

ADSS: A WEB-BASED AGROFORESTRY DECISION SUPPORT SYSTEM

By

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To Aunt Jyoti

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Abstract of Thesis Presented to the Graduate School
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Online geographical information based decision support systems have been developed for over a decade in various disciplines. Some of their more famous applications include natural hazard calculation, study of migratory patterns of animals, and image views of geopolitical boundaries. An emerging application area for these systems is the field of agroforestry. Currently, a number of these systems exist, which provide partial information about the agricultural aspects of a region. The major drawbacks of these systems are load time, response time, lack of integrity, traditional use of servlet technology, very little decision support, and little consideration of user needs. This thesis presents the development of a decision support system for tree and shrub selection which addresses these issues, suggesting possible corrections to the above flaws.

CHAPTER 1 INTRODUCTION

Geographical Information Systems (GIS) store a huge amount of spatial data. These data may be useful by themselves in some cases, but most of the times we need some mechanism that reduces this wealth of information to a subset for some specific use. This is the realm of decision support systems (DSSs). DSSs can be defined as interactive, flexible, and adaptable computer programs that are specially developed to help obtain a solution for a particular management problem [ELLI01]. They help decision makers compile useful information from raw data, documents, and personal knowledge to identify or solve problems and make decisions [INFO02]. The Internet is a prodigious resource, making vast quantities of information available by remote data sharing and data distribution techniques. The globalization of this data makes DSSs more important and popular than ever. One of the emerging applications of DSSs is in the field of agriculture. Today, there is substantial information available to understand the complex nature of variables affecting plant establishment and growth in region.

What is Agroforestry?

“Agroforestry is the deliberate growing of trees or shrubs in rural areas. Agroforestry is being promoted in the United States as an alternative resource management system that can bring landowners economic benefits and provide environmental services such as reduced soil erosion, improved water quality, and wildlife habitat” [ELLI01, p. viii]. Due to its importance, we need some mechanism that helps

users decide the types of trees and shrubs that they can grow, without having to manually search for them.

Why GIS?

GIS can be defined as any of the various software applications, running on PCs or workstations, that stores, analyzes, and displays multiple layers of geographic information. It can be thought of as a spatial database [LANG01]. This data can be viewed, queried (if required), symbolized on the map, and modeled according to the users' needs. The use of maps has made it possible for man to see the world on a piece of paper. But it had always remained a dream to know much more about the local features of a region without spending significant time in research. GIS now makes this possible. Clients interested in aesthetic beauty, agriculture, and flora are distributed all over the world. There is a need for a mechanism that makes it possible for them to evaluate a remote location just by clicking on a point on a map.

Why DSS?

The purpose of GIS is to provide a spatial framework to support decisions (possibly made through a DSS) for the intelligent use of earth's resources and to manage the man-made environment [ZEIL99]. For example, these systems can aid in the buying or selling of a site based on the location attributes and values of the region. Such a system can extract useful spatial data from the GIS, query it according to the user needs, and present the user with information including the set of trees and shrubs that satisfy their specific constraints, thereby helping them make decisions.

Problem Statement

GIS can provide ample soil information as part of its returned spatial data. We need a mechanism to put these data to use for tree and shrub selection. Decision making, in

this arena, is not only useful for farmers and landowners but also for extension agents, who are continuously questioned regarding the kind of plants their clients can grow on their property. While some of this can be accomplished through educated guesses, there is a significant probability of errors. Also, such decisions are usually based on a what-we-see-is-what-we-believe basis. There are many species of trees and shrubs that could be planted in an area but are not, because they are not found in nearby areas. What we need is a more reliable, logical, precise, and accurate decision support system. Since this system should be easily accessible by all users, developing it as a web-based application is ideal. This system should have an easy to use, user friendly interface since the capability to view the information in the form of tables is not sufficient. Users always look for ways to obtain data tailored to their needs. This thesis addresses the issues involved in designing such an Agricultural Decision Support System (ADSS), and implements an optimal interface for the same. Since it is being developed for the south eastern parts of North America, it is also called the South Eastern Agroforestry Decision Support System (SEADSS).

Organization of the Thesis

Chapter 2 gives a brief overview of background, related work, and tools available. Chapter 3 provides a walk through the system and a description of how the system works. Chapter 4 discusses the issues involved with design followed by the design of the ADSS. Chapter 5 discusses the implementation details. Chapter 6 concludes and suggests extension ideas as part of future work.

CHAPTER 2 RELATED WORK

ADSS uses spatial data of a GIS for soil characteristics and other geographical attributes. These data and the data about trees and shrubs are collected from various sources and are used to determine the type of trees and shrubs that can be planted in that region. Before discussing the design and the implementation of the ADSS, let us first have a brief overview of these sources.

Background and Related Work

An enormous amount of research has been performed to make the existing agricultural industry more logical and automated. Tools are continuously being developed to help farmers make scientific decisions.

United States Department of Agriculture (USDA)

The USDA is a well-known agricultural institution (website www.usda.gov [USDA02]). One of its branches, called the Natural Resources Conservation Service (NRCS), provides a wealth of data about plants, their characteristics, and their habitats at <http://plants.usda.gov>. A screenshot of this site is shown in Figure 2.1. These data provide us with important parameters required to match plants with the corresponding soils and the climate of the region. This is important for decision support because, even if we have abundance of soil and climate information of a county, if there is no data about the trees and shrubs to match it against, the information might be useful in some other field, but does not help decision support. Soil data is also provided by the NRCS. Alas, the data are

available only by performing a search either by common name, scientific name, or the plant's symbol [NRCS02].

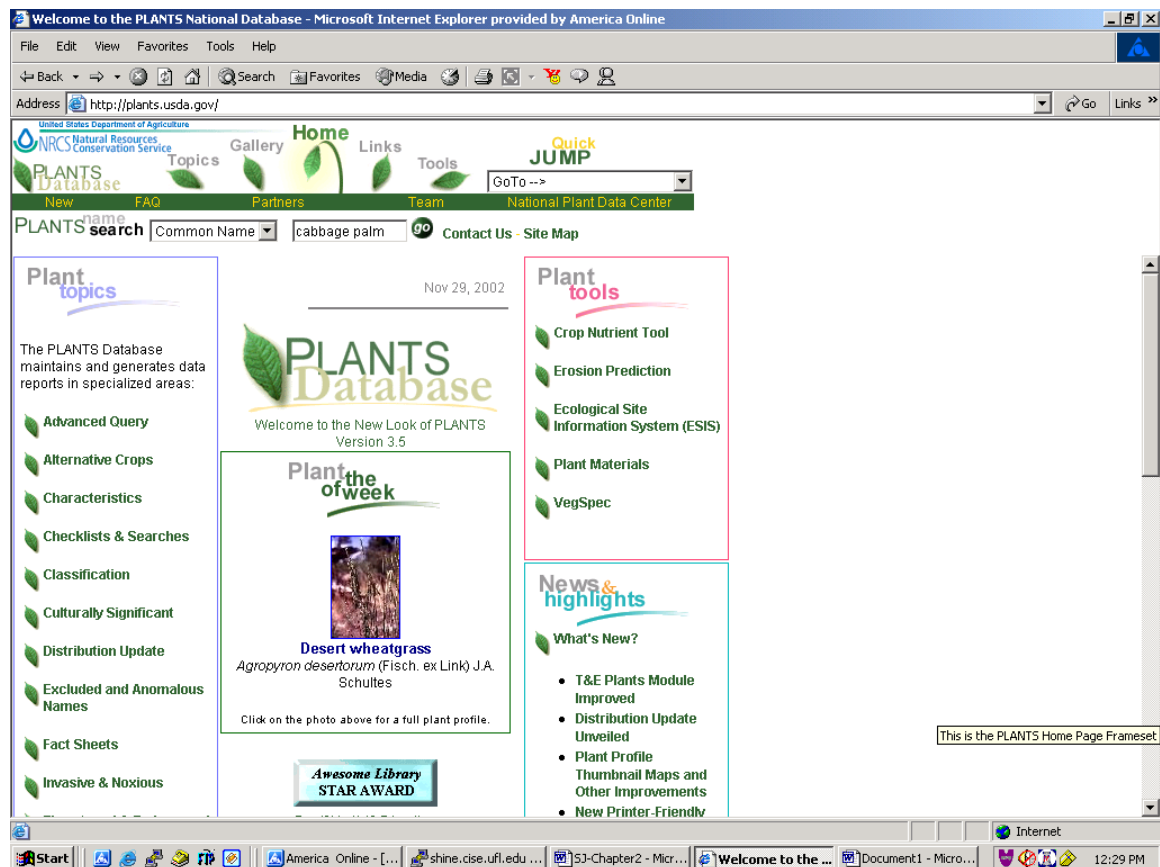


Figure 2.1. A screenshot of the USDA Plants database

Figure 2.2 shows the search results for common name “cabbage palm.” These data are provided in a file format, available for us to download. The data include aspects on the the plant characteristics, ecology, management properties, and uses. As we can see in the figure, the images on the right hand side, the plant characteristics, the plant classification, stating the family to which the plant belongs, its scientific name, its common name, other names for the plant, and the plant guide, are actually links to files of information. Sometimes, they also have factsheets, plant guides, and images of plants. These documents provide other useful information including services provided by the plants, as well as their resistance to pests and diseases.

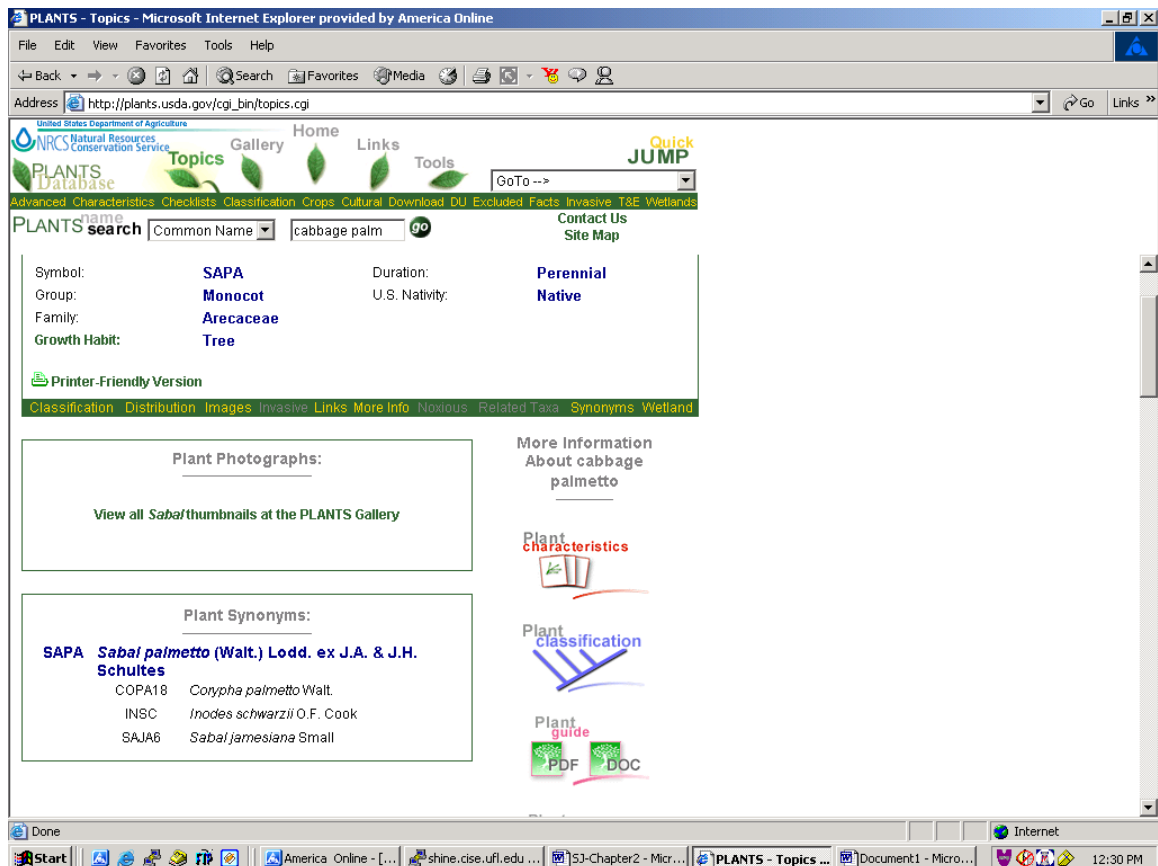


Figure 2.2. USDA query results for “cabbage palm”

This site also gives a pictorial view of where these plants are mostly found. This is illustrated in Figure 2.3. The “states” in the map that are shaded green are the regions where there is a high likelihood of finding these plants. Soils within a state can have vast variations in pH. Trees that cannot withstand high pH variations should not be grown there. Making the data general over a state, makes it susceptible to these mistakes! Although this site provides the required knowledge about plants, users are forced to manually search the entire set of files to obtain the information about the kind of plants they want! The site could provide some search options to locate plants based on the common name, the scientific name, and the symbol of the plant. But this data is difficult to use, for example, to a person interested in trees that can be used as landscape ornamentals. An expert could make a smart guess and find such trees searching by

common names, but what happens when a person, who has never taken a botany class, wants to know if the plant that he/she has planted in the backyard is capable of tolerating sunlight or not!

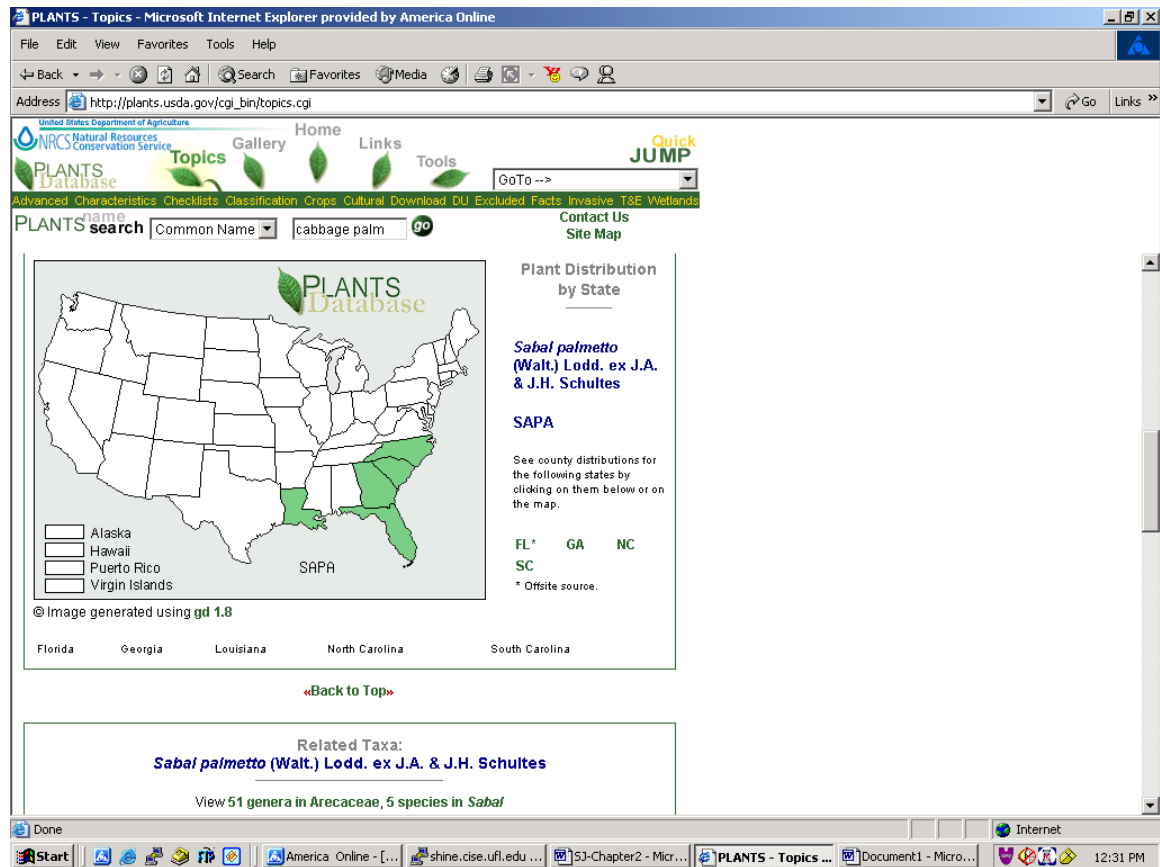


Figure 2.3. Location map for “cabbage palm”

NRCS has another site at

<http://ironwood.itc.nrcs.usda.gov/Netdynamics/Vegspec/pages/HomeVegspec.htm>. This

site is also a decision support system helping users to find information about trees and shrubs. But the user has to know a lot of information about the place for which he is searching to get any useful information from the site. On clicking “Start Vegspec” on the above site, we get an interface as shown in Figure 2.4. For the “Alachua County” in the state of “Florida,” the user needs to know the soil map unit. The same is true for the climate station associated with the county [VEGS02].

The site name, project location and user name are optional fields. They will appear on report.

Site Name

User Name Project Location

State:

Soils:

Complete items 1, 2, and 3 below (in sequence) to describe soils for your location. Related information will be included from the database. You may view or enter selected soil attributes in the [soil attributes suboption](#).

1. Soil Survey Area Id

2. Soil Map Unit

3. Soil Component

Climate:

Use choice lists to select climate data from the database. You may view or enter selected climate attributes in the [climate attributes suboption](#).

Climate Station

Landscape:

Select general landscape characteristics from the displayed lists.

Generally, what aspect does the site face?

☒ N/A ☐ East ☐ North ☐ Northeast

☐ Northwest ☐ South ☐ Southeast ☐ Southwest

☐ West

Does the site receive additional water?

☒ No ☐ Yes

Is the site irrigated?

Figure 2.4. View of NRCS's VegSpec

Although VegSpec provides an excellent collection of data and little decision support for the end user, it is not automated. It assumes that the end user is not naïve and expects him to pass many parameters to obtain what he wants! We use these data as our base of information about the properties of the trees and shrubs.

Institute of Food and Agricultural Sciences (IFAS)

IFAS is a University of Florida Institute. The Electronic Data Information Source (EDIS) at IFAS (http://edis.ifas.ufl.edu/MENU_MG:ST_SCIENTIFIC) provides useful information about trees and shrubs sorted by their scientific name [IFAS02]. The information includes the habitat, plant characteristics, uses and management, pests, and diseases of the tree. See Figure 2.5 for description about “Acer saccharinum.”

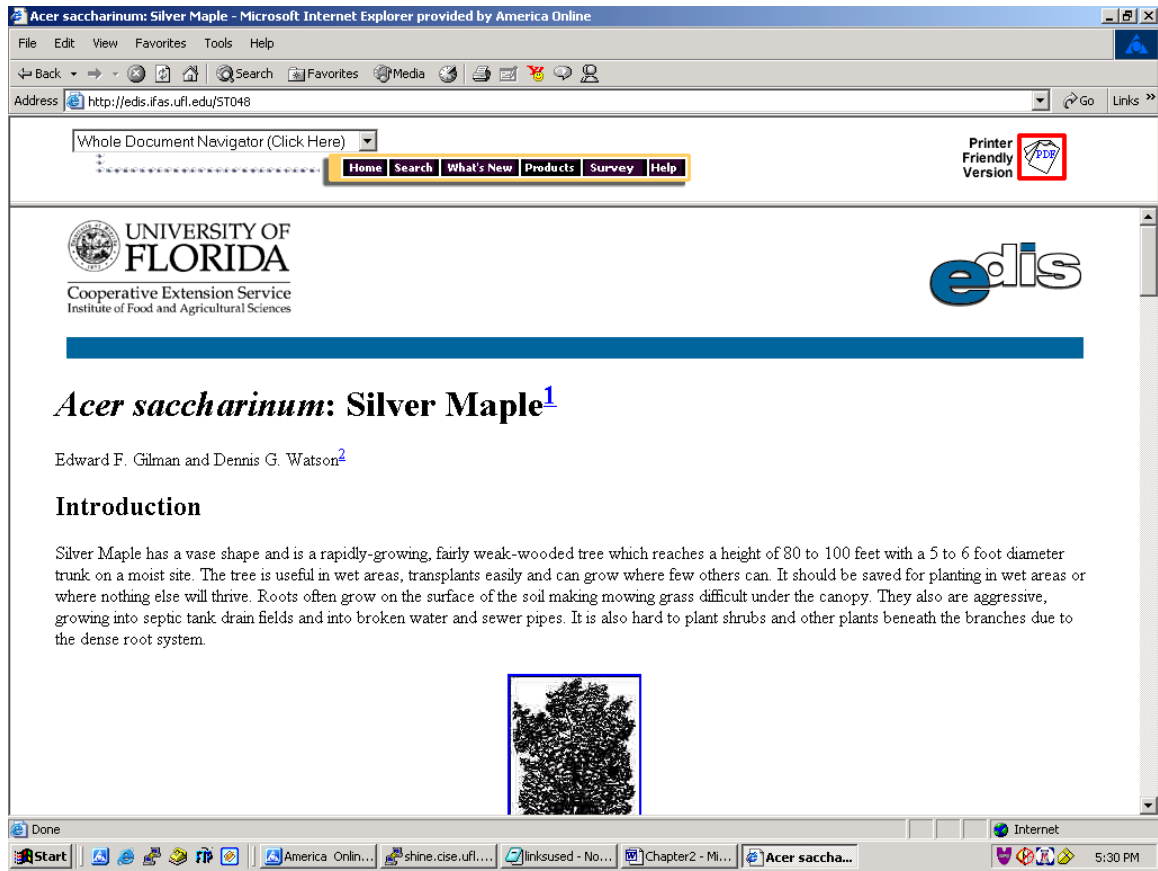


Figure 2.5. Snapshot of EDIS at IFAS for “*Acer saccharinum*”

As we scroll down through this webpage, we see that this data is also in the form of name-value pairs, makes it more readable for the user. But again, it does not provide any decision support.

University of South Florida (USF) Herbarium

Another site, <http://www.plantatlas.usf.edu/>, provides partial information about plants [USFH02]. Figure 2.6 is an example with the search string “*Acer saccharinum*” (silver maple).

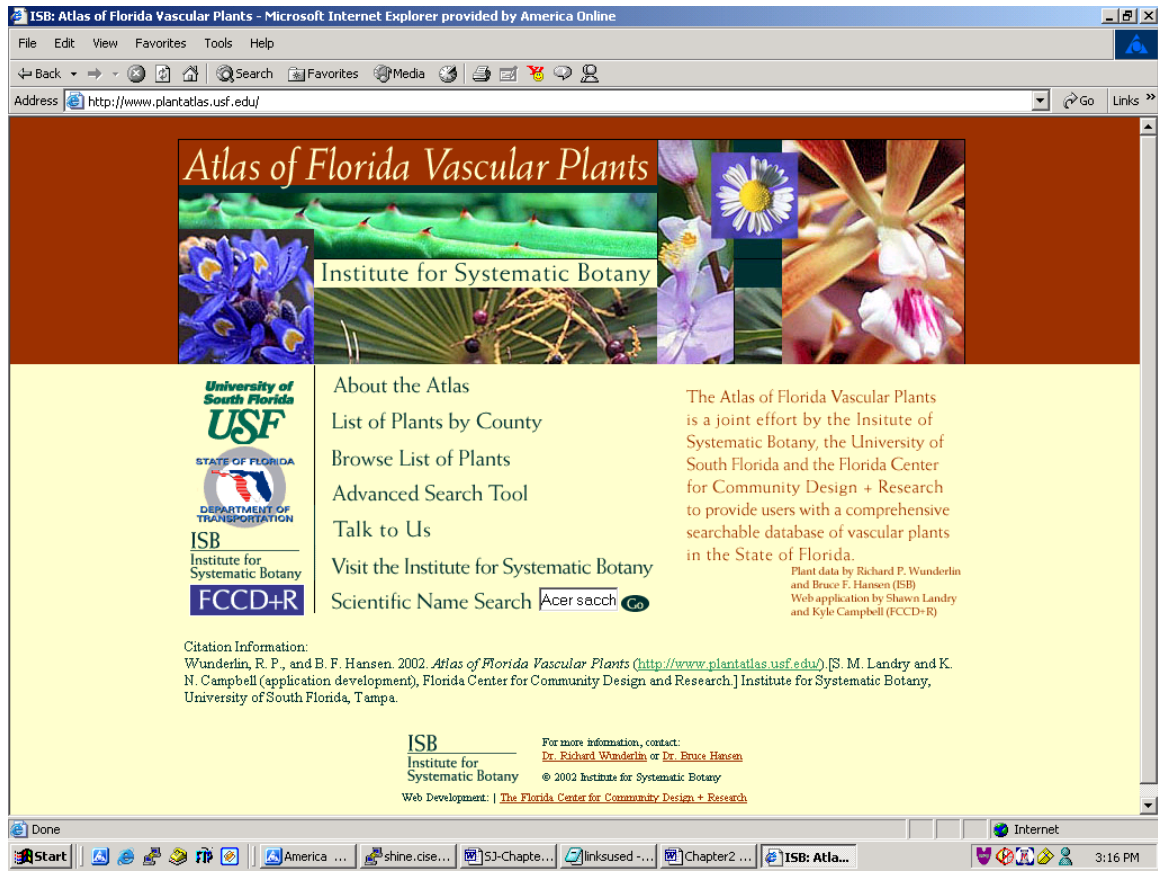


Figure 2.6. Snapshot of USF Plant Atlas with search string “*Acer saccharinum*”

There is no information available about the properties of these plants like their height, life span, anaerobic tolerance, and minimum temperature tolerance. Since, we already have the distribution map information and all the other desired data from NRCS, these data are useful mostly for the vast gallery of pictures and for the short descriptions of the various ecosystems as seen in Figure 2.7.

Their work is substantial and useful but is only limited to the State of Florida. Also, not all information about the trees and shrubs is available here, and it does not provide any decision support tool. Besides, it is information about where these trees and shrubs “are found” rather than where they “can be grown.” This is another source of data for our tree and shrub selection process.

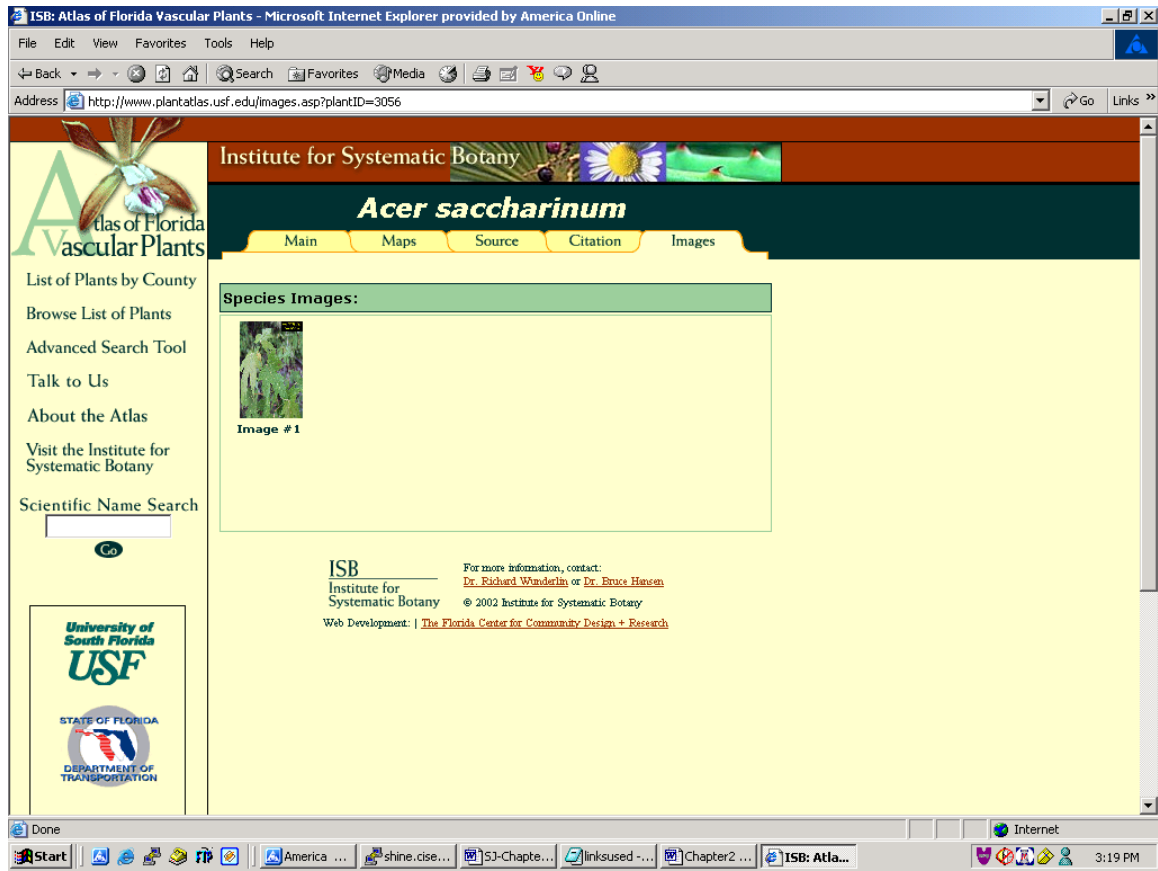


Figure 2.7. Images of “*Acer saccharinum*”

Treeguide – Athenic Systems

The treeguide is a public service provide by Athenic Systems at its website www.treeguide.com [ATHE02]. It provides information about the regions where plants are usually found in abundance along with a list of their uses. This guide consists of data concerning native North American trees. Although the information provided by this website covers most species, it is very limited in its description of the trees. A screenshot of the site with the search string “silver maple” is shown in Figure 2.8. Compare the kind of information available at this website with those available at the sites shown in Figure 2.5 and Figure 2.6.

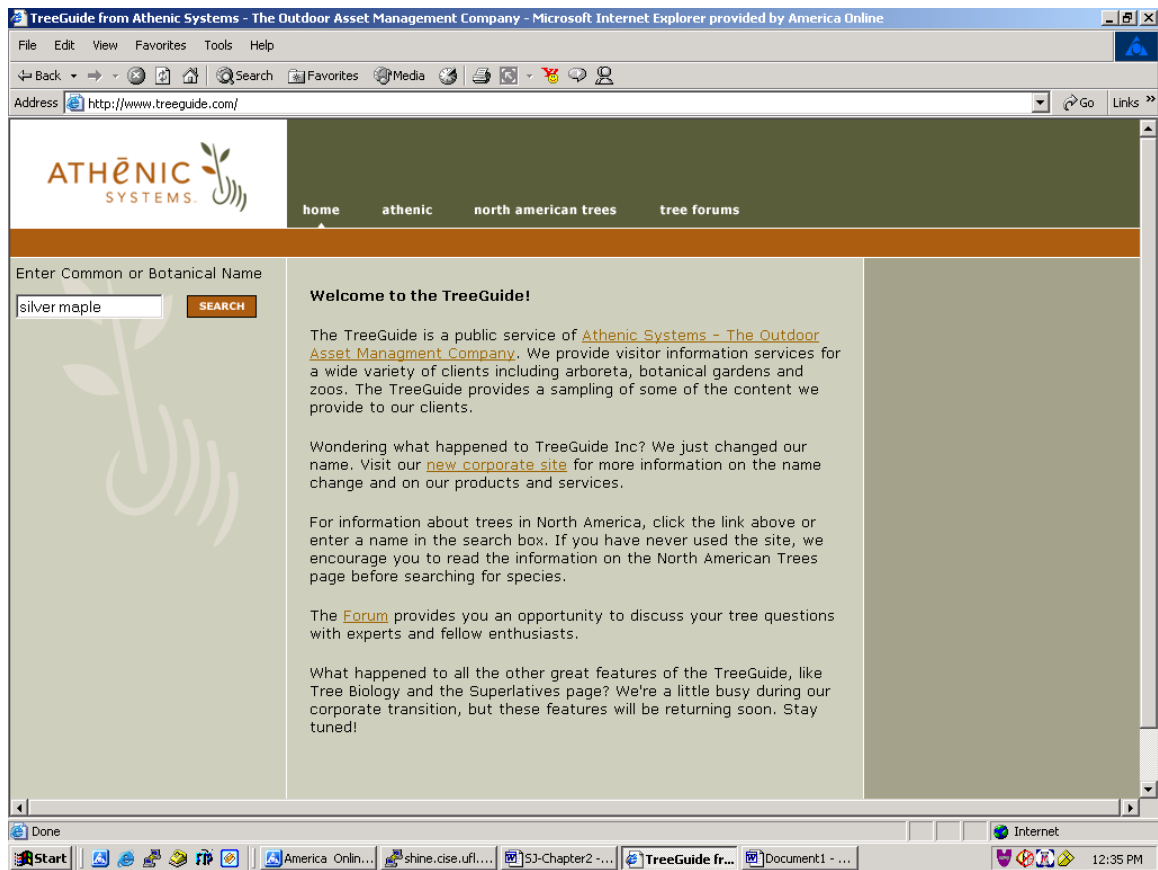


Figure 2.8. Treeguide website with search string “silver maple”

On clicking “SEARCH” on the left in Figure 2.8, we are provided the result as shown in Figure 2.9 if the tree is available in the database. On clicking the family name “Aceraceae” in Figure 2.9, we obtain common characteristics of plants belonging to the “Aceraceae” family along with a list of plants that belong to this family. The list of plants is hyperlinked so we can jump to any one that interests us. The other information like the common and botanical names, although hyperlinked, are still displayed on the same page.



Figure 2.9. “silver maple” search results at Treeguide

On clicking “silver maple” in Figure 2.9, we get a narrative description about the tree’s distribution, ecology adaptation, life history, pollination, and other uses. This is depicted in Figure 2.10. A short description of the species and interesting notes including the reasons for the plant’s name is also provided along with other information. A link to images of the plant is provided on the left frame of the page. The descriptive nature of this information is very helpful for users who are performing a study on this particular species. But, users who are looking for “trees found in dry soils” will not know that this tree is “never found in dry soils” until they either enter this phrase as a search string, or accidentally happen to see this description by searching in some search engine.

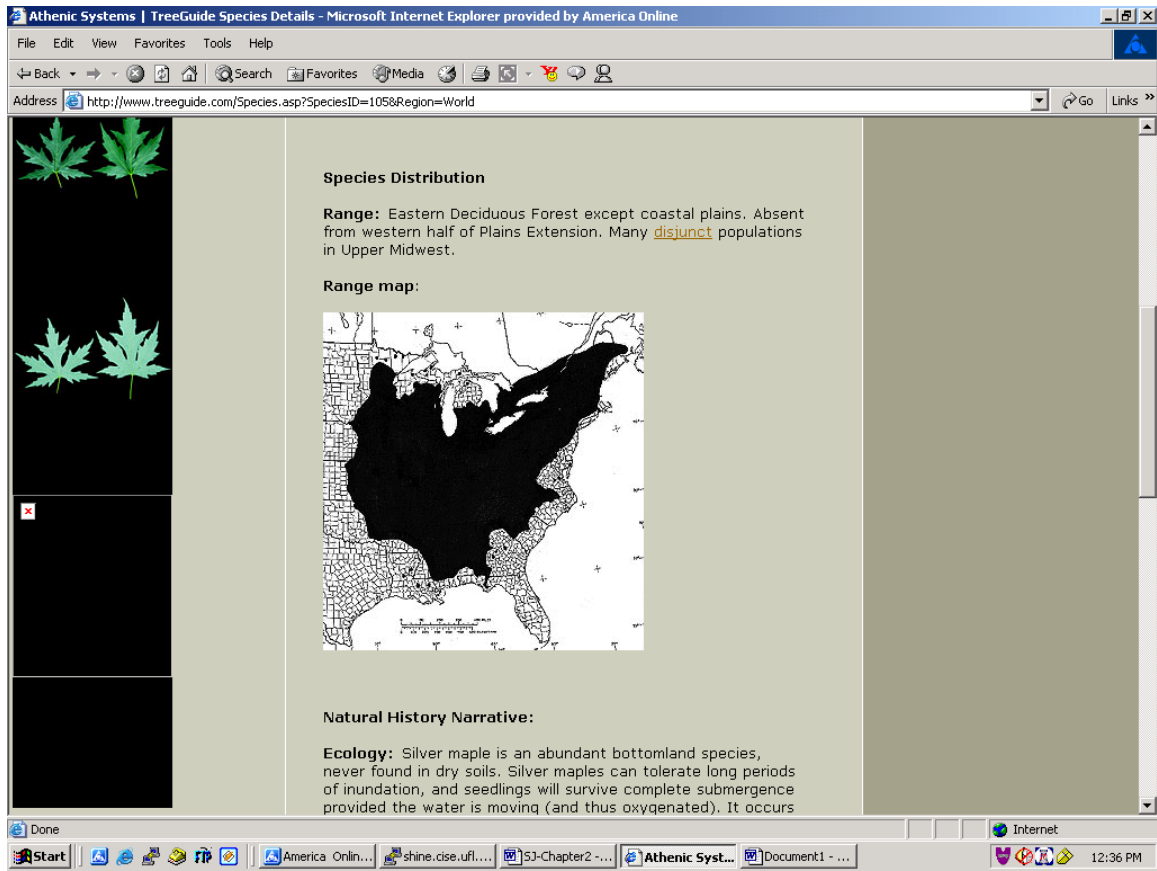


Figure 2.10. Information about “silver maple” at Treeguide

This makes the information provided by this site less accessible than that from NRCS, which has information in the form of attribute name and value pairs. So, once the user is accustomed to the NRCS data format, he knows exactly where to look for the data within the document.

When we look at all these data available at these various sources of information, we realize the need to put them all together into one common database, thereby making it easier to search. The details of this database’s structure are discussed in Chapter 4.

Now that we have discussed the data needed for problem solving, let us examine the tools available: the GISs available for current use in agriculture, their strengths, and weaknesses.

ESRI

ESRI is a GIS and mapping software company (www.esri.com). Many GIS applications use ESRI products and tools for development [ESRI02]. One of their tools, ArcIMS, provides the foundation for distributing high-end geographic information systems (GIS) and mapping services via the Internet. ArcIMS software enables users to integrate local data sources with Internet data sources for display, query, and analysis in an easy-to-use Web browser [ARCI02b]. A number of applications, including agricultural applications, have been written using ArcIMS.

We now provide a brief survey of the agricultural applications designed using ArcIMS [ARCI02a]. These applications are available at www.esri.com/industries/agriculture/index.html.

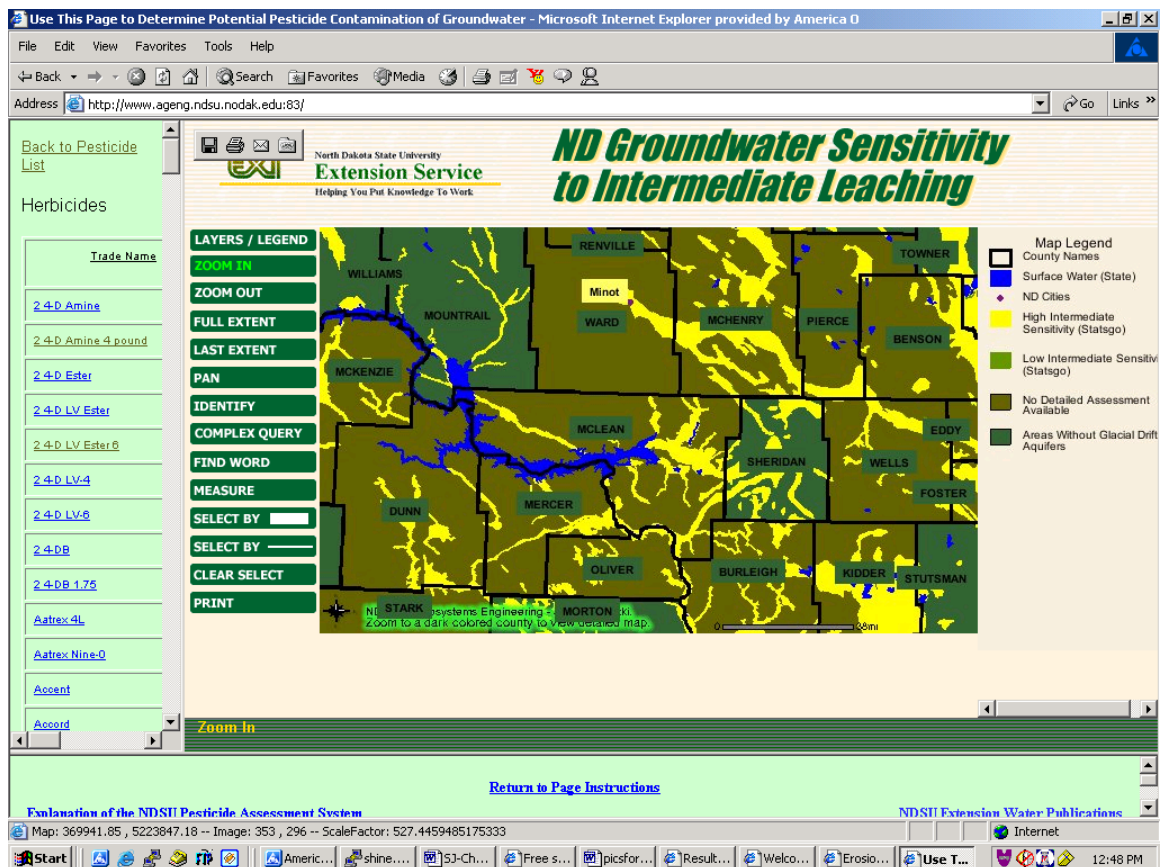


Figure 2.11. Search results with a herbicide selected

One of the applications involves potential pesticide contamination to North Dakota groundwater (<http://www.ageng.ndsu.nodak.edu:83/>). It starts by asking the user to select from a set of herbicides, fungicides, and insecticides. When selected, it shows a map with areas that are sensitive to contamination [NDSU02]. Figure 2.11 shows a sample when one of the herbicides is selected.

The legend, to the right of the map, marks the map into high intermediate sensitivity, shown in yellow color, and low intermediate sensitivity, shown in light green color. The buttons used for navigation are found to the left of the map.

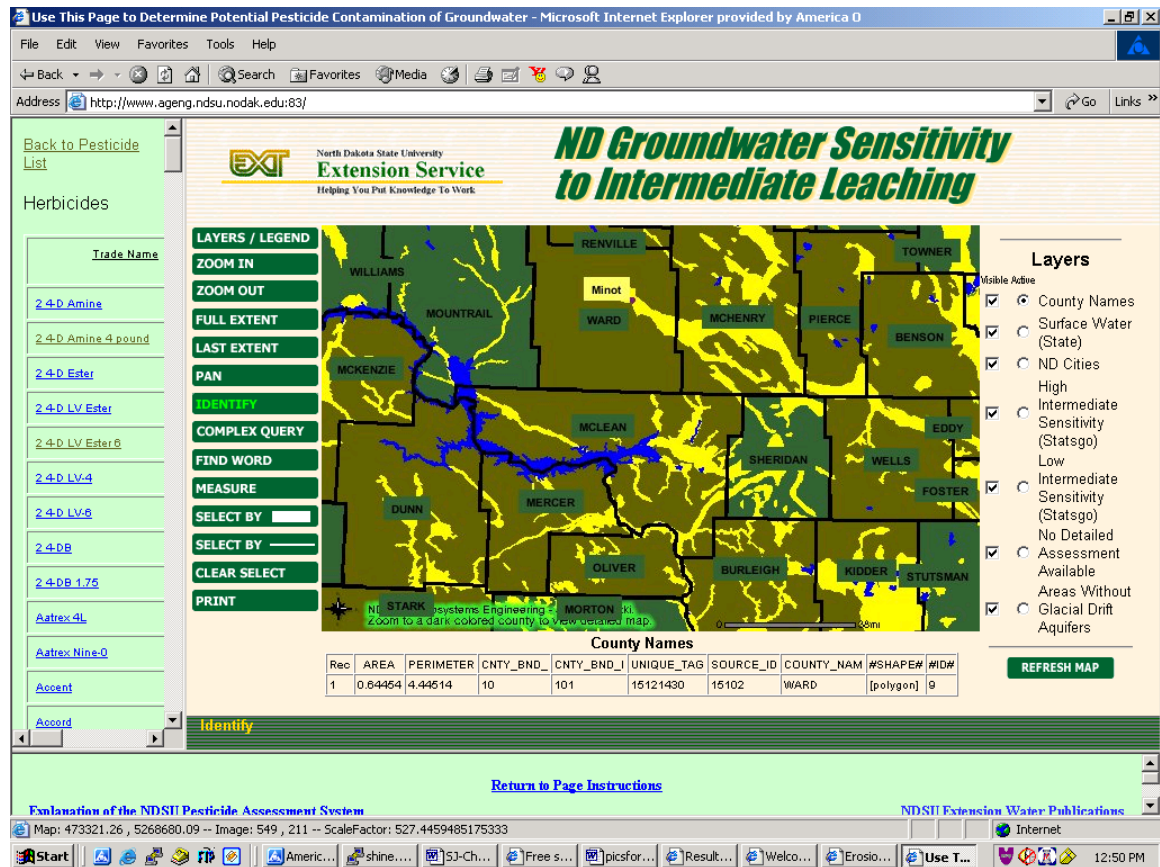


Figure 2.12. Information about the county where map is clicked

This site is a good example of the use of GIS and of the ArcIMS tool for the website development, but at the same time the information is restricted to the pesticides

and their effects. Also, once the information is found, as shown in Figure 2.12, nothing can be done with this information. This means by looking at the information in Figure 2.12, we cannot determine the usefulness of the information provided in numbers below the map. This must be extrapolated from that data! So, although these data are important, they are not presented in a manner making them immediately useable.

Also, the information presented is only information about the currently active layer, county names. To view the information about the other layers (see the list in the frame to the right of the map in Figure 2.12), the users have to switch back and forth between the active layers.

Another interesting site that uses ArcIMS for development is www.addboard15.sk.ca. The goal of the project is to develop improved resource information to assess local land and water issues [GISC02]. Live maps of the district are provided. This site promotes the discussion in Chapter 4.

This chapter provides some background on various systems that currently exist and the problems that these systems have. The next chapter presents a brief walkthrough of the ADSS.

CHAPTER 3

WALK THROUGH THE ADSS

The previous chapter gave us a brief idea about the issues involved with design of the ADSS. In discussing the development of the system, we take the outside-in approach moving from a high level view, which gives the reader an idea about how the system works, to a lower level, which explains the design and implementation details. This chapter provides a walkthrough of the system. The ADSS has currently been developed for Walton, Putnam, Broward, and Alachua counties of Florida using Florida Agroforestry Decision Support System (FADDS) as a guideline [ELLI01]. It was developed at Center for Subtropical Agroforestry (CSTAF), School of Forest Resources and Conservation (SFRC) at University of Florida. We use Alachua County as our example.

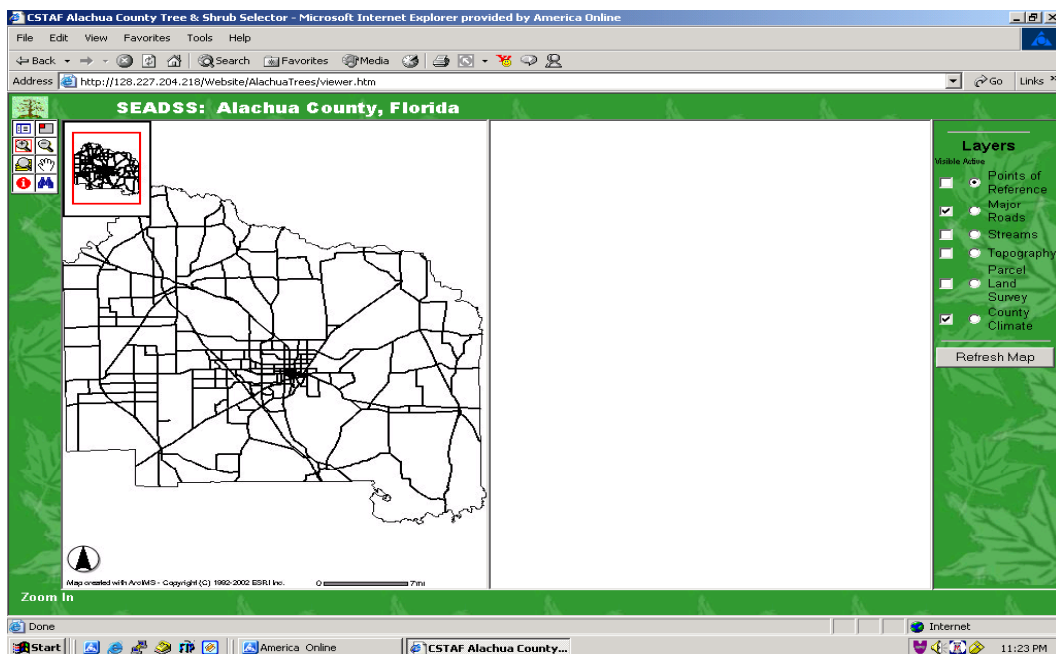


Figure 3.1. View of the ADSS with the overview map

Figure 3.1 shows the application when the user first types the website link in the browser. The toolbox to the extreme left is used to navigate through the map.

Icons and Their Functions

The tools shown in Figure 3.2 are explained below in row order. A small description of these icons is provided on “mouse over” when executing the application.









	Toggle between layer list and legend		Toggle for overview map
	Zoom in		Zoom out
	Zoom to full extent		Pan
	Identify		Search

Figure 3.2. All icons of the application

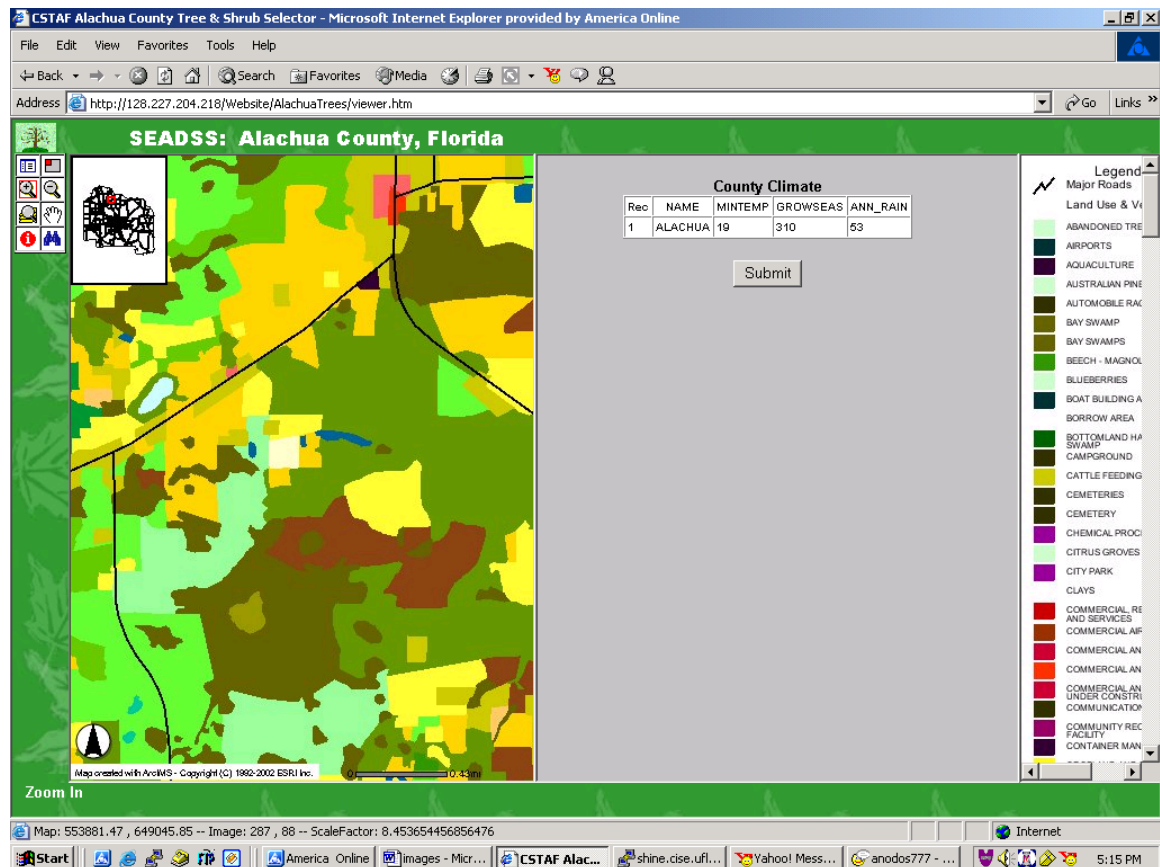


Figure 3.3. View of ADSS with Legend mode

These icons are:

- Toggle between layer list and legend. The extreme right of the map presents the default layer list. If the user is unfamiliar with the coloring scheme of the map, this toggle switch can be used to see the coloring scheme used. Figure 3.3 shows the map with the legend active.
- Toggle for overview map. In the left top corner of the map frame is a small reference map that provides an overview of the entire map when the user is at a specific location deep inside the map. This helps by giving the user a general idea of the location that he has selected. But if a user does not wish to see this reference map, he can switch to “only main map” mode. Figure 3.4 shows the ADSS without the overview map.

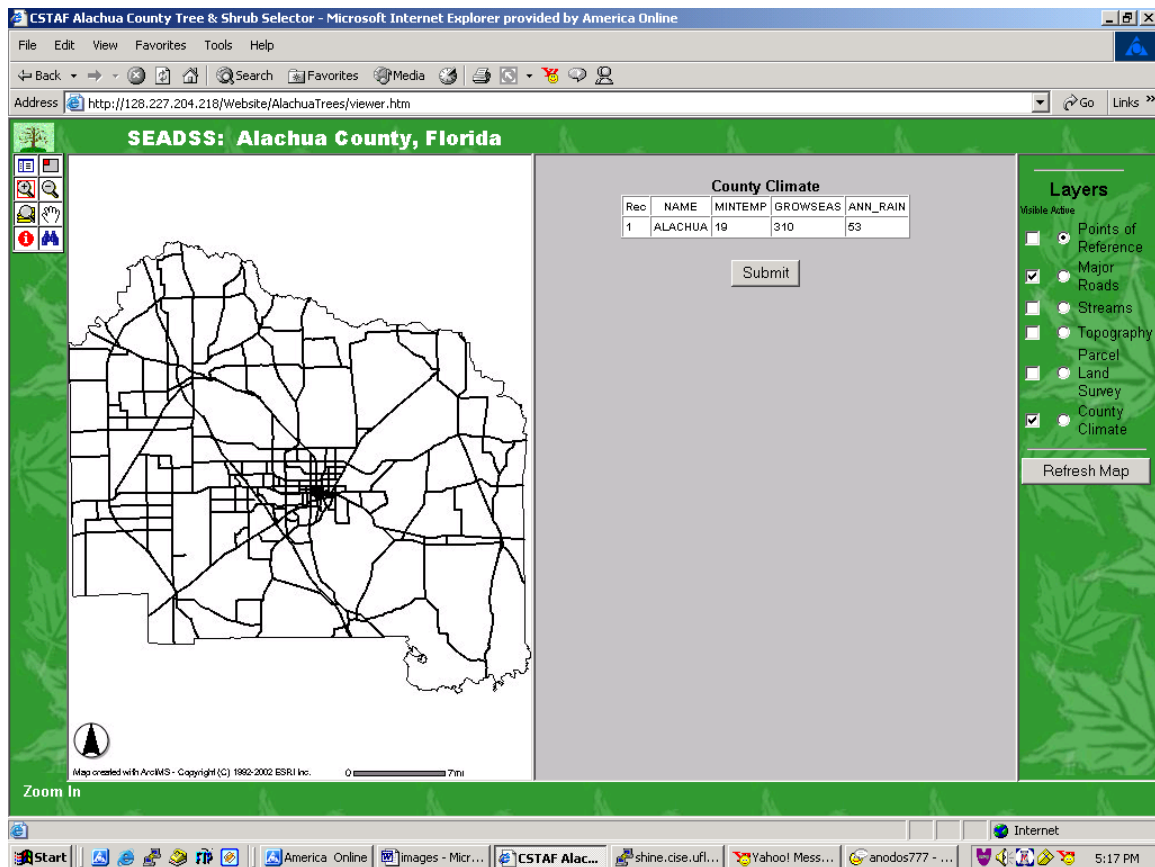


Figure 3.4. View of the ADSS without the overview map

- Zoom in. The magnifying glass with the “+” sign is used to zoom into an area or a point in the map. This icon is selected as the default button when the map loads, since the most likely action the user would perform upon viewing this page is clicking a known area on the map to see what happens. Figure 3.5 presents a zoomed in view of the map. As we can see, the zoomed in area is highlighted in red on the overview map to identify where the area shown in the larger map is roughly located.
- Zoom out. The magnifying glass with the “-” sign is used to zoom out of an area.

- Zoom to full extent. This icon is used to bring the map back to its original size.
- Pan. This icon is used to pan (i.e., move) around the map. The user uses this tool by clicking on the map and holding the mouse button down. They can then drag the map in any direction they wish. This helps the user find their specific region of interest.

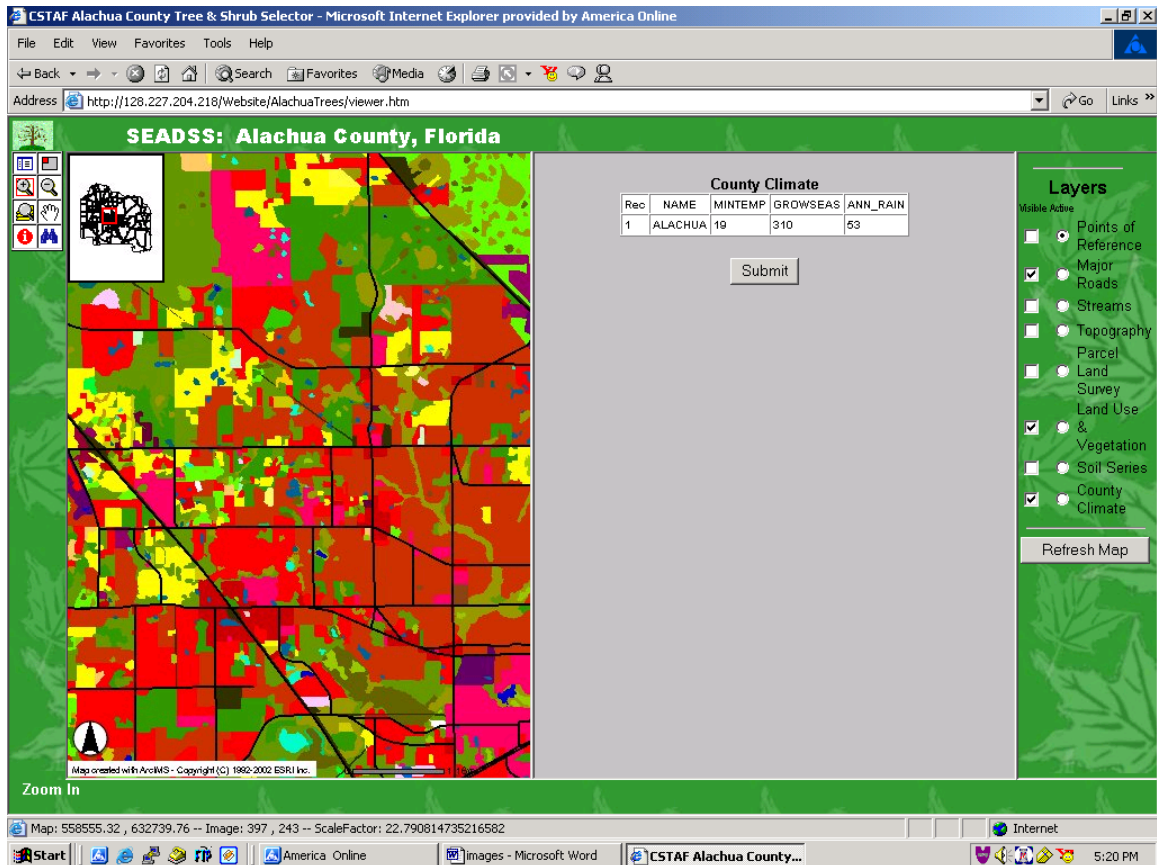


Figure 3.5. A zoomed in view of the ADSS

- Identify. This icon is used to obtain data about the selected region. When a user has zoomed into a particular region, they can click on the “i” icon and then select a feature on the map. Information about the select point is displayed on the right hand side of the screen. This information is saved according to the map’s georeferenced spatial features in each layer, so only one point on the map can be selected at a time. Figure 3.6 shows an example of using this “i” icon. The information displayed to the right of the map is the soil and climate information that is used for decision support in addition to land use and vegetation. This information is stored in the GIS in the form of spatial features. Each spatial feature represents a record. The record may belong to an area, in which case, it is called a polygon vector; in the form of a line, in which case, it is called a line vector; or a point, in which case, it is called a point vector. This is discussed in the next section of this chapter.

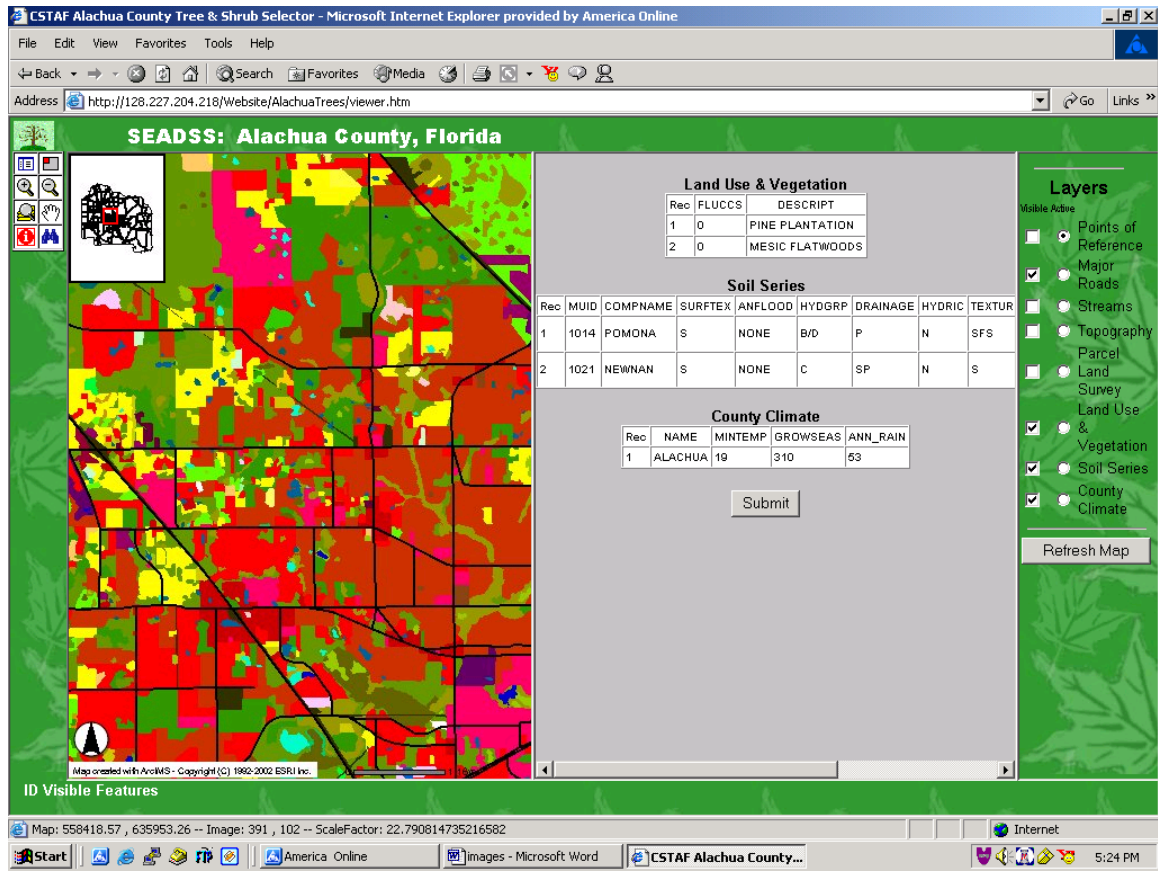


Figure 3.6. View of the ADSS with “i” selected

- Search. The binoculars image icon is used to find information on the map. Figure 3.7 shows the screenshot when a search string is entered. When a “Find String” button is clicked, we are presented a list of all records containing the string “RICHARD” within the active layer data table. See Figure 3.8 for this result. Since the active layer in Figure 3.7 is the “Parcel Land Survey,” only those records containing the string “RICHARD” are returned. To be able to see all regions in the map containing the string “RICHARD,” the map has been zoomed back to its original size. The yellow colored regions on the map are the regions matching the search criteria. But, if we have already zoomed into an area that we know is approximately the area that is owned by someone named Richard, we need not zoom back. If the area is found, it will be highlighted. Each parcel is numbered, so we can click on the numbers to zoom into a particular parcel. If we had checked the “Major Roads” radio button with search string “NEWELL,” all records related to major roads would be searched for that string. This is a powerful tool provided by ArcIMS. If a novice user wants to know areas close to Newell Drive and the plant information on these areas, they can search for the road and click “i” to get information on those areas. For example, if we decide we want to see Richard Carter’s parcel, we simply click on 10. This is shown in Figure 3.9. If we now click on “i” to get information about his parcel, this information is displayed on the right. The overview map shows us the approximate location of this parcel for verification.

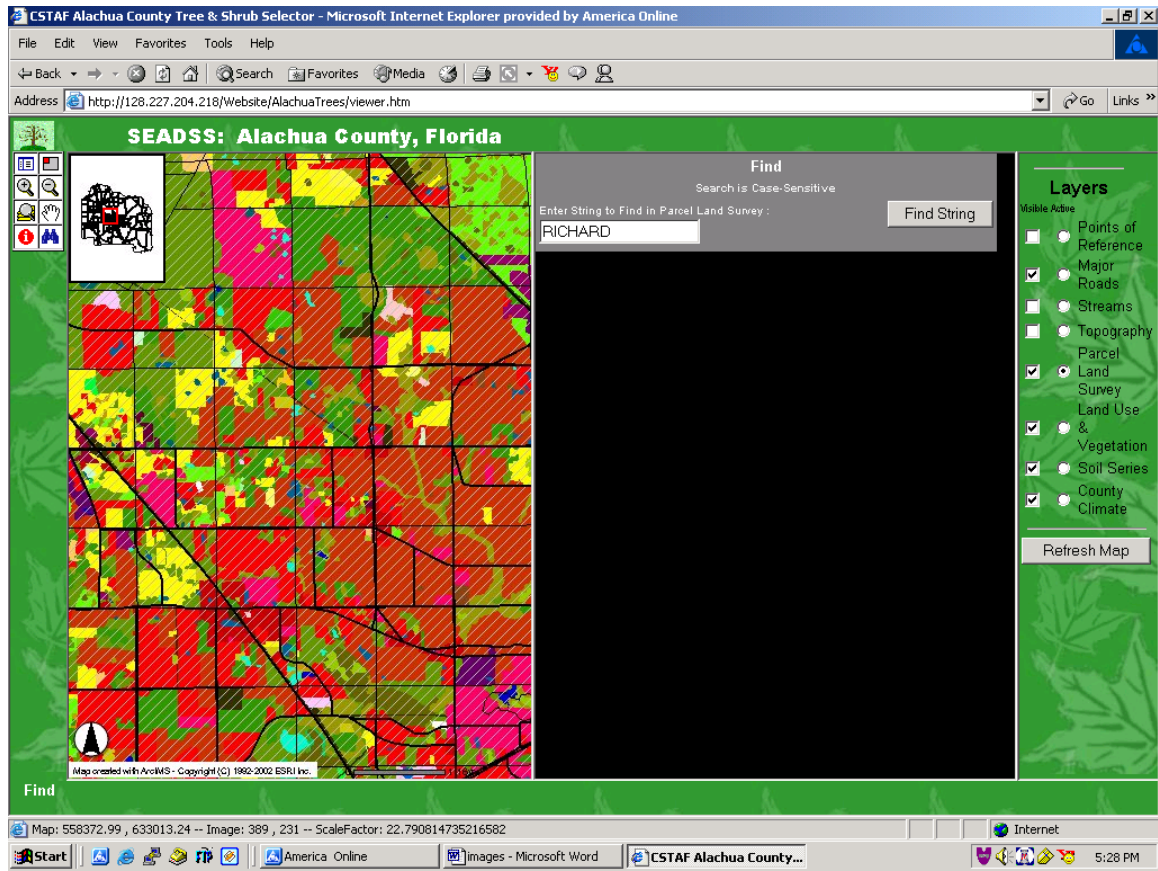


Figure 3.7. View of the ADSS with Search feature

As we can see, the toolbar is a useful feature of the ADSS. Note how the tools have been grouped together into a toolbar so that they do not confuse the user. Modifying the “viewer.html” file can change its position, but it has been placed in this particular position because it can only be used with the map frame. It is easier to select an icon on the left and click the area on its immediate right.

The placement of the overview map with the main map is an important feature. Users can become disoriented after going several levels deep. This overview map helps them determine where they are.

Irrespective of what information we obtain (i.e., a search string, a result of a search string, data layer information, or no information), it is always placed in the frame to the

right of the map. This makes it easier for the user to locate information and differentiate it from the other features on the page.

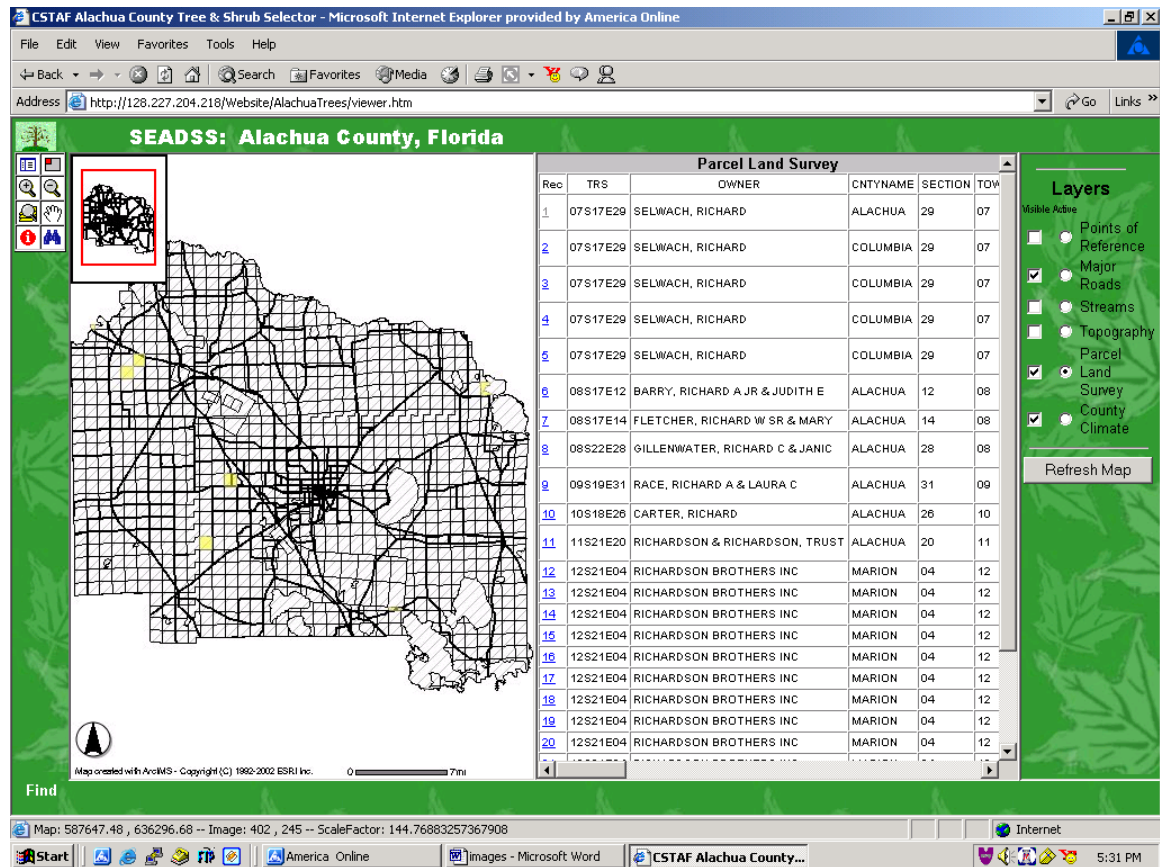


Figure 3.8. View of ADSS with search string “Richard”

The reason for grouping of checkboxes and radiobuttons is that all layers can have active and/or visible information. To present this information to the user in a compact fashion and to keep the page clean as much as possible, it has been grouped together. The placement of the layers on the extreme left would have made the user think that the layer information was related only to the map. Placing it between the map and the information frame would have confused them. Hence, it is placed on the right extreme to make the system easier to understand.

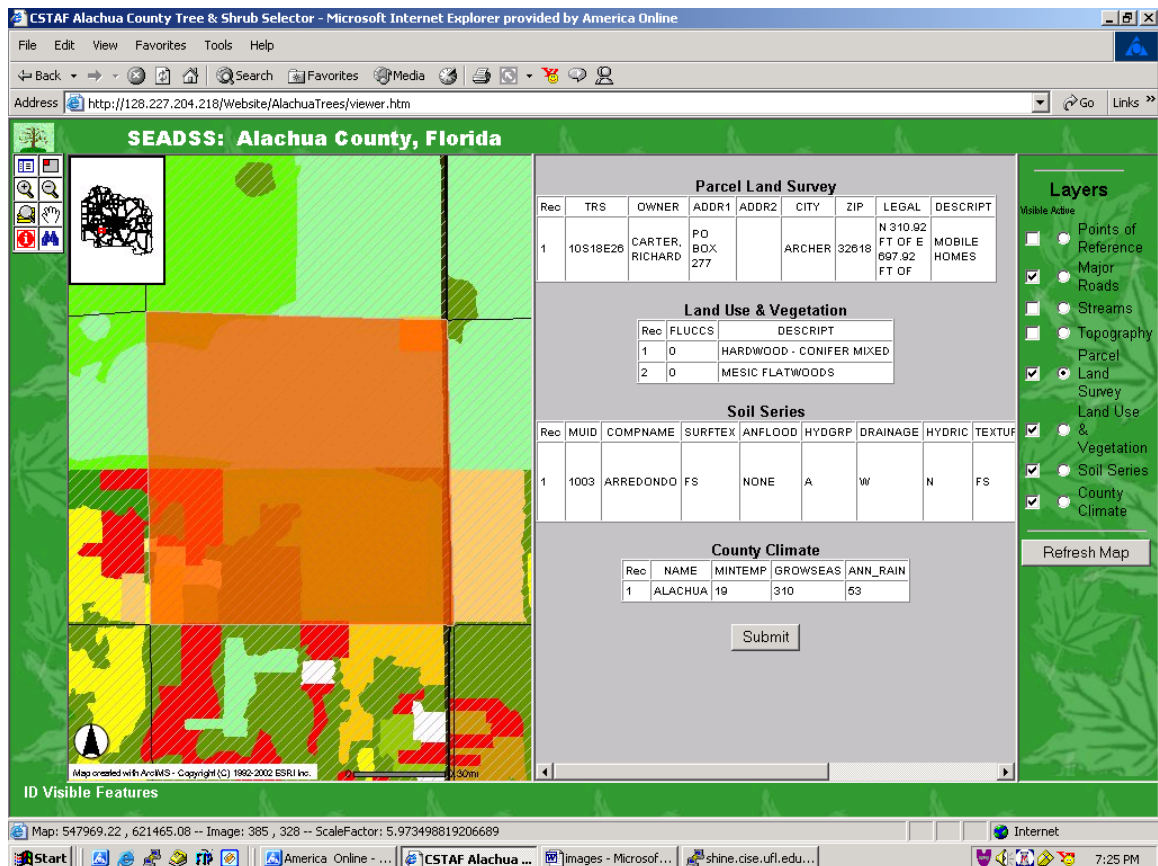


Figure 3.9. View of ADSS for Richard Carter's parcel

Layers and Their Functions

Let us now discuss the features on the layer list and their uses. The different types of layers can be explained by the functions they serve. The items in the list have two functions:

1. **Visible.** This checkbox list is used to make a feature visible on the map. The default features are set to major roads and county climate, so as to reduce the load time of the application and to make it easier for the user to find a general location on the map. But during the course of running the application, if the user decides that he wants to see the streams on the map, he checks the box next to streams and hits "Refresh Map" button below the features. This reloads the map making the streams visible. Every time the map is reloaded, we see a "Retrieving Map" progress bar over the map as shown in Figure 3.10. The progress bar is another useful feature of the ADSS. Users always prefer to know that some processing is taking place on such occasions rather than have to debate if the browser has crashed so the application should be closed, or wait because the connection is bad. Another important use of this feature is that visibility of a feature provides information about that feature in the frame to the right of the map.

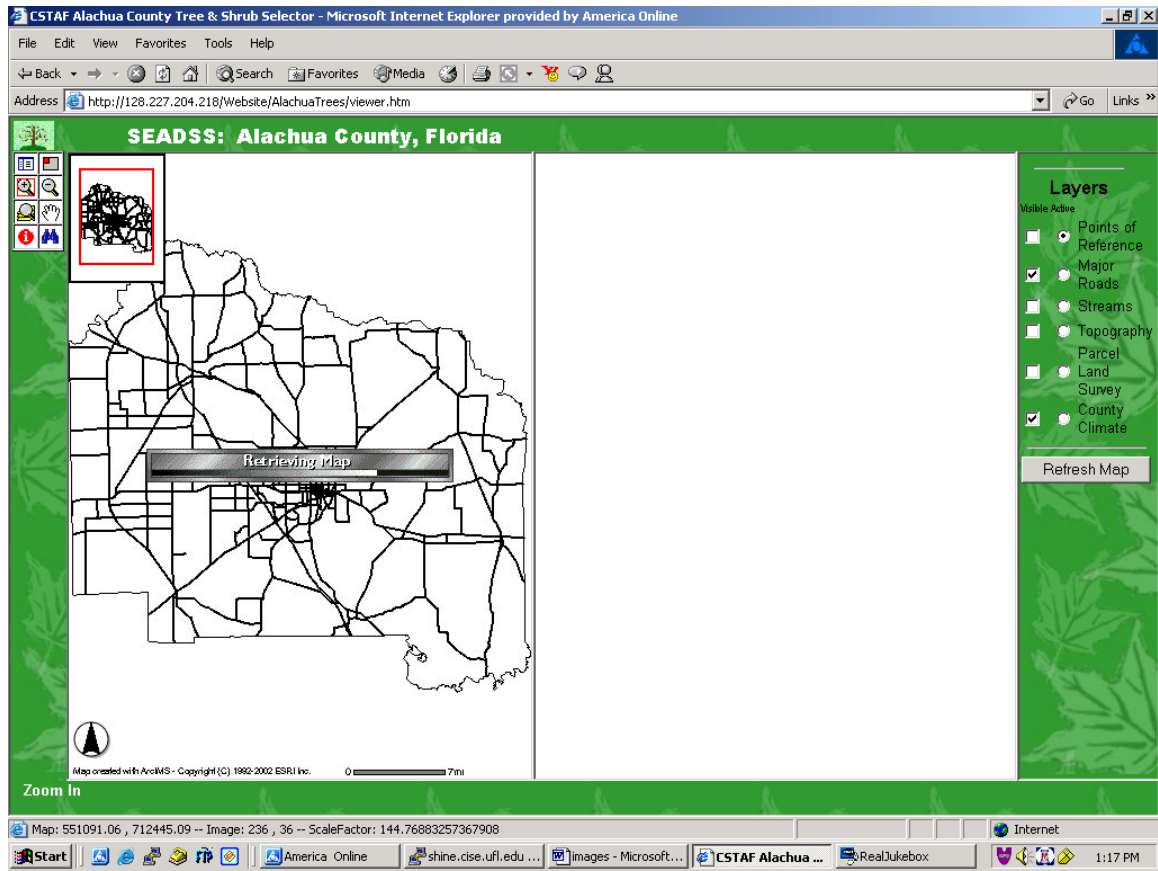


Figure 3.10. View of the ADSS when it is refreshing the map.

So, if streams are set to be visible and a user clicks on an area that is a stream, information about the stream is displayed. There are three types of visible layers. The first is composed of soil series, county climate, parcel land survey, and land use and vegetation information. The information about these layers is stored in the form of polygon vectors. The soil series layer provides information about the soil at some point. The county climate layer gives information about the climate of the county at all points. The parcel land survey divides the map into small parcels, approximately 300 square yards in area. This provides information about the parcel landowners. The land use and vegetation layer provides information about the kind of land, urban, agricultural, and others. These layers are always present at all points in the map. So, when they are checked as visible, information about them is always seen in the frame to the right of the map. Figures 3.4, 3.5, 3.6, and 3.9 show this information when one or more of these layers are checked. Major roads, streams, and topography form the second type of layers. The information about these is stored in the form of a line vector and is only available if the point clicked on the map happens to be on that line. So, if you click on a point that is not on a major road, information is not be available for display. The topography layer shows information if the point clicked is on an incline or at an elevation. The third type of layer is the points of reference. Information about this layer is stored in the form of point vectors. This layer shows small stars on the maps that can be used as

landmarks. Major roads layer shows information about a road, when a point on the major road is clicked. See Figure 3.11.

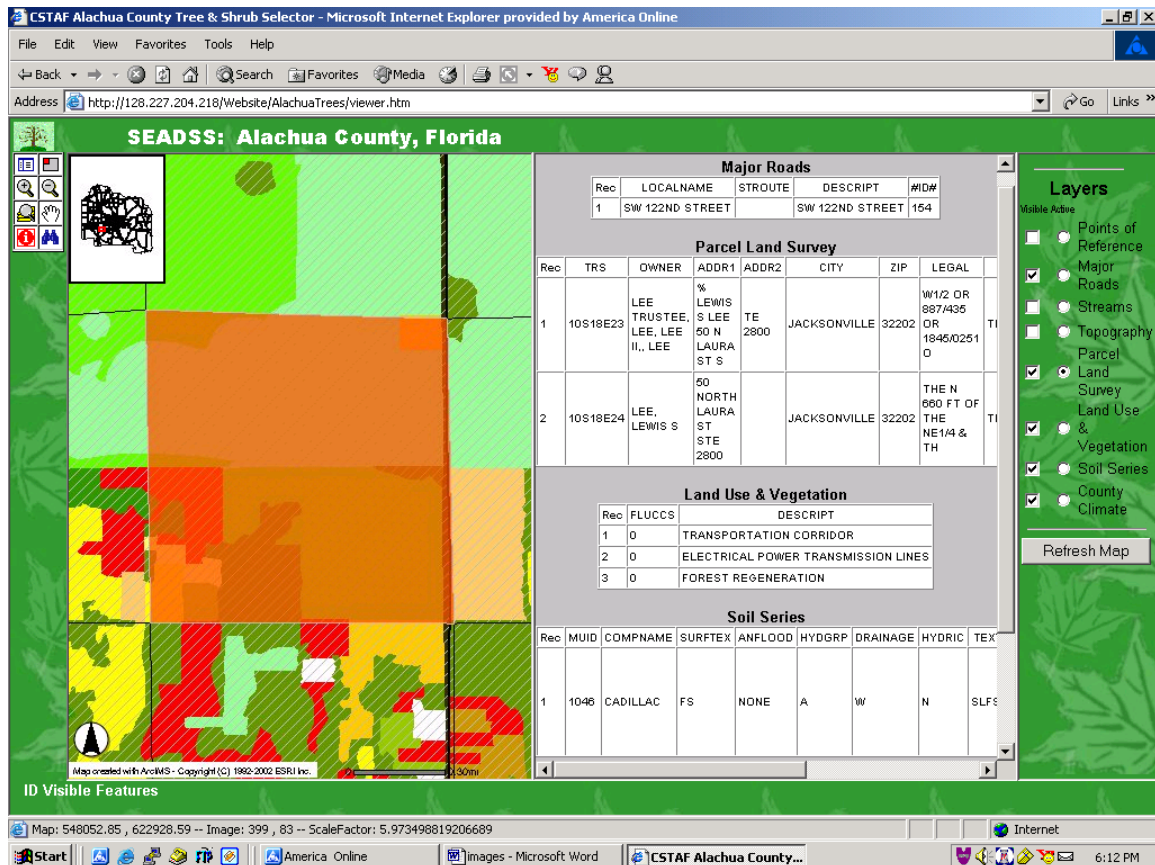


Figure 3.11. Information of ADSS when a major road is clicked

- Active. An active layer is used for the search icon. The search is performed for the layer that is currently active.

Information and Its Functions

Now, let us talk about the information presented in the frame to the right of the map. The ADSS is designed to help landowners, extension agents, and other users make decisions about the kind of trees and shrubs they would like to plant on their properties. To make these recommendations, we use the soils GIS data available at the GeoPlan center at the University of Florida and the county climate information. The NRCS soil survey data is converted to GIS data by GeoPlan.

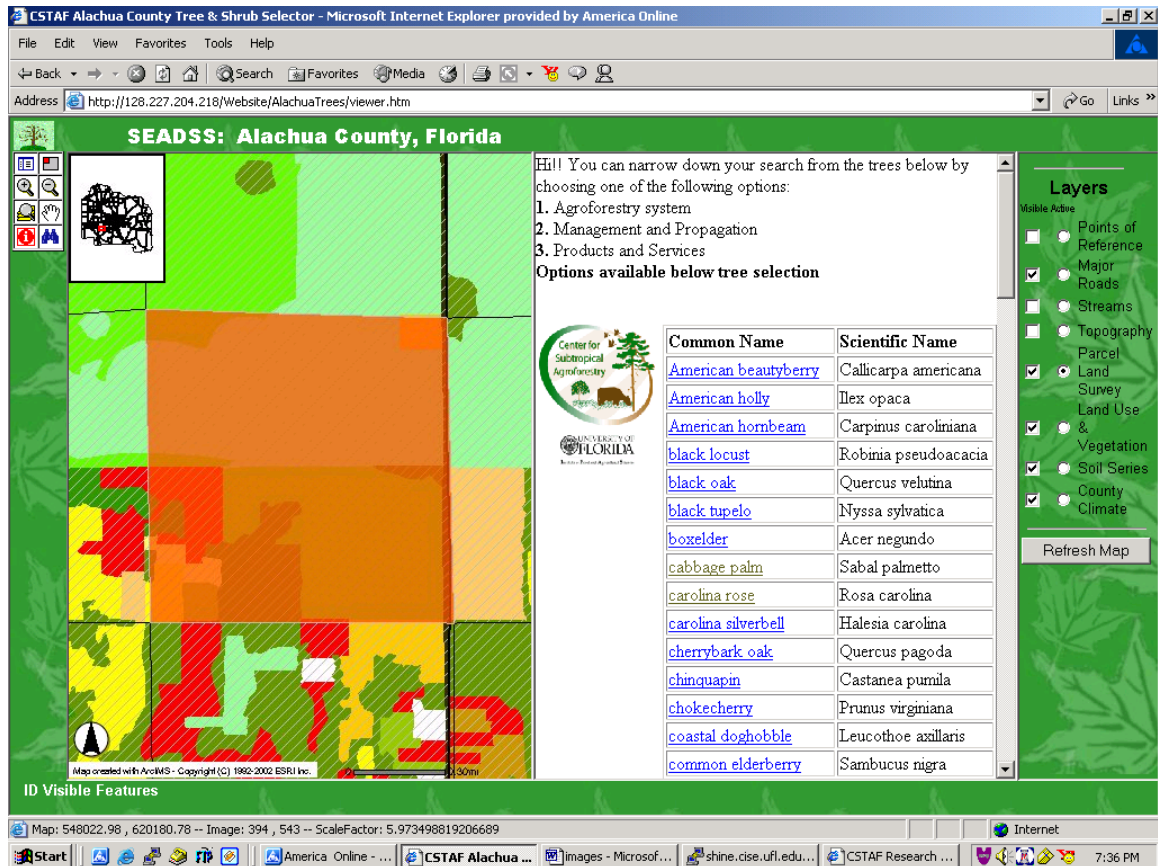


Figure 3.12. View of trees and shrubs selected on clicking “Submit”

The “Soil Series” layer information in Figure 3.9 is used to discover which trees are suitable for the existing soil type. At the bottom of the information frame is a “Submit” button. On clicking that button, we obtain a list of trees and shrubs that satisfy the soil conditions and climate conditions. Figure 3.12 shows the screenshot when the “Submit” button is selected. Note how the process has been automated so that the user does not have to know and input all this information for obtaining the list of plants.



Figure 3.13. View of the Tree Shrub database for “carolina rose”

The list in Figure 3.12 consists of the common names and scientific names of the trees and shrubs that can be grown at the point selected. Clicking on one of the hyperlinks obtains information about that tree in a new window. This information is general information about the tree from the Tree and Shrub database, which is discussed in the next chapter. Figure 3.13 shows the window that appears when “carolina rose” is selected. This window is a child window of the main application. The main application is not affected by this window. The user does not have to switch back and forth fifty times between selecting a point on the map and viewing information about fifty trees selected.

The hyperlinks on this page are links to the respective tables in the tree and shrub database. Clicking on any link allows viewing of the information about that tree or shrub.

For example, if you click on “Photos,” a set of links to photographs of carolina rose is displayed. This is illustrated in Figure 3.14.

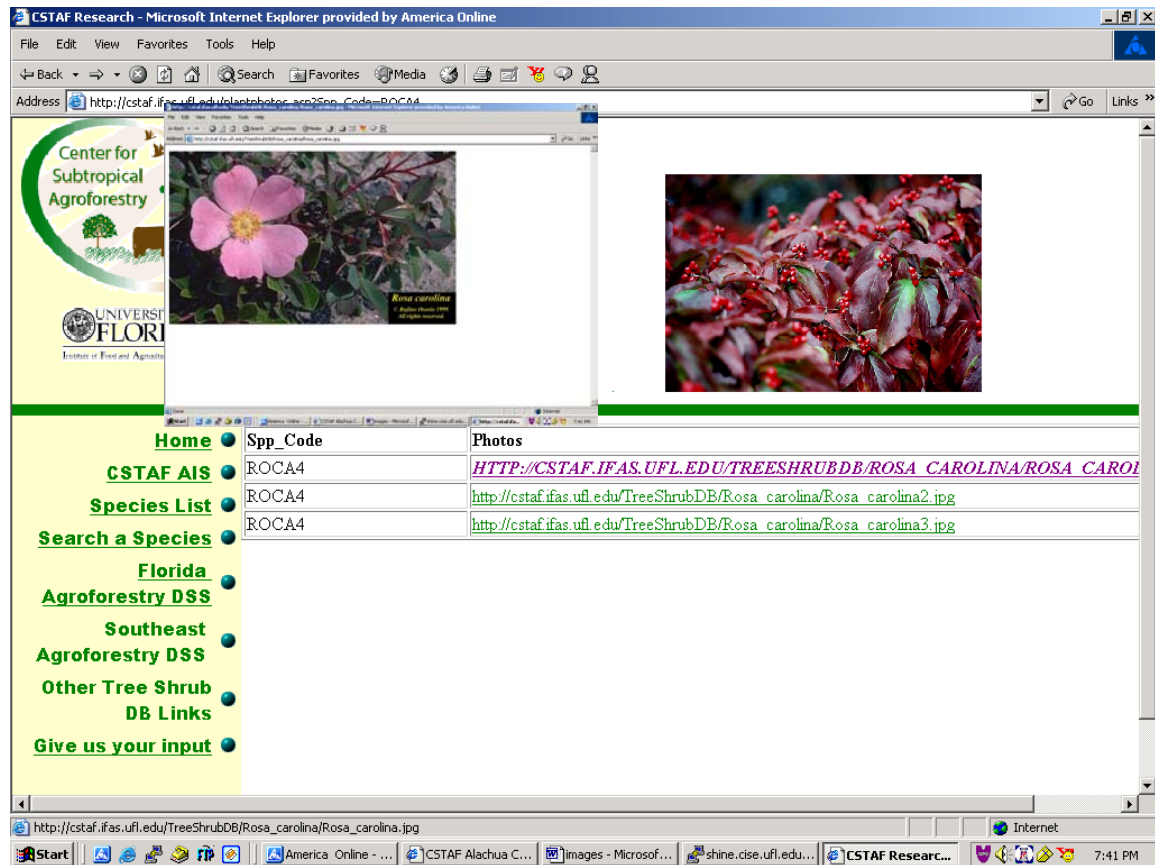


Figure 3.14. View of “carolina rose”

Similarly, upon selecting some other link, a different set of attributes is displayed. This is useful if the user just wants to see the properties of the trees and shrubs but some users like to perform a more specific search. A specific search is categorized into the agroforestry system, the management and propagation properties of trees and shrubs, and the products and services provided by trees and shrubs. A clear definition of all of the agroforestry systems is listed in Appendix B.

Let us consider an example. Suppose a user wants trees and shrubs that have alley cropping, propagation by bare roots, rapid growth, and wildlife value. This type of specific search is made possible by letting the user choose from the set of options found

on scrolling down the screen in Figure 3.12. The values mentioned above are highlighted in snapshots of the screen in Figures 3.15 and 3.16. Figure 3.15 shows the top half of this web page, while Figure 3.16 shows the bottom half.

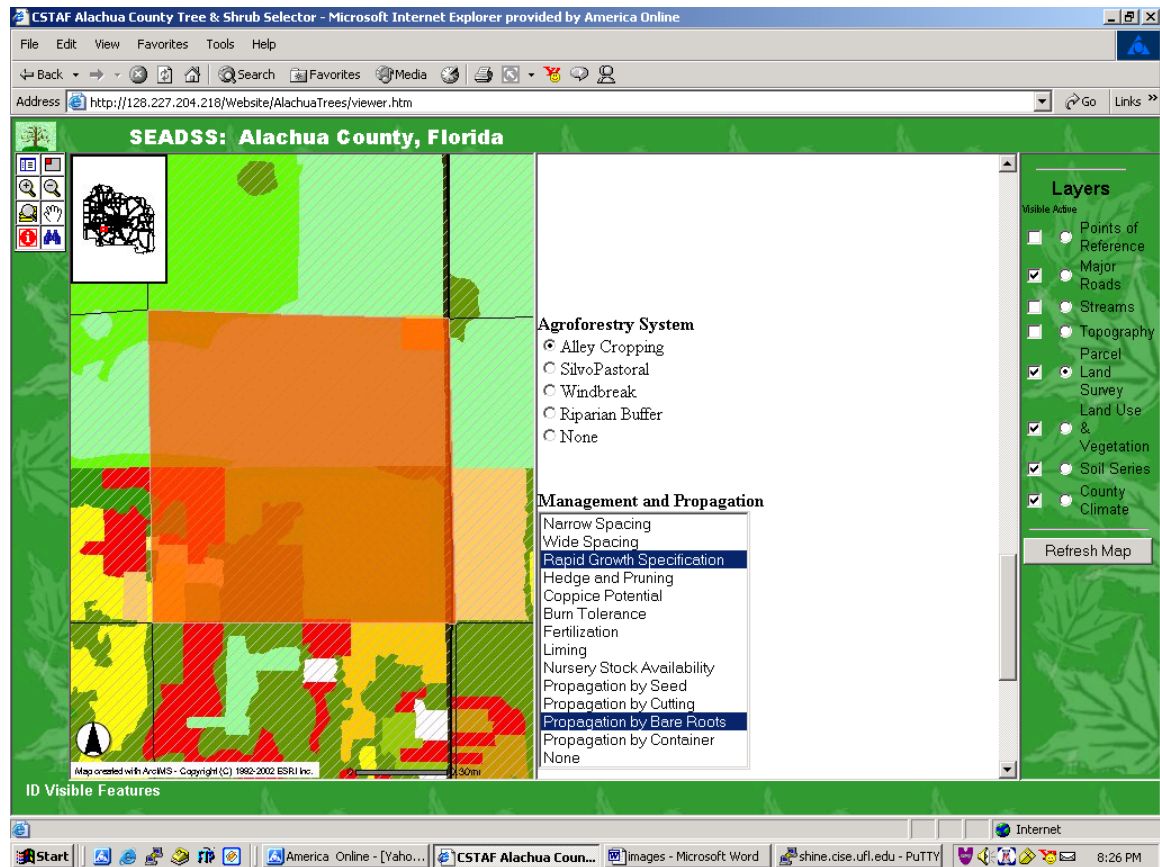


Figure 3.15. View of ADSS with Agroforestry System and Management Properties

Clicking the “Submit” button in Figure 3.16, results in a subset of the trees found in Figure 3.11 (i.e., those suitable for alley cropping, rapid growth, propagation by bare roots, and wildlife value). This subset is shown in Figure 3.17. As we can see, carolina rose and cabbage palm are eliminated due to this narrowing of choices.

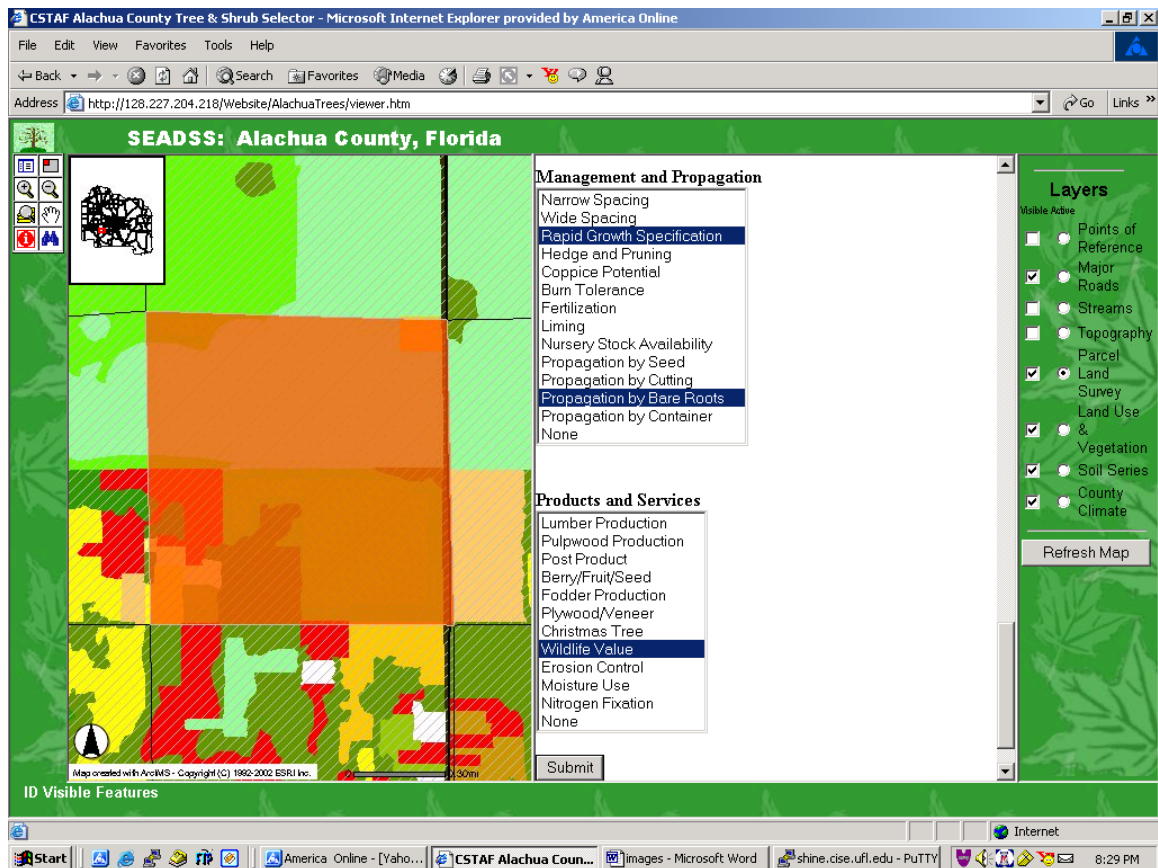


Figure 3.16. View of ADSS with Management and Product Services selected

To maintain consistency, the common names of the trees and shrubs are hyperlinked so users can still see the same properties of these trees and shrubs by clicking on the hyperlink. Even here, when the hyperlink is clicked, it opens a new window. So, the user can go through the entire list of trees. Of course, if each one of the trees would trigger a new window, it would be more confusing than useful for the user. To avoid this situation, a single child window takes care of displaying the information about trees. Each time a user clicks on a new tree, this new tree overwrites the information of the previous tree.

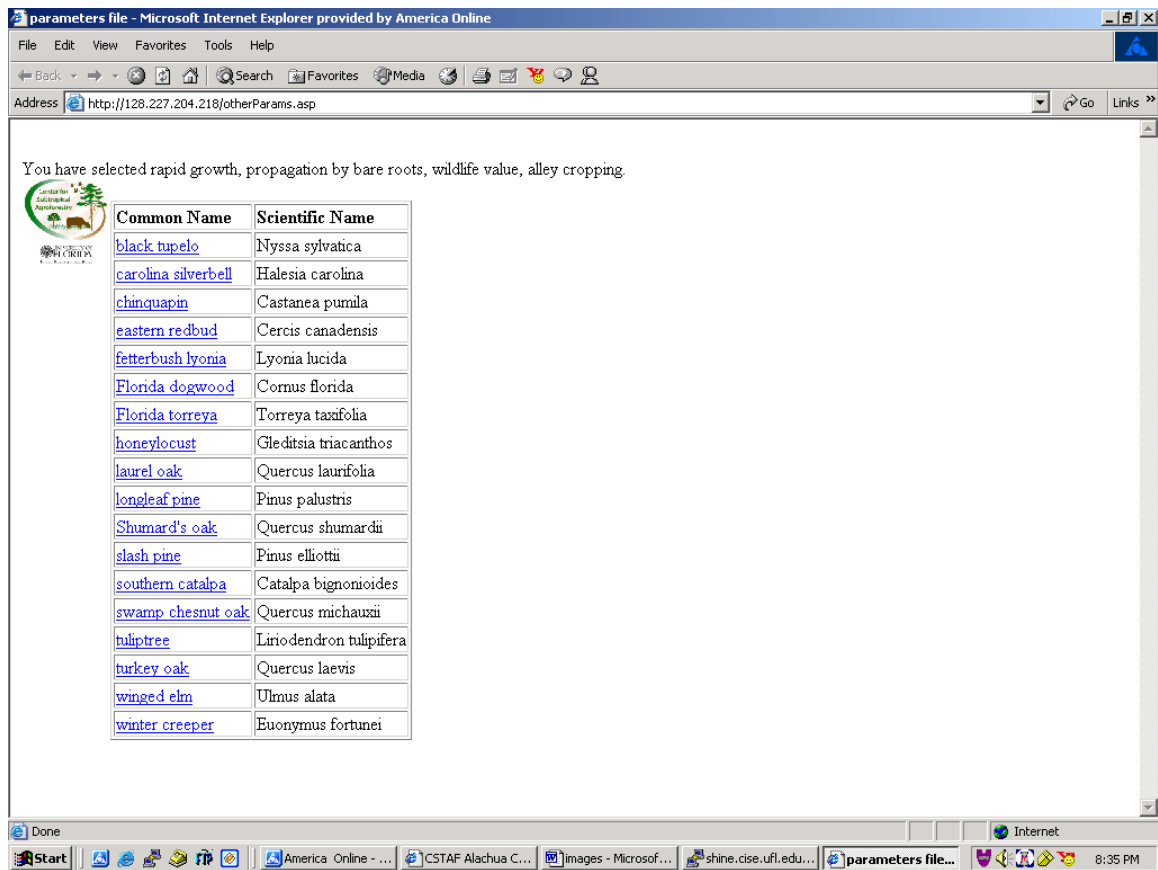


Figure 3.17. View of ADSS with the narrowed down properties satisfied

Conclusion

This chapter presented an overview of the operation of the ADSS. The next chapter discusses the design that was used to develop the ADSS.

CHAPTER 4

DESIGN OF THE ADSS

The previous chapter provided a brief walkthrough of the ADSS. To obtain the ADSS that we have seen in Chapter 3, we need a system that is complete, user friendly and time efficient. The CSTAF, SFRC at the University of Florida is currently working towards developing such a system. This chapter discusses the system design.

Issues

There are a number of issues that need to be considered when developing the ADSS. Each of these is discussed in the subsections below.

GIS

First and foremost, we need a reliable and accurate GIS from which we can collect soil information and other relevant data for decision purposes. This choice is critical because if the base is unstable, not much can be said about the precision of the ADSS.

Tools

Another important aspect is the choice of the tools that coordinate the mapping of images with attributes. There are a number of tools available that provide the attributes or properties of a region. But accuracy is an important factor driving this choice. We need a consistent, reliable tool that picks the correct GIS data for the selected point on a map.

Database

The data that we obtain from the GIS are used to retrieve valuable information about the trees and shrubs that can be planted in an area. This requires a rich database of trees and shrubs and their characteristics.

Interface

Another important facet that needs to be considered is the web application interface design. Research has been performed into what constitutes a good interface design. Areas of consideration for interface designing include precision, accuracy, communication of ideas to the end user, navigation abilities, consistency, required as opposed to unnecessary features, predictable behavior, web-application load time, and response time.

- Precision. Alan Cooper, in his book The Inmates Are Running the Asylum discusses how difficult it is to be able to satisfy all system requirements and at the same time to develop the application precisely as it was designed. He discusses this at length and concludes by saying “The end result is to have a program that does the right thing, and we are willing to accept some friction in the system to get it,” [COOP02, p. 129]. In our case, we have tried to make the system as precise as possible, which does result in some conflict with its usability. For example, in our case the application is tested to work for Internet Explorer and AOL browsers. It might or might not work with other browsers. But taking into account the economic considerations, it is not all that bad!
- Accuracy. The ADSS is also a GIS. Its geographical data are accurate as they are taken from reliable sources. The information about the TreeShrub database is from a variety of sources, which might have other drawbacks, but they are nevertheless, all accurate. If the data on which the system is based are accurate, then the overall accuracy of the system depends on its implementation and the queries. These have been verified and tested for various counties.
- Communication of ideas to the end user and navigation abilities. “Communications can be precise and exacting while still being tragically wrong” [COOP02, p. 4]. A careful choice of icons was made while designing the ArcIMS tool, which makes the interface easy to understand. The soil and the climate information is insufficient for the user to make a decision about which trees and shrubs to plant. A step-by-step process (which does not require the human remember values, enter data into text fields, and which provides enough automation) makes navigation easier for the user and provides good communication [SPOL01].
- Consistency. The user always likes to see consistency over a series of web pages within an application. This allows the user concentrate on the important information, rather than having to search for the placement of tools or information on the page, or look for information on the page. We have tried to make the pages look as identical as possible by using this characteristic wisely.
- Features. “Sometimes features are needed to reach goals, but more often than not, they merely confuse users and get in the way of allowing them to get their work

done”[COOP02, p. 47]. Sometimes it is a gamble deciding which features should be added to a system, but developing a brief flowchart showing the step-by-step functioning of the system, usually helps clarify these doubts. Features like being able to see the map in shades of black and white rather than color might be nice feature to have, but are unnecessary! On the other hand, not having a zooming feature available would be unwelcome.

- Predictable behavior. Sometimes, poorly written scripts in web applications cause the browser to crash, or images not to be shown. Care was taken in developing the ADSS to make its behavior as predictable as possible. The user does not have to install any software to be able to view the information. If the user does not select any products and services, management and propagation properties, and agroforestry systems, the information is still displayed to the user letting him know that he has not selected anything. If the user tries to select a region on the map when the map is being retrieved, a popup window lets them know that the previous request of map retrieval is still being processed. If the user performs a search for an active layer that is not visible, a popup window tells them that the layer is not visible on the map.
- Web application load time. Users become frustrated with applications that take a long time to load [SPOL01]. For example, in Chapter 2 we mentioned the project that develops improved resource information to assess local land and water issues. This application was mentioned because although it was one of the GIS applications for display, it could not be seen because it did not load even after waiting for thirty minutes! The load time of a GIS usually is increased because of the different layers of information that need to be added to the map on its initial load. Even when using a fast connection and the right tools to see the application, users are impatient. ADSS takes this into consideration and displays only the skeleton of the county map during the initial load. Two reasons exist. The user does not have a long wait for the initial system and the user will almost certainly zoom into an area before trying to get information about it! The loading of the soil information layers can take place during that time, when a smaller region is being considered.
- Web-application response time. More frustrating than the initial load time is a long response time [SHNE93]. When a user clicks “Submit” and must wait excessively to see the effects because the application is taking too much processing time, they certainly will not come back to that website. The ADSS makes careful use of scripts can avoid this problem.

Now that we have seen the issues involved with designing the ADSS, let us examine the approach taken in designing the system.

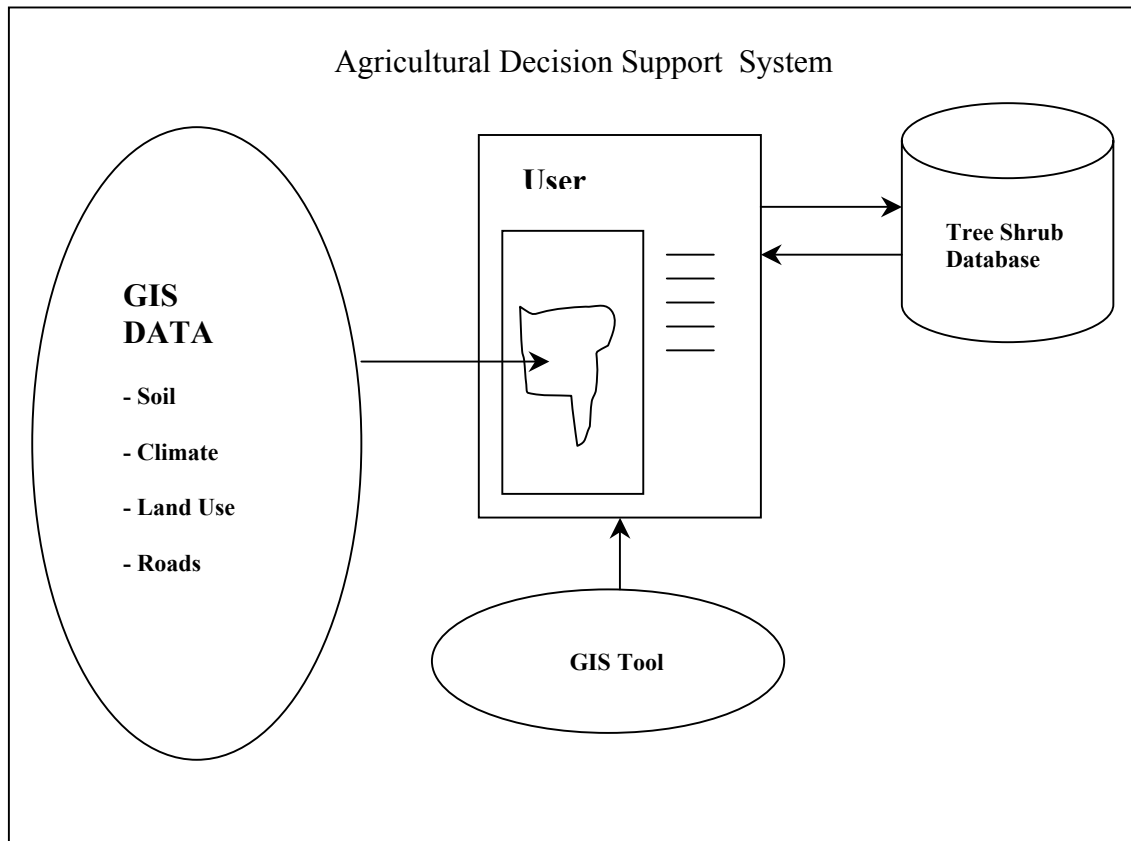


Figure 4.1. Overview of the system

Figure 4.1. provides a brief overview of what is required of the system. We discuss our design by dividing it into three parts.

GIS Data Design

The GIS data are the data related to the soil type and the climate of a region. These include attributes of the soil and climate that help determine the trees and shrubs that can be planted in a specific region. A few important attributes that need to be considered in this decision are the pH, salinity, drainage, hydric content, and annual flooding of the soil, and minimum temperature tolerance, annual rainfall, and growing season climate characteristics.

pH

The pH value of the soil identifies the acidic or alkaline state of the soil, which depends on the concentration of the hydrogen ion” [ROWL01]. The growth of trees and shrubs is highly dependant on the pH range of the soil in which they are planted. Some trees and shrubs are known to handle a wide range of pH. Such trees can be planted anywhere, provided the other parameters favor their growth. But many trees and shrubs that are strongly acidic in nature do not blend well in alkaline soil environments and vice versa, thereby making soil pH value a very important factor in decision making.

Salinity

Salinity is a measure of the total soluble salts in the soil [VROS02]. A highly saline soil can have salts in such abundance that they form a layer over the surface of the soil. The lower the soil salinity, the safer it is for planting purposes. Only trees and shrubs that are tolerant to high salinity conditions should be planted in such areas.

Drainage

Drainage is defined as the management of excess water on the land or in the soil [ANDE02]. Excessive moisture at the surface of the soil causes problems including insect infestation, delays the growing process of the plant, and increases in the subsurface moisture. Subsurface moisture deters the flow of oxygen to the roots, breeds toxicity into the plant, and reduces soil aeration and soil strength. Soils with poor or no drainage should only be used for planting trees and shrubs that are resistant to such effects or are tolerant of such problems.

Hydric Content and Annual Flooding

Another important factor in the selection of trees and shrubs is the hydric value of the soil. Hydric soil is a soil formed under conditions of saturation, flooding, or ponding

for a long enough period during the growing season to develop anaerobic conditions in its upper layer [WHIT00]. As a result of the large water content in the soil, it contains less diffused oxygen. This deters the growth of trees and shrubs that need large amounts of oxygen for survival.

Apart from the soil type, a crucial consideration for ensuring good growth of the trees and shrubs is climate. Important parameters that determine the climate of a region are minimum temperature tolerance, annual rainfall, and growing season.

Minimum Temperature Tolerance

The soil temperature changes with the climate of the environment. Trees do better if their minimum temperature tolerance is lesser than that of the soil.

Annual Rainfall

To help the plant survive extreme changes in water supply, without having to deal with irrigation and related issues, it is recommended that plants grown in a soil should have minimum precipitation value less than or equal to the annual rainfall of the region. The plants then avoid dying if there is lesser or no rainfall in region. To avoid plants from dying due to excessive water supply (i.e., flooding) we also check to see if the maximum precipitation value of the plant is greater than or equal to the annual rainfall of the region.

Growing Season

The number of frost free days, on an annual basis, required by a species of plants, is a good indicator of a region in which it can grow. It is always better if the number of frost free days that the plant requires is less than or equal to the growing season in the region.

The GIS data that we need must contain the above attributes to make the decision process reliable and accurate. The GeoPlan Center at the University of Florida collects these data and has developed a database including soils on a county basis. The data

ranges from points of references, to major roads, soil attributes, and climate. We have chosen this database because of its rich usability.

Tree Shrub Database

The second component is the collection of known trees and shrubs. Trees and shrubs have certain attributes that need to be checked against the soil type. Users often like to have a summarized view of their selection. For this, we need to design a database that has complete tree and shrub information and has adequate queries that can be performed on its tables. Trees and shrub information is categorized as:

- **Plant Description.** The “Plant Description” table contains attributes describing the appearance of the trees and shrubs, including the height, foliage texture, flower properties, fruit properties, branching, and crown properties. This information is mainly derived from the NRCS website.
- **Ecology Site Adaptation.** The “Ecology Site Adaptation” table contains attributes related to the ecological tolerances where the plant is found, the kind of environment where the plant grows well, the kind of soils it can tolerate, pH value, and other tolerance properties. This information is derived from the IFAS website and documents, and the NRCS website.
- **Management and Propagation.** The “MgmtPropagation” table contains the various ways in which the trees and shrubs can be propagated, the pruning requirements, hedging requirements, seed dormancy information, and pest resistance information. This table contains needed information concerning the plant’s maintenance. This information is derived mainly from the NRCS website.
- **Product Services.** The “ProductServices” table contains the information regarding whether or not the tree can be used for lumber production, for landscape ornamentals, for grazing by animals, eating by humans, and other related uses. This information is also mainly derived from the NRCS website.
- **Species.** The “Species ID” table contains the scientific name, the common name, and the family to which the plant belongs. It also specifies a code called the Spp_code that is unique to each tree or shrub. This information is derived from the NRCS website.
- **Documents.** The “Documents” table contains links to the respective NRCS and IFAS documents. It acts as a measure of verification for skeptical users.

- Photos. The “Photos” table contains numerous pictures of the tree or shrub. Sources of this data mainly include the NRCS and USF websites.

The database is developed using MS Access. The tables and their attributes can be viewed in Appendix A.

Interface

The third part of the system is the interface design. Meriam Webster’s Dictionary defines an interface as “the place at which independent and often unrelated systems meet and act on or communicate with each other” [MERR02]. The interface allows interaction between users and the system when performing decision making. Since, the interface is the only way an end user can access the system, we must take care to not only make the task easy for the user but also ensure that the user cannot modify the data. Much research and literature identifies what constitutes a good interface. Some important factors that need to be considered for web interface design have been previously discussed.

Jeff Johnson’s book, GUI Bloopers Don’ts and Do’s for Software Developers and Web Designers, suggests many interesting do’s and don’ts of interface design. We have used the following design tips in the interface design:

- “Focus on the users and their tasks, not the technology” [JOHN00, p. 10]. This involves answering questions like for whom is this application written, for what purpose is it written, what are the skills of the user, what is the users’ preferred way of looking at such an application, and do not complicate users’ task. The application is written taking into account an average users’ application navigation skill set.
- “Software should be designed neither for users nor by them, but with them” [JOHN00, p. 13]. It is of ultimate importance that the user has a hundred percent satisfaction after using a product. We constantly involved extension agents and land owners, who constitute a majority of our application users, from the early design state.
- Use users’ vocabulary. Users like to see meaningful terms in an application. Complicated keys and instructions frustrate them. It is a good practice to use appropriate images as buttons, for example, to facilitate the users’ understanding.

Back buttons do not always take the user to the most recent previous page. They should be used with caution. Ambiguity of instructions does not fit into the users' vocabulary and skill set. It is always better to look upon the user as a novice computer user or a computer illiterate. We use unambiguous terms where text is concerned and easy to understand images for buttons.

- Be consistent in presentation. A related term that can be used to describe this is preserving display inertia. It always helps if similarity in looks is maintained throughout the application. This is important because once the user is familiar with the way the application looks, he can concentrate his attention on other aspects of the application. A problem that arises due to inconsistency in an application is naïve users discarding a new window as a pop-up advertisement when it is part of the application and later complaining that the window just did not show up! But making an application pop new windows for every link (so it is always consistent) could lead to redundancy of information and an increased load time.
- Perform testing. Testing is a task that needs to be done before, during, and after writing the application. It is always a good practice to verify and validate the development process. Various forms of testing were performed on the ADSS. We performed informal testing where the users of the system were asked for what they would use the system, whether the ADSS satisfied their requirements after it was developed, did they need any additional or fewer features while the ADSS was being developed. Formal testing included running queries where expected results were compared to actual results.
- Use meaningful tools. Radio buttons should be used only when one of the given set of options is allowed. Checkboxes should be used when any number of options within a given set can be chosen. Drop down boxes can be used in place of radio buttons if screen space is a problem, but it is recommended that in such cases there is a default option. Multiple choice drop down boxes can be used in place of checkboxes. Graphical buttons should be self explanatory. All tools that are mentioned were used appropriately in the ADSS. No tools perform duplicated function.
- Let the user see only what he is supposed to see: no more and no less. The ADSS is solely designed for the purpose of aiding users with the decision making process for planting trees and shrubs. If the application is designed in the right way, no human keyboard intervention should be required for this task. This can be accomplished by eliminating text boxes or text fields for queries wherever possible. The only place that a user is allowed to enter anything in our application is in the query by owner name.
- Minimize highlighting. Highlighting has a prominent side effect. It distracts the user from other important information on the page. So, highlighting should be minimized as far as possible.

- Differentiate between visited and unvisited links. Users always like the application to remember what links they visited earlier during their search process.
- Use progress bars. Since the ADSS uses maps extensively, which take a little more time to load, we use a progress bar while the map is being retrieved to let the user know that the application is retrieving information.
- Provide error messages only where necessary. Unexpected error messages intimidate the user. They should be used only when it is necessary. The same is true for pop-up windows.
- Avoid deep leveling of pages. By the time the user is four levels deep, he forgets why he is there and for what he is there. The ADSS application is at most three levels deep.

This chapter has provided an overview of the design decisions used in implementing the ADSS. In Chapter 5, we examine the implementation details of the system.

CHAPTER 5 IMPLEMENTATION DETAILS

To implement the design discussed in the previous chapter, we need an appropriate tool for the interface. This tool must be able to location specific soil and climate information from the point selected on the map, interact with the TreeShrub database obtaining the set of trees and shrubs that can be planted in that location, return those results to the user, ask the user if he wants to further narrow the search, give him appropriate options to do so, and return the set of trees and shrubs that satisfy the results. This chapter is divided into sections that describe how each of the above actions is implemented what tools, database, and language are used.

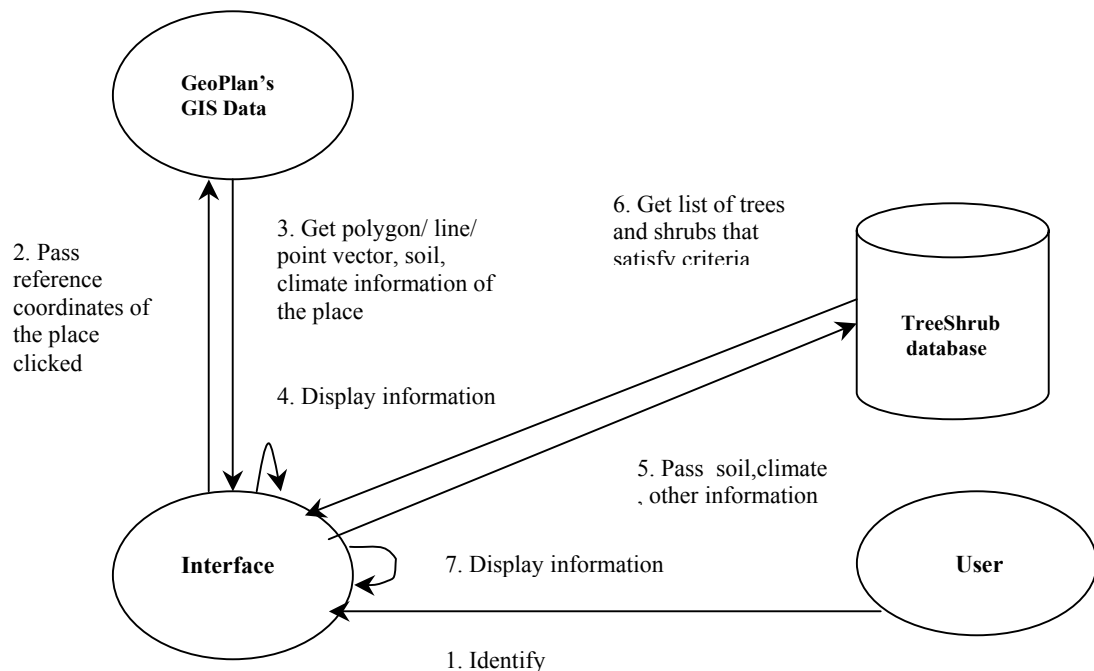


Figure 5.1. Working of the ADSS

Figure 5.1 shows the working of the system. When the user clicks “identify,” the reference coordinates of the point clicked are passed to the dbf file compiled by GeoPlan. The corresponding record belonging to the coordinates is returned to the interface. The ArcIMS tool has an abundance of icons including ones we have used in the toolbar so, it is used to create the interface [ARCI02b]. Each of the icons have their own javascript files. If any information related to the icon needs to be changed, these files have to be modified. Most records of GIS data have close to fifty fields for soil information and climate. Not all the fields are important for tree shrub selection. So, we modify the display file, to let the user see only information of his interest. This information is passed as parameters to the TreeShrub database. Connection to the database is via another file called the dbConnect.asp file. This component is shown in Figure 5.2.

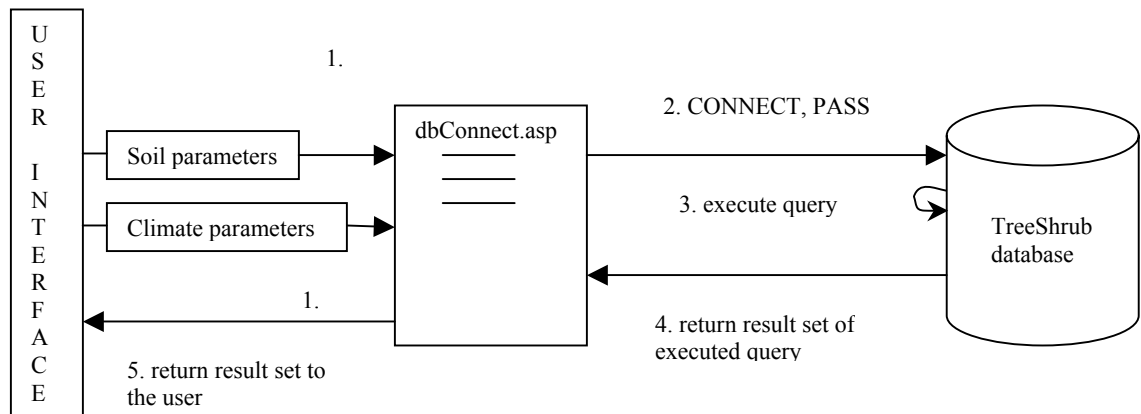


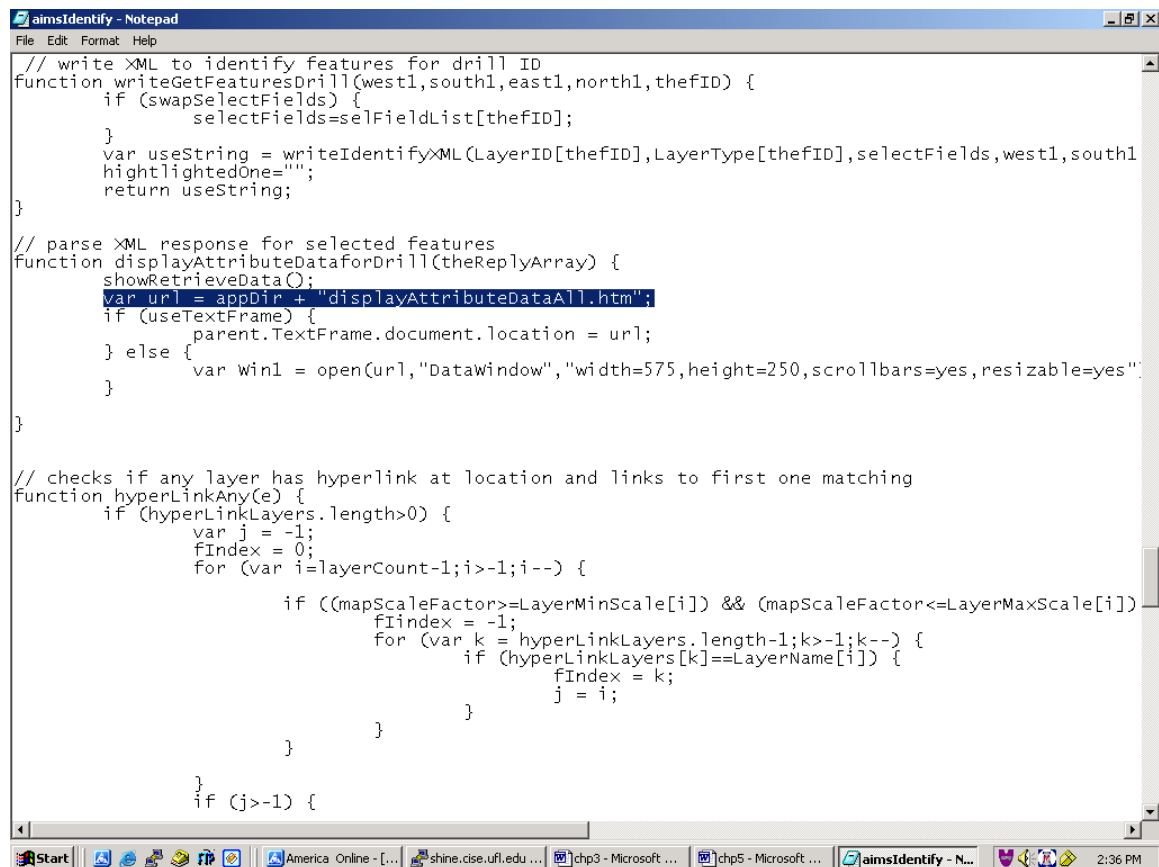
Figure 5.2. Working of dbConnect.asp

Getting Location Specific Information

The tool used to implement the interface is called ArcIMS, which is an ESRI product used to publish websites. It can be considered an Internet solution for GIS online. ArcIMS takes information about maps in the form of axl files. These files contain the map image, or as they call it shape information, in the form of shp files and dbf files

containing soil data and other data about these shapes. When a user zooms into a region by clicking a point on the map, the point is converted to a smaller scale view of the map.

When a user clicks “i” (i.e., “identify”) on a point in this polygon, the data about the coordinates of this point are extracted from the dbf file. This dbf file loads the information for this set of coordinates and displays it to the user. Now, we need only the specific information that is used for the decision process about the soil, major roads, streams, topography, and climate. There is more information in the records available for these, but since it is not useful for the selection process, display of this information would be confusing to the user. What is done to avoid this problem is modification of the aimsIdentify.js file [ARCI02b]. The ArcIMS file for the identify icon is a javascript file. This file is responsible for display of information to the user when the “i” icon is clicked.



```

// write XML to identify features for drill ID
function writeGetFeaturesDrill(west1,south1,east1,north1,theID) {
    if (swapSelectFields) {
        selectFields=selFieldList[theID];
    }
    var useString = writeIdentifyXML(LayerID[theID],LayerType[theID],selectFields,west1,south1,
    highlightedOne="");
    return useString;
}

// parse XML response for selected features
function displayAttributeDataForDrill(theReplyArray) {
    showRetrieveData();
    var url = appDir + "displayAttributeDataAll.htm";
    if (useTextFrame) {
        parent.TextFrame.document.location = url;
    } else {
        var win1 = open(url,"DataWindow","width=575,height=250,scrollbars=yes,resizable=yes");
    }
}

// checks if any layer has hyperlink at location and links to first one matching
function hyperlinkAny(e) {
    if (hyperLinkLayers.length>0) {
        var j = -1;
        fIndex = 0;
        for (var i=layerCount-1;i>-1;i--) {
            if ((mapScaleFactor>=LayerMinScale[i]) && (mapScaleFactor<=LayerMaxScale[i]))
                fIndex = -1;
            for (var k = hyperLinkLayers.length-1;k>-1;k--) {
                if (hyperLinkLayers[k]==LayerName[i]) {
                    fIndex = k;
                    j = i;
                }
            }
        }
        if (j>-1) {

```

Figure 5.3. Snapshot of aimsIdentify.js

In ArcIMS version 3, direct modification of this file was required to change the display the information that is useful to the user. But in the newer version, ArcIMS version 4, this file calls another file called `displayAttributeDataAll.htm` to perform this function. Since, we are currently using ArcIMS 4, I discuss everything based on this new version. A snapshot of the `aimsIdentify.js` file is shown in Figure 5.3. The highlighted line is the place where it calls `displayAttributeDataAll.htm` to perform the display function [ARCI02b].

Modularization is an apparent reason for calling `displayAttributeDataAll.htm` to perform the function. Modification of the `displayAttributeDataAll.htm` is required to let the user see only useful information. Another functionality that has been changed is to let the user see all the information at once rather than switching back and forth between the radio buttons. Previously the `displayAttributeData.htm` file was modified to give the user the information. The information in the file is not only important for display purposes but is also important for getting information from the TreeShrub database. This information is the soil information that is used as parameter values to query the TreeShrub database for trees and shrubs. Figure 5.4 shows a snapshot of `displayAttributeDataAll.htm`. The highlighted part gives an example of a situation where only relevant information is to be displayed and passed to another file for further querying purposes.

The passing of this information to another file is to make the data more modularized.

Interaction with the TreeShrub Database

Now that we have the soil and climate information, we need to add decision support to the display. The information displayed to the user about the soil needs to



Since ArcIMS works best with Internet Information Services (IIS), we use it as our server. ASPs are programs that run inside the IIS. They provide connection to databases and perform other dynamic HTML related work. As we see, the content of the web application depends on the number of records found in the database. The ASP engine performs this functionality for us. We could have done this using Java Server Pages (JSPs), but then we would have a trade-off with speed of execution. No installation

procedure is required at the user's end. This is only done for implementation purposes. After careful installation of the IIS, we need to write ASPs to connect to the TreeShrub database and execute queries in the database. Also, we need to know where to call these ASPs from the application. Since, the soil information is displayed in displayAttributeDataAll.htm, and it needs to be passed to an ASP from there for further manipulation, we call the ASP from the displayAttributeDataAll.htm. A snapshot of the displayAttributeDataAll.htm file where it is calling the ASP file is shown in Figure 5.5.

```

        if (isHyper) document.write('</a>');
        document.writeln('</td>');
    }
    document.writeln('</tr>');
    fName1 = null;
    fValue1 = null;
    //}
    t.selectCount += 1;
}
document.writeln('</table></center>');
lyrCount++;
} else {
    if (t.listAllLayersInIDAll) {
        document.writeln('<center><FONT FACE="Arial" SIZE="-1"><b>' + t.Laye
        document.writeln('<br>' + t.msgList[64] + '<br><br></font></
    }
}
if(s){0arr[b]=mid;
//document.write(arr[b]);
}
else0arr[b]="";
} //end for
    if (lyrCount==0) {
        document.writeln('<center><FONT FACE="Arial" SIZE="-1"><b>' + t.msgList[112] + '<b>
    }
for (j=0;j<t.replyArray.length;j++) {
    // document.write(arr[j]);
    if((s)&&(arr[j]!=""))
    stu=stu+arr[j];
}
s=false;
document.writeln('<FORM NAME=mid ACTION="/dbconnect.asp\" METHOD=POST>');
document.writeln('<input type="hidden" name="midval" value= "'; stu ;'");
document.writeln('<p><input type="submit" value="Submit"></p>');
document.writeln('</FORM>');
    document.writeln('</body>');
    document.close();
    t.hideRetrieveData();
</script>
</html>

```

Figure 5.5. Snapshot of displayAttributeDataAll.htm calling ASP

The ASPs for this application are written using VBScript. One of the functions of this ASP is to connect to the TreeShrub database. A string consisting of the soil

parameters and the climate parameters is passed to this ASP. A snapshot of dbConnect.asp is shown in Figure 5.6.

```

%>
<BR><b>1.</b> Agroforestry system<BR><b>2.</b> Management and Propagation<BR><b>3.</b> Products and :
<%
Const adCmdStoredProc = 4

Set objConn = Server.CreateObject("ADODB.Connection")
Set objComm = Server.CreateObject("ADODB.Command")
Set objCommClimate = Server.CreateObject("ADODB.Command")
Set objRS = Server.CreateObject("ADODB.Recordset")
Set objRSC = Server.CreateObject("ADODB.Recordset")
Set objParameter1=Nothing
Set objParameter2=Nothing
Set objParameter3=Nothing
Set objParameter4=Nothing
Set objParameter5=Nothing

Set objParameter1 = Server.CreateObject("ADODB.Parameter")
Set objParameter2 = Server.CreateObject("ADODB.Parameter")
Set objParameter3 = Server.CreateObject("ADODB.Parameter")
Set objParameter4 = Server.CreateObject("ADODB.Parameter")
Set objParameter5 = Server.CreateObject("ADODB.Parameter")

objRS.CursorType = adOpenForwardOnly
objRSC.CursorType = adOpenForwardOnly

strDatabaseType="Access"
objConn.Open "Provider=Microsoft.Jet.OLEDB.4.0;" & _
"Data Source=I:\TreeShrubDB\Tree_ShrubDB.mdb;" & _
"Persist Security Info=False"
//Response.Write("The tree names for ph values " & phh & " " & phl & " salinity " & salinity & " dra
Set objComm.ActiveConnection = objConn
Set objCommClimate.ActiveConnection = objConn
queryname=""
objCommClimate.CommandText="climate"
objCommClimate.CommandType = adCmdStoredProc
Set objParameter3 = objCommClimate.CreateParameter("gs", 3, &H0001, 5)
Set objParameter4 = objCommClimate.CreateParameter("mt", 3, &H0001, 5)
Set objParameter5 = objCommClimate.CreateParameter("ar", 3, &H0001, 5)
objCommClimate.Parameters.Append objParameter3
objCommClimate.Parameters.Append objParameter4
objCommClimate.Parameters.Append objParameter5

```

Figure 5.6. Snapshot of dbConnect.asp connecting to the TreeShrub database

After connecting to the database, the dbConnect.asp executes the suitable query in the database depending on the soil tolerance parameters for drainage, salinity, pH values, texture, hydric nature, annual flooding, and climate tolerance parameters of minimum temperature, annual rainfall, and frost free days. Figure 5.6 shows a partial view of the “climate” query.

Display Results to the User

After executing the query, it is necessary to display the results, in proper format, to the user. We choose to have the common name and the scientific name of the trees and

shrubs visible to the user from the entire result set. This serves two purposes. It gives more space to display other important information to the user and avoids display of redundant information. The common names of the trees and shrubs are actually hyperlinks on which the user can click to see details of the trees and shrubs, if required.

Figure 5.7 gives a snapshot of the dbConnect.asp that is used for displaying the result set.

```

objRS.Open objComm
Set objComm=Nothing

count=0
%>
<table border align=right><tr>
<%
Do While Not objRS.EOF
intVal=Cdbl(objRS("pH_max"))
intValMin=Cdbl(objRS("pH_min"))
intValphl=Cdbl(phl)
intValph=Cdbl(phh)
if intVal >= intValph and intValMin <= intValph Then
strs=objRS("Spp_Code")
strcn=objRS("Common_Name")
strsn=objRS("Scientific_Name")

For k=0 to ci
if strscq(k) Then
fc(k)=fc(k)+1
strspp=strspp+"*"+strs
strc=strc+"*"+strcn
strsn=strsn+"*"+strsn
%>
<tr><td><a href="http://cstaf1.fas.ufl.edu/speciesatt.asp?Spp_Code=<%=Response.Write(strs)%>" target=
<%
End if
Next 'k

End if
objRS.MoveNext
count=count+1
Loop
//count=1.5*count
%>
</table>
<%

```

Figure 5.7. Snapshot of dbConnect.asp used for displaying result set

Narrowing Down the Search Result Set

Once we have displayed to the user the set of trees that can be grown in the location, we add more decision support abilities to the system. A survey to determine the kind of options landowners would like was performed, and we have tried to optimize their requirements. The dbConnect.asp includes a form that the user needs to fill

regarding future improvements that he wants from the existing result set. Figure 5.8 shows an overview of the execution of the narrowed search.

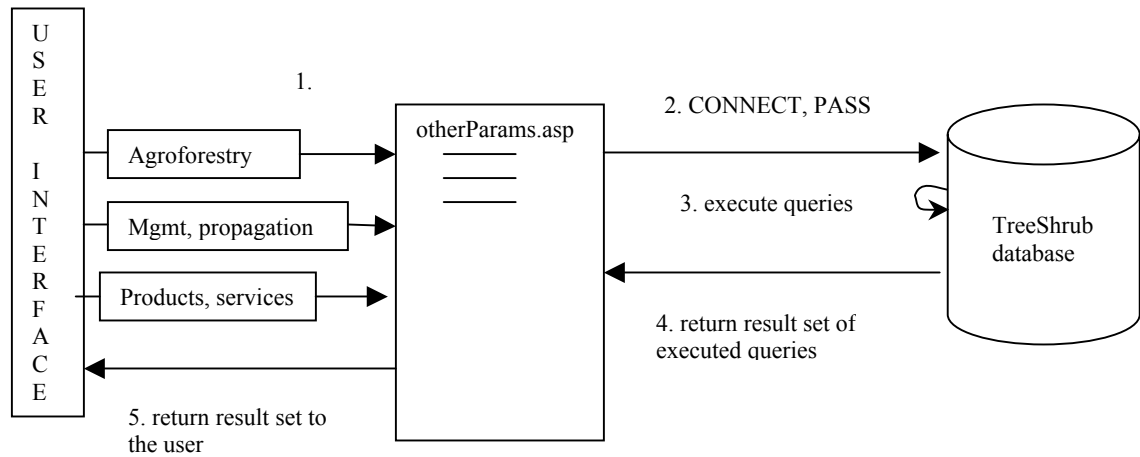


Figure 5.8. The working of otherParams.asp of the ADSS for a narrowed search

These options are divided into three categories.

1. The agroforestry system, includes five options: alley cropping, silvopastoral, windbreak, riparian buffer, and none of the above. None is set to be the default value. Since a given tree can only belong to one of the above, this option is implemented using radio buttons. A snapshot of this is shown in Figure 5.9.
2. The second option is for management and propagation related properties. These include narrow spacing, wide spacing, rapid growing plants, hedge pruned plants, plants with coppice potential, burn tolerant plants, fertilization required plants, liming plants, plants with nursery stock availability, plants that have propagation by seeds, cutting, bare roots or container, and none of the above. This can also be seen in the snapshot of Figure 5.9.
3. The last option, the products and services option, lets the user choose plants according to the services they provide. The services that are specified are lumber production, pulpwood production, plants that can be post products, plants with berries, fruits or seeds, plants that can be used as fodder, plywood or veneer producing plants, ornamentals that can be used for Christmas, plants that have wildlife values, plants that can control erosion, plants that have a high moisture use, plants that have nitrogen fixation capability, and none of the above. Figure 5.9 shows a snapshot of this specification.

```

<FORM NAME=p1 ACTION="/otherParams.asp" METHOD=POST target="_new">

<br><br><b>Agroforestry System</b><br>
<input type="radio" name="agrosys" value="alley">Alley Cropping<br>
<input type="radio" name="agrosys" value="silvo">SilvoPastoral<br>
<input type="radio" name="agrosys" value="windbreak">Windbreak<br>
<input type="radio" name="agrosys" value="riparian">Riparian Buffer<br>
<input type="radio" name="agrosys" value="none" checked>None<br><br><br>

<b>Management and Propagation</b><br>
<select name="properties" align=bottom size=14 multiple=multiple>
<option value="narrow space">Narrow Spacing</option>
<option value="wide space">Wide Spacing</option>
<option value="rapid grow">Rapid Growth Specification</option>
<option value="hedgeprune">Hedge and Pruning</option>
<option value="coppice">Coppice Potential</option>
<option value="burn">Burn Tolerance</option>
<option value="fert">Fertilization</option>
<option value="liming">Liming</option>
<option value="nursery">Nursery Stock Availability</option>
<option value="propseed">Propagation by Seed</option>
<option value="propcut">Propagation by Cutting</option>
<option value="propbare">Propagation by Bare Roots</option>
<option value="propcont">Propagation by Container</option>
<option value="none">None</option>
</select>

<br><br><br><b>Products and Services</b><br>
<select name="management" align=bottom size=12 multiple=multiple>
<option value="lumber">Lumber Production</option>
<option value="pulp">Pulpwood Production</option>
<option value="postproduct">Post Product</option>
<option value="berryfruitseed">Berry/Fruit/Seed</option>
<option value="fodder">Fodder Production</option>
<option value="veneer">Plywood/Veneer</option>
<option value="christmas">Christmas Tree</option>
<option value="wildlife">Wildlife Value</option>
<option value="erosion">Erosion Control</option>
<option value="moisture">Moisture Use</option>
<option value="nitrogen">Nitrogen Fixation</option>
<option value="none">None</option>
</select><br>

```

Figure 5.9. Snapshot of dbConnect.asp with further options for decision support

Since, zero or more of the last two options can be chosen, we have implemented them using multiple valued drop down boxes. Again, for choosing the subset of trees and shrubs from the returned result set, we need to perform appropriate queries. To further modularize the different parts of the application, we call another file called `otherParams.asp` from the `dbConnect.asp` that performs the functions of executing the appropriate queries and displaying the results to the user in a new window. A snapshot of `otherParams.asp` is shown in Figure 5.10. The code is partially what would be executed if the user chose propagation by container and lumber production as the options required.

```

ElseIf arrSelectedItems(y)="propcont" Then
objCommpo.CommandText="propcont"
Response.Write("propagation by container, ")
objCommpo.CommandType = adCmdStoredProc
objRSpo.Open objCommpo
Set objCommpo=Nothing
Do While Not objRSpo.EOF
    for k=0 to intCount-1
        if arra(k)=objRSpo("Spp_Code") Then
            flag(k)=flag(k)+1
            Response.Write(arra(k))
            Response.Write(flag(k))
        End If
    Next 'k
    objRSpo.MoveNext
Loop
Else
noney="true"
Response.Write("no management propagation properties, ")
End If
Next 'y

for x=LBound(arrm) To UBound(arrm)
if arrm(x)="lumber" Then
objComl.CommandText="lumber"
Response.Write("lumber, ")
objComl.CommandType = adCmdStoredProc
objRl.Open objComl
Set objComl=Nothing
Do While Not objRl.EOF
    for k=0 to intCount-1
        if arra(k)=objRl("Spp_Code") Then
            flagm(k)=flagm(k)+1
            Response.Write(arra(k))
            Response.Write(flagm(k))
        End If
    Next 'k
    objRl.MoveNext
Loop

```

Figure 5.10. Snapshot of otherParams.asp with propagation by container and lumber

If the user selects propagation by container and lumber production, these options along with no option for agroforestry system are passed to otherParams.asp from dbConnect.asp. Then, the propcont and lumber queries are executed on the resulting set of trees, and a subset of ones that have propagation by container and lumber production are displayed. This process is detailed in Figure 5.8.

The user can choose from a set of options and can go back and forth by choosing less or more or no options at all. A sample “lumber” query is shown in Figure 5.11. The query selects the trees and shrubs that have the “Lumber Production” attribute in the ProductServices table checked.

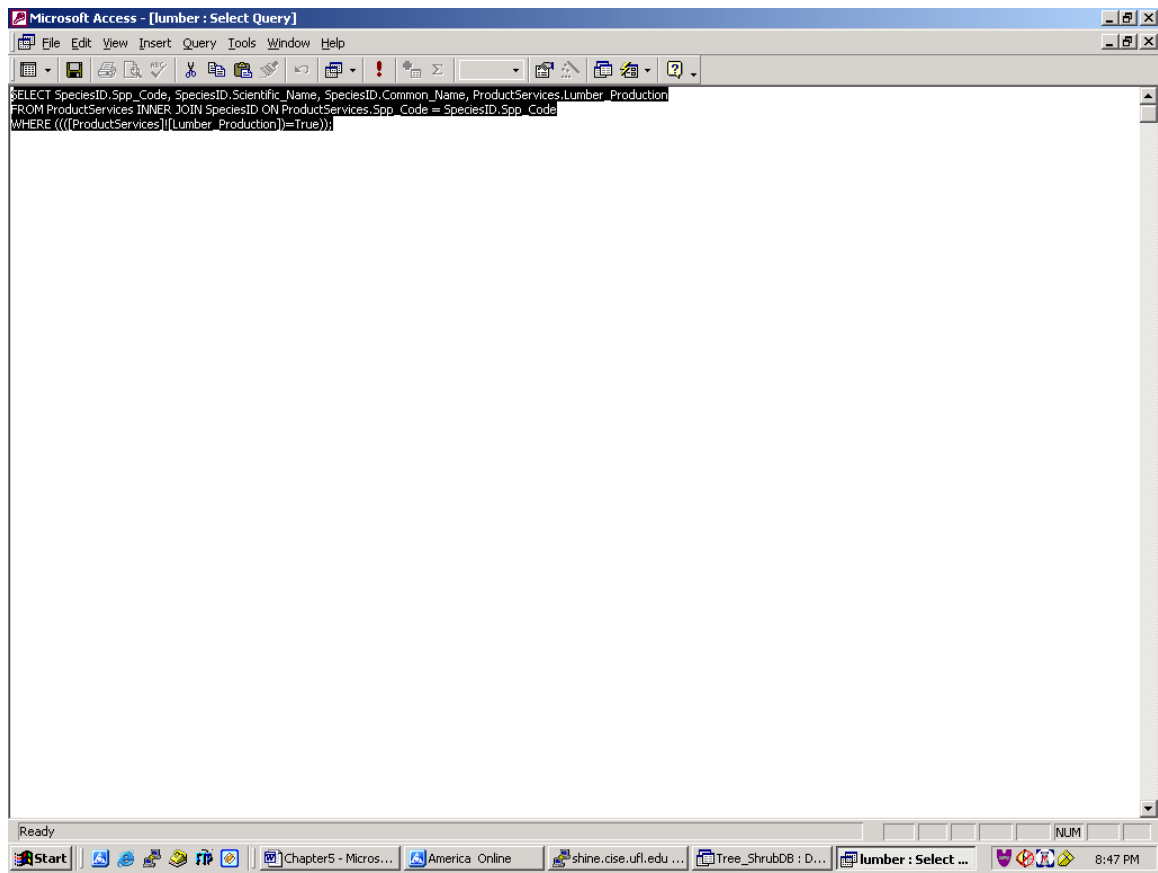


Figure 5.11. Snapshot of the “lumber” query in MS Access

The next chapter discusses the conclusion and future work of this thesis.

CHAPTER 6

CONCLUSION AND FUTURE WORK

This thesis examines the issues involved in designing an ADSS, suggests methods to take care of these issues, and implements the interface for the ADSS. Chapter 1 provides a brief introduction to the problem statement. Chapter 2 discussed research performed in the area by other people. Chapter 3 introduced us to the actual working interface of the system. Chapter 4 provides a deeper discussion of the system design. Chapter 5 further discusses the implementation of the system. Currently we have a working ADSS for Alachua, Broward, Putnam and Walton counties of Florida.

What It Is and What It Is Not

The ADSS has a user interface that is designed so the user rarely must type information. This is done for two reasons. First, it avoids providing a way by which the user can manipulate the TreeShrub database through a query string. This can be illustrated in the following example.

The query:

```
select * from Photos where Scientific_Name=[sn];
```

selects all the fields from the Photos table where the Scientific_Name that equals the value of sn which was entered by the user. Our ADSS takes the input from the GIS database and passes it to the appropriate query. Alternatively, the system could be designed without a GIS. In this case, the user would manually input the parameters of his soil and look for output. But instead of entering a Scientific_name as sn, suppose the user had the opportunity to enter the entire following string:

`delete * from Photos where Scientific_Name = "Aesculus pavia"`

The above is a valid string for the value of sn as input. Although the select statement will return the null value, a record has been deleted from the database without reason by an end user! Our approach restricts the user to input just the value of a parameter (i.e., "Aesculus pavia", in our case). Although the average users would not try to enter strings that delete values from the database, disgruntled employees, who might be up to mischief, might decide to execute such statements as revenge. Using our approach makes the system more, if not fully, secure.

Unfortunately since the ADSS uses ASPs, the interface is partially visible with some browsers like Netscape and Mozilla. The ADSS has been tested with and works fine with Internet Explorer and AOL browsers.

Extensions and Future Work

Apart from including more counties of Georgia and Alabama in the near future, there are some additional features that can be added to the system.

One of them is report generation ability. One of the tasks that extension agents want is to see a brief summary or a report of the entire selection process. Users usually like to have printed copies of reports showing the list of trees and shrubs that satisfy their search criteria. This will add another useful feature to the system.

Another task to be performed is to make the application portable to all browsers. Currently, the ASPs engine is running in the IIS. What can be done is to import the application to an Apache Tomcat server and use some software, like ChiliASP, that can enable the ASP engine to run from within this server. This will allow the system to be used with all browsers.

As the number of counties on which we have data grows, the number of trees and shrubs in the TreeShrub database will grow. Also, an increasing number of users will quickly make the system unusable with MS Access. To handle a large quantity of data and a large number of users, the database needs to be ported to an Oracle SQL database.

Another extension idea is to give a brief description of the icons on “mouse over” instead of just providing the users with the name of the icon.

Summary

ADSS has been designed to help extension agents, landowners, and people in related fields with decision-making without having to manually search for information on the growth of trees and shrubs. This is done by the use of a GIS. We hope that this application finds use in related areas and encourages users to develop extensions to it.

APPENDIX A
TABLES OF TREESHURB DATABASE

Table A-1 Plant Description

Attribute	Value
PrimaryID	Sequence number
Spp_Code	NRCS/USDA plant codes
Form_Habit	tree, shrub
Life_span	moderate, short, long
Growth_Rate	Slow, Fast, Moderate
Leaf_Persistence	evergreen, deciduous, semievergreen, semideciduous
Sex_Expression	dioecious, monoecious
Tree_size	small, large, medium
Mature_Height_Max	maximum height
Mature_Height_Avg	average height
Height_twenty_years	height in twenty years
Tree_shape	round, oval
Mature_DBH	diameter
Crown_spread	spread
Crown_uniformity	symmetrical, asymmetrical
Crown_shape	oval, conical, upright
Crown_density	moderate, dense
Crown_texture	medium, fine, coarse
Foliage_Texture	medium, fine, coarse
Foliage_Porosity_Summer	dense, moderate, porous
Foliage_Porosity_Winter	dense, moderate, porous
Trunk_type	single/multiple stem
Trunk_orientation	erect, climbing
Branching_type	droop/ don't droop
Branch_breakage	resistant, susceptible
wood_specific_gravity	number between 0 and 1
Fruit_type	berry, capsule, other
Fruit_shape	shape of fruit
Fruit_period_start	start season
Fruit_period_end	end season
Fruit_seed_abundance	high, medium, low, none
Flower_conspicuous	yes/no
Flower_color	color of flower
Flower_showiness	yes/no
Flower_time	season of flowering
Pollinators	wind, insects, bees

Table A-1 Plant Description (contd.)

Root_depth_min	number
Root_surfacing	yes/no
Active_growth_period	season of active growth
C_N_Ratio	high, medium, low, none
Nitrogen_fixation	yes/no
Mycorrhizae	VA, ecto
Allelopathy	yes/no
Toxicity	yes/no

Table A-2 EcologySiteAdaptation

Attribute	Value
Primary_ID	Sequence number
Spp_Code	NRCS/USDA plant codes
USDA_hard_zone_min	Hardiness zone minimum value
USDA_hard_zone_max	Hardiness zone maximum value
Ecosystem	where the plant is found
NA_native	yes/no
Frost_free_days_min	minimum frost free days annually
min_temp_tolerance	minimum temperature tolerance
Precipitation_min	minimum precipitation
Precipitation_max	maximum precipitation
Fine_text_soil_adapt	fine soil texture
Medium_text_soil_adapt	medium soil texture
Coarse_text_soil_adapt	coarse soil texture
pH_min	minimum pH
pH_max	maximum pH
CaCo3_tolerance	high, medium, low, none
Drought_tolerance	high, medium, low, none
Moisture_use	high, medium, low, none
Light_requirements	sun, shade
Shade_tolerance	tolerant, intolerant, intermediate
Fire_resistant	yes/no
Salinity_tolerance	high, medium, low, none
Aerosol_salt_tolerance	high, medium, low, none
Invasive_potential	low, weedy native
Threatened_Endangered	yes/no
Soil_Tol_Sand	yes/no
Soil_Tol_Loam	yes/no
Soil_Tol_Clay	yes/no
Flood_Tolerance	yes/no
Anaerobic_Tolerance	high, medium, low, none
Soil_Tol_Drainage	well drained
Soil_Tol_pH	acidic, alkaline

Table A-3 MgmtPropagation

Attribute	Value
PrimaryID	Sequence number
Spp_Code	NRCS/USDA plant codes
vegetative_spread_rate	high, moderate, slow, none
Coppice_potential	yes/no
Fire_tolerance	high, medium, low, none
Resprout_ability	yes/no
Hedge_tolerance	high, medium, low, none
Pruning_requirement	little, needed
Fertility_requirement	high, medium, low, none
Cold-stratification	yes/no
Prop_bare_roots	yes/no
Prop_cutting	yes/no
Prop_seeds	yes/no
Prop_container	yes/no
seed_Dormancy	internal, seedcoat
Germination	epigeal, hypogeal
Seeds_per_pound	number of seeds per pound
Seeds_spread_rate	high, medium, low, none
Seedling_vigor	high, medium, low, none
Plant_dens_min_acre	number
Plant_dens_max_acre	number
Nursery_availability	yes/no
Pest_resistant	resistant, sensitive
Pests	pests found
Diseases	diseases found

Table A-4 ProductServices

Attribute	Value
PrimaryID	Sequence number
Spp_Code	NRCS/USDA plant codes
Berry_Nuts_Seeds	Berries, nuts, seeds
Christmas_Tree	yes/no
Fodder_Production	yes/no
Fuelwood_Production	high, medium, low, none
Lumber_Production	yes/no
Naval_Store_Production	yes/no
sap_resins	yes/no
Palatable_Browse_Animal	high, medium, low, none
Palatable_Graze_Animal	high, medium, low, none
Palatable_Human	yes/no
Post_Production	yes/no
Protein_Potential	high, medium, low, none
Pulpwood_Production	yes/no

Table A-4 ProductServices (contd.)

Veneer_Production	yes/no
Erosion_control	yes/no
Windbreak	yes/no
Landscape_Ornamental	yes/no
Reclamation_potential	yes/no
Wildlife_value	yes/no

Table A-5 SpeciesID

Attribute	Value
Primary_ID	Sequence number
Spp_Code	NRCS/USDA plant codes
Scientific_Name	scientific name of the plant
Common_Name	common name of the plant
Family	family of the plant

Table A-6 Documents

Attribute	Value
Primary_ID	Sequence number
Spp_Code	NRCS/USDA plant codes
FLTreesDoc	hyperlink to Florida trees document
IFASDoc	hyperlink to IFAS trees document
NAGuideDoc	hyperlink to North American document
NRCSDoc	hyperlink to NRCS document
NRCSFactSheet	hyperlink to NRCS fact sheet
NRCSPlantGuide	hyperlink to NRCS plant guide

Table A-7 Photos

Attribute	Value
Primary_ID	Sequence number
Spp_Code	NRCS/USDA plant codes
Photos_link	hyperlink to photos

APPENDIX B AGROFORESTRY SYSTEM TERMS

Alley Cropping

This practice combines trees, planted in single or grouped rows, with agricultural or horticultural crops which are cultivated in the wide alleys between the tree rows [ELLI01].

Silvopastoral

This practice combines trees with forage (pasture or hay) and livestock production [ELLI01]. The overstory tree component provides shade and wind shelter, thereby protecting livestock from temperature stresses.

Riparian Buffer

Riparian buffers consist of strips of perennial vegetation (tree/shrub/grass) planted between cropland or pastures and streams, lakes, wetlands, ponds, or drainage ditches [ELLI01]. They are managed to reduce runoff and non-point source pollution from agricultural activities on adjacent lands by trapping sediment, filtering excess nutrients, and degrading pesticides. They can also stabilize streambanks, protect floodplains, enhance aquatic and terrestrial habitat, improve landscape appearance, provide harvestable products, and function as a windbreak in some situations.

Windbreak

Windbreaks are planted and managed as part of a crop or livestock operation to enhance crop production, protect livestock, and control soil erosion [ELLI01]. Field windbreaks are used to protect a variety of wind-sensitive row, tree and vine crops, to

control wind erosion, and to provide other benefits such as improved bee pollination of crops and wildlife habitat. Windbreaks can function as living snow fences to help with water management by dispersing snow more evenly across cropland.

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BIOGRAPHICAL SKETCH

Sapna D. Jeswani was born in the state of Maharashtra in India on Sept 7, 1978. She was brought up in the city of Mumbai and completed her Higher Secondary Certification majoring in biology at D. G. Ruparel College of Science in 1996.

She then went on to complete her bachelor's degree in computer engineering at Sardar Patel College of Engineering in 2000. Soon after that, she joined the Computer and Information Sciences and Engineering Department at the University of Florida in Fall 2000.

Her industrial work experience includes two internships at MarCon Global Data Solutions. Her areas of interest include information systems, databases, and wireless communication.