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Wireless Vineyard Monitoring Technology

Providing Flexibility in Compiling and Observing Data,
and the Ability to See Multiple Areas of the Vineyard
at the Same Time and in Real-time

Story and Photos by Ted Rieger > senior feature editor

Recent advances in wireless technology, battery operated nodes and sensors, and microchip data recording are making real-time monitoring of vineyard weather and environmental conditions more efficient and affordable with the ability to monitor more types of data in more locations in the vineyard than ever before.

Traditional weather station monitoring systems in use can provide comprehensive weather and environmental data, however, they are commonly single point monitoring stations, with one serving an entire vineyard, or a localized region. Given the cost per weather station, it can be expensive to place multiple stations in a vineyard. Regional grower networks exist in some areas to share information from multiple stations, but this data may not be individualized to specific vineyards, particularly vineyards with variable soil, terrain, elevation, and climatic conditions.

Methods for transferring and accessing data from weather stations or monitoring sites also have various cost and time issues. With some systems, a worker can go into the vineyard to each site to record data, or download recorded data to view on a PC or laptop. Another option in some locations is running a hard wire transmission cable through the vineyard to connect the monitoring station to a PC database in the vineyard office. Radio telemetry, and satellite transmission are two

wireless options that provide timely data transfer, but now cellular technology is available that can be a less expensive option with more flexibility.

Ranch Systems LLC, based in San Francisco, began commercial production and installation of RanchMaster

At a Glance

- ▶ Wireless cellular technology, battery operated nodes and sensors, and microchip data logging have made vineyard monitoring more affordable and more effective with multiple point and multiple block monitoring.
- ▶ This technology is well-suited to precision viticulture and for vineyards with variable terrain, elevation, climate, and soil conditions that have different irrigation and management needs from block to block.
- ▶ Ranch Systems LLC has installed wireless monitoring systems in several North Coast vineyards, ranging in size up to a 105-acre vineyard with 70 sensors to monitor temperature, wind speed, relative humidity, solar radiation, soil moisture, and irrigation water flow in multiple locations.
- ▶ A Ranch Systems installation includes a hosted Internet software program and database management system with login and password access. This provides security while allowing data access for cooperative management and decision making from any location for all of the vineyard's key personnel.
- ▶ Ranch Systems components can also be used to remotely schedule irrigation and automatically activate irrigation valves.

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TECHNOLOGY

wireless vineyard monitoring systems in 2005 using cellular technology. The company's system can monitor all the standard climatic data, as well as soil moisture and irrigation water flow, with data accessible in real-time from any web browser connection, and it monitors multiple locations in a vineyard, for a cost that is comparable to a single point weather station. A system can be cost-effective for vineyards of almost any size that are interested in data monitoring and collection for precision viticulture and better vineyard management. However, a system can be most valuable for medium to larger vineyards that have variable soil and climatic conditions, are located in more remote locations, may not have onsite full-time management, or for vineyards in which multiple parties are involved in management and decision making who each need regular access to data.

Ranch Systems owner/founder Jacob Christfort has extensive professional experience in wireless technology, and software and database management, formerly serving as Oracle's wireless chief technical officer in Silicon Valley. He later acquired a 1,500 acre ranch in Mendocino County where he developed and tested a wireless monitoring system. He launched Ranch Systems as a commercial operation with his wife, Kimberly, in 2005, with the goal of specializing in vineyard installations for North Coast growers. As of the end of 2006, seven systems were installed and operational in North Coast vineyards. Explaining how this new age of vineyard monitoring has become possible, Christfort said, "Only in the last few years did commercial companies like us have access to this type of technology and data chips, and I don't think it has been economically feasible for many vineyards to have this type of coverage in multiple blocks for this range of data. Previously, to have this type of data access you had to use satellite technology. Over the last five years, as cellular service has expanded and moved into more rural areas, it's made this technology possible, and it's much less expensive than satellite."

Ranch Systems now has four employees that focus on system component sales, installation, and service,

A Ranch Systems node with a wind speed anemometer at Obsidian Ridge Vineyard in Lake County

and on maintaining and improving the system software and database management. The company plans to gradually expand its service to vineyards beyond California's North Coast, and hopes to serve Paso Robles in the near future. Ranch Systems designed the base station equipment and nodes, but outsources the manufacturing of these components.

SYSTEM COMPONENTS

A Ranch Systems RanchMaster installation includes three basic components, a cellular base station, wireless sensor nodes located in the vineyard, and a hosted Internet software and data management system. A basic starter system, a base station and four nodes that support a total of eight sensors, can be purchased and installed for less than \$3,000. The purchaser owns the system components, which have a two-year warranty. In addition, a monthly maintenance fee is required to access and maintain data through the hosted Internet site that is comparable to a monthly cell phone bill.

The cellular base station (RM100C) is the core of a RanchMaster system with capacity to manage up to 50 wireless nodes within a line of site, half-mile range. The base station can use cellular or WiFi connectivity back to the Ranch Systems data center via a local cellular service tower. The base station is powered with a 10 watt photovoltaic (PV) solar panel and a storage battery for nighttime operation. The base station control unit includes a four-line LCD display and a 15-key waterproof keypad to access vineyard data onsite or to change system program parameters. The base station includes its own sensor and input



capabilities, with a built-in temperature sensor. If sensors and nodes are located more than a half-mile from the base station, a WiFi substation (AM100C) can be placed to relay to the main base station. The base station hardware costs about \$1,000.

A node is a small palm-size box with a short antenna and two cable ports for attaching up to two sensors per node. The node is battery operated with a 3V lithium battery that can be found at more specialized electronics stores such as Radio Shack. The batteries are easy to replace, and generally last about one to two years. Ranch Systems' real-time monitoring system indicates when a battery becomes weak and needs replacing. Each node costs from \$100 to \$150, depending on the number purchased for installation.

The nodes work with a wide range of third-party, commercially available sensors. Christfort explained: "We can design the system around any probes or sensors currently used, and we also carry a full line of commercially available sensors for people who want our advice. Under our business model, we want to be able to integrate with people's existing system components or others available on the market." Common sensor measurements include: temperature, relative humidity, wind speed, precipitation, solar/UV radiation, soil moisture, and water flow. Each node is designed to access sen-

sensor data at 5 minute intervals. In addition, each node has its own built-in temperature sensor that is used to monitor node temperature to ensure it is within the tolerance of the electronics. The node temperature sensor data is also accessible to system users, but external temperature sensors with radiation shields are used in critical locations for more accurate vineyard temperatures.

The hosted internet software and database management system make sensor data easily accessible in real-time and manageable for vineyard managers. Data is stored at an enterprise-level, high security data center with nightly backups. Ranch Systems maintains the database, and manages and upgrades all required software that is designed for easy viewing of sensor data, has vineyard maps of sensor locations, and provides graphing of daily, weekly, or longer interval data information and trends. Information can be accessed by an approved user at any location by logging in through a web browser. This provides security while also allowing access to multiple parties in different locations (such as vineyard owners, managers, and winemakers or grape buyers) who can collaborate on management decisions. The software can generate complete PDF reports nightly, and reports can be customized to user needs.

Based on sensor data, the software can calculate other data such as dew point, degree days, and evapotranspiration. Weekly irrigation schedules can be programmed into the software and be used to activate irrigation valves on and off. Beckstoffer Vineyards installed a RanchMaster system specifically for irrigation control in its St. Helena vineyard in 2006. The base station controls four separate irrigation valves, and sensors in each block monitor soil moisture, water flow, and temperature. The online software irrigation calendar is used to input how many minutes to irrigate per block per day, and at what time of day. The online reporting and graphing features enable verification that the system opened the valves as requested and that the actual amounts were applied. Information on soil moisture content at different depths enables adjustment of irrigation parameters as needed during the growing season.

The online software program enables users to set and modify triggers for alerts for temperature extremes, such as frost warnings in winter and spring. Alerts and controls can also be interfaced with cellular phones using text messaging to notify vineyard personnel. The system can be set up to open valves for overhead sprinklers for frost protection when a trigger temperature is reached, or to activate wind machines.

Ranch Systems handles all cellular service and connections for data transmission as part of the monthly service fee. The monthly maintenance fee is based on the number of nodes used in the vineyard, and ranges from about \$50 to \$150/month. Ranch Systems provides ongoing customer support and also monitors the “health” of the entire system 24/7, able to recognize problems occurring to the level of individual nodes and sensors.

The system offers great flexibility in locating sensors for data acquisition, and the ability to easily add or relocate nodes, sensors, and data points after the system is installed, and to add points for vineyard expansion and tie into the existing system. The following information discusses specific

Ranch Systems installations in two commercial vineyards.

OBSIDIAN RIDGE

Obsidian Ridge Vineyard is 105 planted acres within the Mayacamas Mountains within the Red Hills AVA of Lake County. With elevations ranging from 2,350' to 2,640', it is one of the higher elevation vineyards in the North Coast. The main variety planted is cabernet sauvignon, with seven different clones, along with syrah, cabernet franc, and petite verdot. About 20 percent of vineyard production goes into the 5,000 cases/year of estate wines produced under the Obsidian Ridge label, and remaining grapes are sold to other wineries. Owned by the Molnar Family that also grows grapes in the Los Carneros AVA, the Lake County property was purchased in 1998 and is managed by Nissen Vineyard Services based in St. Helena.

Although the vineyard's grapes cannot command the prices of Howell Mountain fruit grown in Napa County, Obsidian Ridge co-owner Peter Molnar notes that the vineyard, like Howell Mountain, is still within the Mayacamas range, but 20 miles farther north. Molnar says the vineyard produces “hillside cabernet for



The 105-acre Obsidian Ridge Vineyard in Lake County has elevations ranging from 2,350' to 2,640' presenting challenges of variable terrain, climatic conditions, and irrigation needs.

the rest of us,” priced at about \$30/bottle.

The vineyard site creates several management challenges: variable terrain and elevation affecting soil moisture and irrigation distribution; climate challenges with low humidity, wide diurnal temperature changes during the growing season, and frost danger in the winter and spring; and a remote location. The vines are on a VSP trellis, drip irrigated, and yields average 4 tons/acre.

A RanchMaster system, the largest installation to date, was installed in 2005, but 2006 was the first full season of use. The system includes one base station with a NovaLynx rain gauge, and 35 nodes distributed throughout the vineyard with sensors that measure temperature, relative humidity, wind speed, UV radiation, soil moisture, and irrigation water flow. The base station is strategically located in the vineyard to receive data from all 35 nodes, and the data is relayed to a cellular phone tower located on nearby Mount Konociti. Temperature sensors are located in each block, positioned within the fruiting zone of the vine trellis with a radiation shield covering the sensor to ensure better accuracy. Some nodes are mounted to trellis posts, but in some locations nodes are mounted at the top of longer poles to provide the necessary line of site transmission to the base station. Cable wires that connect sensors to the port attachments on the nodes are strung through PVC tubing attached to the trellis system, acting as conduit to protect the cables from vineyard machinery and operations.

Decagon Ech20 soil moisture sensors are buried in the drip irrigated root zone at depths of 12”, 18” and 24”. In-line irrigation flow meters are in 15 locations, spliced directly into the drip line that hangs below the trellis posts. Explaining the use of flow meters, Molnar said, “On a hillside vineyard, the dynamics of irrigation are a challenge, and we get concerned about getting enough water to the top of the vineyard. And up here, if you under water too early in the season, it’s very difficult to catch up.” Molnar said the flow meters show immediately if there is a water pressure problem or a valve problem. In addition, by looking at several pieces of sensor data, such as soil moisture,

Ranch Systems base station at Obsidian Ridge Vineyard in Lake County collects and relays sensor data from 35 nodes placed in the 105-acre vineyard.

relative humidity, and water flow, it can indicate the need to adjust the irrigation schedule. “We found we weren’t getting enough water to adequate depth in some locations, so we did two longer watering cycles a week to get ahead of the curve before the irrigation got too far behind,” Molnar said.

Frost protection is a concern in some pockets in the lower part of the vineyard, which has two wind machines and five S.I.S. frost protection units. Temperature sensors in these locations trigger alerts that text message cell phones for Molnar and vineyard managers when temperatures reach about 35 degrees F. Molnar said the system’s data monitoring ability will better indicate patterns of cold air locations and the effectiveness of the frost protection units in order to make future decisions on adding or relocating units.

Measurements of UV radiation, which is generally greater in higher elevation vineyards, are also of interest to Molnar. He believes that greater UV intensity removes the “green” pyrazine flavors from the grapes earlier in the season than in lower elevation vineyards, and that greater UV intensity produces thicker grape skins with higher polyphenolic content. Over time, Molnar hopes to accumulate data on UV radiation in relation to ripening and grape chemistry and compare this with UV measurements in the family’s lower elevation Carneros vineyard.

Molnar is pleased and impressed with Ranch Systems’ hosted Internet software and database system that he



logs onto and checks about twice a day during the growing season. Molnar said, “It’s very visual and very basic, with the ability to go on-line and see the important information summarized on one screen. When I go online, within 20 seconds I can know whether the irrigation system is working right or not.” With the vineyard managers and owners in different locations, the ability to easily access real-time, and longer term data patterns, helps all parties better manage and communicate to make decisions. With Ranch Systems hosting and managing the software and database, it allows the limited staff to spend time managing the vineyard without having to invest in its own computer equipment and personnel to manage the data. Molnar believes Ranch Systems is playing a role in helping Obsidian Ridge understand and develop its terroir. Molnar observed, “We now have an ongoing data set for every season, and over a period of years we hopefully will see some patterns that are useful to us.”

Molnar summarized, “This system gives us the advantage of farming better. We can communicate this data with the wineries that purchase the grapes if they want it, but just the fact that we measure this data impresses the people we do business with.”

TERRA DE PROMISSIO

Located in the Petaluma Gap area of the Sonoma Coast AVA, Terra de Promissio (Land of Promise) is a 32-acre vineyard planted exclusively to pinot noir that is sold to seven different wineries. The family-run operation is owned and managed by Charles and Diana Karren along with Diana's parents. The vineyard was planted in 2002 and the first harvest was 2005. It is a hillside vineyard that receives a lot of wind in some locations, with conditions different near the top of the hill compared to lower areas. Charles Karren said the site has three distinct areas, with different environmental conditions that have different management and irrigation needs. Particular concerns are that vines on the lower part of the hill don't need as much irrigation as those at the top of the hill, and botrytis can also be an issue in the vineyard.

A RanchMaster system was installed for the 2006 growing season, with a base station and six nodes spread among the vineyard's six management blocks. Sensors monitor and record temperature, wind speed, soil moisture, relative humidity, and water flow. Explaining some of the reasons for installing the system, Karren said, "We sell our grapes to seven different wineries and each uses different blocks and rows. We wanted to see how the conditions differed by location, and we wanted a unified place to record and observe all the data inputs."

Determining how much to irrigate each block has been a major benefit of the system, particularly at critical times such as during heat waves and the period closest to harvest. Kar-

A Ranch Systems node (top of vineyard post) collects and relays data from a temperature sensor (placed in vine fruiting zone along a trellis wire) and a water flow meter (in irrigation dripline).


ren also believes the data compiled over time from year to year will be a big benefit in comparing weather data to irrigation in order to schedule and manage in the future for best results. The ability to measure wind speed, relative humidity and temperature also indicates optimal times for spraying and canopy management activities. "Before we had to do everything visually and make assumptions, but now we don't have to make those assumptions," Karren said.

During the 2006 growing season, Karren compared Ranch Systems data with the nearest available weather station data taken at the Petaluma Airport. "Although there was not a major difference in weather data on average, there definitely are hotter places and cooler places in our vineyard, and the wind creates different temperature and moisture conditions," Karren observed. Based on the 2006 season, Karren commented, "We're very pleased, the system has been very reliable. The Internet database provides flexibility in compiling and observing data, and the ability to see multiple areas of the vineyard at the same time and in real-time."

Karren said he plans to expand the system in 2007 with additional nodes



and sensors for more comprehensive monitoring. The property has an additional 20 plantable acres, and sensor data nearest to this location will be evaluated to determine whether future plantings should use different rootstocks or clones more suitable to this particular location. "This doesn't replace the hands-on farming we do on a daily basis, but it's a great tool, and the more data you have, the better decisions you can make," Karren summarized.

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Questions or Comments?

Please send your replies to feedback@vwm-online.com.