Groundwater sustainability in the San Joaquin Valley: Multiple benefits if agricultural lands are retired and restored strategically

Restoring habitat in retired farmland could reduce water demand and provide ecosystem services for farmers and local communities.

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Sustaining the remarkable scale of agriculture in the San Joaquin Valley has required large imports of surface water and an average annual groundwater overdraft of 2 million acre-feet (Hanak et al. 2017). This level of water demand is unsustainable and is now forcing changes that will have profound social and economic consequences for San Joaquin Valley farmers and communities. Land will have to come out of agricultural production in some areas. Yet, the emerging changes also provide an important opportunity to strike a new balance between a vibrant agricultural economy and maintenance of natural ecosystems that provide a host of public benefits — if the land is retired and restored strategically.

Once characterized by widespread artesian wells, the San Joaquin Valley now averages groundwater depths of over 150 feet below the surface, exceeding 250 feet in many areas. Decades of groundwater withdrawals have led to the declining reliability and quality of groundwater (Hanak et al. 2015; Harter et al. 2012), widespread land subsidence exceeding 25 feet in some areas (CADWR 2014; Farr et al. 2017) and degradation of groundwater-dependent ecosystems (The Nature Conservancy 2014). The 2011–2016 drought exacerbated the situation. Severely constrained surface water supplies resulted in a near doubling of average annual land fallowing (Melton et al. 2015) and a rapid increase in groundwater depletion. In response, during the drought in 2014, California passed the Sustainable Groundwater Management Act (SGMA).

SGMA requires communities — through newly established groundwater sustainability agencies (GSAs) — to bring their groundwater basins into balance by 2040 through implementation of groundwater sustainability plans (GSPs). When implemented, the plans are meant to stabilize groundwater levels, decrease water quality degradation and halt land subsidence. Implementation of SGMA in California is going to have a significant impact on farming, particularly in the southern San Joaquin Valley, where farmers are highly dependent on groundwater for irrigation.

In some areas, it is likely that large amounts of agricultural land will need to come out of production; some predictions suggest that as many as 500,000 acres will need to be retired over the next 10 to 20 years to achieve basin sustainability (Hanak et al. 2017).

A pistachio orchard in Tulare County next to the dry bed of Deer Creek. Implementation of the Sustainable Groundwater Management Act in California is going to have a significant impact on farming, particularly in the southern San Joaquin Valley, where farmers are highly dependent on groundwater for irrigation.

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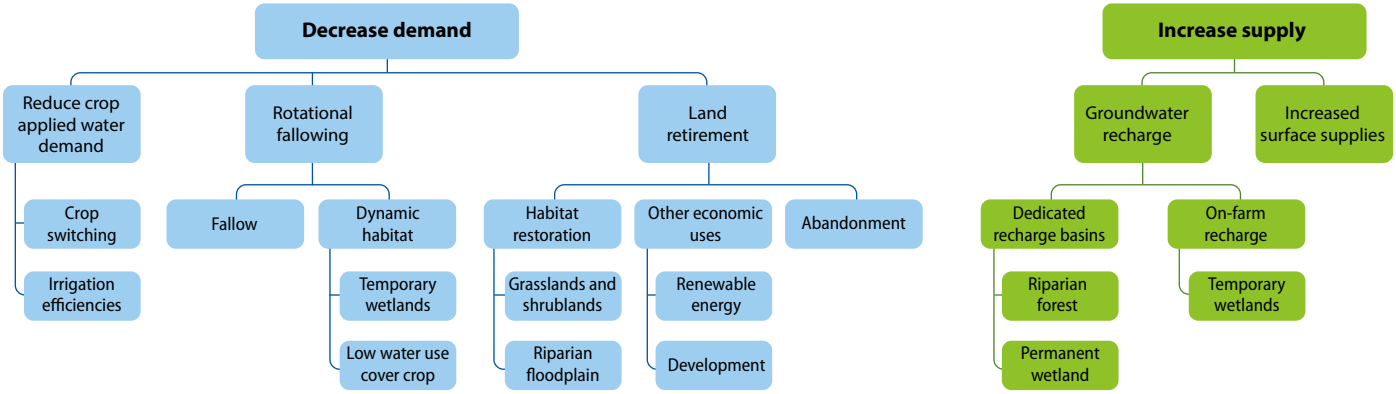

FIG. 1. Groundwater sustainability agencies (GSAs) have many strategies to balance groundwater use in local basins. Some GSAs will be more able than others to find new surface water supplies. Agencies in areas with chronic overdraft problems will need to decrease demand. Strategies are available that would provide multiple benefits to the environment.

A major opportunity lies in that scale of land use change. If portions of those retired lands are restored as a connected network of natural lands, multiple benefits could be created for farmers and San Joaquin Valley communities, in addition to helping meet groundwater sustainability. Realizing those benefits without exacerbating the impacts of the changes to this large agricultural economy is important. It will require spatially optimizing retirement and restoration of lands based on their productivity, access to water and ecosystem potential.

Options to achieve sustainability

GSAs are choosing strategies from among a palette of options to achieve groundwater sustainability (fig. 1). Increasing surface water supplies and recharging groundwater from dedicated recharge basins or temporary wetlands on fallowed fields will be valuable options in some basins. However, for areas with little or no surface water in many years, supply-side solutions will only address a small proportion of the deficit (Hanak et al. 2017). These parts of the San Joaquin Valley are where reducing demand will be necessary.

Options for reducing demand like crop switching and increasing water use efficiency through infrastructure improvements or soil management practices like those supported by the USDA-NRCS Environmental Quality Incentive Program (fig. 1) will be essential but also fail to fully close the deficit in the most critically overdrafted basins. In those basins, rotational fallowing and permanent retirement of some agricultural lands will be necessary.

Multiple benefits from retiring or restoring land

Areas that come out of production provide a range of opportunities, from habitat restoration to renewable energy (fig. 1). On lands where both agricultural productivity and potential habitat values are low, renewable energy may be among the best options (Butterfield et al. 2013; Pearce et al. 2016). On lands where the potential habitat value for natural communities is high, restoration is an important option (Butterfield et al. 2017; Lortie et al. 2018) and offers multiple other benefits. As GSAs design their plans, they might intentionally adopt strategies that secure some of these opportunities instead of leaving the lands fallow and unused or converting them to houses or industrial uses.

Converting the valley to irrigated agriculture resulted in one of the highest losses of natural diversity anywhere. The San Joaquin Valley has one of the highest concentrations of endangered species in the United States (Williams et al. 1998). Retiring and restoring parts of the farming landscape to natural habitats could significantly change the potential for recovery of dozens of endangered species in the valley (Stewart et al. 2018). The current San Joaquin Valley recovery plan for threatened and endangered upland species estimates that approximately 80,300 acres (Williams et al. 1998) of protected natural lands will be needed to recover and delist 11 species. With carefully planned restoration of some agricultural lands in the right places and in large enough, connected blocks, recovery becomes a much more realistic possibility. Species recovery, in turn, may contribute, eventually, to reducing constraints on water availability that currently protect endangered species.

Permanently restoring upland habitats that have been lost from the valley could also reduce water demand and generate other benefits for people and nature. Restored lands can provide tangible services for farmers, such as providing a reservoir of abundant native pollinators needed for crop production (Klein et al. 2012; Kremen et al. 2002) and natural enemies of agricultural pests that can reduce the pest burden in many crops (Bianchi et al. 2006).

Reducing the agricultural footprint may also help reduce air quality problems that are contributing to chronic human health issues in the valley (Almaraz et al. 2018; Keet et al. 2017). It will create the possibility, over time, of reducing overall nitrate loading in groundwater, which currently affects rural communities and contributes to higher rates of birth defects than state averages (Brender et al. 2013; Community Water Center 2013). Further, it could significantly contribute

to helping the state meet its 2030–2050 targets for reducing greenhouse gas emissions (Cameron et al. 2018). These and other benefits, such as creating recreational opportunities for valley residents, may be the basis for public and private investments that help defray the economic costs of lost agricultural production and land restoration.

Strategic retirement and restoration

The San Joaquin Valley is an agricultural powerhouse. California is the largest food producer in the nation and exports food around the world. Seven of the state's top 10 counties for food production are in the San Joaquin Valley; in 2016, those seven counties generated over $30 billion in agricultural revenue, 67% of the state total (CDFA 2017). Ask any San Joaquin Valley farmer, many of them fourth- or fifth-generation farmers, and they are justifiably proud of their legacy and the important role they play in growing food. The benefits of retiring land from agricultural use are clear, but it will come with very real costs to individual landowners, the broader community that relies on this agricultural economy and the reliability of a locally produced food supply. Thus, retirement and restoration need to be done strategically.

The Nature Conservancy and other organizations are developing and testing approaches to strategic land retirement and restoration (SLRR), whereby lands would be targeted for retirement and restoration where habitat, ecosystem service and human benefits can be best achieved with minimal additional impact to the agricultural economy and food production. The idea of land use planning to balance human needs and environmental health is not new (DeFries et al. 2004; Kennedy et al. 2016). A variety of technical tools are available to model and plan for optimizing land use to get the most benefit and minimize trade-offs (Beyer et al. 2016). For the San Joaquin Valley, these approaches can be used for spatially targeting land retirement in order to redesign the landscape in ways that offer the greatest ecosystem service benefit for local communities (e.g., open space for recreation and improved air quality) and for farmers (e.g., water reliability and pollination services).

The opportunity for SLRR will depend in part on the flexibility GSAs build into their GSPs for water trading and other mechanisms for basinwide water management. Consolidating retired and restored lands into the most optimal locations will be most effective when paired with water-trading options that allow landowners to support retirement of land in other GSAs or basins in exchange for water use rights on highly productive farmland kept in production.

Incorporating land retirement and restoration into GSPs

Without coordinated planning, land retirement is not likely to occur in ways that achieve the highest benefit. In many cases, GSAs may have limited capacity, knowledge and financial resources for incorporating land retirement and restoration into their GSPs. In addition,


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Conservation land use options that can be part of the solution for meeting groundwater sustainability include: *top left*, temporary flooding of farm fields at the right times of year to create "pop-up" wetlands for wildlife; *top right*, wetland and riparian habitat in dedicated recharge basins that can provide high-value habitat for migratory birds and the threatened giant garter snake; *bottom left* and *bottom right*, restored riparian corridors along rivers and restored upland grasslands and scrublands, which could reduce the demand for water and provide ecosystem service and human benefits.

to demonstrate the potential of SLRR, further work is needed to develop and evaluate different scenarios of land use that include land retirement and restoration based on different options and values. We need direct, on-the-ground experiments of land restoration to measure the costs and benefits, refine methods for land restoration, and resolve questions about the exact types and amounts of benefits that can be derived. Another need is collaborative exploration of funding mechanisms to compensate farmers for lost production and to pay for land restoration. Therefore, new partnerships and broad collaboration are needed to shape San Joaquin Valley land retirement in a way that increases the long-term viability of agriculture while improving social and environmental outcomes.

An emerging partnership between Pixley and Lower Tule GSAs (Tulare County) and The Nature Conservancy to develop a pilot project is one example of such a collaboration. The Nature Conservancy is providing scientific capacity to inform where SLRR can best be positioned in the Tule subbasin, using analyses to evaluate optimal selection of lands for SLRR and to quantify potential water quality and greenhouse gas benefits. South Valley Water Association is working with the GSAs to identify landowners willing to implement on-the-ground restoration experiments that demonstrate how to design, fund and implement land restoration. Collaboratively, we are identifying and working to secure public and private funding that can support broad-scale implementation of SLRR as an important part of the solution to groundwater sustainability for GSAs.

Incorporating SLRR into GSPs will be most successful when GSP priorities are aligned with, or supported by, other planning tools. County general plans, regional conservation investment strategies, natural community conservation plans and habitat conservation plans will all play a role in ensuring land retirement unfolds in a way that maximizes benefits and minimizes economic impacts to San Joaquin Valley communities. Making sure these planning efforts include SLRR, and that they can be successful in achieving multiple benefits that serve many members of the community, will require partnerships and collaboration between counties, state and federal agencies, and the local GSAs.

Meeting the long-term sustainability goals of SGMA will require land use changes. Planning for that eventuality in a strategic way could transition the San Joaquin Valley landscape to one that is more agriculturally, socially, economically and ecologically resilient. CA

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