A Spatial Analysis of Terroir of Wine in Bordeaux, France

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Introduction

Terroir is a term that refers to the role geography plays in imparting characteristics to the plants that are grown for food and drink production. This project looks at the role that geography plays in wine production in Bordeaux, France (Figure 1). The slope, altitude, and aspect of the terrain was taken into consideration as well as the underlying soil. Certain wines are regarded more highly than others in the compact growing region that forms the study area for this project and this analysis intended to determine if there is a geographic basis for this price difference.

The Bordeaux Wine Official Classification of 1855 ranked the wines of the region from First to Fifth Growths (crus). In addition France employs a system of labeling, AOC (appellation d'origin controlee) a protected geographical indication (PGI), to limit the naming and labeling of products to a certain region.

New GIS based forms of visualization were used in an attempt to make geographic information available to the farmers and vintners. I also investigated free and open source GIS software which can be easier to adopt than proprietary software if software cost is an issue.

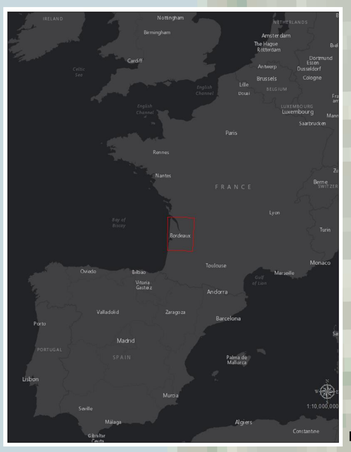


Figure 1. *Bordeaux, France*

Data and Data Sources

The data for this project (Table 1) were obtained from the U.S. Geological Survey. The digital elevation model (DEM) was a 30 arc second grid (approximately 1 kilometer resolution). The imagery was also obtained from the USGS in the form of LandSat8 imagery. After pansharpening, the resolution of this imagery is 15km. The Food and Agriculture Organization of the United Nations, headquartered in Rome, supplied the soil information. For the "appellations" shapefile I found descriptions of the area they encompass to digitize them. I looked up the addresses of the first growth châteaux in located in the study area and digitized their locations.

Table 1. *List of data and data sources used in the project*

Dataset	Source
DEM	USGS
LandSat8 imagery	USGS EROS
Europe Soil Map	Land and Water Development Division, FAO, Rome
Appellations	Digitized by author
Châteaux	Digitized by author

Methodology

After downloading the data I ran the compressed LandSat8 files through a Python script that I developed. This script decompressed the downloaded datasets, layer stacked (Composite Bands in ArcMap) the important bands, pansharpened the resulting layerstacked image, and also generated a Normalized Difference Vegetation Index raster. These images were put into Windows Movie Maker software to make an animation of three years of the growing season in NDVI form.

Using the DEM I created aspect, slope, and hillshade. I used this along with the shapefiles I digitized and the soil data to find unique characteristics for the First Growth wineries in the region.

Using the DEM and false color imagery in ArcScene I created a 3D fly through animation showing the locations and prices of First Growth châteaux.

In QGIS I added my digitized appellations and châteaux along with a hillshade from the DEM to make an interactive webmap. Clicking on a château or appellation will give information about the price of a bottle or number of acres under vine and hectolitres of wine produced.

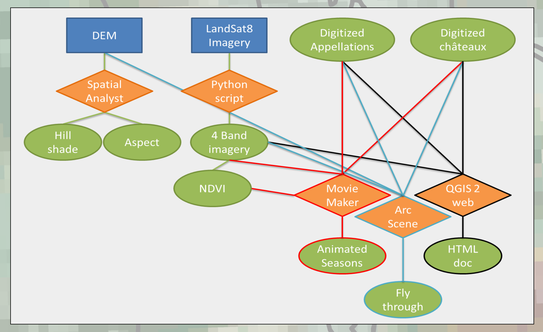


Figure 2. *This model represents the steps taken in processing the data for incorporation in the project's map products*

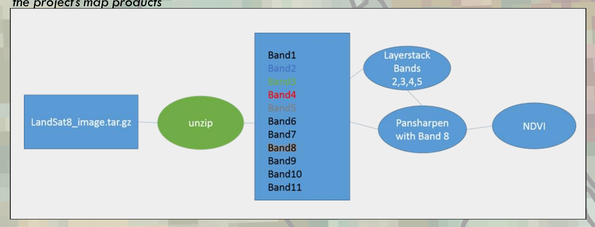
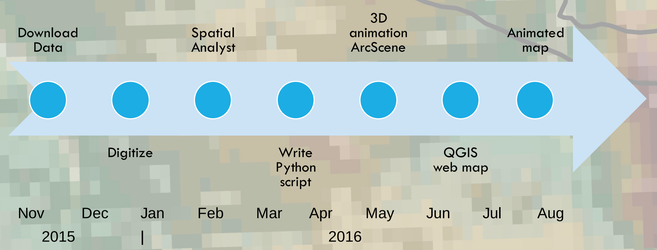


Figure 3. *Model of the Python script*

Timeline



Results

I started the analysis focusing on the First Growth Châteaux in the Classification of 1855 (Table 1). These are the most prestigious wineries. There are some similarities that stand out. All of these vineyards are nearly flat. None of the First Growth fields have over 1 percent slope. The slight slope that is there causes the fields to face either Northeast or East (Figure 5). There is a commonality in the relatively low altitude of these wineries. Ranging from 4 to 23 meters, these are all relatively low lying areas. The soil is also the same for these sites.

The animated maps and the interactive webmap add another dimension to exploring the results of this analysis (Figures 6-8).

Table 2. *Characteristics of First Growth Châteaux*

Château	Aspect	Altitude (m)	Slope %	Dominant Soil
Lafite	Ne 40.71	23.6068	0.652038	Jc
Mouton	E 105.25	22.8747	0.994868	Jc
Latour	E 68.80	10.7422	0.099363	Jc
Margaux	Ne 45.00	4.0533	0.923124	Jc
Haut-Brion	Ne 45.00	24.3008	0.652038	Jc

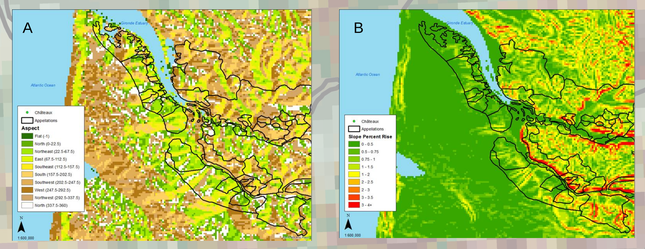


Figure 5. *Aspect (5A) and Slope (5B) derived from the DEM*

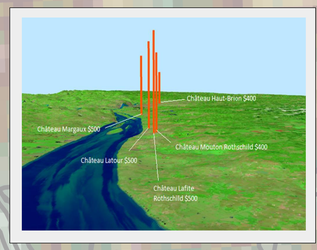


Figure 6. *Image from the 3D flythrough animation*

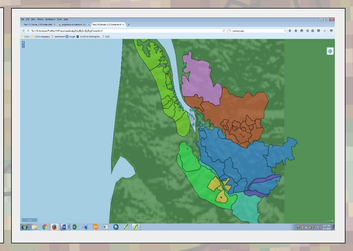


Figure 7. *Interactive web map made with QGIS*

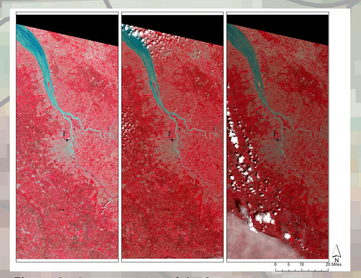


Figure 8. *Representation of the Seasons animation*

Discussion

By comparing the terroir characteristics of the First Growth vineyards I found a few things in common. The fields are very flat. The little slope that exists faces east or northeast. This means that the fields are getting the early morning sunlight and some shade in the later afternoon. The soil for all the best wineries was the same too. The sandy gravely soil of the area has been long acclaimed for producing some of the best wines and all of the most sought after wines shared the Calcaric Fluvisols classification.

Although many of the other Growths that have less prestigious reputations also shared these characteristics, all the First Growths were consistent in the geographic factors I considered. Thus this information is useful for farmers looking to convert their fields, and for existing vintners. There are many other variables in the wine making process that are not accounted for in this analysis. The method of crushing and destemming the grapes was not considered nor was the type of container used to store and age the wine. This is an area for future work to increase the robustness of the analysis.

The use of the imagery and NDVIs in particular did not lead to much insight. I did not have enough information to determine if the weather and the biomass, or lack thereof, makes a better wine. The reason for this is simple: the imagery data I used was from LandSat8 and which only goes back three years. The grapes that were growing that season have already been processed are either still maturing in barrels or have just hit the market and there are very few reviews in on them so far.

Conclusion

The data used in this project are free and available for download on the internet, and can easily be incorporated into spatial studies of other agricultural areas and crops. It may take some training for farmers and vintners to get these data, but once trained the data provide a biweekly data source that they themselves can gather at no cost beyond their normal computer and internet connection.

There are likely sources of similar data for any arable land on Earth. There is higher spatial and temporal resolution imagery available for a fee. This could be useful to the farmers or government users in an analysis of this kind. Higher resolution would enhance the ability to perform change detection and crop forecasts. Starting with the free imagery, and assessing its usefulness, would help the decision making process as to the cost benefit for funding of premium imagery. The individual would be able to tell how much the free imagery is helping their process and whether the expense of finer imagery would be worth the investment. In this project the free imagery was sufficient to perform spatial analyses and visualizations. The investment in premium data was not necessary for a study of this spatial and temporal scale.

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