More Modern Than You Might Think:
Four Uses of GIS in the Wine Industry
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The production of wine is an ancient craft, a rich blend of art, science, and technique. Few other trades have adhered to strong tradition while embracing sophisticated modern technology as the wine industry has. This is nowhere more seen than in the impact of GIS on viticulture, the growing of grapes in a vineyard to ferment into wine. Wine grapes come in many varieties, each requiring specific climatic and geomorphological conditions to reach their ideal yield at harvest. These conditions, along with various production techniques, have led to the designation of numerous wine-grape growing regions around the globe, known as appellations. The notion of appellation is so crucial to the study of viticulture, and indeed, to wine culture itself, that we shall pause here to define it before continuing any farther.

Distinguished appellations are a common part of our culinary lives, even if we commonly fail to recognize them as such. Champagne, France, for instance, is the region of that country that has traditionally used a secondary fermentation process for finishing wine made from Pinot noir and Chardonnay grapes grown there. This product produced in exactly the same fashion anywhere else in the world would be known as sparkling wine. But coming from the Champagne Appellation in France it is something more; it is champagne. The limited annual production from Champagne, along with its renown worldwide, keep the price of true champagne up, while many fine sparkling wines are enjoyed for less than seven dollars a bottle. The obvious economic implications, along with the art of tradition and terroir, have made the delineation and study of these appellations even more important as Geographic Information Systems have proliferated and gained familiarity in all industries.

The obstacles facing each of these appellations are unique to their geography, but many challenges are shared by all of them, inherent of any vineyard. These are easily broken up into several categories: first is the influence of global climate change on grapes, given their narrow preferences. Second is the establishment of new vineyards that will share the qualities of their appellation, or perhaps not. Third is the ongoing delineation of these appellations, and lastly is precision farming within the confines of the vineyards.

Geographic Information Systems, GIS, and Remote Sensing data, RS, have played a crucial role in the progress vineyard operators have made overcoming these challenges. They have, of course, had the input of consultants, lawyers, lawmakers, conservationists, and researchers, but the end result has always been a win for the viticulturists.

Climate change, ever a contentious topic, is of great concern in the viticultural world. Perhaps surprisingly, it is no less contentious in the wine industry than anywhere else. Given that each grape variety has a very narrow band of conditions considered ideal for the production of fruit to be used in producing wine it is obvious why climate change is a “hot” topic for the future of the industry. Many models have been compiled from remote sensing data collected by the Terra and other satellites, to estimate growing degree-days, frost degree-days, and from these, models of regions with ideal suitability 50 years from now1. Yet even this research has been called into question2, and with good reason. Many appellations are currently growing wine grapes outside of their supposed maximum average temperature, and growing them quite well. Burgundy, France, is renowned for its Pinot noir burgundy. Pinot noir plants prefer cooler regions, and for this reason are also popular varieties in Oregon’s Willamette Valley and other west-coast American Viticultural Areas. Burgundy, however, is already at an average seasonal growing temperature hotter than previously thought Pinot noir could succeed in, and continues to produce an outstanding product3. The explanation for the continued success of viticulture in Burgundy, and
elsewhere experiencing record growing season highs, is a human factor that was originally considered to
be fixed, and not nearly as pliable as it now appears to be: quite simply, as the terroir of a traditional wine
appellation changes, consumer’s tastes change to match. In this way it can be seen that at burgundy from
the mid 1970’s is completely different from a 2012 burgundy, but not necessarily a superior product now
unattainable, just a function of the times that produced it. Much research continues to be done in this
arena, using ever more detailed RS data from an increasing time series database to construct the finest
climatic models possible.

In the United States grape production continues to grow, with the acreage devoted to vineyards in
Washington State alone increased nearly 400% over the last 18 years³. Selecting new land on which to
establish a crop as finicky as grapes is a task ideally suited to GIS programs. Most varieties of Vitis
Vinifera produce the highest quality fruit only under very specific conditions, heavily dependent on the
climate and geomorphology of the region. Each of these conditions, once studied and digitized into a
database, can be represented as a layer in a GIS program. Overlaying these layers and searching for a
desired combination of attributes using map algebra⁴ provides an index of suitability for where vineyards
might be most successful. In creating this index commonly used data and layers are climatological
factors such as growing degree-days, frost degree-days, and even prominent wind direction, as well as
physical attributes of the site such as soil clay content (representing drainage), soil type, elevation, slope,
aspect, and land use. All these layers are weighted differently in the final calculation, leading to a
prediction of the best possible sites for establishment of a vineyard. Groundtruthing with GIS and soil
pits is then preformed to verify this model if a likely site is selected, and the vineyard can move into the
legal stage of development.

The analysis of land suitability by GIS is also used in the ongoing delineation of appellations in
the New World. While the appellations in Europe have been established since the early 1700’s in Italy⁵,
American Viticultural Areas (AVAs) continue to evolve. AVAs, though widely known, are still very new
in this country, with the first being legally recognized in 1980 in Augusta, Missouri. Unlike traditional
European appellations vineyards, AVAs are established at the request of petitioners such as wineries and
viticulturists and may be as small as an individual vineyard. The requirements for legal recognition are
simple; an AVA must demonstrate to the Alcohol and Tobacco Tax and Trade Bureau that it is composed
of unique growing conditions and thus possesses a terroir different from all the regions around it.
Though much less restrictive and exacting than the European system, AVAs are still used as a seal of
quality by many consumers, and still have huge economic implications for the vineyards that fall within
their borders. Given this, a similar GIS overlay is used to identify areas belonging to individual AVAs as
is used to identify sites suitable for development. By exploring the physical and climatic factors that
make up an AVA new applicants can either be admitted or redesigned as a new viticultural area.

At the individual vineyard scale, Geographic Information Systems and Remote Sensing data are
being used for precision agriculture. Precision agriculture is the targeted application of pesticides,
fungicides, fertilizer, and irrigation where it is most needed instead of blanked across the entire crop.
This technique greatly reduces the volume of all additives used, benefitting both the farmer by reducing
costs as well as having a substantially smaller impact on the environment in the surrounding land.
Decisions about what products must be applied where are based on data including remote sensing near-IR
images and climate data, GPS-collected data, soil maps, and samples of grapes and vine health. The
process of precision viticulture is not a cut-and-dry method implemented easily based on a few aerial
photos of the farm, but rather an ongoing cyclical science⁶. All the above inputs must be analyzed with
geospatial reference to the vineyard and over a period of many seasons (usually about three years) to
account for any annual variations. Once trends have been observed precision viticulture decisions may be
enacted and the process of observation and correction begins anew, targeted not at the greatest quantity of
wine, but rather the highest quality.
Geospatial data and analysis has become an integral part of the wine industry over the last few decades, affecting all aspects of viticulture. From the legal and economic ramifications of where grapes are grown down to what special care must be given to an individual plant GIS and RS systems have made profound improvements for vineyards across the world. The wine industry clings to its traditions strongly, but is not afraid of incorporating in new technology where there are obvious benefits to be gained. This versatility is part of the charm and mystique of wine, so next time you uncork a Pinot noir from Burgundy, don’t think just of an ancient village in the picturesque country. Think satellites and GPS receivers too. Think soil maps and hill aspect and elevation above sea level. The history of wine is evolving around us, with viticulturists and scientists studying the grape’s reaction to a changing climate, and new vineyards being established every day. So sit back, enjoy that Pinot and the art that went into it, but give a nod to the Geographic Information System too, for you never know where the next best appellation is going to be found.
Paper References:


Annotated Bibliography:


Mathews starts off this paper with the strong claim that GIS is revolutionizing wine industry. He backs this up with a fantastic, detailed summery of that revolution in three research areas: site suitability, vineyard identification, and the evolution of precision viticulture. Site suitability is concerned with the vineyards of the future; where they will be located and what qualities they will have. Many viticulturists are studying this question, and GIS is the perfect tool for the job. Formulating models using many layers, which Mathews gives, and weighting those layers differently in the models has allowed for the extrapolation of current vineyards onto future sites. Vineyard identification has many components, but Mathews focuses in not on the delineation of appellations as many other studies do, but rather on the challenges and solutions that abound in using remote sensing information for a crop so heavily grown in separate rows. Lastly, precision viticulture (PV) is being developed to utilize fertilizer, pesticides, irrigation, and other inputs most effectively to reduce costs in increase yield. PV is the most integrative example of geospatial techniques in viticulture, drawing on satellite near-IR data, GIS models, and GPS accuracy for best management of individual plants and entire appellations.


This paper is dedicated to advancing the techniques used to delineate American Viticultural Areas (AVAs). Yau begins with an introduction to AVAs and a few statistics about the Inland Pacific North West wine industry as a whole. Yau then moves quickly into what factors most strongly affect grape health and character, and how small variations in these factors have led to the American appellations we have today. This is a good summery of not only why our appellations are established in the way that they are, but also how they differ from the European appellation system. Yau then demonstrates how using various geospatial data the demarcations between AVA’s can be solidified to precise lines rather than more vague descriptions. Specifically, Yau includes soils, frost-free and growing-degree days, topography, and hill slope and aspect. This paper was great for enhancing my overall understanding of appellation composition and providing an overview of the application of GIS to the delineations there of.
If Yau’s paper was a short and sweet overview of GIS use in the delineation of AVA’s, Wood’s thesis is an exhaustively detailed study of the specific methods and their application. Wood has a leg up on this subject already; before pursuing his Masters he worked as a GIS consultant helping vineyards, lawmakers, and distributors to delineate and understand their appellations. Of all the factors defining appellation, Wood focuses on soils as his main interest, as his study area in the Willamette Valley is uniquely focused on soil variations over climatic factors. In particular, Wood makes the case for the Sub-AVAs being broken out exclusively based on site-specific soil types, again referencing his previous experience as a consultant. Chapter two includes a great summery of GIS versatility for the business, both in terms of technical functionality as well as utility of the results to many interested parties.


Hannah et al. wrote this short paper from a conservation perspective, but it seems to me that many of the insights it contains are of more concern to the vineyard owners and workers than they are to conservationists. In short, Hannah argues that in the very near future rainfall and temperature changes over all grape-growing regions will force farmers to draw increasingly on already taxed water supplies, and clearing new land as they seek better growing regions. He makes the case for the impending changes well, using MODIS and other RS data to compile models of current and predicted climatic suitability, all pointing to the loss of biodiversity as farmers migrate to the best growing conditions. What he totally misses, though, is the human element, that the wine industry, already in decline globally, could be hit with another huge blow over the next 50 years.


This is a response to the paper by Hannah et al. and does not contain any GIS usage. Nonetheless, I am including it in this bibliography as it serves to illustrate both the inherent dangers of making predictions using RS climate data as well as the wine industry’s tendency to embrace new technology. Leeuwin argues that Hannah did not use his references well in the construction of his models and did not look up from the computer screen to what was happening in the real world. Globally, vineyards are being faced with hotter, drier days. To a degree, this is exactly that the grapes want. However, under too much stress the grapes will not ripen ideally for traditional wine production and the desired terroir will be forever lost. Vineyard operators have combated this with the latest irrigation and harvesting technology, and more interestingly, consumer’s tastes have changed to match the new character of the wine. For instance, Pinot Noir grapes are currently being grown in Burgundy above the maximum temperature cited by Hanna, and the appellation has suffered no backlash from consumers, despite the fact that burgundy today will taste quite different from the burgundy of the 1970’s.

Porte, B; J. Rochard, M. Helden, J. Guenser, and E. Fulchin. GIS for Planning Conservation Actions in Viticulture Landscapes. European Environmental Commission, LIFE Project, LIFE09
Porte et al. are concerned with the biodiversity and conservation of species in wine growing regions. They describe methods of using GIS mapping as a tool for habitat analysis and restoration/conservation planning. Specifically, they assessed study sites at appellation scale by constructing overlays of several physical and conservational properties to locate sampling areas representative of the landscape. Site-specific surveys were designed in GIS as radii around a sampling point, and then potential habitat and human land use were assessed within these regions for more detail than could be provided by remote sensing. GIS was used as a tool to determine areas for immediate conservation as well as a communication tool to interface with the vineyard operators. I also like that this paper admitted to some of the shortcomings of GIS, that at smaller scales their data did not represent ecological connectivity very well.