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Societies**

Solving the irrigation puzzle in the Pacific Northwest

Tools for getting more crop per drop

By Vicky Boyd

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Photo credits: Top row (l to r): University of Idaho, Jemila Chellappa, and Doug Wilson (USDA-ARS). Bottom row: Vicky Boyd.



As water supplies tighten across the Pacific Northwest, growers are turning to a combination of technology, data, and improved irrigation practices to get the most crop from every drop. Experts say maximizing center-pivot efficiency requires more than just new

equipment—it also depends on regular maintenance, weather-based scheduling, soil moisture monitoring, and careful planning. From updated crop water-use research to high-efficiency sprinkler packages, a growing toolbox is helping producers and their CCAs balance yields, costs, and increasingly limited water resources.

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As Pacific Northwest water availability continues to shrink and pumping costs escalate, many producers and consultants are striving to get the “most crop per drop” from their center-pivot irrigation systems.

To maximize irrigation efficiency, they’ll need a toolbox that includes proper system maintenance, effective nozzle packages, meteorological data, evapotranspiration

forecasts, soil moisture sensors, and an annual irrigation plan.

“When you bring it all together, it makes a pretty nice puzzle,” says Emily Bedwell, University of Idaho Extension irrigation technology specialist at the Kimberly Research and Extension Center.

But she says the solutions are not one size fits all and depend on several factors, including topography, well output, soil types, regional water supplies, crops, and producers’ budgets.

Annual system check-up

At the start of the growing season, Bedwell recommended that producers give their center pivots a once-over while the systems are running with water. This includes checking for plugged, cracked, or broken nozzles and pressure regulators; uniform water patterns; and leaking sprinklers or pressure regulators.



At the start of each season, check for plugged, cracked, or broken nozzles, and replace nozzles every five to seven years or after about 10,000 hours of operation.

A rule of thumb is to replace nozzles every five to seven years or after about 10,000 hours of operation, she says, citing Nelson Irrigation recommendations. Pressure regulators on drop tubes typically last three

to seven years and should be checked every one to three years to ensure they meet manufacturers' targets. Actual wear on both components depends on water quality, the chemicals run through the system for chemigation, and hours of operation. For more pivot maintenance information, download Oregon State University's "[Inspecting and Maintaining Irrigation Systems](#)" publication.

In the past, water consultants periodically conducted center-pivot system uniformity tests by placing cans under sprinklers and measuring the output and how it varies spatially. Today, many Washington-state producers also enlist drones to fly fields to look for spatial variability to ensure their sprinklers are operating uniformly, especially at the beginning of growing high-value crops such as potatoes, says Washington State University Extension Irrigation Specialist Troy Peters.

The drones are outfitted with specialized cameras to capture multispectral and infrared images that can reveal plant water stress, crop vigor and striping caused by broken, worn or plugged nozzles.

Evapotranspiration-based irrigation

Evapotranspiration (ET)-based irrigation, also known as weather-based scheduling, calculates how much water plants lose through evapotranspiration and replaces only that amount. Like most parts of the country as well as the United Nations' Food and Agricultural Organization, the Pacific Northwest (PNW) uses alfalfa as the ET reference crop or ETr. California uses a cool-season pasture grass as its reference crop or ET_o.

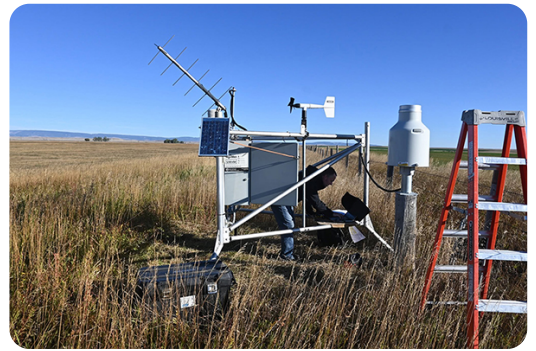
The Bureau of Reclamation operates the AgriMet network of automated weather stations throughout the PNW and the Rocky Mountain West that provides daily ET readings accessible online. Washington State University (WSU) has its own network of automated weather stations, dubbed [AgWeatherNet](#), that includes 360-plus stations and more than 27,000 registered users.

To obtain a crop-specific ET, multiply the reference ET reading from the nearest weather station by the crop coefficient (K_c) specific to the plant's growth stage. Or you can use WSU's Irrigation Scheduler program, which has a mobile version and allows users to customize the setup based on the crop, the planting date, and soil type. Based on data pulled from the nearby weather station, the program shows available soil moisture, whether irrigation is needed, and if so, how much.

Updating 50-year-old crop coefficients

Meetpal Kukal, an assistant professor of Hydrologic Science and Water Management at the University of Idaho–Boise Water Center has taken on that challenge.

"With water budgeting in any state in the western U.S., ET is a significant part," he says. "It's the largest outflux from the system, and even a little bit of uncertainty amounts to a lot."



The Bureau of Reclamation operates the AgriMet network of automated weather stations throughout the PNW and the Rocky Mountain West that provides daily evapotranspiration readings accessible online. Photo courtesy of the Bureau of Reclamation.

Before the start of the 2025 growing season, Kukal set up a network of eddy covariance flux towers in cooperating growers' fields along the Snake River from Wilder to Delco, ID. The targeted crops included Clearwater russet potatoes, spring wheat, alfalfa, sugar beets, and barley.



Eddy covariance sensors measure radiant and wind energy in the field to calculate the precise volume of water and energy that would evaporate from the plant and soil. Photo courtesy of the University of Idaho.

Eddy covariance sensors measure radiant and wind energy in the field to calculate the precise volume of water and energy that would evaporate from the plant and soil. The results are considered the “gold standard,” he says.

Because ET doesn't happen in a vacuum, researchers also are documenting soil characteristics and grower management practices. After one year, Kukal says

preliminary results show the original 1970s crop coefficients may be suggesting under-irrigating potatoes early in the season and over-irrigating during the peak water-use period when tubers are bulking. In the end, though, he says seasonal water use appeared similar to the 1970s crop coefficient.

Kukal is continuing the research this year and has added dry beans since they were part of cooperating growers' rotations. In addition, the researchers have included sagebrush and turf for comparison. Their goal is to have these revised crop coefficients be disseminated to irrigators by the start of 2027.

Soil moisture sensors

Oregon State University Agricultural Water Management and Statewide Irrigation Extension Specialist Maria Zamora Re says some producers in her state irrigate based

on ET and “kicking the soil,” as she described how they inspect the top few inches for soil moisture. Even if the surface is dry, soil moisture may still be available to crop roots a few inches deeper, and moisture sensors could provide that information.

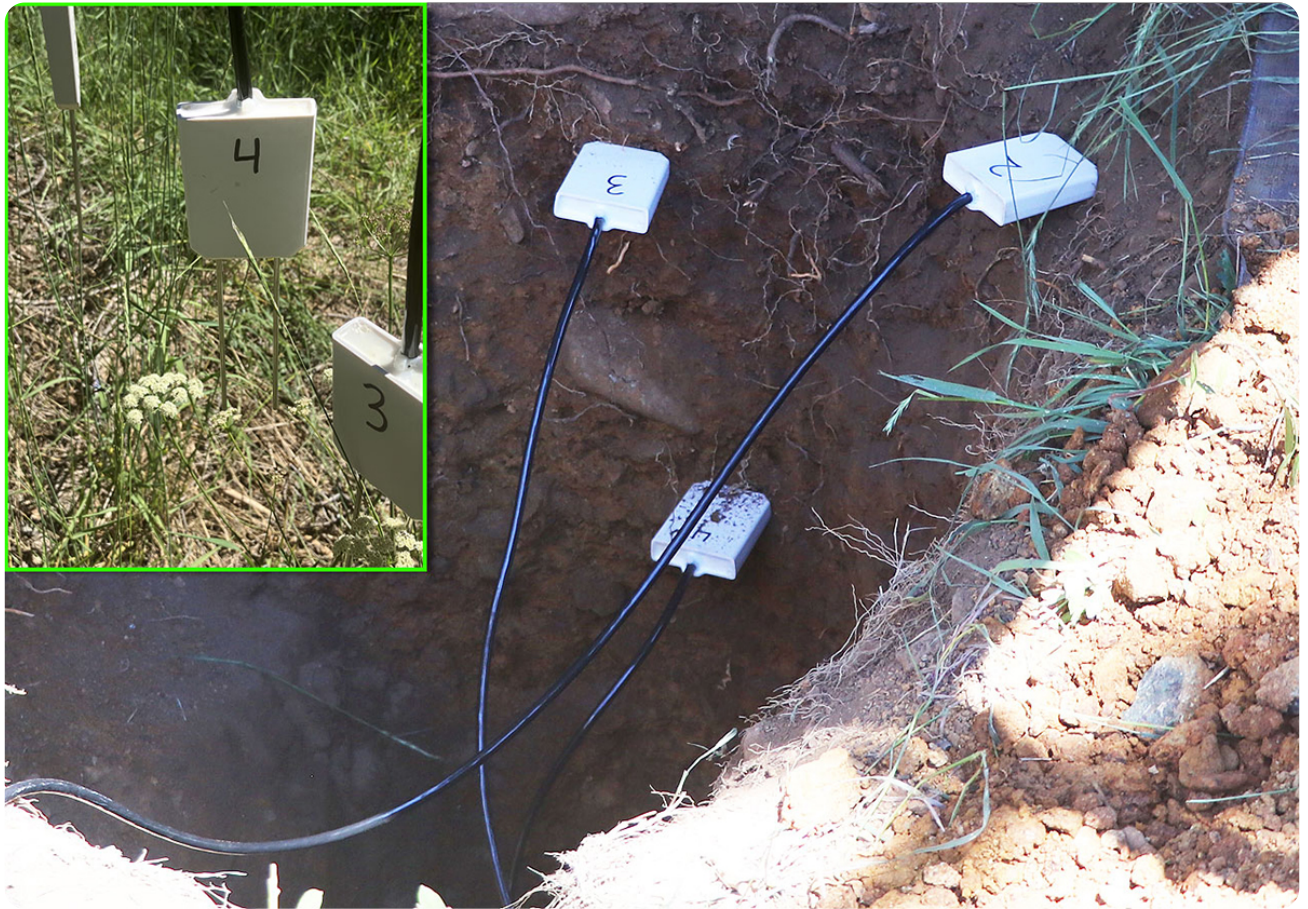
Based on conversations with producers, Zamora Re said moisture sensor adoption is not widespread. Producers frequently cited sensor costs as a deterrent and say they didn't know how to interpret sensor data or use it in their operations.

To address those concerns, researchers from OSU and Clemson University received a three-year \$500,000 grant from the USDA Natural Resources Conservation Service to develop and implement cost-effective soil moisture sensors. The systems also include a smartphone app that allows growers to monitor soil moisture levels remotely.

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As part of the project, Zamora Re said they're working directly with producers to teach them how to use the technology to understand when to irrigate. Soil moisture sensors installed at 6, 12, 18, and 24 inches, for example, can tell producers and consultants

what's happening in the root zone.



Soil moisture sensors installed at multiple depths provide real-time information about water availability throughout the crop root zone, helping growers make more precise irrigation decisions. Photo courtesy of USGS.

Irrigation planning

Along with Todd Peplin, former lead planner with the Deschutes Soil & Water Conservation District, Zamora Re developed a hybrid online and in-person course that walks participants through building an irrigation plan. They also partnered with several other agencies to help teach different educational segments.

Participants learned how to assess their own irrigation systems and received a water management plan template they could customize as the course progressed. The resulting irrigation plan is not set in stone but is a living document that can be revised as conditions change, she says.

In addition, the course included three field workshops hosted by producers, who discussed the irrigation management technologies they used. Attendees also participated in hands-on activities.

“A lot of producers are really happy with the course and the really comprehensive document they can modify,” Zamora Re says.

The course underwent a soft launch this spring, and she said they would review participants’ comments and modify the sessions before a full-scale launch in early 2027.

Higher-efficiency nozzle packages

Faced with looming water shortages, some producers may consider upgrading center-pivot sprinkler configurations and nozzle packages to higher-efficiency models. These systems also require lower operating pressure, potentially saving users on pumping costs. Because each option has pros and cons, producers and consultants need to best match choices to their conditions.



Most Idaho producers have moved away from center-pivot irrigation with impact sprinklers and have transitioned to mid-elevation spray application, or MESA, where the emitters are about 4 to 7 ft from the ground. Photo by Vicky Boyd

High-pressure impact sprinklers mounted on the tops of pivot spans have fallen out of favor in the PNW due to their higher energy use and lower application efficiency. Based on work led by Peters, the systems require 70–110 psi at the pivot point and yield an irrigation efficiency of about 60%, based on catch can tests without canopy.

On the other hand, outlets are spaced 20–30 ft apart, requiring fewer sprinklers per span. They also produce a larger wetted area, allowing more time for the water to infiltrate into the soil as the pivot passes.

Mid-elevation spray application, or MESA, has replaced most of the impact sprinkler pivots in the PNW, Peters says. With MESA, application heads or nozzles are typically

suspended on drop tubes about 4–7 ft above the ground, allowing them to clear plant canopies.

They require about 35–40 psi at the pivot point to operate and 15–20 psi pressure regulators on the drop tubes. With sprinkler heads spaced about 10 ft apart, MESA irrigation efficiency is typically about 85%, based on catch can tests without plant canopy. They also produce a smaller wetted area, which doesn't allow as much time for water to infiltrate as the pivot passes. This may require speeding up the center pivot slightly to avoid ponding.

Low-elevation spray application (LESA) and low-energy precision application (LEPA) require only about 10–15 psi at the pivot point to operate properly. As a result, they’ve become popular in areas, such as West Texas, where well output has dwindled due to groundwater overdraft. With LESA, sprinkler heads suspended on drop tubes are about 12–18 inches above the ground, reducing wind and evaporative water losses. They use 6–10 psi pressure regulators. While the system typically requires twice as many drop tubes as MESA, it can achieve up to 97% irrigation efficiency, according to Peters’ trials. LESA also produces a smaller wetted radius than MESA, making it prone to ponding or runoff on some soils.



Some producers have converted center-pivot systems to LESA, or low-elevation spray application, where nozzles are 12–18 inches above the ground. These systems have become popular in areas such as the Texas Panhandle (pictured), where well output has dwindled because of groundwater overdraft. Photo by Vicky Boyd.

Although the low-hanging LESA sprinklers will run under the canopies and heads of taller crops, such as corn and grains, he says researchers haven't seen any ill effects.

"We've found dragging it through corn is just not a problem," Peters says.

LEPA involves specialized bubbler heads or drag socks that apply water close to the ground or directly into furrows, reducing wind drift and evaporation losses to close to zero. Because the water is applied to the soil in much less time and over a small area, use should be limited to fields with slopes of 1% or less to avoid runoff. If the soil has low permeability, such as some clays, producers also may need to furrow-dike to manage water intake.

Like LESA, LEPA has about a 97% application efficiency, according to WSU studies. Since LEPA bubblers or drag socks run along furrows, Peters says producers typically plant in circles and set up their irrigation systems so there's one bubbler or sock per row. This differs from LESA, which also can be used on straight rows because the sprinklers wet a slightly larger area and can compensate for rows without a nozzle.

"LESA is much more flexible, and that's why many more people are doing it in the PNW," Peters says. "Of course, you're just moving the drops very close to the ground."

Both LEPA and LESA typically require at least twice as many drop tubes per span as MESA because they produce smaller wetted areas. Newer spans, which have removable plugs for new drop tube installation, can be easily upgraded.

“LESA is much more flexible [than LEPA], and that’s why many more people are doing it in the PNW.”

But older center pivots may need to be modified with double goosenecks and truss-row hose clamps to accommodate the increased number of sprinkler drops.

Try before taking the plunge

Regardless of the nozzle package, Peters recommended trying it on one span before making the leap.

“If I was a grower, I’d convert one span of pivot to LEPA/LESA and see how it did. It may require operating the pivot slightly differently.”

“If I was a grower, I’d convert one span of pivot to LEPA/LESA and see how it did. It may require operating the pivot slightly differently,” he says.

Conversion costs also may be a consideration due to increased number of sprinklers, drop tubes, and other material expenses. Depending on the state, cost-share, rebates, or other incentives may be available to producers to retrofit irrigation systems to improve their efficiency, Zamora Re says.

A [three-year study](#) by Utah State University (USU) conducted on commercial and university farms evaluated MESA, LESA, LEPA, and MDI—or mobile drip irrigation. The trials, which involved several different soil types, topographies, pumping capacities, and crops from 2018–2020, yielded variable results.

“Research on 11 trials over three years has demonstrated that LEPA, LESA, and MDI can sometimes, but not always, maintain crop yield with about 20% less water than MESA,” wrote USU graduate student Jonathan Holt, who was part of the study. “Thus, one system is not ideal for all scenarios, and each field should be carefully assessed to determine which technology might be ideal for the good years and the bad.”

The USU researchers also calculated investments of \$58, \$96, and \$208 per acre for LESA, LEPA, and MDI, respectively. For MESA, the cost was \$44 per acre. The upgrade costs should be factored into the package’s lifespan and account for anticipated water shortages. While a higher-efficiency system may not always affect yields during a normal precipitation year, it may be worthwhile during a drought year, they note.

“If more than the cost of the upgrade—\$14–\$164 per acre, based on the cost of the various systems—can be recovered over the lifespan of the package, then using advanced systems makes sense,” Holt wrote.

Self-study CEU quiz

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1. What is the rule of thumb for replacing center-pivot nozzles?

- a. Every 3–5 years or about 5,000 hours of operation.
- b. Every 5–7 years or about 10,000 hours of operation.
- c. Every 8–10 years or about 15,000 hours of operation.
- d. Every 10–12 years or about 20,000 hours of operation.

2. How is crop-specific evapotranspiration typically estimated for irrigation scheduling?

- a. Multiplying reference ET by a crop coefficient.
- b. Multiplying soil moisture by rooting depth.
- c. Dividing rainfall by crop growth stage.
- d. Dividing pump output by field acreage.

3. What was the primary goal of installing eddy covariance flux towers in cooperating growers' fields?

- a. Collecting water-use data to update crop coefficients.
- b. Collecting yield data to update fertility recommendations.
- c. Collecting weather data to improve planting dates.
- d. Collecting groundwater data to estimate aquifer recharge.

4. Which statement best describes MESA systems compared with traditional impact sprinklers?

- a. They typically operate at lower pressure and achieve similar irrigation efficiency.
- b. They typically operate at higher pressure and achieve higher irrigation efficiency.
- c. They typically operate at higher pressure and achieve similar irrigation efficiency.
- d. They typically operate at lower pressure and achieve higher irrigation efficiency.

5. What does Troy Peters recommend before fully converting a center-pivot system to LESA or LEPA?

- a. Compare multiple nozzle manufacturers before upgrading.
- b. Test the system on one pivot span first.
- c. Install soil moisture sensors throughout the field.
- d. Complete a uniformity test after harvest.

6. What type of imagery do drones commonly collect to identify irrigation uniformity problems in fields?

- a. Radar and sonar imagery.
- b. Satellite elevation imagery.

- c. Thermal and multispectral imagery.
- d. Fluorescent and ultraviolet imagery.

7. According to the article, why do some producers hesitate to adopt soil moisture sensors?

- a. Sensors require daily calibration in the field.
- b. Costs and data interpretation can be barriers.
- c. Sensors are incompatible with center pivots.
- d. Sensors only work in sandy soils.

8. Where are LESA sprinkler heads typically positioned?

- a. Near the top of the pivot span.
- b. About 4–7 ft above the ground.
- c. About 12–18 inches above the ground.
- d. Directly beneath the soil surface.

9. Under what field condition is LEPA generally recommended to reduce the risk of runoff?

- a. Fields with slopes of 1% or less.
- b. Fields with slopes of 3–5%.
- c. Fields with terraces and steep grades.
- d. Fields with standing water throughout the season.

10. According to the Utah State University study cited in the article, which irrigation technology had the highest estimated investment cost per acre?

- a. MESA.
- b. LESA.

c. LEPA.

d. MDI.

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