GIS-Based Forage Species Adaptation Mapping

David B. Hannaway
Oregon State University

C. Daly
Oregon State University

W. Gibson
Oregon State University

G. Taylor
Oregon State University

J. P. Bolte
Oregon State University

See next page for additional authors

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GIS-BASED FORAGE SPECIES ADAPTATION MAPPING

D.B. Hannaway[1], C. Daly[2], W. Gibson[2], G. Taylor[3], J.P. Bolte[4], I. Sriprisan[4] and T. Griggs[5]

[1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331

[2]Spatial Climate Analysis Service, Oregon State University, Corvallis, OR 97331

[3]Oregon Climate Service, Oregon State University, Corvallis, OR 97331

[4]Department of Bioresource Engineering, Oregon State University, Corvallis, OR 97331

[5]Grant-Adams Area Cooperative Extension, Washington State University, Ephrata, WA 98823

Abstract

Selecting forage crops adapted to the climatic and edaphic conditions of specific locations is essential for economic sustainability and environmental protection. Yet, currently, proper selection is difficult due to the absence of advanced selection tools. Significant improvements are being made in the process through Geographic Information System (GIS)-based mapping. Climate and soil GIS layers are being matched with forage characteristics through rules describing species tolerances. Better matching will reduce economic risks and environmental hazards associated with sub-optimal crop selection and subsequent performance. Once developed, these forage crop selection strategies and tools can be adapted for use with other crops. A matrix of species characteristics is being assembled for 6 major forage crops. GIS-based climate and soils maps are being developed and reviewed. Base layer climate and soils maps and the species adaptation maps will be placed on a CD-ROM to help educators, consultants, farmers, and ranchers match their conditions to suitable forage crop species. A WWW segment is being

developed to provide a source of current information and links to original data and supplementary materials.

Keywords: Climate, Soils, WWW, CD-ROM

Acronyms or Abbreviations: Geographic Information Systems (GIS)

Introduction

A major focus in agriculture today is sustainability - seeking to utilize plant, animal, soil, and water resources in the most-productive and least-damaging manner. Consequently, farmers and ranchers frequently request recommendations on which species and varieties would best fit into their forage-livestock system (Bolte et al., 1991; Hannaway et al., 1992). Current crop selection tools are too generalized and do not utilize the wealth of knowledge currently available from different disciplines. The goal of this project is to develop improved forage crop selection tools which (1) better capture and disseminate the collective knowledge of forage agronomists, grassland ecologists, GIS specialists, climatologists, soil scientists, information science specialists, farmers, and ranchers, and (2) facilitate improved, individually tailored, on-farm/ranch decision making. With interagency / interdisciplinary teamwork and collaboration with the private sector, this project is improving the forage crop selection process, thereby reducing economic risks and environmental hazards when less appropriate or inappropriate crops are selected.

Current Situation and Need

Most textbooks, seed catalogs, crop fact sheets, and technical guides include an adaptation zone description or a map that shows a zone where the species being discussed could be grown. A

graphics artist working with a crop specialist typically uses general agricultural concepts and broad groupings of precipitation and temperature and/or soils to develop maps. The result is a general idea of where the crop might be successful. These currently available maps give general adaptation zones using a few factors, and are of minimal value in decision-making. They are not adequate for individually tailored decision making, since they do not give specific locations for successful or optimal yield. In fact, they cannot, since they are not based on quantitative measurements of the critical factors (minimum, maximum, and optimal ranges for precipitation, temperature, photoperiod, soil pH and drainage, elevation, slope, aspect, etc.).

This universal problem of sub-optimal crop selection could be solved, however, by the assembling and effective use of "quantitative ecology" techniques. Quantitative ecology information can be used to define the highly productive range and survival limits of crops in specific terms (i.e. minimum, maximum, and optimal ranges for temperature, precipitation, pH, drainage) (Jackson and Gaston, 1992).

Materials and Methods

Objective. Create forage crop suitability zone maps that integrate climate, soil, and crop information.

The following steps are being used:

a. Assemble existing data resources from various agencies and disciplines responsible for climate, soil, and crop characteristics.

b. Identify missing data required for development of optimal forage crop selection tools.

c. Coordinate activities needed for filling in missing data.

d. Coordinate map development of forage crop suitability zones using assembled resources.

e. Establish and use “ground truthing” methodology to evaluate map accuracy.

f. Overlay initial maps with econometric analysis data, transportation, marketing, and other appropriate data layers that influence crop selection strategies.

Techniques and Procedures

Our approach differs from traditional species adaptation and selection approaches in that we are developing a matrix of crop growth limitations and matching these quantitative data with the GIS maps of each: climate, soil, and geophysical elements (temperature, precipitation, etc.). This will allow for individually tailored recommendations for farmers and ranchers in predicting adaptation zones for specific crops.

The required crop eco-physiology information currently is available for many crops but is scattered throughout various research papers and isolated crop species literature so that profitable use is greatly hindered. This project is assembling and making these data readily usable, thereby encouraging a more ecologically based selection process for identifying crop adaptation zones (Hannaway et al., 2000). Missing data are being identified and applied research needs identified to fill those knowledge gaps. GIS-based maps for climate and soils of the US are available, though scattered in various WWW and ftp sites and not immediately usable or “user-friendly.”

This project is assembling these data and providing links to the original sources.

"Ground truthing" will be accomplished with the help of US and international collaborators in collecting data from applied research trials, both those developed specifically for this project and those adapted from other projects to include the data needed by this validation effort.

Results and Discussion

A web site has been developed that provides links to the climate, soil, and crop characteristics data. The draft web site is located at the following URL: http://forages.orst.edu/Projects/OFSSS/ as a part of the Forage Information System (Hannaway et al., 1995). Maps are being developed using ArcInfo (commercial GIS software), GRASS (public sector software), and PRISM (Daly, 2000; Taylor, 2000). Maps are being posted to the web site as developed. Access is currently restricted to cooperators using a password system to reduce the use of draft maps in advance of their validation. A crop characteristic matrix is being developed for the factors that limit the adaptation zone for each species. The draft matrix also has been posted to the above-mentioned web site address. It identifies the quantitative limits used to create the draft adaptation maps. Additional overlays will be provided by economists and marketing and transportation specialists. Other social factors are being considered and will be added as the concepts are developed with collaborators with that expertise.

Difficulties Experienced

Complete data sets for the climate, soil, and crop eco-physiology data are difficult to obtain. Dealing with incomplete data and making first approximations have been the reality. However, developing the initial maps with the assumptions quantitatively defined is allowing cooperating scientists to make recommendations for improvements and to conduct experiments to obtain the

necessary missing data. Keeping collaborators "on task" is a significant challenge. However, the "core development team" is located at Oregon State University and we are collaborating on other projects and developing an efficient working relationship including faculty, students, and staff. The funding provided by extramural grants is helping to focus energy on this effort to make significant progress.

Future Activities and Components

Funding has been requested through other grant opportunities to develop a dynamic mapping component to the project. This will allow interactive exchanges by cooperators in changing crop characteristics and seeing the changes that occur on species adaptation maps. Base layer maps (climate and soils) will not be modified, but the characteristics describing the tolerances of species to climate and soils will be changeable.

Linkage of species adaptation maps to dynamic simulation models is anticipated as a further development of the project. This will allow "production profiles" to be created for forage species, thus predicting seasonal yield and linkage with grazing capacity decision-making.

References

Bolte, J. P., D.B. Hannaway, P.E. Shuler, and P.J. Ballerstedt. (1991). An intelligent frame system for cultivar selection. AI Appl. in Natural Res. Mgt. **5**:21-31.

Daly, C. (2000). Spatial Climate Analysis Service. http://www.ocs.orst.edu/PRISM/

Hannaway, D.B., J.P. Bolte, P.E. Shuler, and P.J. Ballerstedt. (1992). ACE: Alfalfa cultivar expert. J. of Prod. Agric. **5**:85-88.

Hannaway, D.B., S. Griffith, P. Sohn, and K.J. Hannaway. (1995). Forage Information System. http://forages.orst.edu/

Hannaway, D.B., C. Daly, I. Sriprisan, J. Bolte, and T. Griggs. (2000). Forage Information System. Optimal Forage Species Selection System. http://forages.orst.edu/Projects/OFSSS/

Jackson, P.L., and G.G. Gaston. (1992). Maximum extent of potential non-irrigated crop growing areas in the coterminous United States: maps of the relative geographic range of crop production based on inherent environmental factors. Contract EPA-OBO201NAEX, U.S. Environmental Protection Agency, Global Climate Research Program, Corvallis, Oregon.

Taylor, G.H. (2000). Oregon Climate Service. http://www.ocs.orst.edu/