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Author
Crowder, Lucien

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Research highlights

Recent articles from the Agricultural Experiment Station campuses and UC ANR's county offices, institutes and research and extension centers.

Envisioning optimal land use in Pajaro Valley

The Pajaro Valley is a highly productive California agricultural region comprising parts of Santa Cruz, Monterey and San Benito counties. For decades, more water has been pumped from the valley's aquifers than has been replenished, resulting in decreased aquifer levels and seawater intrusion. Researchers from UC Davis and UC Cooperative Extension (UCCE), along with colleagues from universities in Iran and Mexico, conducted a study to estimate the sustainable carrying capacity of agricultural land in the valley — that is, to determine which uses of land might minimize groundwater withdrawals while maximizing agricultural profit. The researchers built a simulation model that accounted for the valley's hydrology, water use patterns and groundwater storage. Next, they constructed an optimization model to determine which crop acreages, given constraints on uses of water and land, would maximize profit. Finally, combining the two models, they estimated the optimal land distribution — that is, how much land could be devoted to various crop types without causing excessive groundwater overdrafts. Ultimately, they identified an optimal land use scenario that, over 25 years, would entail a 15% reduction in agricultural acreage — resulting in an 8.5% reduction in food production, just a 4% loss in profit and ultimately 79% less aquifer depletion.

Online: https://doi.org/10.3733/ca.2020a0005

The authors emphasize that they do not mean to dictate how land and water should be used. Rather, they present their work as a "vision of what can ideally be accomplished" when water management strategies "harmonize individual decisions and shared natural resources."

Garza Díaz LE, DeVincentis AJ, Sandoval Solis S, et al. 2019. Land-use optimization for sustainable agricultural water management in Pajaro Valley, California. J Water Res Plan Man 145(12). doi:10.1061/(ASCE)WR.1943-5452.0001117

Groundwater recharge and nutrient management can reduce nitrate contamination

Nitrate contamination of groundwater-derived supplies of drinking water — caused primarily by use of nitrogen fertilizers on agricultural land — can cause serious human health problems if nitrate concentrations exceed 10 milligrams per liter of drinking water. Concentrations above that level have been detected in more than 450 wells that supply community water systems in California. To evaluate means of reducing nitrate in water supplied from public wells and nearby domestic wells, two UC Davis researchers — Mehrdad Bastani (a doctoral candidate in the Department of Civil and Environmental Engineering) and Thomas Harter (a UCCE specialist based in the Department of Land, Air and



Agriculture in the Pajaro Valley is extremely productive, but decades of groundwater pumping have led to challenges such as seawater intrusion.

Water Resources) — modeled water flow and contaminant transport in the Modesto basin, which lies within the Central Valley aquifer system.

Focusing on a specific public well in an economically disadvantaged community near Modesto, they assessed the effects on nitrate concentrations of managed aquifer recharge and of improved nutrient management practices on local agricultural land. They evaluated a business-as-usual scenario; a scenario involving agricultural changes such as replacing almond orchards with low-impact crops such as alfalfa or wine grapes; and several groundwater recharge scenarios. The researchers found that when groundwater recharge was increased while nitrate leaching from agriculture was simultaneously decreased, nitrate in drinking water could be reduced by 80% over 60 years (compared to the business-as-usual scenario). They also found that recharging groundwater regularly would produce far better results than would recharging only during times of high water availability.

Bastani M, Harter T. 2019. Source area management practices as remediation tool to address groundwater nitrate pollution in drinking supply wells. J Contam Hydrol 226:103521. doi:10.1016/j.jconhyd.2019.103521

For strawberry growers, birds may help as much as they hurt

Amid rapid intensification of agriculture around the world, biodiversity conservation in agricultural areas has become the subject of considerable research. Diversified farming systems — characterized by integration of crop and noncrop vegetation on and near farms — have gained attention for their ability to retain biodiversity. Many species that benefit from biodiversity efforts can provide growers valuable services such as pollination and insect control. But efforts to conserve bird populations are sometimes controversial because birds can harm crops as well as help them.



Efforts to conserve bird populations in agricultural areas are sometimes controversial because birds can both help crops and harm them.

Research comparing the services and disservices that birds provide to strawberry growers on California's Central Coast was recently conducted by researchers from UC Berkeley's Department of Environmental Science, Policy and Management; UC Davis's Department of Wildlife, Fish and Conservation Biology; and colleagues from other institutions. The researchers designed an experiment that allowed birds access to certain strawberry plots and denied them access to others. They found that birds damage strawberries at about the same rate that they prevent insects from damaging the berries. They also found that farms surrounded by landscapes with more seminatural vegetative cover exhibit greater richness of bird species — as well as greater abundance of insectivorous as opposed to strawberry-eating birds.

These results, the researchers write, highlight the need for land managers to consider both the services and disservices that birds provide. With new funding from the U.S. Department of Agriculture, the authors are now studying, on a wider array of strawberry farms, the impact of farmland diversification on the benefits and costs associated with birds. Further, they are using molecular diet analysis to determine which bird species provide pest control benefits.

Gonthier DJ, Sciligo AR, Karp DS, et al. 2019. Bird services and disservices to strawberry farming in Californian agricultural landscapes. J Appl Ecol 56(8). doi:10.1111/1365-2664.13422

Growers: On-farm food loss driven by retailer requirements

Partly because food disposal is associated with environmental harm, food loss and food waste have gained greater attention as policy issues in recent years. Little research, however, has delved into growers' experiences with and viewpoints on food loss and waste. Two years ago, three researchers at UC Davis — Anne Gillman (then a postdoctoral scholar in the Department of Human Ecology, now a professor at American River College), David C. Campbell (then associate dean in the College of Agricultural and Environmental Sciences, now retired) and Edward S. Spang (assistant professor in the Department of Food Science and Technology) — sought to fill this knowledge gap by conducting interviews with 25 growers of fresh produce in California.

A primary insight of the interviews was that, from the growers' perspectives, on-farm losses mostly occur as a result of forces beyond their control. For example, losses can occur because of unpredictable weather or because buyers of farm products demand consistent quantities of flawless produce. The researchers argue that because on-farm losses are often tilled into the soil or used as animal feed — whereas food lost at the retail or consumer level often goes to landfill, producing environmental problems such as methane emissions — growers who decline to harvest edible but unmarketable items may prevent future environmental harm. The researchers also argue that, although food loss is a problem requiring a solution, efforts to increase the proportion of produce that flows from farm to fork must be pursued with an awareness that the environmental risk of food losses can increase as food moves closer to the consumer.

Gillman A, Campbell DC, Spang ES. 2019. Does on-farm food loss prevent waste? Insights from California produce growers. Resour Conserv Recy 150:104408. doi:10.1016/j.resconrec.2019.104408

Regional approach to U.S. bioeconomy proposed

A bioeconomy, broadly defined, is an economic system in which renewable biological resources replace fossil fuels and in which processed biomass fulfills society's requirements for food, feed, fuel and more. Attempts to establish effectively functioning bioeconomies have taken different forms in different countries but — according to Laura Devaney (a researcher at Dublin City University who in 2017 conducted research as a Fulbright scholar at UC Berkeley) and Alastair Iles (an associate professor in UC Berkeley's Department of Environmental Science, Policy and Management) — the U.S. bioeconomy has so far attained only a "marginal status." The two researchers characterize the U.S. bioeconomy as a highly fragmented system — one in which federal visions for bioeconomic development have had little impact.

To gain further understanding of the obstacles that impede development of the U.S. bioeconomy, the researchers interviewed stakeholders from government departments, multinational corporations, start-ups, universities and nonprofit organizations. A key insight derived from the interviews was that the U.S. bioeconomy might thrive if it were organized around regions — agglomerations of neighboring states with similar resource bases, industrial infrastructures and cultural identities. The authors build on this insight by developing a map of regional bioeconomic governance — proposing a "polycentric governance system" in which states and regions, "in keeping with their regional strengths," create clusters of activity in bioeconomic research, production and processing.

Devaney L, Iles A. 2019. Scales of progress, power and potential in the US bioeconomy. J Clean Prod 56(8). doi:10.1016/j.jclepro.2019.05.393

Avocado rootstocks show promising salinity tolerance

In many places around the world, agricultural production is hampered by water quality challenges such as increased salinity. Avocado production is highly sensitive to salt; indeed, along with avocado root rot, salinity threatens the long-term survival of the California avocado industry. Avocado production typically involves grafting scions, or aboveground plant matter, onto rootstocks, the selection of which influences the crop's salinity tolerance. Researchers from UC Riverside's Department of Botany and Plant Sciences and its Department of Environmental Sciences grafted scions of the commonly grown Hass variety onto three rootstocks — R0.05, Dusa and PP40 — to assess tree performance under high-salinity irrigation conditions and control irrigation conditions.

The researchers allowed the trees to grow for 2 years and 8 months before they began salinity treatments. Fruit was harvested 15 months after treatments had begun and tree survival was assessed some months thereafter. The researchers report that trees grown on the three rootstocks displayed comparable canopy damage (42% to 48% more damage than trees in the control group). One-third of the trees grafted on R0.05 and PP40 died, as did 57% of trees grafted on Dusa — whereas 100% of trees in the control group survived. On average, trees under the salinity treatment bore 63% less fruit than did trees under the control treatment. Nonetheless, the three rootstocks performed better under the high-salinity conditions than other rootstocks previously investigated. The researchers suggest that the three rootstocks — which have also been verified as tolerant of root rot — are prime candidates for further trials and eventual use in commercial avocado operations.

Acosta-Rangel AM, Li R, Celis N, et al. 2019. The physiological response of 'Hass' avocado to salinity as influenced by rootstock. Sci Hortic-Amsterdam 256:108629. doi:10.1016/j.scienta.2019.108629

Drip irrigation may be appropriate for organic spinach production

Over the last decade, California acreage devoted to spinach production has increased by more than 30%. In 2017, the farm-gate value of the state's spinach crop amounted to more than $240 million. The spinach industry is threatened, however, by spinach downy mildew disease, which thrives in the wet canopy conditions typically associated with sprinkler irrigation. At the same time, spinach is highly dependent on nitrogen fertilizer application, so irrigation water must be applied efficiently to minimize nitrogen leaching. Three researchers — Aliasghar Montazar, a UCCE advisor in Imperial and Riverside counties; Michael Cahn, a UCCE advisor in Monterey County; and Alexander Putnam, a UCCE assistant specialist based in UC Riverside's Department of Microbiology and Plant Pathology — conducted experiments at the UC Desert Research and Extension Center to investigate whether drip irrigation is viable in organic spinach production and in management of spinach downy mildew disease. Comparing sprinkler irrigation with multiple configurations of drip line depth and spacing, the researchers determined that plots irrigated by drip lines after emergence displayed lower incidence of downy mildew. They also observed a somewhat lower yield in the drip-irrigated plots. The researchers concluded that drip irrigation in organic spinach production might conserve water and manage downy mildew, but that additional work is necessary to optimize drip line system design and nitrogen management practices.

Montazar A, Cahn M, Putnam A. 2019. Research advances in adopting drip irrigation for California organic spinach: Preliminary findings. Agriculture-Basel 9(8). doi:10.3390/agriculture9080177



Drip irrigation in organic spinach production shows promise as a means of conserving water and managing disease.