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Ground Penetrating Radar used to Guide Precision Viticulture

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The largest agricultural market in the United States is in California, and wine is the state's most valuable finished agricultural product, with an industry valued at $1.7 billion (in 1997). Most of California's agricultural production would not be possible without irrigation. However, California uses the largest volume of water of any state in the nation, and is on the verge of a major water shortage. As vineyards consume more rural acreage, competition for water resources is increasing, which has increased the pressure on California vintners to use water more efficiently.

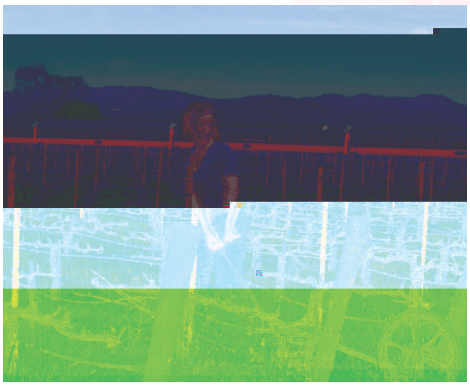
Wine grapes at Robert Mondavi Winery, Napa, California

Mike Kowalsky, Lawrence Berkeley National Laboratory

In addition to the impact of irrigation on water resources, the volume and timing of irrigation has a great impact on winegrape yield, fruit color, and ripening. Viticulturists know that soil moisture is key to growing quality wine grapes, but accurately monitoring the soil's water content is a difficult and expensive task. There are well-documented variations in soil moisture due to natural geological changes, topography, land cover, and micrometeorology. Indeed, these natural variabilities govern the concept of 'terroir,' which distinguishes many of the premium wine regions. Current techniques of measuring soil moisture typically involve sampling the soil at a few spot locations within a vineyard. Not only are such techniques costly and invasive, they may not always create an accurate representation of the vineyard's soil moisture distribution since the soil at one location may be quite different from the soil a few meters away.

High spatial resolution soil moisture data from GPR can improve ecosystems research and enhance water efficiency and profitability for crops such as wine grapes, whose quality is sensitive to moisture conditions during growth

Researchers at the University of California, Berkeley, with funding from USDA's National Research Initiative (NRI), have shown that ground-penetrating radar (GPR) provides a high-tech tool for the fine art of grape growing. The GPR system is about the size of a vacuum cleaner, and can be manually pulled through the crop rows or hooked to the back of farm machinery. The GPR transmitter sends an electromagnetic wave into the subsurface, which travels through the soils and is subsequently recorded by a receiver. The velocity of GPR waves traveling in the near subsurface soils is proportional to water content. Tests conducted within vineyards at the Robert Mondavi Winery in Napa County and the Dehlinger vineyards in Sonoma County, CA, show that analysis of GPR wave velocities can provide accurate 3-D estimates of soil water content with a spatial resolution that is unparalleled by conventional measurement techniques.



Dr. Susan Hubbard, UC Berkeley researcher, pulling the GPR system through Napa Vineyard rows to estimate soil moisture

Mike Kowalsky, Lawrence Berkeley National Laboratory

Impact

The ability to obtain dense estimates of soil moisture holds potential for improving both precision viticulture and ecosystem investigations. By providing detailed information about soil moisture, researchers can help grape growers refine their irrigation strategies to produce an improved agricultural product while saving water resources. Vineyard managers can use the technology to better develop new vineyards by planting vineyards within areas where the soil is spatially uniform, and further refining the practice of matching grape variety to soil conditions. While GPR technology could potentially benefit other crops, researchers chose wine grapes to test the GPR approach because it is a high-cash crop and is particularly sensitive to soil moisture. Researchers are further using their developed approach to investigate the control of soil parameters on natural and managed ecosystems at a resolution that has never before been possible.

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