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An internet-based GIS application for vineyard site assessment in the U.S. and matching grape variety to site

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ABSTRACT
Vineyard site selection and determination of adapted grape varieties for a site are the most fundamental factors contributing to vineyard success, but can be challenging to ascertain, especially in developing wine regions. The objective of this research is to demonstrate, and describe the development of an internet based, scientifically objective tool to facilitate vineyard site assessment and grape variety selection in the US. The core of this tool is a spatially explicit environmental database relevant to wine grape production including climate, soil and topography data. The climate summaries are sourced from the U.S. National Climatic Data Center (NCDC) and the World Meteorological Organization (WMO). The daily elements included in our dataset are maximum temperature, minimum temperature, mean temperature, dew point, precipitation, and elevation for 1929 to present. Similarly, our soil database is derived from the Soil Survey Geographic (SSURGO) database for the continental U.S.A and the Harmonized World Soil Database for global soil data. Parameters include soil texture, pH, soil depth, water holding capacity, etc. This database was used to derive established and novel environmental indices relevant to grape production. The indices were used as inputs to mathematical and statistical models to examine the relationship between environmental factors and variety production in selected established growing regions. Finally, we incorporated both the environmental database, and the site/varietal selection models into a web-based site and grape variety selection tool. This tool enables a potential wine grape grower to either determine varieties most suited to a particular site or delineate areas most suitable for growing a particular grape variety.

Keywords: GIS, viticulture and site sélection.

1 INTRODUCTION

The US wine industry has been steadily growing over the last decades with increasing demand for high quality grapes and wine. Given the financial burden associated with growing grapes, choosing a location or variety becomes paramount. The process of matching grape varieties to environmental conditions will affect yields and profitability for the life of the vineyard and is a determining factor for economic success in wine grape production. The environmental conditions within vineyards have a large influence on the quality of grapes for wine production. The goal of this project is to develop models that relate environmental conditions to the culture of successful grapes for wine making. At the most basic level, this will allow users to select potential sites most likely to support grapes of a given variety or select the varieties that are most suitable for a particular location. The foundation of this technology is grounded upon 3 functional principles that will allow viticulturists to effectively explore, compare, and analyze a scientific approach to vineyard selection. The process of site selection or matching varieties to location is becoming an increasingly exact science that involves careful objective analysis of climate, soil, and

topographic data. For any location around the world, a user can explore raw environmental data, compare between one or several locations or analyze locations using pre-existing models and or novel environmental indices.

2 METHODS

2.1 System architecture

The system was designed to support research through Web-based GIS applications structured to rapidly share model results via the internet. The client/server architecture proposed in Figure1 was implemented using open source tools in order to guarantee the web application's sustainability. Implementation of customized geospatial and analytical functions were easily developed given the current design which allows user specified queries driven by a comprehensive collection of environmental factors relevant to grape vine growth.

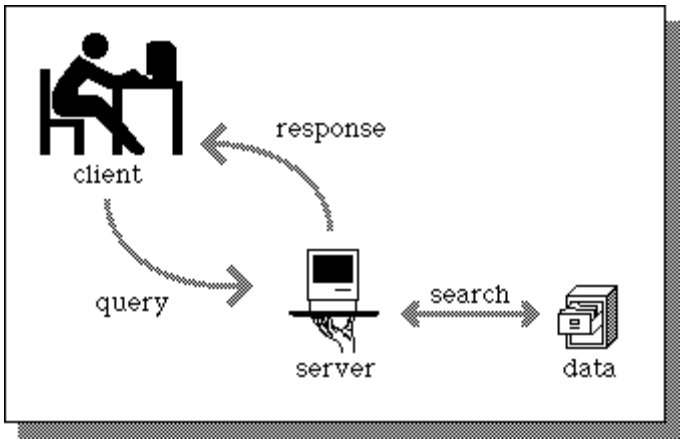

Figure 1. Web-based system architecture.

The client server structure provides growers with the information they need at a scale they can use for managing spatially based information. This architecture played a key role in integrating spatially based information from a variety of sources. A central database of relevant climate, soil, and topographic variables as well as grape variety information lies at the core of this system architecture. The ability to query all environmental factors relevant to viticulture within one central location is a novelty of this system architecture.

2.2 Environmental Database

One of the initial steps in this endeavor was to assimilate a spatial database of environmental indices most relevant to viticulture. This process involved collecting climate, soil and topographic data from various sources for careful construction of an SQL database. The climate data summaries include descriptions of global surface summary data ranging from 1929 to present produced by the National Climatic Data Center (NCDC) and the World Meteorological Organization (WMO). For the purposes of our project, the climate data ranged from 1960 to December of 2011 with daily elements of mean temperature, dew point, maximum temperature, minimum temperature, precipitation, and elevation. Soils data was derived primarily from the Soil Survey Geographic (SSURGO) database which provides the most detailed level of soil information for the continental U.S.A. and the Harmonized World Soil Database for global soil data. Parameters included in the soil database were soil texture, pH, soil depth, and water holding capacity. One of the goals of this project was to provide a useful, geographically coherent, multi-source and site-specific data base to support viticulture. The environmental database is a relational database designed to store, query, and manipulate geographic information and spatial data relevant to viticulture. The primary advantage of spatial databases, over file-based data storage, is that they allow implementation of geospatial functions and GIS procedures necessary to model viticultural environments best suited for specific varieties. This includes support for SQL and the ability to generate complex geospatial queries. Moreover the database's client/server architecture supports multiple users and allows them to query and visualize the database with a standard web browser.

2.3 Data Modeling

The conceptual design of the database is based on the idea of georeferenced queries and data retrieval for statistical analysis of site-specific environmental variations with the potential to expand the relations given new data for new growing regions. Our modeling efforts reflect continued research into the development of information management systems to gain a more complete understanding of regional factors and their influences on grapevine growth and yield. Techniques for identifying the interactions among these factors range from modeling specific affects of the environment within and among vineyards. Simple yet novel indices describing summary variations include cumulative degree days (CGDD), frost dates (FFD and LFD), growing season average temperature (GSAT), bud break (BB) estimations and ripening period mean

temperature (RPMT) were established for any location within the global map interface.

3 DISCUSSION

The development of this system centered upon 3 main stages which were critical to the success of this technology. Simply stated, users of the system can explore, compare, and analyze data within and between locations. In the exploratory phase, raw data of environmental factors can be downloaded in both tabular and graphical formats. This is then returned to the user as an excel spreadsheet in its most native form prior to any user specified analysis. The comparative phase involves applying user specified indices which are part of the graphic user interface (GUI) for comparisons of two or more regions of interest. Figure 2 depicts a simple comparative analysis of daily annual average temperature in Dijon France and Napa California.

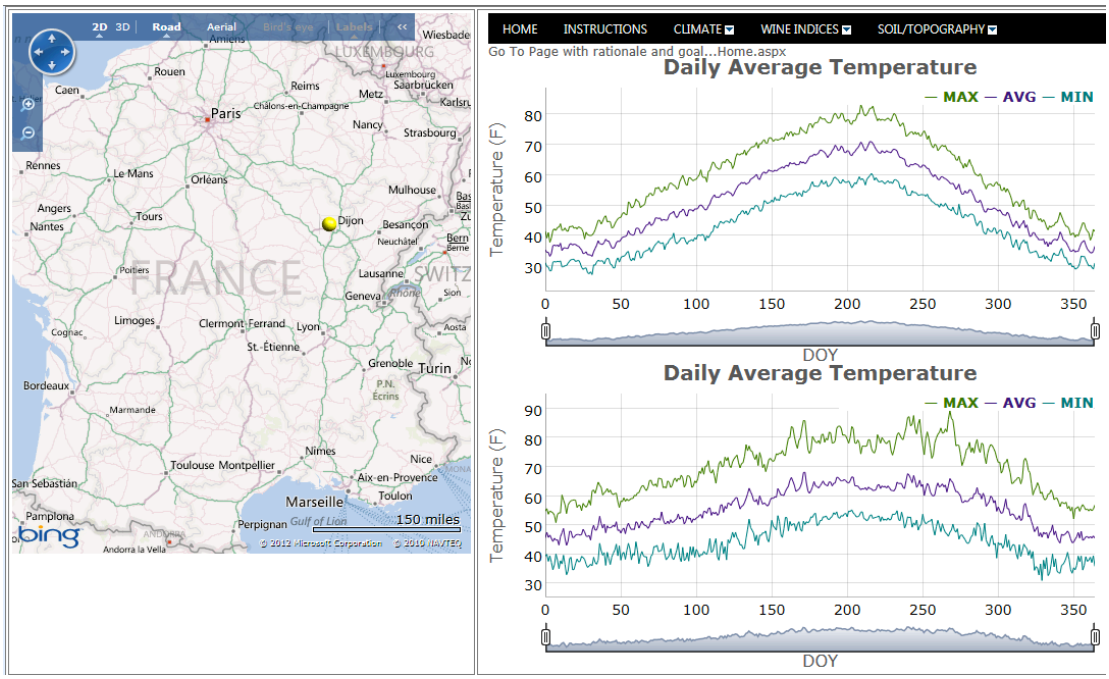

Figure 2. Simple comparison of Daily Annual Average Temperature in Dijon France and Napa California.

Users can choose any global location for comparative analysis based on derived environmental indices. The ability to graphically compare variations at one or several locations by analysis of indices such as degree days or soil texture type, demonstrates one of the key objectives of this research. The analysis and consequent extrapolation of model out to new locations illustrates the final stage of the design functionality. Selecting a location quickly allows the user to explore existing raw environmental data, compare between one or many locations, and analyze variation of environmental factors.

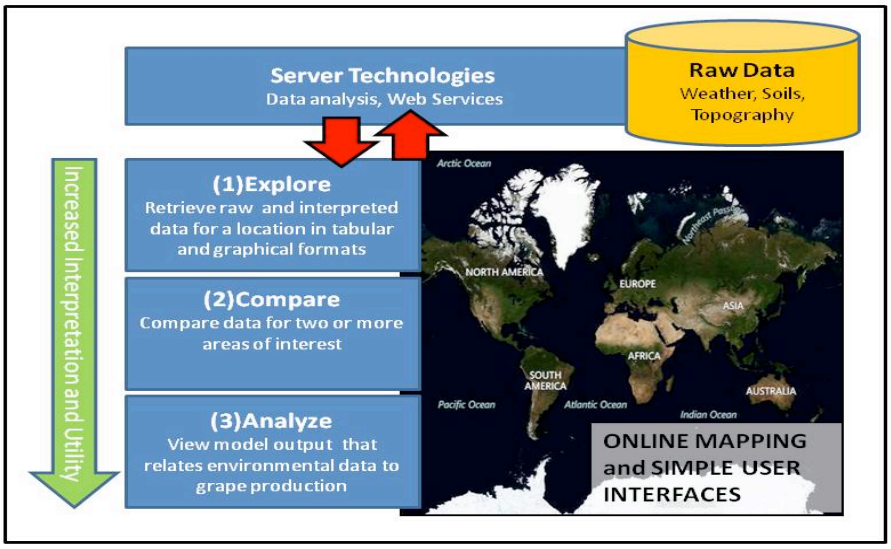

Figure 3. Visual display of system functionality and levels of interaction.

There is an increased level of interpretation as the user interacts with the technology lending to the uniqueness of the system. Users can now interact, visualize, and interpret factor variations between locations to make decisions about where to grow specific varieties or what varieties are best suited for a particular location. Figure 3 outlines a complete description of the system, displaying the levels of user interaction and increased interpretive utility. Our models will provide a brief demonstration of the system by exploring a scientific approach towards determination of adapted varieties to a particular location.

4 CONCLUSION

Data acquisition, visualization and modeling of information in viticulture was used to determine varieties most suited to a particular site and sites most suited to particular varieties. By implementing dynamic web-based technology, viticulturist and researchers can access geographic information and data using a standard desktop computer without installing expensive GIS software. A centralized database of environmental variables allows instant access to data and information for any location in the world. User interpretation of data and model results allows for extrapolation in order to delineate locations most suited for growing a particular variety. Exploratory and comparative analysis of environmental variation between locations is one of the key aspects of the system technology. Moreover, future developments of this web application will address a fully customizable GUI with statistical and analysis tools beyond the current descriptive indices.

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Identifying New Zealand Sauvignon blanc terroirs

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ABSTRACT

The concept of terroir is well established in the 'old world' wine industry but its use is still relatively new in New Zealand. Marlborough Sauvignon blanc has become a benchmark for Sauvignon blanc around the world. However, under *The NZ Geographical Indications (Wines and Spirits) Registration Act 2006,* this label covers all the Sauvignon