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Groundwater Markets under SGMA

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The 2014 Sustainable Groundwater Management Act (SGMA) requires local agencies (groundwater sustainability agencies; GSAs) to bring groundwater basins into balance by the early 2040s. The Public Policy Institute of California (PPIC) estimates that an average 16% cutback in pumping across the San Joaquin Valley is needed to achieve SGMA goals. SGMA also opens the doors to local groundwater trading, which may provide some flexibility for producers.

A groundwater market is a system for voluntary, compensated transfers of individual allocations to pump a specific amount of groundwater. Unlike surface water, which relies on canals and dams, groundwater trading doesn't typically involve any physical movement of water.

The primary reason to facilitate trade is cost reduction. Research by the PPIC suggests that trading could reduce the overall economic burden of SGMA by 33% to 50%. By allowing water to move around, producers can find the most efficient uses of water. This could allow more agricultural land to remain in production relative to a no-trade alternative. At the same time, there are concerns that markets might only benefit big players and/or lead to a loss of small-scale farming.

Lessons Learned from the Mojave Basin Groundwater Market

To see how this works in practice, we can look to the Mojave Desert in San Bernardino County, which has operated one of the West's most active groundwater markets for over 30 years. Approximately 15% of total water use in the Mojave is traded in any given year.

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- **Water tables stabilized after setting allocations:** Groundwater levels that had been dropping for decades leveled off. (Note: This resulted from the initial allocations to individual pumpers, which set a cap on the total amount of water pumped from the basin, as opposed to trading itself.)
- **The region experienced large economic gains:** Research by Andrew Ayres and co-authors (2021) documented significant net benefits for agricultural landholders.
- **Mild ownership consolidation occurred:** Our research shows that the top 10% of owners grew their share of water rights from 65% to 75% over a 25-year period. (However, some of this might have occurred in the absence of trade.)
- **"Sellouts" were typically smaller agricultural users:** About half of the original water right holders eventually sold their allocations and exited the market. While this signals a loss of small-scale farming in the region, it also represents an exit strategy—providing a way for those small producers to receive compensation for their water assets if they choose to retire or shift their business model.

What's next?

Several GSAs in the Central Valley are exploring or piloting groundwater markets. For dairy producers looking to understand more or have a say in the process, you may want to get involved in your local GSA. The specific rules your agency writes today regarding how water can be traded will carry economic implications.

On-farm evaluation of lagoon water quality for forage nutrient management on California dairies

Rúbia Branco-Lopes – UC ANR, Nicholas Clark – UC ANR, Jennifer Heguy – UC ANR, Joyce Pexton – UC Davis and Deanne Meyer – UC ANR & UC Davis

The nitrogen (N) concentration of lagoon water is highly variable. It changes due to diet, animal and milk cooling systems, manure management and seasonal weather. Nitrogen concentrations in blended lagoon water can vary during a single irrigation event due to changes in lagoon water levels and irrigation flow rates. This variability makes it challenging to apply N to crops precisely when utilizing lagoon water. Lab analyses can provide accurate N measurements but fail to capture the variability that occurs during an irrigation event in real-time. On-farm N measurement of lagoon-blended irrigation water could improve farm N management by providing instant information. However, there is no practical on-farm tool that can directly measure total N in lagoon-blended irrigation water quickly, easily, and at a low cost.

Ongoing study. We are evaluating if different water quality parameters (electrical conductivity, ammonium-N, specific gravity and turbidity) measured with handheld meters can quickly, accurately and inexpensively estimate N concentrations in lagoon-blended irrigation water. Lagoon water contains N in several forms but mostly as organic N and ammonium-N. Ammonium-N is plant-available; organic N is not available until soil microbes decompose it into ammonium-N. However, both are important to quantify because they both contribute to plant nutrition over a crop season.

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We are collecting blended lagoon water samples at irrigation valves on eight dairies in the San Joaquin Valley. During irrigation with lagoon water, water quality is measured on-farm at the irrigation valve using handheld meters, and samples are also collected for lab analysis. We are sampling during summer and winter over two years at dairies with and without anaerobic digesters, and the first year is almost complete.

Preliminary results. Nitrogen concentrations in lagoon-blended irrigation water varied (Table 1). Nitrate-N and ammonium-N are plant-available. Total Kjeldahl Nitrogen represents the sum of ammonium- and organic N.

Table 1. Concentrations of different forms of N measured in lagoon-blended irrigation water, shown in pounds applied per acre-inch of water, collected from eight dairies in the San Joaquin Valley (n = 122).

	Nitrate-Nitrogen (lb/ac-in)	Ammonium-Nitrogen (lb/ac-in)	Total Kjeldahl Nitrogen (lb/ac-in)	Total Nitrogen (lb/ac-in)
Maximum	3.51	118.97	267.39	267.39
Minimum	0.004	0.14	0.36	0.004
Average	0.88	47.18	68.39	63.17

A strong relationship was observed between electrical conductivity (EC) measured on-farm and ammonium-N and Total Kjeldahl Nitrogen (TKN) both measured in the lab (Fig. 1). This demonstrates that EC measured with handheld meters can be used as an indirect indicator of N concentrations in lagoon-blended irrigation water. Electrical conductivity is an indicator of how much charge is in water which in turn indicates how many salts are dissolved in the water. As ammonium-N is electrically charged, higher ammonium concentrations increase EC. The relationship between EC and TKN makes sense because ammonium-N is part of TKN.

Take-home message. N concentration in lagoon-blended irrigation water can vary widely. Measurements with a handheld meter (EC) may provide a quick indicator of N concentrations during irrigation, however they do not replace the lab analyses required for environmental compliance.

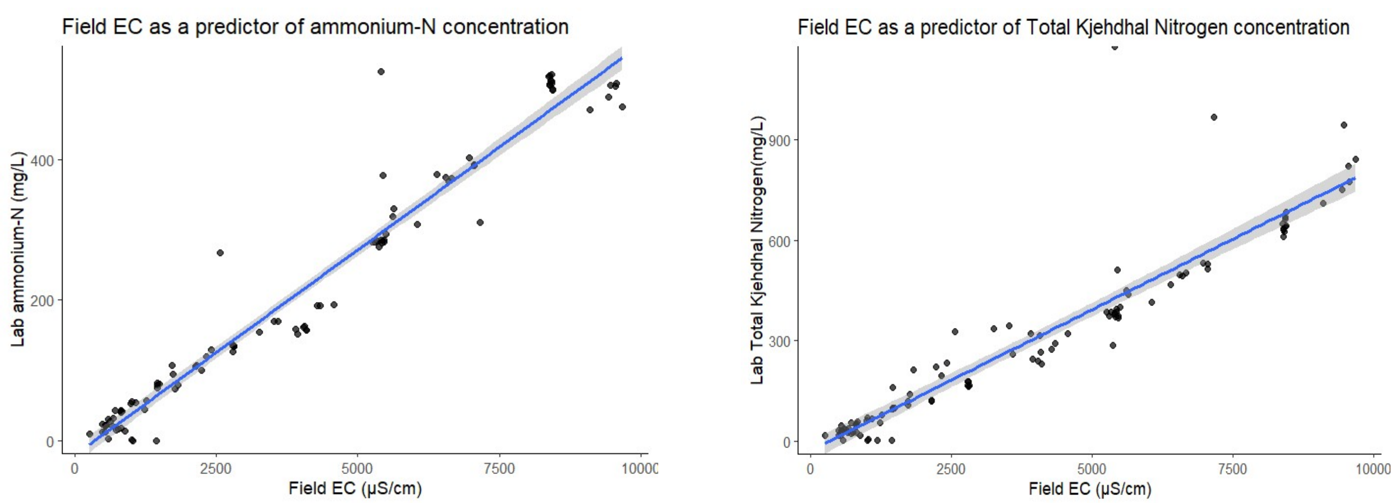

Fig. 1. Relationship between electrical conductivity (EC) measured on-farm and N (ammonium-N or Total Kjeldahl Nitrogen) measured in the lab *[R^2 = how related the EC and ammonium-N or Total Kjeldahl Nitrogen are (closer to 1.0 = stronger)].*

Herbicide Resistance in Forage Cereal Crops

Jorge Angeles, Weed Management Farm Advisor – UCCE Tulare, Kings & Fresno Counties

Weed management continues to be a growing concern in cereal forage crops. Managing weeds at planting is important because weeds compete with the crop for water and nutrients, leading to poor stand establishment. Weeds can also lower the quality of harvested forage. When weeds are left uncontrolled, they produce seeds and increase the number of seeds in the soil seed bank, which can lead to greater weed pressure in subsequent years.

Pre-irrigation before planting can help stimulate the germination of many weed seeds prior to planting. These weeds can then be controlled with shallow tillage, postemergence herbicides, or preemergence herbicides with short residual activity. Controlling this initial flush of weeds before planting allows the forage crop to establish with less early competition and gives the forage crop a competitive advantage.

Once weeds emerge after planting, the primary control option is the use of postemergence herbicides. Early weed identification is important so the appropriate herbicide can be selected. Most weeds are more susceptible to postemergence herbicides when they are small, typically at the 3 to 4 leaf stage and no more than 4 inches tall. Spraying weeds at this stage improves spray coverage and herbicide penetration, resulting in better control. Several herbicides are labeled for cereal forage crops, and rotating herbicides with different modes of action is important to reduce the risk of resistance development.

Due to a lack of herbicide mode of action rotation and applications made at improper timing, we are beginning to see an increase in weed species developing resistance to herbicides used in cereal forage crops. A few years ago, weed escapes of common chickweed were observed in several areas of the Southern San Joaquin Valley. Research conducted by UCCE Farm Advisor Nick Clark and Anil Shrestha's team at Fresno State confirmed that these populations were resistant to ALS inhibiting herbicides commonly used in these crops, including tribenuron (Express) and pyroxsulam (Simplicity).

More recently, escapes of littleseed canarygrass and Italian ryegrass have been reported following applications of pyroxsulam (Simplicity) and pinoxaden (Axial XL). Herbicide resistance screenings confirmed that these populations had developed resistance to both herbicides. In 2025, shepherd's purse escapes were also reported in multiple triticale fields, and resistance to pyroxsulam and tribenuron was confirmed.

Herbicide resistant weeds in cereal forage crops are increasing, and without new control tools this will continue to be a major challenge for the industry. An integrated weed management approach should be adopted that uses all available tools to manage weeds, including rotating herbicides with different modes of action, applying herbicides when weeds are small, and using pre-irrigation to control the initial flush of weeds.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

Better Yields, Lower Emissions: The Benefits of Dairy Manure Compost in Almond Orchards

Adolfo Coyotl, Soil Biogeochemist – UC Davis

In California, dairy is the state's top agricultural commodity, which results in large amounts of manure. Manure nutrients are applied to nearby forage systems, but too much or repeated use can reduce water and air quality. A key challenge is finding ways to use these nutrients that support both crop productivity and long-term environmental and economic sustainability. One potential solution is to compost the manure and apply them to crops like almond orchards. However, we still don't fully understand how this practice affects almond yields and soil health under typical farm management.

The Dairy Soil & Water Regeneration project at the University of California, Davis is running a four-year field study in a 40-acre commercial almond orchard in Escalon, California. The study looks at how surface-applied dairy manure compost affects crop yield, soil health, and greenhouse gas emissions. Made from southern San Joaquin Valley dairy manure, the compost had an average C:N ratio of 9.75 and was applied to tree rows every November.

We studied crop performance and tracked soil greenhouse gases and carbon-nitrogen cycling. The study used four treatments: A control with no inputs, dairy manure compost only (5 tons/acre), fertigation only (90 lbs. N/acre), and a combination of both (5 tons/acre compost + 90 lbs. N/acre).

The combination treatment consistently produced the best results, with higher yields by the fourth year. Trees grown with compost also grew faster than those in the control or fertigation groups. Additionally, leaf nitrogen levels were highest—and within the ideal range—in all compost-treated trees, especially those receiving both compost and fertigation.

The combination treatment released less nitrous oxide, a potent greenhouse gas, than the conventional fertigation, even though it contained more total nitrogen. This is likely because the carbon in dairy manure helps soil microbes hold onto nitrogen instead of letting it escape as a greenhouse gas. These results show that the type of nitrogen used is just as important as the amount. We are still studying exactly how the soil processes these different forms.

While we are still analyzing the data, early results show that integrating dairy manure compost into standard almond orchards builds soil carbon and reduces greenhouse gas emissions. Importantly, these environmental benefits were achieved while maintaining—or even increasing—almond yields without adding more synthetic nitrogen.

Since dairy farms and almond orchards often share the same regions in California, this strategy offers a practical way to recycle nutrients and create a more sustainable agricultural loop.