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Is It Time To Water? Wireless Soil Moisture Monitors Provide the Answer

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Irrigating individual fields only when they need water reduces energy and water use at forest nurseries, reduces the cost of labor, reduces diseases, and improves the quality of the seedlings. Typically, nursery personnel have to check several plots to determine when a field needs to be irrigated. Some fields may be overwatered (which can cause root and foliage diseases) or underwatered (which can stunt growth or kill plants). The Coeur d'Alene Nursery asked the Missoula Technology and Development Center (MTDC) to develop or evaluate commercial soil moisture monitoring systems that could send data wirelessly to a central location.

Highlights...

- Tree seedlings grown in forest nurseries need just the right amount of water—too much and they're subject to disease, too little and they may be stunted or die.
- Soil moisture monitors can relay data wirelessly from nursery plots to a base station in the nursery headquarters, saving employees the time of going to the plots to see whether the seedlings need to be watered.
- After a growing season, seedlings watered based on soil moisture monitoring looked healthier than seedlings grown during previous years.

Site Description

The Coeur d'Alene Nursery wanted to monitor soil moisture at four fields (figure 1) ranging from 6 to 21 acres. The plots were growing 1-year-old western white pine and Douglas-fir and 2-year-old western larch and ponderosa pine. Soil types were uniform at each plot, so only one soil moisture probe was needed per plot. The monitoring stations had to be powered by batteries or solar panels because the plots do not have electrical service.

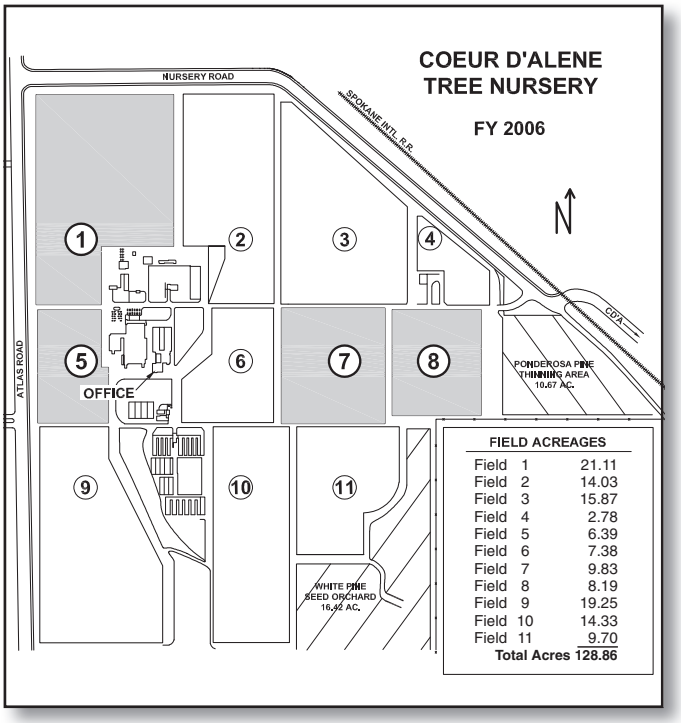

Figure 1—Wireless soil moisture monitors were tested in fields 1, 5, 7, and 8 shown on this map of the Forest Service's Coeur d'Alene Nursery in Idaho.

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Background

Several commercial weather station manufacturers sell low-cost, battery-powered data loggers with a soil moisture probe and a remote base station that can collect data wirelessly. MTDC published "Evaluation of Affordable Battery-Operated Weather Stations for Remote Sites" (*http://www.fs.fed.us/t-d/pubs/htmlpubs/htm07242321/*, Username: t-d, Password: t-d), which describes field tests of three battery-powered weather stations, including two that transmit data wirelessly: the Vantage Pro2 by Davis Instruments, Corp., and the HOBO Micro Weather Station by Onset. The Watermark soil moisture sensor manufactured by the Irrometer Co. also supports wireless data transmission.

MTDC evaluated each of these systems for the cost per site, base station cost and complexity, data transmission range, data logger programming requirements, and the accuracy of the soil moisture sensor (table 1).

Table 1—Comparison of three soil moisture monitoring systems that support wireless transmission of data.

Model	Cost of base station (dollars)	Cost of each field station (dollars)	Total cost for four fields (dollars)	Transmission range (line-of-sight)	Programming	Moisture sensor
Vantage Pro2[1]	590	1,110	5,030	1,000 feet	Plug and play	Watermark
HOBO[2]	274	1,066	4,538	2 to 3 miles	Plug and play	ECH_20
Irrometer[3] system	695	1,720	7,575	Several miles	Unknown	Watermark

[1] Each field station comes with four soil moisture probes and four soil temperature sensors.
[2] One base station can receive data from seven field stations.
[3] This interface was not field tested.

Field Trial

The HOBO Micro Weather Station with the soil moisture sensor, soil temperature sensor, and a radio modem (table 2) was used for the field trial because this combination was the least expensive, easiest to set up, and easiest for downloading and exporting data. The weather stations with wireless radio modems and temperature and soil moisture sensors (figure 2) were deployed in fields 1, 5, 7, and 8. The base station (figure 3) is connected to a personal computer in the nursery office building. The base station's Remote Site Manager software allows the nursery manager to set how frequently the sensors collect field data and when they automatically transmit the data to the base station. Nursery personnel can check the data at any time to determine whether a field needs to be irrigated.

Table 2—Components of the HOBO Micro Weather Station used for the field trial. One base station could receive data from up to seven radio modems.

Component	Cost (dollars)
Base station (total cost $274)	
C-003 base station with Remote Site Manager software	265
Cable PC3.5	9
Each field site (total cost $1,066)	
H21-002 HOBO four-channel micro station logger	199
C-002 radio modem (obsolete)	599
S-SMA-M005 ECH2O soil moisture sensor	139
S-TMB-M002 temperature sensor	90
Cable HWS-F	39

The C-002 radio modem is powered by six D-cell batteries that lose charge rapidly. Field personnel had to replace batteries regularly. A better solution was to use a solar panel and battery to power the radio modem (see figure 2). Because Onset (which manufactures the HOBO Micro Weather Station) does not supply a solar system for its radio modem, the MTDC electronics shop purchased solar panels with a regulator and gel cell battery (table 3). A small circuit board was designed to regulate the solar power system's 12-volt gel cell battery to 9 volts for the radio modem. Figures 4 and 5 show the system's circuitry. A 10-watt solar panel charged the 12-volt gel cell battery (figure 6).

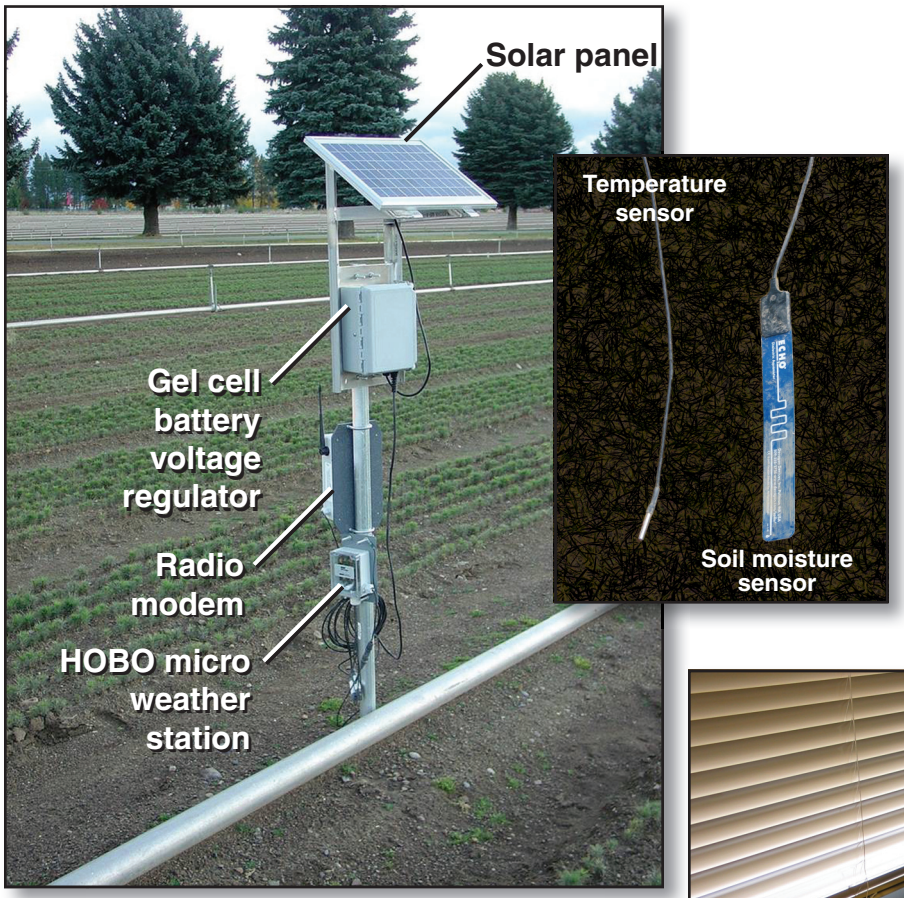

Figure 2—This wireless soil moisture monitoring station used a gel cell battery charged by a solar panel. The inset photo shows the temperature (left) and soil moisture (right) sensors.

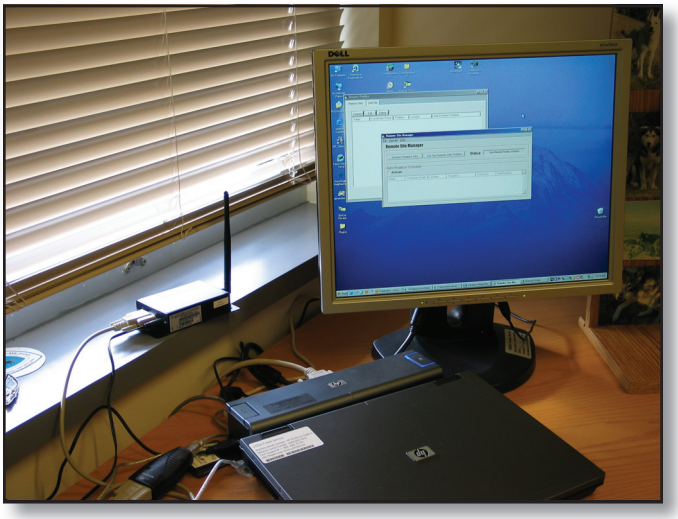

Figure 3—The system's base station allows data to be collected wirelessly using the HOBO weather station's radio modem.

Table 3—Materials used to provide solar power for the radio modem (total cost $236).

Model	Specifications	Cost (dollars)
Solartech Power Inc. solar panel STP0105-12	12.2 by 14.4 by 7 inches 3.31 pounds	109
Morningstar Corp. charge controller SG-4	4.5 amperes	23
12-volt gel cell battery	7.5 ampere-hours	19
Hoffman Enclosures Inc. fiberglass NEMA enclosure A864CHQRFG	8 by 6 by 4 inches	85

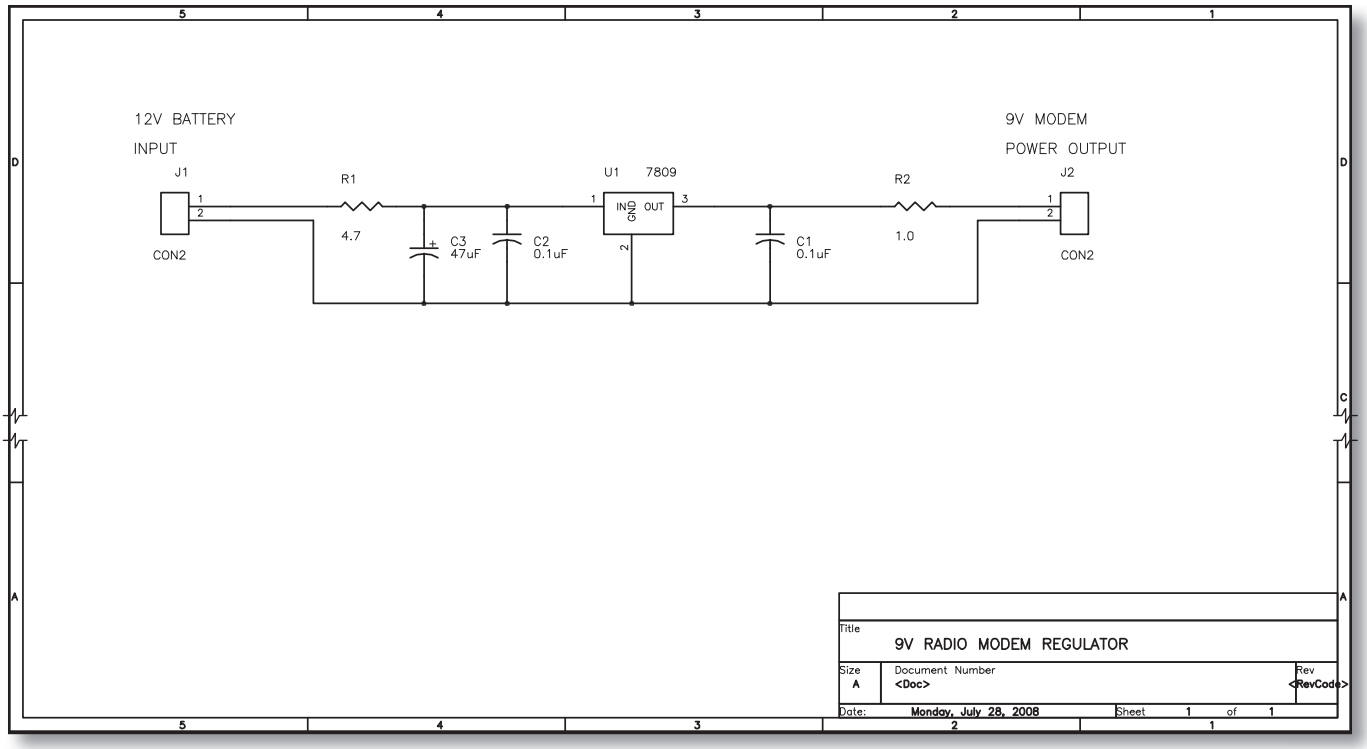

Figure 4—This drawing shows the circuitry that regulates 12-volt power from a gel cell battery to 9-volt power for the radio modem.

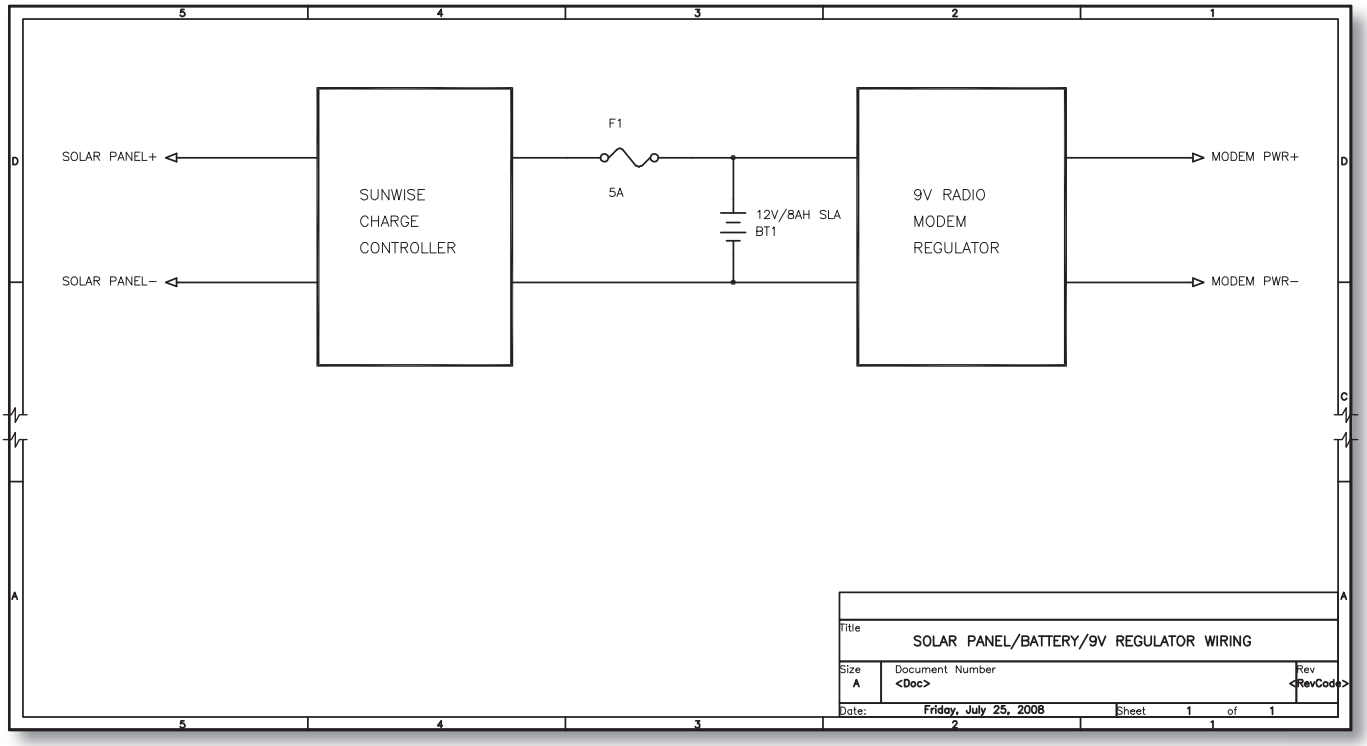

Figure 5—This drawing shows the circuitry that connects the solar panel, charge controller, and voltage regulator.

Figure 6—The solar panel's power box opened to show the gel cell battery and voltage regulator.

New HOBO Wireless System

During 2009, Onset Computer Corp. introduced a new radio modem system. The HOBOnode wireless sensors send data by radio, but do not store data.

The new hardware includes:

- W-RCVR-USB HOBOnode wireless receiver—$220
- W-SMC HOBOnode soil sensor—$230
- W-TMB HOBOnode temperature sensor—$179

Wireless repeaters are available for situations when the clear line-of-sight distance from the sensor to the base station is more than 1,000 feet.

Conclusions

Nursery employees were able to schedule irrigation more efficiently using data from the soil moisture and soil temperature sensors and felt that the 1-year-old seedlings looked healthier than in previous years. Water-loving weeds, such as pigweed and pearlwort, did not thrive. Because the nursery has just one electrical meter, energy savings could not be measured just for the wireless soil moisture monitoring system.

In one plot, some spruce seed was sown with the seeds of other species. The spruce seedlings needed more water than the seedlings of the other species. The nursery will isolate the spruce planting next year so the spruce seedlings can receive more water without affecting other seedlings.

Nursery employees were surprised by the high temperatures in the top 10 inches of soil during late July to early September. Temperatures were well over 100 degrees Fahrenheit, drying the soil faster than expected.

Even though one plot was about ½ mile from the base station, data were transmitted without any problems.

The HOBO Micro Weather Station automatically detects sensors. The soil moisture probe outputs volumetric water content of the soil in cubic meters of water per cubic meter of soil. You can calibrate the probe for your soil using the bake-and-weigh method (*http://www.onsetcomp.com/files/support/pdfs/Soil_calibration.pdf*) to relate volumetric water content to percent water.

About the Authors

Mary Ann Davies received a bachelor's degree in mechanical engineering with a minor in industrial and management engineering from Montana State University. She worked in the Pacific Northwest Region as a facility engineer and as a tramway engineer. Davies has worked in fire management as a crewmember and as a crewboss. She worked for 5 years with the Rocky Mountain Research Station in the fire chemistry and fire behavior groups before coming to MTDC in 1999.

Ted Etter joined MTDC in 2002 as an electronics engineer and project leader. He has 20 years of experience working for private industry in the design of test equipment, display devices, and medical instrumentation. In the 6 years before he joined MTDC, he taught courses in the electronics technology program at the University of Montana College of Technology, Missoula. His work at MTDC includes projects in wireless communications, alternative energy sources, instrumentation, and process control. Etter has a bachelor's degree in mathematics from the University of Oregon and a master's degree in teacher education from Eastern Oregon State University.

Library Card

Davies, Mary Ann; Etter, Ted R. 2009. Is it time to water? Wireless soil monitors provide the answer. Tech Tip 0924–2316–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 8 p.

This tech tip discusses the use of the HOBO Micro Weather Station with a soil moisture probe and an optional temperature sensor to communicate data wirelessly with a base station at the headquarters of the Coeur d'Alene Nursery in Coeur d'Alene, ID. Soil moisture was monitored at four plots as far as one-half mile from the nursery's headquarters, saving employees the time of going to the fields to check whether they needed to be watered. After one growing season with watering based on the wireless soil moisture monitors, the seedlings looked healthier than seedlings grown in previous years. Weeds weren't as common as they had been in previous years when plots were more likely to be overwatered.

Keywords: Coeur d'Alene Nursery, equipment development, evaluations, nurseries, solar power

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Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/eng/t-d.php

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