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A Web-based Decision Support Tool for Forage Species Selection

D. A. Miller, M. H. Hall, J. Voortman, and P. J. Kolb, The Pennsylvania State University, EMS Environment Institute and Department of Agronomy, 2217 Earth-Engineering Sciences Building, University Park, PA 16802

Corresponding author: D. A. Miller. miller@essc.psu.edu

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Abstract

Extension agents, agricultural consultants, and producers of forage crops seek to optimize forage production and, at the same time, create surface conditions that maximize soil conservation and nutrient management efforts and minimize adverse impacts on water quality. Selecting the "best" forage species or species mixture requires a knowledge and understanding of the requirements of the animal being fed, soil and climatic characteristics, and forage species. We have developed a Web-based forage species selection tool that allows the agriculturalist to choose the appropriate forage species for specific field properties and intended management objectives. This tool is based upon a Web mapping approach that guides the user to the desired farm field and then matches this spatial location information with the intended management objectives. A decision support component then generates a list of recommended forage species. The Web-based forage species selection tool provides a common environment for extension and NRCS personnel, individual producers and consultants in forage management and can be used effectively in presenting forage management concepts during group training sessions as well as in individual queries and consultations. The tool also provides a consistent and reliable reference that can be easily updated as new information on forage productivity becomes available. The selection tool can be accessed at www.forages.psu.edu.

The forage industry represents the major agricultural enterprise in Pennsylvania and the northeastern United States. Forages are the major food component in the diet of dairy cattle, beef cattle, and sheep in the state. These animals provide, in turn, nearly 60% of the total cash receipts from agricultural product sales in Pennsylvania. Forage crops are obviously critical to the overall success of many agriculture-related enterprises within Pennsylvania. The multi-dimensional nature of this industry presents challenges to those interested in maximizing available resources and minimizing negative impacts. These individuals would benefit from an easily accessible tool that is accurately linked to the best available knowledge of the soils underlying the management units in the landscape. In the following sections, we describe the design, development, and implementation of a Web-based forage species selection tool.

Design Requirements

Forage species selection is a spatial problem. The producer is interested in choosing the best forage species for a specific field and use that will maximize production capacity while minimizing susceptibility to risks such as erosion, water quality degradation, and drought. The criteria for forage species selection can be broken into three categories: spatial location of the management unit (field), soil properties, and the intended forage use. The forage expert considers

these factors when responding to a recommendation request. A web-based forage species selection tool would need to emulate the process used by an expert to arrive at a set of recommendations for the producer.

The user of a recommendation tool would like to easily locate the desired field and determine the physical properties of the soils at that location. This basic information should be seamlessly integrated with additional user input information on management practices and desired forage uses. The user should be presented with a complete report of recommended forage species and their anticipated performance by the decision support tool.

After locating the specific field for which a recommendation is desired, the user would need to provide basic use information to the decision support system. A simple, easily navigated interface would allow collection of the relevant information in a straightforward manner. The user would provide the requested information and the system would respond with the recommendations for the specified field. The user could review the results on-screen or print the content of the Web browser for a permanent copy of the query results. Overall, the system should require no special skills or capabilities beyond knowledge of personal computer-based Web browser software. The system would be built with the most recent spatial data resources available.

Implementation

User Interface. The Forage Species Selection Tool (FSST) employs a clear, uncomplicated interface that allows the user to easily navigate and locate desired information (1). The FSST home page explains the purpose of the tool and provides additional information about the developers as well as a response area for users to forward comments and questions. The actual FSST is located as a link from the main page and, as depicted in Fig. 1, initially provides an interactive map interface for the United States.

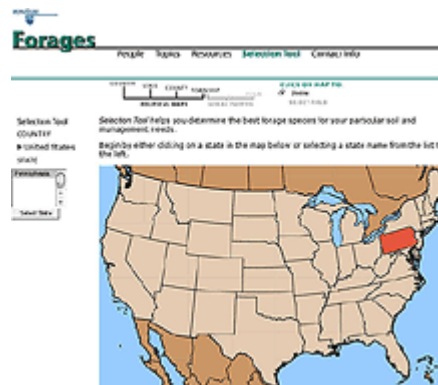


Fig. 1. Main map interface page for the Forage Species Selection Tool.

A tabular navigation system is included on the left margin of the page for users who want to locate a recommendation for a specific soil series or who wish to lower the overhead of downloaded graphics and images through their Web connection. States with completed counties are highlighted on the interactive map and indicated in the tabular navigation system.

A click on an active state or selection of a state in the table begins the descent of the hierarchical structure of the site. The second level in this hierarchy is the state where the user is presented, either graphically or through the navigation table, with completed counties (Fig. 2). A click or selection at this level moves the user to a county map, with shaded relief background and delineated minor civil divisions (city, borough, township) (Fig. 3). Each successive click or selection is designed to help the user move closer to the desired management unit. The maps in the portion of the hierarchy traversed to this point are interactive images generated through a combination of manual and automated cartographic techniques. In keeping with the theme of a simple, navigable interface, the maps have been designed with the intent of providing only

sufficient detail needed at the particular level to allow the user to move ever closer to the field of interest.



Fig. 2. Pennsylvania county map in the Forage Species Selection Tool page hierarchy.

The next level of map interface is the individual minor civil division map for the area selected using the interface level depicted in Fig. 3. The city, borough, or township entity map has now been augmented with roads and streams as an aid to the user in finding their desired location (Fig. 4). The maps at this level were generated in an automated, batch job approach using geographic information system (GIS) software and then transformed into interactive image maps that move the user to the next level in the hierarchy, where digital orthophotography quadrangles (DOQs) are used as the navigation mechanism for moving the user to the desired field location.



Fig. 3. Adams County map in the Forage Species Selection Tool page hierarchy.



Fig. 6. Zoomed view of the township DOQ page.



Fig. 7. Management use screen in the Forage Species Selection Tool.

The tabular navigation area contains a scrolling list of all the soil series map units that exist within the currently selected county. If the user is familiar with the soil series present in the field of interest, selecting this soil series will move the user to the same selection page for management use that is accessed via the map interface in Fig. 4. A hot button is provided just below this scrolling window that links the user to a soil legend. Clicking on this link provides, in a separate browser window, a full description of the soil series map units found in the selected county.

The selection page requires the user to choose from three broad management types: hay, pasture, or conservation. This is the introductory screen for the management questions that prime the decision support component of the FSST. A click on the desired option moves the user to a forms-enabled Web page that queries the user for information regarding management practices (Fig. 8). The user completes the query form and clicks “Finished”. The decision support system then responds with a results page, depicted in Fig. 9, that provides a summary of the input information supplied by the user and a list of the recommended, acceptable, and not tested forage species for the particular field and management inputs.



Fig. 8. Pasture use management screen in the Forages Species Selection Tool.



Fig. 9. Forage species selection results screen.

Data Resources. A web-based mapping system for forage species selection requires spatial information resources that can be combined to create a hierarchical system of maps and imagery that allow the user to navigate to the desired field location. Developing this nested system of maps requires combining geographic information system processing and analysis with advanced cartographic design. The data resources required include: political boundaries, roads, streams, topography, digital orthophotography quadrangles, and soils information. We used standard spatial data processing techniques to create the data layers required for the selection tool.

Cultural and Physiographic Information. Cultural features such as roads and political boundaries and physiographic features such as streams are useful for orientation and navigation in the interactive web mapping environment. The Pennsylvania Spatial Data Access facility (PASDA), Pennsylvania's node on the National Spatial Data Infrastructure (NSDI), maintains a wide range of spatial data resources. We used PASDA's holdings of the Pennsylvania Department of Transportation spatial data on political boundaries (county, borough, cities, towns), as well as roads and streams to build the map layers for the FSST.

Digital Orthophotography. Digital orthophotography provides an important element of realism in the user interface. With the goal of allowing the user to locate specific fields, DOQs offer the most realistic depiction of the land surface available to the project with minimal cost of download and processing. The DOQs used in this project were obtained from PASDA. The DOQs, which are available as individual quarter quads of standard US Geological Survey (USGS) 7.5-minute quadrangles, have a nominal 1 meter resolution and are available for the entire state. All quarter quads for PA were downloaded from the PASDA facility and mosaicked into image tiles of approximately 4000 by 4000 pixels at a re-sampled resolution of 3 meters. The individual quarter quads were carefully processed to minimize illumination differences between adjoining quadrangles.

Soil Information. Soil series information for the FSST is obtained from the Soil Geographic Database (SSURGO) developed by the USDA-NRCS (4). The SSURGO data, at scales ranging from 1:15,840 to 1:24,000 represent the most detailed digital soils information currently available in the United States. The SSURGO data are most commonly distributed on a county-level basis and consist of map unit delineations in the form of polygons with associated tabular files of soil attribute information.

For the purposes of the FSST, information on natural soil drainage status, pH, and predicted yields of forage crops for specified soil series were extracted from the SSURGO data tables. This information formed the basis for the

development of estimated yield tables based on experience for the county of interest. At the time of this writing, only 12 of 67 Pennsylvania counties have NRCS-certified SSURGO data.

Decision Support System. The FSST decision support system is implemented via a MySQL relational database (5). The field location information, soil attributes, and management use information collected from the user are passed to the MySQL database via the CGI using a script written in Perl (3). The database contains tables, prepared by a forage expert, that contain potential yield information (under natural and artificial drainage), pH adjustment factors, species acceptability and species test status for each soil series. Each potential species for the selected soil series is evaluated against the input information and a list including recommended, acceptable, unacceptable, and untested species is generated. This list is then presented back to the user through the Web browser.

Summary

The Forage Species Selection Tool addresses the challenge of providing accurate recommendations to forage producers who seek to maximize their production resources, primarily soil, and minimize the costs associated with negative impacts in the form of soil erosion, water quality, disease, pests, and drought. A web mapping approach that focuses on the spatial nature of the forage species selection problem provides the user with the ability to target a request to the specific farm field and quickly obtain a recommendation. The FSST may be accessed at www.forages.psu.edu.

Simply creating a GIS database and placing the system on the Web would not provide the useable interface that we have created with the FSST. Few users have been trained to use GIS software and providing a solution using a typical GIS software interface, even those currently being developed for Web applications, would fail to serve the majority of users who would benefit from the selection tool. In developing the FSST, we applied cartographic design to create a set of standard parameters (e.g., color, line weight, text placement) that were then passed into the GIS environment where they were fed to a series of scripted programs developed to automate the map creation process.

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