AS U.S. AND GLOBAL DROUGHT CONDITIONS WORSEN, SCIENTISTS LOOK OFF-SHORE FOR WATER SOLUTIONS

California's Water Woes Shared by Much of U.S. Agriculture

California is entering the third year of a drought, and Gov. Jerry Brown is under pressure to declare a drought emergency that could ease pumping restrictions. Lack of water for irrigation is a huge problem for the state's vital agriculture sector, which in turn will impact all of America's food supply as well as U.S. exports to global markets.

California reservoirs typically store water that flows from the snow pack in the Sierra Nevada mountains. This year, however, many of those reservoirs are at less than 50 percent capacity. A recent survey of the water content in the snowpack in the Sierras found it at 20 percent of average for this time of year. Representatives from the California Department of Water Resources are characterizing current water levels as "dismal."

Water shortages are affecting urban areas too. Voluntary and mandatory water restrictions are in effect in Northern California cities and counties. For example, Mendocino County in northern California has declared a state of emergency. Likewise, the city of Folsom's 72,000 residents are under mandatory water restrictions relating to watering of lawns, washing cars, *etc.*

San Joaquin Valley, one of America's most productive agricultural regions, is at great risk, especially on the west side, which relies largely on the runoff from the mountains. Farmers are being doubly challenged for water access because federal pumping restrictions in place to protect endangered species also constrict available irrigation resources. A salmon restoration project in the San Joaquin River is typical of the projects that compete for increasingly scarce water supplies.

California agricultural officials have reported that Fall planting of lettuce in Fresno County, which provides 95 percent of the nation's head lettuce, was half what it was the previous year. Southern California, which also draws water from the northern part of the state, is not feeling the squeeze as much because it built more storage in recent years and its Metropolitan Water District was able to stockpile in wetter years. However, most of those dams and storage projects were built more than 50 years ago, when California had less than half its current population.

One Possible Solution: Offshore Aquifers

A massive supply of freshwater has been discovered beneath the sea floor on continental shelves around the world, a finding that could provide a new solution to a looming global water crisis according to a report published in the scientific journal Nature. According to the researcher's abstract, there is mounting evidence that massive offshore fresh and brackish groundwater reserves exist throughout the globe. The scientists report that the potential use of these non-renewable reserves as a freshwater resource provides a clear incentive for future research.

The article's scientific team was led by Dr. Vincent Post, a researcher for Australia's National Centre for Groundwater Research and Training and a lecturer at the School of Environment at Flinders University in Australia. According to Dr. Post:

> Freshwater on our planet is increasingly under stress and strain so the discovery of significant new stores off the coast is very exciting. It means that more options can be considered to help reduce the impact of droughts and continental water shortages. . . Knowing about these reserves is great news because this volume of water could sustain some regions for decades.

Water scarcity affects almost half of the world's population, and scientists predict that by 2030 almost one-half of the global population will be living in areas of high water stress, according to UN-Water, an inter-agency of the United Nations that supports states in water-related efforts. According to UN-Water's October, 2013 report entitled Water Security & the Global Water Agenda: A UN-Water Analytical Brief, humans also are over-consuming natural resources, including water, at an unsustainable rate.

Against these concerns, the Flinders University study reports that there is an estimated half million cubic kilometers (nearly 120,000 cubic miles) of low-salinity water buried under the seabed. The water could be used to supplement water supplies of coastal cities in North America, Australia, China, and South Africa that border continental shelves beneath which such water reserves are believed to exist.

If these recent findings are confirmed, the volume of potentially-potable water resources located in aquifers under sea beds could be up to one hundred times greater than the amount of water extracted from the Earth's sub-surface in the past century since 1900. However, even if such reservoirs are located and ultimately accessed, filtering and refining processes will be required to render the water potable.

Undersea water reserves were formed over hundreds of thousands of years when the sea level was much lower than it is today, and the coastlines were further out. When it rained, the water would seep into the ground and fill up the water table in areas that are underwater today. The Flinders University study suggests that these coastal aquifers were formed all around the world, and when the global sea level rose as polar ice caps began melting approximately 20,000 years ago, these coastal areas and their underground aquifers were covered by the rising ocean.

The new research concludes that many of the underground aquifers now covered by seawater remain protected from saline intrusion by covering layers of clay and sediment. Consequently, the undersea aquifers contain what is called "low-salinity" water, which is much less salty than seawater and can be converted to drinking water with less energy than seawater desalination — the process of converting salt water to drinking water.

Other scientists caution that while the water in undersea aquifers is relatively fresh compared to seawater, none of it is drinkable without some level of desalination. Because desalination generally is an expensive process, the ultimate question is whether the development of these

newly-discovered resources can be achieved in a cost-effective, and ultimately profitable fashion.

What to Do in the Meantime

For now, all farmers are well-advised to begin implementing effective water conservation practices. "Water conservation" refers to practices, techniques, and technologies that improve the efficiency of water use, thereby reducing overall demand. Increased efficiency expands the use of the water resource, freeing up water supplies for other uses, such as population growth, new industry, and environmental needs.

But efficiency is not the only factor to consider. Agricultural water conservation also encompasses (i) reduced crop consumptive use, (ii) decreased evaporation losses, and (iii) lowered uptake and use of water by non-beneficial weeds and phreatophytes.

Below are five helpful water conservation resources for farmers that can be implemented immediately:

1. More Efficient Irrigation Equipment & Effective Measuring Tools

Irrigation equipment upgrades can be costly, but will produce a valuable return on investment in the long run. As droughts continue (and perhaps grow in severity), the reality of an ever-shrinking water supply in the face of growing needs will become more evident. Sooner rather than later, the true market cost of water will emerge.

The most efficient irrigation system will depend on the type of crop, the type of soil, area climate and other factors. Generally, buried drip irrigation systems are the most efficient. Irrigation efficiency is defined as the amount of water stored in the root zone of the crop divided by the amount of water applied to the field. Typically surface irrigation is the least efficient, followed by sprinkle and drip and trickle irrigation is the most efficient. However, efficiency greatly depends on management and characteristics of a particular system.

Irrigation scheduling and monitoring are generally the most cost effective mechanisms to improve efficiency. To manage irrigation effectively, it is very important to know the application rate, *i.e.*, how much water is being applied in a given time period (inches/hour). The most accurate way of determining this application rate is to measure it; using water flow meters can provide accurate measuring and assist in controlling the amount of water being used in irrigation. There also are calculators for various irrigation systems including center pivots, drip, hand-line and wheel line, and solid set sprinklers.

Where meters are not affordable or practical, simple measuring methods are an alternative option. For sprinkler irrigation, this can be done by putting a straight sided can (catch can) underneath the sprinkler for a given time period and measuring the depth of application in the can. Because no irrigation system applies water perfectly uniformly, it is often a good idea to put out several cans in different areas where the sprinkler throws water and take an average.

2. Runoff Reduction & Water Recycling

Avoiding or mitigating runoff can save millions of gallons of water over the course of a growing season. Runoff can occur due to overwatering, poor soil and other factors.

Recycling runoff not only helps save water, it helps save entire ecosystems. Agricultural runoff typically contains large amounts of phosphorous, herbicides and other chemicals that can seep into groundwater and pollute rivers, streams and other bodies of water. The costs to mitigate runoff can be significant, but the benefits can be equally valuable.

Also, where available through nearby municipalities, treated urban wastewater is a good substitute for groundwater or imported surface water for irrigation and other on-farm uses. Recycled water typically is subject to state regulation. For example, The California Water Recycling Criteria, codified as Title 22 of the California Code of Administration, allow 43 specified uses of recycled water—including irrigation of all types of food crops. These criteria include different water quality requirements for irrigation of each type of crop; those eaten raw, those receiving processing before consumption, and those not involving any human contact before industrial processing. California growers using recycled water meeting the Title 22 criteria have shown over the last 50 years that this practice is safe and economical.

The individual grower can protect against future droughts, interruptions, higher water costs, and severe water shortages by tapping into the nearest available source of recycled water. Such sources can include:

- Major wastewater treatment facilities of large cities, many of which now are becoming recycled water production facilities;
- Medium-sized wastewater treatment plants serving smaller rural communities;
- Small or package treatment plants serving clusters of residences in isolated areas; and
- Tailwater from upstream furrow and flood irrigation practices with their inherent excesses and inefficiencies.

Reclaimed water from any of the first three sources can be conveyed either by gravity of pressure pipe to the farm and reused to free up drinking water. Tailwater reuse is a significant water source for farms where runoff at the end of the furrows is an inevitable consequence of surface irrigation. With laser leveling and highly controlled irrigation practices, tailwater is minimized on the more modern, well-operated farms. Nonetheless, tailwater is a potential water resource and can be captured for reuse.

Proactive use of recycled water by farmers requires careful consideration of the microbial and chemical quality of the delivered recycled water. The level of treatment mandated by regulations is simply a floor—a minimum required quality that would protect the public health. Farmers need water quality that also protects their soils in the long-term use of recycled water. Wastewater treatment plants can change the chemicals they use for various treatment processes if they are given the necessary information and incentives to do so. Thus, growers should insist on a recycled water chemical quality with criteria that will not be injurious to their particular soils and crops. Because soils, cropping patterns and climatic conditions vary so much from one

location to another, careful assessment of acceptable levels of these critical parameters is a necessity before using municipally-treated, recycled water for irrigation.

3. Soil Management, Tillage & Minimization of Runoff

Proper soil management can be a vital tool for conserving water. It is the soil that absorbs, transmits and holds the water for crops to use. Farmers have many options for manipulating the nature of soil, and soil management techniques become especially important where the soil quality is compromised.

For surface irrigation: shorter set times, altered length of run, slope modification, and use of surge irrigation techniques are the most common options. For sprinkler irrigation: proper nozzle packages and depth of application are most common practices. In situations where soil type and slope are such that runoff is common, changed tillage and planting practices can help reduce runoff.

Some advocates suggest the no-till option for conserving water. However, the USDA's Agricultural Research Service released the results of a comprehensive, multi-year study regarding the use of no-till management practices on water conservation and soil erosion. In a June of 2013 study entitled "Effect of No-Till and Extended Rotation on Nutrient Losses in Surface Runoff" USDA-ARS researchers compared nutrient and sediment loss from no-till, conventional tillage, and reduced-input rotation watersheds. The study, which was published online in *Soil Science Society of America Journal,* concluded that by keeping a protective layer of plant matter on the soil surface, no-till practices reduce the loss of soil and phosphorus attached to soil particles. But no-till requires herbicides to control weeds, and even after adoption of the practice by many farmers, harmful algal blooms were still occurring in surface waters. Consequently, the researchers concluded that no-till, while decreasing particulate phosphorous loss, was leading to increased runoff of dissolved phosphorous. Study results instead recommended further consideration of reduced-input rotations, which do not require herbicides but can lead to higher levels of soil loss. The USDA-ARS researchers suggest further work looking at reduced-input rotations that use less tillage to tease out even more management options.

Regardless of how the till/no-till debate ultimately resolves, in the near term additional options exist to conserve agricultural water. Other practices such as using compost and utilizing cover for crops can be huge boons to water conservation. Ultimately, what works the best to conserve water will depend on what kind of soil is being managed.

4. Crop Rotation and Organic Farming Methods

One of the most effective ways to reduce the amount of water needed to sustain an irrigated operation is to adopt crop rotations which include crops with low water use requirements – both daily and seasonally. Correspondingly, cultural practices such as reduced or minimum tillage, minimum soil disturbance, uniform plant spacing, appropriate variety selection, and crop sequencing or rotation can all contribute to conservation of agricultural water.

Water recycling is far less expensive when a farmer doesn't have to treat the water before reusing it. Organic farming methods that reduce or eliminate the use of chemicals are yet another way for farmers to conserve water by taking out a costly step in the recycling process. Using organic farming methods can arguably also lower the water-use footprint by preserving the quality of water that would otherwise be negatively affected by polluted runoff. That said, not all organic farming methods reduce the amount of water used, so conservation-minded farmers should carefully consider the options.

5. Technology & Weather Applications

Some farmers may be inclined to set an automated irrigation schedule and let it run regardless of the weather. Adjusting irrigation systems to work in better harmony with natural precipitation takes more work, but it is an inarguable way to save significant amounts of water.

There are numerous weather apps available that provide up-to-the-second precipitation reports. Using these along with irrigation systems can help save water, which will save farmers money and reduce wear and tear on systems. Current examples include:

DTN/The Progressive Farmer Weather Tools app for Android. Provided by Google, this app is reportedly the agriculture industry's first weather app to deliver exclusive GPS-based roaming alerts, top-rated forecasts, touch screen interactive weather displays and unique agricultural commentary. This app helps producers improve operational planning with highly-local, farm-level forecasts, and gives them advance notice to weather risks via customized alerts.

Optimizer 2.0 (update). The new function from Advanced Ag Solutions LLC models anticipated irrigation to reduce data entry for farmers and their crop advisors. It is part of the company's Optimizer 2.0 app, which also recently unveiled the ability to download variable rate files to control seed and nitrogen rates within the field in its Solver feature. The app utilizes weather forecasts and soil moisture levels along with crop needs and common practices of area farmers to estimate when the farmer may have turned on or off his irrigation pivot. The software then allows the user to easily edit irrigated rates and timing in cases where estimates of irrigation might be off. *(Available on most devices)*

Apache on the Go. This mobile app from Equipment Technologies enables users to learn about the features and benefits of the Apache sprayer with a virtual 360 walk around, detailed specs and photos and videos on each Apache sprayer model. *(iPad)*

CP Products Calculator. This mobile app allow users to set up calculations for all CP's nozzles, both for aerial and ground. Need to know what is the best tip for your aircraft? CP Products' calibration app will help you figure it out. Meanwhile, the flow rate calculator app will help users determine the best tip and orifice for their sprayer. *(Android, iPad, iPhone)*

Totheshelf. This mobile app from Agrotypos SA links growers to traders and vice versa. Totheshelf intends to build a global network of agricultural products sellers and buyers. Farmers, cooperatives, wholesalers, brokers, importers, exporters, industry, retailers and anyone who involves in animal or plant products trading can download the app and seek new customers or

business partners. The app is available in all countries and in two languages, English and Greek. *(iPad, iPhone)*

VRPETERS (Vehicle Rollover Prevention Education Training Emergency Reporting System). Developed by University of Missouri researchers, VRPETERS can detect vehicle collisions, side and rear overturns and rollovers due to centrifugal forces while turning curves. In case of an accident, VRPETERS transmits emergency notifications to predefined contacts automatically. VRPETERS can save lives by changing the human behavior as a training tool; providing warning messages to the operator to prevent an accident; reducing the deployment time of rescue teams; and providing the GPS coordinates, the date and time of an accident. *(Android, iPad, iPhone)*

UNL Climate App. This University of Nebraska-Lincoln app helps agricultural producers track key temperatures. The Climate App publishes maps that show recent highs, lows and soil temperatures. The High Plains Regional Climate Center in UNL's School of Natural Resources released the app to keep agricultural producers aware of the temperature ranges that could affect production timelines. The Climate App's homepage currently presents five options: "Maximum Temperature (F) yesterday," "Minimum Temperature (F) yesterday," "7 Day Average Soil Temperature (4″)," "1 Day Soil Temperature (4″)," and "1 Day Precipitation Total." Each option links to a map with a color scale that indicates the corresponding local information. (*Available on most mobile devices*)

iCropTrak Soil App. Replacing its PrecisionEarth mobile app, Cogent3D has introduced the new iCropTrak Soil. It can go from login to your field sample in three clicks; add new growers, farms, field boundaries and zones from the iPad while in the field; and export soil sampling results while in the field using one button via e-mail to the lab and customer using synchronization with the cloud, other iCT users and export to iCloud. *(iPad)*