Drought Management Conference Targets Tree & Vine Crops

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The United States Department of Agriculture (USDA) sponsored a drought management workshop, "Water Management Strategies for Perennial Crops with Limited and Impaired Water Supplies," in Modesto, CA January 12-13. To my knowledge, this was the first such workshop specifically targeted at the perennial tree and vine crops that are so important to California's agricultural economy. The workshop's speakers were experts from around the world, with heavy input from Australia and Israel, two large agricultural producers who are familiar with drought.

The workshop was broken into several sessions over the two days, focusing largely on technological solutions, alternative water supplies and management strategies. The second day included specific breakout sessions concerning different crops, including tree nuts, grapes and citrus, avocado and olives.

The workshop started with an overview of the current drought conditions in California and forecast information for the current El Niño. Not to anyone's surprise, the early winter rainfall received by much of California has done little to reduce the overall drought conditions, and more than 60 percent of the state remains under extreme or exceptional drought as of mid-February. However, what struck me the most was data presented by Michael Anderson, state climatologist with the California Department of Water Resources (DWR). In his talk, Anderson addressed why the forecasts for this year's El Niño have been so far off. Essentially, forecasters are dealing with weather conditions that are completely outside the realm of the historical norms on which they base their forecasts, resulting in greater inaccuracy.

Technology

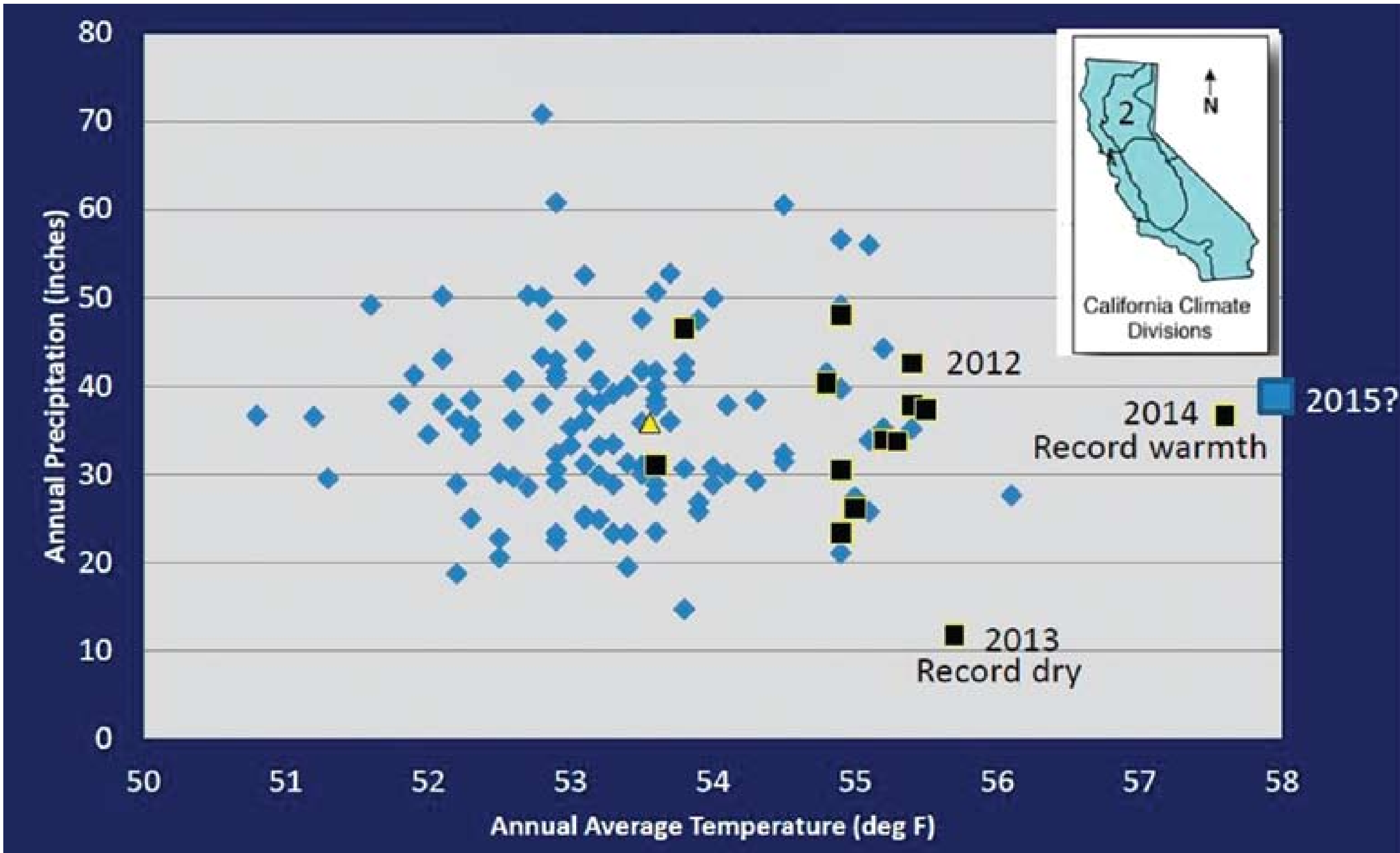
Several talks focused on various technologies available to help growers deal with drought. The primary theme of these talks was utilizing tools to improve irrigation application rates and timing by knowing precisely when to apply irrigation and how much to apply.

For most tree crops, knowing when to irrigate is based on soil moisture content with the goal of maintaining your soil between field capacity and the permanent wilting point. This is primarily achieved by using various forms of soil moisture sensors. The different types of soil moisture sensors and knowing how to use them in scheduling irrigation have been covered in previous *From the Grove* articles (see Fall 2014 and Fall 2015 issues), and not much has changed with respect to soil moisture sensors and monitoring.

The other aspect of drought management is knowing how much water your trees are using to avoid over irrigation. This is what we refer to as crop evapotranspiration (ETc), which is based on a reference evapotranspiration (ETo) value that is multiplied by a crop coefficient (Kc). Historically in California, growers rely on California Irrigation Management Information System (CIMIS) data to obtain ETo values. The ETo calculated by CIMIS is based on a well-watered grass field of specific standards. However, there are inherent flaws in this system because the grass plots are quite small and, especially over the past couple of years, not all of them are equally "well-watered." In addition, the plots are usually on relatively flat ground so they don't take into account how exposure aspect affects ETo, which is very important to avocado growers, many of whom are growing on slopes.

ET calculations are an active area of research that was discussed at the workshop. DWR has been working on a project for the past several years utilizing state-of-the-art technology to refine the models used for the calculation of CIMIS ETo. Other groups have been working on developing ETc data directly from satellite image analysis. The current satellites provide resolution of a couple of meters, but the next generation of satellites will provide sub-meter resolution. This technology not only allows a grower to look at ETc for their specific field or orchard, but allows them to zoom in to specific plots, which is extremely valuable if you are growing on slopes or you have trees of different ages.

The group that has made the most progress developing this satellite technology is led by John Hornbuckle at Deakin University in Australia. The system they have developed is available online at https://irrisat-cloud.appspot.com/ and utilizes Google Earth as the underlying map engine (a Google account is required, but is free). The system uses analysis of different spectral bandwidths to calculate



Annual average temperature for the northern Sierra Nevada region plotted against annual precipitation for the period 1895-2000 (blue diamonds). The yellow triangle in the center is the historical average (1895-2000). The black squares are the years 2001-2014. The projected number for 2015 is shown to the far right. All but two of the years since 2000 have been at or beyond the limits of the historical data. (Figure compiled by Michael Anderson, California Department of Water Resources, from National Oceanic and Atmospheric Administration climate data.)

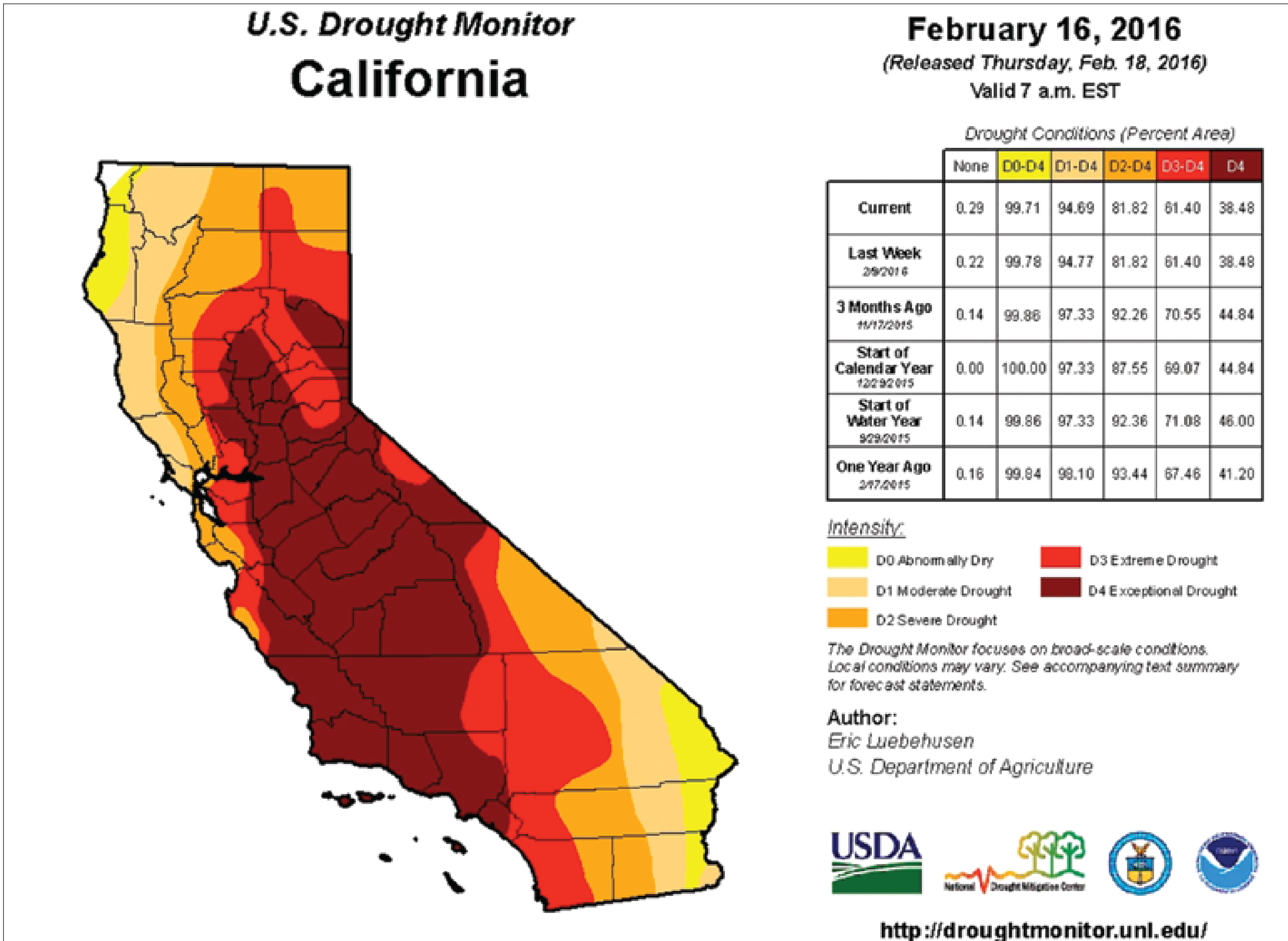
the ET for a given location. These satellite-based systems will probably become the norm over the next 10 years in part because there's no maintenance of ground-based stations needed and they can provide precise data about specific locations.

There also are significant advances being made on soil salinity management, especially with respect to mapping salinity within a given area. Two systems being used to map salinity in a plot are electromagnetic induction and electrical resistivity units. Both of these technologies involve a small device that is dragged along the ground behind a tractor or four-wheeler to give an estimate of soil salinity and their data can be used to generate maps of a given field so that management practices can be tailored to specific conditions. Both of these technologies are best used to map a field before planting. However, satellite technology also is being developed to use specific canopy reflectance data to determine salinity levels. Although this technology is not commercially available yet, it was recently used experimentally to perform large scale mapping in the western San Joaquin Valley, determining that 1.35 million acres of land are affected by salinity in that area.

Alternative Water Supplies

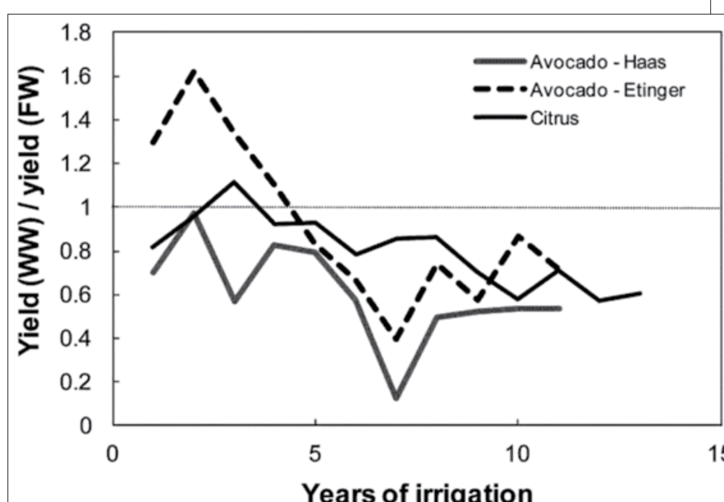
The talks on alternative water supplies focused on reclaimed water and the long-term effects of irrigating with water high in salts, and were presented by three leading Israeli researchers and Don Suarez from the USDA Salinity Lab in Riverside. Overall, the long-term use of saline water for irrigation results in the loss of soil structure and poor infiltration, which is exacerbated with water that has a high pH. One of the interesting points made by Don Suarez was that our method of measuring soil salinity usually averages the salinity across the root zone, but this tends to overestimate the salinity because there is a gradient of salts in the root zone — becoming more concentrated at deeper depths. This is important to consider, especially for a relatively shallow rooted tree like avocado where the majority of water uptake occurs in the top few inches of soil. In addition, Don pointed out that leaching is most effective during the winter months, when ET is generally lower so a larger portion of the applied water can infiltrate and move salts lower in the soil profile.

Data from a 16-year trial in Israel in which avocados were irrigated with treated waste water illustrated the points made by Suarez. The waste water had a pH of 8.1, 220 ppm



U.S. Drought Monitor map of California showing that more than 60 percent of the state is still under extreme to exceptional drought conditions, despite some promising early season rains. (Figure from the United States Drought Monitor droughtmonitor.unl.edu/).

chlorides, EC 1.8 and 7.4 ppm sodium, compared with fresh water at pH 7.1, 70 ppm chloride, EC 0.83 and 1.3 ppm sodium. Over 10 years, the yield of both 'Hass' and 'Etinger' declined by 50 percent. The authors noted that the long term use of the treated waste water led to a "degradation of soil hydraulic properties." Such data led Alon Ben-Gal from the Gilat Research Center to conclude that the long term sustainability of irrigation with high saline water is questionable, even when best practices are followed.



The ratio of yield of trees watered with treated waste water to those watered with fresh water in Israel. From: Assouline, S. and K. Narkis. 2013. Effect of long-term irrigation with treated waste-water on the root zone environment. Vadose Zone Journal 12(2).

Management Strategies During Drought

Strategies for coping with drought were discussed by two Australian and one Israeli researcher. Unfortunately, the Australian researchers didn't provide many new strategies that California growers aren't already familiar with. These include removal of unproductive trees, grafting over to new varieties or stumping trees, irrigation system maintenance to reduce leaks and improve efficiency, and conversion to drip irrigation. However, one option that was mentioned that hasn't been widely adapted in avocados is spatial man-

A screen capture of the Irrisat ET estimation tool developed by John Hornbuckle, Deakin University Australia. The screen capture shows the mature trees (right) and young trees (left) at the California Avocado Commission's Pine Tree Ranch demonstration grove and the colorized crop coefficient for each block for the week of February 2-9, 2016. By clicking on a block the weather forecast and estimated evapotranspiration for that block can be seen.

agement of irrigation. This involves mapping groves for soil types, tree age/size, and slope/exposure, then breaking up irrigation zones into smaller units based on these characteristics so that each zone can be more optimally irrigated to match the soil conditions and the tree needs. Examples presented for apples and peaches showed water savings of 10 to 35 percent.

Shabtai Cohen of the Volcani Center presented what I would consider the most extreme idea for saving water: cultivation under protective structures. While this isn't a new idea, it has not received a lot of attention specifically for water savings. Data presented by Shabtai showed that the screens used to cover structures can reduce mid-day maximum temperatures and slightly increase night temperatures for an overall reduction in average temperature of about 3°F. There is also an increase in humidity, which reduces evaporative demand. The structures also can help reduce wind damage since wind speeds are reduced by about 35 percent. In apples and bananas, the combined effect reduced evapotranspiration by 35-60 percent, reduced irrigation by 25-30 percent and increased water use efficiency by 10-30 percent.

A group in Florida has been using similar structures to grow citrus to protect trees from the Asian citrus psyllid and Huanglongbing (HLB). In addition to protecting the trees from HLB they have seen reduced water use and reduced wind scarring of the fruit, which leads to an increased percentage of unblemished fruit.

The greatest take home message from the meeting is that there is no easy solution to drought or salinity issues. In order to be sustainable with less and poorer quality water, growers are going to have to adopt an array of technologies and tools that each provide an incremental benefit. Of course the question always asked is: "Are these technologies and tools affordable?" Perhaps the more appropriate question is: "Can we afford not to adopt them?"