Teaching Methods

An interactive online database for the selection of woody ornamental plants

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SUMMARY. Web sites such as the University of Connecticut (UConn) Plant Database allow large volumes of information and images to be stored, published and accessed by users for the purpose of informed decision-making. Sorting information on the World Wide Web (Web) can be difficult, especially for novice users and those interested in quick results. The advent of Internet search and retrieval software fosters the creation of interactive decision support systems. The Plant Selector was designed to complement the UConn Plant Database plant encyclopedia by allowing Web site users to generate lists of woody ornamental plants that match specific criteria. On completion of an HTML-based search form by users, a Web-enabled database is searched and lists of matching plants are presented for review. To facilitate analysis of the Plant Selector's efficacy, an online questionnaire was implemented to solicit user feedback. Survey data from 426 responses to the online evaluation tool were analyzed both to understand user demographics and gauge satisfaction with the Plant Selector module. Survey data revealed that most Plant Selector users are between 40 to 65 years of age and homeowners with minimal horticultural experience. A large percentage of Web site visitors (68%) is located across the United States beyond Connecticut and the New England region. The great majority of survey respondents (65%) use this tool to select plants for the home landscape. Most (77%) either agree or strongly agree that the Plant Selector is easy to use and delivers results that are useful (66%), while 70% agree or strongly agree that the categories used by the Plant Selector are sufficient. The survey results in general suggest that Web-based decision support systems may serve useful roles in the field of horticulture education.

The University of Connecticut (UConn) Plant Database is a Web site that aims to assist students, homeowners, green industry professionals and others with the selection of woody ornamental plants. Initially, this Web site consisted of two primary modules. An online encyclopedia known as Plant Pages provided information and images describing over 600 species of trees, shrubs and vines along with thousands of their associated cultivars. Virtual Plant Walks served primarily as a supplementary teaching tool for university students enrolled in woody plant materials courses at several New England colleges. The Web site has been well received, with patronage climbing steadily to current levels of about 1100 unique visitors per day and 35,000 unique visitors per month as of October 2002. The UConn Plant Database can be accessed at <http://www.hort.uconn.edu/plants> (Brand, 2002).

Information contained in Web sites such as the UConn Plant Database and books with a similar focus such as the industry standard, *Manual of Woody Landscape Plants* (Dirr, 1998), may pose some difficulty for the novice horticulturist. While these tools contain large volumes of accurate information, they provide no mechanism for sorting through this compendium to locate specific material of interest to the user. This fault may partly explain why a recent survey conducted by Brand and Leonard (2001) indicated that only 9% of homeowners surveyed used the Internet as a plant information source. Survey respondents instead relied predominantly on the professional staff of independent garden centers and nurseries (Brand and Leonard, 2001), businesses that may provide more personalized assistance. A similar survey of garden writers (Garber and Bondari, 1999) revealed that only 29% of respondents reported using the Internet for the purpose of plant selection. The results of such surveys must always be analyzed keeping in mind that different sample groups may demonstrate differential access to the Internet due to factors such as socioeconomic status and occupation.

While the benefits of interacting with nursery professionals cannot be denied, the availability of these individuals cannot always be assured. Recent developments in Internet search and retrieval engines, however, provide a vehicle that allows users to find specific online information in any home or office outfitted with an Internet connection (Eastwood, 1998). Modern database management systems provide an interface between Internet users and online databases to allow efficient dispersal of information over computer networks and the customization of information through complex queries and other functions (Fortier, 1997). The interaction between a database, database management system and the Internet can transform online information sources into user-friendly decision support systems (Cameron, 2000). Agriculture is witnessing an upsurge in the use of computerized decision support modules in response to many factors, including decreased staff in academia and cooperative extension systems, increasingly complex information and high demand from society (Eastwood, 1998).

Given the potential of the Internet and associated technologies to simplify the woody ornamental selection process, we endeavored to create an interactive decision support system

(known as the Plant Selector) that would allow UConn Plant Database users to customize the information contained in the Plant Pages encyclopedia. It was our objective to create a Web-enabled tool that would allow high specificity in the selection of specialized plant material while remaining accessible to users of varied horticultural and computing aptitude.
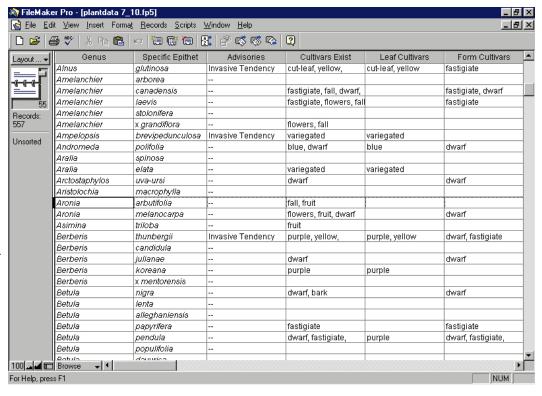
Procedures

DATABASE DESIGN. The logical first step of this project was to select database software to serve as the Plant Selector's search engine. To make this choice, we considered 1) compatibility with common Web browser software likely to be employed by our users; 2) ability to sort fields according to multiple criteria; 3) capacity to handle high levels of user traffic; and 4) ease of maintenance and design. After some consideration, we chose to use FileMaker Pro 5 Unlimited (FileMaker, Inc., Santa Clara, Calif.), a database management system that has demonstrated high facility while serving similar roles with Texas A&M University's Aggie Horticulture Picture Pages (Lineberger, 2002) and Ohio State University's Plants of Horticulture Plant Dictionary (Rhodus et al., 2002). This software program is unique because it includes a common gateway interface that facilitates interaction between the users' Web browser software and the database files housed on our Dell PowerEdge 2400 server (Dell Computer Corp., Round Rock, Texas).

The database file stores information in a flat file spreadsheet organized into columns and rows. Figure 1 shows that each row serves as a species record, while the columns each represent a search criterion. Fields within these columns contain value(s) that describe the attribute for each plant species. Data entry into this database was a simple matter performed solely by the database manager. Plant Selector users may only retrieve information from the database by executing queries through the UConn Plant Database Web site. The FileMaker Pro 5 Unlimited database sorts through the records using

information stipulated by the user. This functionality uses Boolean-type "and" logic, whereby a database record must express every value indicated by the user to be retrieved as a match. Only those fields selected by the user are sorted by the database.

INTERNET INTERFACE DESIGN. The most challenging aspect of this project was designing the HTML-based form that would allow users to extract and customize information contained in the Plant Selector's FileMaker Pro 5 Unlimited database. This process involved organizing the many categories used to describe specialized woody ornamental plants. Primary consideration focused on selecting appropriate search criteria to facilitate accurate query results. At the same time, we attempted to ensure a high degree of resource usability for visitors with varied horticultural and computer backgrounds. To pursue this goal we designed the search form using clear organization and clean presentation of the graphical elements.

The Plant Selector search form was created with the assistance of Dreamweaver 3 (Macromedia, Inc., San Francisco), a Web page design software program. The search form was separated into categories that organize search criteria into logical groupings (Fig. 2a and b). Included on the two-column HTML table were traits deemed to be of interest to most prospective users. Notable

Genus	Specific Epithet	Advisories	Cultivars Exist	Leaf Cultivars	Form Cultivars
Alnus	glutinosa	Invasive Tendency	cut-leaf, yellow,	cut-leaf, yellow	fastigiate
Amelanchier	arborea	--			
Amelanchier	canadensis	--	fastigiate, fall, dwarf,		fastigiate, dwarf
Amelanchier	laevis	--	fastigiate, flowers, fall		fastigiate
Amelanchier	stolonifera	--			
Amelanchier	x grandiflora	--	flowers, fall		
Ampelopsis	brevipedunculosa	Invasive Tendency	variegated	variegated	
Andromeda	polifolia	--	blue, dwarf	blue	dwarf
Aralia	spinosa	--			
Aralia	elata	--	variegated	variegated	
Arctostaphylos	uva-ursi	--	dwarf		dwarf
Aristolochia	macrophylla	--			
Aronia	arbutifolia	--	fall, fruit		
Aronia	melanocarpa	--	flowers, fruit, dwarf		dwarf
Asimina	triloba	--	fruit		
Berberis	thunbergii	Invasive Tendency	purple, yellow,	purple, yellow	dwarf, fastigiate
Berberis	candidula	--			
Berberis	julianae	--	dwarf		dwarf
Berberis	koreana	--	purple	purple	
Berberis	x mentorensis	--			
Betula	nigra	--	dwarf, bark		dwarf
Betula	lenta	--			
Betula	alleghaniensis	--			
Betula	papyrifera	--	fastigiate		fastigiate
Betula	pendula	--	dwarf, fastigiate,	purple	dwarf, fastigiate,
Betula	populifolia	--			
Betula	dahurica	--			

Fig. 1. Screen capture showing the FileMaker Pro 5 Unlimited Plant Selector database.

categories include those grouped within the Cultivar Availability section, as well as various miscellaneous traits listed under Special Qualities. These search criteria have rarely been included in other plant selection resources. Users may select values for each trait using text entry fields, pull-down menus and radio boxes (Fig. 2a and b). Optional additional information about specific Plant Selector search criteria and other general aspects of the resource may be accessed using links provided on the search form. For example, clicking the Help link next to the Stem/Bark Texture category opens a new browser window that details supplementary information and pictures describing this search criterion.

Upon completing the Plant Selector search form, users click a button that initiates the query. Embedded within the HTML code are special tags known as Claris Dynamic Markup Language (Claris Corporation, Santa Clara, Calif.) which instruct the user's Web browser to contact the FileMaker Pro 5 Unlimited database. The database then sorts the records to find plants that match the criteria stipulated by the user. Search results are transmitted back to the user's Web browser where they are displayed
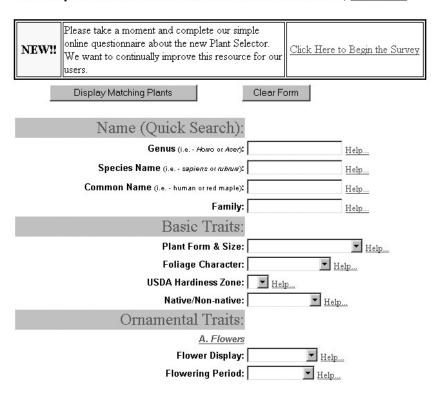
Fig. 2. (a) Opening screen capture showing the Plant Selector search form.

on a separate search results page. Figure 3 shows that the search results page enumerates matching plants by listing their Latin name, common name and any special advisories such as invasive tendency or severe skin irritant. Also provided is a link that allows users to review more information about matching candidate plants in the UConn Plant Database's Plant Pages encyclopedia.

EVALUATION TOOLS. After releasing the Plant Selector for public use, we were interested in generating feedback concerning the usability and quality of the tool. It was hoped that such data, both in quantitative and qualitative form, might lead to future improvements and the correction of any current

problems. Since the Plant Selector is a Web-based resource, we surmised that constructing a Web-based evaluation tool would be the logical way to survey our intended audience. Web-based surveys have been used successfully for many purposes (Waliczek et al., 2000), thus we began construction of an evaluation tool using principles outlined by Dillman (2000).

The online survey was designed to be completed by Plant Selector users who accessed the evaluation tool via links provided on the UConn Plant Database homepage and Plant Selector search form. The HTML-based survey form included 19 questions, 18 of which featured preset, closed-ended responses. Nine closed-ended survey items utilized the same ordered response matrix, whereby respondents
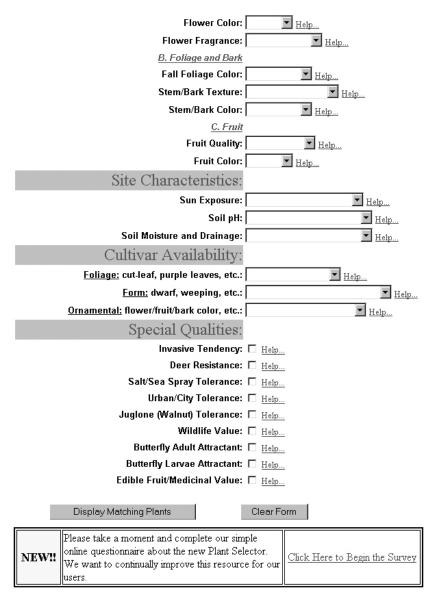
were asked to express their level of agreement with several statements related to their satisfaction with the Plant Selector. Fifteen of the survey questions limited respondents to selecting one answer, while three allowed multiple responses. One final, open-ended item provided a text field allowing respondents an opportunity to record any additional qualitative comments concerning the Plant Selector.

DATA ANALYSIS. Data collected by the online survey were analyzed using SAS for Windows Version 8.0 (SAS Institute, Cary, N.C.). This nominal data was processed using both enumeration statistical methods and descriptive statistics. For closed-ended questions that allowed a single answer, chi-square tests (Zar, 1996) and Levy's multiple comparisons for proportions (Levy, 1975) were used to determine differences in user demographic characteristics, Plant Selector usage patterns and perceptions of user satisfaction. For the items that utilized an ordered response matrix, comparisons of mean rank were also used to provide a barometer of overall user preference when analyzing user satisfaction.

Results

Four hundred-twenty six responses to the online survey evaluation tool were received from Apr. 2001 through Oct. 2001. Since respondents completed the questionnaire voluntarily, this self-selection process generated data that may only be used to analyze trends and perceptions among the given sample population. These data are not intended to provide generalizations about other populations. Demographic information indicated that individuals between the ages of 40 through 65 comprised the largest group of respondents, at 57.7% (Table 1). Table 1 shows that the great majority of users, about 75%, identified themselves as homeowners or amateur

Fig. 2. (b) Continuation of the screen capture showing the Plant Selector search form.

gardeners. Small percentages were either students (14.6%) or professionals (10.5%). The number of survey respondents who indicated little and moderate horticultural experience, at 39.9% and 46.3%, respectively, was statistically the same and far exceeded the percentage of individuals who expressed that they were very experienced (13.8%) (Table 1). In terms of geographic location, the greatest statistical percentage of survey respondents claimed residence in the central U.S. (20.2%) (Table 2), followed closely by Connecticut (16.2%), other New England states (15.7%), the mid-Atlantic U.S. (15.5%) and other areas (16.2%). Most respondents, 65.8%,

indicated that they consulted the Plant Selector less than once per week (Table 2). Most respondents indicated that they used the Plant Selector to select plants for the home landscape (65.2%). Relatively small percentages used the resource for professional (13.6%), academic (11.0%) or leisurely purposes (10.1%) (Table 2).

Aside from demographic information, the online survey tool collected feedback from respondents concerning various aspects of the Plant Selector itself. Users were asked to choose one of five ordered responses to express their level of agreement with several statements (referred to as statements A-I in Table 3). For purposes of analysis, each answer choice was coded with a numerical value as follows: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly

agree. In comparing the Plant Selector to other sources of plant information (statement A), respondents most often agreed (46.3%) that the Plant Selector was more useful (Table 3). A large percentage (31.6%), however, indicated a neutral response to this item and therefore the mean rank was 3.64. Results were similar for statement B, in which participants responded to the idea that they would use the Plant Selector before other information sources. Statistically equivalent percentages both agreed (42.7%) and expressed a neutral response (34.2%) (Table 3), generating a mean rank of 3.61 that was the second lowest for all items in this group.

Statements C and D generated similar responses, as the largest percentage of respondents, 49.9%, indicated that they agreed with the statement that the Plant Selector was easy to use (Table 3). More than half of respondents, 51.1%, expressed similar sentiments when responding to statement D, which stated that the Plant Selector searches fast enough. The mean ranks for statements C and D, 3.98 and 4.01, respectively, were the highest of all items and suggest that respondents overall agree with these statements (Table 3). The Plant Selector provides varied optional instruction sheets and help sheets to assist users. Statement E asked respondents to evaluate the idea that these resources are useful and complete. The largest statistical percentage, 53.1%, agreed with this idea, while the numbers that expressed a neutral response (22.9%) and strongly agreed (20.1%) with the statement were statistically the same (Table 3). Statements F, G, and H addressed design and performance aspects of the Plant Selector. Since a great deal of deliberation was invested in choosing the Plant Selector search criteria, statement F prompted respondents to evaluate the idea that the categories were sufficient. Most (69.7%) either agreed or strongly agreed with this statement,

Fig. 3. Screen capture showing an example of the Plant Selector search results page.

while only 19.2% indicated a neutral response (Table 3).

Perhaps the ultimate measure of the Plant Selector's success is user perceptions regarding the functionality of the resource in delivering results. Statement G asked users to express their feelings regarding whether the plants recommended by the Plant Selector were useful and met their needs. More than half of respondents (53.3%) agreed with this statement (Table 3), with the second-largest group (28.3%) indicating a neutral response. These results paralleled those recorded for statement H, which addressed the idea that plants recommended by the Plant Selector match the criteria selected by users on the search form. Once again, the largest statistical percentage, 53.5%, agreed

with this idea while 27.2% expressed a neutral reaction and 14.4% agreed strongly (Table 3). As a primary module of the UConn Plant Database, the Plant Selector was engineered to work in concert with other components of the Web site. The last item in this section, statement I, asked users to evaluate this idea. Results were inconclusive, as the percentages that agreed with this idea and those that expressed a neutral response (45.8% and 39.6%, respectively) were statistically the same (Table 3). The mean rank for this item, 3.59, was the lowest observed and suggests a more neutral feeling for this item as compared to the other questions that utilized the ordered response matrix.

Discussion

Demographic results collected by the online survey tool suggest a profile for the typical Plant Selector user: a homeowner between the ages of 40 and 65

with minimal horticulture experience. This finding is not surprising, given that home gardeners and amateur horticulturists clearly comprise the largest sector of horticulture consumers. Unlike students and professionals in the field, home gardeners often practice horticulture part-time with little formal training. Thus, an informational resource such as the Plant Selector may be of greatest benefit to this constituency. It is also possible, however, that busy students and professionals were less likely to invest time in completing the survey tool. Despite this possible bias, the challenge still remains to achieve a balance between high academic standards and high usability for novice users. It is the responsibility of a university-based public outreach tool such as the Plant Selector to pursue this goal. Responses to the online evaluation tool indicate that the Plant Selector is reaching this level. Without exception, the majority of questionnaire participants responded positively to survey items that addressed issues of usability and functionality. These findings, combined with a multitude of positive email messages and rising Web site usage statistics, suggest that users with varied levels of horticultural and computer aptitude are ready to accept a new generation of interactive information delivery systems such as the Plant Selector. Analyses of the online survey tool's findings, however, must be interpreted in light of the survey sample. The self-selection methodology of the evaluation tool dictates that results only apply to the survey population. Since such sampling bias is unavoidable with tools of this type, we may use the findings to analyze trends within the Plant Selector's core audience.

Data derived from the online survey tool provided a framework for making improvements to the Plant Selector. Approximately 30% of survey participants, for instance, indicated "neutral" responses to statements sug-

Table 1. Age, occupation and horticultural experience of respondents to the online survey evaluation tool for the Plant Selector component of the University of Connecticut Plant Database.

Respondent characteristic	Respondents (no.)	Respondents (%)
Age (years)		
<18	8	1.9 d[z]
18–25	28	6.7 c
25–40	120	28.7 b
40–65	241	57.7 a
65+	21	5.0 cd
Occupation		
Horticulture student	28	6.8 b
Landscape architecture student	10	2.4 c
Other student	22	5.4 bc
Professional horticulturist	28	6.8 b
Professional landscape architect	15	3.7 c
Homeowner/amateur gardener	307	74.9 a
Horticultural experience		
Little	167	39.9 a
Moderate	194	46.3 a
Very	58	13.8 b

[z]Separation of percentages within columns by multiple comparisons for proportions and the Tukey test at $P \leq 0.05$

Table 2. Location, frequency of use and motivations for use of respondents to the online survey evaluation tool for the Plant Selector component of the University of Connecticut Plant Database.

Respondent characteristic	Respondents (no.)	Respondents (%)
Location		
Connecticut	68	16.2 ab[z]
Other New England	66	15.7 ab
Mid-Atlantic U.S.	65	15.5 ab
Southern U.S.	28	6.7 c
Central U.S.	85	20.2 a
Western U.S.	40	9.5 bc
Other	68	16.2 ab
Frequency of use		
Less than once per week	277	65.8 a
Once per week	74	17.6 b
More than once per week	51	12.1 b
Once per day or more	19	4.5 c
Motivations for use		
Select plants for home landscape	277	65.2 a
Assist with professional tasks	58	13.6 a
Assist with academic tasks	47	11.0 b
To view pictures/just for fun	43	10.1 b

[z]Separation of percentages within columns by multiple comparisons for proportions and the Tukey test at $P \leq 0.05$.

gesting that plants recommended by the Plant Selector are useful or match choices selected on the search form. This rather high percentage, combined with several informal email messages and other suggestions recorded in the survey tool's open-ended text field, prompted several revisions to the search form that we believe enhance clarity. We renamed the former "provenance" category "native/non-native" to avoid semantic confusion and added height designations to the choices listed under "plant form and size" to more clearly define these options. Despite these and other amendments, occasional future revision of the Plant Selector will no doubt occur as a natural process.

One of the more surprising aspects of this project was the ease with which simple electronic technologies can be fused to create a powerful tool. Only a modicum of computing skill was required to design and implement the Plant Selector. Most challenging was developing a tool that balanced high functionality with high usability. Reaching such a compromise is important when addressing a varied audience in any media. The Plant Selector serves as evidence that Web-enabled decision support systems are a viable tool for applications in the field of horticulture, complementing existing resources. The progress of technology will only serve to enhance the capabilities of these tools over time, just as greater public acceptance of computers will increase traffic.

Table 3. Attitudes of respondents as expressed through the online survey evaluation tool for the Plant Selector component of the University of Connecticut Plant Database.

	Statement	Respondents in designated response category (%)					
		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5	Mean rank
A	The Plant Selector is more useful than other sources.	2.2 e[z]	6.0 d	31.6 b	46.3 a	14.0 c	3.64
B	I would use the Plant Selector before other sources.	1.7 d	7.0 c	34.2 a	42.7 a	14.5 b	3.61
C	The Plant Selector is easy to use.	1.9 d	2.6 d	18.5 c	49.9 a	27.1 b	3.98
D	The Plant Selector searches fast enough.	1.7 d	1.5 d	18.2 c	51.1 a	27.6 b	4.01
E	The Plant Selector's instructions and help sheets are useful and complete.	1.5 c	2.5 c	22.9 b	53.1 a	20.1 b	3.88
F	The categories used by the Plant Selector are sufficient.	3.6 c	7.5 c	19.2 b	52.7 a	17.0 b	3.72
G	Plants recommended by the Plant Selector are useful and meet my needs.	2.5 d	3.0 d	28.3 b	53.3 a	13.0 c	3.71
H	Plants recommended by the Plant Selector match the choices I selected.	2.5 d	2.5 d	27.2 b	53.5 a	14.4 c	3.75
I	The Plant Selector works smoothly with other modules of the UConn Plant Database.	3.1 c	1.0 c	39.6 a	45.8 a	10.4 b	3.59

[z]Separation of percentages within columns by multiple comparisons for proportions and the Tukey test at $P \leq 0.05$.

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