Summary 14

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Title: **"Remote estimation of vine canopy density in vertically shoot-positioned vineyards: determining optimal vegetation indices"**

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This paper explores the use of digital cameras mounted on aircraft - a technique called remote sensing - to estimate the density of vine canopies in vineyards. The concept had been previously used in woodlands and forests, as well as in phylloxerated vineyards to distinguish healthy areas from infested ones. But here the authors take it one step further, and ask themselves whether remote sensing is sensitive enough to detect canopy density variations in a healthy vineyard situation. They were able to come up with some positive answers.

- First, the authors explain the underlying principle. The reason why we are able to use optical sensors to evaluate a plant's canopy is the fact that green vegetation –that is, photosynthetically active vegetation– strongly absorbs certain wavelengths of light (around 650 nanometers, or visible red), and strongly reflects certain others (around 900 nanometers, or near-infrared). Thus, if we have an instrument able to independently read both wavelengths within the light reflected from a canopy, a decrease in the first and an increase in the latter would suggest the presence of "more vegetation".

- Fortunately, these instruments do exist, and the authors use two types in their study. At the vine level, when they need to take measurements vine by vine, they use a hand-held sensor called a spectral radiometer. In another experiment at the vineyard level, when whole area pictures are needed, they use a remote sensor mounted on an aircraft. The first technique is called **field spectroscopy**; the second, **aerial imagery**. Regardless of the name, both instruments do the same thing: they record light intensities in the same four bands of the spectrum: blue, green, red, and near-infrared.

- Once the photos are taken, scientists shuffle and combine them in many different ways to create what they call **vegetation indices.** These indices give an indication of the relative growth and vigor of green vegetation. The indices have been shown to correlate with real plant parameters, such as leaf area, percent vegetative cover, green leaf biomass, photosynthetic rate, crop coefficient, and others.

- There are many types of vegetation indices, each with its pro's and con's. They also have complex names, such as ratio vegetation index, normalized difference vegetation index, perpendicular distance index, etc. What researchers look for in a good vegetation index is that it shows great sensitivity to canopy density, both at the vine and whole vineyard scales. And they prefer that this relationship be linear, something that simplifies the remaining analyses. What they want to avoid is a vegetation index that is too sensitive to background variation, such as shadows, atmospheric conditions, or presence of a cover crop, all of which would interfere with the accuracy of the target vegetation readings.

- As if all these interferences weren't enough, vineyards, particularly those trained to a traditional VSP trellis system, pose an additional challenge to remote sensing, This is due mainly to factors such as the small amount of vineyard soil covered by vegetation, the interference from cover crops in non-disked situations, and the discontinuous growth pattern of individual vines.

- With the above in mind, much of the work presented in this paper is devoted to finding the ideal vegetative index for vineyards. This index would later be used to obtain an accurate estimation of vine canopy density.

- To achieve this, the authors take measurements of reflected light in two different scenarios. In one scenario, they are able to reproduce increasing degrees of **canopy density** within the same vines, by gradually stripping vines of their leaves and taking measurements in between. In a second scenario, they are able to get increasing degrees of **canopy spacing,** by choosing vines with different in-row distances. By measuring leaf area and vegetation indices at the same time in each of these situations, they were able to study how well the two correlated, and which was the best-fitted index.

- Measuring leaf area, as stated above, was not an easy task. To do this, the authors needed to keep track of all the leaves removed, and measure their area. They were able to do this directly by using a time-consuming leaf area meter. But also, having previously proven that there is a relationship between the length of a shoot and the area of leaves in that shoot, they were able to get additional data indirectly, by actually measuring the shoot length and then calculating the corresponding leaf surface.

- The authors were able to come up with a relatively simple vegetation index that appears to work fairly well in vineyards. Called RVI (Ratio Vegetation Index), it is calculated by dividing the infrared absorbance by the red absorbance data, either from an individual vine, or from the whole vineyard. What is more important, the authors are able for the first time to give a meaning to this index, by translating what each index value represents when expressed as vine canopy density or vine canopy spacing.

But how can growers benefit from this index? In their next paper the authors answer this question by addressing the relationship between remote sensed data and pruning weights, and how the information obtained can be used to make management decisions.

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