBase) (REGIS, 1988).

1.6 Current project description

In late 1992, the UW-Madison Arboretum submitted a project proposal, officially titled "ArborLIS: Arboretum Woody Plant Collection Interpretive Exhibit," to the Brittingham Fund. The purpose of the project was the development of an interactive computerized exhibit for the Arboretum's woody plant collection, which would allow visitors to access an extensive base of relevant information. By means of the exhibit, visitors would

be able to learn about the collection, receiving information relative to their own individual needs and interests, rapidly and independent of other assistance (Armstrong, 1992).

The Longenecker Gardens woody plant collection was selected as the prototype visitor/ArborLIS link for several reasons. It is recognized as the largest collection of its kind in Wisconsin, consisting of over 2000 plant species indigenous to the Midwest region. It contains plants hardy to southern regions of the state, many of which are useful for landscaping purposes. Major collections of lilacs, ornamental crabapples, maples, junipers, viburnums, and arborvitae are included (Armstrong, 1992).

Also of relevance is the fact that this particular collection draws interest from several different audiences. University students make use of the Longenecker Gardens area for educational purposes, and research is often conducted by investigators engaged in landscape plant evaluation. Further, the collection provides a unique, pleasing aesthetic experience to the general public, displaying examples of indigenous species suitable for use in their native environment (Armstrong, 1992).

Four major accomplishments were projected through the creation of the system just discussed: 1) initiation of the next major development phase of ArborLIS (the creation of a visitor interface); 2) establishment of a model for future computerized exhibits of other collections within the Arboretum, and a prototype for similar systems elsewhere; 3) enabling visitors (including University faculty, staff, students and the general public) to independently

obtain information concerning location and features of plants in a important collection; and
4) creation of a permanent exhibit in the McKay Visitor Center detailing the woody plant collection, a first major interpretive effort (Armstrong, 1992).

Chapter 2: User interface

A major aspect in the creation of an interactive public display is that of graphic design in human-computer interfaces. Such a system must be set up so that it is not only usable, but intelligible, functional, aesthetically pleasing and memorable. It should present both simpler and more complex information in a manner understandable to most anyone in the general public. Aspects of cognitive psychology are involved - how color, shape/grouping, varied representations, logical organization and other perception-based factors influence effective system usage and design. While icons, control panels, menus, dialogue boxes and navigational devices can be used to aid the user, there are a number of guidelines. Within these, symbol systems, spatial composition, sequencing and animation can greatly affect design. Perceptual, conceptual and communication issues are key; the overall concept being to make the system interface intuitive, flexible, and easy to work with from all standpoints.

2.1 History

The Graphical User Interface (GUI) is said to be one of the most revolutionary changes to occur in the evolution of modern computing systems (Mandelkern, 1993). To understand how computerized user interfaces have evolved, it may be useful to review the means through which human-computer interaction has taken place over the years. Up through the 1940s, mechanical models and devices were the standard visual user interface

for control systems. The mechanical engine room annunciators of large warships and model aircraft used in tactical situation room displays during World War II are examples of these. User interface was mainly limited to direct physical interaction with a mechanical emulation of the real world system (Mandelkern, 1993). Recognizing the difficulties in operating such equipment, natural scientists, engineers and psychologists worked together, resulting in initial advances in both psychological theory and design of man-machine systems. This wartime collaboration produced signal detection and manual control theories, as well as a cockpit instrument display methodology (Card et al., 1983).

Electromechanical devices such as teletypewriters, keypunch card readers, and mechanical "scoreboard" displays became prevalent in the 1950s. These presented the first alphanumeric means of communication between computer and human (Mandelkern, 1993). Response to user typing no longer required minutes, or even days, via batch processing. Although there was some delay between input and output, direct on-line computer interaction was now possible (Reichman, 1986). Approximately ten years later, on-screen computer-generated displays were introduced. They took the form of tabular alphanumeric display terminals or vector graphics CRTs. The 1970s spawned raster graphic terminals linked to mainframes or minicomputers; full-screen, high-resolution graphics were starting to become workable. Pointing-device driven, icon and menu-based interfaces began to appear in research laboratories, and later in a select group of desktop systems (Mandelkern, 1993).

During this time, a new conceptual image concerning the nature of human-machine interaction, whereby man was seen as an active processor of information, became the accepted view in cognitive psychology. In the last decade of that period and continually thereafter, new techniques and understandings have developed, which encompass the major areas of human experimental psychology: perception, performance, memory, learning, problem solving, psycholinguistics (Reichman, 1986; Card et al, 1983) Some of these will be addressed in the section which follows.

Since the 1980s, development and widespread use of stand-alone, low-cost personal computers and workstations, initially designed for workers in technical and engineering fields, have led to the Graphical User Interface (GUI) we now recognize. These systems "combined features such as high CPU performance, multiple megabytes of memory, and large hard disk storage, along with high-resolution, high-performance color bit-mapped graphics, and high-speed local area networks to interconnect large numbers of these [systems]" (Mandelkern, 1993). Such increases in computers' power and performance/cost ratios have meant an increasing amount of computational resources can now be spent on the human-computer interface itself, rather than computational tasks alone (Card et al, 1983).

Today, advanced GUIs such as Windows, Macintosh, Motif or OpenLook provide a relatively "standardized set of metaphors for interaction with the computer based on a series of 'user friendly' on-screen input techniques, such as icons and pull-down menus", sometimes referred to as a Windows, Icons, Menus and Pointing device (WIMP) interface

(Mandelkern, 1993). These multiwindow display screen systems enable several interactive processes to run concurrently, and allow users to switch between them (Reichman, 1986). While this technology has increased the accessibility and usability of computer systems to the general public (Mandelkern, 1993), the science of user interface design continues to evolve.

2.2 Visual Cues

In all user interfaces and information graphics, there is a need to present data objects, processes, their status, and structure of various kinds. The designer must determine means for enabling the user to navigate, select, and manipulate these objects in various ways. A number of visual cues help to establish the perception of space (Tufte, 1989).

Several factors which influence perception are related to position. These are texture (the gradual increase in density of texture of a receding surface), size (gradual decrease in size as objects become more distant), and linear perspective (objects are gradually reduced in size as they are farther away in a scene, and parallel lines recede to vanishing points). Additional cues are based on parallax; these are binocular perspective (that is, an image has a separate shifted object location for each eye) and motion perspective (objects moving at uniform speeds appear slower as distance increases) (Marcus, 1992).

Many visual cues function independently of the relative position and motion of the observer. Aerial perspective results in increased haziness and bluish color with distance. This occurs because light must travel through more of the atmosphere at greater distance; dust and water vapor scatter the light and reduce intensity and clarity of an object viewed from afar. Blur is the fuzziness seen when objects are nearer or more distant than the focal plane (Marcus, 1992; Podger, 1991).

Vertical location cues are seen when the lower portion of a scene appears closer, and the upper part (which is often nearer to the "horizon") seems farther away. With abrupt changes in relative depth shifts of different objects, there is a shift of texture or linear spacing. Shifts in double imagery occur in distant views; nearer objects have doubling gradient. Another cue is the completeness or continuity of outline. Nearer objects will be seen to overlap others; an object or feature that obscures another from view is perceived to be closer than the occluded object. This spatial cue is more commonly termed interposition.

As distance varies, there is also a shift in rate of motion, as close objects move much more than distant ones. The relative shift of light and dark causes abrupt changes to appear as edges, and more gradual changes to be perceived as roundness. Shading and shadowing convey information on the three-dimensional shape of an object, and its depth within a scene. Finally, the user's own past experience can be called upon to compare known sizes of objects with their relative size in a scene, and thus judge the relative distances of the objects (Marcus, 1992; Podger, 1991).

"Some, but not all, of these cues are currently employed within user interfaces and information graphics to create convincing spatial images. As user interfaces and dynamic information graphics become more complex visually, designers will utilize more of these depth cues and consequently will need to determine the listed spatial depiction attributes in a systematic manner" (Marcus, 1992).

2.3 Layering and separation

Tufte (1989) discusses in further detail the technique of separation, as well as that of layering, as means of visual stratification to reduce noise and enrich information content of displays. Even relatively small variations in design can result in a strong visual effect, as demonstrated with the illusory borders and shapes shown here in Figure 2.1:

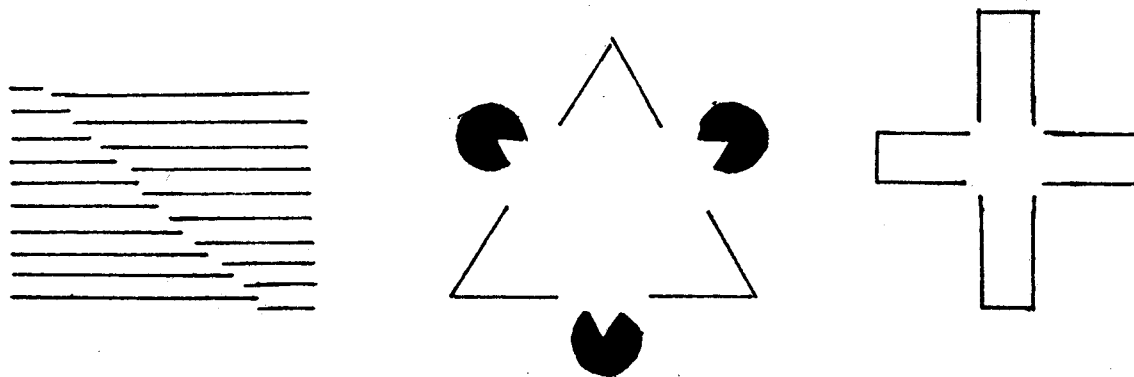


Figure 2.1: Boundary/shape effects

Visual elements are highly contextual and interactive in nature. "1 + 1 = 3 or more" forms a fundamental principle of information design. In Figure 2.2 for instance, where two black lines are drawn, a bright white path seems to exist between them. "A complexity of marks generates an exponential complexity of negative shapes. Most of the time, that surplus visual activity is non-information, noise, and clutter." Included in this activity are activation of white spaces, and vibration effects. In most cases, these effects should be minimized; careful visual editing diminishes such clutter (Tufté, 1989). Figure 2.3 shows an example of these effects.



Figure 2.2: Line examples

SAMPLE TEXT IN HIGH CONTRAST

**NOTICE: PHRASES SURROUNDED BY EXTRANEIOUS NOISE
CAN OFTEN BE HARDER TO INTERPRET IN CERTAIN CASES**

Figure 2.3: Text factors

There are a number of variations perceptible to the eye which can be used in graphics, in order to show relationships of resemblance, order and proportion. On a computer screen, a mark or symbol can appear at particular X and Y locations, transcribing a relationship between the two planar dimensions. Two differently positioned marks or symbols can further vary in size, value, texture, orientation, shape or color; each of these visual variables may be used to describe an information component. For instance, X and Y could represent time and numeric value respectively, and "size" might show population (Bertin, 1981).

In reviewing Garner's earlier work, Goldsmith and Schvanevelt briefly discuss integral and separable dimensions. Separable dimensions are distinct and separate; a series of vertical bars on a graph would be an example. "Separable dimensions.. produce neither facilitation with redundant dimensions nor interference with orthogonal dimensions in a discrimination task." (Goldsmith and Schvanevelt, 1984)

Integral dimensions appear as an integrated whole, and often mean that the existence of one dimension depends on the existence of another. Brightness, hue and saturation of a color are a representative example. These integral dimensions "facilitate the discrimination of stimuli on one dimension when another dimension varies in a correlated manner, and inhibit the discrimination of stimuli on one dimension when another dimension varies in an orthogonal manner." (Goldsmith and Schvanevelt, 1984).

2.4 Color

Beyond other factors, use of color plays a crucial role in perception; it is the most sophisticated and complex of the visible language components. Here, it may be useful to examine the underlying principles which affect color itself. The human eye is on average capable of distinguishing 7.5 million colors; this forms a prominent part in our perception of reality. Color vision can however be broken down into several main elements (Marcus, 1992; Bertin, 1981).

An important idea is the concept of trichromacy; Maxwell's theory provides the basis for this concept. It is as if the retinas of our eyes were lined with three types of cells (cones) that perceive color as red, green, or blue. Color is the unequal stimulation of these cones (Bertin, 1981). Each color in the visible spectrum can be reduced mathematically to a group of three numbers. In the 1920's, the Commission Internationale d'Eclairage (C.I.E.) in France developed a system of international standards of color perception from these numbers. Color phenomena can be classified in terms of three factors. Hue is the combination of spectral wavelengths that produces perceptions of a particular named color such as red, orange, blue, or brown. Saturation (chroma) is the purity of a color in a scale from gray to the most vivid variant of that color. Brightness (value) is a color's relative amount of lightness or darkness. CRT screens typically combine light additively. The primary colors of illuminated light from red, green and blue phosphors can produce a full range of colors; with all three at full intensity, the result is white light (Marcus, 1992;

Microsoft, 1993; Schneiderman, 1992). Figure 2.4 on the next page shows a diagram of color relationships.

Further, color has spatial properties. For instance, we tend to see the edges with the black and white receptors (rods) of our eyes, and later fill in the edges with color. Colors are seen in relationship to other colors in the same proximity. The red/green opponent cones make us tend to see color in opposites, as we have difficulty focusing on both red and green simultaneously (Marcus, 1992).

There are also emotional and psychological properties involved with color use. It has been shown in various psychological tests that color improves learning; the eye is attracted to color images (Marcus, 1992). Color can soothe or strike the eye, evoking emotional response such as joy, excitement, fear or anger (Schneiderman, 1992; Marcus, 1992). For instance, red generally excites the eye, while blue has an emotionally calming effect. Different people have different tastes in color; some prefer one particular scheme, while others may have a strong dislike for it (Marcus, 1992). User expectations also play a key part. "From automobile-driving experience, red is commonly considered to indicate stop or danger, yellow is a warning, and green is go. In investment circles, red is a financial loss and black is a gain. For chemical engineers, red is hot and blue is cold. For map makers, blue means water, green means forests, and yellow means deserts." (Schneiderman, 1992)

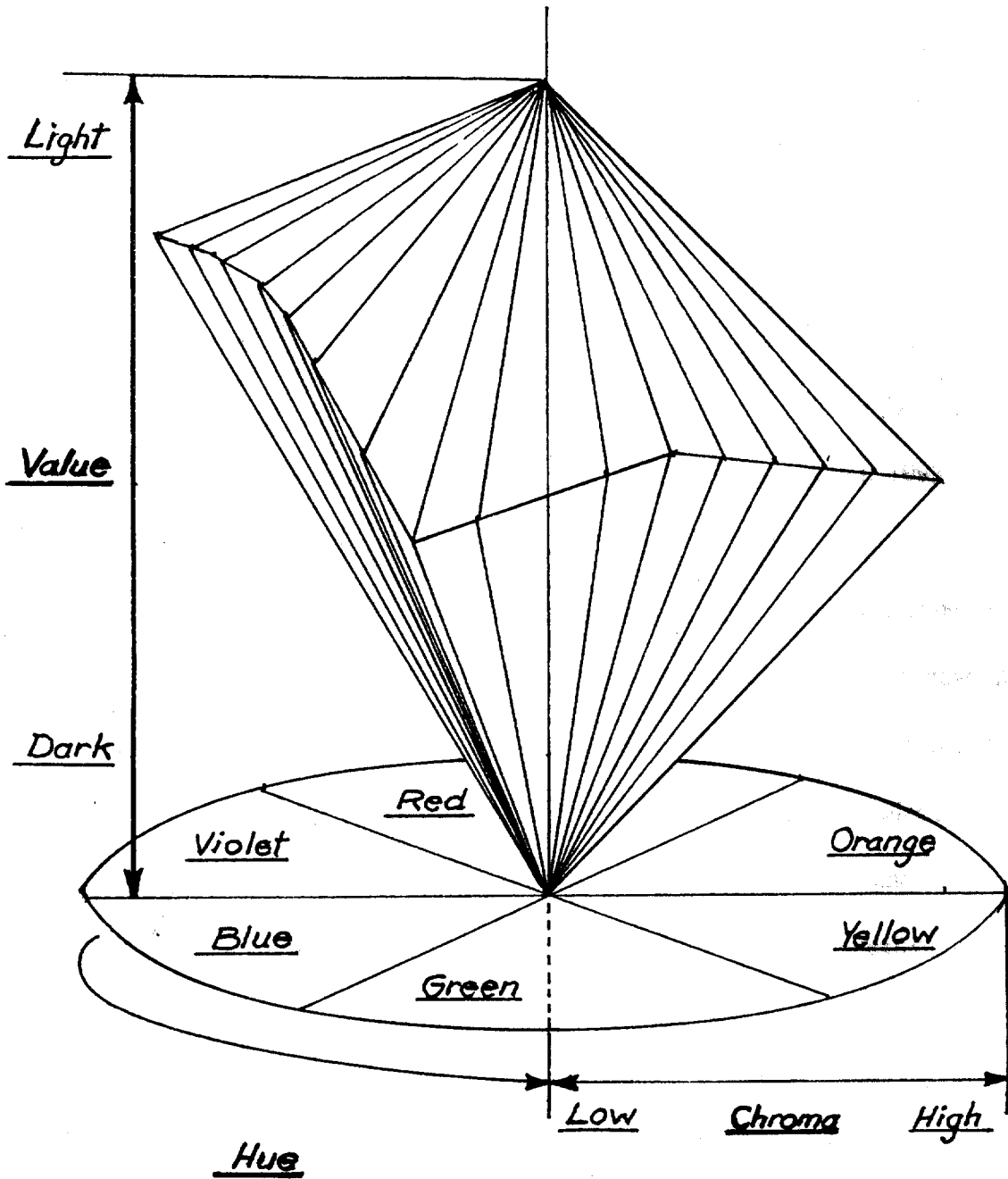


Figure 2.4: Color relationships diagram
(adapted from Marcus, 1992)

A number of advantages are gained through the use of color. Color can call attention to specific data or information, and identify elements of structures and processes (Marcus, 1992). This can aid in rapid recognition and identification of several categories of data, especially where data items are dispersed on the display (Schneiderman, 1992); errors in legibility or interpretation can likewise be reduced. Colors may be used to depict the logical structure of ideas and processes, or to portray time and progress. Color can be used to increase the number of dimensions for coding data, and to show qualities and quantities within a limited space. Further, colors portray natural objects realistically, and increase appeal and believability, along with memory and comprehension (Marcus, 1992). Well chosen colors can also give an impression of friendliness (Microsoft, 1993).

At the same time, color usage has several potential drawbacks. More expensive and complicated equipment is required for color display; many such displays have poorer resolution than their monochrome counterparts (Schneiderman, 1992). Some members of the population are not accounted for; for instance, 8 percent of Caucasian males are affected by color deficient vision. Problems may appear due to the visual fatigue and after images induced by strong colors, and visual confusion is possible because of complexity and potency of color phenomena (Marcus, 1992). Inappropriately colored areas can mislead users into searching for relationships that do not exist (Schneiderman, 1992). Poorly selected colors can inhibit performance and severely affect usability (Schneiderman, 1992; Microsoft, 1993). Further, certain colors may have negative cultural or historical associations, or exhibit confusing cross-disciplinary and cross-cultural connotations (Marcus, 1992).

2.5 Typography

Most every form of graphical display relies on text, lists, tables, and forms to relate information; typographic annotation is likewise used on maps, charts and diagrams. Legibility (a reader's ability to find, identify, discriminate and absorb text) and readability (ease of interpretation, and the text's appeal) play an important role in graphic design (Marcus, 1992). Several principles relating to these areas are discussed here.

The system of writing we now use has evolved over the course of thousands of years. This visible language system is a merged collection of CAPITAL and lowercase letters, numbers, punctuation, and other symbols. Research has demonstrated that both legibility and readability are improved through careful type selection and layout of material (Marcus, 1992).

For instance, variable-width letters occupy less space and are generally more legible than fixed-width versions. Studies have shown sans serif (without serif, ie stroked letterforms) fonts to be somewhat more legible than serif types. Further, in low-resolution screen displays or printout the fine strokes of the latter may not appear clearly (Marcus, 1992). Earlier experiments show raw reading speed for computer screens to be up to 30% slower than that achieved with text on paper. This appears to be mainly caused by the way the characters were shown. A later study conducted with anti-aliased fonts (where rough character edges have been smoothed out with shaded grey pixels) found an almost identical

reading rate and accuracy in locating spelling errors (Nielsen, 1990).

There appears to be no marked difference in reader preference or legibility based on text justification, but a 12 percent decrease in reading speed has been observed with CRT screens showing justified text. Word shapes are important for efficient reading; the variability provided by lowercase, in combination with uppercase characters, makes for more legible and readable text. Further, division of the display medium into several regularly organized zones improves both legibility and readability (Marcus, 1992).

Many computer applications rely on forms as their primary means of typographic display for data and information output. Forms contain a collection of components such as text captions, graphic display areas, and data entry boxes. The figure below shows an example of such a form.

Figure 2.5: Sample data entry/display form

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Many computer applications rely on forms as their primary means of typographic display for data and information output. Forms contain a collection of components such as text captions, graphic display areas, and data entry boxes. Figure 2.5 (below) shows an example of such a form.

The screenshot shows a window titled "Arboretum Database". The form contains the following elements:

- Location:** TD (W of SG)
- Date Planted:** Apr 17, 1987
- Rank:** var
- Dead?:** no
- Bed A:**
- Bed B:**
- Rec. No.:** 147
- Access #:** 83255-m
- Buttons:** Prev, Next, Print
- Scientific Name:** Betula platyphylla japonica 'WHITESPIRE'
- Family:** BETULACEAE
- Genus:** Betula
- Common Name:** Whitespire Japanese White Birch
- Family (Common):** BIRCH
- Buttons:** QBE, Clear, Set QBE
- Image:** A large, dark, grainy image of a tree, likely a birch, is displayed on the right side of the form.

Figure 2.5: Sample data entry/display form

Analysis of content to group appropriately related titles, labels and fields together, and sequencing information follow a straightforward natural order is important. Aligning major locations of type, symbols and images on the form on a standard grid lessens confusion on the part of the reader and establishes spatial structure. Large lettering, bold titles, ruled lines or gray areas may be used to separate major zones (Marcus, 1992). Information presented graphically using line widths, markers on scales, and other techniques minimize the need to read and interpret that data (Schneiderman, 1992). Discrete use of color and shaded patterns can draw attention to or lowlight a particular form element, such as a data item or instructions; this can be used to enhance recall of the location of that information (Marcus, 1992; Nielsen, 1990).

Standardized abbreviations, along with consistency in labeling and graphic conventions in form design maintains user understanding. Likewise, presentation of data only when knowledge of that is actually useful and necessary reduces visual clutter. Research has indicated that suppressing the presentation of redundant text information fields reduced users' location time for such data (Schneiderman, 1992). Verbal content that is "terse, specific, unambiguous, familiar, and in the active voice" aids in understanding. Further, having potential users examine and evaluate a given design can affect conceptual, visual and verbal content of a form, while possibly revealing confusing usages (Marcus, 1992).

2.6 Icons and Symbolism

Among other types of graphics, symbols, glyphs, pictograms and icons are widely used as constructs within user interfaces. Present-day applications may employ several hundred of these graphics to perform a varied range of functions, such as representing a group of choices as to the course of action the user wants taken; they function for guidance purposes, as well as identification and appearance (Marcus, 1992).

The "icons" generally spoken of within iconic interfaces are a mixture of three types of signs within visual semiotics (the study of visual signs and symbols). An icon is simply a graphic similar in appearance to the concept it is intended to represent. A curved line drawn in a textbook used to portray a mathematical equation would be an example. Indices show a resultant state caused by a thing or process; steam rising from a kettle might indicate boiling water. Symbols, unlike the first two, may not have a direct correlation in appearance; often the associated meaning must be learned. A gold medal for instance symbolizes first place standing in a competition (Marcus, 1992). Figure 2.6 shows several icon examples.

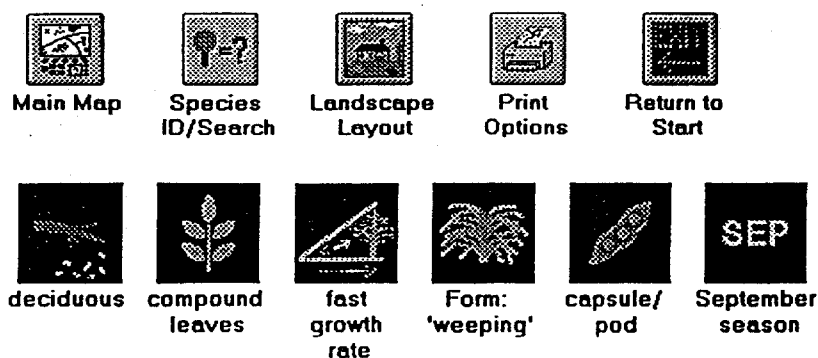


Figure 2.6
Example icon sets

In development of a system of icons, there are three main entities: 1) the words or names the icons are intended to represent; 2) the potential icons that could provide a visual representation of these names; and 3) the interpretations that people make in terms of what these icons represent (Glenn and Chignell, 1992). "From an information theory perspective, the designer encodes the names into icons, and the user then has to decode the icons back into the names. The effectiveness or usability of icons will be jointly determined by the encoding accuracy of the designer and the decoding accuracy of the user (Glenn and Chignell, 1992)." Schneiderman (1992) lists a number of icon design considerations and suggestions drawn from his own experience, and suggests a 'dynamics' level to be considered along with the four levels of icon design (lexical qualities, syntactics, semantics, and pragmatics) described by Marcus (1992).

Several advantages can be gained through use of iconic representations. They require less screen display area than equivalent written text, which may be a major factor in map-like displays and annotated diagrams. Well-designed iconic representations prove less difficult to recognize quickly within a high information content display. They can further provide a visually attractive interface which exhibits a certain identity. Icons can convey more of a universal meaning for individual functions, or even a series of steps - reinforcing previously delivered information (Marcus, 1992).

Iconic representation cannot always replace wording, especially in complex situations. Schneiderman (1992) however cites evidence that in many situations (road signs, for

example) combination of both a visual icon and text can aid in viewer comprehension. Proper study and development of appropriate groups of icons for an application requires both time and monetary expenditure; if this is not done, user confusion and lower productivity can result. Further, different sizes, weights and styles of icons may be necessary; no standard system exists which can be incorporated for design purposes (as with text fonts for instance) (Marcus, 1992).

2.7 Windowing-System Components

"The appearance and behavior of the windowing system as experienced by the user is determined by a small group of standard components. The systems make use of essentially the same set of human-interface objects, but the names by which these components are identified vary significantly among vendors." However, the basic elements remain relatively standard across different platforms (Marcus, 1992).

The mouse/keyboard interface is used as primary method of interaction. Each of these two devices is well-suited to a certain set of interaction tasks. While the mouse provides efficient means to accomplish tasks that require spatial manipulation (menu navigation and window sizing/positioning, for instance), the keyboard is more suited for sequential tasks (such as text entry, and shifting the order of window appearance) (Marcus, 1992).

Windows are any discrete area of the visual display that can be moved, sized, and rendered independently on the display screen; display objects allow the user to change the view of their contents using these techniques such as sizing, scrolling, or editing. Menus provide a means of command retrieval via visual examination and pointing, rather than having to rely on typing and memory. Problems caused by limitations of human memory are greatly reduced, with only a slightly reduced motor performance as the trade-off. *Controls* are visually represented window component that can be directly manipulated with mouse or keyboard. Windowing systems generally define a common set of controls that can be incorporated within applications to provide consistent interaction protocols (Marcus, 1992). Figure 2.7 shows a generic window.

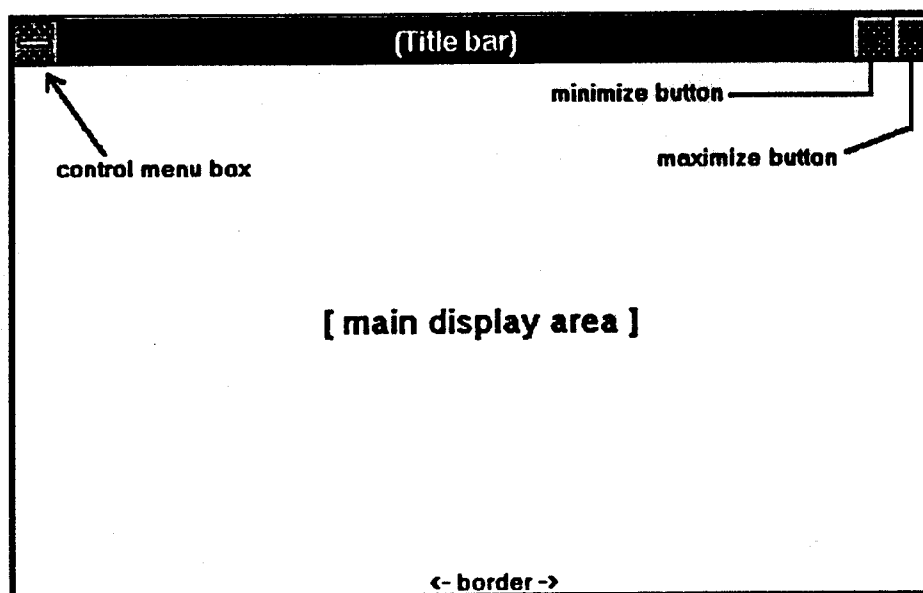


Figure 2.7

Standard
Microsoft(tm)
window

Single menus present the user with a number of distinct choices, from which only one may be chosen. In graphical user interfaces, two choices might be represented with a pair of icons or command options. When dealing with more than two options, radio buttons are

often used (Schneiderman, 1992). Figure 2.8 shows 'Gray' as the selected item for a choice of foreground color:

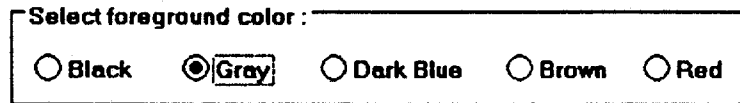


Figure 2.8: Radio buttons

Multiple-selection menus allow the user to make multiple selections from a group of choices. Check boxes are a graphical means of accomplishing this (Schneiderman, 1992). For instance, through mouse clicks on the check box squares in Figure 2.9, several different plant species layers are selected within ALGIS.

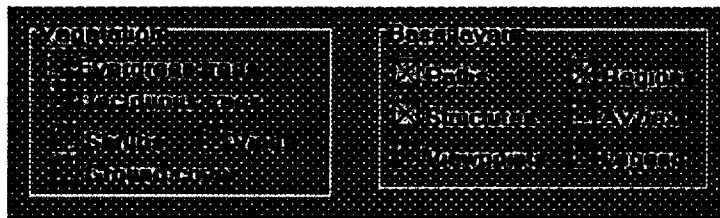


Figure 2.9: Checkboxes

Further, pull-down and pop-up menus provide alternate means of constructing single- and multiple-selection menus. Pull-down menus are available via selections from a top menu bar, while pop-up menus appear on the screen in response to a click from a pointing device (Schneiderman, 1992). An example pull-down menu is shown as part of a window in Figure 2.10.

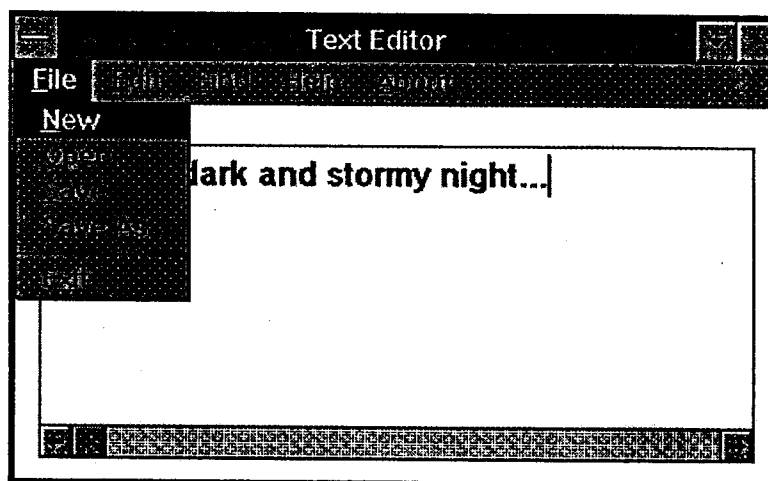


Figure 2.10: Pulldown menu example

Another of the basic windows design elements are *dialogue boxes*. Dialogue boxes present options from which the user can select, within a visual and functional context. Interactive exchange of information between the system and the user that takes place in a limited spatial content is considered a dialogue. Modeless dialogue boxes are limited in scope, but do not restrict further operations by the user. Users are able to continue work without necessarily responding, and may be allowed to keep the modeless dialogue active on the display ever after they have given a response. Modal dialogue boxes, on the other hand, force the user to respond before any other action may be taken. Application modal dialogues prevent the user from invoking any other application functions until the dialogue has been satisfied, whereas system modal dialogues will not allow the user to perform any operations in the entire system (Marcus, 1992).

There are three distinct classes of dialogue box: control panels, query boxes, and message boxes. While each has some amount of overlap with the other classes, they can be

characterized by a clearly defined scope. *Control panels* appear in response to a user request, and provide information which reflects the current state of a group of related system parameters, allowing the user to interactively modify their values while the panel is displayed. These changes do not take effect unless they are explicitly accepted (Marcus, 1992). Figure 2.11 shows a control panel example.

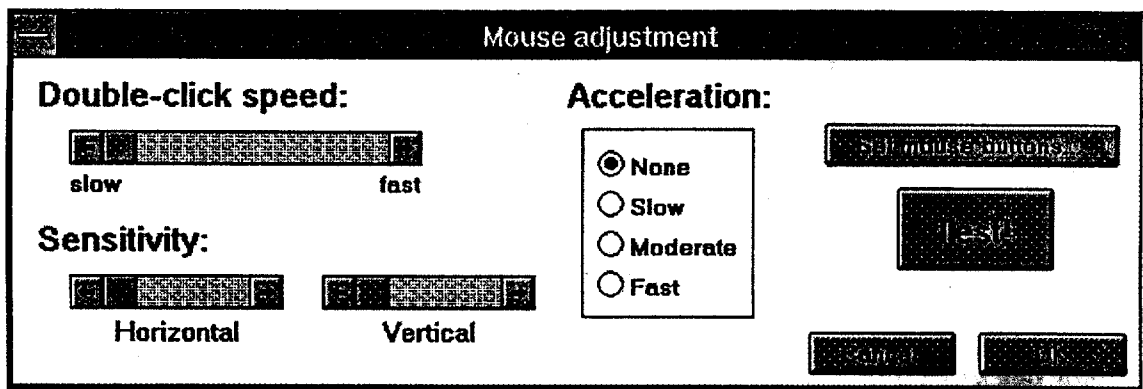


Figure 2.11: Control panel (mouse)

Query boxes (such as Figure 2.12) appear in response to user actions, but are not explicitly requested. They prompt the user for a single piece of information (such as a yes/no response), and give a context in which this information can be provided. As with control panels, the user has the ability to cancel the action which brought up the query (Marcus, 1992).

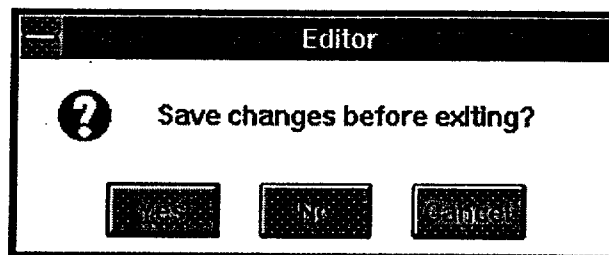


Figure 2.12: Query box

Message boxes (see Figure 2.13), also a non-requested form of dialogue box, provide critical information to the user, typically when the system has entered or is about to enter an unrecoverable or otherwise dangerous state. The user is usually limited to a yes-or-no decision, or in more serious cases only an acknowledgment of the message (Marcus, 1992).

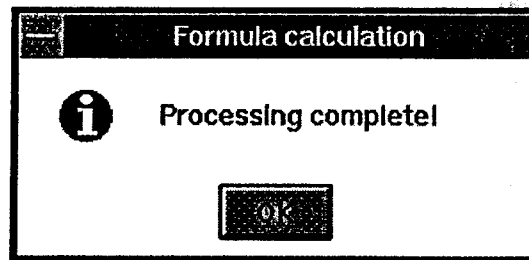


Figure 2.13: 'Info' message box

Skillful visual design of computer screens -- with care given to color, typography, layout, icons, graphics, and coherency -- substantially contributes to quality and usability. These grow from a coherent set of ideas; answers to come from thinking about user tasks and the information to be displayed -- and then applying principles that make for effective visual and verbal communication (Tufte, 1989).

Various products now available on the market make it easier to create a user interface, but at the same time also make it easier to assemble a poor user interface than ever before. Well-designed user interfaces must account for the following key components. One of these is an easily grasped metaphor and idea or image that captures the essence of the system. Appropriate organization of data, functions, tools, roles, and people in a task-oriented cognitive model should be arranged, as well as an efficient navigation schema in this model (that is, action relationships that enable the reading and writing of these data,

functions, tools, etc.) (Marcus, 1992).

High-quality appearance characteristics (such as size, shape, color, orientation, etc.) of visual elements on the screen must be accounted for. An effective interaction sequence (logical protocols for visual elements), along with their relation to hardware input/output devices, is also important. Other relevant factors concern available UIMS and computer-platform constraints, tool sets, customizability to end users, and help/on-line documentation (Marcus, 1992).

2.8 User differences

There exists a diverse range of human perceptual and cognitive abilities, backgrounds, and workstyles. The complexity of interfaces as a function of the number of potential end users poses a challenge to the interactive system designer. This can be seen in considering the differences among user interfaces developed for the following: the programmer's own use; the programmer's coworkers; a single known customer, who may represent a larger group of users; a set of unknown customers with a certain level of technical training; a large, unconstrained set of customers with little technical training (Morse and Reynolds, 1993). Also, as Schneiderman (1992) points out, "Some people dislike or are made anxious by computers; others are attracted to or are eager to use computers... Even people who enjoy using computers may have very different preferences for interaction styles, pace of interaction, graphics versus tabular presentations, dense versus sparse data presentation,

step-by-step work versus all-at once work, and so on."

A user's relative level of expertise has a large impact on how they use a particular system. For instance, Nielsen (1990) cites evidence that users who had been given even 30 minutes of practice working in a fairly simple window system performed substantially better than users who started as novices. Further, other findings suggest that their relative frequency of use of different access mechanisms change as they grow more experienced with that system.

Depending on their ethnic, racial, or linguistic background, users may be used to scanning information in a different manner, or have certain preferences for interface style. Visual and auditory acuity, along with perceptual abilities may vary by individual, sometimes due to age, disease or disability. User interface designers must consider the needs of all potential users. Larger fonts, greater display contrast, easy-to-use pointing devices, reasonably loud audio, and simpler command languages can aid in accommodating a range of ability levels. Some viewing angles and distances make the screen easier to read (Schneiderman, 1992).

As individuals, users may have particular styles or methods for accessing and using data they encounter. Whether due to motivation, knowledge of a field, energy, extroversion, some are more active than others in their exploration of information. Subjects with high spatial visualization abilities have been shown to be better able to construct conceptual

models and thereby better locate and navigate information (Nielsen, 1990). Research points to three major types of learning strategies (linear, associative, and jumping associative); recommendations have been made that different teaching techniques be implemented to match the preferred learning strategy of each user. However, variations in the types of information presented in different applications may suggest a certain means of access and retrieval generally more appropriate to the task (Glenn and Chignell, 1992).

2.9 Information retrieval

"How do people present knowledge so that others can understand it? The traditional method is a linear, narrative unfolding of sequential information - for example, lectures and textbooks. Other methods rely on a nonlinear, spatial layout of information - for example, diagrams and maps. We are still discovering more sophisticated approaches; for example, conversational methods, in which one person queries another in no particular order and in which the other responds with specific answers; and hands-on activities and simulations that let people learn by trying things out or by building interactive models of the world." (Florin, 1990)

In a paper dealing with touchscreen interface, Sears, Plaisant, and Shneiderman (1992) define a seven-stage model of user interaction based on the syntactic/semantic (Shneiderman, 1987) and seven stages (Norman, 1988) models. These concepts are similarly functional for other input devices and user interface itself. In a more generalized adaptation

of this model, the user proceeds through the following steps:

- 1) **Formulation of goal** - development of a plan concerning what needs to be accomplished within the task domain
- 2) **Forming of intention** - Evaluation of the computer screen to identify all selectable and non-selectable regions that represent actions and objects relevant to the task
- 3) **Specifying the action** - identification of the desired region, by action or object
- 4) **Execution of action** - activation (the syntax being a mouse click, for instance) of the desired region, and feedback received from position and on-screen changes (the cursor itself, selectable area(s) becoming highlighted, etc.)
- 5) **Perception of current system state** - confirmation that the input device is over the desired area, and activation of that area
- 6) **Interpretation of system state** - a check that the desired area has been activated
- 7) **Evaluation of outcome** - interpretation and evaluation of the result of the selection, in terms of whether the task domain goal is furthered

Standard approaches in computerized interaction have sometimes concentrated their focus on raw data, and less on informational content or ideas represented. This data-driven approach contrasts with both direct expression of ideas (as with use of visual and aural devices, in the arts), and teaching methods which encourage examination and understanding of interconnected ideas. Of importance is that in learning, humans tend to make rapid, wide-ranging (often nonlinear) connections between data, information and ideas; these are

primarily visual in nature (Lengel and Collins, 1990).

The mind works by association; thus, to facilitate interpretation and understanding, a computerized system might include similar methods. Direct and visual links between ideas and meanings can portray a broader meaning to prospective users. This type of organization also permits users to select their optimal means of interacting with given material. While they might choose to jump from one idea to another, they also have the option of following a linear path through the information.

While this form of exploratory learning allows users greater freedom and motivation to learn, it also induces certain mental burdens - cognitive load - involved in digesting and organizing information, which may not be fully understood when first examined. While textbooks for instance often include means of organizing material and measuring progress, exploratory learners are frequently left to determine the level of complexity they encounter; failure to control this can lead to cognitive overload and diminish learning effectiveness (Oren, 1990).

Navigation factors in hypermedia systems create further cognitive load, in terms of orientation ("Where am I in the data?") and affordance ("How and where do I go from here?"). Note for instance that some applications display only one screen image at time - this actually acts to increase cognitive load, as prior information must be retained in the users' memory while they proceed through a sequence of steps, especially as the number of

informational links increases. These various methods have been determined in an attempt to reduce cognitive load (Oren, 1990).

One of these is the construction of simple landmarks within the system. Here, strong visual cues can help to orient the user within the interface environment, relating overall or specific location. A general overview showing connectivity and structure might be provided by a diagrammed flow chart such as shown in Figure 2.14.

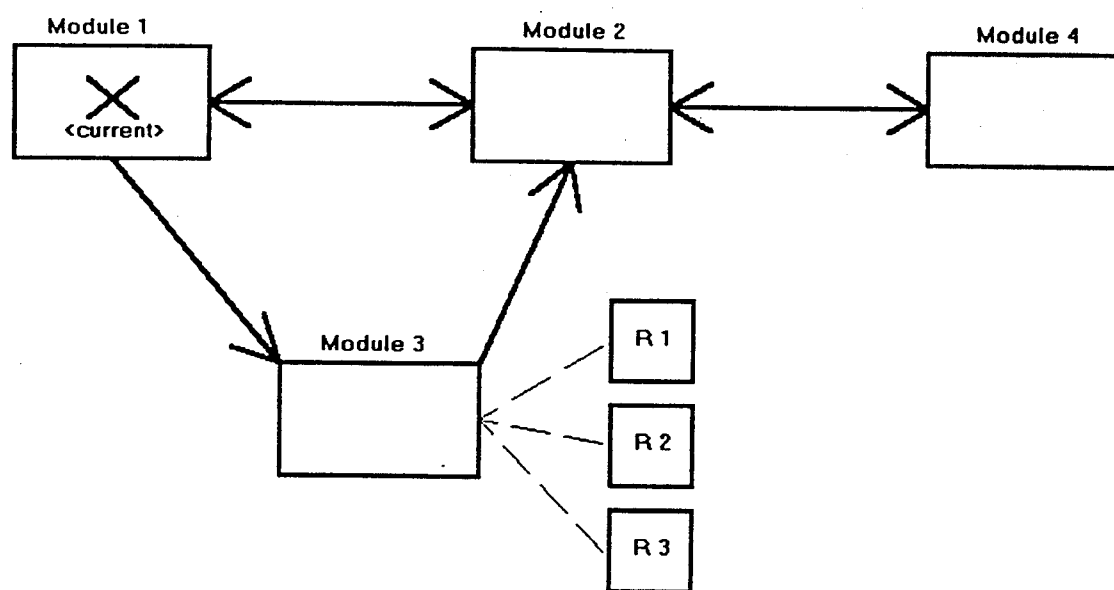


Figure 2.14: Sample system organization chart

Another common means for lessening cognitive load is through information hiding, i.e. reduction of the alternatives visible to the user by way of hiding less-used options. This could be done by actively displaying controls of most interest (for instance, those directly relevant to the current screen), while placing the remainder in pull-down menus (as with

commands to move to other parts of the system). Further, "The concrete nature of physical systems allows their use for externalizing information. Designing features analogous to bookmarks and annotations back into electronic systems allows the learner to save parts of mental states for later reference." (Oren, 1990)

Chapter 3: Functional System Description

3.1 General design

ALGIS provides a graphical point-and-click interface, with simple mouse dragging and keyboard entry. Most user actions require only pointing and/or clicking with the mouse; few operations require the latter two, and no more complicated manipulations are necessary. The prospective audience is assumed to be the general public; ALGIS attempts to accommodate both computer novices and those experienced with Windows, while not assuming they possess any general botanical knowledge.

ALGIS is comprised of a set of functional program modules, each of which performs a specific task. While some of these modules are completely independent, others rely on shared data arrays for input, or alternately produce resultant data for use by one or more other modules. This modular design facilitates modification of existing system functions - individual modules can be worked with separately and reintegrated when changes are made. Future expansion is possible by adding modules to perform new functions, and/or changing the way the modules interact. After initial configuration of ALGIS' design for instance, several modules were added, while one was partially merged with another and removed from the command bar selection.

Individual users have many different ways of locating information; it is helpful to include various strategies to perform searches that will match their requirements. With an analytical search, for instance, the user systematically specifies a set of requirements for information to be retrieved. In searching by analogy, the user's needs are assessed by analyzing information concerning a previously examined object or set of conditions, in order to find something similar by selecting appropriate search parameters. Further, a user may have requirements which are too ambiguous for a search template to be specified. Instead, they may browse through the contents of an entire database or portion thereof, exploring possible matches between the intuitive current need and the available items (Pejtersen and Goodman, 1988).

Field testing of the the Book House (a graphical and iconic interface to a database, designed for retrieval of information on works of fiction within a library) confirmed the use of these different strategies. Of the four strategies provided, Pejtersen found that analytical searches accounted for 31% of the total; pictorial browsing, 23%; search by analogy, 20%; and random browsing the remaining 20% (Nielsen, 1990). ALGIS supports varied approaches in working with information available. Unstructured browsing is illustrated in scanning through individual sounds, pictures, and video. Users may examine an areal location on the Overhead Vector Map, and get information on any given plant they run across. More structured approaches, such as a database search of name fields and/or characteristic features of plants, can be used. The scope of materials being examined might later be expanded by reducing requirements or narrowed by adding further conditions.

Searches on information can be begun without necessarily having a clear idea of what the target is; people may know what they are looking for yet cannot adequately describe it beforehand (Glenn and Chignell, 1992).

Further, the Overhead Vector Map presents several different means of map movement. Module windows may be activated either from command bar icons, clicked on directly, or brought up in response to other events.

3.2 Introductory Screens

While the system is in its inactive mode, it runs through a series of introductory screen pages. These give a brief visual background of different scenes and plants within the Gardens, the system itself, as well as design credits and miscellaneous useful information. The changing screens function to draw user interest, relate information, and also work as an effective screensaver.

After the user hits the space bar (or any other key) to proceed, a starting screen appears. Here, users can set their user level to either the Beginner mode (default), or a more Advanced mode of operation. In the current implementation, a major difference between the levels is that users may have any number of module windows on-screen in Advanced mode, and take advantage of usual MS-Windows functionality, whereas Beginner mode users work with one window at time and do not need to perform such actions as

double-clicking. These user modes are discussed further in the sections that follow.

At the starting screen (see Plate C-1), three command choices are available. For those users experienced with the system, 'Start System' will jump directly to the main map and other program modules. The 'Introduction' gives a general overview of the UW Arboretum, its history, background information, and so on. The first part of this takes the form of a brief narrated video segment - a speech by Greg Armstrong, recorded near the main Longenecker Gardens sign. This was originally recorded on location with a consumer Hi8 video camera, and later digitized to Windows .AVI format for use in the system. The second portion of the overview contains further narration and shows various planting regions within the Gardens.

Next, a 'System Tour' of the system can be selected. This option is recommended for first-time users, as it demonstrates system use by running through examples of actual program modules as they'd normally be worked with. Many users prefer to learn by experience or observation rather than reading about how to do something in a manual, where they must continually attempt to correlate instructions in the manual with objects and behavior observed. The user is graphically shown all necessary steps (mouse movements, selections, etc.) for typical operations, with accompanying text and an optional audio voiceover (see Plate C-2). They have the option to skip portions, or break off and take active control of the system from any point. Through communications with the Windows event recorder utility, real-time playback of pre-recorded demonstration sequences is

possible.

A large-font text window, containing instructions and example notes, remains up for review until the user proceeds with the next segment of the Tour. Visual (both static text and dynamic motion) and auditory information are available; re-presentation of related information can function to reinforce key concepts. Depending on which of these is most effective for their individual learning style, or a particular program section, the user can choose which to actively use.

Various forms of user assistance which provide training, reference, and reminders about features or syntax have become standard features in many systems. Some examples are the online manual, an electronic version of the paper variety; help facilities, which present this information hierchically and include keywords; online tutorials that teach novices by showing simulations of the working system, possibly including animation or interactive user sessions; and demonstrations which give an overview of the software via a guided walkthrough. (Schneiderman, 1992; Nielsen, 1990). Information is immediately accessible and takes no physical space; help files can be rapidly updated at low cost. Color graphics, sound and animations can be incorporated to explain complex actions and affect user interest. "The form and content of the online help facility make a profound difference. Good writing, task-orientation, context sensitivity, and command examples may all contribute to improved online help (Schneiderman, 1992)."

Initially, upon entering the system (either directly, or during the first part of the System Tour) two things are visible. At the left is the main command bar. ALGIS by design is divided into distinct functional areas. Each of these is set up as separate 'module', or program in itself. Graphical icons are used to represent these modules on the command bar, and module names are shown as the mouse pointer is moved across icons. The latter serves an obvious purpose - Glenn and Chignell (1992), for instance, found that without prior knowledge, college students had difficulty recognizing the meaning of a set of commercially produced icons by themselves... as did an executive of a company that used those same icons in its products. While the mouse pointer is over an icon, holding down 'F1' (generally used in MS-Windows as a standard help key) brings up a pop-up window briefly explaining its function. To start a module or bring its window into view, the user clicks on the appropriate icon.

3.3 Overhead Vector Map

The module of primary importance is the Overhead Vector Map (shown on Plate C-3), which is automatically launched when the command bar is brought up. This map displays an overhead view of the regions and plants that comprise the Longenecker Gardens area. Each map layer can be selected individually via checkboxes - initially shown are Paths, man-made Structures and planting Regions outlines. A Text legend overlay is also available. Originally part of a larger Arc/Info coverage with a UTM coordinate system, these layers were converted to .DXF form (AutoCAD's universal graphic exchange format)

and thereafter to Windows metafiles. They likewise maintain the same relative (real) coordinate system, although this information is not apparent to the casual user.

Each of the major five plant types (evergreen and deciduous trees, shrubs, vines, and ground cover) can be clicked on or off in a similar manner. Individual plants appear on the map as generalized outlined icons respective to their type. Their point locations were obtained through measurements from portable GPS units within the Gardens, and differential post-processing steps. Attribute information keyed to records within the database was later attached in a separate Arc/Info coverage, in the same coordinate system as the vector boundaries above.

In addition, there are two other layers: Scenic Viewpoints, and Text/Audio/Video. Scenic Viewpoints are multi-directional scene pictures taken at a specific location in the Gardens; these are discussed later. Clicking on a signpost graphic retrieves an associated text passage. Similarly, a speaker symbol plays back Audio (sound, perhaps a narration) when clicked on, and a video camera shows a Video segment connected to that point on the map. Keyed text, audio, and video information (text fields, including filenames) are stored within a separate database; this can be referenced from other modules (such as Scenic Viewpoints) as well. If an entry has X/Y coordinate values, it will automatically appear on the map.

When the map is first shown, the user sees a full-scale view of the Longenecker Gardens in the larger window. However, by moving the mouse pointer over a region and hitting the plus key ('+'), he can zoom in further and examine the surrounding area in closer detail. This can be repeated several times, up to 32x magnification; the minus key zooms back out. Captions (common names) for individual plants are shown only at an 8x or greater view, to minimize screen clutter, ensure legibility, and eliminate unnecessary display steps.

While examining a magnified view, a couple of useful things are seen. One of these is the blue box which appears on the small 'Location' map at the upper left. This highlights the relative position and view extent of the current view area, and also serves as a way to jump to alternate locations on the map. Pointing to an area and clicking there moves the box (and the current map view) immediately to that region. An alternate way to move around the map is through use of the scrollbars next to the large view window. Multiple input techniques provide an easier means of operation in many instances, either for reasons of necessity or convenience, though it is important to implement input methods that appear natural for the tasks involved (Sears et al., 1992).

Tufte (1989) discusses the concept of micro- and macro- levels of detail in composition as an effective representation strategy. "Panorama, vista, and prospect deliver to viewers the freedom of choice that derives from an overview, a capacity to compare and sort through detail... thus the power of micro/macro designs holds for every type of data display as well as for topographic views and landscape panoramas. Such designs can report

immense detail, organizing complexity through multiple and (often) hierarchical layers of contextual reading."

In our system, the Overhead Vector Map demonstrates several levels of information detail; users may locate a particular plant and also see it in a broader context. When a user first examines the map, the entire collection of hundreds of plant species can be observed; distinct clusters are apparent. As the view magnification is increased, characteristic outlines of each general plant type are seen, along with distributions within single planting regions. Zooming in still further shows common name captions for individual plants. The fact that not all of these are available at once is due to limitations imposed by video display resolution (1024x768 pixels, in our case) and map window area. A laser printer, however, may have sufficient resolution to show all of these levels simultaneously on a map printout.

3.4 Species Information

After the user is familiar with map navigation, obtaining information on a plant species is fairly straightforward; all they need do is move the mouse pointer over a given plant, and click somewhere on it - naturally, its respective map layer must be selected or it will not have appeared on the map. Thereafter, a Species Information form displays a picture of that plant (if available), along with related name and characteristic information. At the left are the scientific name and family, the common name and the common family name. Location code, relative map coordinates (where called from the map) and date

planted are also shown, along with numbers of bed plantings and rank. If an individual plant has been placed as a memorial, sponsor name will also appear. The presence of a backpack icon means this plant may be used in the Landscape Layout module, discussed further under that topic. The Species Information form is shown on Plate C-4.

Other useful information can be found elsewhere on the Species Information form. This is divided into three major sections: Identifying Features, Growth Requirements, and Landscape Characteristics. Here, plant attribute information read from a DBase III file (via a set of Visual Basic custom controls produced by Q+E) is reassembled as brief text descriptions. These are organized in logical sequences within separate boxes, each with a light blue group heading, indented yellow text, and varicolored items in certain fields (such as flower color, or soil acidity). Where no information is available or known, an <unknown> indicator will be shown. By default, all three information sections are on-screen at once. Users in Beginner Mode are shown one section at a time, and click command buttons to switch between them; the additional space is used for further instructions.

Studies conducted by NASA and others have demonstrated that improving data labels, grouping clusters of related information, using indentation and underlining, alignment of alphanumeric values, and elimination of extraneous information can improve performance. Denser displays can be more difficult to scan, especially for novice users; however, more experienced users may prefer the higher information content available (Schneiderman, 1992).

The first section (Identifying Features) shows text concerning the plant's general growth habit (tree, shrub, vine or ground cover), its leaves, flowers, fruit and bark. Specific types are listed, along with seasons and color where appropriate. To obtain further information on term meanings, users simply click on the words and an information window appears. This window shows a representative icon, caption, and brief definition for all possible values of that characteristic feature. Terms which apply to the particular plant species are highlighted, and their icons colored; the remainder are greyed out. Text within Growth Requirements and Landscape Characteristics functions similarly. Growth Requirements are attributes describing sunlight, soil acidity, soil moisture and soil type, as well as pest/disease problem indication, and plant hardiness zone. 'Hardiness Zone' differs somewhat in that it displays a small Wisconsin map delineating an effective region. Landscape Characteristics include growth rate, form, texture, attractive features, use, toxicity and native region.

Additionally, the Identifying Features section allows viewing of related pictures for the plant itself, as well as its leaves, flowers, fruit, bark and buds. If any of these has an available image, a small icon is shown at the left - images are viewed by clicking on these. In Beginner Mode all pictures are displayed on the main form one at a time. Advanced Mode works in the same manner, except that multiple pictures can be shown simultaneously in their own separate windows. This allows users to compare different attributes of various plants, which can be from related or dissimilar species. The picture windows can be minimized to icons, and later clicked to restore them to full size. [close] removes an image

from the screen entirely, while [view plant] jumps to the Species Information form corresponding to that plant image. Plate C-5 shows a picture window and an attribute form.

3.5 Species ID/Search

Species ID/Search enables users to search for a collection of plants that match a given set of conditions. Search conditions can be named fields, Identifying Features, Growth Requirements, and/or Landscape Characteristics; any combination of these factors may be included concurrently in the search. In one capacity, this module can be used as a tool for general identification of plant species based on characteristic traits, primarily with regard to identifying features and landscape attributes including form. A more practical use involves scanning for plants which would fulfill certain conditional requirements. A typical question posed by Arboretum visitors, for instance, concerns whether a particular variety or group of plant species could work reasonably within their home environment, perhaps as a backyard planting.

The search module begins with a form which examines only the named fields: scientific/common names, family and common variant, location code, memorial dedication names, and date planted. This form is shown in Plate C-6. While the scientific fields are probably not of interest to many users, they remain available for specialists or others who might want to use them. The above information is termed 'Inventory Background.' Except for the date information, each of these fields has a textbox with a drop-down list. Users can

enter either a complete name or a portion thereof, as all entries are treated as sub-patterns to be matched. Alternately, they can select a specific entry from the attached list; all distinct entries for these fields are read from the database when the form is loaded.

As an example, say a user wanted to find all maple trees - they would click the mouse on the Common Name box, and enter 'maple'. After starting the search via the GO! button, all records having maple as part of their common name would be retrieved. During this process, the Browser flashes a 'searching' message while scanning through record numbers; a message box stating number of plants matched appears upon completion of the search. Using the Browser now allows paging through a series of Species Information forms, which otherwise function as they normally would. Common names of matching species are shown in a scrollable listbox - clicking there jumps to that particular plant. Below this are the << and >> arrows, which page forward or backward one plant. The [Exit] command quits the Browser, although it can be returned to at any time, or left active. The results of this search are shown on Plate C-7.

After switching over to the Main Map, several plants may be highlighted with red boxes - these show the spatial location of all plants matching the latest set of requirements. Starting a new search requires clicking on the Species ID/Search icon again. The user is given the choice to return to the Browser (and look at the results of the previous search) [Yes], continue and execute a different query [No], or do nothing [Cancel]. If they choose to run another search, the old search patterns remain as they were. The user now has the

option of editing these, blanking every field of the current form ('Clear Screen'), or resetting all search parameters on this screen as well as elsewhere ('Reset All').

To illustrate a time-based search: a user might want to find all trees planted before 1990 (older than 3 years) with the genus designation 'Cercis'. After typing 'Cercis' in the Scientific Name box, they'd move the mouse to where the ANY / < / = / > symbols are located. A search can be conducted with the Date Planted field on ANY (any time OK), < (before a given date), = (exactly a specific date), or > (after a given date). After clicking <, year, month and day may be entered directly, or increment/decremented via spin arrows nearby.

Searching on non-text characteristic information - Identifying Features, Growth Requirements and Landscape Characteristics - is handled differently, through a more graphically oriented and less complicated interface. Any of these three sections may be switched to from the Inventory Background form, or vice-versa. Upon switching to one of these (such as 'Growth Requirements'), the user will notice that each characteristic has several representative iconic graphics below (see Plate C-8). These icons are identical to the ones shown alongside definitions linked to respective Species Information terms, which provides consistency.

Selecting a group of specific attributes to actively search for or to exclude, is only a matter of clicking on/highlighting the appropriate choices. The icons start as grey,

meaning they are not selected. Clicking once highlights that icon in color, which means you're looking for a plant that might have that feature. Another click changes this to a crossed out version, meaning you want a plant that does not have that feature. A third click and the picture returns to grey. These form the basis for a simple yet powerful search; you can choose the types of characteristics you're specifically looking for (say, fast OR medium growth rate), while at the same time marking features NOT to include (such as innate pest/disease problems), and leaving possibilities open (greyed out) if multiple values exist. Factors for several different characteristic types are checked for via a logical AND. The search process is made faster through the use of a binary representation of the original characteristic/name database, so these logical operations are performed efficiently.

As an example, such a search could find plant species ideal for your backyard conditions. This might be an area of moderate soil moisture, with loam and clay soil types and an acidic pH. Further, you'd like a plant that has no pest/disease problems. A preliminary step might be to use the [Clear All] command button to start afresh, clearing all names or other characteristics that may have been chosen elsewhere. Thereafter, clicking once on 'clay' and 'loam' would highlight these beneath Soil Type; leaving 'sand' greyed doesn't preclude plants which function in sandy soil, if they also work in one of the two other types. Similarly, the remainder of the search would be specified by clicking once on 'acidic' (Soil pH), and twice on 'Pest problems' to show a crossed-out icon. Note that any combination of different characteristics may be chosen. If in addition a user wanted to find plants with a rounded shape, they could 1) click Landscape Characteristics; 2) click > >

twice (there are several connected pages - all icons/information won't fit on a single form); and 3) click on 'round' under Form. Clicking GO! here would begin a search using all of the above requirements.

In performing the above searches, Q+E database tools permit construction of powerful SQL(TM)-like queries. For instance,

Select Plant_Record from Plant_DB where:

LocationCode = LG

(FamilyComm = Magnolia AND DatePlanted >= 2/25/83)

(GrowthRate = Fast OR GrowthRate = Medium)

Learning this query specification format takes time and may be tedious to use for more complex search requirements. To alleviate this difficulty, the Q+E tools support a Query-By-Example feature which allows users to specify values by entering a pattern (an instance of what they're searching for) in one or more database field boxes. Novices can use this method with little training, and it can be powerful enough for expert users. SQL allows only a single value range to be searched on easily for each field; a full set of Boolean conditions is difficult to express, requiring knowledge of syntactic forms (Schneiderman, 1992). Further, Q+E's Query-By-Example permits text pattern matching only.

Plant species searches in ALGIS are conducted by first running an SQL search constructed from name fields and planting date range (if any) specified by the user. The

resulting record set is then filtered based on characteristic features. Characteristic information for a particular attribute (e.g. leaf type) is stored in the database as a concatenated list of alphanumeric codes, and a pattern matching search would normally be needed. Were these values stored in separate fields, the SQL expression needed to match even a simple sequence of these fields could reach great length, and result in a marked increase in search time. Therefore, characteristic fields were converted into a separate database of binary values, which could then be rapidly ANDed, ORed and NOTed according to the conditions specified.

3.6 Scenic Viewpoints

Scenic Viewpoints are locations within the Longenecker Gardens which have been selected for particular interest or scenic value. These Viewpoints allow users to look off in one of several directions from a given spot, graphically depicting what they would observe at that location were they actually standing there, in a first-person perspective. In doing this, the user may retrieve information on an area in the Longenecker Gardens they would like to visit, or have already been. Scenic Viewpoints are a separate layer on the main map, and appear as octagonal symbols; as with other map features, a mouse click on its symbol activates the Scenic View form. Initially a scene image is shown, with the name of the current directional facing (North, South, Southwest, etc.) noted above. An example Scenic Viewpoint is shown on Plate C-9.

The lower caption (which names what's being pointed to) changes appropriately as the mouse pointer is moved across different plants or other objects/areas within the scene. Clicking on an object will often retrieve further information - a Species Information form, or alternately text, sound, or video may be shown. The compass at the lower left indicates the current direction with a green arrow. Other possible directions are shown in black; directions with no picture views are greyed out. Clicking on one of the black compass arrows changes your view. Directional facing may also be rotated left or right by clicking one of the large arrows to either side of the picture.

A separate database exists for scenic viewpoints; real coordinates are included, thus the viewpoint octagons appear at their respective locations on the map. Directional view images were scanned from 35mm slides taken on-site via a tripod-mounted camera. Different regions (zones) within the scenes were then delineated with a utility program constructed for this purpose (the 'Zone Editor'). Within the database, zone areas may be named, and further connected to a record within the Text/Audio/Video database, or a reference to a particular plant for Species Information.

3.7 Landscape Layout

The Landscape Layout module allow users to get an idea of what certain plants might look like if grown at a general type of location. Selected plant images from the Gardens have been specially clipped out (through one option in the Zone Editor), such that they can

be picked up and positioned over a background picture. This permits visualization using several different species, alternate sizes and varying appearances.

As mentioned earlier, selection of plants to be brought over to the Landscape Layout module is done via the "backpack"; certain plants' Species Information forms display an icon for this purpose. Whenever plant information is examined and this icon appears, there are connected plant images available. These are read from file names stored in a database referenced by plant record numbers. Clicking on the backpack icon brings up a form showing current backpack contents. A command option is to 'Add Plant' to the current selection; the plants appear as icons with common name captions. Initially, the backpack is loaded with 2-3 plant image sets for demonstration purposes - a total of five different plant species held at one time. To acquire more space, individual plants may be removed with a mouse click, and another plant can then be added.

Next, clicking on the Landscape Layout icon at the main command bar brings up a window showing an image background. Alternate background scenes may be switched to by clicking the radio button group to the right ('open field' or 'typical backyard' for example). A future possibility would allow users to bring in their own scanned images for use as background. Plants currently in the backpack are shown at the bottom of the screen. To move one of these into the scenery, the users points to its icon, and (holding the mouse button down) drags it across onto the background image. A plant image should appear, highlighted by a green rectangle which indicates the current plant object being manipulated

on-screen. Plate C-10 shows a background scene containing several plants.

Each species may have 4-5 different pictures. When a plant is highlighted, these alternate pictures (which might include varying scales, seasonal pictures, or different growth stages) can be cycled through by pressing the '+' and '-' keys. Also, further plant objects of any of the available species may be added by dragging them across. Repositioning is accomplished simply by holding the mouse button down on a plant, dragging the plant image to a new location and releasing it there. Note that plants may be dropped 'over' each other, as with a series of stacked photographs; when one is picked up, it moves to the topmost position in the ordering.

When several plants have been placed, the user may wish to remove one or more from the screen. This is done by hitting the <- (backspace) key on a highlighted plant, causing it to disappear and redraw the scene. Note that there is also an upper limit on the number of plant objects that can be on-screen at one time, due to memory and Windows resource constraints.

3.8 Images/Video/Audio

The Images/Video/Audio module allows access to any pictures, video segments and sounds contained within the system. Users choose from a scrollable listbox showing all available selections. Component images from the Species Information section are listed by

type (main [picture], leaves, flowers, fruit, bark, buds) followed by the scientific and common name. Clicking on one of these shows that image in a pop-up window, separate from those obtained directly from a Species Information icon. Individual audio and video selections are played back in the same manner (see Plate C-11).

3.9 Print Options

The Print Options command handles printout of Species Information, or a view from the Overhead Vector Map. The system automatically tracks which of the two (if either) has just been accessed. In both cases, the information currently being examined (a particular plant species form, or current map view area, scale, and layers visible) is exactly what the user receives as hardcopy ("What You See Is What You Get"). A Lasserjet III printer is currently in place at the McKay Visitor Center, allowing generation of sharply defined maps and species data printouts while the user waits.

3.10 Bookmark

A bookmark option exists to preserve the user's current position within the system. After a fixed period of no activity from the user (meaning no windows reactivated, within a span of approximately 20 minutes by default), the 'Exit' procedures are automatically invoked. At present the Bookmark icon resets and pauses this time-out temporarily, so users can step away from the screen for a few moments (to question a staff member, for instance).

In the future, this feature may be used to save the current system state in its entirety. The main map view position and layers selected, database search results, module windows active as well as their screen positions and format would be written to a file specific to that user. This could be retrieved later to return the user to their former position (after a brief walk through the Gardens, or even several days later).

3.11 Activities

The Activities module form (shown on Plate C-12) displays a window briefly describing upcoming monthly events (with dates and times) and current daily activities (listed by time), which also includes space for additional notes. This information is drawn from several files that can be updated periodically by Arboretum staff. Further expansion in this module might include command buttons linked to other program sections such as a Longenecker Gardens-related quiz, tic-tac-toe game or other diversions.

3.12 Online Help

In addition to the System Tour and brief pop-up definitions shown with the command bar, other assistance is available. The Online Help feature (refer to Plate C-13) displays text pages detailing all modules shown on the main command bar, as well as information on how to operate the mouse/Windows interface. Clicking on one of these familiar command bar icons within its form brings up a text window that can be paged through via the << and

> > buttons, which will remain on-screen until closed. Context-sensitive help allows users to get specific information about the particular area of the system in which they are currently working (Schneiderman, 1992). In ALGIS, when 'F1' is pressed on any module's form window, its respective help file will be brought up. This might be further expanded to include specific help on each control or other functional area within a form.

3.13 Exit

The Exit command functions primarily to halt system execution and restart from the beginning. All forms are repositioned to their starting location; many of these, including plant species pictures, are unloaded from active memory. Database search icon settings and results are cleared, and map layers reset. Thereafter, the program returns to its inactive mode, showing the introductory screens.

3.14 Cycle Windows

As Schneidman (1992) notes, "The general problem for many computer users is the need to consult multiple sources rapidly, while minimally disrupting their concentration on their task... With 9- to 27- inch displays (approximately 640x480 to 2048x2048), it becomes a design challenge to offer users sufficient information and flexibility to accomplish their tasks while reducing window housekeeping actions, distracting clutter, and eye-head movement."

The Cycle Windows command serves to advance through the currently available set of module windows, which are those that have been brought up on the screen and left open. In Beginner mode, users only work with one module at a time. The remainder are automatically minimized to an icon at the bottom of the screen, as the user switches to a different module. While clicking these icons directly allows Beginner mode users to jump to their respective modules, 'Cycle Windows' presents an alternative choice. Also, for the Species Information window, the Characteristic and Backpack windows are automatically hidden and brought back when appropriate. In Advanced mode, this option can be used to maintain a relatively organized screen; while windows are not all minimized automatically at first, 'Cycle Windows' will proceed to minimize them one at a time and cycle through the list of currently active windows. One resulting state is shown on Plate C-14.

Plate C-1: ALGIS starting screen

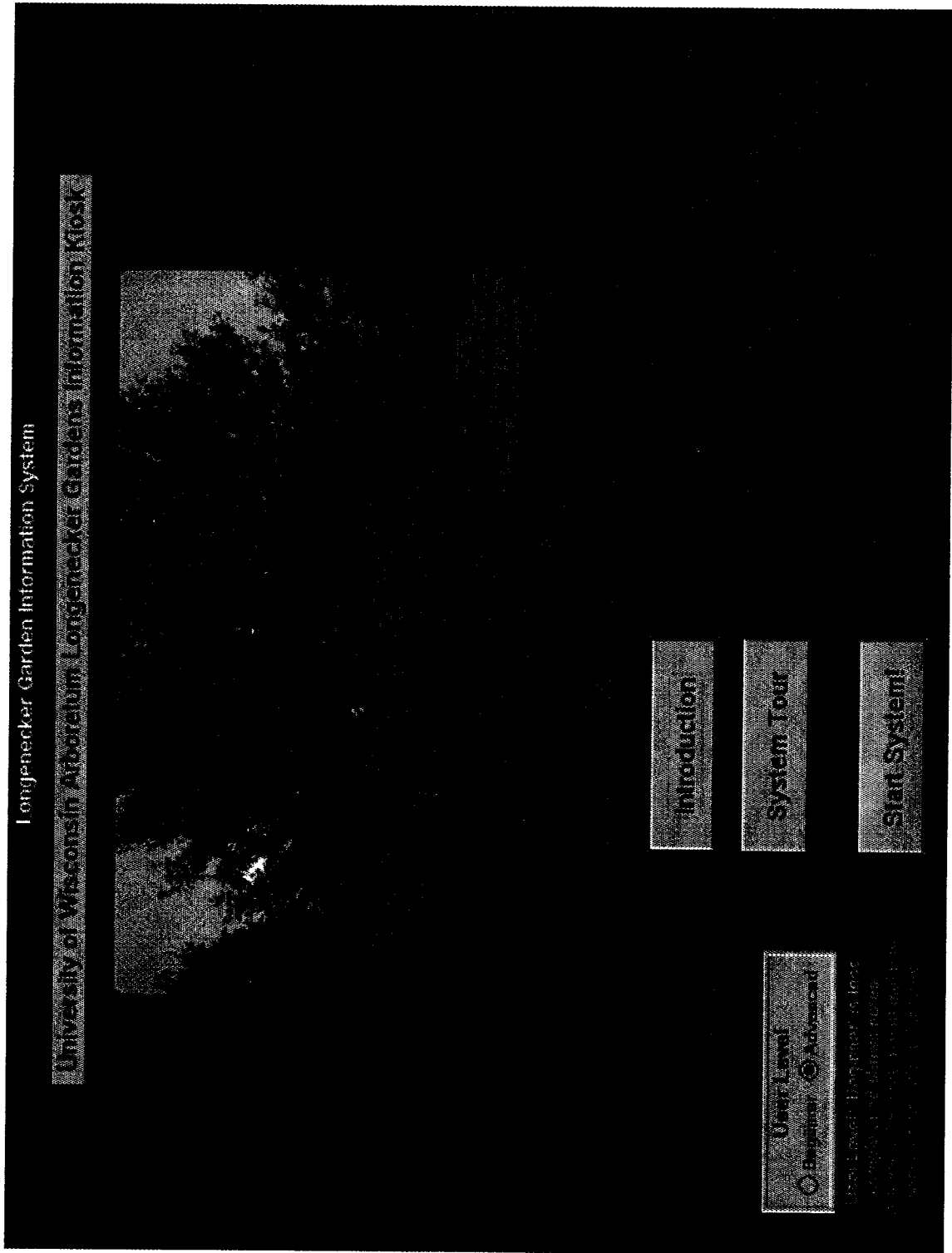


Plate C-3: Overhead Vector Map

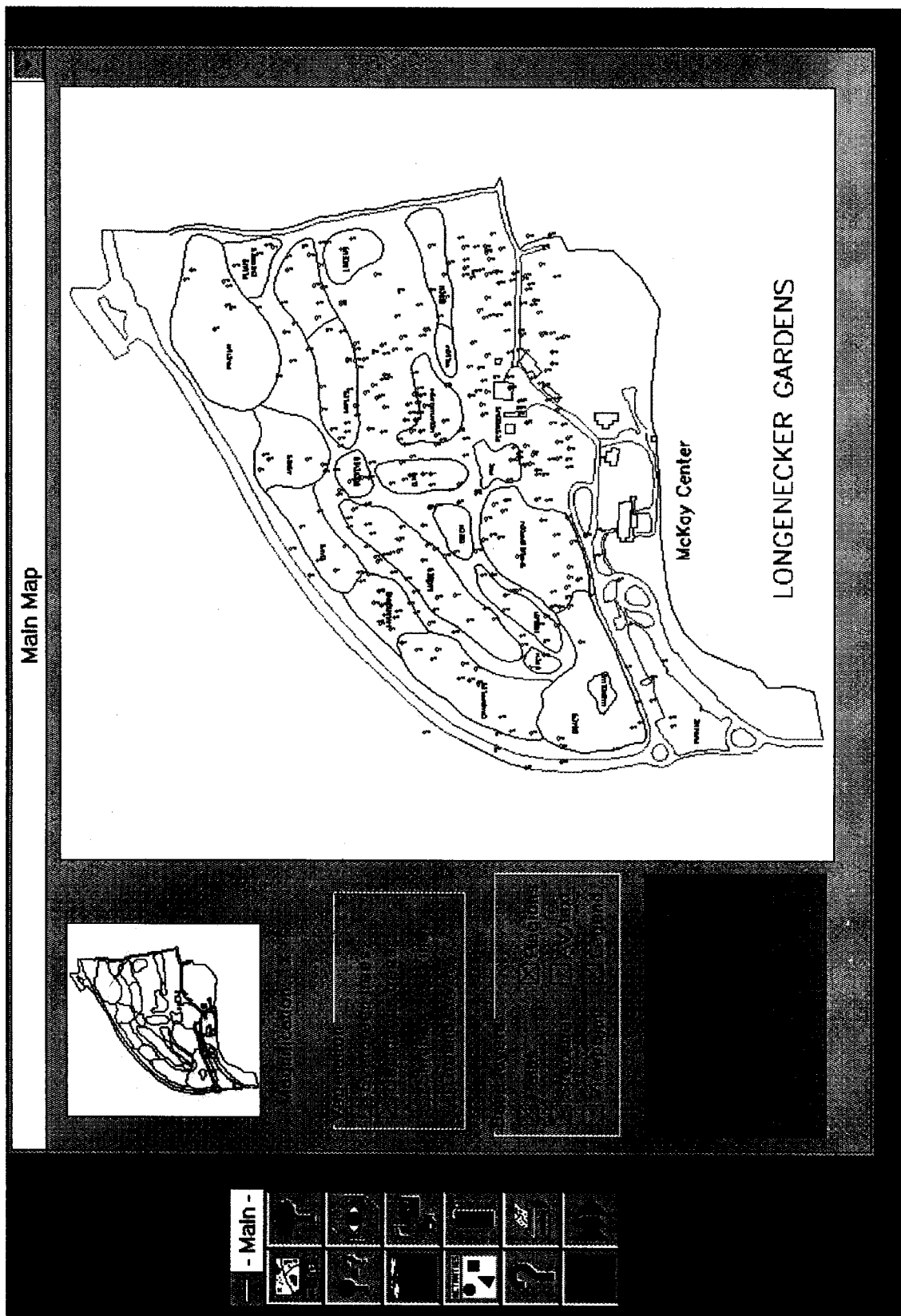


Plate C-4: Species Information, initial

Main

Main Map

Species Information - Cercis canadensis (Eastern Redbud)

Scientific Name

Family

Common Name

Family (common)

Location

Coordinates

Date planted

Used A, B, C, D, Rank

Identifying Features

Plant type: <unknown>

Deciduous: broadleaved

Leaves alternate, simple

[yellow] (fall)

Flowers: Per[er]d

bloom mid-season

Fruit: dry, capsule or pod

season - Winter, persists

Bark: Cantal[er]ful

Growth Requirements

Hardiness Zone 4B

full sun - light shade

Soil pH: -

Soil moisture: moderate

Soil type: loam

No pest/disease problems

Landscape Characteristics

Growth rate: medium

Form: <unknown>

Texture: medium

Attractive Features: flowers

Use: specimen

Not native to Wisconsin

Plant is not toxic

Individual

Species Info

Plate C-5: Species Information, plant image

- Main -

Individual
Species Info

Main Map

id) **d: Bark**

Eastern Redbud: Flowers

View Plant Close

View Plant Close

Identifying Characteristics: Fruit type

	Cone A conical fruit consisting of seed-bearing, overlapping scales around a central axis
	Apple- or berry-like A fleshy fruit with a seed.
	Nut A dry, 1-seeded fruit with a thick, hard shell.
	Dry, winged A fruit/seed with thin, shelflike projections.
	Dry, capsule or pod A dry, thin-walled, rounded structure.

Plant type: <unknown>
Deciduous; broadleaved
Leaves alternate, simple
yellow (Fall)
Flowers: Perfect
bloom mid-season
Fruit: dry, capsule or pod
season - Winter; persists
seed: Coarctate

Plate C-6: Species ID/Search on 'maple'

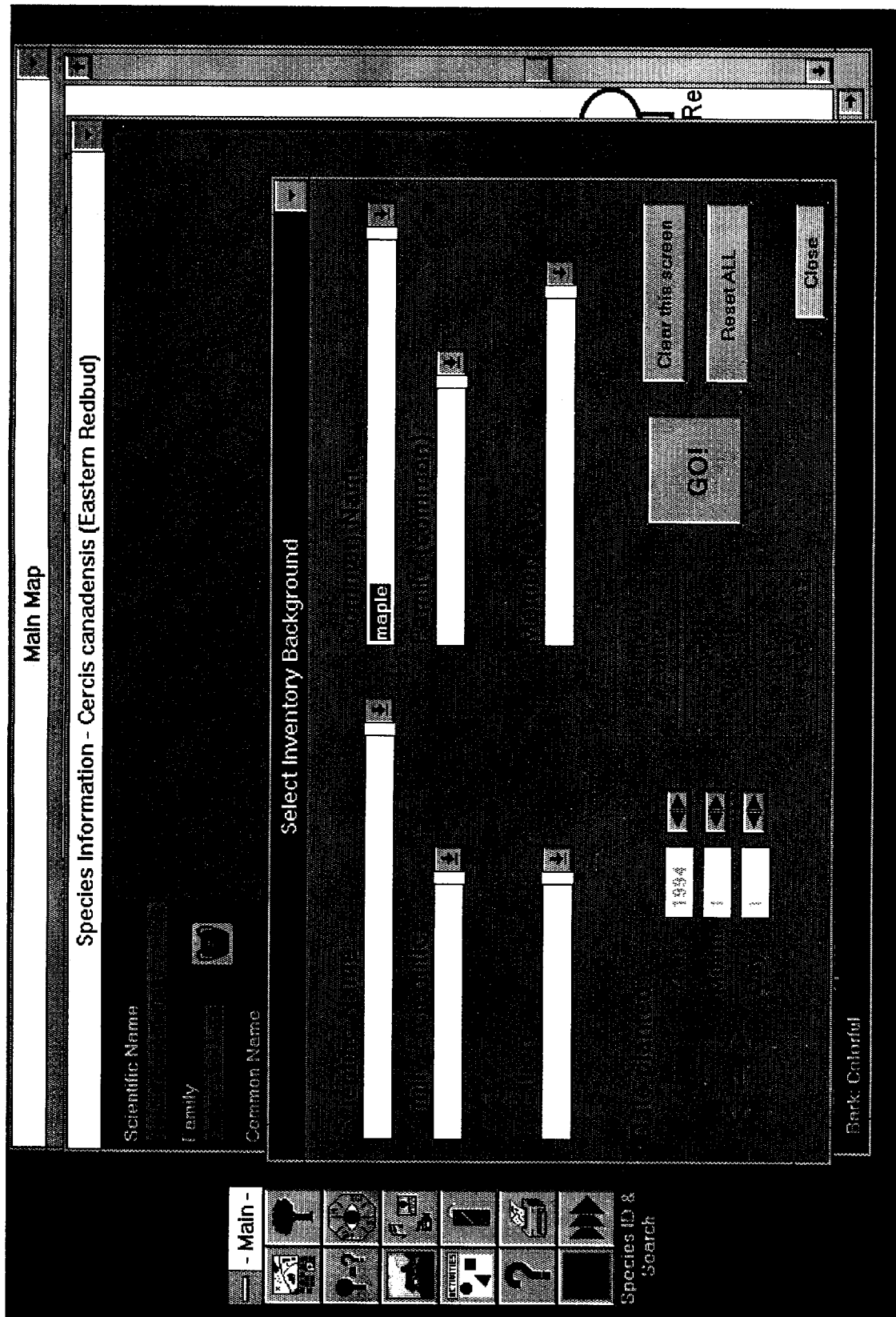


Plate C-7: Spec. ID/Search, search results

Main Map

Species Information - Acer platanoides 'ROYAL RED' [Royal Red Norway Maple]

Identifying Features
Tree (30-40 ft)
Deciduous; broadleaved
Leaves opposite, simple
Red -> [yellow] (Fall)
Flowers: Perfect
bloom early Spring
Fruit: dry, winged
season - October
Bark: Not distinctive

Growth Requirements
Hardiness Zone 5A
light shade - shade
Soil pH:
Soil moisture: moderate
Soil type: sandy - clay
No pest/disease problems

Landscape Characteristics
Growth rate: slow
Form: round
Texture: med
Attractive Fe
foliage

Use: shade
Not native to
Plant is native

Browser
Globe Norway Maple
Greenlace Norway Mapl
Royal Red Norway Mapl
Red Maple
Red Maple

Scientific Name:

Family:

Common Name:

Family (common):

Location:

Date planted:

Use A Use B Rank:

- Main -

Species ID & Search





Plate C-8: Spec. ID/Search, characteristics

Main Map

Species Information - *Acer glabrum* (Amur Maple)

Select Cultural Requirements




ZONE


GO!

Close


Sunlight



full sun




light shade




shade


Soil reaction



acidic




neutral




alkaline


Soil moisture



wet




moderate




dry


Soil type



sandy




loam



clay

Pest/disease problems:



- Main -

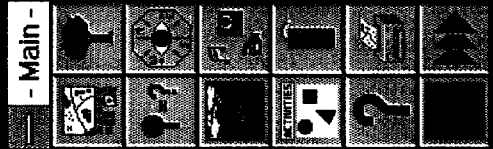


Plate C-9: Scenic Viewpoints

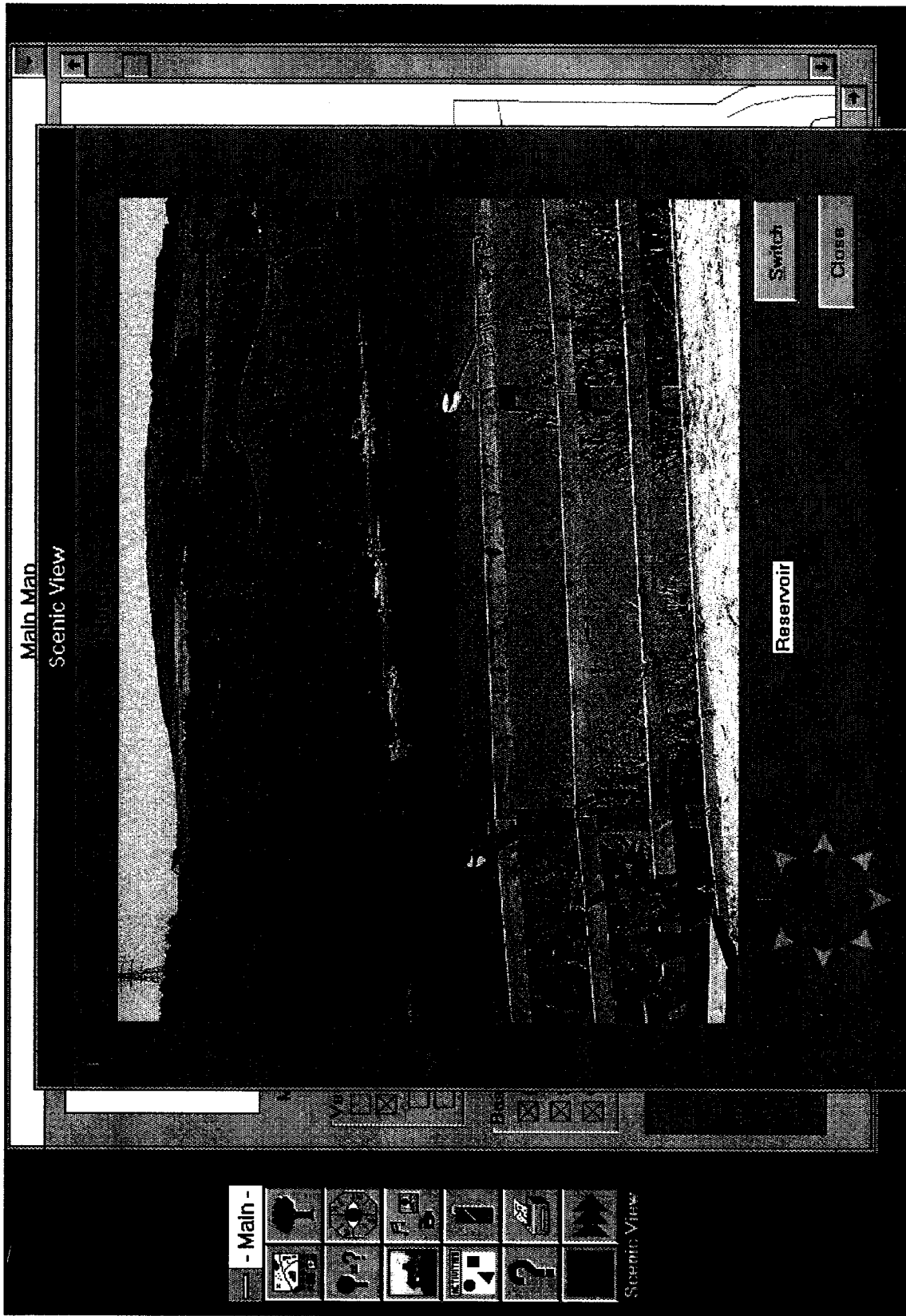


Plate C-10: Landscape Layout

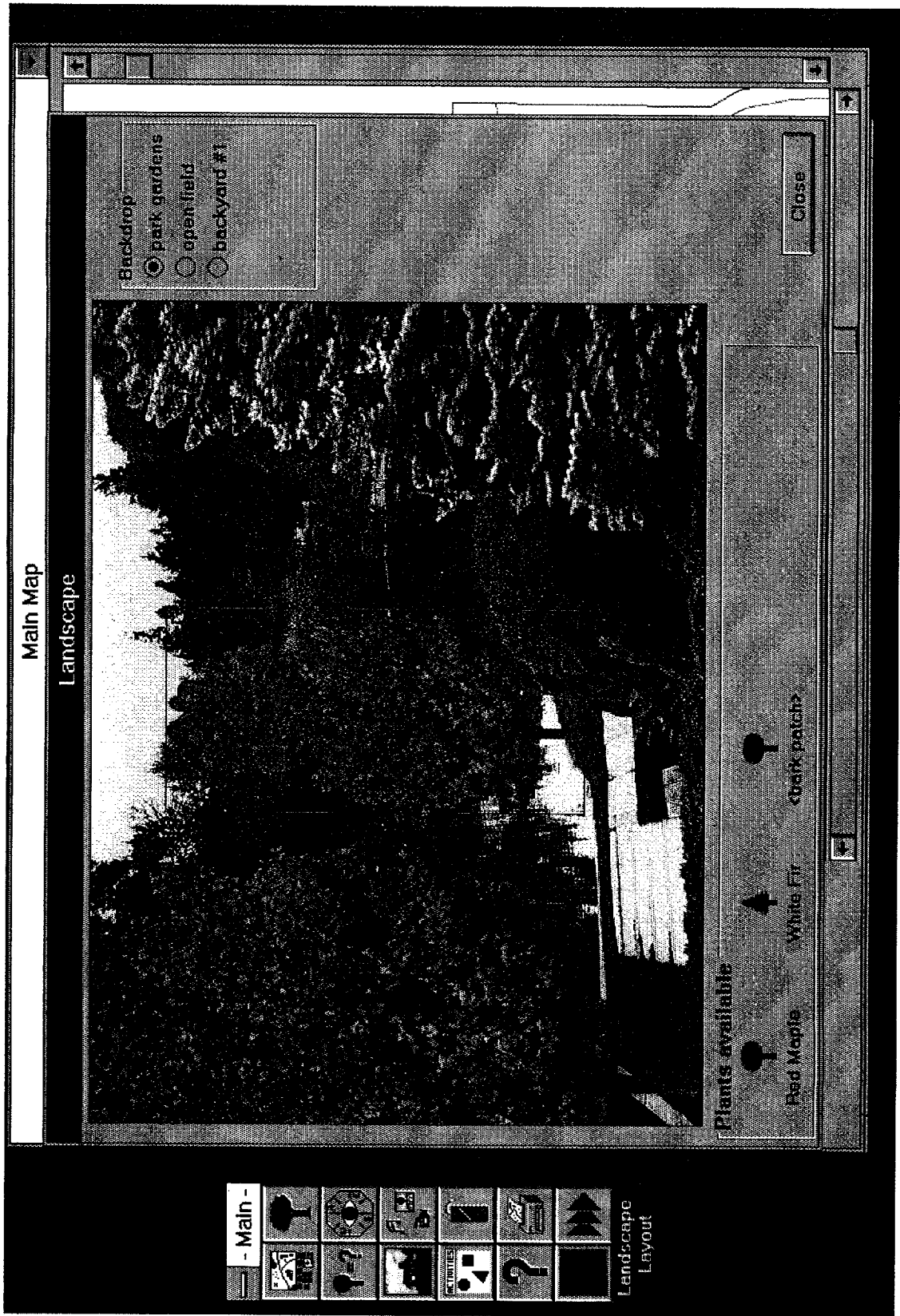

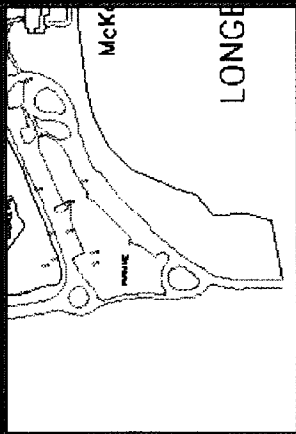
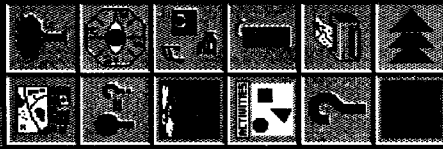


Plate C-11: Images/Audio/Video




fruit - *Acer rubrum* 'AUTUMN FLAME' (own root) [Autumn Flame Red]
 fruit - *Acer saccharinum* 'SKINNERI' [Skinner's Cutleaf Silver Maple]
 fruit - *Aesculus glabra* [Ohio Buckeye]
 fruit - *Aesculus hippocastanum* [Common Horsechestnut]
 fruit - *Aesculus parviflora* [Bottlebrush Buckeye]
 fruit - *Aronia melanocarpa glata* [Glossy Black Chokeberry]
 fruit - *Betula platyphylla japonica* 'WHITESPIRE' [Whitespire Japanese Trumpetcreeper]
 fruit - *Celtis occidentalis* [Common Hackberry]
 fruit - *Cercis canadensis* [Eastern Redbud]
 fruit - *Chionanthus virginicus* [White Fringetree]
 fruit - *Crataegus crus-galli* [Cockspur Hawthorn]
 leaves - *Abies concolor* [White Fir]
 leaves - *Acer platanoides* 'ROYAL RED' [Royal Red Norway Maple]





fruit - Glossy Black Chokeberry



Done

Main Map

Today in the Arboretum

9:00am - Nature walk
11:00am - ...
1:00pm - ...
1:30pm - ...
1:45pm - ...
3-4:15pm - AEGIS demonstration

Upcoming Events

<p>11/21 Sunday, 2 pm Introductory Birdwatching: Species in Your Backyard</p> <p>11/25 Thursday, 10:30 am New Volunteer Orientation / Training Session</p> <p>12/7 Wednesday, 3 pm Winter Arboretum Walk and Ski Pathways Tour</p>	<p>12/20 Tuesday, 5 pm Annual UW Arboretum Holiday Party - Open to public, sign up for meal registration.</p> <p>12/30 Friday, 9 am One more test (text) passage for testing purposes; this is the fifth one...</p> <p>1/5 Thursday, 4 pm Arboretum system test and evaluation session...</p>
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Current Events

Additional notes and further information such as scheduling changes, specific locational information and recent notes/ observations can be placed in this area; further, users may be able to jump to a trivia quiz or other diversions from command icons at the lower right...

Plate C-13: Online Help

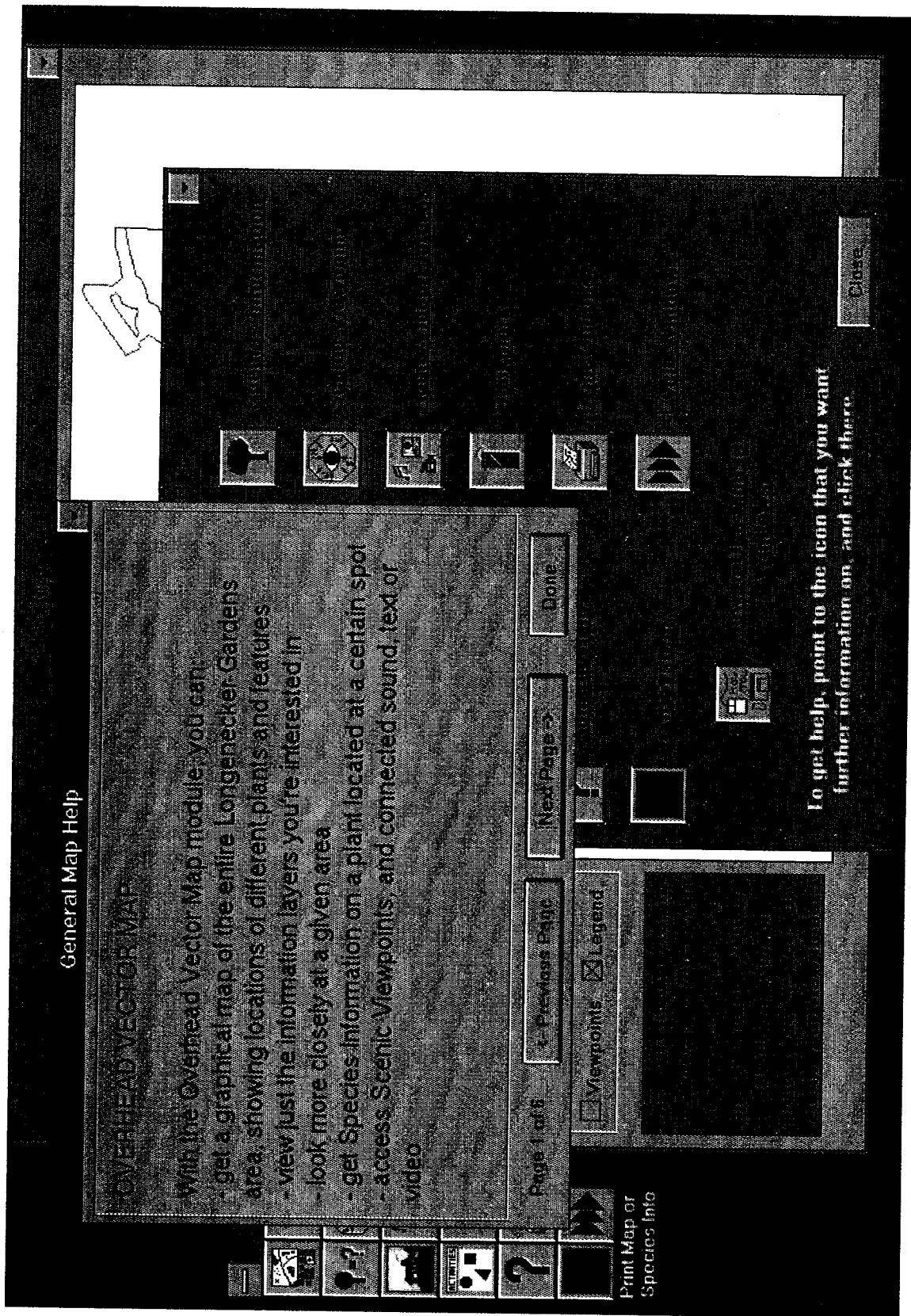


Plate C-14: Cycle Windows example

Scientific Name

Family

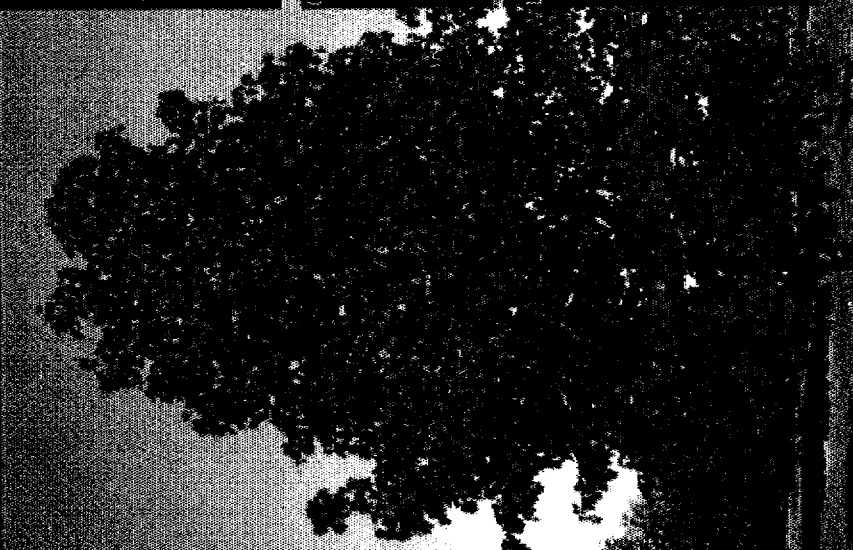
Common Name

Family (common)

Location

Date planted

Dee A. Dee B. Rank



Identifying Features

Tree (30-40 ft)

Deciduous, broadleaved

Leaves opposite, simple

Red → yellow (Fall)

Flowers: Perfect

Bloom early Spring

Fruit dry winged

season: October

Bark: Not distinctive

Growth Requirements

Hardiness Zone: 3A

Light: shade - full sun

Soil pH:

Soil moisture: moderate

Soil type: sandy - clay

No pest/disease problems

Landscape Characteristics

Growth rate: slow

Form: round

Texture: medium

Attractive Features: **urban tolerant** foliage

Use: shade tree specimen

Not native to Wisconsin

Plant it and love it.

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Chapter 4: Current Project Implementation

4.1 Assembly of base system

Beyond the requirements discussed in the Introduction, preliminary meetings among design team members focused on aspects of system design. During this time, it was determined that of key importance was a user interface which would be user friendly, able to be expanded upon easily with future programming (and made to access external modules), contain hypertext functionality, a query-oriented layout, and database access capabilities. The latter would function with files created in a format supported by FoxPro (the database program used by the Arboretum), act on direct user queries, and return information acquired to various functions within the system. Major capabilities were to include textual and map hardcopy production (location and coordinate system), pictures, hypertext links, with additional media such as video and sound set as a secondary goal.

Further discussion of system design with Arboretum staff generated a list of desired system capabilities. In fulfilling these objectives, such a system would:

- Provide graphical map of Longenecker Gardens area, showing planting locations
- Allow users to obtain information on particular plant species, i.e. 16-bit images (the plant itself, along with leaf, flower, fruit, bark details), attribute information: identifying features, growth requirements, landscape characteristics
- Print out species information, or a map

- Determine a group of specimens that meet a particular combination of criteria, e.g. plant name, characteristic features
- Relate information on history, purpose of Arboretum
- Be upgradeable/expandable to accommodate changes in plantings, additional data or images, inclusion of other areas in the Arboretum
- Tabulate usage of different program sections
- Accommodate both beginning and more advanced users

During this time, members of the preliminary design team (Pete Weiler, Eric Kolstad, Frank Scarpace, and Larry Seidl) were assigned information gathering tasks. These included consideration of available software tools, conversion and display of 8- and 256- TIFF images for test/comparison purposes, drafting of delivery/deadline dates, and evaluation and pricing of hardware alternatives.

Although hardware factors were a major concern, the first issue we focused on was selection of the base software under which programs would be designed. While several software packages were considered, Visual Basic 2.0 was the software of choice. Visual Basic is essentially a form design and programming language which allows the programmer to create Windows-based application programs with a graphical user interface; this package will be discussed more in depth later.

When final funding was approved, we attempted to configure the most effective computer system which could be acquired for our purposes, within the budgetary constraints; a total of \$5000 was available for hardware along with necessary software tools. After some deliberation, we arrived at a fairly workable combination of system performance and cost. The system design is based on an IBM-compatible Zeos 80486 DX-2 CPU, running at 66Mhz with 16Mb RAM, with VESA local bus architecture. Incorporated in this system is a 345Mb SCSI hard disk, a 24-bit Diamond Speedstar Pro graphics board (VESA local bus compatible), an NEC 5FG 17" monitor, and a Talon TA-2000 CD-ROM Multimedia upgrade kit (which included a Texel 300K/s CD-ROM drive, Soundblaster compatible sound card, and powered speakers).

Having a powerful machine with a VESA bus results in benefits such as rapid retrieval and presentation of information from various devices. Images containing up to 16 million colors can be shown on a large-format screen for public interaction, with timely hard disk access. The reasoning behind the acquisition of a CD-ROM (Compact Disc-Read Only Memory) drive may not seem as immediately obvious.

CD-ROMs have a storage capacity of between 550 to 650 Mbytes, which is equivalent to between 500-1000 text-only novels or textbooks (Nielsen, 1990), or roughly 300,000 pages of printed material. This proves very effective for the large amounts of pictorial information, associated text, digitized sound or video, etc. which may be included in the Arboretum project. Newly available low-cost CD-ROM recording technology provides

the ability to create customized CD-ROM discs. Relatively inexpensive media are used to record information in the International Standards Association 9660 data format; multiple session recordings are possible with advance planning. The unit functions via a IBM hardware interface card, providing direct control throughout the recording process.

The Institute for Environmental Studies will have access to CD-ROM recording devices recently acquired by the UW-Madison Geography and CEE departments. The cost per blank disc (approximately \$30), including any operational expenses, is well below that of hiring an outside organization to create a CD-ROM master disc (a service which ranges from \$200-1500). Moreover, the purchase of additional hard disks for each sufficiently large permanent data collection is no longer necessary. Start-up cost for the acquisition of the CD-ROM drive itself is becoming progressively lower, with technology improving over time. Recent "quad-speed" drives produced by manufacturers such as the NEC allow a transfer rate of up to 600 Kb/s for graphic images.

CD-ROM technology presents several benefits for our purposes. One of these is permanence of copy; wear on the media from frequent use is minimized, as there are no mechanical parts to break down. Switchable libraries and applications are possible by organizing information on various discs. Applications concerning not only the Longenecker Gardens, but the whole Arboretum, and other areas could be set up; users could simply change discs as needed. Further, discs can be reproduced relatively easily, and possibly distributed (in the standard ISO 9660 format).

4.2 Practical considerations

The majority of the digitized images incorporated in ALGIS have been scanned at 600x400 (or 400x600) resolution. At 256 colors (one byte per pixel) these images require 240K storage space each. Because scanned images possess significant color variation, non-lossy compression schemes such as run-length encoding do not allow a worthwhile reduction in image file size. There are 500 plant species which are initially included in this system, with an average base of 3-4 unique component pictures for each. A maximum of just under 500M storage space would be required. The 600M storage capacity of standard CD-ROMs proves sufficient to store these images, along with the plant attribute database, text information, several minutes of video (see below) and sound, and the main ALGIS program itself. Note that the CD-ROM drive in our system has a 300K/s transfer rate and 280ms access time, meaning that each image may be retrieved in roughly one second.

The Kodak Photo-CD format was also originally investigated for this purpose. At the time (February 1992), locally quoted prices averaged \$2.37 per 35mm slide scanned and written to Photo-CD disc. Photo-CD discs hold 100 24-bit .PCD images, at five different resolutions each: 64 x 96 (thumbnail), 128 x 192, 256 x 384, 1024 x 1536, and 2048 x 3072 (near photojournalistic quality). Both of these factors, however, made Photo-CDs impractical for on-line image retrieval in our system, because of the quantity of images involved. Although cost was somewhat a concern, the 100-image limit per disc proved the limitation - use of 10-15 discs was clearly not a workable solution.

At present (April 1994), automated scanning procedures have reduced the price of Photo-CD scans to approximately \$0.74 per image for full rolls of undeveloped film, or \$1.70 per image for selected slide photos. This may prove an excellent cost-effective archival tool, allowing permanent random-access storage of several different resolutions. Further, the Photo-CD format allows images to be recorded incrementally up to their 100-image capacity.

The Diamond Speedstar Pro graphics card included with the Zeos system acquired had a fixed memory of 1 Megabyte. This effectively prevented display of 1024x768 screens at greater than 256 colors (8 bits), as that alone requires 768 Kbytes of memory. A 800x600 display mode results in 480,000 pixels, and 16 bits (65,000 colors) could be used in this case. While the original digitized plant images were 24-bit bitmaps, the number of unique colors in each often did not range beyond 65,000; the impressive natural variation of colors inherent could thus be maintained without perceptible difference.

With the graphics drivers then provided, however, certain Windows API functions failed to perform acceptably in the latter display mode. Controls and window areas were occasionally displaced across forms; similar effects were observed in commercial programs. Further, 800x600 resolution proved to be a very limiting factor. Some information display windows (such as the Species Information form, which contains a 600x400 image and accompanying text) already approached those dimensions. Another group of windows could not be displayed without significantly obscuring each other.

Since that time, a new graphics card (ATI Graphics Ultra Pro, VL-Bus version) has been purchased. This card has 2M of memory, thereby allowing full display of 16-bit 65,000-color screens at 1024x768. Other benefits include a higher image-to-screen transfer rate, and reasonable quality display drivers.

Video segments were initially digitized during a trial evaluation of means available through the Instructional Technology Services, a part of the Computer Science facility at UW-Madison. For our purposes, video capture was accomplished via an IBM ActionMedia II board, using Microsoft Video for Windows 1.0. This setup allowed digitization of a 160x120 Windows .AVI (Audio/Video Interleave) file with Indeo(tm) format compression. Audio could not be recorded concurrently with this configuration; instead, a sampled .WAV (waveform) file was later spliced in and synchronized with the video segment.

One problem encountered in recording digitized video is the amount of storage space necessary. For instance, a single color television image would normally take up 105 kilobytes of storage; therefore, a minute of live video would require nearly 200 megabytes! However, various compression schemes have recently made it possible to store a full hour of video on a CD-ROM disc (Nielsen, 1990).

<u>Uncompressed picture size</u>	<u>Video frame rate</u>	<u>Color depth</u>	<u>kbits per sec</u>	<u>Disk space for a 10-sec file</u>
160 x 120	30 fps	8 bits	4608	5.49 Mbyte
320 x 240	15 fps	8 bits	9216	10.99 Mbyte
320 x 240	30 fps	8 bits	18432	21.97 Mbyte
640 x 480	30 fps	8 bits	73728	87.89 Mbyte
640 x 480	30 fps	24 bits	221184	263.67 Mbyte

Table 4.1: Video bandwidth and storage space requirements
(adapted from Advanced Imaging, April 1993)

Uncompressed # channels	Audio sample rate	Sample resolution	kbits/s	Disk space for a 10-sec file
1 (mono)	11 ksps	8 bits	88	0.11 Mbyte
1 (mono)	22 ksps	8 bits	176	0.22 Mbyte
1 (mono)	44 ksps	8 bits	352	0.44 Mbyte
2 (stereo)	22 ksps	16 bits	352	0.44 Mbyte
2 (stereo)	44 ksps	16 bits	704	0.88 Mbyte

Table 4.2: Audio sampling/storage requirements

Indeo(tm) is a COmpressor/DECompressor (CODEC) standard, which is most effective when used with machines having specific video boards that include a custom Intel chip set. These hardware cards fully decode the format in real-time, resulting in low storage requirements (up to 5:1 compression) and high-speed visual quality video, which can be played back expanded several times with a hardly noticeable loss of resolution. However, software-only drivers are also available.

Following the initial trials, the UW-Arboretum acquired an inexpensive digital video card (the Video Spigot, by Creative Labs). Although this card does not have a specialized chip set for compression/decompression, it can accept both composite and S-video signals as input, and will record a compressed .AVI file in the Cinepak(tm) CODEC standard. Cinepak allows up to a 20:1 compression ratio for digital video. As this is a software-only CODEC, any computer with Microsoft Windows 3.1 and the respective software driver can play .AVI files recorded in this format. A video window up to 320x240 pixels in size can be played back at between 12 and 30 frames per second. Video quality and playback speed are dependent on the

host computer's clock speed and video bus transfer rates.

Chapter 5: Testing of Design

5.1 Methods overview

The main goal in interactive user interface design is to create a system which functions in an acceptable manner. Usefulness of such a system may be determined by its general utility (whether it fulfills the purposes for which it is intended) and by its usability (i.e. measurable quality criteria). "Interfaces in general have to balance two needs: that of making large amounts of information available through multiple access routes and maintaining the users' orientation so that they know where they are in a program, and what can be done within the context they are in." (Glenn and Chignell, 1992) "The basic performance variables of a human-computer system are concerned with what tasks the system can do (functionality), how long it takes to acquire the functionality (learning), how long it takes to accomplish tasks (time), how frequently errors occur and how consequential they are, how well tasks are done (quality), and how robust the system is in the face of unexpected conditions." (Card et al., 1983)

Human-factors goals in interactive system design can be divided into five measurable quality criteria. The ease of learning typically means the time involved

for typical users to learn functions relevant to a set of tasks and to understand generally most basic command structure and navigation options needed to locate specific information. The efficiency of use measures the length of time necessary to perform a certain set of (benchmark) tasks, orientation in the information base and understanding of meaning. User error rate concerns the quantity and types of errors made in carrying out these types of tasks. Also important is the ease of retention, i.e. how well users remember how to use commands and navigate through the system, after a period of time not having used it. Further, subjective satisfaction concerns users' likes/dislikes of different aspects of the system. While system designers would normally want to excel in each of these areas, trade-offs must be made in most cases as goals of most importance are determined, and multiple design alternatives reviewed (Nielsen, 1990; Schneiderman, 1992).

Various strategies may be employed to determine the effectiveness with which the user interface accomplishes the design requirements, and the goals described above. There are briefly described here. "Procedures vary greatly depending on the goals of the usability study, the number of expected users, the dangers of errors, and the level of investment" (Schneiderman, 1992). These methods also vary widely in complexity and expense. Informal methods such as reviews and heuristic evaluation are widely used. Techniques such as logging of keystrokes necessary are not practical, as no relative basis for comparison is established (Nielsen, 1990).

The thinking-aloud technique was originally developed for use by PhDs trained in the field of psychology, but more recently computer scientists have used this means of analysis. In an informal atmosphere, the user is given several well-chosen tasks and is asked to 'think aloud' through the process undertaken in the steps they follow in dealing with the system. After a reasonable length of time, the user can return comments and make suggestions for improvement; this permits timely feedback on user interface design and usability problems with only a limited number of test subjects (Nielsen, 1992; Schneiderman, 1992).

Alternately, by reviewing videotaped sessions of users performing tasks, useful insight may be gained by examination of specific incidents in which users are confused and in which they encounter problems; however, video equipment is costly, and analysis can be time-consuming. Expert reviewers with skill in certain areas can be utilized to directly evaluate the system, recognize potential problems and come up with suggestions. Another form of testing is the 'can-you-break-this' approach, in which users attempt to find harmful design flaws by purposely trying to cause errors (Shneiderman, 1992).

Several other methods can be implemented during active use for evaluation. One of the more formal means of doing so is via surveys. These consist primarily of numeric scales and comment sections users fill in to express their opinion of various

components within the system. In Schneiderman's example surveys, topics are logically grouped into major sections that gauge factors such as 'Overall User Reactions', 'Terminology and System Information', 'Learning' and 'System Capabilities'; both general or more specific survey formats may be implemented. Designers thereby receive a relatively clear indication of which areas cause dissatisfaction and thus need re-working (Schneiderman, 1992; Nielsen, 1990).

Individual interviews can highlight specific issues of concern, and group discussions function to gather common thoughts on a particular area. Although interviewing can be costly and/or time-consuming when more a few users are included, this direct contact frequently provides constructive feedback regarding user concerns (Schneiderman, 1992).

In addition to the quantitative methods mentioned above, qualitative evaluation methods can prove valuable in some cases. Careful experimental design and statistical analysis in human-computer interface are complex topics (Schneiderman, 1992). One relatively direct qualitative means evaluation involves continuous logging of user performance data, which allows several advantages. A user's behavior can be monitored automatically and unobtrusively, without influencing their normal working style. No human experimenter is needed, and data can therefore be collected directly over longer time spans (Nielsen, 1990). Schneiderman (1992), citing Good's work,

notes that, "The software architecture should make it easy for system managers to collect data about the patterns of system usage, speed of user performance, rate of errors, or frequency of request for on-line assistance. Specific data provide guidance in the acquisition of new hardware, changes in operating procedures, improvements to training, plans for system expansion, and so on."

5.2 ALGIS Testing

As a review of the test objectives, evaluation was designed to determine primarily whether the ALGIS system answered user questions relevant to the information base, and produced these answers within a reasonable time. Subjective evaluation via user survey and examination of functional capabilities are also important. As noted in the Introduction, logging of user interaction data was suggested in the original framework for the Arboretum Longenecker Gardens Information System design. By having the user specify their time of use, logged information concerning amount of usage of specific program modules could be later observed. Due to the budgetary constraints and scope of this project, studies were conducted by a single member of the design team, rather than the team of specialized staff which is sometimes used.

Several primary groupings were established in the early stages of testing methodology development. Each of these may have a certain perspective that the others do not, and provide useful information which can be used to improve the system. First, informal Arboretum staff feedback would be collected to gauge initial reactions to the system design. As Nielsen (1990) points out, "Current practice in usability engineering is to refine user interfaces iteratively, since one cannot design them exactly right the first time around." This information can be very useful when redesign is needed. The second stage would involve user interaction feedback, where the potential audience would be asked to subjectively evaluate the system. Also, quantitative factors concerning system performance for several key areas would be of importance.

5.2.1.1 Staff evaluation

In the initial research session, a group of 10 Arboretum staff members volunteered to help test and evaluate the ALGIS system in its form at that time. Although these people were generally very knowledgeable in matters relating to the subject material and to the Arboretum itself, they had varying levels of expertise with computers and the use of particular types of software. A brief overview of system operation was conducted, and the system was left at the McKay Visitor center for a period of two weeks.

Members of the evaluating team were asked to comment on what they considered particularly effective, what portions functioned reasonably, and which areas of design might be further improved. Aside from what had been reviewed before, the only available on-line 'help' consisted of the general system text helpfiles, and a limited guided introduction of one module. The latter was less than users would normally have available; this was done for several reasons. The staff had received a small amount of introductory/overview information, and further assistance might influence findings. A more noteworthy point was that at this stage, examining the overall operation and system usage would reveal its relative strengths and weaknesses, and determine where changes might be affected.

5.2.1.2 Initial concerns raised

At the time the testing was conducted, the ALGIS system was not yet in its completed prototype stage. Some of the comments generated related to interface usability concerns, while others referred to desirable options, some of which were still under development.

I. Introduction/starting screens:

Staff evaluators noted that user selection of Novice or Advanced mode was not yet present; a radio-button choice was later added for this. Also, there was thought

that functions such as searching for a plant by name (Latin or common), Landscape Characteristics, location, memorial name, etc., and examining the main map, or accessing the calendar of events might be presented immediately. However, all of these options are effectively available via the main command bar after the system is started. An argument for leaving this unchanged is that users should be encouraged to try out the System Tour or examine Online Help, before reaching these options for the first time - possible confusion is thereby reduced.

At least one person thought the video Introduction (then approximately one minute in length, containing only the general overview speech by Greg Armstrong) should be shorter, while others noted that the second video segment (further detailing sections of the gardens via panned shots) was not yet present. ~~Time-length~~ captions were later added, and the introduction was arranged as two individual segments instead of one continuous length of video.

II. Donor/contributor screen:

It was noted that the planned display of a list of funding sources and contributors was not present at the time. A scrolling credits screen has since been added to the system.

III. System Tour:

The evaluators confirmed the effectiveness of the System Tour's guided mouse movements, text and verbal narration. As the Tour was completed for only the Overhead Vector Map, the difference was probably more pronounced. Varying suggestions were also made regarding speed of the tour and logical breakoff points, and these were taken into account for future revisions.

IV. General screen format:

- 'Need for larger text in information boxes'

Several evaluators pointed out that informative text was sometimes hard to see or didn't stand out sufficiently, notably at greater distances, because of font size. Where this was the case, size adjustments were made; this modification generally posed few problems in implementation. As with research noted in the 'User differences' section of the chapter on User Interface, larger fonts are a means of accommodating a broad range of human skills and abilities. A hierarchy of text sizes dependent on the relative importance of the information was recommended, and implemented to a degree.

- 'Have consistency of buttons/procedures for closing windows, advancing through options etc.'

In the ALGIS system version evaluated, the procedure for closing windows was

not always uniform from window to window. 'Close' command buttons appeared in different relative positions, and although MS-Windows control boxes at the windows' upper left can also be used to perform this function, some forms did not have them. 'Close' buttons now appear on all major forms, at the lower right where possible. Control boxes have been eliminated, as they are multi-function controls. To the user, the universal function of a Close button is to signal that they're done with a form, and remove it from the screen. While forms may be either shut down or only hidden, the user does not need to concern themselves with this. Further, the organization of Species ID/Search buttons were grouped consistently across related Characteristic attribute forms.

V. Command bar:

In general, the staff perception of the icon symbols used for the main command bar (which are accompanied by changing text captions at its lower edge) were positive. However, two staff members suggested that the text flash or be displayed with larger fonts to enhance the effect. This idea was taken into consideration, but has not been implemented at this time.

VI. Overhead Vector Map:

- 'Make the map view region as large as possible'

The original Overhead Vector Map's map view region occupied a 400 by 400

pixel area. Evaluators commented that features on the overall map itself could be larger, and that its text captions did not show up distinctly at lesser magnifications. As 1024x768 resolution was available, there was clearly "room" for improvement. The map view region was enlarged to a 600 by 600 size (maintaining the same relative scale), resulting in increased clarity, while still leaving space for window movement and minimized icons at the lower edge of the screen. An unforeseen benefit was that this redesign allowed more space for and more effective placement of instructional text, and map layer checkboxes (which were moved to the lefthand side of the Map form).

- 'X/Y map coordinates are generally not useful'

At first, the Map window displayed X- and Y- coordinates of the relative center of the current map view; this information had little apparent value to potential users (and in fact, had been used primarily in system tests). These coordinates were removed, freeing window space for additional map layer boxes.

- 'The blue box on the Location map should be more clear'

The square box representing the current map view was drawn with 1-pixel wide lines at the time, making it difficult for some users to see it. Thus, the box outline was simply changed to be drawn with a greater line width to alleviate this problem.

- 'Have all map layers turned on when the system is started'

Initially, several map layers (paths, regions, and structures) were shown. It was decided that one of the planting layers (deciduous trees) would also be selected by default. Having most or all layers on at the start, however, proved somewhat confusing due to the cluttered map presented.

- 'Have some way to show that a specimen on the map doesn't have full information'

Evaluators noted that some plants on the map might be identified with a name, but might not have complete database information, or attached pictures. A solution was to grey out names of plants which had only partial data, leaving those with full information with standard black text.

5.2.2 User testing

In this portion of the research, 12 individuals were selected in an attempt to represent some of the prospective users of the ALGIS system; it was hoped that they would encompass a range of varying abilities in terms of computer knowledge, prior experience with the subject material, educational background, and so on. General profiles were obtained during initial contact and later examination of the user surveys (see Appendix, ALGIS User Survey).

Five test subjects were asked to participate through personal contact. Additionally, a testing sign-up sheet placed at the McKay Center main desk drew seven volunteers, four of whom worked at the Arboretum in some capacity (as volunteers or staff). A total of two males and ten females, ranging in age from 20-70, participated, and the majority of test subjects had either not seen the system before, or if so had not worked with it for any significant length of time prior to the experiment.

The majority of the 12 test subjects had at least some general knowledge of computers. Four had extensive experience, although one had no prior exposure to computers, and three had had only minimal contact to that point. Plant-related knowledge of the test subjects was very evenly distributed among what could be interpreted as low, medium, and high levels (four people in each category). Levels of expertise ranged from none to backgrounds in botany, horticulture, and ecology.

Originally, the experiment was designed to be run in the following manner. At the beginning, general purposes and intent of the testing would be clearly stated, with a brief discussion of methods and means of operations. Test subjects would be placed within the system, at the introductory screens, and receive two pages of standard instructions which briefly explained how to use the mouse, what the different objects were on the starting screen, and how to activate them. A short explanation

of how to move to different parts of ALGIS via the main command bar, and how to obtain help within the system was included here. Next, subjects would have a recommended testing time of one hour, although they were free to stay longer or leave at an earlier time if they so choose.

In ALGIS' usual environment, users would likely have access to staff members who could answer at least some of these questions, and provide further assistance with problems that arose (presuming they had trained in the operation of ALGIS). The objective here, however, was to determine how intuitive the system was on its own, with very limited outside assistance; users were to learn to use the system using their own facilities in conjunction with the guided tour and on-line help. Arboretum staff would not always be available. This was done with the understanding that the experimenter (Eric Kolstad) would be there to intervene and answer questions if they became stuck at some point, and that it was the system which was being tested rather than the subject.

After having a period of approximately one-half hour to become familiar with most aspects of the system, users would be given 4-5 sample tasks designed, with the help of Arboretum staff, to be similar to the types of questions often asked by Arboretum visitors in general. These would be presented one at a time in order to make it possible for subjects to end a particular section without feeling they had failed

because not all tasks had been performed. Attempts were made to set relatively straightforward objectives for each task, keeping tasks of reasonable size, yet not trivial in nature. These objectives would be clearly stated at the beginning of each task. Times to complete tasks were measured via stopwatch, to gauge the effectiveness with which these formerly manual methods could be performed. Tasks which could not be carried out reasonably (completed without undue problems) by any particular user would be noted in detail.

Users would be asked to comment on areas they found particularly effective or encouraging, or the opposite.. to engage in limited "thinking aloud" strategy while working through the system, "...reporting questions that were raised in their minds, plans and strategies they might be considering.. and inferences and knowledge that might have been brought to awareness by ongoing experience (Thomas and Schneider, 1984)." Comments generated from this observation would be marked down for later review.

The general atmosphere before, during and after testing was made as relaxed and comfortable as possible. It would be suggested to users that they envision the tasks as if they had thought of them themselves after entering the McKay Visitor Center, and were proceeding normally at the pace they were comfortable. The user would be reassured of the role they had as evaluator of the system, and made aware

that this was not intended to see how fast a particular user could get through, or some sort of intelligence measure... that it was (as stated) a test of how effectively the system functioned.

Upon completion of their testing session, users would be given the questionnaire shown in Appendix A16. This survey contains subjective evaluation measures and ratings for particular program module sections within the system, as well as an area for further comments and feedback.

5.2.2.1 Experimental Trials

In actual implementation, the experimental procedure took a slightly different form, mainly because of time considerations. Within the first two trials, it became apparent that users would want to (and in fact did want to) proceed through the ALGIS' entire System Tour in order to become familiar with all major portions of the system. Unfortunately, following through all steps of the System Tour would take a considerable amount of time - too much time, in fact, to allow testing afterwards. While relaying a similar amount of information, computer playback of mouse movements, text descriptions and narration sometimes takes more time than a human would to give a general overview. Further, McKay Center testing sessions were limited to 30-45 minutes due to time constraints.

Clearly, a compromise was necessary. To alleviate the problem encountered here, the experimenter chose to allow the System Tour to run through the first several steps, and thereafter take active control of the tour himself. By running through the same sequence of steps and attempting to present an objective, non-responsive demonstration of the material (using examples which followed the same procedure as those in the System Tour), it was hoped that a similar end effect could be achieved. In the experimental trials which followed, test subjects received a less verbose and more direct tour of the system modules via manual means.

5.2.2.1.1 Qualitative Results

Throughout the testing sessions, numerous useful suggestions and comments were made. Several relatively minor bugs in the system were uncovered, but perception of reliability remained high. ALGIS was also seen as interesting and powerful, with a marked response time and acceptable degree of functionality. In general, user reactions and feedback obtained through the subjective survey were positive and enthusiastic. When evaluated, major individual ALGIS program modules were given high ratings. The exception was the Scenic Viewpoints module, which was rated only average by several test subjects. This was probably because the Arboretum-specific viewpoints in the system at the time were taken from less than ideal 35mm slides. These were acquired on an overcast date after most plants had lost

their leaves. However, the Viewpoint locations are marked, and their directional views will be re-created in Spring/Summer 1994.

The overall system information content was likewise rated highly. Digitized plant images (even at the current 256 colors) were rated highly, and text information was seen as well-organized on-screen and easy to interpret. Users generally agreed that sound quality was good, but that the current video segments (while acceptable) could stand improvement. After the original video footage is re-digitized, however, this should no longer be a problem.

One concern that arose initially was the legibility of the text in certain portions of the system. Several test subjects encountered difficulty in reading some of the smaller captions and map wording at lesser magnifications. This problem is understandable, as two test subjects wore bifocals, and one actually had cataracts. While map legends and species names can be magnified by zooming in or out, some font sizes will clearly need enlargement. This change should also prove useful when a small group of people may be gathered around the system at one time.

Through active usage of ALGIS, several test subjects expressed some degree of confusion when faced with the range of available choices within the system. While these subjects were primarily beginning-level users, the general idea communicated

was that there were too many options; they wanted to understand the entire system immediately and were not prepared for the amount of possibly available information. Because of ALGIS' modular design, it should be relatively simple to give beginning users access to only the primary core functions which are truly necessary, and to provide a reasonable amount of power. These functions can be reduced to six major areas: the Overhead Vector Map, the Species Information form, the Species ID/Search section (for those who want to expand their interests slightly), the On-line Help system, current Activities sheet, and naturally the 'Exit' button. This solution was also suggested by a couple of more expert users.

5.2.2.1.2 Quantitative Results

Because of the usual 30-45 minute session length, only three of these seven subjects at the McKay center were able to take part in the problem-solving evaluation portion of the experiment. Of the remainder of the test group, four out of five participated. Representative sample tasks, which would represent questions that could be answered from the collection of information the system contained, had already been selected as a basis for testing. After test subjects had gained familiarity with this system by watching a demonstration, the following tasks were assigned:

- 1) Get a listing of Arboretum current events (i.e. daily planned activities, upcoming monthly events, etc.)

In ALGIS, the user simply clicks the 'Activities' command from the main command bar, and a form appears showing daily, weekly and monthly planned events. Users typically took from 5-15 seconds to do this. Manual means (i.e. looking at the current events board in the McKay Center) would not require any more time than this. However, ALGIS' text editors may allow the staff slightly faster revision of information concerning these events.

- 2) Get information (pictures, characteristic features, etc.) on a particular plant species in the Gardens: 'Norway Maple'

There are at least two ways to approach this task within ALGIS. One way is by first running a database search with 'Norway Maple' entered as the common name. This could be either typed directly or selected from the drop-down list at that field. Thereafter, ALGIS would bring up its Browser with a list of all unique Norway Maples, whose Species Information forms could be paged through one at a time. As discussed earlier, Species Information forms include pictures of that plant species, along with three sections of characteristic attributes. This attribute text can be clicked on to provide descriptive information on term meanings. This approach usually required 30 sec - 2.0 minutes, including search time.

The other way this task might be carried out is by going to the Main Map, locating the planting region containing Maples (turning on Legend and/or zooming in if appropriate), and thereafter finding a tree captioned 'Norway Maple' and clicking there - this would likewise bring up the respective Species Information form. This second method sometimes took slightly longer than the first, at 40 sec - 2.5 minutes.

To accomplish this task manually (for an unfamiliar plant species), a staff member would be required to scan through one or more texts concerning plant characteristics, and thereafter probably need to search for slides or pictures of that particular species as well. Although this might be accomplished in a timely manner with appropriate reference materials, repeating this process several times would get tedious, as would possible re-explanation of terms.

3) Bring up the record on a memorial plant dedicated to 'Prof. Wm. Longenecker'

In ALGIS, this can be done via a database search on the Memorial field, where the above name is either typed or selected from a list. Thereafter, the user is presented with a Species Information form for that particular plant. This process took test subjects between 30 sec - 1.5 minutes. Likewise, a staff member might walk down to a filing cabinet and retrieve the appropriate folder, which might contain an original photograph together with further and more detailed information; this might take 2-3 minutes.

4) Find all plants which would work well for this set of backyard conditions:

- Moderate to full sunlight, neutral soil, appropriate Hardiness Zone for Madison

AND

- Is a deciduous tree of any size, oval or rounded in shape, with an attractive fall color

To do this within ALGIS, the user goes to the Species ID/Search and switch to Growth Requirements, clicking on the icons for 'partial shade', 'full sun', 'neutral soil', and 'Hardiness Zone 4B' (and/or 5A). They must also switch to the Landscape Characteristics section at some point and click on Habit: 'Deciduous', the 'tall', 'medium' and 'short' trees, the icons for oval and rounded, and the 'attractive fall color' icon. Clicking the [GO!] command thereafter will start the search. Depending on the complexity of the search, this entire process may take from 3 - 5 minutes, including search time. While determining all plants matching these conditions could physically be done via manual means, it is doubtful any staff member would want to attempt this, as it would normally take at least several hours of concerted effort.

5) At a particular location, find out what you might see there.

ALGIS allows users to approach this problem in two distinct ways. Users may either zoom in to a section of the Overhead Vector Map and examine the area (possibly bringing up information forms on plants and other information), or alternately locate a nearby Scenic Viewpoint and obtain direction views and further

information attached to those scenes. Users were able to accomplish one of these within 1 - 3 minutes. In the McKay center, general maps of the Longenecker Garden exist; a person could inquire about plant species in the area, or might alternately opt to walk there directly.

In addition to the timed task evaluations just discussed, quantitative factors also included simple statistical logging of ALGIS module usage. Upon activation of a particular program module, its name and time switched over to were noted in a main log file. From this, the total number of transitions to each module could be calculated for trials where test subjects were able to work with the system beyond the predefined sample tasks. This represents only an initial summary. Later, a continuous sampling of modules accessed can be used to examine the overall behavior of a larger group of users.

The three most frequently accessed were the 'Overhead Vector Map', 'Species Information' and 'Species ID/Search' modules, which is to be expected as they form many of the primary functions within the system. 'Scenic Viewpoints' were accessed next most, followed by 'Landscape Layout'... both of these seemingly proved useful (or at least interesting) to Arboretum visitors. The 'Online Help' module was invoked more frequently than anticipated, 'Exit' was used often enough to suggest that users may prefer to return to the introductory screens and use the guided System Tour.

'Text/Audio/Video' and 'Activities' were less often used, and the 'Bookmark' feature was rarely called. 'Cycle Windows' was used a varying amount, usually either very often, or very seldom at any one local time period.

From the function/module use data obtained during logging, it should be possible to gauge which modules are the most popular, and thus might be good areas to optimize for speed. Rarely used modules may suggest a need for improvement. If, after closer examination of patterns, a couple of common orders of steps (from module A to module B to module C) are seen, interdependence of those modules and logical steps may be a subject for further study.

5.2.3 Experimental conclusions

In terms of the hypothesis originally presented, in order for the ALGIS system to be considered effective, it should satisfy the following requirements. First, within a reasonable amount of time, it must both answer the types of questions and retrieve information relevant to areas typical McKay Center visitors will be interested in. After examining the results and methods that can be applied where the five sample tasks (discussed above) are involved, it is clear that ALGIS is able to arrive successfully at a solution in each case. According to quantitative measurements, ALGIS does this in a timely manner - it is at least as fast, if not significantly faster,

than the equivalent conventional means. Subjective user surveys have shown that test subjects likewise perceive ALGIS' speed in a positive manner. The above tasks demonstrate ALGIS' value as a useful and complementary tool which may relieve burden on the staff. Assuredly, there are certain tasks which are only reasonably performed either by the computer or by a human staff member.. many more of the latter.

At its base level, ALGIS was constructed such that it would contain a number of basic functional components initially set forth by the Arboretum. Over time, further requirements have been added and successfully implemented; ALGIS appears to have satisfied the majority of these functional requirements. The last and perhaps most important measure of ALGIS' effectiveness is whether or not subjective user measures were satisfied. These measures have been reviewed during discussion of the user survey. There are two major areas where improvements can be made: first, the text sizes, and secondly, the breadth of beginner-level choices that are presented. When these are satisfactorily resolved, a system will in fact have been designed whereby all of the design objectives are an integral part of the implementation.

Chapter 6: Afterward/Recommendations

At present, all major modules and features within ALGIS are functionally complete and operational. The remaining scanned image sets for individual plant species are in the process of being compiled. Positional locations of plantings within the Arboretum were originally surveyed by the 1991 IES Practicum class via manual methods, and were somewhat inaccurate. Numbered identifiers (which were not keyed to species record identifiers) were attached for only a subset of the planting locations. Recent total station surveying will result in feature information for each individual plant. Various clusters of plants have been annotated based on available image/information sets and species distributions. This will allow creation of updated layers which show the more precisely delineated planting regions.

The conversion of the initial plant characteristic database to digital form is nearly complete. Future expansion of image and characteristic information will include a full 2000 additional species, and further directional Scenic Viewpoints taken at other sites are to be added to ALGIS. The Arboretum plans to create a mowed pathway through the Gardens area, following a route of scenic interest; this pathway will be incorporated as a separate layer in ALGIS' main map. At present, remaining photographs and text attribute data are being converted to digital form and placed

within the system database; re-surveying of plant locations is also underway. Testing and review has been conducted, and final revisions are being made within the program itself; a fully functional prototype is expected within the next several months.

The advent of recent technological advances in affordable high-speed personal computing and related hardware devices provide tremendous opportunities for the construction of interactive learning tools. Possible applications include digitized photographs, drawings, maps and so forth. A series of plant life-cycle photographs or animated nutrient-flow diagram could be shown in the same manner. Digitally sampled audio, such as an animal call, narrated voiceover of a text passage, a segment of music or other sounds can be retrieved for playback along with other associated information. When a number of different forms of information are combined within one coherent application, the combined result is termed "multimedia." Windows 3.1 includes Multimedia Extensions, program libraries and utilities which handle CD-ROM disc access, digital audio playback and recording, simple video sequencing, and so on.

In recent history, multimedia systems such as ALGIS have become more prevalent, as an ever-increasing amount of information becomes available. To communicate this material effectively is not a trivial task. In designing such systems it is important to realize that users will possess a wide range of backgrounds, skills,

and interest levels, and in fact there may not be just one audience, but several. A number of users will expect to be able to sit down and immediately be shown interesting material, where retrieval of this information does not involve conscious activity on their part. They may have neither the inclination or the time to become involved with any more advanced system features. While there are concise instructions available concerning the steps needed to have ALGIS 'get information on a particular tree' or 'find all plants well-suited to a set of backyard conditions', users may instead prefer to see an overview of the subject area, in the form of graphic menu pages with pictures and text, or narrated slide shows.

One recommendation for future revisions of ALGIS would be the further inclusion of capabilities in the latter areas, in addition to what is currently contained within the system. ALGIS by design permits users to choose their own means of exploring available information, rather than requiring them to follow a directed, predetermined route. It might be argued that this approach, while allowing greater power and flexibility, also increases the level of difficulty first encountered. ALGIS does however contain several directed portions such as the System Tour, which graphically demonstrates on-screen how to use each of ALGIS' different modules. Also, the digital video Introduction forms a brief narrated overview on the Longenecker Gardens.

Many possibilities exist with regard to directed approach. For instance, several additional buttons made available at the starting screen might show video segments detailing Arboretum history, the construction of the McKay Center, nesting behavior of waterfowl, etc. A series of slides and text information concerning different planting groups (such as the Lilac collection) could likewise be implemented. Currently, there are plans for a physical mowed path and marker stakes to be placed in the Longenecker Gardens. Because of ALGIS' modular design, it would be relatively straightforward to create an interactive "guided walkthrough" of several different regions on the map. As an indicator followed through a series of key points on the pathway, signposts, narrations, Scenic Viewpoints, Species Information forms etc. could be easily triggered in response as the tour progressed. The author, in fact, has given much thought to this.

After following this project to completion, and performing a detailed examination of design and implementation issues, the final research results look promising. A computerized information system has successfully been constructed which allows users access to a broad range of uncomplicated yet powerful features. ALGIS users can take an active role in exploratory learning concerning different plant species within the Longenecker Gardens region of the UW-Arboretum. With the possible addition of varied directed informational sequences, and continued future expansion, ALGIS should prove a worthy participant in the next generation of

computerized information systems.

REFERENCES

- Armstrong, Greg (1991). ArborLIS Brittingham Fund grant proposal, University of Wisconsin-Madison Arboretum.
- Bertin, Jacques (1981). Graphics and Graphic Information-Processing. Walter De Gruyter & Co., Berlin.
- Card, Stuart K., Moran, Thomas P., and Newell, Allen (1983). The Psychology of Human-Computer Interaction. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Communications of the ACM: 'Multimedia in the Workplace' (January 1993).
- Dannenberg, R. and Blattner, M. (1992). "Introduction: The Trend toward Multimedia Interfaces." In Blattner, M. and Dannenberg, R. (Eds.), Multimedia Interface Design, pp. xvii-xxv. ACM Press.
- Florin, Fabrice (1990). "Information Landscapes." In Ambron, S., and Hooper, K., eds., Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education, pp. 29-49. Penguin Books.
- Glenn, Bernice T. and Chignell, Mark H. (1992). "Hypermedia: Design for Browsing." In Hartson, H. Rex and Hix, D. (Eds.), Advances in Human-Computer Interaction, vol. 3, pp. 143-183. Ablex Publishing Corp., Norwood, NJ.
- Lang, Laura, "GIS Comes to Life", Computer Graphics World, October 1992. PennWell Publications.
- Laurel, Brenda, ed. (1990). The Art of Human-Computer Interface Design. Addison-Wesley Publishing Company Inc.
- Lengel, James G. and Collins, Sue (1990). "HyperCard in Education: Perspective from the Field." In Ambron, S., and Hooper, K., eds., Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education, pp. 190-198. Penguin Books.
- Little, Elbert E. (1991). The Audubon Society Field Guide to North American Trees: Eastern Region. Alfred A. Knopf, Inc.
- Mandelkern, Dave, "GUIs: The Next Generation", Communications of the ACM: 'Graphical User Interfaces: The Next Generation', April 1993, pp. 37-39.

- Marcus, Aaron (1992). Graphic Design for Electronic Documents and User Interfaces, ACM Press, Addison-Wesley Publishing Company Inc.
- Morse, Alan, and Reynolds, George, "Overcoming Current Growth Limits in UI Development", Communications of the ACM: 'Graphical User Interfaces: The Next Generation', April 1993, pp. 73-81.
- Nielsen, Jakob (1990). HyperText & HyperMedia. Academic Press Inc., San Diego, CA.
- Nielsen, Jakob (1992). "Evaluating the Thinking-Aloud Technique for Use by Computer Scientists." In Hartson, H. Rex and Hix, D. (Eds.), Advances in Human-Computer Interaction, vol. 3, pp. 69-82. Ablex Publishing Corp., Norwood, NJ.
- Oren, Tim (1990). "Cognitive Load in Hypermedia." In Ambron, S., and Hooper, K., eds., Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education, pp. 126-136. Penguin Books.
- Pejtersen, Annelise Mark, and Goodman, L.P. (1988). "Beyond the Desk Top Methaphor: Information Retrieval With An Icon-Based Interface." In Gorny, P., and Tauber, M.J., Lecture Notes in Computer Science: Visualization in Human-Computer Interaction, 7th Interdisciplinary Workshop on Informatics and Psychology, pp. 149-182. Scharding, Austria, Springer-Verlag.
- Podger, Nancy (1991). "Displaying Three Dimensional Data Using An Autostereoscopic Technique On Microcomputers", Masters' Thesis, University of Wisconsin-Madison, pp. 6-9.
- "Ready For Action", Computer Shopper, February 1994, pp. 202-214.
- "REGIS, Restoration Ecology Geographic Information System: Demonstration Pilot Projects for the UW-Madison Arboretum", UW-Madison Practicum class project, 1988.
- Reichman, Rachel (1986). "Communications Paradigms For A Window System." In Norman, Donald A. and Draper, Stephen W., eds., User Centered System Design, pp. 285-313. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Saint-Martin, Fernande (1990). Semiotics of Visual Language. Indiana University Press.

Sears, A., Plaisant, C. and Shneiderman, B. (1992). "A New Era for High Precision Touchscreens." In Hartson, H. Rex and Hix, D. (Eds.), Advances in Human-Computer Interaction, vol. 3, pp. 1-33. Ablex Publishing Corp, Norwood, NJ.

Shneiderman, Ben (1992). Designing the User Interface: Strategies for Effective Human-Computer Interaction. Addison-Wesley, Reading, MA.

Thomas, John C., and Schneider, Michael L. (1984). Human Factors in Computer Systems. Ablex Publishing Corp, Norwood, NJ.

Tufte, Edward R. (1989). Visual Design of User Interface. IBM Corporation.

User Interface Strategies '93 (live satellite TV broadcast, Dec. 9, 1992; produced by The University of Maryland Instructional Television System; featured speakers: Ben Shneiderman, Marilyn Mantel, Tom Furness, James Martin)

Visual Basic Design Guide. Microsoft, 1993.

3 March '94 DRAFT KWLHG

Z = field not applicable for this record

INVENTORY BACKGROUND

Scientific name:	Memorial:
Common name:	Source:
Other common names:	Genus:
Accession number:	Family:
Location in the Gardens:	Family Common Name:

IDENTIFICATION

Habit:		LEAFHABIT
Evergreen foliage		E
Deciduous foliage		D
Herbaceous		H
Tree		GROHABIT
Tall (40 - 100 feet)		TT
Medium (30 - 40 feet)		TM
Low (20 - 30 feet)		TL
Shrub		
Tall (8 - 12 feet)		ST
Medium (5 - 8 feet)		SM
Low (2 - 5 feet)		SL
Vine		
Habit of growth		
Tendrils		VT
Twining		VW
Holdfasts		VH
Ground Cover		GC

Leaves	LEAVES
Needle-, or Scale-like (conifers)	N
Broadleaved	
Opposite	O
Alternate	A
Whorled	W
Simple (one blade per leaf)	S
Compound (several blades per leaf)	
Palmate (arranged like fingers on a hand)	L
Pinnate (arranged like barbs on a feather)	T
Summer leaf character	LEAFCHAR
Cutleaf	C
Silver, gray, or bluish	S
Light Green	L
Yellow	Y
Red or purplish, becoming green	B
Red through summer	R
Purple	P
Bronze	N
Variegated	V
Green	G
Fall foliage color	FALLCOLOR
Purple	P
Red	R
Pink	K
Orange	O
Yellow	Y
Russett	U
Not colorful	N
Evergreen	E
Thorns	THORNS
Yes	Y
No	N

Flowers

Color	FLOWRCOLOR
Pink	K
Red	R
Orange	O
Yellow	Y
Green	G
Blue	B
Purple	P
White	W
Gray	A
Varies with cultivar	V
None (rarely flowers)	N

Season	FLOWRSESON
Very early spring (late March to mid-April)	VE
Early spring (mid- to late April)	ES
Mid-season (early to mid-May)	MS
Late spring (late May to early June)	LS
Early summer (late June to mid-July)	EM
Mid-summer (late July to mid-August)	MM
Early autumn (late August, September)	EA
Late autumn (October - November)	LA
Late May, with repeat bloom through summer	RE
June to August	JA
June until frost	SU

Type	FLOWRTYPE
Perfect (pollen and seeds in same flower)	P
Monecious (pollen & seeds in seperate fls. on 1 plant)	M
Dioecious (pollen fls. & seed fls. on different plants)	D
Sterile, produces no seed	S
Double, produces little or no seed	B

Fruit

Color	FRUITCOLOR
Red	R
Orange	O
Yellow	Y
Blue	B
Purple	P

Fruit**Color (continued)**

Pink
Brown
Green
White
Black
No fruit

FRUITCOLOR

K
N
G
W
L
X

Type

Cone
Apple- or Berry-like
Nut
Dry, winged
Dry, capsule or pod

FRUITTYPE

C
B
N
W
P

Season

Early (May - June)
Late June to July
August
September
October
Winter

FRUITSESON

E
L
A
S
O
W

Persists

Yes
- No

FRUITSTAY

Y
N

Bark character

Not distinctive
Distinctive

BARK

NOT

Colorful

COL

Colorful and with interesting texture

CTX

Texture

Smooth

TXS

Coarse

TXC

Peeling

TXP

CULTURAL REQUIREMENTS

USDA Plant Hardiness Zone Rating 3A, 3B, 4A, 4B, 5A, or 5B as per map			HARDINESS
Sunlight			SUNLIGHT
Full sun			F
Light shade			P
Shade tolerant			S
Requires light shade or full shade			PS
Soil reaction	SOILPH		SOILPH
Acidic	C	Neutral to alkaline	NK
Neutral to acidic	NC	Alkaline	K
Neutral	N	Adaptable, not particular	CK
Soil moisture			SOILMOIST
Wet			W
Moderate to wet			MW
Moderate			M
Moderate to dry			MD
Dry			D
Soil type			SOILTYPE
Sandy			S
Loam			L
Clay			C
Pest or disease problems			PESTDISEAS
Yes			Y
No			N

LANDSCAPE CHARACTERISTICS

Growth rate		GROWTH
Fast		F
Medium		M
Slow		S

Form	FORM	FORM
Upright	U	Weeping W
Oval	O	Creeping K
Round	R	Mound M
Wide-spreading	S	Suckering N
Vase	V	Irregular I
Pyramidal	P	Clinging vine G
Columnar	C	
Texture		TEXTURE
Coarse		C
Medium		M
Fine		F
Attractive features		ATTRACTFEAT
Form		FO
Flowers		FL
Fragrant		FR
Attractive to birds		AB
Fragrant foliage		FF
Fragrant fruit and foliage		FT
Fruit		
Display		FD
Edible		FE
Attractive to birds		FA
Foliage		LF
Fall color		FC
Bark		BK
Texture		TX
Tolerance of urban, or difficult conditions		TU
Use		USE
Street tree		T
Shade tree		S
Specimen		P
Naturalizing		N
Windbreaks		W
Hedge, or screen		H
Ground Cover		G
Vine covering trellis, fence, or wall		F

Parts of plant toxic

TOXIC

Yes	Y
No	N
Uncertain	U

Native to Wisconsin

NATIVEWIS

No	N
Yes	

Widespread, or of uncertain community type	Y
---	----------

Northern Wisconsin

Dry forests	NDF
Rich forests	NRF
Wet forests	NWF

Southern Wisconsin

Dry forests	SDF
Rich forests	SRF
Wet forests	SWF
Prairies, dunes, or marshes	SPR

Main DB editor

Scientific name
Cercis canadensis

Common name
Eastern Redbud

Family
Fabaceae

Family (common)
Pea

Location
LG


Date planted
Apr 22, 1977

Rank
Bed A Bed B

Memorial

Rec. No.

info update
 data rewrite

 >home<

Identifying Features

Leaf habit

Growth habit

Leaves

Leaf char.

Fall color

Thorns

Flower color

Flower season

Flower type

Fruit color

Fruit type

Fruit season

Fruit stay

Bark

Cultural requirements

Hardiness zone

Sunlight

Soil pH

Soil moisture

Soil type

Pest/disease

Identifying Features

Leaf habit

Growth habit

Leaves

Leaf char.

Fall color

Thorns

Flower color

Flower season

Flower type

Fruit color

Fruit type

Fruit season

Fruit stay

Bark

Landscape Characteristics

Growth rate

Form

Texture

Attractive feat.

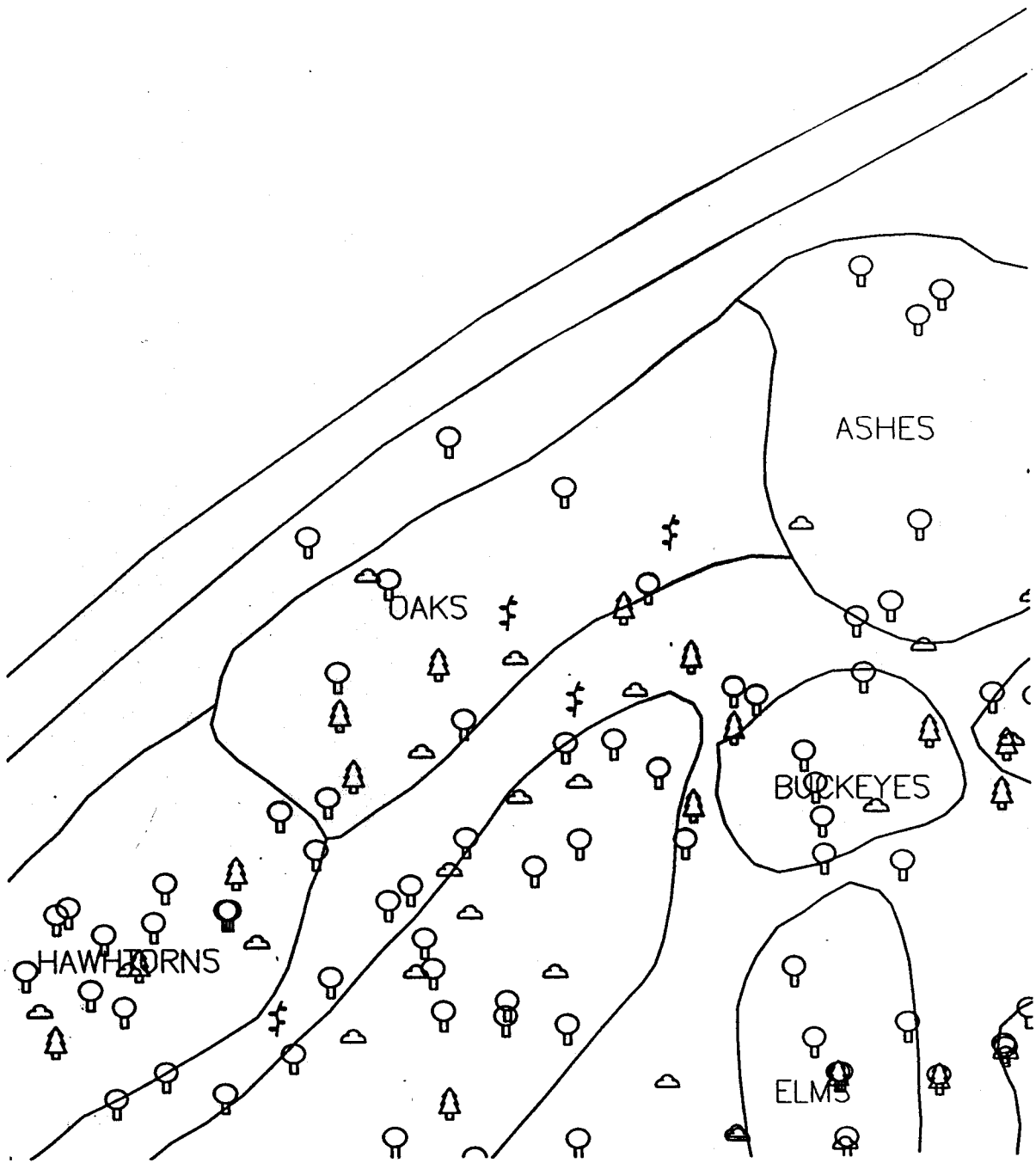
Use

Toxic

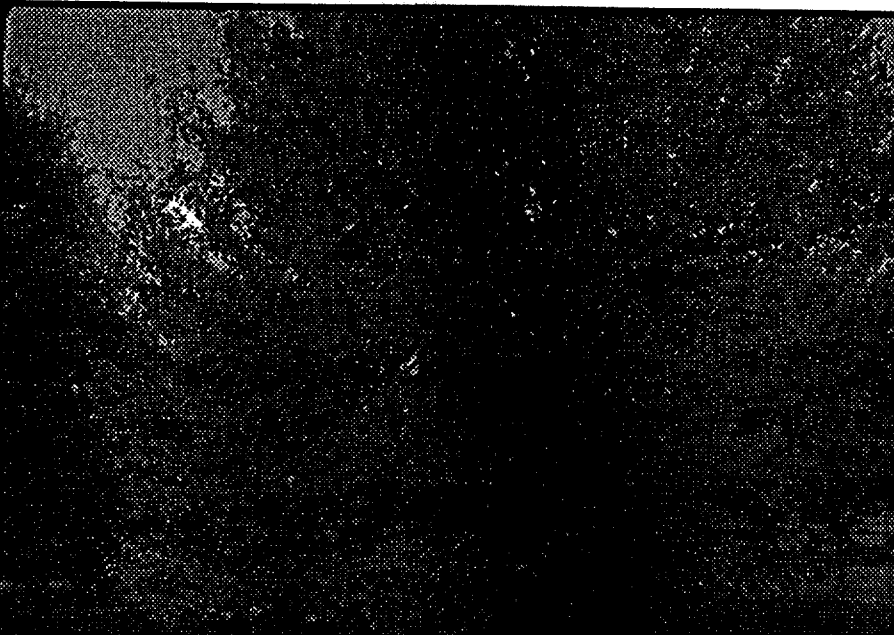
Native Wisc.

Photos

Photos



Overhead Vector Map printout

Scientific Name <i>Acer rubrum</i>			
Family Aceraceae			
Common Name Red Maple			
Family (common) Maple			
Location	Coordinates		
TD-CC	558 1148		
Date planted Apr 24, 1981			
Bed A Bed B Bank			
Identifying Features			Growth Requirements
<ul style="list-style-type: none"> ◆ Tree (40-100 ft) ◆ Deciduous; broadleaved ◆ Leaves opposite, simple ◆ Green → [red] (Fall) ◆ Flowers: Monocious [red] bloom v. early Spring ◆ Fruit: dry, winged [red] season - Early (May-June) ◆ Bark: <unknown> 			<ul style="list-style-type: none"> ◆ Hardiness Zone 3A ◆ light shade - shade ◆ Soil pH: acidic - neutral ◆ Soil moisture: moderate - [red] ◆ Soil type: sandy - clay ◆ No pest/disease problems
		Land-use Characteristics	
		<ul style="list-style-type: none"> ◆ Growth rate: fast ◆ Form: round ◆ Texture: rardura 	
		Attractive Features:	
		<ul style="list-style-type: none"> ◆ flowers: Full color ◆ Use: shade tree, specimen ◆ Wild. native; N. dry, S. wet forest ◆ Plant is not toxic 	

Species Information printout

ALGIS User Survey

Instructions:

If you would like to help us to improve the system, please take a moment or two to fill out this sheet. Positive feedback is welcome, but we are likewise open to any suggestions for improvement.

Today's date/time: _____

Background information

* Sex (optional): male female

* Age (optional): _____

* How much time have you spent using ALGIS, so far?

<input type="checkbox"/> less than an hour	<input type="checkbox"/> 7-8 hours
<input type="checkbox"/> 1-2 hours	<input type="checkbox"/> 9-10 hours
<input type="checkbox"/> 3-4 hours	<input type="checkbox"/> 11-12 hours
<input type="checkbox"/> 5-6 hours	<input type="checkbox"/> more than 12 hours

* In the past, how many different types of computer systems (that is, kinds of personal computers, workstations, mainframes and so on) have you worked with (ex. IBM PC, Macintosh, Sun Sparcstation, DEC VAX)?

<input type="checkbox"/> none	<input type="checkbox"/> 3-4
<input type="checkbox"/> 1	<input type="checkbox"/> 5-6
<input type="checkbox"/> 2	<input type="checkbox"/> more than 6

* Of the items below, mark those which you are familiar with and have used before:

<input type="checkbox"/> keyboard	<input type="checkbox"/> text editor	<input type="checkbox"/> dumb terminal
<input type="checkbox"/> mouse	<input type="checkbox"/> word processor	<input type="checkbox"/> personal computer
<input type="checkbox"/> joystick	<input type="checkbox"/> electronic mail	<input type="checkbox"/> workstation
<input type="checkbox"/> trackball	<input type="checkbox"/> spreadsheet	<input type="checkbox"/> floppy drive
<input type="checkbox"/> touch screen	<input type="checkbox"/> paint/draw program	<input type="checkbox"/> hard drive
<input type="checkbox"/> light pen	<input type="checkbox"/> computer games	<input type="checkbox"/> CD-ROM drive
	<input type="checkbox"/> multimedia software	<input type="checkbox"/> color monitor

* If you have prior plant-related knowledge, please note area(s) here:

System Ratings

On a scale of 1 to 5 (1 = terrible/strongly disagree, 3 = fair/neutral, 5 = excellent/strongly agree), please rate the following:

General Impressions

Rate the system, overall:	1	2	3	4	5
Was it.. easy to use?	1	2	3	4	5
interesting?	1	2	3	4	5
powerful enough?	1	2	3	4	5

Display

Characters on screen easy to read?	1	2	3	4	5
Screen organization/layout	1	2	3	4	5
Screen resolution, graphics quality	1	2	3	4	5

Information Content

Are consistent terms, explanations used?	1	2	3	4	5
Does the textual information make sense?	1	2	3	4	5
Status messages that appear on screen are:	1	2	3	4	5
Does the computer keep you informed about what it is doing?	1	2	3	4	5
Pictures: plants, scenic views, etc.	1	2	3	4	5
Video: Introduction, other video segments	1	2	3	4	5
Sound: narration, digitized sounds, etc.	1	2	3	4	5

Using the System

Did you find ALGIS easy to learn?	1	2	3	4	5
Were the system's reference materials helpful? (i.e. System Tour, Online Help etc)	1	2	3	4	5
If there were no help available, do you think people could understand most of the system?	1	2	3	4	5
Are commands and their function easy to remember?	1	2	3	4	5
Can most commands and operations be done in a straight-forward manner?	1	2	3	4	5

System Capabilities

Overall speed/system response time 1 2 3 4 5

(Does the computer seem reasonably fast in responding to your commands? i.e. retrieving information, showing pictures etc.)

Reliability 1 2 3 4 5

(Can you depend on getting consistent results? Anything unexpected happen? System troubles?)

Suitability for beginners/experts 1 2 3 4 5

(Do you think that people of most skill levels could use this system reasonably well?)

Functionality 1 2 3 4 5

(Given the kinds of information available, did the system seem to let you do the kinds of things you wanted to?)

Specific Features

Overhead Vector Map 1 2 3 4 5

Species Information 1 2 3 4 5

Species ID/Search 1 2 3 4 5

Scenic Viewpoints 1 2 3 4 5

Landscape Layout 1 2 3 4 5

Activities 1 2 3 4 5

Bookmark 1 2 3 4 5

Online Help 1 2 3 4 5

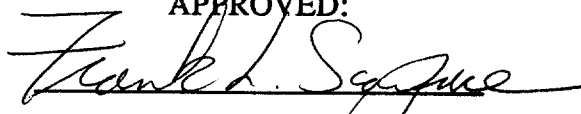
(System Tour, at start) 1 2 3 4 5

Cycle Windows 1 2 3 4 5

Comments

Please write comments, concerns, or ideas you might have below!

APPROVED:

A handwritten signature in cursive script, appearing to read "Frank L. Scarpace", written over a horizontal line.

Frank L. Scarpace, Professor
Environmental Studies and Civil Engineering

Date: 5/20/94