Using Aerial Photography to Divide Vineyards for Harvest

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Summary
At Robert Mondavi Winery we have had the pleasure to be involved in a number of NASA (National Aeronautic and Space Administration) projects.

Phylloxera Project – 1993-1995
The first NASA project was an attempt to find phylloxera, a small aphid-like insect, using remote sensing technology.

Maturity Project – 1997
We used an image based on Normalized Difference Vegetation Index or NDVI to break up the blocks. NDVI is a ratio of near infrared and red light. This ratio lessens the influence of brightness differences associated with viewing angle and sunlight.

The test block was not a high quality block in previous years. We separated the vigor areas out in the field using the GPS unit attached to a laptop computer with a georeferenced image on the screen.
The low and moderate vigor areas ended up going into our Reserve program. We were able to produce reserve wine from a block that had never before made reserve wine by separating the vigor areas but without making any additional changes. This type of technology although useful for dividing blocks up by vigor is not required. Very similar patterns can be seen when leaf fall begins.

We do not always follow the image map, we still need to taste the fruit and use our eyes but the image does give us a starting point.

Auf der Robert Mondavi Winery konnten wir an einer Reihe von Projekten der NASA (National Aeronautic and Space Administration) teilnehmen.

Phylloxera-Projekt – 1993-1995
Das erste NASA-Projekt war ein Versuch, Phylloxera, ein kleines Blattlaus-ähnliches Insekt, mit Hilfe von Fernerkundungstechniken aufzuspüren.

Reifeprojekt – 1997
Hierbei wurden Bilder auf Basis des Normalized Difference Vegetation Index (NDVI) zum Unterteilen der Blöcke verwendet. NDVI ist ein Verhältnis von nahem Infrarot und Rotlicht. Dieses Verhältnis schwächt den Einfluss von durch Betrachtungswinkel und Sonneneinstrahlung bedingten Helligkeitsunterschieden ab.

Der Testblock war zuvor kein hochqualitativer Block. Unter Verwendung eines GPS-Systems, das an einen Laptop mit geografischem Bezugsbild am Bildschirm angeschlossen war, wurde das Feld nach Wuchskraftbereichen eingeteilt.
Die Bereiche mit geringer und mäßiger Wuchskraft landeten schließlich im Reserve-Programm. Wir konnten Reserve-Weine aus einem Block erzeugen, von dem nie zuvor Reserve-Weine gemacht wurden, indem wir die starkwüchsigen Bereiche absonderten, sonst aber keinerlei Änderungen vornahmen. Zwar ist diese Art Technologie nützlich bei der Aufteilung der Blöcke nach Wuchskraft, doch ist sie nicht erforderlich. Sehr ähnliche Muster sind anhand des Herbstlaubs zu beobachten.
Wir folgen nicht immer der Bildkarte, wir müssen die Trauben nach wie vor kosten und uns auf unsere Augen verlassen, doch liefert uns das Bild einen Anhaltspunkt.

Our goal at Robert Mondavi Winery is, as it is with many of the people in attendance today, to make great wines. We continue to look for new ways to understand the process of growing wines with help from other members in the wine industry and from people outside our industry. At Robert Mondavi Winery we have had the pleasure to be involved in three NASA (National Aeronautic and Space Administration) projects. These projects are part of an effort by NASA to transfer advanced technology to private industry.

NASA Projects

Phylloxera Project – 1993-1995

The first NASA project started in 1993, and was an attempt to find *phylloxera*, a small aphid like insect, using remote sensing technology. The participants were the University of California at Davis, Chico State University, NASA, and Robert Mondavi Winery. NASA asked other wineries to be involved in the project but we were the only winery that expressed an interest in the project. At the time of the initial discussions, we knew that the solution to our *phylloxera* problem lay in resistant rootstocks. We also thought that if we had a better idea of the location of *phylloxera* we could make better plans for replanting. Our second motivation for participating in this project was that we thought we could use the technology in other ways than just finding *phylloxera*.

Although we did not find a wavelength unique to *phylloxera* during this project, this project was able to:

- Show the movement of phylloxera between years within a block.
- Create a risk map based on the degree of infestation.
- Correlate yield and pruning weights to the NDVI values.

Maturity Project – 1997

While working with NASA on the *phylloxera* project we used some of the images to subdivide blocks for harvest in our Carneros vineyard. We grouped areas with similar vigor or leaf area and harvested them as a unit. We used an image based on Normalized Difference Vegetation Index or NDVI to break up the blocks. NDVI is a ratio of near infrared and red light. This ratio lessens the influence of brightness differences associated with viewing angle and sunlight. These pictures are digital pictures and thus a computer can classify the pixels into patterns. The images end up heightening the differences between leaves and non leaves. It is very easy to show patterns of vigor in the vineyard.

This Carneros vineyard was originally a dairy and was first planted to wine grapes in 1989. We had the thought that if the images showed differences with *phylloxera*, they would also show differences in wine quality and grape maturity. We already knew that leaf area and thus vine vigor was correlated with the NDVI images from our previous work.

This second project included NASA, Terraspase (a vineyard consulting firm), and Robert Mondavi Winery. The questions we asked ourselves were:

- Do aerial images show differences in grape/wine quality and maturity?
- Can we transfer Nasa technology to the wine industry?

By including a consulting firm we hoped to increase the number of customers who would use this type of technology. We had some initial wine quality success and we're hopeful to begin another project with NASA. These images are expensive, one flight costs about $18,000. The more customers for the product the less expensive the price per unit would be. The digital sensors are expensive and it is almost as cheap to fly a large area as it is to fly a small area. Presently there are two private satellites that will take these types of images anywhere in the world. NASA collected images from Napa and Sonoma counties during this project.

The image is an NDVI image of our Carneros ranch. You can choose the colors for each group and the colors do not have any intrinsic value. Notice that the reservoirs and the areas without vegetation are red in color. Purple is the most vigorous area, then blue, then green, then yellow, and finally red.

The second slide is a close up of the study area in the maturity trial. The black lines are from the GPS unit and the image is georegistered to the block outlines. The block is 7.5 acres (2.9 HA). The block varies from 106 to 257 feet (32-83 meters) above sea level and the rows were planted NE by SW due to the side slope. The block was planted to a high quality chardonnay clone called "old Wente". It is a field selection of multiple clones. Although we had liked other blocks planted to this clone, this block was not a high quality block.

The purple and dark blue are the most vigorous vines, followed by the light blue, and finally by the green and then the yellow. The purple and dark blue areas are on eastern facing slopes that are on deep soil. The green and yellow areas are on shallow soils that are compacted from winter rain. The red flags show where the data vines were located.

We had an early rain in late August that caused vines in the high vigor areas to rot. Rich Arnold, the enologist, also noticed that the fruit in the high vigor areas was of poorer quality and higher pH. The vines in the low and moderate vigor areas had virtually no *botrytis*. We separated the vigor areas out in the field using the GPS unit attached to a laptop computer with a georeferenced image on the screen. We placed flagging tape to show the harvest crew where to pick. The three vigor types were picked within 5 days of each other.

The next slide shows leaf water potential related to vine vigor. This data was taken using a pressure bomb instrument that measures vine stress. The data was taken in July the day before the next irrigation. A reading of less than 10 means the vines are not under any stress and a reading of 13-15 are an indication of high stress. Notice how the leaf water potential matches the vigor areas with readings between 7-9 in the high vigor areas and 11-15 in the low vigor areas.

The low and moderate vigor areas ended up going into our Reserve program. The low and moderate vigor made up 80% of the grapes. We were able to produce reserve wine from a block that had never before made reserve wine by separating the vigor areas but without making any additional changes. In addition, we greatly increased our knowledge of the block. The following winter we changed the pruning practices in the high vigor area and will continually change the viticultural practices until the wine quality improves in the high vigor areas. In our latest attempt to improve the uniformity in the vineyard, we cultivated the vineyard based on the NDVI image. We mounted a computer screen and GPS on a tractor and cultivated the areas with lowest vigor and mowed a cover crop in the strong areas. As the

tractor driver came into an area with higher vigor the GPS and a cursor on the computer screen showed him that he should stop cultivating.

Most of the variation in vigor appears to be caused by drainage patterns either from uneven terrain or different soil types. This type of technology although useful for dividing blocks up by vigor it is not required. Very similar patterns can be seen when leaf fall begins. The most vigorous vines will hold onto their leaves for a few days or weeks longer than the weakest vines. If you go into the vineyard at leaf fall, you can mark your vines for next year's harvest by choosing vines with or without leaves.

Since 1997 we have divided many blocks up for harvest, irrigation, and cover crops based on the NDVI vigor map. We do not always follow the map, we still need to taste the fruit and use our eyes but the image does give us a starting point. We have also used this type of technology to establish new vineyards.

This type of technology is a means of sharpening our observation skills. I'm always amazed walking vineyards how my understanding of growing wine increases as I spend more time in the vineyard and how a greater understanding makes better and more consistent wine.