Radar in the Vineyard

A High-Tech Toast to Better Wines

David Pescovitz

Between the rows of ripening grapes at the **Robert Mondavi** Vineyard in Napa Valley, a **UC Berkeley** researcher pushes a wheelbarrow outfitted with a ground-penetrating radar device. The field trip is part of a project that combines time-tested agricultural methods with high-technology geophysics to improve the quality of Northern California's finest wines.

Yoram Rubin, UC Berkeley professor of Civil and Environmental Engineering, is leading research to map the soil's water content at California vineyards using data generated from high-frequency radar systems. The aim is to give grape growers a tool for managing "stressed irrigation," a technique that keeps the plants a little bit thirsty, resulting in smaller grapes with better flavor rather than larger fruit and leafy vines.

"Our approach is noninvasive. There's no drilling, and we can provide quick and accurate estimates of soil moisture content over large areas," says Rubin, whose principal collaborator on the project is his former student **Susan Hubbard**, now a staff scientist in Lawrence Berkeley National Laboratory's Earth Science Division. The project is part of the **Institute for Environmental Science and Engineering** (IESE) and the **Center for Information Technology Research in the Interest of Society** (CITRIS).

Currently under way at Mondavi and **Dehlinger Vineyards**, Rubin's field research originated from an earlier study to monitor and understand the transport of bacteria through subsurface soil. Rubin realized that applying a similar noninvasive technique to measure distribution of water in soil could help conserve water resources in agriculture. The trick, however, was finding a receptive audience. Grape growers, he quickly realized, had a lot to gain from knowing what lies beneath the surface of their vineyards.

"If there's one community that's very interested in soil moisture, it's wine grape growers," he says. "Managing stressed irrigation yields higher quality fruit and enables growers to get higher prices."

To map the subsurface of a vineyard, Hubbard, Rubin, and his graduate students push a vacuum cleaner-sized radar instrument between the vines. The device sends high-frequency electromagnetic waves into the ground to depths of several meters depending on the type of soil being tested. The velocity of the waves' reflection is dependent on the ground's dielectric constant, the ability of a material to store electrical energy under the influence of an electric field. Soil has a low dielectric constant that is dramatically elevated in the presence of water. The signal's travel time is then interpreted as a measurement of soil moisture, much like data from a medical computed tomography (CT) scan provides physicians with information about a patient's tissue properties.

Every vineyard's soil will have different characteristics. At the Dehlinger vineyards, the waves bounce off a natural reflector in the ground-soil layer with significant variation in its electrical properties-and return to the radar's receiver. At Mondavi, there is no natural reflector. Instead, the instrument emits ground waves that travel laterally in a shallow zone of the soil. Depending on their frequency, the waves can penetrate up to one-half meter. The researchers take measurements using multiple frequencies and, combined with other projected data generated by a mathematical model, generate an accurate profile of the moisture around the roots of the vines.

"Once we identify the topology of the field, we can provide just six or so pivot points in a block (approx. 300 meters squared) that the farmers can check biweekly," Rubin says. "Collecting information from those points provides enough data to determine an irrigation schedule."

Firm control over stressed irrigation, Rubin says, also enables grape farmers to create uniform ripening patterns. Rather than return to the same plot multiple times during a harvest, farmers could increase efficiency by collecting all the fruit at one time, he explains. These techniques may provide insight into the biology of the vines as well.

"We'd like to understand which parts of the plant get water from particular soil depths," Rubin says. "For example, do the vines need uniform moisture to thrive?"

To answer these questions, Rubin is currently working on a proposal to collaborate with **Todd Dawson,** a UC Berkeley professor of Integrative Biology, on the next phase of the vineyard project. The hope is that, by combining the soil moisture profiles with Dawson's isotope analysis, a method used to determine distribution of certain elements in a material, the researchers will be able to produce a high-resolution picture of how the vines drink from the soil.

Susan Hubbard drags a ground-penetrating radar instrument through the Robert Mondavi vineyard in Napa, California.

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